Demo results assessment and data collection report – Spain

D9.6

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About OneNet

The project OneNet (One Network for Europe) will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure.

OneNet is funded through the EU's eighth Framework Programme Horizon 2020, "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage, and small-scale (RES) generation," and responds to the call "Building a low-carbon, climate-resilient future (LC)."

As the electrical grid moves from being fully centralized to a highly decentralized system, grid operators have to adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. The project brings together a consortium of over 70 partners, including key IT players, leading research institutions, and the two most relevant associations for grid operators.

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services that aim at the coordination of all actors, from grid operators to customers;
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters, including countries in every region of Europe and testing innovative use cases never validated before.

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List of Abbreviations and Acronyms

Acronym	Meaning
A	Availability
BUC	Business Use Case
DER	Distributed Energy Resource
DSO	Distribution System Operation
E	Energy
ES	Spain
FSP	Flexibility Service Providers
HV	High Voltage
i-DE	i-DE Redes Eléctricas Inteligentes, S.A.U. (Spanish DSO)
IMO	Independent Market Operator
KPI	Key Performance Indicator
kW	Kilowatt
kWh	Kilowatt-hour
LMP	Local Market Platform
LT	Long-term
LV	Low Voltage
MV	Medium Voltage
MTU	Market Time Unit
NEMO	Nominated Electricity Market Operator
OMIE	Iberian Electricity Market Operator
P	Power
RT	Real Time
SO	System Operators (referring to both DSOs and TSOs)
SRA	Scalability and Replicability Analysis
ST	Short-Term
SUC	System Use Case
TSO	Transmission System Operator
UFD	Union Fenosa Distribución (Spanish DSO)
UMU	Murcia University
WECL	Western Cluster
WP	Work Package

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Executive Summary

This deliverable presents the results and main recommendations of the Spanish demonstrator implementation. It also provides an evaluation of the achievements of the demonstration in terms of services and products, market design, market platforms, participation of aggregators, and the delivery of system services. Subsequently, the main challenges encountered in developing the demonstrator are discussed, along with the proposed next steps beyond the achieved results in the Spanish OneNet demonstrator.

The Spanish demonstrator has made significant contributions in the following areas:

1. Definition of services and products for local markets as key element for providing system operators services: Two Spanish distribution system operators (DSOs) agreed to define the products' key attributes to acquire congestion management services, catering to long-term and short-term DSO needs.
2. Local markets require a specific design to fulfill their intended purpose. Various design elements, such as the prequalification process, locational granularity, selection of resources, market clearing rules, activation and measurement procedures, among others, were successfully implemented in the Spanish demonstrator.
3. The development of a local market platform is a key element to ensure a transparent procurement of system services: The technical and functional development of market platforms for trading long-term and short-term products was successfully accomplished in the Spanish demonstrator.
4. Engagement of a diverse range of customers, including aggregators is a must to ensure high participation in the market and competition in the service provision: The Spanish demonstrator involved various resources, including industrial facilities, buildings, and aggregators interested in coordinating the flexibility service providers (FSP) response.
5. System services can complement grid investments and solve technical issues. Delivery of required services with high accuracy: The activation process and service delivery were effectively measured, ensuring the provision of services with high accuracy and reliability.

During the development of the demonstrator, several key challenges were encountered:

1. Customer engagement: Engaging resources connected to distribution networks in new service offerings posed additional challenges for aggregators and final resources. Various behavioral, economic, technical, and legal barriers were identified and addressed.
2. Platform functioning and integration of market platforms with the OneNet system: The integration of the market platform into the OneNet system faced challenges related to cybersecurity measures, ensuring a secure operation of the market and the protection of participants' data.
3. Baseline definition: The selection of the baseline definition was mainly driven by practical reasons, without a comprehensive assessment of alternative options based on technological characteristics, product attributes, accuracy of methods, outcome efficiency, and other relevant factors.

Besides the progress in the Spanish demonstrator, additional related developments related to the demonstrator are addressed in OneNet Work Packages 9 and 11, including:

1. Scalability and replicability analysis of demonstrated solutions: The Spanish OneNet demonstrator requires analyzing broader contexts beyond the involved resources. Conducting a scalability and

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replicability analysis in a broader context is essential to evaluate the applicability and outcomes of the demonstrated solutions. This analysis is presented in OneNet Deliverable 9.8.

2. Integration of the local market with the wholesale market: European electricity markets are interconnected. The short-term local market is part of this sequence, and linking it with other markets, such as the intraday market managed by OMIE, can provide benefits by increasing the likelihood of bid clearance and enabling resource value stacking. OneNet Deliverable 11.2 outlines the conditions for linking intraday with short-term local markets through bid forwarding.
3. Business model assessment: To fully realize the benefits of the Spanish demonstrator, implementing new business models, such as aggregators or independent market operators (IMOs), needs to be considered and defined within the Spanish regulatory framework. Additionally, expanding the role of DSOs in procuring system services1 is crucial. Currently, there is no business model and procurement process for distribution utilities to implement flexibility products. Existing regulatory barriers for these business models and strategies for engagement of critical stakeholders are detailed in OneNet Deliverable 11.6 [2].

Finally, several key steps have been identified for the development of local markets in the Spanish context:

1. Definition of roles and responsibilities by the regulatory authority: Clearly defining the roles and responsibilities of each agent is crucial in determining the actions required from each party to unlock the use of flexible resources.
2. Further implementation of market procedures: Due to limitations in time and resources, certain market procedures were not implemented. These procedures include information exchange between DSOs, transmission system operators (TSOs), and IMOs, market settlement, penalties for non-delivery, and the definition of baseline methodologies, among others.
3. Incentives for DSOs to utilize flexibility: The current remuneration scheme for DSOs is biased towards capital expenditure (CAPEX). To encourage the use of flexibility as an alternative to network reinforcements or traditional operation costs, modifications to the remuneration scheme are necessary, ensuring that DSOs have incentives for acquiring and managing flexibility services when that is the most cost-effective solution.
4. Customer engagement strategies: Successful market implementation requires tailored customer engagement strategies to attract FSPs to provide services. These strategies should consider the technical capabilities of resources, the knowledge and skills of flexibility asset owners, their motivations, incentives, and other key factors influencing their engagement.
5. Comparison of local markets and alternative mechanisms for acquiring system services: While local flexibility markets are one tool for acquiring and activating system services, limitations in liquidity can arise due to network topologies or a lack of flexibility resources capable of providing the services. Therefore, alternative mechanisms such as bilateral contracts, dynamic tariffs, or rule-based solutions should be analyzed based on specific needs and contextual characteristics.

[1] The Framework Guideline on Demand Response defined it as System Operator services meaning market-based procurement of balancing, voltage control and congestion management [1].

1 Introduction

This deliverable presents the results of the OneNet Spanish demonstrator and aligns the Spanish demonstrator's main findings with the development of local flexibility markets in Europe, highlighting the main achievements and challenges for future developments. The Spanish demonstrator is part of the OneNet Western Cluster together with France and Portugal.

The OneNet Spanish demonstrator aims to develop market-based solutions for congestion management at the distribution network. The demonstrator involves two DSOs: i-DE and UFD. Three demo areas were tested: two in Madrid and one in Murcia. OMIE (Iberian market operator) developed local market platforms (LMPs) to solve long-term and short-term congestions, consisting of interfaces between the market operator and DSO and final consumers. The demonstrators involve a wide range of Flexibility Service Providers (FSPs), including commercial and industrial consumers, who provide flexibility services by making temporary changes to the way they consume when requested.

1.1 Objectives of Deliverable 9.6

The objective of the work reported in this deliverable is to present the main results of the Spanish demonstrator of the OneNet project. First, the document presents the Spanish demonstrator's ambition, including the business and system use cases and the market design developed and adopted in the project. Then, it introduces the real-world implementation of the market platforms developed, the demonstrator sites and resources, the tests performed and resulting KPIs.

This document evaluates the results by specifying the achievements of the demonstration in terms of the services and products, market design, market platforms, the participation of the aggregators, and the delivered system services. Then, the main challenges encountered in the demonstrator development are presented, together with the next steps beyond the results achieved in the Spanish OneNet demonstrator. Some of these next steps are developed in OneNet work package 11, but others are beyond the project.

1.2 Interactions with other tasks and WPs

This document is a follow-up to Deliverable 9.3 [3], which presents the Validation and results of the concept test of the Spanish demonstrator. As presented in Figure 1, the Spanish demonstrator has been involved in close collaboration with the horizontal work packages:

- WP2: the definition of standardized products, business uses cases and KPIs [4]
- WP3: market design framework applied to local markets [5]
- WP4: integration of system services and data exchanges

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- WP5: system use cases definition and platforms architecture [6]
- WP6: interconnection of the OneNet connector
- WP11: providing inputs for the European-wide solutions in terms of market designs, ICT and platforms standardization, business models, customer engagement and scalability and replicability analysis of the designed solutions.

In addition to previous interactions, this deliverable refers to the main findings reported in Deliverable 9.1 on the specifications of the Western demonstrations [7]. The results of the Spanish demonstrator are presented in Deliverable 9.3 [3]. The follow-up interactions presented in Deliverables 9.8 [8] and D9.9 [9] address the overall results of the Western demonstrators, the regional use case results and present the scalability and replicability analysis.

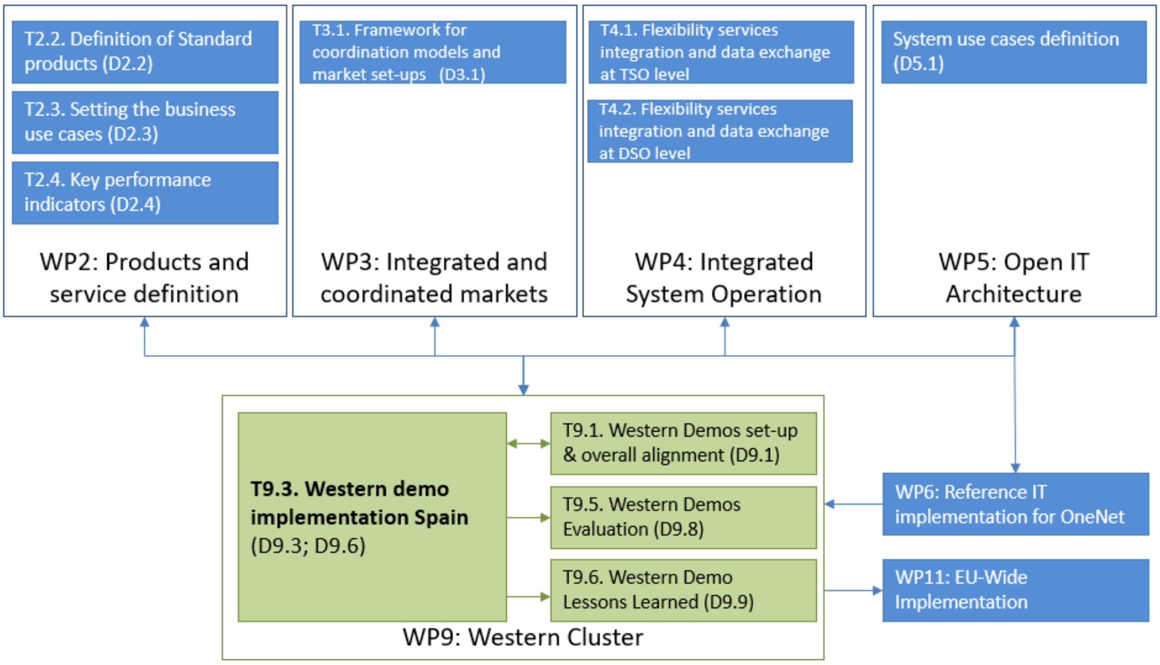

Figure 1 -Interaction within WP9 and other WPs.

1.3 Outline of the Deliverable

The rest of the document has the following sections:

- Section 2 describes the Spanish demonstrator set-up, including the description of resources and networks, market designs, the platform development, the tests made and resulting KPIs.
- Sector 3 presents the evaluation of the Spanish demonstrator highlighting the main achievements, challenged faced and next steps within the OneNet project and beyond.
- Section 4 provides the main conclusions and policy recommendations of the Spanish demonstrator.

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2 Spanish Demonstrator description

The primary objective of the OneNet Spanish demonstrator is to create market-driven solutions for congestion management within the distribution network. This demonstration project encompasses the participation of two DSOs, namely i-DE and UFD. Three separate demonstration areas were utilized for testing, with two located in Madrid and one in Murcia. The Iberian market operator developed local market platforms to acquire flexibility to manage short-term and long-term congestions. The demonstrators involve various FSPs, encompassing public facilities, university buildings, biogas generators and industrial consumers and aggregators. These aggregators are intermediaries between the market operator, DSOs, and the FSPs.

2.1 Spanish demonstrator's ambition

Table 1 shows the overview of the Spanish demonstrator, including the service considered, the products, BUCs, SUCs and submarket design. The demonstrator aims to provide solutions for both corrective and predictive congestion management. For predictive congestion management, long-term and short-term solutions are envisioned. For corrective services, a short-term solution is developed. The local market platform supports services and BUCs.

The products used are active power, for both short and long term congestion management, considering energy activation for corrective and predictive services and with the possibility of power availability for predictive services. A local market design was used to perform the demonstrator tests. The complete description of the BUC and SUC is provided in Deliverable 9.3 [3]. Below is presented a summary of the main features.

Table 1 - Overview of Spanish demonstration
Source: OneNet Deliverable 9.3 [3]

Service	Product	BUC	SUC	Submarket design
Corrective active power for Congestion management	Corrective local active	WECL-ES-02: Short-term congestion management	SUC-ES-01: Local Market Platform	DSO coordination Short-term Intraday market: -Power Activation, P-E
Predictive active power for congestion management	Predictive short-term local active	WECL-ES-02: Short-term congestion management	SUC-ES-01: Local Market Platform	DSO coordination Short-term Day Ahead market: -Power Activation, P-E; -P Availability and Activation, P-A-E
	Predictive long-term local active	WECL-ES-01: Long-term congestion management	SUC-ES-01: Local Market Platform	DSO coordination Long-term market: -Power Availability, P-A; -P Availability and activation, P-A-E

Where: P=Power, A=Availability and E= Energy (activation)

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2.2 Business Use Cases and System Use Cases

The Spanish BUCs are described in WP2, OneNet D2.3 [10] the Spanish demonstration sites tested the following BUCs:

- WECL-ES-01: Long-term congestion management
- WECL-ES-02: Short-term congestion management

The WECL-ES-01 focuses on the DSO's long-term procurement of congestion management products. The objective of this BUC is that the DSO can procure the resources' availability to change their schedules when congestions are expected. In this way, the main gain is that network reinforcement can be postponed or completely avoided. The product is agreed upon in advance from years to weeks ahead when the need is forecasted.

The WECL-ES-02 focuses instead on the short-term procurement of congestion management at the day-ahead and intraday timeframes. The day-ahead procurement aims to support the DSO in solving programmed and expected works in the network. The DSO would therefore buy an availability product with high certainty of being used. This product may consider an activation payment or be already included in the availability remuneration. The intraday product is expected to support the DSO operation in case of unexpected faults to restore or reduce network congestions. Due to the characteristics of the product, the payment remunerates for activation.

For all three products, five scenarios[2] have been defined as described below:

1. Preparation/prequalification: in this phase, the FSPs request to pass the technical tests to ensure that the resources meet the products' technical requirements and fulfill the DSO and market requirements.
2. Plan/forecast: the DSO performs an internal analysis to determine the network congestions' needs, which could be solved with the related products.
3. Market phase: in this phase, the DSO calls the market to procure the required products to fulfill the forecasted needs. The FSPs submit their bids, and the IMO performs the market clearing to select the most economical bids.
4. Monitoring: the DSO monitors the grid conditions in real-time and sends activation signals to the cleared FSPs.
5. Measurement: This phase measures the service delivered according to the baseline conditions. If the FSP cannot deliver flexibility by the predefined market conditions and agreed-on baseline, penalties may apply, which would decrease the remuneration received by FSP.

[2] Or phases, the word "scenario" is used in this deliverable, as it is used in the BUC templates, from IEC 62559-2 standard.

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The System Use Case in the Spanish demonstrator presented in OneNet D5.1 [6] describes the local market platform operated by the IMO. It is an interface between the FSPs and DSO to trade congestion management products. Three scenarios are considered for the SUC:

1. Flexibility resource register.
2. Market request: to enable and handle a market session requested by DSO.
3. Market session: to enable and handle market activities, including the bid collection, market clearing and publishing of market results.

2.3 Market design

The Spanish demonstration employs market-driven coordination among DSOs to ensure that the flexibility provided by FSPs addresses the specific local requirements of the DSO while minimizing any impact on other areas. The Spanish demonstrator focuses on developing and testing a local market for congestion management at the distribution system to unleash the flexibility potential of resources connected.

As classified in D3.1, the OneNet Spanish demonstrator belongs to the DSO-FSP market-based coordination category, focusing on establishing mechanisms to procure system services from FSPs to address local needs [5]. This approach involves adopting market practices enabling the DSO to obtain system services from the FSPs efficiently. The demonstrators utilize a local market where the DSO has exclusive access to DERs. While the demonstrator does not directly test the interaction with the TSO, this interaction is considered during the theoretical design of the technical or market-based coordination.

The local markets include long-term and day-ahead availability and activation markets and intraday, real-time activation market. In the case of availability markets, the specification of the number of expected activations is required to assess the overall procurement cost. The FSPs selected in the availability market, if activation has not been contracted at front, must compete with other FSPs in the related activation market to ensure that the cheapest bids are selected.

In parallel with the local markets, existing submarkets are already established, as presented in Figure 2: wholesale energy day-ahead and intraday markets and the balancing and TSO congestion management markets.

Table 2 reports the nomenclature used in Figure 2. The integration of short-term local markets with the existing markets is a pending task outside the scope of the Spanish demonstrator. However, the potential connection of the local markets demonstrated in the OneNet Spanish demonstrator is theoretically investigated in OneNet Tasks 3.3 and 11.2 and described in [11].

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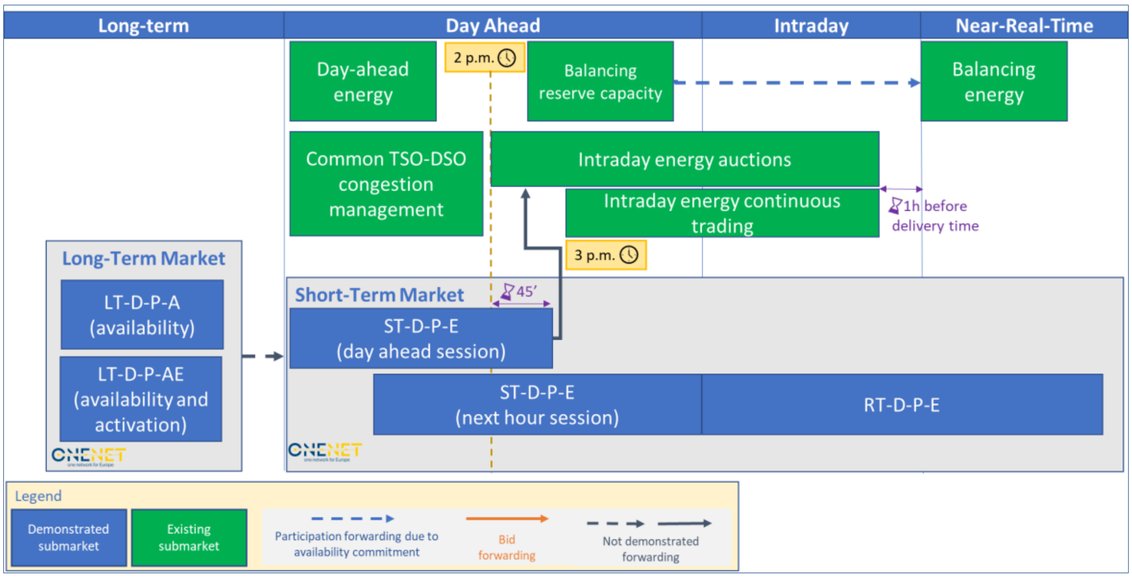

Figure 2 - Overview of the Market Architecture. Source: OneNet Deliverable 11.2 [12].

Table 2 - Formalized nomenclature for naming the main submarkets. Source: OneNet Deliverable 3.1 [5]

Element	**First**	**Second**	**Third**	**Fourth and fifth**
Meaning	Timing	FSP grid connection	Variable related to the product traded	Availability or activation of the flexibility to be provided
Options	LT (Long-Term)	T (Transmission)	P (Active power)	A (Availability)
	MT (Medium-Term)	D (Distribution)	Q (Reactive power)	E (Activation)
	ST (Short-Term)	TD (Transmission and Distribution)	PQ (Active and reactive power)	A-E (Availability and activation)
	WA (weeks ahead)			
	DA (Day-ahead)			
	ID (intraday)			
	NRT (Near-Real-Time)			
	RT (Real-Time)			

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The OneNet Spanish demonstrator has developed a long-term submarket including:

- Long-Term Active Power Availability Submarket (LT-D-P-A)
- Long-Term Active Power Availability and Activation Submarket (LT-D-P-AE)

The Long-Term Active Power Availability (LT-P-A) submarket is part of the long-term submarkets aimed at flexibility procurement. It serves as a local mechanism through which the DSO procures active power flexibility regarding availability from FSPs connected at the distribution system level. FSPs within the procurement area compete by submitting availability bids to the local auction marketplace. The Long-Term Active Power Availability and Activation Submarket (LT-P-A-E) follows a similar structure; however, the bids submitted by the FSPs encompass both availability and activation. This market is designed explicitly for procuring flexibility services when the need for flexibility can be forecasted well in advance. This allows for scheduling the activation of the FSPs with high reliability and long-term planning.

As for the short-term submarket developed by the OneNet Spanish demonstrator, two submarkets are included:

- Short-Term Active Power Activation Submarket (ST-D-P-E)
- Real-Time Active Power Activation Submarket (RT-D-P-E)

The ST-P-E deals with predictive active power management, a service meant to solve forecastable network congestions (e.g. congestion arising due to forecast maintenance activities). The RT-P-E concerns the corrective local active targeting congestion management needs caused by network failures and subsequent corrective actions (e.g. switching state changes, ad-hoc active power intervention) through activating active power generation and demand side sources.

The Short-Term Active Power Activation Submarket (ST-P-E) forms part of the short-term submarkets dedicated to flexibility procurement. It functions as a day-ahead local mechanism for the DSO to procure active power flexibility from the FSPs connected at the distribution system level. In this market, active power activation is procured and remunerated. However, the submarket structure also leaves the possibility of remunerating availability in some cases. The submarket consists of two different time procedures. If the market operator receives the request for flexibility before 2 p.m., the auction opens at 2 p.m. The auction opens an hour later if the request is received after 2 p.m. While all FSPs in the relevant procurement area can participate in the auction, those FSPs cleared in the Long-Term Active Power Availability Submarket (LT-P-A) must participate. These FSPs can bid a different amount and price in the short-term submarket. However, the ST-P-E auction is characterized by a reserve price established by the DSO (maximum price accepted by the algorithm in the auction process). It is related to the long-term matching price. This reserve price cannot be exceeded during the auction.

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The Real-Time Active Power Activation Submarket (RT-P-E) operates on the same day of delivery, allowing the DSO to procure active power flexibility from FSPs connected at the distribution system level. In this market, active power activation is procured and remunerated. Participation of free bids is allowed in the RT-P-E submarket: it is open to all qualified FSPs and independent of long-term submarkets (LT-P-A and LT-P-A-E).

In the following, Table 3 and Table 4 describe the long-term and short-term markets designed for the OneNet Spanish demonstrator using the Theoretical Market Framework pillars and features [5], [12]. Table 5 reports the features corresponding to the interaction between the long- and short-term markets.

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Table 3 - Description of the submarket features of the D3.1 Theoretical Market Framework of the Long-Term markets designed for the OneNet Spanish demo, Source: OneNet D11.2 [12]

Feature	**Attribute**	**Spain**		***Additional Information***
Number of submarkets		LT-D-P-A	LT-D-P-A-E	Long-term markets aimed to delay network investments
Submarket dimension	**Gate Opening Time (GOT)**	From more than one year-ahead to weeks ahead	From more than one year-ahead to weeks ahead	
	Timing of the submarket clearing (GCT)	2 days before activation time	2 days before activation time	
	Sub-market type	Auction market	Auction market	
Procurement frequency		Event-based on DSO call	Event-based on DSO call	
Market time unit		1 hour	1 hour	
Market clearing type	**Discrete; Continuous**	Discrete	Discrete	
Remuneration scheme		Auctions pay-as-bid.	Auctions pay-as-bid.	
Products and services	**Service**	Congestion management	Congestion management	
	Product procured	Active power Availability	Active power Availability Active power Availability and activation	
Remunerated product attribute		Active power Availability	Active power Availability Active power availability and activation	Bids have two price terms: Availability (€/MW) and Energy (€/MWh). Both are considered in the economic valuation of the offer. Valuation [€]= Availability price [€/MW]+Activation price [€/MWh]*estimated activation hours [h]
	Harmonized product acquired	Predictive long-term local active	Predictive long-term local active	
	Bid structure (Simple/complex)	Simple	Simple	
Location	**Level of spatial granularity**	Distribution system areas	Distribution system areas	Two kinds of areas are considered: basic and aggregated areas. Basic areas are a single postal code. Aggregated areas combine basic areas according to the DSOs' needs.
	Responsible System Operator	DSO	DSO	
	Voltage Level where resources are located	MV, LV	MV, LV	
Roles and actors	**Who is the buyer(s)**	DSO	DSO	
	Who is the seller(s)	FSP	FSP	
	Allowed technologies (Generators, Loads, Storage)	Generators, Loads, Storage	Generators, Loads, Storage	
	Aggregation method (area, voltage level, substation)	Area	Area	
	Aggregation mix	All technologies can be aggregated, but upward and downward flexibility cannot be aggregated together in the same bid.	All technologies can be aggregated, but upward and downward flexibility cannot be aggregated together in the same bid.	
	Who is the MO	IMO	IMO	
	Participation in submarket	Optional	Optional	
Sub-market clearing objective	**Minimization of cost,** **Maximization of social welfare** **Reducing the counter-activations**	Minimization of cost	Minimization of cost	
Access to flexibility	**System operators order for the procurement of flexibility within the submarket.**	Exclusivity for DSO	Exclusivity for DSO	

Feature	**Attribute**	**A. Comprehensive grid data**	**B. Partial grid data**	**C. Empirical rules**	***Additional Information***
Grid constraints inclusion					
	Definition of procurement areas	X	X		
	Procurement phase	X	X		

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Table 4 - Description of the submarket features of the D3.1 Theoretical Market Framework of the Short-Term markets designed for the OneNet Spanish demo, Source: OneNet D11.2 [12]

Feature	**Attribute**	**Spain**	**Spain**	***Additional Information***
Number of submarkets		ST-D-P-E	RT-D-P-E	
Submarket dimension	**Gate Opening Time (GOT)**	Day-ahead or the next hour after the DSO request (limit 11 pm)	The day of delivery Next hour market for **intraday** service	
	Timing of the submarket clearing (GTC)	Day-ahead (hourly and quarter of hour negotiation intervals are under consideration) Day ahead market closes at 14:00 for the day ahead product or next hour market for intraday service	Near Real time	
	Sub-market type	Auction market	Auction market	
Procurement frequency		Event-based on DSO call	Event-based on DSO call	
Market time unit		1 hour	1 hour	
Market clearing type	**Discrete; Continuous**	Discrete	Discrete	
Remuneration scheme		Auctions pay-as-bid.	Auctions pay-as-bid.	
Products and services	**Service**	Congestion management	Congestion management	
	Product procured	Active Power Activation Active power Availability (optional)	Active Power Activation	
Remunerated product attribute		Active Power Availability Active Power Activation	Active Power Activation	
	Harmonized product acquired	Predictive short-term local active	Corrective local active	
	Bid structure (Simple/complex)	Simple	Simple	
Location	**Level of spatial granularity**	Distribution system areas	Distribution system areas	Two kinds of areas are considered: basic and aggregated areas. Basic areas are a single postal code. Aggregated areas combine basic areas according to DSOs' needs.
	Responsible System Operator	DSO	DSO	
	Voltage Level where resources are located	MV, LV	MV, LV	
Roles and actors	**Who is the buyer(s)**	DSO	DSO	
	Who is the seller(s)	FSP	FSP	
	Allowed technologies	**Allowed technologies** (Generators, Loads, Storage)	Generators, Loads, Storage	
	Aggregation level	**Aggregation method** (area, voltage level, substation)	Area	
	Aggregation mix	**Aggregation mix**	All technologies, but upward and downward flexibility cannot be aggregated in the same bid	
	Who is the MO	IMO	IMO	
	Participation in submarket	Hybrid	Optional	
Sub-market clearing objective	**Minimization of cost** **Maximization of social welfare** **reducing the counter-activations**	Minimization of cost	Minimization of cost	

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Table 4 continued. Description of the submarket features of the D3.1 Theoretical Market Framework of the Short-Term markets designed for the OneNet Spanish demo, Source: OneNet D11.2 [12]

Feature		**Attribute**	**Spain**	**Spain**	***Additional Information***
Allocation principle of flexibility		**System operators order for the procurement of flexibility within a submarket**	Exclusivity for DSO	Exclusivity for DSO	
		TSO access to DERs	Not applicable	Not applicable	
Grid constraints inclusion		**A. Comprehensive grid data**	**B. Partial grid data**	**C. Empirical rules**	
	Definition of procurement areas	X	X		
	Procurement phase	X	X		

Table 5 - Description of the submarket interaction features of the D3.1 Theoretical Market Framework from Long-Term to Short-Term markets designed for the OneNet Spanish demo, Source: OneNet D11.2 [12]

Feature	**Attribute**	**Options**	**Spain**	***Information request***
Linked submarkets			1. LT-D-P-A 2. ST-D-P-E	
Market optimization		Centralized; Decentralized; Distributed	Decentralized	
Submarkets optimization strategy		Simultaneous; Sequential; Independent	Sequential	
Interaction descriptors	**Forwarding of bids**	Yes/No	Not Applicable	Participation forwarding based on the condition established in the availability bid
	Commitment to bid selection	Formal; Conditional	Conditional	
Timeframe for coordination	**Market phase for coordination between submarkets**	Technical pre-qualification		
		Procurement	X	
		Monitoring and activation		
		Measurement		
		Control of activation		
		Settlement		

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2.4 Market platforms

OMIE, the Iberian Market Operator, developed two local market platforms to trade long-term and short-term congestion management products. The local market platform receives the DSO needs and the bids from FSPs, then performs the market clearing and the communication of market results to different stakeholders.

The functions of the market platforms are presented in Figure 3 and further explained in D9.3 [3].

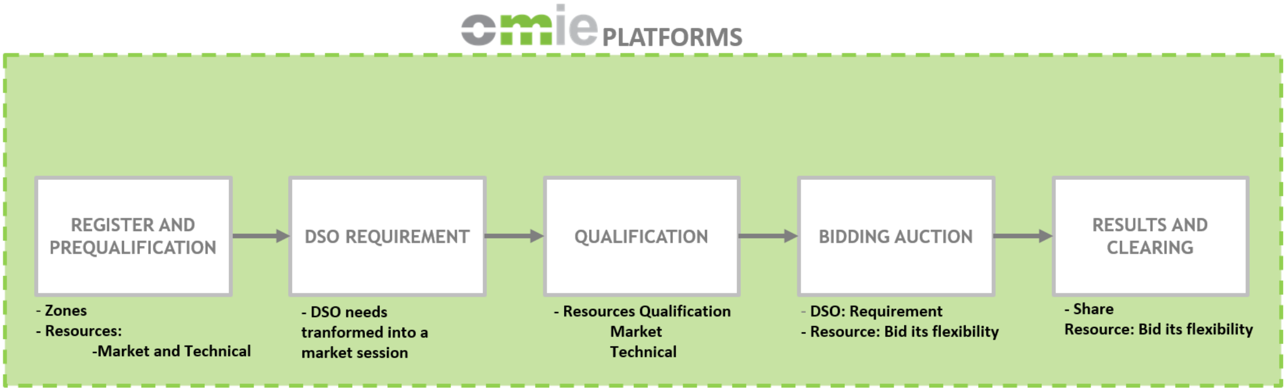

Figure 3 - Local Market Processes.

2.5 Demonstrator sites and resources

The Spanish demonstrator includes two DSOs: i-DE and UFD. The FSPs participating in the demonstrator are located in Madrid in two different areas (Cantoblanco and Alcalá de Henares) and Murcia (Mediterranean region). The list of resources, the corresponding DSO, location, voltage level and flexibility capacity are presented in Table 6. The resources connected to i-DE are university buildings, and the ones connected to UFD are industrial, municipality and biogas customers. The complete description of FSPs' location and characteristics are presented in D9.3 [3].

Table 6 - FSPs involved in the Spanish demonstrator

ID	FSP/Aggregator	Resources	DSO Network	Location	Voltage Level (kV)	Flexibility capacity (kW)
FSP-iDE-01	ODINS (FLEXUM project)	UMU	i-DE	Murcia	20	600-1.000
FSP-iDE-02	Stemy Energy (FLAGS project)	Comillas, Cantoblanco	i-DE	Cantoblanco, Madrid	20	100
FSP-UFD-01	Alcalá de Henares City council	Renewable Energy demonstration center	UFD	Alcalá de Henares, Madrid	15	21

FSP-UFD-02	Alcalá de Henares City council	El Juncal Sport Center	UFD	Alcalá de Henares, Madrid	15	11
FSP-UFD-03	Metalúrgica Madrileña	Metalúrgica Madrileña	UFD	Alcalá de Henares, Madrid	15	312
FSP-UFD-04	Fiesta Colombina	Fiesta Colombina	UFD	Alcalá de Henares, Madrid	15	770
FSP-UFD-05	HERA biogas	HERA biogas	UFD	Alcalá de Henares, Madrid	15	1.000

The university buildings provided flexibility making temporary changes to the way they consume by controlling climatization resources, reducing energy consumption when requested by i-DE. In both cases, aggregators performed the activation of the resources.

As for FSPs connected to UFD, the flexibility comes from:

1. Electric vehicle charging points of the city council of the Renewable Energy demonstration center of the Alcalá de Henares city Council.
2. Controlling the purification of swimming pools in the municipality sports center “El Juncal”.
3. Steel foundry of Matalurgica Madrileña: controlling the tempering furnace, two shot blast machines, and air filtration systems.
4. Licorice product line and its associated air conditioning of Fiesta Colombina factory.
5. Reduction of generation of HERA biogas in the municipal solid waste landfill using a small storage capacity. In the future, the maintenance programming can be aligned with flexibility requirements.

2.6 Description of the demonstrations

Table 7 shows the details of the Spanish demonstrations, the corresponding BUCs, services, product types, locations, voltage level, requested quantities, time when the tests were executed, and the resources involved.

All BUCs were tested: long-term, day-ahead and intraday congestion management predictive and corrective services, including energy and availability products. The tests’ specificities are detailed in D9.3, in section 6 [3].

Table 7 - Spanish demonstrations

ID	BUC	Service	Product	Site	Voltage Level	Problem MW	Timeline	Flexibility resources
ES-iDE-01	ST: WECL-ES-02 Day ahead	Predictive congestion	E	Murcia/ Espinardo	20kV	0,4	28/07/2022 9:30-10:30	Murcia University

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ES-iDE-02	ST: WECL-ES-02 Intraday	Corrective congestion	E	Murcia/ Espinardo	20kV	0,5	28/07/2022 12:00-12:30	Murcia University
ES-iDE-03	LT: WECL-ES-01	Predictive congestion	A+E	Murcia/ Espinardo	20kV	1,1	September Monday to Friday	Murcia University
ES-iDE-04	ST: WECL-ES-02 Day ahead (2 tests)	Predictive congestion	E	Madrid/ Cantoblanc o	20kV	0,1	14/01/2023 21/01/2023 12:30-13:00	Comillas University
ES-iDE-05	ST: WECL-ES-02 Day ahead	Predictive congestion	E	Madrid/ Cantoblanc o	20kV	0,1	04/02/2023 11:00-12:00	Comillas University
ES-UFD-01	LT: WECL-ES-01	Predictive congestion	A+E	Madrid/ Alcalá de Henares	15kV	1,1	From 19/09/2022 To 08/12/2022 L M X J V 6:00-19:00	All FSP in Alcalá de Henares
ES-UFD-02	LT: WECL-ES-01	Predictive congestion	A+E	Madrid/ Alcalá de Henares	15kV	1,1	From 03/10/2022 To 22/12/2022 L M X J V 6:00-19:00	All FSP in Alcalá de Henares
ES-UFD-03	ST: WECL-ES-02 Day ahead	Predictive congestion	E	Madrid/ Alcalá de Henares	15kV	0,63	4/10/2023 17:00-18:00	All FSP in Alcalá de Henares
ES-UFD-04	ST: WECL-ES-02 Day ahead	Predictive congestion	E	Madrid/ Alcalá de Henares	15kV	1,0	6/10/2023 17:00-18:00	All FSP in Alcalá de Henares

Where: P=Power, A=Availability and E= Energy (activation)

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2.7 Key Performance Indicators

The KPIs provided in OneNet WP2 D2.4 [13] for the Spanish demonstration BUCs are presented in Table 8.

Some of the KPIs are specific for each demo site tests:

- 1. Cost-effectiveness,
- 3. Available flexibility,
- 4. Load forecast error,
- 5. Power exchange deviation,
- 6. Asset load profile variation.

Other KPIs are common for the Spanish demonstration (one unique value for all demonstrations sites):

- 2. ICT Costs,
- 7. Volume of transactions (Power),
- 8. Number of transactions,
- 9. Number of products per demo,
- 10. Active participation,
- 11. Number of FSPs,
- 12. Ease of access,
- 13. Number of avoided technical restrictions.

Table 8 - KPIs for the Spanish BUCs

ID	Name	Description	Formula	Unit
1	Cost effectiveness	Compare the cost for flexibility with avoided traditional grid cost (Cost of the flexibility solution against traditional solution).	$Cost_{effectiveness} = \left(1 - \frac{Cost_{flex}}{Cost_{Sub}}\right) \cdot 100$ $Cost_{Sub}$: Avoided traditional solution cost (€/MWh) $Cost_{flex}$: Cost of flexibility (€/MWh)	%
2	ICT costs	ICT cost comprises the information and communication technologies necessary for DSO-IMO-FSP coordination through platforms to develop new local markets.	$ICT_{cost} = \sum_{i=1}^{N_c} c_i$ c_i: generic ith cost directly related new local market implementation (€) Nc: overall number of cost items	€
3	Available Flexibility	Flexible power that can be used for congestion management at a specific grid segment, i.e., the available power flexibility in a defined period (e.g. per day) that can be allocated by the DSO at a specific grid segment, measured in MW. This relates to the total amount of power in the specific grid segment in the same period.	$Flexibility_{\%} = \frac{\sum P_{Available_{Flexibility}}}{\sum P_{Total_{in_{Area}}}} \cdot 100$ $\sum P_{Available_{Flexibility}}$: Power in MW of available flexibility at a specific grid segment in the reporting period (MW). $\sum P_{Total_{in_{Area}}}$: Total power demand in MW at DEMO grid segment (MW)	%

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ID	Name	Description	Formula	Unit
4	Error of load forecast	Error of load forecast calculated T hours in advance	$Load_{FA_{T,h}} = \frac{1}{N}\left(\sum_{t=1}^{N}\left\|\frac{FC_{load,t} - RL_{load,t}}{RL_{load,t}}\right\|\right).100$ FC_{load} : Load estimated T hours in advance (MW) RL_{load} : Real load (MW) N: Number of available data points	%
5	Power exchange deviation	Tracking error between a set-point requested by the SO and the measure.	$P_{Deviation} = \frac{\|P_{accepted} - P_{activacted}\|}{P_{accepted}} \cdot 100$ $P_{accepted}$: accepted (contracted) power (kW) $P_{activacted}$: activated flexibility power (kW)	%
6	Asset load profile variation	This indicator measures the percentage decrease of load demand in the requested asset by a flexibility provider resource.	$CR = \frac{AL_{initial} - AL_{final}}{AL_{initial}} \cdot 100$ $AL_{initial}$: asset load before delivering flexibility (initial asset load (kW)) AL_{final}: asset load a during delivery of flexibility (final asset load (kW))	%
7	Volume of transactions (Power)	This indicator measures the volume of transactions in kW. This indicator will be used to measure the volume of transactions (cleared bids) during the examined period T for each product.	$VT_P = \sum_T \sum_I P_{i,t}$ $P_{i,t}$: Volume offered or cleared capacity by the i-th flexible resource at time t (kW) I: Set of flexible resources. T: Examined period.	kW
8	Number of transactions	This indicator measures the number of transactions. This indicator will be used to measure the number of offered and cleared bids for each product	$N_T = \sum_T n_{Bids,t}$ $n_{Bids,t}$: number of offered or cleared bids at time t T: examined period	#
9	Number of products per demo	This indicator measures the percentage of products tested in the demos with respect to the number of products initially targeted by the demos.	$NPD = \frac{nP_{tested}}{nP_{targeted}} \cdot 100\%$ nP_{tested}: number of products tested in the BUC. $nP_{targeted}$: number of products initially targeted for the BUC	%
10	Active participation	This indicator measures the percentage of customers actively participating in the demo with respect to the total customers that accepted the participation. This indicator will be used to evaluate customer engagement plan.	$R = \frac{N_{active}}{N_{accept}} \cdot 100$ N_{active}: Customers actively participating in the demo. N_{accept}: Customers accepted to participate in the demo.	%
11	Number of FSPs	Number of FSPs joining the platform.	N_{FSP}	#
12	Ease of access	Ease of access to the flexibility market for flexibility service providers, including accessibility, no redundant barriers to entry, user-friendliness.	Survey	N/A
13	Number of avoided technical restrictions	Avoided congestions thanks to the measures implemented in the demo	$ATR\% = \frac{N_{TRFlex}}{N_{TR}} \cdot 100$ N_{TR}: Total number of expected technical restrictions N_{TRFlex}: Total number of technical restrictions solved through activation of flexibility services	%

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2.7.1 KPIs for different demonstrators' tests

Table 9 shows the results of the individual KPIs of the different demonstrator tests. A detailed description of the KPIs and tests can be found in OneNet Deliverable 9.3 [3]. Each column indicates the demonstrator ID presented in Table 7. Notice that for demonstrator number 4, two different tests were executed.

Table 9 - KPI summary of the Spanish demonstrators (individual KPIs)

ID	KPI	Values									
		i-DE						UFD			
		01	02	03	04 (test 1)	04 (test 2)	05	01	02	03	04
1	Cost effective-ness	83%	72%	53%	74%	98%	98%	31%	78%	88%	78%
3	Available Flexibility	9%	10%	25%	12%	12%	12%	28%	20%	28%	28%
4	Error of load forecast	1,2%	2,4%	36%	14%	11%	9%	4,6%	4,7%	3,2%	9,6%
5	Power exchange deviation	15% (above)	24% (above)	48% (below)	63% (above)	61% (above)	52% (above)	0%	9% (below)	0%	0%
6	Asset load profile variation	11%	20%	15%	9%	19%	13%	19%	12%	12%	11%

Although, in all cases, the flexibility solution looks more economical than the traditional one (values of cost-effectiveness KPI higher than 0% mean that flexibility is economically more efficient than traditional alternatives), these values cannot be used to make conclusions as, in some cases, the bid price was agreed between the DSOs and the FSPs to ensure flexibility was procured and activated.

In general, the available flexibility is relatively low, ranging from 9% to 28% of the total load in the different areas, as customers' engagement to participate with their flexibility was one of the biggest barriers. That number needs to increase to assure flexibility availability to solve congestion problems.

The load forecast, in general, was very accurate, as errors remain quite low, except for one of the tests in which the prediction was not so good and reached 36%. Loads from university buildings have higher variability and uncertainty than stable industrial loads that have stable energy consumption.

For the power exchange deviation KPI, positive and negative results were reached: values above the requirements, which means compliance, as it was an over-provision of the service, and values below the

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requirements, which means no compliance, as the commitment was not reached at full rate. But even in the two cases where the delivery power did not reach the requested amount, the congestion problem did not happen because of the load forecast error.

Finally, for the asset load profile variation KPI, it is important to remark that in all the cases, the flexibility activation impacted the asset load up to 20% of the initial load before activation.

In summary, the results show that flexibility providers could deliver the contracted amount on time and for the duration set for almost all cases. The KPIs show positive results in terms of accuracy of load forecast and asset load impact. Conversely, the available flexibility was low due to the challenge of engaging customers.

2.7.2 Common KPIs for the Spanish demonstrators

This subsection presents the KPIs common to all the Spanish demonstrator (see Table 10), excluding the ease of access questionnaire results, which are presented in the next subsection.

Table 10 - Common KPIs Spanish demonstrator

ID	KPI	Value
2	ICT Costs	+10 M€
7	Volume of transactions (Power)	6,63 MW
8	Number of transactions	10
9	Number of products per demo	100%
10	Active participation	88%
11	Number of FSPs	7
13	Number of avoided technical restrictions	100%

ICT costs include developments that need to be done from the market operator and DSOs' point of view, probably in tens of millions, to adapt control systems and planning and operations tools.

The number of cleared bids was 10, reaching 6,6 MW. All the products initially targeted by the demos were tested: corrective local active (1 test), predictive short-term local active (6 tests) and predictive long-term local active (3 tests).

Of the total customers that initially accepted participation, only one dropped during the process.

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The avoided technical restrictions were 100%. However, as commented before, the delivery power did not reach the requested amount in two cases, and the congestion problem did not occur because of the load forecast error.

2.7.3 Ease of access results (KPI #12)

The customer engagement evaluation was performed jointly between Task 11.6 and the Spanish demonstrator. The assessment of the Spanish demonstrator considers, on the one hand, the experience of the resource owners and, on the other hand, the experience of the aggregators to identify the main barriers. These barriers were grouped into behavioral, economic, technical, legal, or regulatory. The detailed description and analysis of the ease of access questionnaire are presented in OneNet Deliverable 11.5 [14]. Below are presented the main results for the Spanish demonstrator.

2.7.3.1 Aggregator

Based on the experience of the Spanish demonstrator, the following are the most relevant barriers faced by the two participating aggregators when engaging six customers:

- **Lack of awareness of the technology:** The advantages of using this new solution are not always clear to customers, resulting in a lack of understanding and hesitation to adopt it.
- **Possible conflicts of interest during use:** In certain situations, conflicts may arise between the proposed measures of the solution to reduce consumption and the desired conditions for users of the buildings.
- **Doubts about the solution's reliability:** Some customers express concerns about the solution's reliability and possible penalties for non-compliance with consumption reduction targets.

By categorizing the barriers, it becomes easier to understand the challenges faced in engaging customers in the demonstrator. The following categorization can help in developing targeted strategies and solutions.

Behavioral barriers

In general, the findings indicate that the behavior of the final customers posed some challenges. While there was interest at the corporate level due to the potential economic benefits, there were also reservations and skepticism from end users. The cultural background and habits of the customers played a significant role, particularly regarding the use of devices that affect user comfort, such as climate control, to reduce consumption. Moreover, there was a lack of trust in the solution, with end-users doubting its ability to justify the effort of making modifications and experiencing unplanned disruptions. However, most customers demonstrated the digital and technical competencies required to understand the project's main features.

The customers were not considered economically vulnerable but were already aware of the possibility of participating in energy markets for economic benefits. Behavioral changes were implemented temporarily for

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testing purposes, and the customers are waiting for technological standardization and unified regulations before committing fully.

While there was skepticism, there was also interest and awareness of the potential benefits.

Economic Barriers

Regarding economic barriers, the respondents generally stated that future potential economic rewards should be sufficiently attractive to foster engagement. The objective was to show that this methodology could reduce energy bills and prioritize sustainability, maximizing energy autonomy through available generation sources like photovoltaic installations.

FSPs experienced low costs in accessing relevant customer data as the university already had an internal consumption monitoring system. The specific characteristics of the products and services defined in the demonstrator impacted consumer engagement strategies, with the minimum duration of the product traded potentially limiting customer participation. A longer technology deployment would have provided a clearer perspective of the economic benefits, considering the importance of stable regulation at the European level.

The flexibility potential of customer resources was not known to the customers, limiting their understanding of the quantitative impact of technology use. While some modifications to the installation were necessary, they were carried out within the expected economic limits.

Technical Barriers

Technology was a significant barrier to engaging with the demonstrator's final customers. While flexibility is not complex, adding variables such as automatic interconnection with markets and payment/penalty systems created complexity. The necessary metering and communication infrastructure to monitor and control flexibility resources was already in place before the demonstration activities started. This existing infrastructure has reused for monitoring the air-conditioning usage.

However, the technological solutions used needed to be fully interoperable with the devices and flexibility resources at the customers' premises, as the existing systems had their specifications. Permission was granted by the final customers to remotely manage flexibility resources at their premises, allowing for tests and authorized operations.

The interfaces provided to the customers were not reported to have caused problems, as there was no direct access on the end customer side but rather an integration to respond to flexibility requests from network distributors via the platforms facilitated by OMIE. Another technical barrier encountered was the integration of legacy devices into the system which had their own operation and control system which was not compatible with the aggregator system. Therefore, a new control system needed to be installed.

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Legal Barriers

It is important to highlight that the regulatory framework in Spain needs to be defined. However, the access to consumer data necessary for aggregation and selling of flexibility resources was allowed by law and efficiently obtained, particularly for a public body where consumption information was publicly available through their website. The rules on consumer data privacy did not pose a problem, as the information was already publicly accessible. Fulfilling all legal duties when contracting with the final customers was manageable, as no extra paperwork was required. Overall, no significant legal barriers were encountered in customer engagement.

Other Barriers

In general, the installation process did not present significant behavioral barriers. The installation process was smooth, and there were no behavioral problems. Some participants mentioned skepticism related to comfort, indicating the importance of considering user preferences. However, overall, there were no major obstacles identified in this regard. Equipment installation was required for some participants, but it did not pose significant barriers.

2.7.3.2 Resource owners

Two universities and four customers, including industrial customers and public facilities managers, answered the survey.

While different customer types may have distinct characteristics, challenges, and preferences, there can be similarities in their responses. One challenge mentioned by participants was the difficulty in determining reference power and understanding workload and demand forecasts. Another challenge was the need to adapt operations to meet the requirements of energy sales. Negotiating terms and conditions with the aggregator and addressing unexpected side effects like accidents were identified as additional challenges. Providing access to installations outside of working hours to minimize disruptions was also a practical difficulty faced by some participants. Furthermore, challenges related to the bidding and auctioning platform, including specifying measurement criteria and calculating energy reduction, were mentioned.

These findings highlight that customers across various sectors may encounter similar barriers, have comparable preferences, or exhibit overlapping behaviors in certain contexts despite their differences.

Behavioral barriers

Common points among the respondents include the absence of vulnerability among them. Most participants possessed the necessary digital and technical competencies to understand the project, with only one exception.

However, significant differences in knowledge and awareness regarding participation in energy markets for economic benefits were observed. Only half of the interviewees knew of such opportunities, indicating their

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prior knowledge. The acceptance of third-party monitoring and control over energy consumption varied among respondents, with some expressing openness and others emphasizing the importance of maintaining control over their equipment.

The willingness to engage with the demonstrator was also diverse. Some respondents were reluctant due to economic concerns or lack of time, while others actively desired to collaborate. It is evident that there is no unanimous consensus, and individual circumstances and priorities strongly influence participants' perspectives and levels of engagement.

Economic barriers

The Aggregator got cascading funds, but the participants got no reward. They also did not require significant investments to participate, as most already had adapted installations. The majority relied on electricity to meet their energy needs, but the presence of flexible devices varied among the respondents.

Technical barriers

The respondents generally avoided significant technical barriers in their participation. Most participants did not face major technology-related issues, although some experienced minor difficulties such as software installation or preparing consumption information systems. The majority of respondents found their existing electricity meters to be sufficient for participation, enabling consumption monitoring. However, one respondent required additional metering equipment, which the aggregator efficiently arranged. Connectivity problems with devices were not commonly reported, although a few participants mentioned issues with weak Wi-Fi connections or required specific device installations.

Regarding granting permission for remote device management, opinions varied, with some participants requiring prior permission while others were open to it. The user-friendliness of the demonstrator interface also elicited mixed responses, with some finding it non-intuitive while others had a positive experience. The aggregator played a role in facilitating usability for some participants, but there were mentions of technical complexities, particularly during the certificate installation process.

Legal barriers

In general, the respondents did not face significant legal barriers. Most participants did not encounter problems with existing contractual or legal obligations, indicating a smooth process. Data protection laws were not perceived as limiting their options, and access to consumer data was generally not an issue.

However, there were mixed experiences regarding the ease and transparency of legal arrangements, with some participants finding it simple and transparent while others faced uncertainties or delays. Additionally, there was limited knowledge or recollection of being informed about the risks associated with participation

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during the agreement drafting process. Overall, the responses suggest varying experiences and awareness of legal aspects among the participants in the demonstrator.

Other barriers

In general, the respondents did not face any other relevant barriers that do not belong to the previous four groups of barriers to customer engagement. However, one respondent mentioned the difficulty in aligning different areas to make the demonstrations, suggesting coordination challenges within their organization. Overall, most did not encounter significant barriers outside the previously discussed categories.

It can be concluded that different customer groups may face different barriers. These barriers can be related to behavioral, economic, technical, legal, or other factors. Understanding and addressing these barriers is crucial for enhancing customer engagement and ensuring the success of the local market implementation.

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3 Evaluation of the Spanish demonstrator

This section evaluates the Spanish demonstrator. To perform this task, the methodological approach is presented below.

3.1 Methodology

Figure 4 shows the methodology followed to assess the Spanish demonstrator. The first step consists in analyzing the demonstrator achievements in terms of the definition of services and products, the market designed, the market platform performance, the role of the aggregators and the evaluation of the services delivered to the DSO. During the execution of the demonstrator, some main challenges were faced related to customer engagement, the platform functioning and the OneNet connector deployment, and challenges related to baseline computation and products activation requests. Then, some next steps developed in the OneNet project related to the Spanish demonstrator are highlighted such as the integration of the short-term local markets with existing ones, scalability and replicability analysis of the proposed solutions and business models assessment.

Finally, the next steps for implementing the Spanish demonstrator's ambition beyond the OneNet project relate to the definition of roles and responsibilities of the relevant actors, pending market procedures to be implemented, customer engagement strategies, incentives for the DSO to use flexibility and comparison of different mechanisms to acquire flexibility.

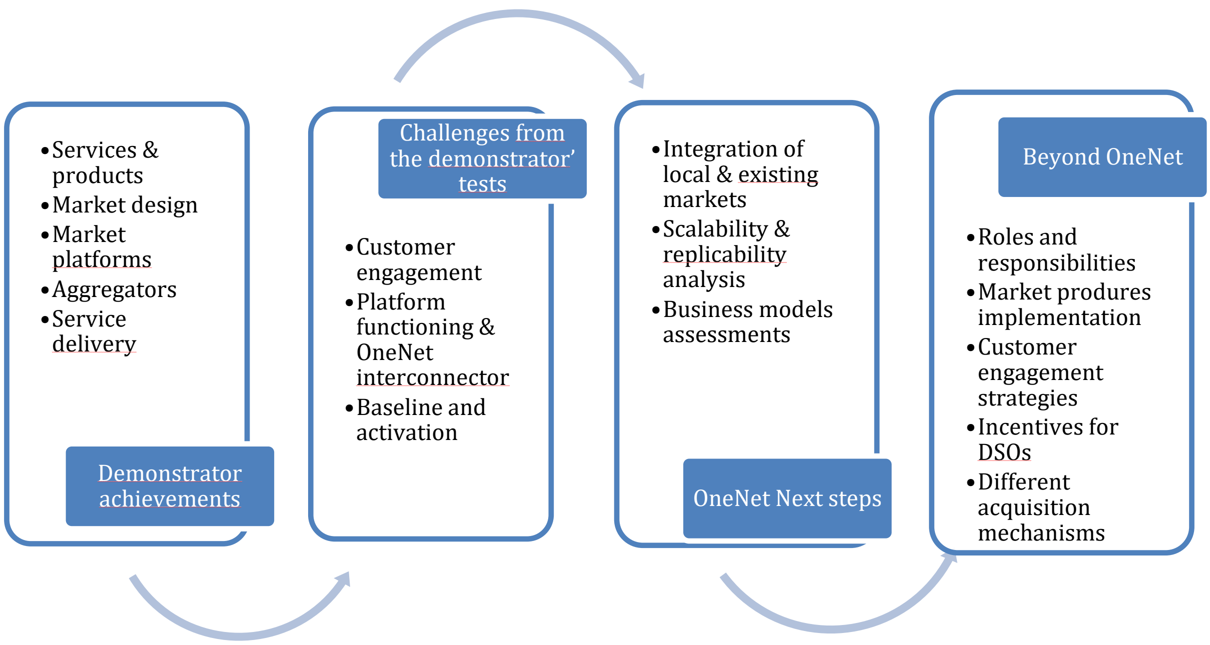

Figure 4 - Methodology for assessing the Spanish demonstrator

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3.2 Main achievements of the Spanish demonstrator

This section presents the main achievements of the Spanish demonstrator related to different topics:

i) the definition of services and products,

ii) the market design definition,

iii) the development and functioning of the market platforms,

iv) the integration of aggregators in the demonstrator and

v) the delivery of the congestion management services.

3.2.1 Service and products definition

One of the first steps for trading system services is the definition of services and products which can fulfill the service needs. The Spanish demonstrator defines two services: the corrective and predictive active power for congestion management. The former is used to solve unexpected failures of network elements. The latter service has two products to manage predicted needs: long-term (e.g. substitutes for network investments) and short-term (e.g. programmed works). The product attributes include the market area specification, the activation direction, the required quantity, the price cap and the delivery period.

The agreement between the two DSOs and the IMO is an important step for the future implementation of local markets in Spain. The proposed services will help to solve the main challenges that the DSOs are expected to face in the coming years due to the increased connection of distributed renewable generation and the increased electrification of loads.

3.2.2 Market design implementation

The local market design was implemented to adapt to the DSOs' needs. The market allows procuring products from small resources and aggregating them, which is yet to be possible in the Spanish market.

3.2.3 Market platforms functioning

To trade system products, transparent market platforms are required to guarantee equal opportunities to all market parties and technologies. IMOs guarantee equal treatment and a level-playing field for all technologies. The platforms allow small participants to participate and connect, allowing units from 10 kW.

As OMIE is the MO of the wholesale day-ahead and intraday markets, synergies between wholesale and local markets are expected regarding financial guarantees, technical connectors with the FSPs, bidding formats and communication protocols, among others. The OneNet implementation is, therefore, likely to be adopted in the future and exploited after the project ends.

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3.2.4 Aggregators capabilities

Aggregation of resources is extremely relevant in the local market due to the small size of some resources connected at distribution networks, the lack of technical capabilities or limited economies of scale (i.e., too costly to individually participate) to directly participate in the markets. Two aggregators were able to connect with the market platforms and provide the agreed services.

3.2.5 Service delivered

As previously stated, the tests were successfully implemented and simulated technical constraints were avoided in almost all the cases.

The DSO acquired flexibility products to manage local congestions using OMIE developed platforms for short- and long-term problems.

The Spanish demonstrator shows that different types of resources, from university buildings, industries and public facilities, and biogas generators, can provide flexibility services when requested, considering both automatic and manual activation. Little differences were observed in the commitments. The FSPs were able to deliver the products, although in some cases, it was not possible to maintain the requested amount for the whole period.

3.3 Challenges

This section presents the main challenges encountered during the development of the demonstrator in the different tests.

3.3.1 Customer engagement

Customer engagement is one of the main challenges in providing system services. Different challenges were faced during the Spanish demonstrator's development, as described below.

1. Lack of economic incentives

To activate flexibility, some investments need to be made to monitor flexible resources, evaluate the flexibility at different timeframes, activate the resources, etc. Thanks to cascading funding for some of the resources, part of the costs was paid. However, the need for economic incentives was a key barrier to attracting more resources.

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2. Alignment of interests within organizations

Only some employees were aligned within companies and organizations to become FSPs and participate in an innovation project. While there is a natural willingness to participate in innovation projects in universities, maintenance staff were concerned about failures and uncomfortable costs suffered by the buildings.

3. Failures management

The monitoring, controllability and flexibility assessment require the installation of appliances located in premises. An accident (failure of one installation asset) during the installation phased occurred in one of the locations in the Spanish demonstrator. This experience caused pushback from the installation managers, which delayed the tests in that location. These pushbacks are likely to happen in a market environment, and proper management is necessary not to lose FSPs. It is recommended to explain the risks clearly to avoid the dropping of resources.

3.3.2 Platform functioning and integration of market platforms with the OneNet system

One of the main challenges faced by the platform development was the integration with the OneNet connector. The OneNet Connector would be used to exchange prequalified FSPs information and market results among the MO and different SOs, nationally and between countries. This information exchange can ease the provision of SO services from FSPs to multiple SOs.

The system deployment requires many concessions, such as installing a Docker on the company servers and opening firewall ports to send and receive information that initially go against company cybersecurity policies. These issues delayed the different deployment attempts and the regional use case implementation.

Once the internal cybersecurity issues were solved and OMIE gave permissions to the installation, some connectivity issues occurred. At the moment of writing this document, the Data App was not available for the Spanish Demo. OMIE continued working with the WP6 team to solve the final issues and connect to the common application.

Regarding demo issues with the platforms, the main challenge was adapting and bringing the electricity market systems closer to the end-users. Following the current Iberian electricity market designs, the systems were defined, so the platforms were aimed at a specialized audience. Training sessions were needed during the demos to facilitate FSPs connection to the platform. The final feedback from FSPs and DSOs was essential to make several modifications to the platform and recommendations for future implementations.

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3.3.3 Baseline and activation requests

Activation must start before the contracted time to avoid violations at the beginning of the period. It is important to consider the ramping time to respond on time to avoid congestions. If the activation starts at the requested time, it could be problems at the beginning of the period, as in the first tests.

From the test experiences, it is not recommended to use a baseline load before activation as a reference to calculate the delivery as there could be an increase of load just before it, for example, to reduce the temperature to maintain comfort longer after refrigeration deactivation. A baseline must be established to avoid these effects and evaluate FSP delivery compliance. In the tests, historical data of similar days were used for the comparison.

3.4 Next steps in the OneNet project

OneNet WP11 evaluates the demonstrator's results and performs a detailed analysis of different topics:

- Techno-economic assessment of proposed market schemes for standardized products
- Recommendation of interoperability platforms and data exchange for TSO-DSO-customer coordination
- Scalability and Replicability Analysis for market schemes and platforms
- Customer engagement strategies recommendations
- Business model analysis of OneNet solutions
- EU-wide implementation of market schemes and interoperable platforms

Some of these analyses consider further developments of the Spanish demonstrator as specified below.

3.4.1 Scalability and replicability of the solutions

The Scalability and Replicability Analysis (SRA) of the solutions devised and tested in the Spanish demonstrator aims to assess the potential for scaling-up and replication, i.e. what would be the expected outcome if the proposed solutions be implemented elsewhere or at a larger scale. The SRA activity outcomes are presented in OneNet Deliverable D9.8 [8].

The proposed SRA approach consists of two main steps:

i. A simulation-based technical analysis: techno-economic assessment of the local market for congestion management
ii. A qualitative analysis of the non-technical boundary conditions can affect the potential for scalability and replication.

The quantitative SRA concerning the techno-economic assessment of the market functioning is addressed by considering several scenarios modeling different load and generation amounts, distributed generation

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presence, and flexibility service provider participation. The market model considered in the SRA focuses on the short-term local congestion management markets and the Alcalá de Henares and Murcia pilots [2]. Figure 5 depicts the schematic procedure for the quantitative SRA analysis adopted for the Spanish demonstrator.

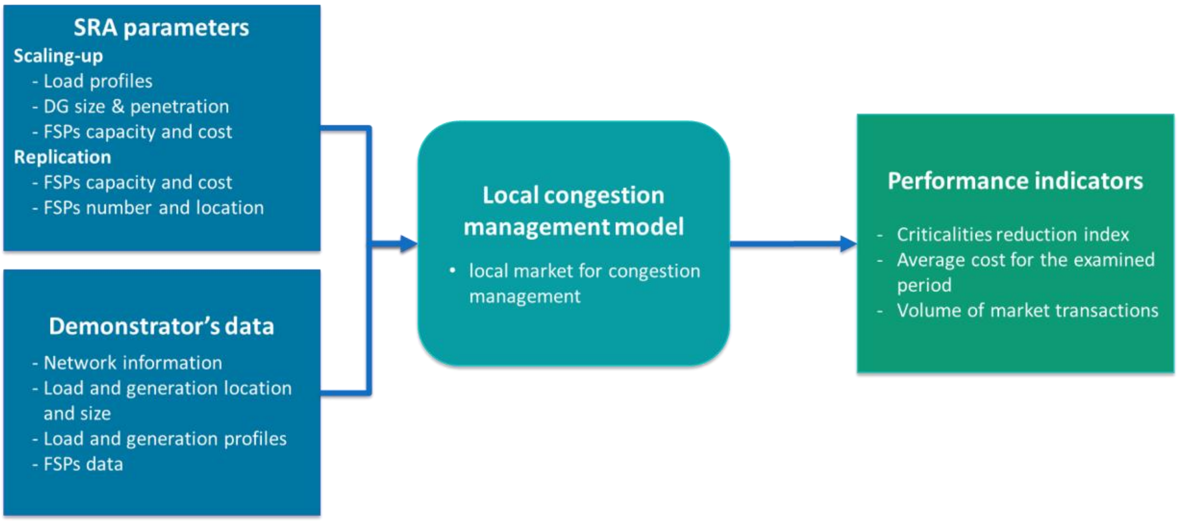

Figure 5 - Schematic procedure for the quantitative SRA analysis adopted for the Spanish demonstrator

The qualitative SRA concerns replicability aspects by addressing a structural analysis of standardization and interoperability aspects for the ICT standards and protocols and communication links between stakeholders. The non-technical boundary conditions considered for the scalability analysis concern regulatory issues, business models' constraints and the perspectives of key stakeholders will be considered.

3.4.2 Integration of short-term local markets with existing markets

The framework guidelines for demand response (FGDR) recommends the forwarding of unused bids from short-term local markets to wholesale markets to maximize the revenue-maximization potential of the flexibility service providers (FSPs) [1]. The bid forwarding process is conceptualized in D11.2 [12] of the OneNet project, and the regulatory barriers for their implementation are discussed in D3.3 [15]. In theory, if two or more markets are compatible, the unused bids from the first market can be forwarded to the second market through an optional bid processing stage [11]. This process is overseen and managed by a predefined market agent, which can either be the system operator of the local grid or the market operator of the first market.

The main potential for bid forwarding in the Spanish electricity markets is between the local short-term DSO congestion management market and intraday markets (see [11] for a detailed discussion). However, several barriers hinder the bid forwarding process, including the differences in minimum bid size and market time units (MTU). The minimum bid size in the local flexibility market is 0.01 MW, whereas, for the intraday market, it is 0.1 MW [16]. Similarly, the MTU of the local market is 15 min, whereas the intraday markets have a 1-hour MTU. Hence, to enable bid forwarding between these two markets (three markets if intraday auctions and continuous

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intraday markets are further connected through bid forwarding), the bid processing stage should include an MTU converter and an aggregation stage, as given in Figure 6.

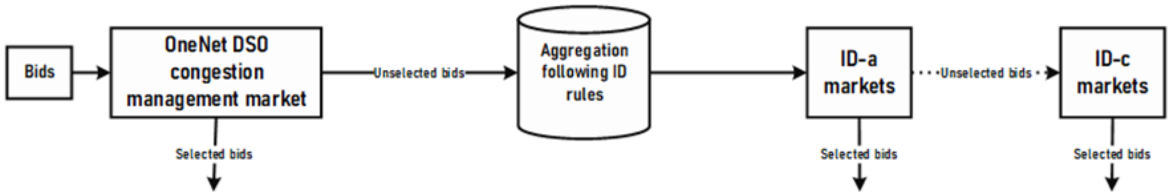

Figure 6 - Possible option for the implementation of bid forwarding between the Spanish OneNet DSO congestion management market and the Spanish intraday markets

The bid forwarding process has the potential to increase the coordination between local and wholesale markets. But bid forwarding requires a clear definition of roles and responsibilities, clarity regarding the allowed bid processing stages, and development of appropriate pricing schemes. Therefore, future developments must address these challenges to coordinate the short-term local markets with the existing wholesale markets, further opening possibilities for their integration.

Another recommendation from the FGDR regarding market integration (and harmonization) is to reduce redundancies in the market processes [1]. For instance, if multiple system operators are procuring the same or similar products, conducting a single prequalification process can reduce unwanted interruptions to the operation of the units and reduce costs and administrative burdens. Coordinating the prequalification process among different SOs can also help lower the entry barriers for small market players and streamline market processes by eliminating unnecessary duplications.

3.4.3 Business models assessment

To make a reality the objectives of the Spanish demonstrator, different new business models are necessary to implement, such as the IMO and aggregator models. At the same time, the role of the DSO needs to be expanded to become a buyer of system services. All these business models are not possible in the current Spanish regulation. The specific regulatory barriers to implementing such models and strategies for engagement of critical stakeholders are analyzed in OneNet Deliverable 11.6 [2]. Furthermore, the CANVAS analyses for the identified key actors and stakeholders analysis supporting or opposing the implementation of the business models for the Spanish business models are presented in [2].

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3.5 Next steps for local market implementation beyond OneNet

The Spain Regulatory Authority still needs to transpose the EU Directive 2019/944 regarding developing local markets for system services [17]. Different relevant regulations need to be detailed and implemented beyond the aspects covered in the OneNet project, as described below.

3.5.1 Definition of actors' roles and responsibilities

Currently, the DSOs cannot buy system services. To enable this to happen, it is necessary to define the DSO roles and responsibilities related to (but not limited to):

1. Prequalification of resources (at least product and grid aspects).
2. Definition of services and products that adapt to the needs (common agreements between DSOs may be required).
3. Data exchange specifications, formats and coordination agreements with the DSOs, TSO, IMO and aggregators/FSPs.
4. Measurement requirements and role in settlement processes, including the definition of baselining methodologies.

As previously stated IMOs can play key roles in facilitating the acquisition of system services; among those are:

1. Financial prequalification.
2. Co-design of products attributes.
3. Bid forwarding from local markets to wholesale markets or vice versa.

OneNet D3.4 [18] analyses which of those roles is better to be developed by the SO or IMO.

Another key design to be developed is the aggregators' models and the relation between independent aggregators and suppliers regarding baselining, imbalance settlement and data exchange.

3.5.2 Pending market procedures implementation

The Spanish demonstrator has made significant steps to develop and test the local market concept described in Section 3.2. However, there are pending aspects to be further developed:

1. Definition of prequalification processes, including product, financial and grid.
2. Revision of penalizations for non-delivered or partial delivery of resources. The tests used a penalty based on the noncompliance delivery concerning the agreed capacity.
3. Agreement and regulation on more advanced baseline methods and quantification adapted to different products and resources.

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4. Before implementing regulation, Sandboxes are an intermediate opportunity to test different alternatives to the identified challenges. Sandboxes provide a controlled environment with real-world conditions before establishing a final solution for the different topics. In Spain, the regulation for regulatory sandboxes was approved in 2022 [19]. The first call for sandbox projects was launched in May 2023 [20].

3.5.3 Incentives for DSOs to use flexibility

Once the DSO can perform the role of buyer system services, the remuneration for opting to use these services must be designed to avoid the unbiased use of traditional solutions or system services [21]. Review current remuneration schemes in 5 European countries (Spain, Italy, France, United Kingdom and Sweden), including Spain and make some recommendations on the principles to be followed to develop such unbiased remuneration. The British regulation is highlighted at the most advance to avoid CAPEX bias and encourages innovative flexible solutions (e.g. the remuneration based on total expenditure, the so-called TOTEX approach [21]).

3.5.4 Customer engagement strategies

Customer engagement strategies must be developed to attract new FSPs and a wider range of resources to provide system services. These strategies are required because of the novel nature of local markets, some small resources not being involved as direct providers of system services, behavioral challenges, and other barriers highlighted in OneNet D11.5 [14]. A tailored strategy for each type of customer is necessary, understating their motivations, explaining the risks and gaining confidence to engage them to participate.

System services and markets are rather complex for most customers, and actions to limit that complexity, such as the definition of value propositions [22], pricing strategies, and the role of aggregators, among other actions, are critical for the engagement of resources and successful procurement of SO services. The viability of some business models and the split of benefits with FSPs are crucial to have enough resources to provide flexibility.

3.5.5 Comparison of local flexibility markets and other procurement mechanisms tools

Local markets are only a tool or mechanism that DSOs can use to acquire system services. Local markets may face liquidity scarcity, meaning more resources are needed to compete to provide system services. This may lead to a high probability of exercising market power. However, other alternatives are also available as stated in [23]: dynamic network tariffs, bilateral contracts, and rule-based options. The mechanism selection depends on different aspects, as stated in [24]: the type of need (e.g. voltage control, congestion management), number of providers, type of network, etc.

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4 Conclusions and policy recommendations

This deliverable analyzes the Spanish demonstrator implementation results and main recommendations. It also presents the evaluation of the results by specifying the achievements of the demonstration in terms of the services and products, market design, market platforms, the participation of the aggregators and the delivered system services. Then, the main challenges encountered in the demonstrator development are presented and the next steps beyond the results achieved in the Spanish OneNet demonstrator.

4.1 Achievements and recommendations from the Spanish demonstrator

The Spanish demonstrator made clear contributions in the following:

1. Defining services and products for local markets
   The definition of standardized products is the first step to trade System Operators services. Two Spanish DSOs agreed on defining the main product attributes to acquire congestion management services for long-term and short-term DSOs' needs.

2. Design local market characteristics
   Local markets require a specific design to serve the purpose for which they are created. Some of the key design elements to establish such markets are: the prequalification process, the locational granularity and the selection of resources that can provide the services, market clearing rules, activation and measurement procedures, among others. All these aspects were successfully implemented in the Spanish demonstrator.

3. Development of a local market platform
   Local market platforms ensure a transparent scheme to procure distribution system services. The technical and functional development of the market platforms for long-term and short-term products trading were implemented in the Spanish demo.

4. Engagement of a diverse range of customers, including aggregators
   Customer engagement is a key element to guarantee enough participation and competition in the market. The Spanish demonstrator involved diverse resources that showed interest in providing DSO services, including industrial facilities, buildings and aggregators interested in coordinating the FSP response.

5. Delivery of the required services with high accuracy
   Distribution system services can become a tool to integrate in the DSOs operation and planning phases. The activation process and the service delivered were successfully measured reaching high accuracy and being able to avoid the stated congestions limits.

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4.2 Main challenges faced during the demonstrator execution

During the development of the demonstrator, some main challenges were encountered:

1. Customer engagement

   System Operators' services are new markets and require additional challenges to engage resources connected in distribution networks. The challenges encountered were detected for both aggregators and final resources. Different barriers from different origins were encountered: behavioral, economic, technical and legal.

2. Platform functioning and Integration of market platforms with the OneNet system

   Integrating the market platform in the OneNet system faced some challenges related to cybersecurity measures. This was due to the fact that OMIE has to ensure a secured operation of the market and participants' data, establishing high cybersecurity requirements.

3. Baselining definition

   The baseline calculation was selected mainly for practical reasons, without a detailed alternative analysis. There was no assessment of the different alternatives and evaluation of them based on the technology's characteristics, the product attributed or following a set of criteria such as accuracy of the method, and the outcome efficiency, among other factors.

4.3 Next steps to be developed in OneNet project related to the Spanish demonstrator

Additionally, the results of the Spanish demonstrator tests have been analyzed in OneNet WP9 and WP11 to extract further conclusions, including:

1. Scalability and replicability analysis of the demonstrated solutions

   Evaluating the BUCs in a larger context is essential to evaluate the applicability and the results obtained in a broader context. The scalability and replicability analysis for the Spanish demonstrator is presented in OneNet Deliverable 9.8 [8].

2. Integration of the short-term local market with the wholesale market

   Electricity markets in Europe are organized as a sequence of markets. The local market is part of such a sequence, and the resources participating can benefit from linking this market with others, such as the intraday market, which OMIE also manages. OneNet Deliverable 11.2 shows the conditions for linking both markets to bid forwarding, meaning unused bids in the local market can be forwarded to the intraday. The likelihood of bids being cleared increases through bid forwarding, favoring resource value stacking.

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3. Business model assessment

   To fully realize the benefits of the Spanish demonstrator, new business models such as aggregator or IMO need to be implemented, which need to be defined in the Spanish regulation. Furthermore, the role of the DSO needs to be enlarged to procure system services. The existing regulatory barriers for these business models and strategies for engagement of critical stakeholders are detailed and presented in OneNet Deliverable 11.6 [2].

4.4 Next steps for local market developments in the Spanish context

Finally, some key steps for developing local markets have been identified below.

1. Definition of roles and responsibilities

   A clear definition of roles and responsibilities is key to determining the actions to be developed by each agent to unlock the use of flexible resources.

2. Further market procedures implementation

   Due to limited time and resources, some market procedures were not implemented. These procedures relate to information exchange between DSO-TSO-IMO, market settlement, and the definition of baseline methodologies, among others.

3. Incentives for DSOs to use flexibility

   Currently, the DSO remuneration is CAPEX-biased. Therefore, modifying the remuneration scheme is necessary to provide DSO incentives and share the flexibility benefits with the system.

4. Customer engagement strategies

   Real market implementation requires tailored customer engagement strategies to attract FSPs to provide services. These strategies should consider the technical capabilities of the resources and the skills and knowledge of flexibility asset owners, their motivations, and interests, among other key factors influencing their engagement.

5. Comparison of local markets and other mechanisms for acquiring SO services

   Local flexibility markets are one tool to acquire and activate SO services. However, liquidity in such markets can be challenging due to network topologies that limit the participation of multiple resources or the lack of resources that can provide the services. Therefore, other mechanisms such as bilateral contacts, dynamic tariffs or rule-based solutions are alternative tools that must be analyzed depending on the needs and context characteristics.

In essence, the demonstrator shows the potential of local flexibility markets in efficiently tackling network constraints. Nevertheless, additional endeavors are imperative to surmount the recognized obstacles and

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materialize these markets. The demonstrator provides insights on the challenges and prospects of local flexibility markets, contributing to forthcoming research and policy determinations in this domain. The realization of these objectives may pave the way for broader integration of flexibility services within the Spanish electricity system, culminating in enhanced resilience and cost-effectiveness. Such accomplishments could contribute to the ongoing European electricity market development.

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