

# D4.5: OPENTUNITY flexibility market (v1)

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Flexibility, Flexibility Market, Market Set Up, Market Design, Flexibility Market Implementation and Adaption.

## Executive Summary

This Deliverable describes the flexibility market set ups at the pilot sites of the OPENTUNITY project, in Greece, Switzerland and Spain. The set-ups presented have been created in collaboration among all pilot partners considering the role of each pilot partner in the flexibility value chain as well as operational and technical requirements. Each pilot presents pilot specific test scenarios that will be addressed to find an optimal solution for the problem of the local, regional and national grids. These scenarios will be examined in the testing phase of Task 4.5 within WP 4 starting in March 2025. Ultimately, each pilot describes the risks they must tackle when implementing market-based flexibility procurement as well as related mitigation measures. The results of the testing of the flexibility markets and scenarios as well as recommendations will be presented in Deliverable D4.6 in October 2025.

The results of Task 4.5 will be directly implemented and applied in WP 6 "Deployment and demonstration activities". WP 6 will examine and test the entire OPENTUNITY flexibility value chain including developments of all categories OpenGrid, OpenFlex, OpenSpace and Openability will be tested.

This document has been peer-reviewed by the consortium partners HYPERTECH and KOLEKTOR. Comments and recommendations to enhance clarity and understandability of the content and accompanying images have been addressed by the responsible parties, ie. NODES and the pilot partners.

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# Index

<b>INDEX</b>	<b>3</b>
<b>1 INTRODUCTION</b>	<b>5</b>
1.1 Background	5
1.2 Scope of the document	6
1.3 Structure of the document	6
<b>2 NODES MARKET AND SERVICES IN OPENTUNITY</b>	<b>7</b>
<b>3 FIELD TEST PROTOCOL AND TIMELINE</b>	<b>8</b>
<b>4 OPENTUNITY FLEXIBILITY MARKET PILOTS</b>	<b>9</b>
<b>4.1 Spain</b>	<b>11</b>
Demo site	11
Flexibility Market Set up	12
Spanish Pilot - Market Agents	12
Flexibility Market Implementation	12
Flexibility Market Scenarios	14
Risks and Mitigation measures	15
<b>4.2 Switzerland</b>	<b>18</b>
Demo site	18
Flexibility Market Set up	20
Swiss Pilot - Market Agents	20
Flexibility Market Implementation	21
Flexibility Market Scenarios	24
Risks and Mitigation measures	25
<b>4.3 Greece</b>	<b>25</b>
Demo site	25
Flexibility Market Set up	28
Greek Pilot - Market Agents	28
Flexibility Market Implementation	28

Flexibility Market Scenarios	33
Risks and Mitigation measures	33
<b>5 CONCLUSION AND OUTLOOK</b>	<b>36</b>
<b>6 REFERENCES AND ACRONYMS</b>	<b>37</b>
<b>6.1 References</b>	<b>37</b>
<b>6.2 Acronyms</b>	<b>37</b>

## List of figures

Figure 1: NODES digital flexibility value chain for secure and reliable flexibility transactions between Buyers and Sellers.....	7
Figure 2: Task 4.5 timeline and milestones.....	8
Figure 3: Overview of Opentunity Flexibility Market Pilots, market agents and roles.....	9
Figure 9: Swiss pilot market area represented by its grid node and sub-nodes.....	22
Figure 10: Sequence of interactions performed by the FSP (orange and red rectangles) and by the DSO (green rectangle).....	23
Figure 11: NODES Dashboard – monthly overview of the demo market activity.....	24
Figure 13: <i>Structure of the Markopoulo HV/MV substation.</i> ....	27
Figure 14: Grid replication of the transmission and distribution grid at Markopoulo substation and corresponding market set up on NODES market according to connected parent grid nodes/order books. ....	30
Figure 15: NODES Coordination Role for Market Coordination and TSO-DSO coordination .....	31

## List of tables

Table 1: Exporting supply points per municipality in Anell's grid.....	11
Table 2: List of selected new buildings included in the second version of the pilot site .....	19
Table 3: Greek pilot local flexibility market rulebook.....	28

# 1 Introduction

## 1.1 Background

The European Union aims at transforming the energy system towards a sustainable, low-carbon and climate-friendly economy. The scope is to increase the share of renewable energy sources (RES) in the energy mix to around 50% until 2030 while guaranteeing security of supply and avoiding unnecessary network investments. To achieve this goal, prosumers across all grid levels will become active participants in the energy system by adapting their generation and consumption, referred to as flexibility. The flexibility of the prosumers will help to stabilize the grid when needed enabling a more efficient use of available resources to support a more sustainable, low-carbon and climate-friendly electricity system. Yet, flexibility will also add complexity and create (so far) unpredictable power flows in the distribution networks. Distribution System Operators (DSOs) need to integrate smart-grid solutions to cope with the new types of load patterns of diverse small-scale assets (e.g. electric vehicles and heat pumps). Furthermore, system operators (SOs) need to identify the location, the required flexibility volume and direction (up regulation or down regulation) to adapt to the power generation of RES. Innovative technologies and solutions are required to transform the challenges of the energy transition into opportunities for the sector, and ultimately for the society.

The OPENTUNITY project supports the energy transition through innovative technology solutions in the 4 categories:

OpenSpace: Data spaces and data exchange technologies,

OpenGrid: Smart grid solutions for system operators (SOs),

OpenFlex: Flexibility services and technology solutions of and for prosumers,

Openability: Fostering the interoperability between existing and innovative technology solutions.

Task 4.5 "Local flexibility market adaptations and management" contributes to the category OpenFlex that is addressed in WP4 "Technologies to boost flexibility in the prosumers' environment".

Flexibility markets enable access to flexibility from the distribution grid to cope with the increasing electricity demand and increasingly diverse load patterns. Implemented correctly, flexibility markets facilitate an optimized use of flexible resources for grid services. They can bridge periods until alternative measures, such as grid reinforcements, are finalized or until an adequate alternative regulatory framework is set in place. Eventually, they may substitute some of the alternative measures entirely. Together with the already existing tools for grid management, flexibility markets complement the toolbox of system operators, enabling them to cope with the increasing diversity and granularity of grid issues.

However, the implementation and use of flexibility markets and of flexibility vary depending on the energy landscape, the system infrastructure, as well as the objectives and challenges of using flexibility at each pilot location.

The project partners of Task 4.5 look into the requirements of a flexibility market at each specific pilot location, ultimately to establish market-based access to distributed flexibility in the grid area.

## 1.2 Scope of the document

The flexibility market pilots in OPENTUNITY described in this document provide insights of possible implementations and use of flexibility markets, as well as developments, risks and mitigation measures exemplified in three different settings, in pilot areas in Greece, Switzerland and Spain. The established flexibility markets and technology solutions will be tested to draw conclusions on operational and technical feasibility during the testing phase starting in March 2025. This phase will be finalized with a second deliverable D4.6 in October 2025 to outline the final set up of OPENTUNITY flexibility markets to be ultimately integrated in the test scenarios in WP6 "Deployment and demonstration activities".

## 1.3 Structure of the document

This Deliverable explains the market setup at each pilot site and is the basis for the second phase of Task 4.5, the testing phase. This deliverable will start off with Chapter 3 "NODES market and services in OPENTUNITY" describing NODES flexibility market and market design as the underlying concept for the flexibility markets implemented within the OPENTUNITY project. The project timeline in Chapter 4 "Field test protocol and timeline" as well as a brief overview of the OPENTUNITY pilot sites in Chapter 5 "OPENTUNITY Flexibility market pilots" will introduce a more in-depth description of each pilot location in Chapter 5.1-5.3. Each pilot site provides an overview of the pilot site characteristics and prevailing challenges, how NODES flexibility market and flexibility as well as related developments will be used to solve these problems describing different scenarios and ultimately outlining technical and operational challenges and barriers. Chapter 6 "Conclusion and outlook" briefly summarizes the conclusions drawn during this preparation phase and finishes with the activities planned in the testing phase starting in March 2025.

## 2 NODES market and services in OPENTUNITY

NODES being a flexibility market technology provider from Norway provides the market environment and related technology solutions for all market agents operating in the market as outlined in Figure 1.

The new digital flexibility value chain displays the logic and concept of market-based flexibility procurement via NODES market platform. Just like in the existing energy landscapes, every market agent has a specific role and responsibility, i.e.:

- Buyers: The network operators (DSOs and Transmission System Operator (TSOs) responsible for network operation and management,
- Sellers: Aggregators/Flexibility Service Providers (FSP) to offer flexibility to the SOs in exchange for financial remuneration,
- NODES: Flexibility Market Operator (FMO): Market operation, infrastructure and integrated products and services to ensure secure and reliable flexibility transactions.

### New digital flexibility value chain

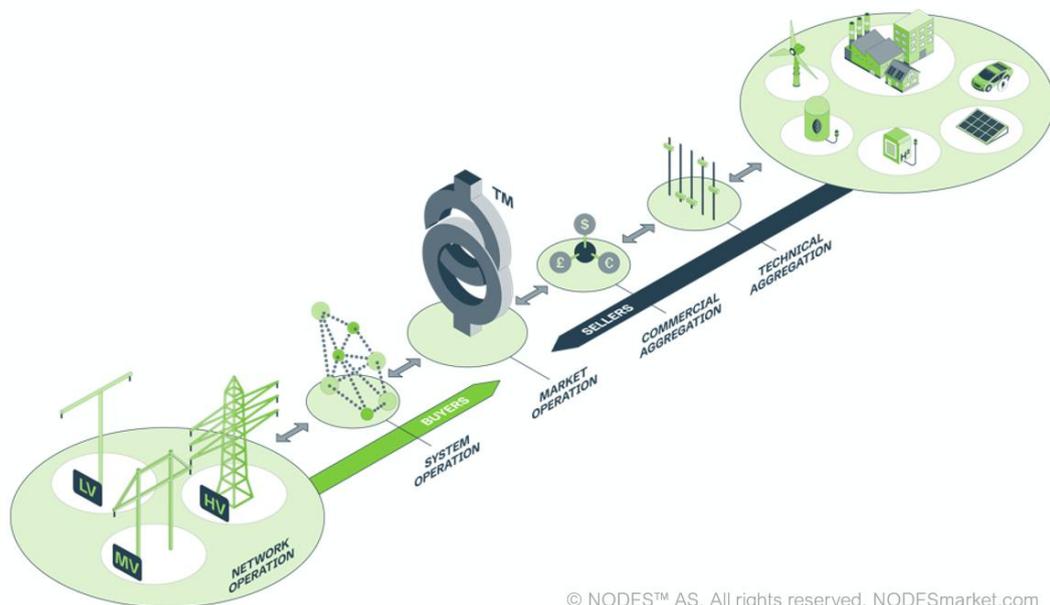


Figure 1: NODES digital flexibility value chain for secure and reliable flexibility transactions between Buyers and Sellers

NODES platform environment, products and services are tailored to the specific needs of utility companies such as Distribution and Transmission System Operators, Aggregators and FSPs.



## 4 OPENTUNITY Flexibility market pilots

In the OPENTUNITY project NODES market platform and technology solutions, operational processes as well as products and services are tested and developed in the different pilot areas proving the versatility and scalability of NODES flexibility market and market design.

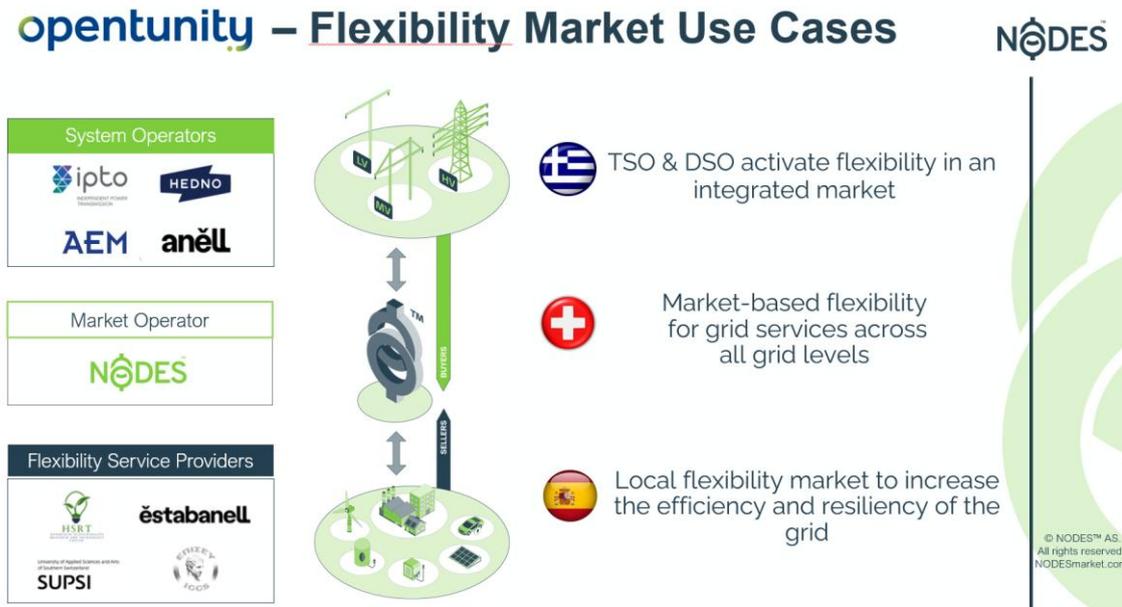


Figure 3: Overview of Opentunity Flexibility Market Pilots, market agents and roles

Figure 3 displays an overview of the project partners according to their business and market roles as well as the scope of each OPENTUNITY flexibility market pilot. The developed solutions aim to achieve TRL 6-9 according to the maturity level of each pilot site and partners. Ultimately, the solutions are planned to transition into Business As Usual.

In Spain, the DSO Anell aims to safely host the increasing share of RES in the pilot location while maintaining the efficiency and resiliency of the grid using market-based flexibility. In Switzerland, AEM, the local DSO, and SUPSI are investigating the interactions and technical requirements of small flexible residential and commercial assets at the pilot site and the local distribution level. Furthermore, they plan to analyze the potential aggregation of flexibility across different network levels. In Greece, the TSO (IPTO) and DSO (HEDNO) work closely together to evaluate a common flexibility market solution both for the transmission and distribution grid, respectively, as well as necessary coordination requirements.

NODES operational steps to transact flexibility, outlined in Figure 4, are divided into 3 categories according to each pilot-specific focus.

## NODES™ flexibility market in Opentunity



Figure 4: NODES operational steps for transacting flexibility and focus of flexibility market pilots.

### Market Setup

- (1) Registration of SOs and FSPs on the NODES platform
- (2) Market setup and establishment of Market Rules
- (3) Flex Zones: Replication of the grid infrastructure by every SO followed by the asset registration and assignment to grid nodes

### Trading

- (4) Trading of Reservation contracts (LongFlex)
- (5) Activation of flexibility in the Day Ahead and Intraday market (ShortFlex)
- (6) Market Coordination where needed due to the market setup
- (7) Notifications as part of the Greek Pilot to facilitate TSO-DSO coordination

### Post Trading

- (8) Validation
- (9) Settlement

Generally, within research projects such as OPENTUNITY, the legal framework associated to the Step (1) Membership is covered within the project grant agreement. Furthermore, no settlement is performed (Step 9).

The flags in Figure 4 mark the focus of operations and developments within the OPENTUNITY flexibility market pilots. As such the Spanish Pilot focuses on short-term flexibility activation via NODES market.

The Swiss pilot looks specifically into data requirements and validation of flexibility delivery. Furthermore, the Swiss Pilot concentrates on the coordination requirements between different DSO levels as well as the Balancing Service Provider (BSP).

The Greek pilot with the presence of the TSO and the DSO focuses on coordination and communication mechanisms to ensure safe and secure flexibility activation for grid services at the transmission and distribution level.

## 4.1 Spain

### Demo site

Anell is a Catalan DSO belonging to the Estabanell business group, whose electrical grid extends from Granollers, north of Barcelona, to Camprodon, close to the border with France covering more than 15,000 km. Over the past years, the number of distributed energy resources connected to Anell's grid such as solar photovoltaic panels for self-consumption behind the meter and electrical vehicles increased significantly. In line with the desired adoption of increased RES in this region of Catalonia, this trend is expected to continue. However, the increased intake of RES generation in the grid increases the voltage volatility in certain regions of the grid and creates new challenges to assure the necessary quality of service to the clients. For this reason, Anell examines several mechanisms to support grid stability, among them a local flexibility market.

With this in mind, the flexibility market will be tested in municipalities with a significant number of energy exporters (Table 1). The table below presents the absolute and relative amount of supply points exporting energy to the grid aggregated per municipality, including the five municipalities with the highest amount of exporting supply points:

*Table 1: Exporting supply points per municipality in Anell's grid.*

Supply Points	Exporters	Ratio (%)	Municipality
2802	330	11.78	L'Ametlla del Vallès
2803	318	11.34	Santa Eulàlia de Ronçana
2810	264	9.40	Bigues i Riells
4946	246	4.97	Tona
8779	278	3.17	La Garriga

Performing a similar analysis with aggregated exporting supply points per secondary substation feeder, high-risk areas for congestion and/or voltage volatility due to the increase of DER become more evident. According to these numbers, the feeders with the highest amount of exporting supply points fall into the municipalities of La Garriga, Les Franqueses del Vallès, Bigues i Riells, Santa Eulàlia de Ronçana, Tona and L'Ametlla del Vallès, which is fairly in line with the results from the first analysis.

When selecting the municipality for the pilot, Anell's interest in other OPENTUNITY use cases was taken into consideration, namely the fraud detection use case, to detect and forecast electrical frauds mainly linked to marijuana plantations. One fourth of the confirmed cases of fraud registered in Anell's grid over the last four and a half years were in Santa Eulàlia de Ronçana. For this reason, from the top 5 municipalities presented in Table 1, Santa Eulàlia de Ronçana was selected as the primary municipality for the pilot. Furthermore, due to the number of energy exporters and its interconnections with the grid infrastructure in Santa Eulàlia de Ronçana, the municipality of Bigues i Riells was also selected.

These two municipalities are quite similar in size and in terms of the grid infrastructure in place. There are two primary substations, one in Santa Eulàlia de Ronçana and one in Bigues i Riells, both

municipalities have over 40 secondary substations, around 30 km of MV network and around 80 km of LV network.

The pilot's target group of FSPs are residential clients who own flexible assets such as air conditioning, electric boilers, heat pumps or electric vehicles. As pilot participants within the Anell grid need to belong to the client base of Estabanell Impulsa, unfortunately not all assets in the region can be considered.

## Flexibility Market Set up

Local flexibility markets offer a solution to DSOs to optimize their grid management and to foster a more sustainable energy consumption by incentivizing the end-customers to become active and consume according to grid requirements. The testing of the local flexibility market at the pilot site will provide valuable insights regarding the impact on the grid operation due to flexibility activation along with an understanding of its economic viability both in the short and long term.

### Spanish Pilot - Market Agents

For the simulation of the Spanish local flexibility market the actors involved are as follows:

- **Anell:** Local DSO responsible for monitoring its grid critical areas and flexibility procurement on the flexibility market accordingly.
- **Estabanell Impulsa:** Energy retailer company acting as FSP, responsible for the participants' engagement and management of the flexibility assets, and seller of the available flexibility on the pilot site on the NODES platform.
- **ETRA:** Technology provider, responsible for the grid energy management system used by Anell for grid monitoring, overall process automation as well as the Building Energy Management System "BESOS". With BESOS, the pilot participants will have access to, to monitor their consumption.
- **HYPERTECH:** Technology provider that manages the Building Flexibility Management System (BFMS) to estimate the available flexibility from the assets included in the FSP's portfolio.
- **NODES:** FMO operating the market platform and services related to registration and prequalification, trading, as well as validation and settlement.

### Flexibility Market Implementation

To set up the Spanish flexibility market, a market rulebook has been agreed. The market set up covers the following framework:

- Traded product: Power
- Imbalance Settlement Period (ISP) size: 15 minutes
- Gate opening: 5 days before delivery
- Gate closure: 60 minutes before delivery

Information on Anell's pilot grid has been introduced to the NODES platform via their API (Figure 5). The code for asset registration, portfolio creation and baseline upload via the API has also been developed, with some examples already present in the NODES platform. Following data privacy concerns, the assets were registered according to their approximate location instead of the exact geographical coordinates. As such, the exact grid infrastructure is not revealed. Further development on Anell's and Estabanell's side is necessary for the automatization of the trading process, along with the actual flexibility activation on the market.

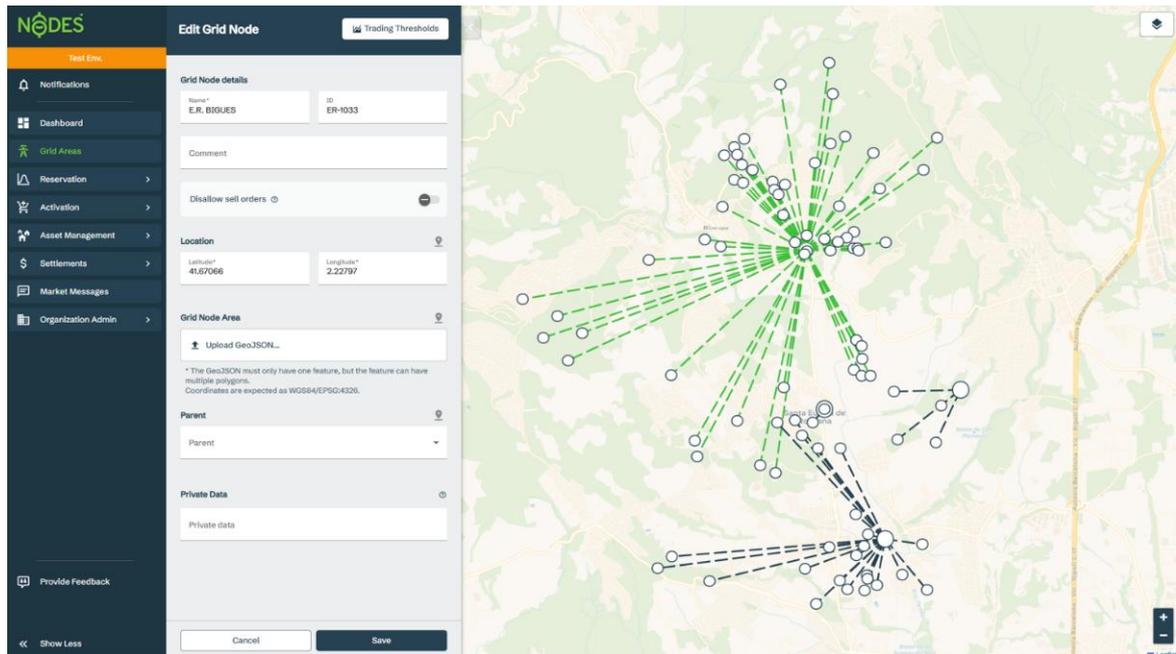


Figure 5: Grid replication of the pilot site in Spain managed by Anell.

Concerning the operational value chain, the Grid Energy Management System developed by ETRA, ETER, predicts future congestions and over/under-voltage in the grid area. With this information, Anell can place a buy order in NODES' marketplace specifying the required flexibility volume, direction, location and time. Hypertech's BFMS forecasts Estabanell Impulsa's baselines per asset and defines the suitable asset to satisfy the DSO's flexibility needs. Based on this information, Estabanell Impulsa can place a sell order on NODES' flexibility market. When corresponding orders match, the users and sellers are notified. The notification and related instructions are sent to the actuators installed at the clients' homes, to activate the requested flexibility. ETRA will provide the technical support to automatize the order submission to the marketplace according to the grid status as well as the communication/notification processes between the FSP Estabanell Impulsa and the asset owners. Moreover, ETRA develops the interface BESOS for the pilot participants to monitor the flexibility activations at their homes and provide feedback regarding the pilot.

From the DSO side, in order to be able to detect and predict a possible congestion or over/under-voltage which could be alleviated with flexibility activation, data is being gathered both at substation and client levels. Active and reactive power at the substation level is known for almost all mentioned substations, while Advanced Supervision allows for current and voltage data monitoring at the feeder level on some substations. Active and reactive power is known at the client

level with a 1-hour granularity, while voltage and current can also be known at 5–20-minute granularities for some clients.

From the FSP side, in order to be able to detect and activate flexibility, the following equipment will be installed at the participants' homes:

- a relay to monitor the total consumption of the household and the energy generated from solar panels (if applicable),
- actuators to enable remote control of air conditioning, heat pumps and electric boiler (if applicable),
- ETRA's Smart Meter eXtension (SMX) to send the activation orders to the remaining actuators.

In May 2024, Estabanell Impulsa started its capture campaign to recruit residential pilot participants amongst their clients in the municipalities of the pilot. The key messages of the campaign were related to the client benefits:

- Control over their consumption on appliance level, with the possibility to keep the equipment after the pilot.
- Contribution to an innovative project with a sustainable goal.
- A symbolic compensation with an Amazon voucher.

The target audience was people interested in topics such as sustainability, innovation, and energy, but would still not have their homes automatised and would find it interesting to have in-depth knowledge about their energy consumption during the OPENTUNITY pilot. This was formalised in a user persona with an average age of 35-55, postgraduate with a minimum 20k€ income, which accounts for around 33% of the population in these two municipalities.

Email campaigns were launched both in Bigues i Riells and Santa Eulàlia de Ronçana, which resulted in 20 registered participants, out of which 16 fulfilled all required criteria. At the moment of writing, 5 clients have submitted all required information to proceed with installations. Another 5 clients have partially submitted information but are still pending some input and the rest are unresponsive and require further follow-up.

To encourage further participation in the pilot areas, it was decided to organize workshops in relevant public spaces in each municipality to demonstrate the technology. On the 30<sup>th</sup> of January 2025 the first event was held in the civic centre of Santa Eulàlia de Ronçana. Given the delays in the pilot development, it was not possible to include an interactive demonstration of OPENTUNITY's technologies and so, there was no message pivot from the previous email campaign. Regarding the workshop planned for Bigues i Riells, a new angle is being developed, pivoting accordingly to increase engagement, with the objective of having a technology demo ready and a fresh captivating message.

## Flexibility Market Scenarios

In the scope of this pilot, Anell will analyse the actual impact of flexibility from aggregated residential assets to alleviate the grid in critical areas and moments. On Estabanell Impulsa's side, the

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goal is to understand how receptive the retailer's clients are to demand-side flexibility, and what is the actual impact of remotely controlling the setpoint of their appliances in their daily lives and comfort. In this way, Estabanell Impulsa explores if new flexibility-based products would be interesting for their current client base. Ultimately, there is an interest in assessing its economic feasibility and relevance for the different actors involved.

Having this in mind, some possible scenarios were drafted in order to test these assumptions:

- Increase power consumption for acclimatizing the house, via air conditioning or heat pumps, in periods with overvoltage, and decrease it in moments with undervoltage.
- Modulate electrical vehicles charging process to compensate voltage volatility and reduce it when there is a higher congestion risk.
- Reduce consumption in the case of an incident or planned intervention which increases the risk of congestion in that area.

This flexibility market pilot will only test the technical and operation feasibility both for buyers and sellers. Further evaluation such as price formation cannot be performed due to the limited participation of one DSO and one FSP. However, an internal analysis will be conducted to estimate the maximum price Anell would be willing to pay for flexibility, as well as the minimum price for which Estabanell Impulsa would sell flexibility in the Spanish flexibility market. From the DSO side, the interest in participating in a local flexibility market comes from the need of assuring a good quality of service and help balancing the system, as well as in some cases deferral of infrastructure investment. This potential reduction of operational costs will be used as a margin of the maximum value the DSO is willing to pay for flexibility activation in a flexibility market (else, it would be more expensive for the DSO to resolve its challenges with flexibility than without). In Spain, an energy retailer is required to predict its clients' base consumption and to purchase energy in the market; accordingly, any deviation of its actual consumption from its prediction will lead to a penalty paid by the retailer. Hence, what happens if the retailer's prediction is not fulfilled because an FSP asked for some of its clients to activate flexibility? Who ought to be responsible for the cost of this deviation? This is still an open debate in Spain, one of the possibilities being that the FSP should pay for this cost. If that is the case, this cost would be an indication of what is the minimum an FSP wants to receive for flexibility activation (else, the FSP would not profit from activating flexibility).

## Risks and Mitigation measures

The risks that could arise during the development of the local flexibility market in the Spanish pilot are divided into three different types. The first type of risk involves technical risks that may impede the proper execution of the deployment and demonstration activities due to a technological barrier. The second category of risks is related to the participation of users during the implementation of the local energy flexibility market in the pilot. The third category includes risks associated with the continuation of the local flexibility market after the conclusion of the project. The definition of risks per category follows, along with the mitigation strategy.

## Technical Risks

### Real-time connection

**Description of the Risk:** Lack of an automated and easy way to share real-time data from certain sources with the project partners.

**Mitigation Plan:** Work closely with the relevant departments of Estabanell and Anell's SCADA and Advanced Supervision providers. The SCADA data shall be sent via MQTT, while the remaining data will be sent via SFTP to a server from ETRA.

### Observability in local flexibility market pilot area

**Description of the Risk:** Given that the Advanced Supervision implementation is ongoing in our grid, and that Advanced Metering Infrastructure data is not always available, these data might not be available for the smart meters of the participants from the local flexibility market pilot and respective secondary substations, which will difficult the calculation and prediction of congestion and voltage volatility in the relevant grid areas.

**Mitigation Plan:** Work closely with the relevant departments of Anell and monitor the situation as new participants register to the pilot. Use state estimation to calculate missing values.

### Flexibility Service Provider Role

**Description of the Risk:** Lack of knowledge/experience for fulfilling some of the activities which are a flexibility service provider's responsibility.

**Mitigation Plan:** Work together with the partners involved in the local flexibility market, to exchange knowledge and support.

### Fail to activate flexibility for technical complications

**Description of the Risk:** Failing to activate flexibility when requested for technical reasons, such as sensor/actuator failure or lack of connectivity.

**Mitigation Plan:** Install Wi-Fi extenders when needed. Monitor equipment performance and connectivity.

### Fail to activate flexibility overall

**Description of the Risk:** Failing to activate flexibility when requested even though the request is fulfilled, because another neighbour changes their consumption patterns in such a way that overall, there is no change in the consumption in the area.

**Mitigation Plan:** Monitor the whole area and see if more flexibility requests are needed to fulfil our goal.

**Fail to detect activated flexibility**

**Description of the Risk:** Failing to detect activated flexibility given the baseline and detection algorithm used.

**Mitigation Plan:** Have regular communication with the end-users to know their perspective and share that information with the technological developers.

**Human resources limitations**

**Description of the Risk:** Lack of human resources for installing the necessary equipment.

**Mitigation Plan:** Work closely with the relevant departments of Estabanell. Subcontract personnel if necessary.

**Time limitations**

**Description of the Risk:** Delays in the implementation and execution of the pilot due to, amongst other things, some trial and error, low responsiveness from the participants, extension of the recruitment for the pilot with a citizen engagement workshop, may complicate finishing the pilot in due time.

**Mitigation Plan:** Keep track of different milestones and predict the needed time to complete the upcoming ones.

**Citizen Engagement Risks****Small number of participants**

**Description of the Risk:** Lack of clients interested in participating in the NILM or local flexibility market pilots, in other words, use cases 1.2, 1.8 and 1.10.

**Mitigation Plan:** Reach to a big pool of people, focus on the identified key messages and highlight the advantages of participating in the pilot for them. Organize a citizen engagement workshop with a second recruitment round, where we can already present a first version of the tool.

**Low responsiveness from participants**

**Description of the Risk:** Participants show little activity and responsiveness to our communications, delaying and hindering the gathering of information, pilot planning, and feedback collection. This affects use cases 1.2, 1.8 and 1.10.

**Mitigation Plan:** Tune the key message and recruitment campaign to a client profile which tends to be more actively involved and who has interest in sustainability and/or new technologies.

**Small volume of data**

**Description of the Risk:** As a consequence of low participation, and/or late registration in the pilot, the number of clients participating and the duration of their participation is low, leading to small volumes of data. This affects use cases 1.2, 1.8 and 1.10.

**Mitigation Plan:** Use open-source data for an initial version of the models to be developed.

**Fail to activate flexibility due to user's counteraction**

**Description of the Risk:** Failing to activate flexibility because the requests don't match the users' needs, who then counteract on the activation.

**Mitigation Plan:** Understand the clients' limitations and priorities and take them into consideration when optimizing and calculating from which users to harness the needed flexibility.

**Exploitation Risks****Product's user-friendliness**

**Description of the Risk:** Final product is not user-friendly, which hinders its future adoption by the DSO or the end-users' interaction with it.

**Mitigation Plan:** Work closely with the developers of the product interface, provide them with feedback from the end-users (DSO staff or clients, depending on the use case).

## 4.2 Switzerland

### Demo site

The Swiss pilot site lies in the municipality of Massagno, Lugano district, in the south of Switzerland (Figure). Initially identified as an energy community including three commercial buildings (i.e., an elderly care home, a warehouse, and an office building) and four residential multifamily houses, the pilot site underwent a renovation during the initial months of the project, necessitating the inclusion of buildings with existing flexible assets to support the activities envisaged in the proposed use cases.



Figure 6: Overview of the Massagno district

After an initial assessment of the buildings in the community, the final configuration of the pilot site retained the elderly care home as one of the main buildings in the community, featuring a 60 kW PV system as the largest source of local electricity production, in addition to centralized air conditioning systems for cooling. Among the other buildings that remained unchanged, the offices were included due to the presence of two water chillers, along with one residential multifamily house equipped with three electric boilers. Despite the availability of data from their smart meters, all other buildings in the original configuration of the pilot site were excluded from the flexibility analysis, as no significant or controllable assets were identified. These were replaced by three new commercial buildings and three new residential ones. Details about these buildings are outlined in Table 2.

Table 2: List of selected new buildings included in the second version of the pilot site

Building ID	Type	PV	Heat Pump	El. Boiler
<b>ECM43</b>	Commercial		2x (A2W, 30.3 kWt, 15.10 kW)	3x (2x1 kW, 1x2.4 kW)
<b>ECM41</b>	Commercial			1 kW
<b>ECM42</b>	Commercial		A2W, 11 kWt, 2 kW <sub>e</sub> , 600 L tank	
<b>ECM25</b>	Residential	10 kVA/6 kW <sub>p</sub>	A2W, 27.6 kWt, 6-8 kW <sub>e</sub> , 980 L tank	6 kW, 925 L tank
<b>ECM12-19</b>	Residential		2.4 kWt, 1.2 kW <sub>e</sub> A2W 110L tank	6 (2x4 kW, 3x2.66 kW, 1.5 kW, 3 kW)

ECM21-24	Residential	4 (6 kW, 2x2 kW, 3 kW)
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The local distribution grid that supplies the pilot site starts from the MV (16 kV)/LV (0.4 kV) transformation cabin, which houses a transformer with a rated power of 630 kVA. This transformer supplies various feeders, including the one serving the pilot site. Both, the secondary side of the transformer and the feeder supplying the energy community are monitored on the low-voltage side to ensure the status of the local distribution grid is continuously tracked.

Along the pilot site's feeder, which is three-phase powered up to each building, two distribution cabinets supply power to the buildings in the area. Thanks to the deployed Advanced Metering Infrastructure (AMI), the pilot site benefits from smart meters installed in all buildings, large PV production systems (>30 kW) and district assets, measuring imported and exported power (kW) at 15-minute intervals. Historical smart meter data have been available since 2022, while real-time data can be accessed through AEM's API, typically with an average delay of two hours.

The final configuration of the pilot site, with its increased flexibility potential, facilitates the investigation and analysis of flexibility market scenarios through the NODES platform, as outlined in the following sections.

### Flexibility Market Set up

The Swiss pilot site aims to explore the potential of the flexibility market, starting from the definition of use cases during the initial phases of the project. To this end, Use Case 5.2 (UC 5.2) was created with the objective of developing a solution to analyze the potential of small residential and commercial flexibility assets in providing services to the local distribution grid operated by the local DSO. Additionally, it aims to investigate the potential integration of these services with other actors like the local Balancing Service Providers (BSP) as proof of concept.

#### Swiss Pilot - Market Agents

Following the pilot renovation to meet the project requirements, initial task activities included bilateral meetings to identify the roles and activities of each partner. This information is summarized in Figure and subsequently described.

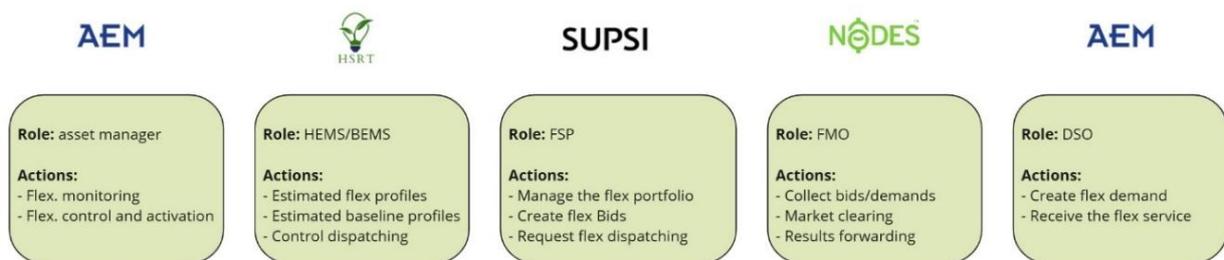


Figure 7: Roles and list of actions associated with each partner involved in the flexibility market

- **AEM:** Swiss pilot leader, which, given the absence of role unbundling, operates in the territory including the pilot site as local DSO, energy provider and Energy Service Company (ESCO). AEM, is responsible for Use Case (UC) 5.1 and 5.2. UC 5.2 focuses on the flexibility market. Given the different roles of AEM in the pilot location, the company will have two distinct roles within the local flexibility market. First, as the DSO, AEM is the buyer of local flexibility services on the NODES platform aiming to exploit the potential of local assets for the provision of grid services. Secondly, as the responsible entity for the direct monitoring and the asset control, AEM will act as the transmitter of the flexibility control signals communicated by the FSP according to the concluded flexibility trades on the market.
- **SUPSI:** acting as the FSP is responsible for the submission of sell orders of the available flexibility from the pilot site on the NODES platform. To introduce the principle of market competition, SUPSI will act as two distinct FSPs: one managing real controllable assets and the other handling simulated assets present in the pilot site but not actively monitored or controlled.
- **NODES:** FMO, NODES is operating the flexibility market platform and services related to registration and prequalification, trading and validation and settlement. Beyond the provision of the flexibility market and products, its role includes supporting the pilot partners in adopting the platform and assisting them in designing scenarios and services tailored to each pilot site.
- **HYPERTECH:** working closely with the pilot leader, HYPERTECH is responsible for gathering smart meter and submeter data of the available assets that are capable of providing flexibility services at the pilot site. This information is available through the BFMS developed by HYPERTECH to calculate baselines and predict the available flexibility of the assets. Ultimately, HYPERTECH is also responsible for the transmission of control signals to the AEM to activate the assets related to the concluded trades on the market.

## Flexibility Market Implementation

A schematic representation of the different steps in the operational value chain carried out by the different actors is described in Figure . Step (0) represents an initial step considered as a preliminary set of actions conducted by the BFMS manager HYPERTECH.

HYPERTECH forecasts the baseline and available flexibility upon receiving asset and meter data of the controllable assets from AEM within the pilot. This information is shared with SUPSI (step 1), the FSP in the flexibility value chain that aggregates the assets in a portfolio and calculates a respective portfolio baseline. The baselines per portfolio are uploaded to NODES platform. In the second step (2), when AEM has identified the need for flexibility in the grid, the DSO places a buy order on the market platform. SUPSI as the FSP places sell orders on the NODES platform. The submission of buy or sell orders can be performed as a proactive measure to demand or offer flexibility, or as a reply to an existing bid.

If not requested otherwise, NODES platform clears the market continuously by applying Pay-as-Bid (3). Involved parties, i.e. the respective FSP and DSO get notified when corresponding orders match (4). In the following step, the FSP communicates the list of assets to be activated and the corresponding setpoints according to the match to the EMS manager (5). Control signals are then

sent to the pilot leader (6) to proceed with the actual activations and service delivery (7). As the final step, the FMO validates the correct delivery of flexibility from the FSP to the DSO using historical meter data of the controllable assets and synthetic data for the asset without applied controlling system.

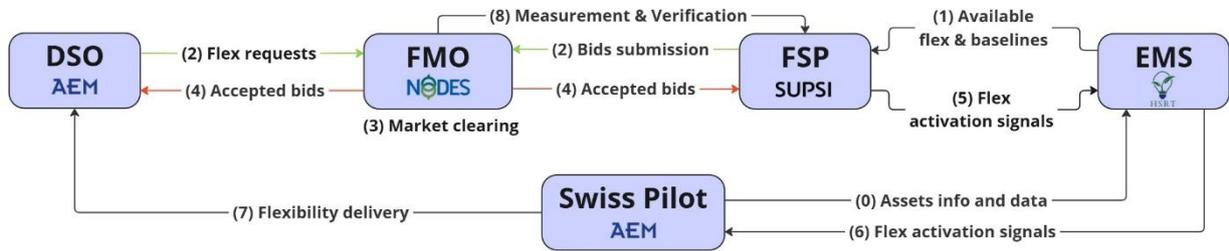


Figure 8: Flexibility market interaction phases considering a single FSP

After conducting preliminary activities to learn to use the NODES platform and identifying the list of assets to be included in the portfolio along with their technical characteristics, the first step is to create the market areas. On the platform, the replication of the grid infrastructure includes grid areas, grid nodes and sub-nodes. As shown in Figure 9, the Swiss pilot consists of a single Grid Node called Massagno\_1 (M1), representing the municipality of Massagno, and two sub nodes: Node\_1 (S1) and Node\_2 (S2), which represent two distinct areas of the pilot site based on the distribution grid layout.

A total of 33 assets, with installed capacities ranging from 1 kW to 10 kW, were identified and uploaded to the platform, 3 in Node\_2 and 30 in Node\_1. For the sake of end-user privacy, although the assets are located in the general area, their positions on the platform do not reflect their actual physical locations.

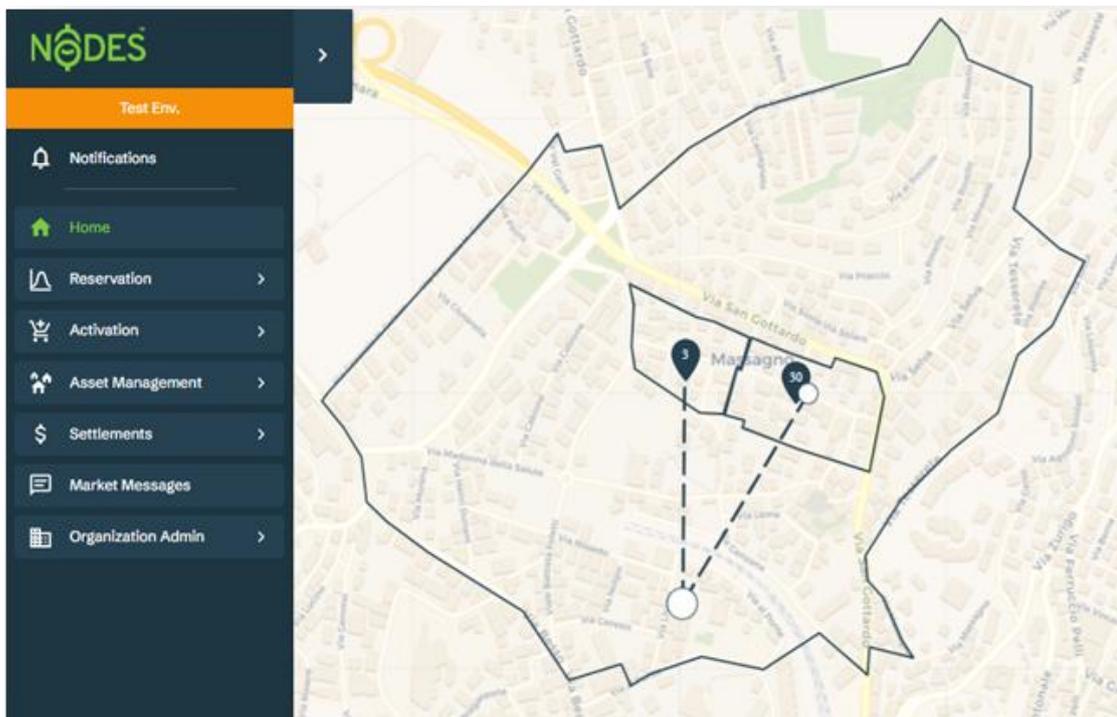


Figure 94: Swiss pilot market area represented by its grid node and sub-nodes

Before initiating the validation phase of the UC and the flexibility market scenarios for the Swiss pilot site, AEM began the deployment activities by engaging with asset owners and conducting technical inspections in the targeted buildings. The goal of these inspections is to install the necessary equipment to monitor and control eligible assets. This process is ongoing and is expected to continue until the completion of the deployment activities, foreseen in WP6.

Meanwhile, SUPSI successfully tested the NODES API, implementing a demo version of the flexibility market, running automatically and continuously on a SUPSI server. This validated the use of the API to automate the bidding process, lays the foundation for the future validation phase of seller (FSP) and buyer (DSO) activities on the trading platform. The following figure shows how the flexibility market demo is operated.

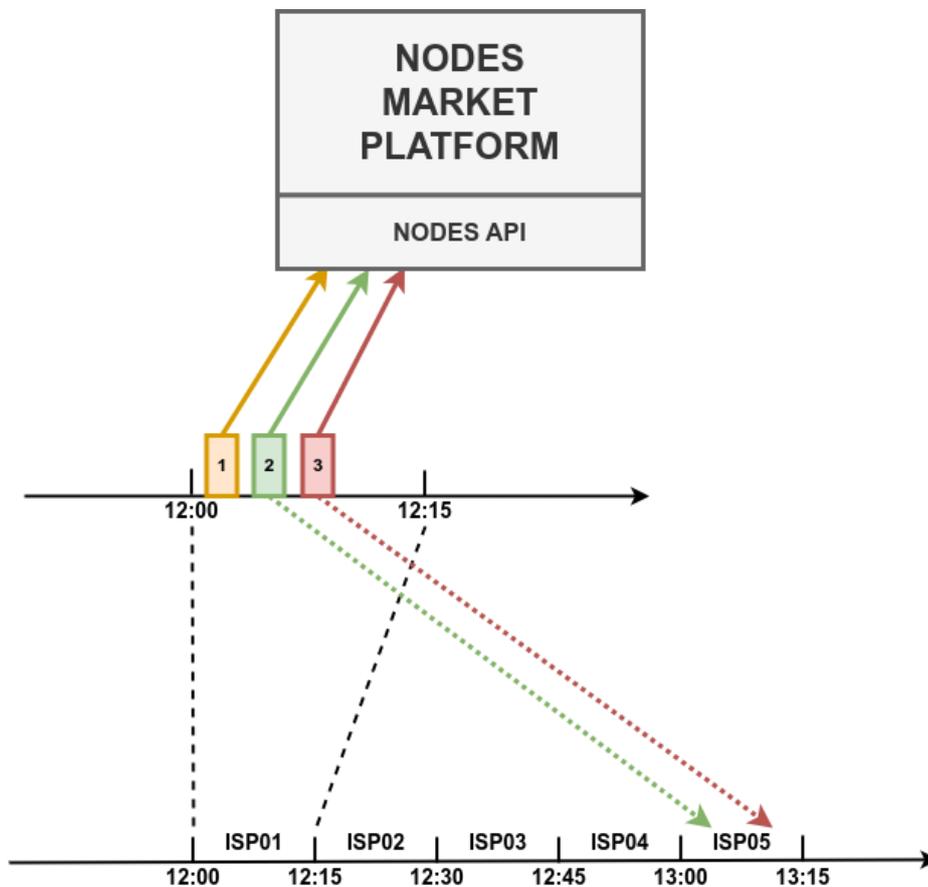


Figure 105: Sequence of interactions performed by the FSP (orange and red rectangles) and by the DSO (green rectangle)

As mentioned above, the implementation depicted in Figure 10 is currently designed for demonstration purposes to exhaustively test the NODES API, running new orders and bids of flexibility every quarter of an hour. The schema shows the operations run on a generic day during the temporal slot [12:00-12:15] and related to the flexibility market time slot [13:00-13:15]. Regarding the price, a fixed scheme has been considered for this preliminary demonstrator. Each operation, performed by a dedicated Python script interacting with the NODES API and running on the SUPSI platform, is described in the following list:

- **Operation 1**, baseline updating: the FSP updates the baseline of a specific portfolio of flexibility assets for the next 24 hours. Currently, this update relies on a persistence model, which uses the measurements from the same quarter-hour period of the previous week.
- **Operation 2**, flexibility demand: the DSO, taking into account any possible issue that could arise on the grid (e.g., consumption peaks, voltage variations, etc.), asks for flexibility in the NODES market. The choice of the requested flexibility is currently implemented considering random data selected among meaningful values.
- **Operation 3**, flexibility bid: the FSP, after having evaluated the flexibility demand of the DSO as well as its predicted baseline for a specific quarter of an hour, submits a corresponding sell offer on the NODES platform. If the buy order of the DSO and the sell order of the FSP correspond in terms of volume and price, the orders will be matched instantly applying Pay-as-bid.

It is important to note that the market operation has to be performed before gate closure according to the agreed Rulebook, i.e., one hour before delivery to allow for notification and asset activation in due time. Indeed, in Figure 10, operations 2 and 3 are related to the market slot interval [13:00-13:15], as shown by the dotted lines.

This demo version is currently running every quarter of an hour, automatically performing the operations shown in Figure 10. The NODES Dashboard provides a monthly overview of the simulated market activity (Figure 11).

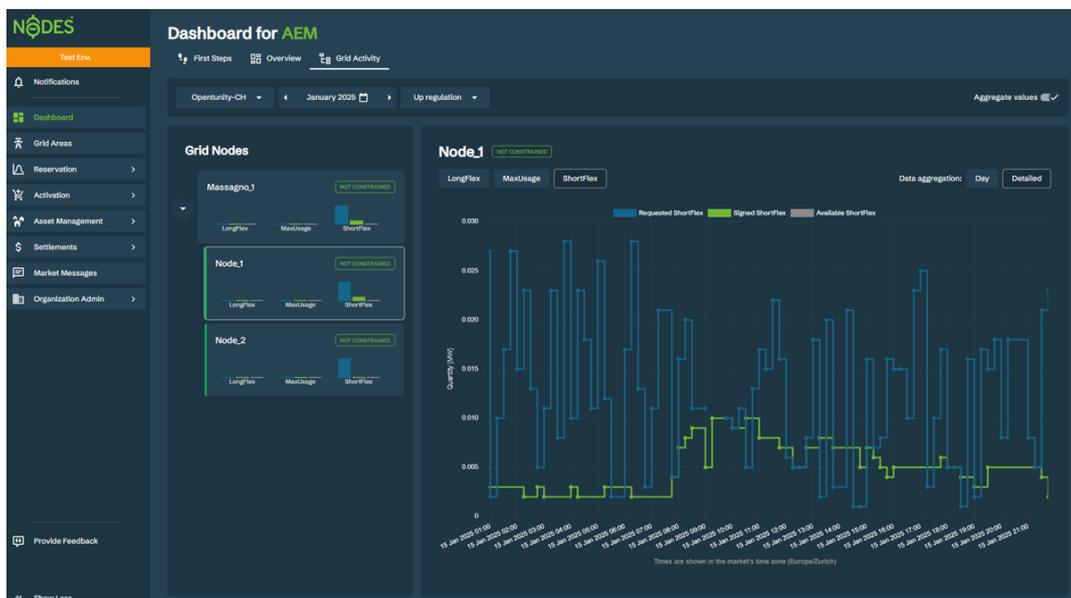


Figure 61: NODES Dashboard – monthly overview of the demo market activity

## Flexibility Market Scenarios

As introduced above the Swiss pilot, in the context of Task 4.5, has identified two relevant scenarios for testing:

**Main Scenario:** This primary scenario serves as the main validation use case due to its feasibility and active participation by all partners and focuses on testing the benefits of local and small flexibility

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to improve the efficiency of the local distribution grid, starting from a single feeder. Two independent FSPs, both represented by SUPSI, will participate in the market to create a more realistic market scenario. One FSP represents real assets and the respective asset control. The second FSP simulates market activity based on data from the pilot site's assets that are not controllable. These FSPs will create portfolios and bid into the flexibility market of the local DSO. This scenario represents a proof of concept for a "win-win" market, where asset owners can offer their assets to the FSP to potentially reduce their investment return period, while the local DSO gains access to highly localized flexibility on the LV side of the grid, potentially at a lower cost than traditional solutions.

**Optional Scenario:** Although not mandatory for the initial scope of UC 5.2, this scenario explores the introduction and simulation of an additional actor in the flexibility market: the local BSP. The objective is to demonstrate the concept of aggregating flexibility via the NODES platform to support balancing activities at higher grid levels. Considering the structure of the pilot site, this scenario allows for the investigation of potential market coordination dynamics between the local DSO and the BSP, focusing on future scenarios with a significantly higher diffusion of assets capable of providing these types of services.

These scenarios aim to evaluate the feasibility and effectiveness of integrating flexibility services into the market while providing valuable insights into future applications.

## Risks and Mitigation measures

A preliminary risk identified at the start of the project during the UC definition in WP2 was the potential lack of sufficient flexible assets available in the pilot site. To mitigate this risk, the pilot leader took proactive steps to verify the availability of assets near the energy community. As a result, three additional commercial and three additional residential buildings were incorporated into the pilot site.

As the pilot approaches the deployment phase, a potential risk is the challenge of controlling the identified heat pumps. To tackle this problem, AEM uses its experience in the field and solutions that have been successfully tested and are currently operational in other pilot projects within its territory.

Another potential risk, although low, is related to the lack of monitoring of the devices and the possible reluctance towards their installation. This risk is easily mitigated thanks to the long-lasting relationship of trust that AEM has established with its customers and asset owners.

We can therefore conclude that no risks are foreseen on the horizon that would jeopardize the validation of the flexibility market tests and the related UC 5.2 of the Swiss pilot.

## 4.3 Greece

### Demo site

The Greek pilot is located in Mesogeia region, a suburban area of Athens, the capital of Greece, within Attica. The energy system in Mesogeia is interconnected with the mainland grid, serving the municipalities of Koropi, Lavrio, and Nea Makri, as well as supplying power to the islands of Kea,

Andros, and Tinos, as depicted in Figure 12. The inclusion of these semi-rural areas features an energy grid that supports both industrial and residential loads. Additionally, the region hosts a variety of renewable energy sources (RES), including but not limited to photovoltaic (PV) farms and residential PV installations.

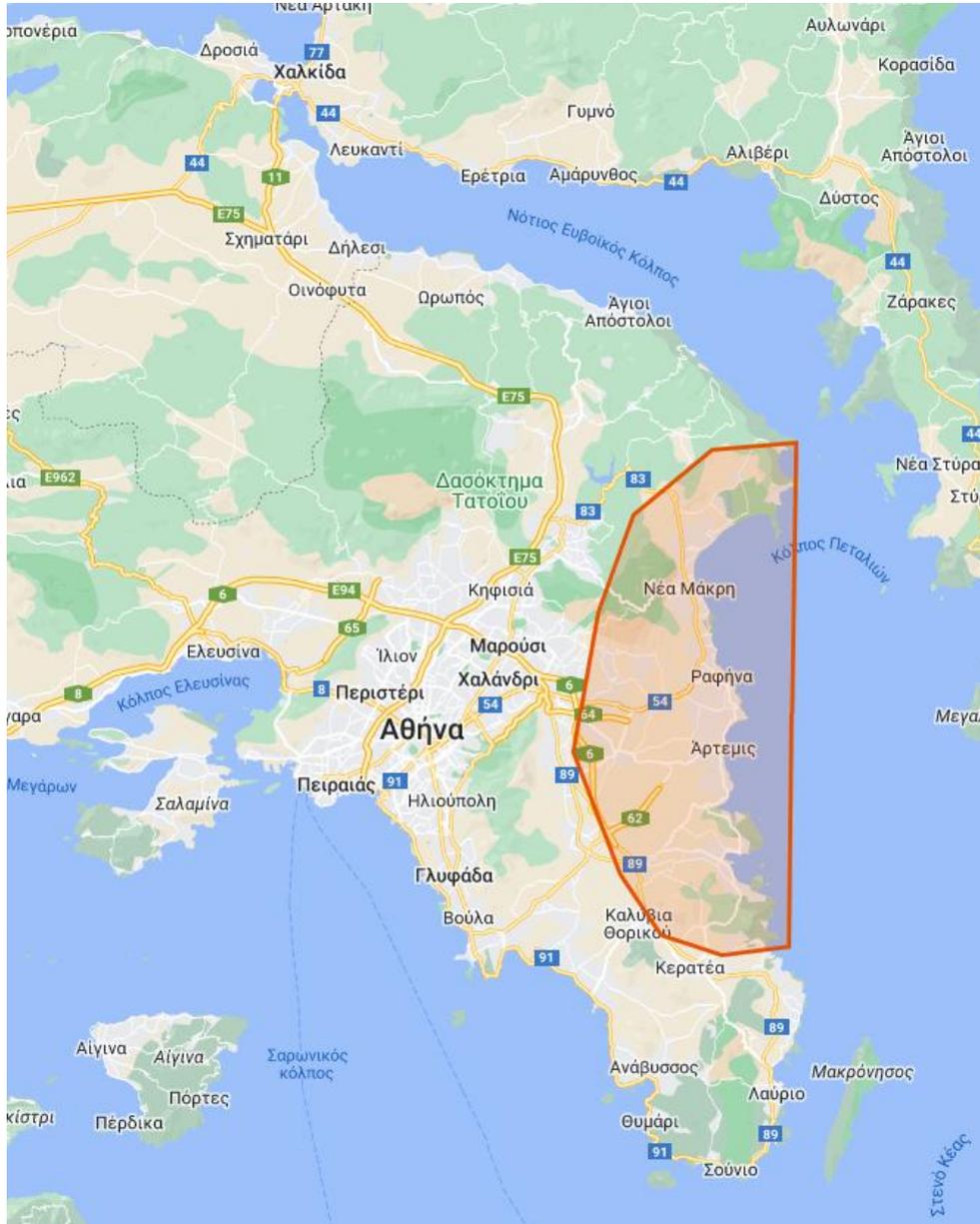


Figure 12: The geographical area covered in the Greek Pilot

The Markopoulo HV/MV substation, consisting of three MV transformers, as shown in Figure 13, steps the voltage down, from 150kV to 20kV. Being located within the pilot area it constitutes the pilot installation of the OPENTUNITY project together with the connected electricity distribution network (MV feeders). The HV/MV substation serves as the interface between the transmission network, managed by IPTO, and the electricity distribution network, managed by HEDNO.

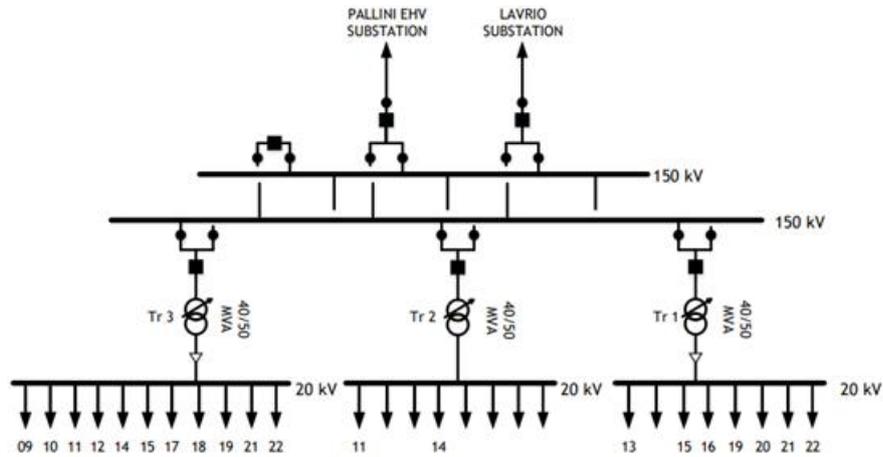


Figure 7: Structure of the Markopoulo HV/MV substation.

The selection of this location as a pilot site was driven by specific challenges and needs aimed at increasing the penetration of RES, particularly through net-metering. This objective is underpinned by three main pillars: a) efficient network management to address challenges posed by rooftop PV installations, b) effective utilization of flexibility, and finally c) implementation of innovative planning techniques in order to support greater RES penetration in the medium term. Moreover, this area is prone to potential congestion issues that might arise due to increased RES penetration, further supporting its selection for the Greek pilot site. The aforementioned issues/concerns can be successfully mitigated through a local flexibility market.

The Markopoulo substation serves 123 medium-voltage (MV) customers and approximately 2,812 low-voltage (LV) customers. Smart electronic meters deployed for all MV customers and selected LV customers are distributed across feeders connected to the substation's three transformers. HEDNO operates an advanced metering infrastructure (AMI) integrated with a meter data management system, which processes, validates, and stores metering data collected at 15-minute intervals. Additionally, automatic meter reading (AMR) retrieves smart meter data via general packet radio service (GPRS) every 24 hours.

The majority of LV customers still rely on electromechanical meters, which require manual data logging, whereas all MV customers use electronic telemetering meters. Moreover, 100 smart meters utilize an unbundled smart meter architecture, dividing functionalities into a smart metrology meter and a smart meter extension. This enables flexible support for billing and energy market participation. The data of the smart meters will be used by the system operators to estimate the required amount of flexibility in the critical assets of the substation, hence the selected number of feeders. As part of the OPENTUNITY project, participants in the pilot demonstration of the local flexibility market will be equipped with smart meters to monitor the total consumption of their loads.

## Flexibility Market Set up

### Greek Pilot - Market Agents

The entities participating in the local flexibility market developed for the Greek pilot according to the flexibility value chain (Figure 1: NODES digital flexibility value chain for secure and reliable flexibility transactions between Buyers and Sellers) are the following:

**System Operators (SOs):** The SOs of electricity transmission and distribution networks, are the buyers of the flexibility services offered in the flexibility market. **IPTO** is the Greek Transmission System Operator (**TSO**), whereas **HEDNO** is the Distribution System Operator (**DSO**). Both SOs have access to the same flexible loads.

**Flexibility Market Operator (FMO):** **NODES** is the flexibility market operator and responsible for operating the flexibility market as well as pilot-specific developments to facilitate flexibility transactions considering the two Buyers in the market.

**Flexibility Service Providers (FSPs):** FSPs are selling flexibility to the SOs by adjusting the consumption and production of various assets within their portfolios. In the local flexibility market of the Greek pilot in the OPENTUNITY project, two FSPs are participating. The first is **HYPERTECH**, which manages a portfolio of residential loads. Including 48kW power from water heaters, 24kW from air conditioning, PV capacity of 4kW and other plugged loads for testing purposes. The second is **ICCS** offering flexible loads from laboratory installations including PV installations of around 3kWp and a battery storage system of 5kWh Li-ion batteries. All these flexibility sources will be part of ICCS FSP portfolio. This portfolio of ICCS will also include 20-25 residential customers which are members mainly of an energy community located in Attica region.

### Flexibility Market Implementation

The implementation of the Greek pilot differs from the other pilots due to the presence of both SOs, the TSO and the DSO. As such, the implementation of the local flexibility market within the Greek pilot includes the operational steps described in Figure 4 (Chapter 4) with enhanced focus on steps 6+7 to develop and test various tools to facilitate TSO-DSO coordination. This latter point is an iterative task in close collaboration between HEDNO, IPTO and NODES to test various scenarios and ultimately to identify an optimal solution for both SOs.

The flexibility market within the Greek pilot focuses on the joint participation and coordination of IPTO and HEDNO, with the key elements of the market rulebook presented in Table 3.

Table 3: Greek pilot local flexibility market rulebook

Parameter	Value
<b>Market product</b>	Power (kW)

<b>Order type</b>	Buy/Sell
<b>Regulation</b>	Up/Down
<b>Fill Type</b>	Normal
<b>Capacity</b>	MW
<b>Price</b>	€
<b>Min. bid size</b>	0,001 MW
<b>Quantity granularity</b>	0,001 MW
<b>Gate closure</b>	120 min before delivery
<b>Granularity</b>	15 min
<b>Data sources</b>	HEDNO/IPTO/HYPERTECH/ICCS

HEDNO's participation addresses congestion events that may occur in the distribution network during periods of increased production or consumption, while IPTO participates in the local flexibility market to secure flexible capacity for the transmission system for balancing issues, more specifically for manual Frequency Restoration Reserve (mFRR). The focus of this pilot lies in the development and implementation of communication scenarios between TSO and DSO to operate in an integrated market with both SOs being able to activate flexibility from assets in the distribution grid. Within this framework, different scenarios will be examined according to step 6 and 7 of the operational processes for market set up (Figure 4).

### Replication of the grid infrastructure by every SO

Based on the structure of the Greek electricity transmission and distribution system in the pilot location, the following hierarchy is established:

- The MV/LV transformers are connected to the HV/MV substation through radial networks.
- The HV/MV substation in the Markopoulo area serves as the interface through which the distribution system of the area connects to the transmission system.

On NODES market platform the replication of the distribution and transmission grid infrastructure is done through grid areas and grid nodes while their interdependencies are defined using the parent-children architecture. The different grid levels and connection of grids have been replicated through the connection of the parent grid nodes of the distribution and the transmission grid. The connection of the parent grid node of the HV/MV substation managed by IPTO (orange boxes in Figure 14) and the parent grid node of the MV/LV managed by HEDNO (green boxes in Figure 14) allowed for the creation of one combined market enabling both SOs to purchase flexibility in connected grid nodes and hence across all grid levels (Figure 14).

Accordingly, the transmission and distribution network infrastructure participating in the local flexibility market may include: HV/MV and MV/LV transformers, as well as lines in the distribution network within the Greek pilot area.

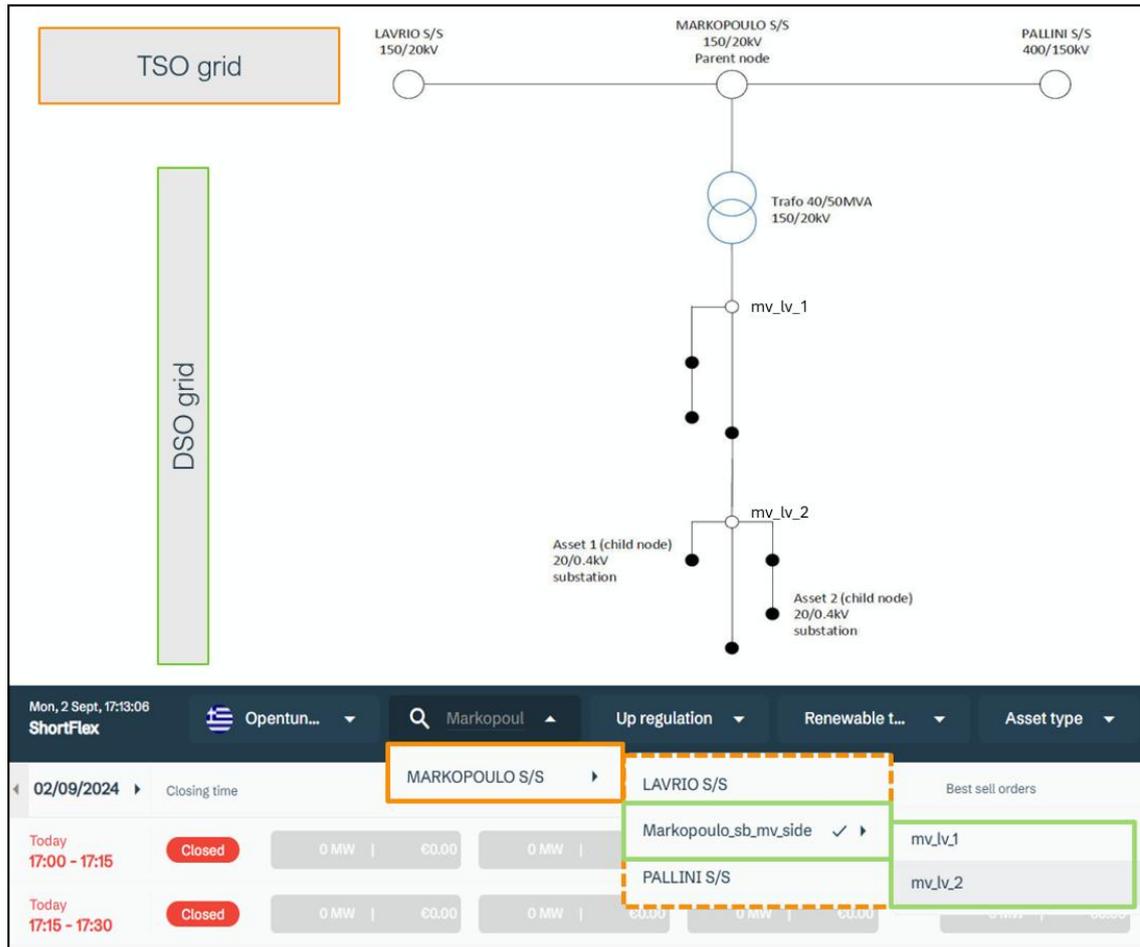


Figure 8: Grid replication of the transmission and distribution grid at Markopoulo substation and corresponding market set up on NODES market according to connected parent grid nodes/order books.

### Registration of assets by each FSP in the transmission or distribution grid

Flexibility assets are registered by the responsible FSP with the provision of the following information:

- Meter ID,
- Characteristics of the flexible load,
- Geographical area.

Based on the meter ID, the responsible SO approves the asset and assigns it to a grid node according to its location and respective impact on grid problems. Following the grid node hierarchy and NODES respective parent-child logic, the asset can then provide flexibility bottom-up in the grid. In other words, in connected grid nodes, flexibility offers are migrated upwards so that the flexibility at the distribution level (LV) can be activated at higher grid levels.

Each FSP (HYPERTECH and ICCS) organizes the assets into portfolios to submit flexibility bids on the NODES platform. The portfolio structure and organization follow the criteria of each FSP.

**Market Operation**

In the local flexibility market of the Greek pilot, NODES ShortFlex – Activation Market is foreseen to be tested in the first place. NODES ShortFlex market allows for instant activation of flexibility in the DayAhead and IntraDay markets without prior reservation of flexibility services over a determined time period. Proceeding in the testing, flexibility transactions in the reservation market may be considered as an additional coordination feature.

**TSO-DSO integrated market coordination and communication tools**

In the integrated market tested in the Greek pilot, both HEDNO and IPTO have access to the same flexible loads connected to the distribution network. To prevent possible grid problems caused by the flexibility activation of two SOs, coordination is necessary. Within this pilot, different coordination tools and communication protocols are developed by NODES based on direct feedback from IPTO and HEDNO:

- a. Establishment of a Coordinator Role in the flexibility value chain
- b. Dynamic grid nodes thresholds
- c. Dedicated market communication tool

a. The Coordinator Role

The Coordinator role (CR) on NODES market (Figure 15) is an overarching role within the flexibility value chain representing an entity that oversees the market activity and supports decision-making in critical situations. The CR may be managed by representatives of both SOs and/or NODES. The respective entity is responsible for the management of the Market Coordination Tool (MCT) and the associated traffic light coordination system. The representation of the CR by different representatives will play a crucial role in the testing scenarios of the testing phase.

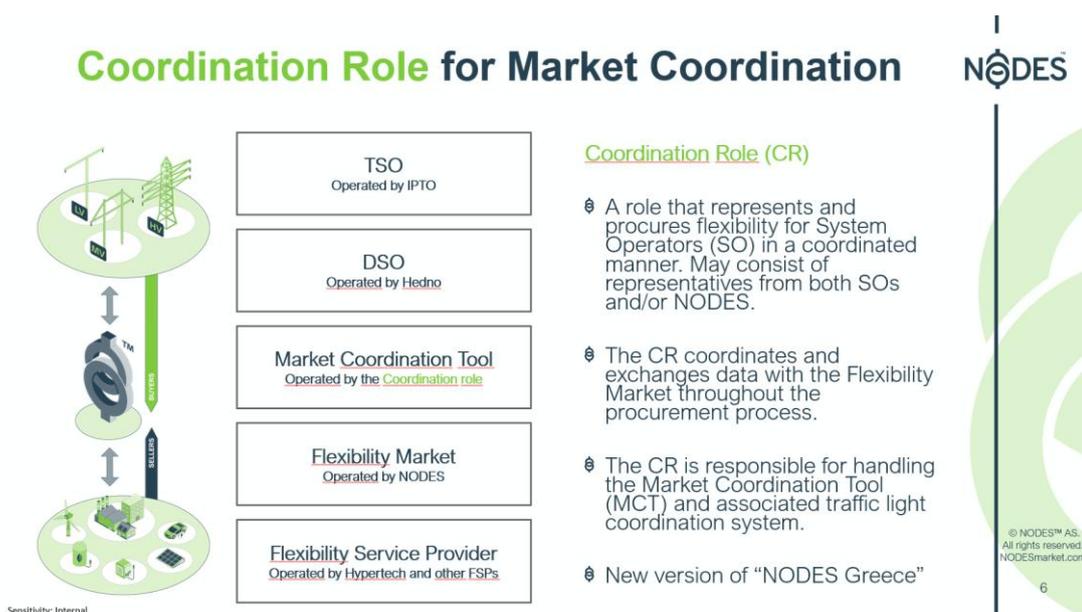


Figure 9: NODES Coordination Role for Market Coordination and TSO-DSO coordination

b. Dynamic grid nodes thresholds

Every SO can insert and modify critical thresholds in his own grid nodes to limit flexibility activation to non-critical volumes and thus prevent/avoid problems (Figure 16). Buyers (SOs) will be notified of the threshold when submitting a buy order.

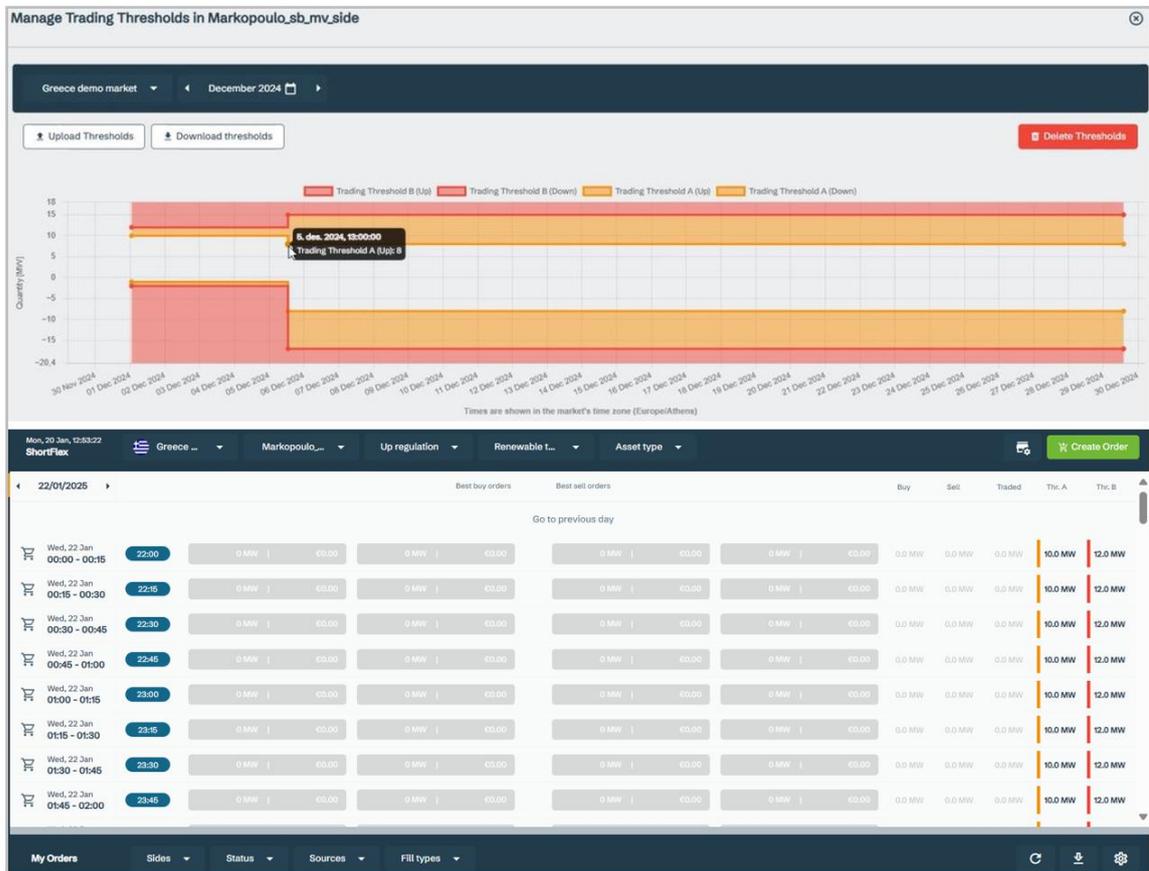


Figure 16 Insertion of grid node thresholds and display in the respective order book indicated as yellow and red volume limits.

The dynamic grid node thresholds work according to the traffic light system. Green (or no colour) indicates no problem. Orange indicates that a problem may arise through activation of flexibility within the ranges and hence coordination with the hosting SO is required. Red indicates a grid problem that will arise in case of flexibility activation beyond this threshold. Ultimately, a red grid node threshold may lead to an invalidation of the buy order. The dedicated market communication tool facilitates the interaction between the SOs to align the flexibility activations while respecting the grid capacity limits of the respective grid.

c. Market Communication Tool

The SO issues a flexibility purchase order on the platform in an order book/grid node of another SO. If the requested flexibility volume exceeds a threshold, the transaction is placed in a pending state. The hosting SO is notified of the transaction and evaluates its potential negative impact on its network's operation. Based on this evaluation, he either approves or rejects the transaction.

Within the operational value chain of flexibility procurement via NODES flexibility market the combination of the coordinator role together with the tools and communication mechanisms will support the controllable and secure activation of flexibility. This approach is scalable enabling the establishment of one integrated flexibility market in Greece.

## Flexibility Market Scenarios

Three market coordination scenarios with alternating representation of the coordinator role are considered to test the usability, usefulness and further requirements of the developed tools as well as respective implications for the grid management for both the DSO and the TSO.

### Scenario 1: NODES as the Sole Decision-Maker Based on Rulebook

In this scenario, NODES assumes full responsibility as the CR, overseeing flexibility transactions across all operational conditions.

### Scenario 2: Hybrid Approach with NODES and System Operators (SOs)

In this scenario, NODES assumes responsibility as the CR in case of green or red-light requests to validate or invalidate the buy order, respectively. In case of the orange light, IPTO and HEDNO comply with previously assigned responsibilities as CRs to agree on the proceeding regarding the pending flexibility request.

### Scenario 3: Multi-Level Coordination with Prioritization

Flexibility request prioritization based on criticality of the arising grid problem. This approach requires a previous definition of grid problems and their categorization according to their criticality.

## Risks and Mitigation measures

The risks that could arise during the development of the local energy flexibility market in the Greek pilot are divided into three different types. The first type of risk involves technical risks, which may emerge due to communication and control issues between the FSPs and the SOs. The second category of risks is related to the participation of many users during the implementation of the local energy flexibility market in the Hellenic pilot. The third category includes risks associated with the continuation of the local energy flexibility market after the conclusion of the project. The definition of risks per category follows, along with the mitigation strategy.

### Technical risk

#### Inadequate communication between participants

**Description of the Risk:** Regarding the Greek Pilot in the OPENTUNITY project, the flexibility market being developed will enable FSPs to trade power and provide services to address challenges in the transmission and distribution systems. However, during the project implementation, the required communication and control systems between the end-users and FSPs, as well as the smart meters from the DSO side to verify FSP behavior in real time, could not be established. Moreover, insufficient coordination, due to lack of proper communication between TSO and DSO, may lead to congestion management and/or balancing issues on the HV side or to the MV and LV side. Those pose significant technical risks, as the absence of these systems could slow down the proper execution of buy/sell orders and prevent the validation of delivered

flexibility services. Such technological limitations may impede the project's deployment and impact on the future exploitation of its technologies.

**Mitigation Plan:** To mitigate this risk, a manual communication system will be implemented. The FSP will communicate flexibility requests to assets via phone or text message, and end users will manually control their loads to provide the requested services. Validation of flexibility delivery will be performed both by the SOs for internal purposes and by NODES as official service as a market operator. While not ideal, this approach offers an interim solution to ensure the demonstration and evaluation of a real-world flexibility procedure. Regarding the DSO-TSO coordination, an analytical scheme will be implemented utilizing the NODES flexibility market platform.

### User engagement risks

#### Low User Engagement in Flexibility Market Participation

**Description of the Risk:** A significant risk associated with the flexibility market is the low engagement of small and medium-sized prosumers, primarily due to the current orchestration of the Greek power system. As the DSO is not positioned to provide financial incentives, the lack of monetary rewards may discourage citizen participation. Additionally, the market's entry barriers—such as complex rules, technical requirements, and mechanisms that may not align with the operational scale and specific energy needs of smaller participants—further exacerbate the issue. These challenges could diminish motivation to engage, impacting both the demonstration activities and the technologies developed in WP4. Insufficient participation would undermine the flexibility market's functionality and scalability, resulting in lower-than-expected flexibility available to grid operators and potentially affecting the overall success of the flexibility market concept.

**Mitigation Plan:** To address this risk, awareness campaigns will be launched to inform citizens about the benefits of flexibility services. This campaign could involve digital platforms, social media, and traditional media outlets to ensure that citizens understand how their participation contributes to energy grid stability and sustainability. Additionally, discussions with end-users will be initiated to create a communication plan and establish baseline incentives to attract more customers into the market. Through channels like social media, email campaigns and targeted questionnaires, a dynamic feedback loop can be created, providing a representative image of user's acceptability. The inclusion of interactive elements such as tutorials, case studies, and live demonstrations of flexibility services in action, will help prosumers visualize the real-world impact of their participation, further boosting their engagement. Also, a user-friendly and accessible platform can enhance participation in the flexibility market as prosumers could easily monitor and control their energy usage. The design should include menu items, labels, concepts, and navigation.

#### Lack of trust in the flexibility market and its participants

**Description of the Risk:** Another significant risk that may affect citizen engagement is the potential lack of trust in the flexibility market system and its participants. Prosumers that are unfamiliar with the energy market or its regulations may have doubts about the intentions of system operators and stakeholders. Concerns could include data privacy, reliability of payments, or transparency in how flexibility services are operated. If users perceive that the market is designed primarily for the benefit of large corporations or if they are unclear about how their data is used, they may be unwilling to participate.

**Mitigation Plan:** In order to successfully build trust among prosumers and the operators, a transparent and user-centric approach is required. First, market operators should ensure clear

communication about the objectives of the flexibility market, the roles of various participants, and the benefits for prosumers. Providing easy-to-understand documentation or videos that explain how the market functions, and data privacy protection can mitigate concerns. Setting clear ethical guidelines regarding the operation of the flexibility market can also reinforce trust. These guidelines should emphasize data privacy, consumer rights, and the fair distribution of benefits. Transparency in how flexibility services influence the broader grid, along with regular updates on market performance and prosumer contributions, should also be prioritized. Trust can also be built through a communication system. Implementing a user-feedback mechanism where participants can mention concerns, ask questions, or provide suggestions would allow for continuous improvement and greater user confidence.

## Deployment risks

### Regulatory Barriers to Flexibility Market Exploitation

**Description of the Risk:** A key exploitation risk in the OPENTUNITY project is related to the regulatory framework in Greece. Currently, there is no specific legislation supporting the operation of a flexibility market at the distribution level, with only preliminary laws covering the transmission system market. This regulatory barrier poses a significant challenge to the exploitation and broader utilization of the project's technologies after the project ends. Without the necessary regulatory framework, it will be difficult to operationalize and sustain the flexibility market within the Greek distribution system.

**Mitigation Plan:** To address this risk, HEDNO and IPTO will collaborate based on the findings and observations gathered throughout the OPENTUNITY project. They will engage with the relevant regulatory authorities, communicating the project's results and operational requirements of the flexibility market. This dialogue will aim to influence and guide the development of new legislation necessary to support operation of a flexibility market in Greece, that includes both DSO and TSO. This proactive approach seeks to ensure the legal framework aligns with the operational needs of the flexibility market following the project's conclusion.

### Regulatory barrier to prosumer engagement in flexibility market

**Description of the Risk:** Complex regulations and limited incentives hold back the utilization of new technologies. The absence of a regulatory framework and possible restrictions on the energy trading platform may also delay or prevent prosumer engagement.

**Mitigation Plan:** Measures to protect prosumers from high wholesale electricity prices during volatile periods through fair pricing mechanisms and anti-market manipulation measures are necessary. However, these measures should not undermine the incentive for prosumers to get involved and offer their flexibility.

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## 5 Conclusion and Outlook

This deliverable describes the market set up of the pilot flexibility markets located in Spain, Switzerland and Greece. Each flexibility market and specific development areas is set up according to the foreseen use of flexibility at the pilot sites reflecting the location-specific grid issues, grid infrastructure and coordination requirements, prevalent asset types as well as risk and mitigation measures. The presented documentation underlines the variability and diversity of flexibility use cases for grid services and hence the respective setup and use of flexibility markets as a complementary tool in the SOs tool box. While the potential of flexibility for grid services is undeniable, aspects like existing and non-existing infrastructure, standardized operational and data exchange processes, as well as customer/FSP engagement and incentives contribute to the effective and efficient implementation and use of flexibility. Regulation plays a crucial role to these aspects and hence to the establishment of flexibility markets and ultimately, the use of flexibility. As such, flexibility and flexibility markets require a holistic approach to be successfully implemented and hence to support the energy transition.

The deliverable forms the basis for the operational testing of the flexibility market scenarios starting in March 2025. The objective of these field tests are the consecutive examination of scenarios per pilot described in this deliverable aiming at evaluating:

1. The usability and feasibility of the developments in the operational value chain.
2. Identification of strengths and weaknesses of the developments and integration into the value chain.
3. Preparatory requirements for planned tests in WP6.
4. Evaluation of problems and challenges referring to the risks and mitigation measures.

The results of the field tests will be reported in D4.6 in October 2025 concluding the end of Task 4.5.

In WP 6 "Deployment and demonstration activities" the entire OPENTUNITY flexibility value chain including developments of all categories OpenGrid, OpenFlex, OpenSpace and Openability will be tested. The flexibility market setups and scenarios described in this deliverable will be integrated into the testing scenarios of WP6.

## 6 References and acronyms

### 6.1 References

1. *Opentunity Grant Agreement. EC, 2022. (s.f.).*
2. *www.nodesmarket.com*

### 6.2 Acronyms

AMI	Advanced Metering Infrastructure
API	Automatic Programming Interface
BFMS	Building Flexibility Management System
BSP	Balancing Service Provider
CR	Coordinator Role
DSO	Distribution System Operator
ESCO	Energy Service Company
FMO	Flexibility Market Operator
FSP	Flexibility Service Provider
ISP	Imbalance Settlement Period
MCT	Market Coordination Tool
mFRR	Manual Frequency Restoration Reserve
SMX	Smart Meter Extension
SO	System Operator
TSO	Transmission System Operator
UC	Use Case
WP	Work Package