Demonstration conclusions and lessons learned

Western Cluster D9.9

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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 a 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 seventy 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 which 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 coming to include 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
API	Application Programming Interface
ASM	Active System Management
BUC	Business Use Case
CCTV	Closed-Circuit Television system
DApps	Decentralized Applications
DDEP	DSO Data Exchange Platform
DER	Distributed Energy Resource
DLT	Distributed Ledger Technology
DSO	Distribution System Operator
EV	Electric Vehicles
FSP	Flexibility Service Providers
GUI	Graphical User Interface
HV	High Voltage
ICT	Information and communication technologies
INESC TEC	Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência
Isc	Short-circuit Current
JRC	Join Research Centre
KPI	Key Performance Indicator
LV	Low Voltage
MV	Medium Voltage
PV	Photovoltaics
RES	Renewable Energy Sources
RUC	Regional Use Case
SO	System Operator
SUC	System Use Case
TDEP	TSO Data Exchange Platform
TSO	Transmission System Operator
UI	User Interface
WP	Work Package

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Executive Summary

This deliverable compares the Western Cluster Key Performance Indicators (KPIs), and further results and reflects on the main lessons learned. This analysis is complemented by Deliverable 9.8 and allows the comparison of the project at European level. It also presents the outcome of the OneNet Connector testing procedure from a user perspective and provides a set of recommendations for future developments. The deliverable also presents the results of the survey launched to partners in the sequence of the conclusion of the Demo stages, summing up the main lessons learned and recommendation. The main take aways from this report are summarized as follows:

- The comparison of the Western Cluster countries' KPIs was carried out considering the following categories: Technical assessment of system service provision, Market platforms and economic performance assessment, Information and communication technologies, ICT and data processing performances, Common Demo KPIs
- 40 KPIs were assessed, 22 for the Portuguese demons, 13 for the Spanish, and 5 for the French.
- 95% of the targets were achieved and all the Business Use Case, BUCs, and System Use Cases, SUCs objective were reached.
- The comparison between the common country KPIs reveal consonance of values estimated, namely the number of participating Flexible Service Providers (FSP) (2 to 250), level of participation (88% to 100%) and forecast error improvement.
- The OneNet Connector was deployed by 4 partners and tested in Portuguese demo Use Case 02. A total of 20 tests of the OneNet Connector were performed from the user perspective. Several features of the Connector still need improvement. As set of recommendations are provided. Three recommendations for future development can be highlighted: i) Incorporate the POST request feature to a third party created service; ii) Place the registry data exchange timeline using a distributed ledger technology (DLT); iii) Consider the integration of faster, scalable and asynchronous message exchange protocol such as NATS instead of the current REST Application Programming Interface (APIs) based communication.
- In order to collect feedback from all demo participants, a survey was sent out to all partners, to which 10 out of 10 partners replied. The results are shared with the lessons learned and recommendations for future replications and developments are provided.
- We learned that the use cases could have been shaped to fit the use of the OneNet Connector to highlight its features.
- We learned that sharing information between system operators improve grid operation and planning.

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- We learned that the cyber-security rules set by each participating organization using the OneNet Connector should have been considered.
- Customer engagement was the key factor to improve in general. Incentives could have been included, or as an alternative, having the FSPs as partners of the consortium.
- We found that using buildings as loads leads to difficulties/resistances when activating demand response resources, mostly because building managers' have the perception it can affect users' comfort.
- The traineeship of market participants (as DSOs, aggregators, etc.) in the use of local flexibility market platforms takes some time, especially when these participants hadn't had contact with market trading before. Thus, enough time and resources should be scheduled for this task.
- The methodology to assess the activation accomplishment by DERs is complex, so enough time should have been foreseen for this task.
- From the Western Cluster perspective, the demonstration activity has successfully ended. This can be visible considering the KPIs targets reached, the objectives fulfilled and the contributions of all the partners to the different WPs. Moreover, there was an active participation and contributions to one of the main outputs of the project, the OneNet Connector, with the test results and recommendations provided here in this deliverable.

Highlighting some of the most important recommendations for the Connector, the following deserve special attention:

- For mass replicability of the Connector, the middleware component should be deployed by trusted parties. The success of the Data Spaces requires such an approach, regardless of the fact that other organizations host the middleware themselves, for their own data spaces. This could be accomplished either by the EU to secure data spaces, which would host the services, dictionaries, accounts, or as an alternative, by moving the middleware to a trustless environment and by building on distributed network such as decentralized applications (DApps) For the data energy spaces to be a reality it needs to scale, but the issue of governance should be considered, having in perspective that the middleware must be assured beyond the capabilities of individual companies, which may eventually come to an end.
- The user interface should be released under an open-source license as light as possible (e.g. MIT). This is a crucial piece to allow access by the masses to data spaces. The UI is seen as a catalyst to the creation, subscription, discovery of services, definition setting and above all, the entry port to the data space concept in a user-friendly way.

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- We have advised the developing partners to make the full Swagger documentation about the backend open and clearly published. From the user point of view not all documentation is available for full replication. For example, in the absence of the UI, the backend should be able to implement all the necessary functions.
- We advise that other entities or partners develop their own UI and make them open source so that a variety of accesses (similar) exist.
- The open-source license format should be formalized for all the components of the Connector, backend, UI, middleware and monitoring dashboard.
- Message exchange tests between other approved data space Connectors is advised. A successful result would be truly the proof of interoperable data space implementation of the OneNet Connector/True Connector.

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1 Introduction

In this deliverable we explore the Western Cluster results. The report commences with a comprehensive overview of each DEMO, providing essential contextualization and enumerating Key Performance Indicators (KPIs) for reference as further described in D9.1[1]. Subsequently, it meticulously conducts a comparative analysis of the KPIs extracted from deliverables 9.5, 9.6 [2] and 9.7 [3] and puts them into perspective against each other whenever possible. Particular emphasis is given to the implementation of the OneNet Connector, given its foundational significance to the project. The report elucidates on how this implementation has significantly influenced the performance of use cases and trade-offs. Following this, the report articulates the recommendations presented by each DEMO, coupled with valuable insights gleaned from the implementation process. This report delivers its content, promoted by a set of subtasks. The task T9.5 is dedicated to the Western Cluster evaluation. It endorses the integration of the results coming from the three different member states involved in the Western Cluster. It is divided in two sub-tasks focused on Result integration (T9.5.1) and Success Metric Analysis (T9.5.2). Task 9.6 is dedicated to the Western Cluster – Lessons Learned, Cost Benefit Analysis and Scalability-Replicability Analysis. Given the distinct approaches required to achieve each of the goals set by the task, T9.6 was divided into three sub tasks. The work developed in Sub-task 9.6.1, and T9.5.1 result in the present deliverable D9.9.

It builds upon the results of the Western Cluster, to provide a vision on the main findings and lessons learned from the comparative assessment of the overall results coming from the different Demos. The principal findings emanate from D11.1 [4], D9.5, D9.6 [2], and D9.7 [3], augmented by a dedicated survey submitted to the partners, and subsequent analysis as well as the results from the tests performed to the OneNet Connector.

Figure 1-1 shows the dependences between deliverables serving D9.9. The input deliverables and corresponding tasks to D9.9 were the ones corresponding to the validation and results of concept test, performed in each individual demonstration and their corresponding evaluation.

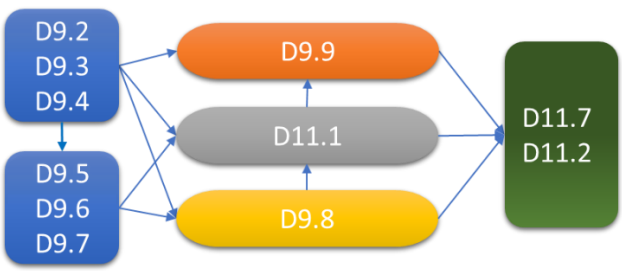

Figure 1-1: Diagram of the dependences of deliverables related to D9.9

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These deliverables were also the basis for the subsequent Demo results assessment and data collection report, for each country, whose inputs served D9.8 (under preparation) and D11.1 [4], the latter being responsible for collecting and evaluating all of the OneNet demonstrators. All three deliverables (not exclusively) D9.8, D9.9 and D11.1 [4] will provide their findings to D11.7 and D11.2, whose coordinated writing happens in parallel with the present deliverable.

1.1 Objectives of the Work Reported in this Deliverable

Our primary objective is to conduct a thorough comparative assessment and in-depth analysis of the Key Performance Indicators (KPIs) derived from the distinct Western Cluster Demos. By scrutinizing and comparing these KPIs, we aim to put into perspective the different results and targets set out by each Demo. Furthermore, the report presents the lessons learned survey responses submitted by the participating partners in the Western Cluster. This involves a meticulous examination of the challenges faced, successful strategies employed, and the overarching lessons derived from the collective experiences of our project contributors. Our goal is to translate this experience into actionable recommendations that can inform and guide future replications.

Recognizing the central role of the OneNet Connector within the OneNet project the report also shares the experience with the OneNet Connector in the use cases and tests. It explicitly states the suggestions and recommendations already provided to WP5/6. This involves a nuanced exploration of the OneNet Connector's performance, its impact on the potential applications and use cases,

1.2 Outline of the Deliverable

The structure of the deliverable is depicted in Figure 1-2. Chapter 1 is the introductory section of the document, including the objectives, outline and the context of the activities carried out in Task 9.5 and 9.6, including how they fit into the general structure of the WP9 and horizontal Work Packages. Chapter 2 presents the process behind the Western Cluster KPI comparison, the Connector tests and recommendation and lessons learned assessment procedure. Chapter 3 provides a brief overview and description of each of the demonstration to help the reader get context of the BUC and SUCs addressed, before presented him with the KPIs and categories. In chapter 4 is where the actual tables with the KPIs are presented, setting the demo results side by side, in order to promote an easy comparison and analysis. The comparison and individual analysis were made using the three Macro-area analysis and Common KPIs categories. The second part of this chapter is dedicated to the test and performance analysis of the OneNet Connector. Even though 20 tests were done, some deserved especial attention for justification and are further described in dedicated subsections, which are identified by the corresponding names. Chapter 5 is dedicated to the Demo's lessons learned and recommendations. The categories of questions are presented at the beginning and each response is presented

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graphically for the reader's convenience and to facilitate the subsequent analysis. Chapter 6 describes the main results gathered from the Western Cluster, highlighting the contribution for the whole project, mainly in the form of recommendations. The Annex presents the survey template used for collection inputs from the demo partners.

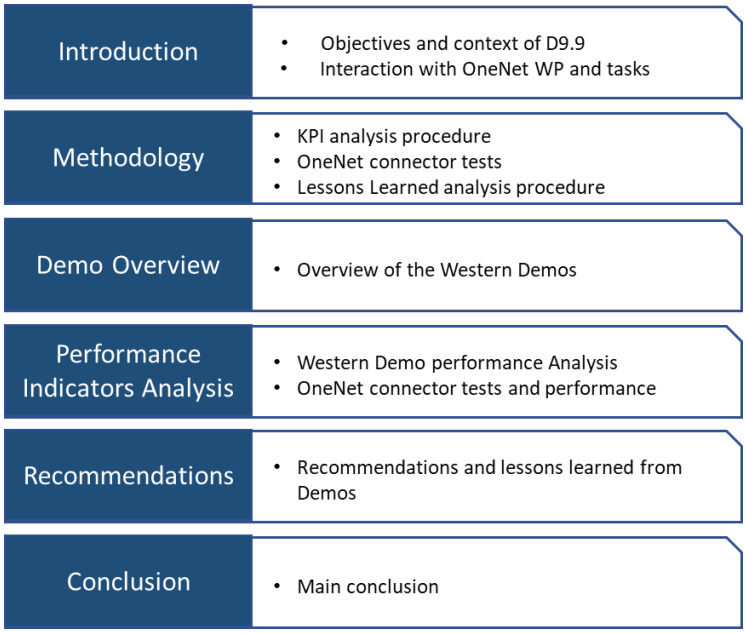

Figure 1-2 Outline of OneNet Deliverable 9.9

1.3 How to Read this Document

This deliverable D9.9 is part of the last output elements from the WP9. Together with D9.8, they constitute the closure of the analysis of the three demonstrations. Not only it provides a dedicated view on the achievements of the KPIs at demo level, but also performs a comparison whenever possible of these KPIs, or an analysis when they stand alone. Moreover, the document provides the readers, the WP5 and WP6 responsible partners, the innovation manager and project coordinator with the perspective of the Western Cluster on the OneNet Connector use. The deliverable also provides a set of recommendations based on the lessons learned during the demonstrations, reflecting on what went well and not so well during the whole time of the Demos, including the project management, preparations and result processing and analysis. The reader may navigate or start reading each chapter individually, but he/she should be aware that pre-requisites regarding the OneNet Connector from WP5 and WP6 and individual Demos, explained in D9.2 [5], 9.3 [6] and 9.4 [7] are important for context and detailed understanding.

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2 Methodology

The Spanish, Portuguese and French demonstrators have estimated 13, 22 and 5 KPIs respectively. Among those, certain similarities can be observed. For instance, both Portuguese and Spanish demonstrations will calculate the ICT costs to develop their solutions. Additionally, they will look at the accuracy of the forecasts and the effect of flexibility activation in reducing congestions. All demonstrations will assess the available flexibility active participation and the number of participating FSPs. Some allow for a partial comparison which will provide a frame of the order of magnitude while the comparison between all Demos can enable a perspective on the results achieved in comparison with the targets initially set and how they reached similar or divergent performances.

Consequently, eight out of the 40 KPIs identified within the Western Cluster are aligned to some extent, 3 are common to the three Demos, 4 are only common to the Portuguese and Spanish Demos and 1 common to the Portuguese and French demo. The remaining KPIs are focused on specific aspects being explored by each demonstration.

The Demos were analysed from two perspectives. The first according to the determined KPIs which could be specific to the Demo in a business-as-usual context and listed in Table 2-1. The second, refers to the implementation of the OneNet Connector and how the Demo characteristics and partners dealt with its integration as well as, performance tests from the user perspective.

Table 2-1: List of all KPIs proposed by the Western Cluster per country, with colours matching common KPIs

Portugal	Spain	France
KPI_H05/Reduc. RES curtail.		
KPI_H15/Req. Flex.		
KPI_N25/ Isc forecasted vs registered		
KPI_N27/Power avoided congestions by flex. Activation		
KPI_N30/ Rated short circuit of circuit breaker vs max short circuit of series		
KPI_N31/Congest Nbr. on DSO network		
KPI_N32/Congest Nbr. on TSO network		
KPI_N34/Success on Prequal. Process		
KPI_N46/ Prequal. Process needing additional info		
KPI_H04 / ICT costs	KPI_H04 / ICT costs	

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KPI_H20B/Error of load forecast	KPI_H20B/Error of load forecast	
KPI_H20A/Error RES forecast 24 h		
KPI_H21B/Share of false pos. vs neg. congest. Forecast.		
KPI_N28/Max ratio false positive and negative congest. Forecast		
KPI_N33 / Forecast Improv.		
KPI_H01 / Nbr of FSPs	KPI_H01 / Nbr of FSPs	KPI_H01 / Nbr of FSPs
KPI_H02 / Active participation	KPI_H02 / Active participation	KPI_H02 / Active participation
KPI_H09A/Received bids		
KPI_H09B/Cleared bids	KPI_H09B/Cleared bids	
	KPI_H03 / Cost-effect.	
	KPI_H06 / Ease of access	
	KPI_H07 / Nbr. of transactions.	
KPI_H09D/Cleared bids		KPI_H09D/Cleared bids
KPI_H12 / Avoided restrictions	KPI_H12 / Avoided restrictions	
KPI_H14 / Available flexibility	KPI_H14 / Available flexibility	KPI_H14 / Available flexibility
	KPI_H13/Asset load variation	
		KPI_N26 / Tracked flexibility
	KPI_H23A/Power exchange Deviation	
	KPI_H11 / Nbr. of products per demo	

Legend: coloured KPIs indicate partial or full similarities

The demo KPIs are described in detail and identified in D9.1 [1], D2.4 [8]. This report summarizes the BUCs and SUCs for contextualization and each category of KPIs along with the results for comparison between countries. The following Demo KPI categories were defined as: i) Technical assessment of system service provision; ii) Market platforms and economic performance assessment; iii) ICT and data processing performances and iv) Common KPIs among Demos.

The OneNet Connector was tested as part of the demonstration of SUC02 in the Portuguese Demo. The other deployments were applied to the regional use case and did not perform individual tests. A total of 20 tests to the user interface and backend functionalities were done. Two partners were involved in SUC 02, InescTec and Nester, while tests were performed partially jointly and separately by InescTec. Based on the experience using the Connector a set of recommendations is provided.

Still as part of the methodology, for the Lessons learned section, a survey was conducted and submitted to all participating Western Cluster partners in order to reflect on the positive and least positive elements of the demonstrations. This resulted on a Lessons learned list from the overall demo compiled for future use.

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All 10 Western Clusters partners replied to the survey. 33 Questions were posed to all partners after the Demos were ran. The Surveys were sent by email and collected individually also by email. The responses were collected between 16th and 27th of October 2023.

According to the Project Management Institute (PMI) best practices [9], when assessing the Lessons Learned during the Demo runs, standard categories for each Demo should be defined when collecting feedback from intervenient. The following categories of questions are proposed, considering the OneNet Demo goals: Demo management, resources, technical-economic, communication, regulatory and business processes, requirements, design and build, implementation/operational. For each category the goal is to analyse from each partner's perspective, what went right, what went wrong, what needs to be improved. For that, the questions must be filled by every involved partner of the Western Cluster Demos. The surveys answers will be kept anonymous to allow conflict free recommendations and perspectives. Figure 2-1 show the overall process of documenting lessons learned. The identification stage will be the result from the answers given by the partners, followed by the explicit incorporation in D9.9 with the corresponding analysis. The storage stage is part of the submission of the deliverable and dissemination activity within and outside the OneNet project allowing it to be retrieved for future projects and/or Demos.

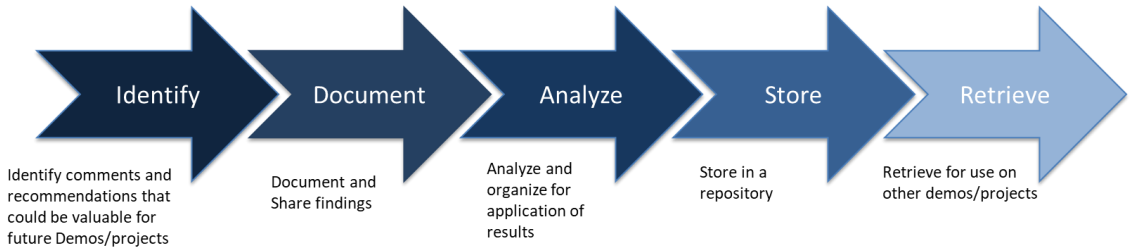

Figure 2-1: Lessons learned process

The results are presented by categories with aggregated answers for all the partners. In the cases in which "No", "partially", "which" or "open" question are made, a comment is provided after each plot with the results. The results and answers are presented according to the categories defined: project management, resources, technical-economic, communication, regulatory and business processes, requirements, design and build, implementation/operational.

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3 Demos overview from Western Cluster

The Western Cluster demonstrator followed the OneNet inspiration from the ASM report [10]. The enriching environment and participation of several DSOs and TSOs provided an ideal moment to discuss, reflect, plan and test several coordination aspects highlighted in the ASM report. The demo includes Portugal, Spain and France and the focus was particularly on the alignment between the demonstrations and the joint report written by ENTSO-E and the distribution associations on the TSO-DSO coordination in the context of balancing and congestion management. A common focus of three Demos was on the procurement of local flexibility by the DSO, the TSO or both, while other aspects of TSO-DSO coordination such as information exchange for grid operational and planning purposes were also tackled. Right from the start a list of KPIs was defined for each of the use cases proposed and an effort was made to search for common metric to allow for a comparison regarding the targets reached and their performance. Searching an alignment with the unified vision of OneNet and the contribution of the OneNet Connector, its deployment was planned from the start and included in this report. The development of the Connector intended the widespread of energy connected data spaces, ensuring privacy, interoperability and data sovereignty in data sharing between market players (SO, Aggregators, FSP). Hence, the Western Cluster partners set a target to incorporate the OneNet Connector in selected use cases to test its applicability, value added and verify use case eligible features, whose experience is shared in this report.

3.1 Portuguese Demonstration

3.1.1 The Portuguese Demonstration in practice

The Portuguese DEMO ran from 14th to the 28th of August 2023 and all 4 Portuguese partners were involved, InescTec, E-redes, Nester and REN. The technical specifications of the demo will be available in D9.5 which is in progress at the time of writing.

The primary objective of the OneNet Portuguese demonstrator is to formulate solutions for the flexibility provision focuses on the pre-qualification and forecast phases and to create operational planning synergies between TSO and DSO. These demonstrations involve the collaboration of the Portuguese TSO (REN), Portuguese DSO (E-REDES) and two Portuguese R&D research centers (R&D NESTER and INESC TEC). R&D NESTER since is partially owned by REN, during the demonstrations, represents the TSO role and INESC-TEC play the role of aggregator. Five different use cases were demonstrated, two of them related with the flexibility provision and other three associated with the operational planning activities. The demonstrations encompass 4 distinct areas for testing, one in the Northeast of Portugal (Pocinho), one in Coastal Beira of Portugal (Mourisca), two in the center of Portugal (Zêzere and Batalha) and also one in the South of Portugal (Portimão). The

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demonstration involves FSPs data, namely supermarkets and industrial consumers, and real data from the planning departments of the Portuguese SOs.

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 operational planning purposes was addressed the short and long-term horizons, although with more focus in the day-ahead operations. A total of 22 KPIs were assessed after the Demo ran. The data sets were published openly in Zenodo [11] complying with the FAIR approach of the project.

3.1.2 Portuguese Demo focus

As described in D9.2 [5], the Portuguese demonstrator has the aim to specify the exchanges of information between system operators (SOs) to enable flexibility provision and to improve the operational planning. For the business use cases (BUCs) concerning flexibility, the corresponding ASM report stages were considered, to define the coordination process between TSO and DSO. Given that the goal is to focus on the information exchange, all the stages, except for the settlement process, were considered. For the BUC concerning operational planning, the operational processes of the SOs that can be improved with the exchange of information between network operations are considered. Table 3-1 shows the summary of the BUCs and SUCs in this demo further detailed in D2.3 [12].

Table 3-1: List of all BUCs and corresponding SUCs development in the Portuguese Demo

BUC	SUC
WECL-PT-01: Exchange of Information for Congestion Management – Short Term	SUC-PT-01: Evaluation of the Product & Grid pre-qualification requirements
	SUC-PT-02: Day-Ahead & Intraday Flexibility needs
WECL-PT-02: Exchange of Information for Congestion Management – Long Term	SUC-PT-01: Evaluation of the Product & Grid pre-qualification requirements
WECL-PT-03 : Exchange of Information for Operational Planning	SUC-PT-06: Maintenance plans information exchange
	SUC-PT-07: Consumption and generation forecast information exchange
	SUC-PT-08: Short-circuit levels information exchange

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3.1.2.1 WECL-PT-01 - Exchange of Information for Congestion Management – Short Term

This BUC focuses on describing in detail each process phase of the ASM report, mentioning what kind of information is exchanged and what rules are established between the DSO and TSO, in order to procure congestion management products for short-term, in intraday and day-ahead time periods.

The main objectives of this BUC are to:

1.1 design the process phases of the ASM report, so that it can serve as a basis for future developments.

2.1 Coordinate the usage of flexibility for different voltage levels.

3.1 Identify what information should be shared between DSO and TSO for each of the flexibility procurement process phases for short terms congestion management, including for the technical selection and validation of the bids by the relevant SO.

4.1 Construct information exchange mechanisms to enable market-based procurement of flexibility products.

Within this BUC two SUC were tackled:

- SUC-PT-01: Evaluation of the Product & Grid pre-qualification requirements
- SUC-PT-02: Day-Ahead & Intraday Flexibility needs

Within this context the OneNet Connector was tested as an alternative to using solely REST APIs based communication. It was used to share flexibility availability between the Aggregator and the System Operator under SUC02.

3.1.2.2 WECL-PT-02 - Exchange of Information for Congestion Management – Long Term

This BUC focuses on describing in detail each process phase of the ASM report, mentioning what kind of information shall be exchanged and what rules shall be established between DSO and TSO in order to procure congestion management products for long-term (over 1 year).

The main objectives of this BUC are to:

1. design the process phases of the ASM report, so that it can serve as a basis for future developments.

2. Coordinate the usage of flexibility for different voltage levels.

3. Identify what information should be shared between DSO and TSO for each of the flexibility procurement process phases for long terms congestion management, including for the technical selection and validation of the bids by the relevant SO.

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4. Construct information exchange mechanisms to enable market-based procurement of flexibility products.

Within this BUC, one SUC was tackled:

- SUC-PT-01: Evaluation of the Product & Grid pre-qualification requirements

3.1.2.3 WECL-PT-03 - Exchange of Information for Operational Planning

This BUC is centered at defining and describing the TSO and DSO information exchange, with the aim to improve and facilitate long-term to short-term operational planning for both networks.

The main goals of this BUC are to:

1. Identify the scheduled/forecasted information exchanged between the SOs, with the aim to improve the programming of the DSO and TSO operations.

2. Anticipate and solve constraints in the distribution and transmission grids.

3. Develop information exchange tools to share the identified information.

Within this BUC three SUCS were tackled:

- SUC-PT-06: Maintenance plans information exchange
- SUC-PT-07: Consumption and generation forecast information exchange
- SUC-PT-08: Short-circuit levels information exchange

3.2 Spanish Demonstration

3.2.1 The Spanish Demonstration in practice

The Spanish DEMO ran from July 2022 to February 2023 with different individual days corresponding to request, market and activation days as can be seen in Table 7-1 of D9.3 [6]. All 4 partners were involved, Comillas, OMIE, UFD and I-DE. The technical specifications of the demo can be found in D9.3. Involved as recruited participants were a set of FSPs connected to the medium voltage system, with flexibility capacity between 10 to 1.000 kW, which participated in the provision of flexibility services, located in areas where DSOs operate: i-DE in Murcia and Cantoblanco, Madrid and UFD in Alcalá de Henares, Madrid.

To enable the trading of flexibility products, two local market platforms (LMP), long-term and short-term, have been developed by OMIE in which the DSOs can buy flexibility services from FSPs in two main submarkets:

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• Long-term market: long term procurement of flexibility services through a market mechanism to avoid congestions at the distribution medium or low voltage networks, from years to days ahead of delivery.

• Short-term market: short term procurement of flexibility services through a market mechanism to avoid congestion management at the distribution medium or low voltage network, for the Day ahead or intraday.

The Long-Term Market Platform has been designed as an online platform where the participants are identified under a username and a password provided by the Independent Market Operator (IMO), represented by OMIE, while the Short-Term Market Platform has been developed following the current design of the platforms used in the Iberian Electricity Market to facilitate the usability for those participants that already negotiate with OMIE's platforms, and it is also prepared to be integrated with the Global Electricity Markets, such as, the Intraday Continuous Market (XBID).

Ten field tests were performed where local congestion problems have been resolved by acquiring flexibility in the local market platform: 3 long term market agreements (1 in Murcia and 2 in Alcalá de Henares), 6 short term day ahead agreements (1 in Murcia, 3 in Cantoblanco and 2 in Alcalá de Henares) and 1 short term intraday market agreement in Murcia.

The FSPs could be efficiently connected to the OMIE market platforms and go through all market phases: from prequalification, forecasts, qualification, market clearing, monitoring and activation until settlement.

A total of 13 KPIs were assessed after the Demo ran. The data sets were published openly in Zenodo [17] complying with the FAIR approach of the project.

3.2.2 Spanish Demo Focus

As described in D9.3, the Spanish demo focused on the actual provision of flexibility of resources connected to the distribution system to contribute to congestion management. Local markets were considered for testing, in which, the DSO is the sole buyer of available flexibility services, the FSPs are the sellers and OMIE operates and manages the market platforms. The Spanish demo involved two DSOs, namely i-DE[3] and UFD[4], as well as OMIE[5], the nominated electricity market operator (NEMO) for managing the Iberian Peninsula's day-ahead and intraday electricity markets. Different FSPs also participated in the provision of flexibility services. Table 3-2 shows the summary of the BUCs and SUCs in this demo further detailed in D2.3 [12].

Table 3-2: List of all BUCs and corresponding SUCs development in the Spanish Demo

BUC	SUC
WECL-ES-02: Short-term congestion management	SUC-ES-01: Local Market Platform
WECL-ES-01: Long-term congestion management	SUC-ES-01: Local Market Platform

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3.2.2.1 WECL-ES-02: Short-term congestion management

This BUC is centered in two services: i) the Corrective active power for Congestion management and ii) Predictive active power for congestion management.

The first service aims at targeting congestion management needs caused by network failures and subsequent corrective actions (e.g. switching state changes, ad-hoc active power intervention), through the activation of active power generation and demand side sources. Given that these services are caused by unexpected situation, they could only arise in our operational time frame. This service needs products with fast activation and their duration should be aligned with the thermal limits of the congested assets.

The second service is meant to solve congestions that are forecastable (e.g. congestion arising due to forecast maintenance activities or long-term planning process). These needs could arise in all three times frames considered in our framework. However, the reasons behind these needs could be different which could result in different products to address them.

For example, at the operational level, the SO could forecast congestion as a result of a change in the weather forecasts affecting the availability of some FSPs while in the long-term timeframe, this service can be considered either as a complement or even an alternative to traditional grid investments.

Within this BUC one SUC was tackled from two perspectives, intraday and day-ahead markets DSO coordination:

- SUC-ES-01: Local Market Platform

3.2.2.2 WECL-ES-01: Long-term congestion management

This BUC is centered in the predictive active power for congestion management service. Only one SUC was tackled from a perspective of a long-term market from DSO coordination.

- SUC-ES-01: Local Market Platform

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3.3 French Demonstration

3.3.1 The French demonstration in practice

The French DEMO ran from September 2022 until June 2023 and both partners were involved, RTE and Enedis. The technical specifications of the demo can be found in D9.4 [7]. The demo phase started once the platform was released for production. Following this milestone, the French Demo partners organized 2 workshops to collect the specific requirements of the FSPs in relation to their use, in a more advanced phase of the project. Three FSPs were particularly active in providing feedback. For example, the FSPs discussed the importance of having a way to provide their input on data shared by system operators, while avoiding having to stop systematically the back-office management process. This feedback resulted in a product feature regarding the integration of producers' feedback flow, being addressed by system operators. A request for feedback was sent to each FSPs in order to evaluate the methodology of use of the platform and its relevance to the initial needs for both FSPs and system operators.

The OneNet French Demonstration is divided in two parts: the implementation of STAR (System of Traceability of Renewables Activations) and the study on innovative ways for TSO-DSO information exchange for DER activation. In the STAR project, the objective was to ensure a better integration of FSPs into the French electricity grid. It is in this context that STAR was born with the vision of a decentralized platform bringing together France's TSO RTE, its main DSO Enedis and RES producers, identified as Flexibility Service Providers (FSPs) in the current document, and building trust between them, focusing, up until now, on demonstrating its potential in the case of simple congestion management. The OneNet project aims at creating the conditions for a new generation of system services able to fully exploit demand response, storage and distributed generation while creating fair, transparent and open conditions for the consumer. The STAR project aims at being fully integrated and involved in the OneNet project philosophy, by streamlining congestion management in a transparent way for flexibility providers and system operators. In parallel, RTE and Enedis have reflected on further coordination means between TSO and DSO, focusing on possible new data exchange in order to improve both entities' flexibility usage optimizations in a broader context than congestion management.

A total of 5 KPIs were assessed after the Demo ran. The data sets were published openly in Zenodo [11] complying with the FAIR approach of the project.

3.3.2 The French DEMO Focus

As described in D9.4, the French demo focused on optimizing the management of renewable production curtailments, by covering the entire life cycle of a flexibility offer, from the formulation of offers to the control of their activations for invoicing using blockchain technology. Coordination between TSO and DSO to avoid undesired constrains during the flexibility provision process, setting out to Improve the information exchange

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between TSO and DSO in the specific context of local DER flexibility activation. Table 3-3 shows the summary of the BUCs and SUCs in this demo further detailed in D2.3 [12].

Table 3-3: List of all BUCs and corresponding SUCs development in the French Demo

BUC	SUC
WECL-FR-01 - Improved monitoring of flexibility for congestion management	SUC-FR-01: Automated congestion management
	SUC-FR-02: Manual congestion management
WECL-FR–2 – Improved TSO-DSO information exchange for DER activation	N/A

The core of the French demo was the application of the STAR platform and the use of blockchain technology in the monitoring process. The Star platform itself is a monitoring system that allows sharing relevant information for the settlement but not directly undertaking the physical activations at grid level. Encompassing use case BUC1, the STAR project aims to build a shared ledger to simplify and optimise the management of renewable production curtailments by covering the entire life cycle of a flexibility order, from its formulation to the monitoring of the invoicing process from their activation. The final goal has been to build a platform enabling such objectives and test it for each participating entity on a chosen area of the French network. The generation curtailment monitored by the STAR platform is determined by the French energy code and the nature of the contract between the system operators and generators. Therefore, the active power generation curtailment is similar to the activation of flexibility for congestion management purposes.

The flexibility services tracked by STAR are mainly focused on congestion management. The STAR platform only tracks information regarding curtailments orders but does not activate any of them. The activation remains the responsibility of System operators. The core of the STAR demonstrator is proving the technical feasibility of the platform. Aspects related to the flexibility procurement are out of the scope of the French demonstration. The platform to be built in the STAR project only tracks the producers' production, curtailments orders and compensation rights.

The analysis of the implementation of STAR, which tracks the active power generation curtailment of renewable generators, is linked to the mechanisms used to define the network access agreements that specify the producers' curtailment obligations and compensation. The STAR platform uses existing mechanisms; therefore, no new markets or flexibility procurement mechanisms are developed within this OneNet demonstrator. As mentioned in the deliverable D3.1 [13], the compensation mechanisms in which STAR will be used as a data register are the connection agreement contracts (both for TSO and DSO).

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3.3.2.1 WECL-FR-01 - Improved monitoring of flexibility for congestion management

This BUC is based on blockchain technology. It aims to simplify renewable production curtailments by improving the back-office of the transactions, reducing administrative burden and risks of dispute. It should provide enhanced monitoring during the entire life cycle of a flexibility order, from the traceability of the renewable production curtailment to checking their activations for invoicing. The final goal is to build a platform enabling such objectives and test it for each participating entity on a chosen area of the French network.

Within this this BUC two SUC were tackled from two perspectives:

- SUC-FR-01 - Automated congestion management (described in the OneNet deliverable D5.1 [14]): to simplify and optimize the management of renewable production curtailments, upon the development of the STAR platform, it is required to define the information exchanges and processes needed to perform the related BUC's traceability objectives in the case of TSO automated activations,
- SUC-FR-02 – Manual congestion management (described in the OneNet deliverable D5.1 [14]): this SUC provides requirements for data exchanges and processes between TSO, DSO, FSPs / FSPs for the STAR platform to handle the related BUC's traceability objectives in the case of DSO manual flexibility activations.

3.3.2.2 WECL-FR–2 – Improved TSO-DSO information exchange for DER activation

RTE and Enedis are regularly required to activate flexibilities on the transmission and/or distribution network for various reasons (e.g. balancing, voltage and congestion management). These activations are carried out either manually or automatically, through various mechanisms (direct activations and/or market mechanisms) and are expected to play an increasingly important role in the management of networks and the power system, on the different time scales.

Both Enedis and RTE support the development of these flexibilities' use at the lowest cost for the community, from the grid planning phase to the activation of these flexibilities. Whatever the chosen scheme, the activation of a flexibility must be done while guaranteeing that the impacts for each SO on its perimeter are checked (safe and secure operation of the networks and more widely of the power system). However, it seems that further cooperation between SOs will be necessary to maximize renewables' flexibility potential. The aim is to reflect on future coordination leads that would enhance and optimize flexibility usages, without jeopardizing each SO's prerogatives.

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4 Performance indicators analysis

Since all demo sites pursued different goals, the Western Cluster ended up being very complementary as a whole, ranging from FSPs prequalification, information definition for operational planning, to actual load activation, generation curtailment and monitoring. However, it provides little chance for direct comparison, still this is provided whenever possible. Moreover, the analysis regarding all the other KPIs is provided, analysing each target achievement.

4.1 The Western Cluster performance analysis

4.1.1 Macro-area analysis of KPIs of demonstrated BUCs

The Western Cluster adopted three of four categories defined OneNet KPIs Clustered in these three groups:

- Technical assessment of system service provision
- Market platforms and economic performance assessment
- ICT and data processing performances.

These topics were selected as the most suitable and inclusive to measure the performance of the demonstrations in key aspects of the OneNet project from a macro-area point of view. The description of each of these three categories are here summarized:

4.1.1.1 Technical assessment of system service provision

This subsection concerns the OneNet KPIs that are related to the technical assessment of system service provision in the different demonstrators. Table 4-1 includes the KPIs selected for this topic. The calculated values for each KPI are presented per demonstration, alongside an extensive commentary on the results, the overall performance regarding the system service provision aspects and the macro-level technical prowess of each demo.

It is important to note here that not all demonstrators adopted KPIs related to the technical assessment of system service provision, other than the common KPIs that are relevant to this macro-area and were analyzed in Section 4.1.

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Table 4-1: Technical assessment of system service provision related KPIs for all three Demos

	KPI_H13/Asset load var.	KPI_H23A/P. exch. Dev.	KPI_H05/ Reduct-ion in RES curtail-ment	KPI_H15/ Req. Flex.	KPI_N25/ Isc forecasted vs registered	KPI_N27/Power avoided congestions by flexibility activation.	KPI_N30/ Rated short c. of circuit breakers vs max short circuit value of series	KPI_N31/ Nº of congestions/ violations on DSO network	KPI_N32/ Nº of congestions/ violations on TSO network	KPI_N34/ Success-ful ending of Prequal. Process	KPI_N46/ Prequal. Process. needing additional info
Spanish Demo											
Short-term day ahead Murcia scenario	11% (<100%)	15% above (<35%)	-	-	-	-	-	-	-	-	-
Short-term intraday Murcia scenario	20% (<100%)	24% above (<35%)	-	-	-	-	-	-	-	-	-
Long-term Murcia scenario	15% (<100%)	48% below (<35%)	-	-	-	-	-	-	-	-	-
Short-term day ahead Madrid (30 min – test 1) scenario	9% (<100%)	63% above (<35%)	-	-	-	-	-	-	-	-	-

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Short-term day ahead Madrid (30 min – test 2) scenario	19% (<100%)	61% above (<35%)	-	-	-	-	-	-	-	-	-
Short-term day ahead Madrid (1h) scenario	13% (<100%)	52% above (<35%)	-	-	-	-	-	-	-	-	-
Long-term day ahead Alcalá de Henares I scenario	19% (<100%)	0% (<35%)	-	-	-	-	-	-	-	-	-
Long-term day ahead Alcalá de Henares II scenario	12% (<100%)	9% below (<35%)	-	-	-	-	-	-	-	-	-
Short-term day ahead Alcalá de Henares I scenario	12% (<100%)	0% (<35%)	-	-	-	-	-	-	-	-	-
Short-term day ahead Alcalá de Henares II scenario	11% (<100%)	0% (<35%)	-	-	-	-	-	-	-	-	-

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Portuguese Demo											
SUC-PT-01 Mainland Portugal	-	-	-	-	-	-	-	-	-	100% (100%)	100% (100%)
SUC-PT-02 Batalha	-	-	0 (0)	0 (0)		0 (0)	-	-	-	-	-
SUC-PT-02 Pocinho	-	-	0 (0)	0 (0)		0 (0)	-	-	-	-	-
SUC-PT-06 Batalha	-	-	-	-	-	-	-	0 (0)	0 (0)	-	-
SUC-PT-06 Pocinho	-	-	-	-	-	-	-	0 (0)	0 (0)	-	-
SUC-PT-08 Batalha	-	-	-	-	-576 A (>0)	-	3424 A (>0)	-	-	-	-
SUC-PT-08 Pocinho	-	-	-	-	853 A (>0)	-	12153 A (>0)	-	-	-	-

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4.1.1.2 Market platforms and economic performance assessment

This subsection concerns the OneNet KPIs that are related to the market platforms and economic performance assessment in the different demonstrators. Table 4-2 includes the KPIs selected for this topic. The calculated values for each KPI are presented per demonstration, alongside an extensive commentary on the results and the overall performance of each demonstrator regarding the market platforms and economic aspects viability and impact. It is important to note here that not all demonstrators adopted KPIs related to the market platforms and economic performance assessment, other than the common KPIs that are relevant to this macro-area and were analysed in Section 4.1.

Table 4-2: Market platforms and economic performance related KPIs for all three Demos

Demo / KPIs	KPI_H04 / ICT costs	KPI_H11 / Nbr. of products per demo
Spanish Demo	10 M€ (>0)	100% (100%)
Portuguese Demo	184k€ (100k€-200k€)	-
French Demo	-	-

4.1.1.3 ICT and data processing performances

This subsection concerns the OneNet KPIs that are related to the ICT and data processing performances in the different demonstrators. Table 4.3 includes the KPIs selected for this topic. The calculated values for each KPI are presented per demonstration, alongside an extensive commentary on the results and the overall performance of each demonstrator regarding its prowess in harnessing information technology and data to meet its objectives.

Table 4-3: ICT and data processing related KPIs for all three Demos

Demo / KPIs	KPI_H20B/Error of load forecast	KPI_H20A/Error RES forecast 24 h	KPI_H21B/Share of false pos. vs neg. congestion Forecast.	KPI_N28/Max ratio false pos. and neg. congestion Forecast.	KPI_N33 / Forecast Improv.	KPI_N26 / Tracked flexibility
Spanish Demo						
Short-term day ahead Murcia scenario	1,2% (as close to 0 as possible)	-	-	-	-	-

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Short-term intraday Murcia scenario	2,4% (as close to 0 as possible)	-	-	-	-	-
Long-term Murcia scenario	36% (as close to 0 as possible)	-	-	-	-	-
Short-term day ahead Madrid (30 min – test 1) scenario	14% (as close to 0 as possible)	-	-	-	-	-
Short-term day ahead Madrid (30 min – test 2) scenario	11% (as close to 0 as possible)	-	-	-	-	-
Short-term day ahead Madrid (1h) scenario	9% (as close to 0 as possible)	-	-	-	-	-
Long-term day ahead Alcalá de Henares I scenario	4,6% (as close to 0 as possible)	-	-	-	-	-
Long-term day ahead Alcalá de Henares II scenario	4,7% (as close to 0 as possible)	-	-	-	-	-
Short-term day ahead Alcalá de Henares I scenario	3,2% (as close to 0 as possible)	-	-	-	-	-
Short-term day ahead Alcalá de Henares II scenario	9,6% (as close to 0 as possible)	-	-	-	-	-
<u>Portuguese Demo</u>						
SUC-PT-07 Batalha	4,8% (<5,55%)	• Solar: 1,9% (<7,87%) • Wind: 7,46% (<7,58%) • Thermal: 4,49% (<24%)	0% (0%)	0% (0%)	• Solar: 74,19% (>0%) • Wind: 3% (>0%) • Thermal: 80,69% (>0%) • Load: 7,2% (>0%)	-

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SUC-PT-07 Pocinho	20,2% (<54,84%)	• Solar: 4,37% (<11,64%) • Wind: 5,73% (<7,24%)	0% (0%)	0% (0%)	• Solar: 66,42% (>0%) • Wind: 20,42% (>0%) • Load: 36,6% (>0%)	-
French Demo						
SUC-FR1	-	-	-	-	-	213 orders automatic. triggering 3 to RTE's prod., 210 to Enedis' prod. 3 orders manually triggering from Enedis Total: 216 (7-15)

4.1.2 Common KPIs among Demos

For measuring the demonstrations' performance and impact, each demonstrator selected a set of KPIs based on their demonstration's structure, activities and tested solutions. This led to a big variety of defined KPIs, some of which were only adopted by a few Demos. This is why the common KPIs concept was introduced, as a means of common evaluation ground between the different demonstrators. The common KPIs, presented in Table 4.4, are a set of KPIs that should be ideally adopted by all Demos and measure the performance of the demonstrations in high-interest areas for OneNet like the provision of flexibility services, market performance and consumer engagement.

The selection and definition of common KPIs pertaining to all OneNet demonstrators was not an easy task, due to the big variety of tested products, services and solutions and the different approaches that were followed by each demonstrator. Because of this, some Demos were not able to adopt all common KPIs. The reasoning behind the decision to discard some of the common KPIs was provided by each demo and is discussed below.

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Table 4-4: Common KPIs assessed for all three Demos

Demo / KPIs	KPI_H01 / Nbr of FSPs	KPI_H02 / Active partic.	KPI_H03 / Cost-effect.	KPI_H06 / Ease of access	KPI_H07 / Nbr. of transac.	KPI_H09A/Received bids	KPI_H09B/Cleared bids	KPI_H09D/Cleared bids	KPI_H12 / Avoided restrict.	KPI_H14 / Available flexibility
Spanish Demo										
Overall demo	7 (As many as possible)	88% (100%)		5/10 (N/A)	10 (>0)		6,63 MW (>0)		100% (100%)	-
Short-term day ahead Murcia scenario	-	-	83% (>0%)	-	-	-	-	-	-	9% (>0%)
Short-term intraday Murcia scenario	-	-	72% (>0%)	-	-	-	-	-	-	10% (>0%)
Long-term Murcia scenario	-	-	53% (>0%)	-	-	-	-	-	-	25% (>0%)
Short-term day ahead Madrid (30 min – test 1) scenario	-	-	74% (>0%)	-	-	-	-	-	-	12% (>0%)

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Short-term day ahead Madrid (30 min – test 2) scenario	-	-	98% (>0%)	-	-	-	-	-	-	12% (>0%)
Short-term day ahead Madrid (1h) scenario	-	-	98% (>0%)	-	-	-	-	-	-	12% (>0%)
Long-term day ahead Alcalá de Henares I scenario	-	-	31% (>0%)	-	-	-	-	-	-	28% (>0%)
Long-term day ahead Alcalá de Henares II scenario	-	-	78% (>0%)	-	-	-	-	-	-	20% (>0%)
Short-term day ahead Alcalá de Henares I scenario	-	-	88% (>0%)	-	-	-	-	-	-	28% (>0%)
Short-term day ahead Alcalá de Henares II scenario	-	-	78% (>0%)	-	-	-	-	-	-	28% (>0%)

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Portuguese Demo										
SUC-PT-01 Mainland Portugal	250 (310)	100% (100%)	-	-	-	-	-	-	-	-
SUC-PT-02 Batalha	-	-	-	-	-	70,7 kW (>10kW)	0 (0)	0 (0)	0% (0%)	0,04% (>0,01%)
SUC-PT-02 Pocinho	-	-	-	-	-	31,8 kW (>10kW)	0 (0)	0 (0)	0% (0%)	0,27% (>0,1%)
French Demo										
SUC-FR1	2 (2-3)	100% (100%)	-	-	-	-	-	4984 kWh (>0)		36,66% (>0%)

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Out of the 40 KPIs assessed only 3 are common to the three Demos, 4 are only common to the Portuguese and Spanish Demos and 1 common to the Portuguese and French demo which are compared here.

The 3 KPIs common to all Demos were:

- **KPI_H01 / Number of FSPs** participating in the demo – In this indicator the number of participants varied in a wide range from 2 in the case of France to 250 in Portugal. Both France and Spain with 7 FSP participating, implemented actual flexibility activation related use cases. This may explain the manageable size of the portfolio in comparison to the Portuguese case which reported 250 FSPs. This is explained by the fact that no activations were carried out in the latter demo, but only information used by the users, which authorised the use of their data for flexibility availability estimations. The relative high value of user participation was however, enabled a more accurate estimation of availability, given the variety of historical data which allowed for proper data analytics.
- **KPI_H02 / Active participation –** High participation was reported by all Demos with 100% being reported in the case of both the Portuguese and French Demos and 88% in the Spanish demo which ended up not counting with all the expected users it intended to. This was explained by lack of engagement by initial willing users and problems with data collection.
- **KPI_H14 / Available flexibility** – regarding the available flexibility, this KPIs was estimated by substation or location assessed. In the Spanish demo this indicator varied from 9% to 28% with the initial expectations to be set at having some undefined amount (>0) for the sake of the demonstration. The French demo indicated an availability of 36.66% which is in the same order of magnitude as the Spanish demo, indicating also as initial target that it would be higher than zero (>0). The Portuguese Demos reported much lower relative values of 0.04% and 0.27% for Batalha and Pocinho substations respectively. This can be explained by the fact that in the first two Demos the flexibility provision was intended to be for the distribution network whereas in the Portuguese demo, the calculations of the indicators were based on the TSO substations with a much higher capacity when compared to the flexibility assessed by just a sample of willing users.

The 4 KPIs common to the Portuguese and Spanish Demos were:

- **KPI_H04 / ICT costs** – Reported costs for the Spanish demo related to ICT were 10 M€ while in the Portuguese demo this value was 184k€. the initial expectation for the former was to be higher than zero while for the latter was expected to be between 100k€ and 200k€. Both Demos reported involved costs, however from different perspectives. The Spanish demo referred to actual flexibility activation, accounting for hardware for command and control of resources, monitoring, software for baselining, activation, security elements and all the software and IT at the system operator side necessary. The estimation does however by itself correspond to a very large indicator value and

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perhaps incorporating the scalability and replicability factors. The Portuguese demo referred to message exchange components and the ICT costs that would be necessary to ensure a TSO and DSO coordination such as platform development, servers and computers. It should also be said that the ICT costs could have been broken down into fixed costs and running costs as some of the goods/services can be annually incurred, while others, just a one-time investment.

- **KPI_H09B/Cleared bids –** For the Spanish demo this indicator was estimated in 6.63 MW while in the Portuguese demo it was reported as zero given that no congestions were identified. Both demo initial expectations were only to have some value to show (>0) however since the Portuguese demo this was not achieve because at the moment of the target definition the flexibility needs were not known, including in which substations this estimation would be calculated.
- **KPI_H12 / Avoided restrictions –** In this indicator, the Spanish demo avoided 100% of restrictions it has identified, while in the Portuguese demo no restrictions were avoided since no congestions were identified, hence this indicator was reported as zero. The targets for both Demos were 100% and 0 respectively
- **KPI_H20B/Error of load forecast –** In both Demos there was an improvement in the forecast error. In the Portuguese case, an improvement from an uncoordinated forecast error of 5.55% would mean a successful performance indicator reached. This was accomplished as the error after the information exchange was 4.8%. For the Spanish case it got as close to 1.2% in the short-term day-ahead Murcia scenario while the worse was 36% for the long-term scenario which is typically worse given the time horizon requested.

The 1 KPI common to the Portuguese and French Demos is:

- **KPI_H09D/Cleared bids –** The only common KPI to the French and Portuguese demo refers to the cleared bids value. In the French case this was estimated to be 4984 kWh, way higher than the target of >0. The Portuguese demo reported 0 (zero) since no congestions were observed, hence no bids cleared.

Technical assessment of system service provision

Individually demo assessed KPIs, highlighted the goal of each BUC and SUC and support the measurement of specific performance. For the technical assessment of system service provision, both the Spanish and Portuguese Demos included indicators in their assessments. The Spanish Demo estimated both **KPI_H13**/Asset load variability and **KPI_H23A**/Power exchange Deviation. Similar values were found in the first one for the different substations with slight changes, ranging from 9%to 20%. For the second KPI values ranged from 0 to 63%. The first had a target below 100% which were all met. Regarding the second KPI's target this was set to <35% and not all values were achieved for assets intrinsic nature. For the Portuguese demo 9 KPIs were assessed in this

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category. For five of them, **KPI_H05**/Reduction in RES curtail.; **KPI_H15**/Req. Flex.; **KPI_N27**/Power avoided congestions by flexibility Activation; **KPI_N31**/Congestion Nbr. on DSO network; **KPI_N32**/Congest Nbr. on TSO network, they were all estimated as zero. This is explained by the fact that no congestions were observed in the network for the substations chosen and in the time frame of the demo. For the **KPI_N25**/ Isc forecasted vs registered the values of -576 A and 853 A were obtained. Only the second value achieved the target. The first one was not achieved due to discrepancies in dimensioning and so a negative value was obtained. For the **KPI_N30**/ Rated short circuit of circuit breaker vs max short circuit of series this did not happen while 3424 A and 12153 A were observed, hence the >0 target achieved. For both **KPI_N34**/Successful on Prequal. Process and **KPI_N46**/ Prequal. Process. needing add. Info they reported 100% which meet the target but means that even though the prequalification process was successful, it required additional information to do so.

Market platforms and economic performance assessment

Only the Spanish demo reported an individual KPI which is **KPI_H11** / Nbr. of products per demo. It estimated that all the products were tested (100%) in the demo.

ICT and data processing performances

Regarding individual demo KPI in this section, both the Portuguese and French Demos estimated values. The French demo assessed the **KPI_N26** / Tracked flexibility to which reported that 213 orders were automatically Triggered, 3 to RTE's production, 210 to Enedis' production, 3 orders were manually triggered from Enedis resulting in a Total: 216. This was beyond expectations given the target of 7 to 15 orders. The Portuguese demo estimated 4 individual KPIs. Two of them, **KPI_H21B**/Share of false positive vs negative congestions Forecasted and **KPI_N28**/Max ratio false positive and negative congestions Forecasted were estimated as zero. This can be explained because no congestions were observed whatsoever, hence no error in the classifications of these congestions since no positive forecasts were made (positive nor negative). The other two KPIs are the **KPI_H20A**/Error RES forecast 24 h and the **KPI_N33** / Forecast Improv. Which came out from the coordination and information exchange between TSO and DSO. For the first the following was observed for each of the generation types: Solar: 1,9%; Wind: 7,46%; Thermal: 4,49% for Batalha SE and Solar: 4,37%; Wind: 5,73% for Pocinho SE, all of them below the default errors, which were the targets. For the forecast improvement KPI the following were observed: Solar: 74,19%; Wind: 3%; Thermal: 80,69%; Load: 7,2% for Batalha SE and Solar: 66,42%; Wind: 20,42%; Load: 36,6% for Pocinho SE, all above 0% which as the target.

Common Demo KPIs

For this category, four KPIs were individually estimated. The Spanish demo assessed **KPI_H03** / Cost-effectiveness; **KPI_H06** / Ease of access and **KPI_H07** / Nbr. of transactions. The cost effectiveness KPI had a target above 0% and all Substations reported similar values ranging from 31% the lowest to 98% the highest.

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Regarding the ease of access and number of transactions these were estimated for the whole demo with the values of 5 out of 10 rank and 10 transactions respectively (with a target >0). These KPIs were hence also successfully achieved. The Portuguese demo assessed one KPI individually **KPI_H09A**/Received bids, these were 70,7 kW for Batalha SE and 31,8 kW for Pocinho SE with both having target above >10kW, hence both achieved.

4.2 The OneNet Connector tests and performance

The OneNet Connector is one of the main outcomes from the OneNet project. During the project, the Connector was released in incrementally upgraded versions, as specified in D6.1 [15]. The Connector is integrated into a larger structure composed by: i) OneNet Decentralized Middleware which contains: the Connector (Backend by default), the User Interface (UI), Backend (or middleware) and ii) the OneNet Framework containing: the OneNet Decentralized Middleware; the Monitoring and Analytics Dashboards and Orchestration Workbench. In 2023 it was recognized as an approved Data space Connector for energy by the International Data Space Association (IDSA) [16], ensuring interoperability, data sovereignty, authentication, integrity and privacy. However, its deployment encompasses certain trade-offs, which are here discussed.

The OneNet Connector's backend and user interfaces (and implicitly the middleware) were tested within the Western Cluster in a total of 20 tests by InescTec and partially by Nester. Continuous feedback was provided to WP5 and WP6 with the experience when conducting the tests. The other two deployments of the Connector were used in the regional use case. Moreover, a performance monitoring over the course of 6 months by InescTec was conducted as listed in Table 4-5. The Portuguese case SUC02, was chosen as a functional use case, to establish communication between two partners. This use case is focused on the information exchange for flexibility availability from the Aggregator role to the System operator and it was developed on the 25th of October 2023. Both the User interface and the Rest API based communication were used and the results are reported in this chapter.

The Connector was also used in the regional use case bringing together 4 entities from Portugal, Spain and France, as further described in D9.8. Below, a list of functional tests performed during the Demo and trials. The Regional Use case was developed on the 29th of November 2023.

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4.2.1 List of Tests to the OneNet Connector

Table 4-5: List of Tests to the OneNet Connector

Number	Description	Results
Test 1	Deployment time – The time that it takes to deploy the OneNet Connector following the instructions in its corresponding GitHub	Approx. 20 minutes
Test 2	File exchange time with daily flexibility with 96 observation containing time step and 1 attribute (Power) following the Post request through the REST API	1.04 seconds
Test 3	File exchange time with daily flexibility with 96 observation containing time step and 1 attribute (Power) using the user interface	1.04 seconds
Test 4	Scaling test. File exchange time with annual flexibility with 35040 observation containing time step and 1 attribute (Power) following the Post request through the REST API	9 minutes
Test 5	Scaling test. File exchange time with annual flexibility with 35040 observation containing time step and 1 attribute (Power) using the user interface	3 seconds
Test 6	Number of unhealthy containers using 4 GB RAM deployment	3
Test 7	Number of unhealthy containers using 8 GB RAM deployment	3
Test 8	Frequency of downtime of the Connector using a 4 GB RAM deployment	1 / week
Test 9	Frequency of downtime of the Connector using an 8 GB RAM deployment	0
Test 10	Test of the time window authorization (data sovereignty feature) both initial time and end time	Not working
Test 11	Test of the Data Exchanges Timeline registry of end to end transaction	ok
Test 12	Test of the Data Exchanges Timeline registry of send transaction but not received	ok
Test 13	Data Exchanges Timeline filter by date	Not working
Test 14	Fields observed	Yes
Test 15	Able to publish and subscribe services without the Local App running	Yes

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Test 16	Able to exchange files without the Local App running	No
Test 17	In creating a service, is the file profile format definition limitation to exchange	No
Test 18	Search Available Services filters	Not working
Test 19	My Subscriptions Filters working	Yes
Test 20	Connector settings check buttons (Local Api Url and Data App)	Data App check connection not working. Local Api Url Yes working

Based on the tests developed, some results are straightforward to check given their binary nature such as "yes/no" of quantitative metric. There is however the need for further explanation in some cases for replicability purposes and future updates. For this reason, those tests are further explained in the following section.

4.2.1.1 Test 1

The deployment of the Connector followed the instruction provided by the development responsible partners of the project, Engineering and European Dynamics, which made the corresponding documentation available in GitHub[1]. The deployment was done based on the two accounts created specifically to the Western Cluster wc-user1 and wc-user2. As an example, InescTec carried out their own deployments in dedicated virtual machines while and Nester used AWS (Amazon Web Services), with its own user account. The deployment of the partners within the Western Cluster was made in virtual machines. This was the common approach given that the explicit request for a successful deployment if to assign static IP addresses and ports 8889 and 8084, stated in the Connector settings section as "Ecc, Data App Must Be Publicly Exposed In A Static Ip Via Https To Be Served As An Endpoint For Peer To Peer File Transfer." Below in Figure 4-1 the deployment architecture of the Connector for the two accounts for the Western Cluster.

The deployment was done in two Linux based virtual machine and each deployment takes approximately 20 minutes, for non-expert users and no relevant issues were encountered.

[1] https://github.com/european-dynamics-rnd/onenet

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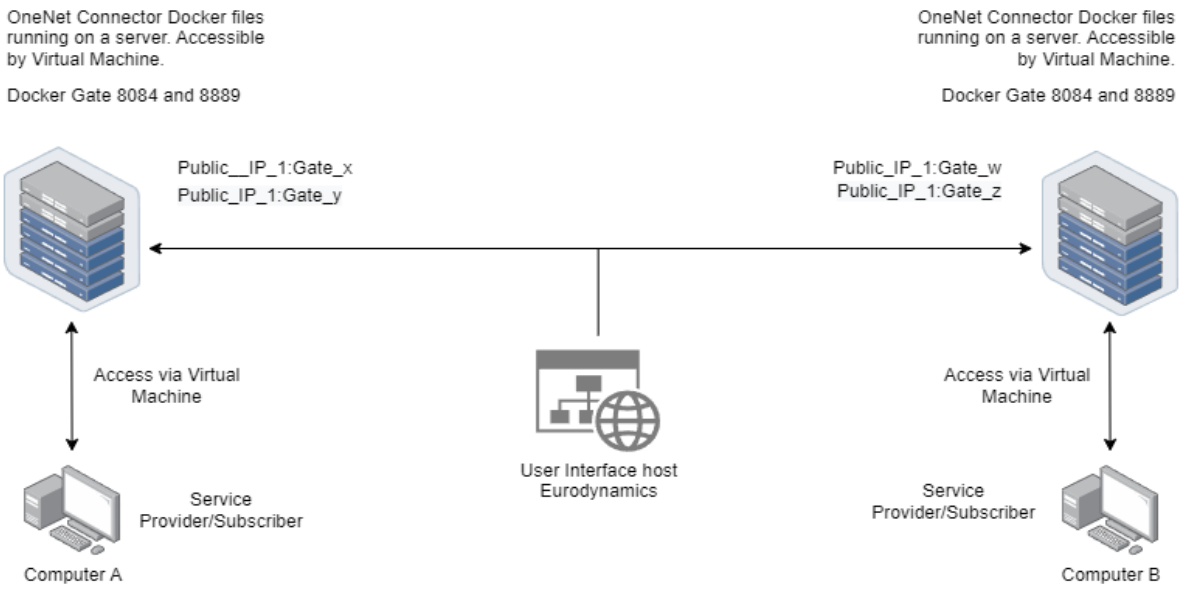

Figure 4-1: Diagram of the OneNet Connector VM deployment

4.2.1.2 Test 2

Acting as an Aggregator, InescTec (user 1), created a service in the user interface to which the acting SO (Nester), subscribed to. After accepting the subscription user 1 (InescTec), within its role in PT-UC02 shared its day ahead daily flexibility availability data with the System Operator (Nester). It did so by Posting data onto a service created named FlexOffers as shown in Figure 4-2.

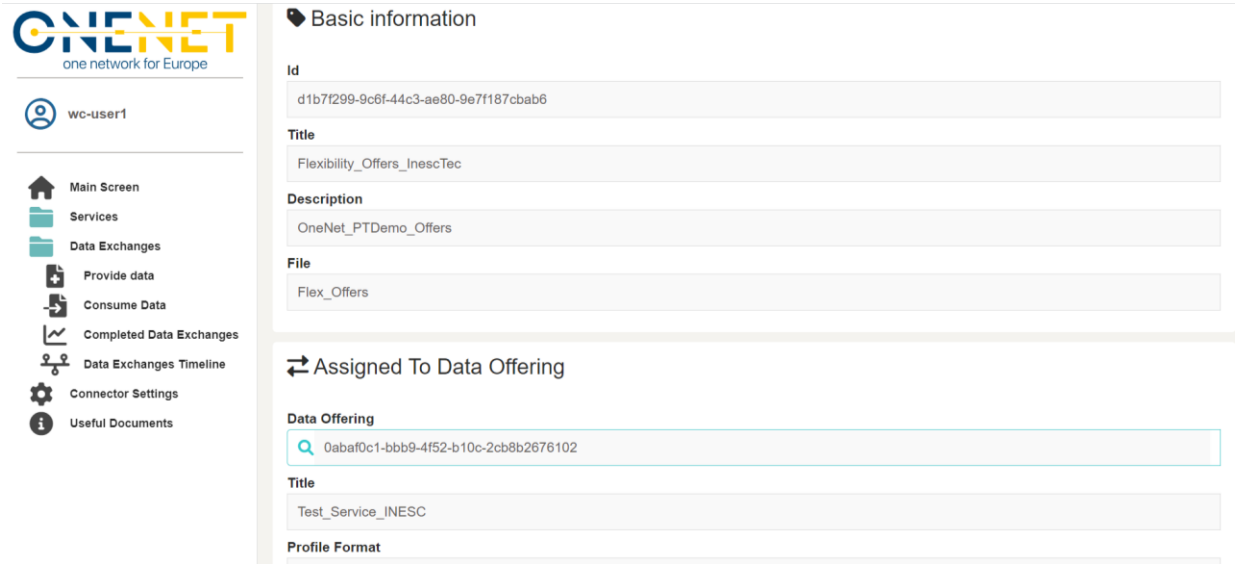

Figure 4-2: Screenshot of the Connector's UI showing the service Data Offering ID used to Post data

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In Figure 4-3 the Jupyter Notebook screenshot of the python code snippet to provide the data to the service. Notice the data_offering_id": "0abaf0c1-bbb9-4f52-b10c-2cb8b2676102" reference in the User interface and in the Jupyter Notebook. This ID acts as a Rest API endpoint for the POST request.

Post to the subscribed service Id

```
import time
start_time = time.time()
data = {
    "title": "Flexibility_Offers_InescTec",
    "description": "OneNet_PTDemo_Offers",
    "filename": "Flex_Offers",
    "file": base64_data,
    "data_offering_id": "0abaf0c1-bbb9-4f52-b10c-2cb8b2676102",#Está no fim do serviço
    "code": "00"}
# define the headers for the request, including the content type
headers = {"Content-Type": "application/json"}
# send the POST request with the JSON data and headers
response = requests.post(url, headers=token, json=data)
response_size = len(response.content) / 1024
# print the response status code and content
print(response.status_code)
print(response.content)
print(f"Posted file size: {response_size:.2f} KB")
end_time = time.time()
# Calculate the elapsed time
elapsed_time = end_time - start_time
print(f"Elapsed time to Post data through the connector: {elapsed_time:.4f} seconds")
# Record the time again after the request is complete
from datetime import datetime
# Get the current time in UTC
current_time = datetime.utcnow()
# Format the current time as a string
formatted_time = current_time.strftime("%Y-%m-%d-%H-%M-%S.%f")
print(formatted_time)
```

```
200
b'{"id":"d1b7f299-9c6f-44c3-ae80-9e7f187cbab6"}'
Posted file size: 0.04 KB
Elapsed time to Post data through the connector: 1.0440 seconds
2023-11-15-10-19-40.766709
```

Figure 4-3: Screenshot of the Jupyter Notebook (Python) to Post data through the Connector API

Notice that, for the flexibility availability to be provided, in practice, it would be the Aggregator to Post its availability in a created service by the System Operator and not the other way around. This is a limitation of the Connector which was identified and provided to the developing partner. It is the SO that should create the service to collect bids/offers/availabilities from multiple interested Aggregators. If the current setting would exist, it would be the SO to discover somehow potential multiple Aggregators without knowing what to look for

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unless directly instructed. For this reason, we suggest that it should be possible for a party to POST data into a third party created service. The timeline of the test within UC02 can be seen in Figure 4-4 showing the file transferred between InescTec (user1) and Nester (user2) on the 25th of October 2023.

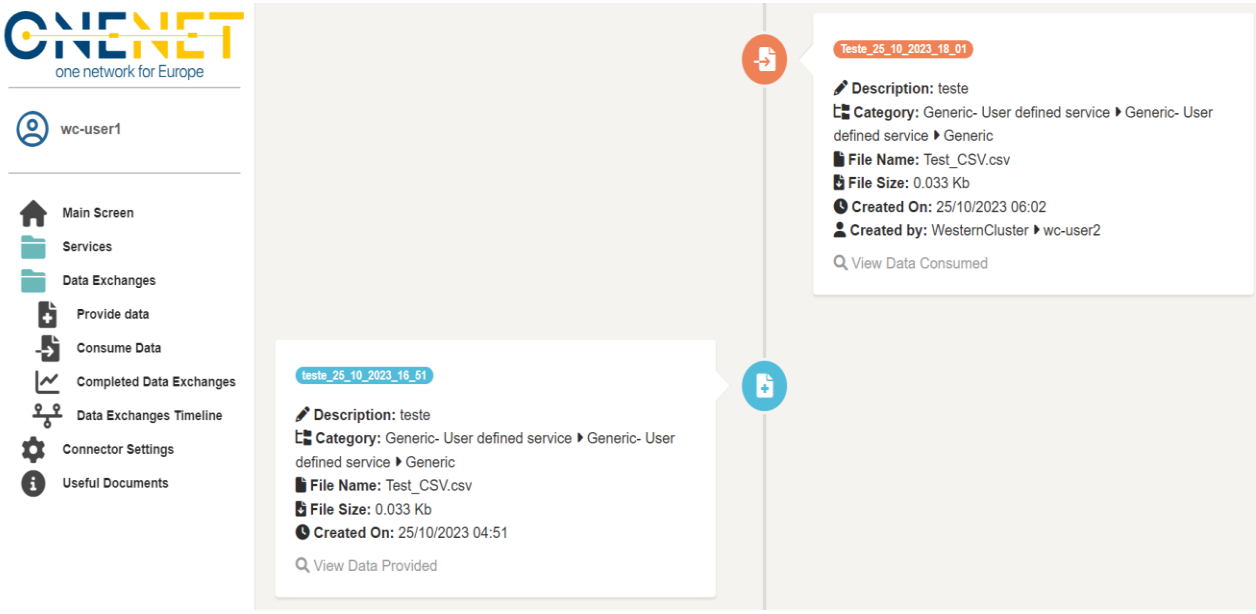

Figure 4-4: Example of transaction registry in the Timeline between user1 and user2 during the PT DEMO

4.2.1.3 Tests 4 and 5

The scaling test could be done by increasing the number of files being exchanged or increase the file size or a combination of both. In this test we chose to check the behavior of exchanging large files. If an historical timeseries was exchanged, not for 1 day but for a full year, what would the behavior of the Connector be. The file exchange will interfere in the synchronous communications and highlight if any bottlenecks exist when scaling the communication. The test was done with a daily (96 observations) file, and 365 days (35040 observations). The csv file exchanged is 724 KB sized. The test was done using the User Interface and the backend REST API.

Using the Rest API approach

Using the API environment in Jupyter Notebook an error message appears stating a timeout issue. An option to modify the timeout limit is provided, but we decided to change IDE and used Spyder. The whole process took 9 minutes to process. This was due not to the POST request itself but to the need to encode the file to base64. The following command for this was used:

base64_data = base64.b64encode(json.dumps(new_data_json).encode('utf-8')).decode('utf-8')

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The issue is that REST APIs use the HTTP protocol and HTTP has a timeout both at the server and client sides typically 60s in webserver like Nginx, and can go a bit higher in the case of Apache or IIS (Internet Information Services). This is contrary to what one can find using a FTP protocol as well as other access protocols database based.

Using the OneNet Connector UI approach

Using the User Interface this difficult was not observed and no delay was experienced. The file was exchanges approximately in 1 minute. As a user, one does not have access to the file conversion process or to the semantic layer, but if a file conversion exists, the same procedure should be used in the REST API code to provide and consume data, which we could not do without the Json64 based conversion.

Discussion

Converting a JSON file to base64 encoding is a way to represent binary data (like the contents of a file) as ASCII text. Base64 encoding is a common technique used for encoding binary data in a way that is safe for transportation in text-based protocols, such as JSON. When interacting with the Connector API the conversion was needed to consume data. For this reason, we have included it in the provide data code as well. Different reasons exist to convert JSON files to base64, they can be:

Data Transmission: When you need to transmit binary data within a JSON payload, some systems may not handle binary data well. Encoding the binary data in base64 allows you to include it as a string within the JSON, making it easier to transmit without potential data corruption or loss.

Data Integrity: Base64 encoding ensures that the data remains intact during transmission. Some character encodings used in text-based protocols may not properly handle binary data, leading to potential corruption. Base64 encoding avoids these issues.

JSON as Text: JSON is a text-based data interchange format, and it may not handle binary data efficiently. By converting binary data to base64, you can include it as a string within the JSON structure without worrying about special characters or encoding issues.

Embedding in HTML or XML: If you need to embed binary data, such as images, within HTML or XML documents, base64 encoding allows you to include the binary data as a text string.

APIs and HTTP Requests: Some APIs or HTTP requests may have restrictions on the types of data that can be included. Base64 encoding provides a way to include binary data within these requests.

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Regardless of the base64 conversion is needed, the synchronous aspect of communication is still relevant to be tackled if scalability is considered. Other message exchange such as NATS[2] could be included, this will become especially relevant when real-time information is to be exchanged.

Generally, for real-time information processing one has to be connected to a messaging system like RabbitMQ, Kafka etc. Every message that lands in the system should be immediately consumed, processing it for a very fast and optimized database. NATS was mentioned is a new way of exchanging data and could be a possible solution due to its asynchronous nature.

When expected responses are foreseen to take longer using REST API communications, what is usually done is to send the request to a task stack, for further computation and return an Identifier for later collection of the results. With Connectors and data access, if there are very large Datasets that takes longer time than the timeout limit, there may be failures and problems in connecting to the HTTP protocol based on crude communication by API.

NATS (Nano Message Bus)

NATS is a lightweight and high-performance messaging system that follows the publish-subscribe (pub/sub) and request-reply patterns. It is designed for simplicity, speed, and reliability. Here's a brief overview of how NATS communication works:

Publish-Subscribe Model: In the pub/sub model, there are two main components: publishers and subscribers. Publishers send messages on topics, and subscribers, express interest in receiving messages on specific topics. Topics are hierarchical, allowing for a flexible and organized way to categorize messages.

Connections: NATS operates over a simple protocol and uses lightweight connections. Clients connect to a NATS server (or a Cluster of servers) to send and receive messages.

Publishing: Publishers send messages by specifying a subject (topic) and the actual payload of the message.

When a publisher publishes a message on a subject, NATS broadcasts the message to all subscribers that have expressed interest in that subject.

Subscribing: Subscribers express interest in receiving messages on specific subjects.

Subscribers can subscribe to a single subject, use wildcards for multiple subjects, or subscribe to all messages.

[2] https://nats.io/

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Message Delivery: Messages are delivered in a fire-and-forget manner. There is no built-in persistence or guaranteed delivery. NATS focuses on delivering messages as quickly as possible, making it suitable for scenarios where low-latency communication is crucial.

Queue Groups: NATS supports the concept of queue groups, which allows multiple subscribers to form a group and share the load of processing messages for a particular subject. Each message sent to the group is delivered to only one subscriber within the group, providing load balancing.

Request-Reply: In addition to pub/sub, NATS supports request-reply communication. A client can send a request, and another client can reply to that request.

Clustering: NATS can be deployed in a Clustered configuration for high availability and scalability. Clusters consist of multiple servers that share information about subscriptions and messages.

Security: NATS provides security features, including authentication and authorization mechanisms to control access to the messaging system.

Overall, NATS is designed to be simple, fast, and scalable, making it suitable for various use cases such as microservices communication, IoT, and cloud-native applications and could be an eligible protocol for consideration.

4.2.1.4 Tests 8 and 9

Tests 8 and 9 were monitoring tests of the downtime of the two assigned RAM 4 and 8 GB to the virtual machines. With the initial deployment with 4 GB, the machined would often crash, and provide frequent error messages (500) when attempting to exchange files. A “500” Internal Server Error, is a generic error message returned by the server when it encounters an unhandled exception or an issue that prevents it from processing the request. The Virtual machines were frequently being overloaded reporting 90% of memory usage and they would crash. This would require constant reboot of the machines with a frequency of once per week. To solve this issue the VM were both upgraded to 8 GB and no downtime was observed since then.

4.2.1.5 Test 10

The date restriction feature of the Connector is the enabler of the data sovereignty element of the Connector, as it provides the service creator to define the condition of the sharing agreement in terms of time. It allows him to keep control of the ownership of the data, deciding with who what and when it wants to share data and inform the service contracting party (consumer) what those conditions are. This can be seen in Figure 4-5 with the fields to be filledin by the service creator.

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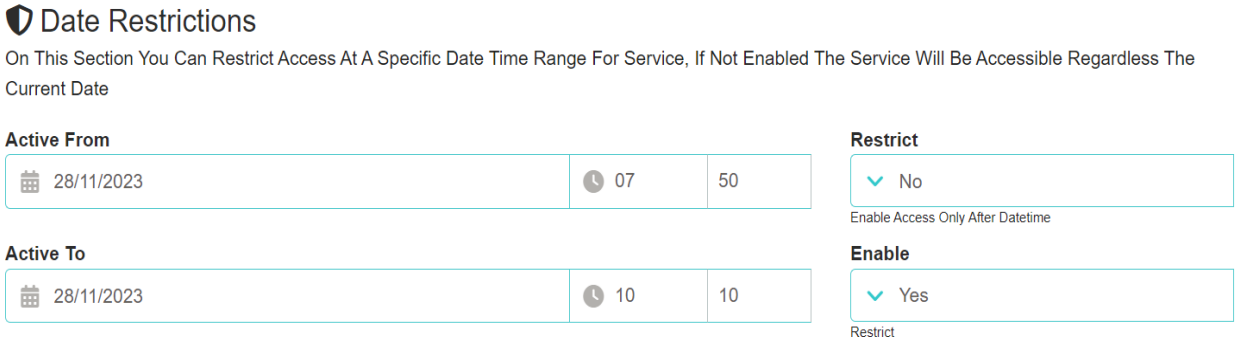

Figure 4-5: Screenshot of the Date restrictions options in the UI

In test 10, this feature was tested. Notice that a restriction was made set to 10:10, however in the timeline one can observe that the data was consumer both before (10:09) and after (10:11) the limitation as can be seen in Figure 4-6. This demonstrates that at the time of writing if was not functioning.

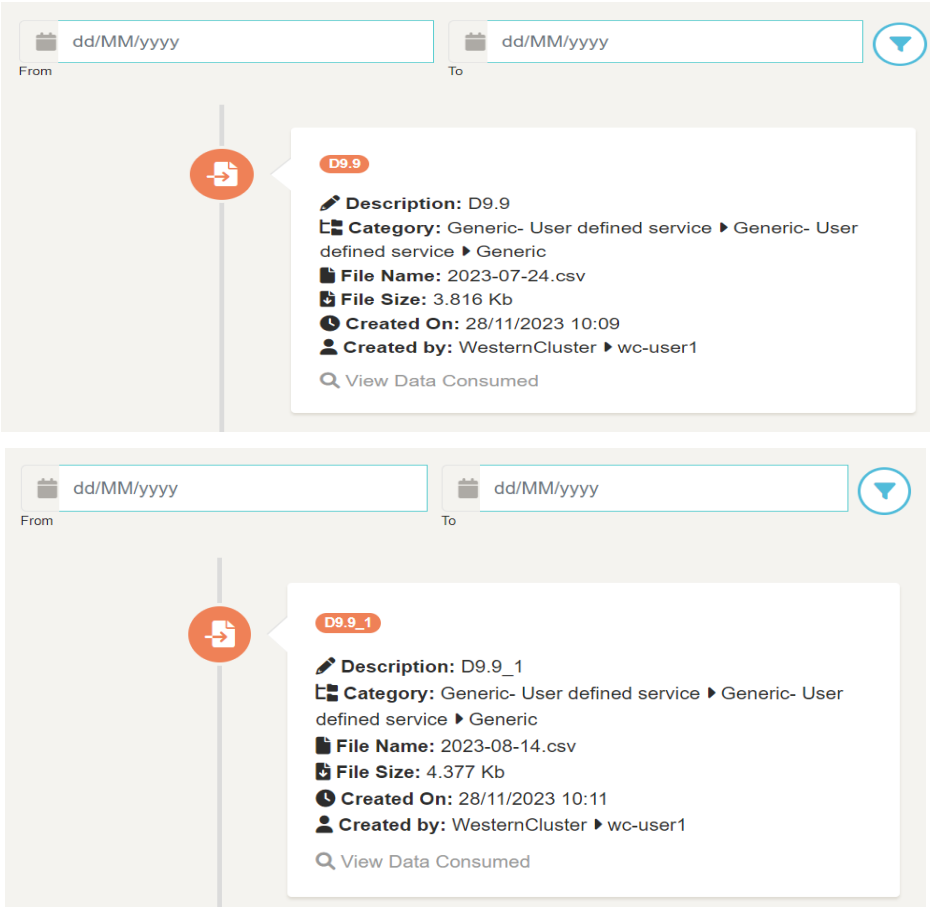

Figure 4-6: Consumed data within and outside the time window specified

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4.2.1.6 Tests 12, 13 and 14

The Data Exchanges Timeline registers all data transferred during a transaction. In the UI, it provides a graphical representation with one side showing the consumed data and the provided of the data with some metainformation associated to it. The following fields can be obtained from the registry:

Description: Annual dataset
Category: Generic- User defined service Generic- User defined service Generic
File Name: Consumption_of_Building.csv
File Size: 723.030 Kb
Created On: 14/11/2023 03:00
Created by: Western Cluster wc-user1

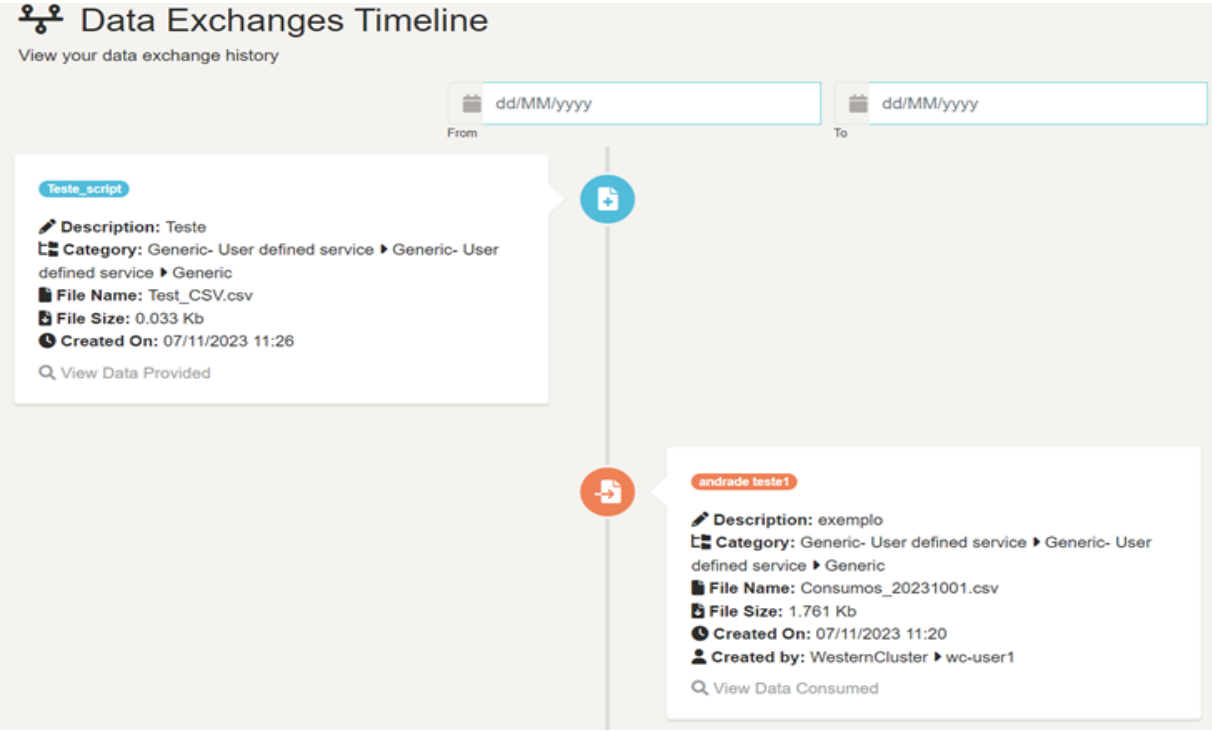

Figure 4-7: Screenshot of the User Interface TimeLine menu of the Connector

As shown in Figure 4-7, two sides of the timeline can be seen, the provider and the consumer of the data. The timeline provides the registry from the provider, on all occasions, even though a time window restriction may exist preventing data from being shared. This works fine and it makes sense it is so, since the time window restriction may be activated, and the provider may want to check if the restriction is in fact active. In this case, the file will be available to be shared, but the consumer will not have access to it (will not be able to consume it). The file size is correctly inserted, which was an upgraded feature requested by the PT demo. The query date

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filter at the top, it was not working at the time of writing, however it is a useful feature especially if scaling of transactions is observed.

4.2.1.7 Test 17

When creating a service, in the semantic definition field, the provider has the chance to indicate the profile format to be Xml, Json ld, Json, Csv or other (providing a description). In Test 17 we have defined the format to be Csv and tried exchanging both Json and Csv formats. Both worked, hence no limitations existed in this regard. This field should be clarified whether or not this field is intended to be a restriction, or an informative element. Semantic definition is important to ensure interoperability in the file exchange, especially in the context of language, knowledge representation, and information retrieval. This feature should be checked if it is working according to what was intended.

4.2.2 Recommendations for the Connector

- Increase RAM minimum requirements for the deployment to 8GB[3]
- Implement the time window restrictions for file exchange, ensuring data sovereignty
- Enable POST request to third party services
- Implementation of faster message exchange method for real time exchange, such as NATS
- Consider asynchronous responses to deal with large files or differed responses such as NATS
- Post the timeline and metainformation of transactions in a DLT
- Implement data origin of the sender or receiver by certificates and include info in the timeline
- Evaluate if the Base64 is required and how to deal with its coding in the REST API code
- Fix search filter to query information in the timeline message exchange menu
- Fix search filter to find available services
- In the semantic definition field for profile format, clarify whether or not this field is intended to be a restriction, or an informative element. At the moment it is not a restriction.
- Considering the replicability of the Connector, it was our understanding that the middleware component should be deployed by a trusted lasting party. This could be ensured by the EU, to secure data spaces, which would host the services, dictionaries, accounts, or as an alternative, move to a trustless environment, using for example a distributed network such as distributed ledger technology (DLT) to this effect. For the data energy spaces to be a reality, it needs to scale, and the maintenance

[3] All recommendations have been shared with OneNet Connector developers. Some have already been implemented; others will be taken into consideration in other ongoing projects.

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of this middleware must be assured beyond the capabilities of individual companies which may eventually close.

- The user interface should also be released under an open source a light as possible (e.g. MIT license or similar). This is a crucial step to make the access to the data space by the masses, as it facilitates the creation of services, subscription, discovery and setting definition by non-technical users.
- Full documentation about the backend should be open and clearly published. From the user point of view, not all documentation is available for full replication. In the absence of the UI, the backend should be able to implement all the necessary functions. To this end, all endpoints and documentation should exist and be clear.
- We advise that other entities or partners, develop their own UI and make them open source so that a variety of accesses (similar) exist and may be adopted by different categories of users.
- The open-source license format should be formalized for all the components of the Connector, backend, UI, middleware and monitoring dashboard.
- Message exchange tests between other approved data space Connectors is advised, since it was not part of this scope. A successful result would be truly the proof of interoperable data space implementation of the OneNet Connector/True Connector

As a final note, regarding the OneNet Connector performance at the time of writing, it indeed allowed for file exchange. However, development issues are still pending and the very elements that it intends to fulfill such as data sovereignty, privacy and interoperability are not yet deployed. This can be seen by the fact that the time window defining the conditions to share data are not defined. Moreover, any user can use a Connector without the consumer knowing who it was exactly the original data provider, because it is not displayed in the timeline nor any certificates exist. Moreover, the seamless user experience of the Connector was not achieved, as many resistances from the partners to use it was observed, much related to the deployment in their organizations. In this regard, some partners encountered problems with the Connector running on different operating system (for instance Windows server). In these cases, the Connector was slow and instable causing sometimes problems with data exchange.

It should be noted that according to the foreseen vision of the European Connected Data Spaces, all full Connector features should be open source (including deployment steps, UI and logs). On the positive side, the inclusion of the User Interface had a very good reception, as it is a “way in” for any user, facilitating the service discovery, subscription and creation.

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5 Recommendations and lessons learned from Demos

The methodology followed was pre-determined by the deliverable setting of the OneNet project for the WP9. It can be considered that the process for the lessons learned followed the typical categories of identification, documentation, analysis, storing and retrieval. Deliverable 9.1 through the characterization of all Demos provided the identification and documentation of all steps of each Western Cluster. Deliverables 9.5, 9.6 and 9.7 performed the analysis of the proposed KPIs of the stored data. It is the intention of this report to retrieve all the data, putting it together for comparison and requesting recommendations to the DEMOS through a specific survey for future improvements or implementations.

The goal of the "lessons learned report" is to document information that reflects both the positive and negative experiences of a project [9]. This is a best practice in project management and hence followed in OneNet. Sharing lessons learned among project team members and future users prevents an organization from repeating the same mistakes and also allows them to take advantage of organizational best practices. Innovative approaches and good work practices can be shared with others. Lessons learned can be used to improve future projects and future stages of current projects, in this case the implementation of the OneNet Connector or simply regarding DSO and TSO coordination activities.

The Demo survey submitted to each Demos partner with the following categories: Demo management, resources, technical-economic, communication, regulatory and business processes, requirements, design and build, implementation/operational. In each category, the successes and difficulty factors were asked and corresponding recommendations. The responses are compiled below as well as recommendations provided.

5.1 Demos' responses to survey

Following the description in the methodology section, the answers to the surveys are hereby presented by category. The results are presented in bar charts with the corresponding answer included at the top of each one. The answers do not disclose the respondent, to maintain the anonymity of the responders. In case there were open questions, or notes included by the responders, these were placed right after the corresponding chart presentation in each section.

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Demo management

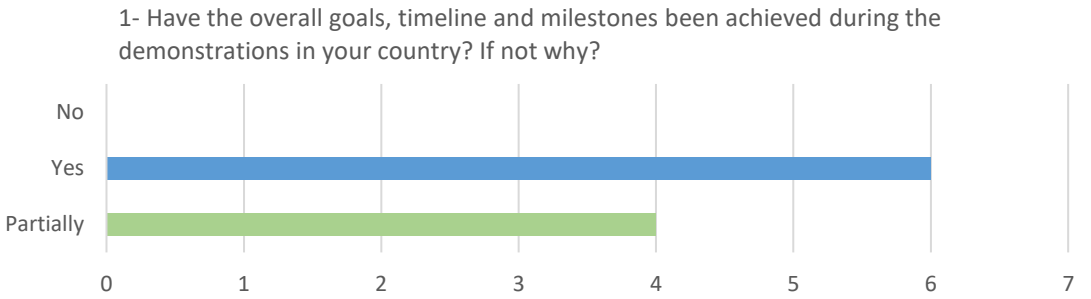

Figure 5-1: Demo management - Question 1

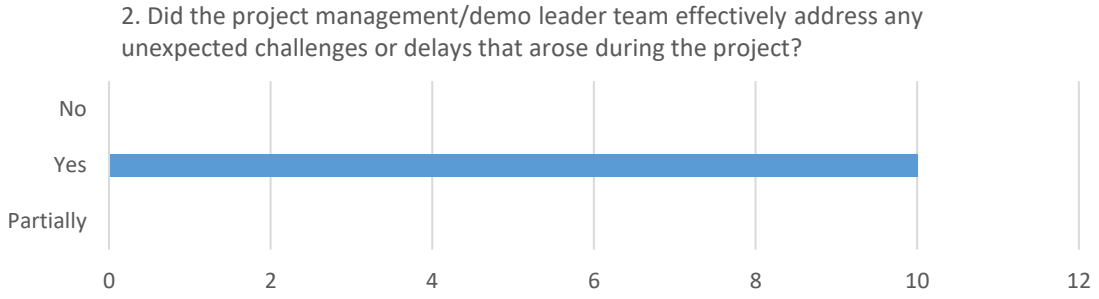

Figure 5-2: Demo management - Question 2

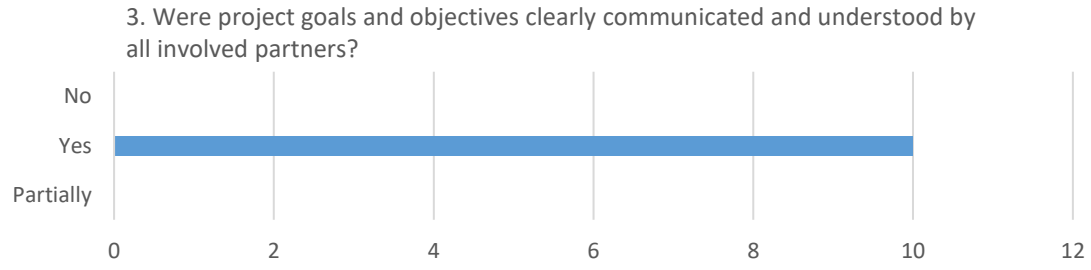

Figure 5-3: Demo management - Question 3

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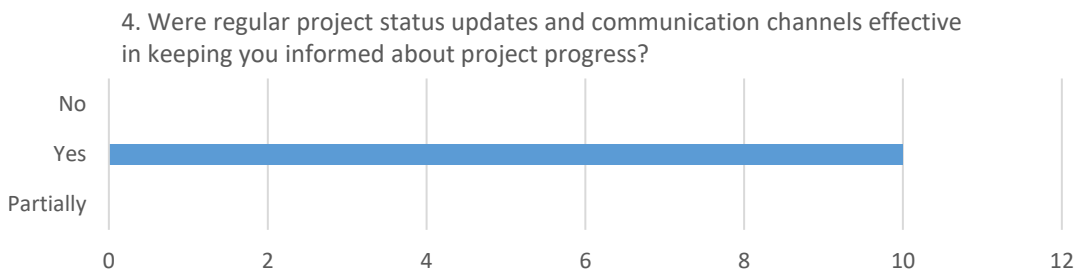

Figure 5-4 Demo management - Question 4

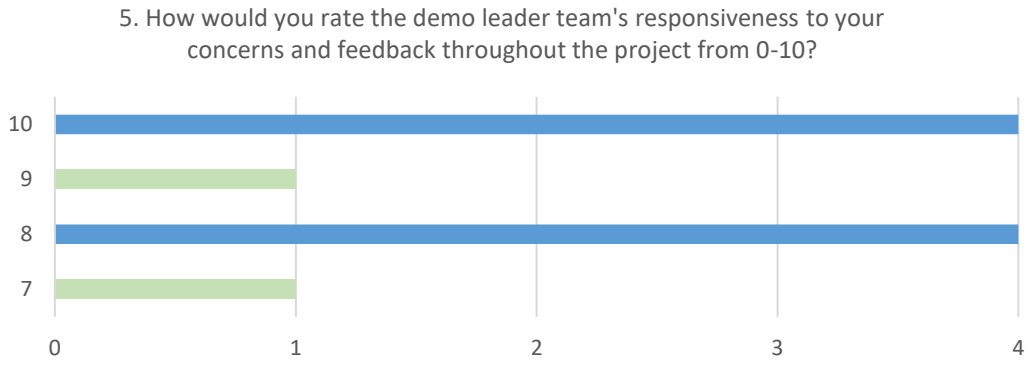

Figure 5-5: Demo management - Question 5

Resources

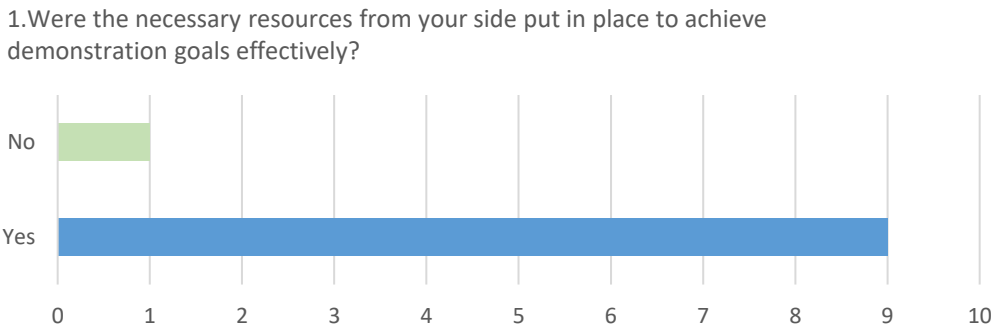

Figure 5-6: Resources - Question 1

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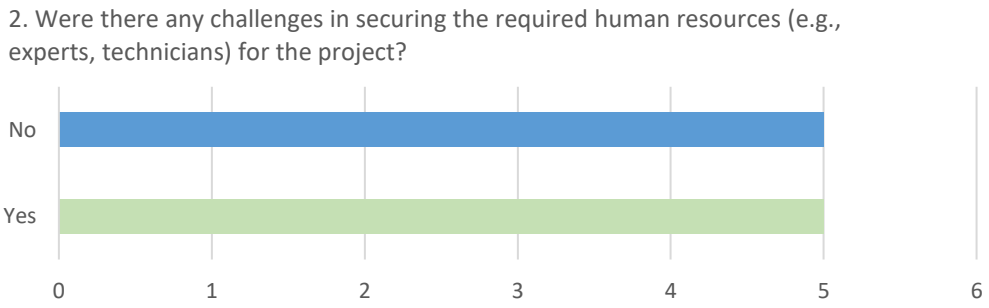

Figure 5-7: Resources - Question 2

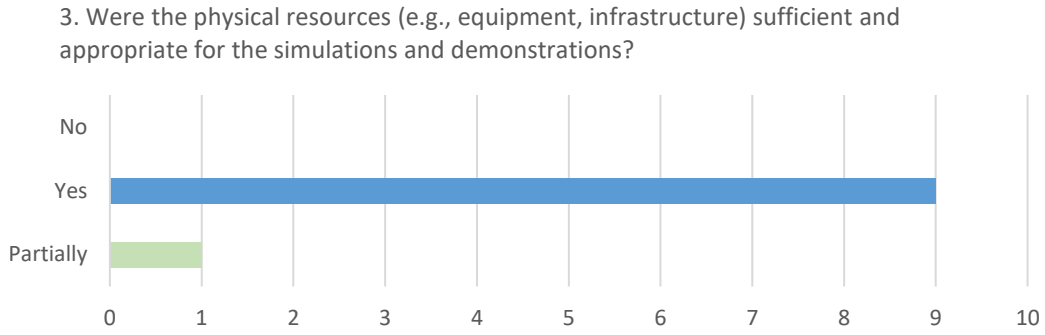

Figure 5-8: Resources - Question 3

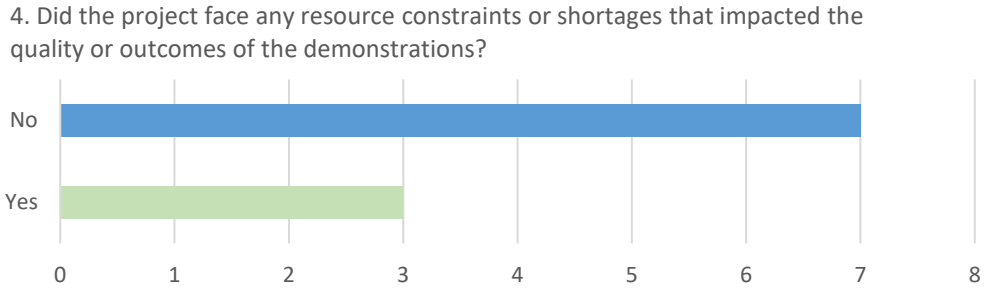

Figure 5-9: Resources - Question 4

Observations: Change in HR, missing data and difficulties in scheduling field tests were reported.

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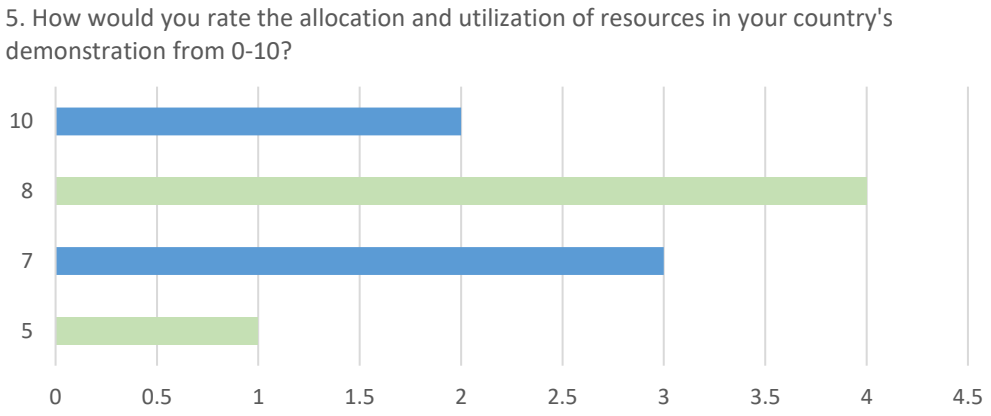

Figure 5-10: Resources - Question 5

Technical-economic perspective

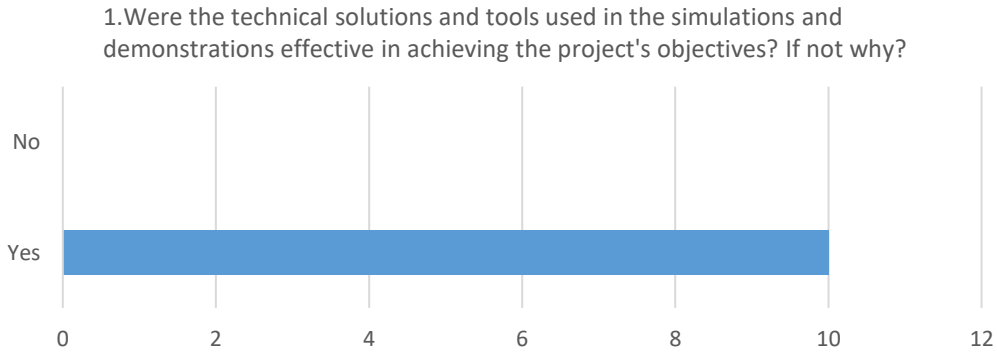

Figure 5-11: Technical-economic perspective - Question 1

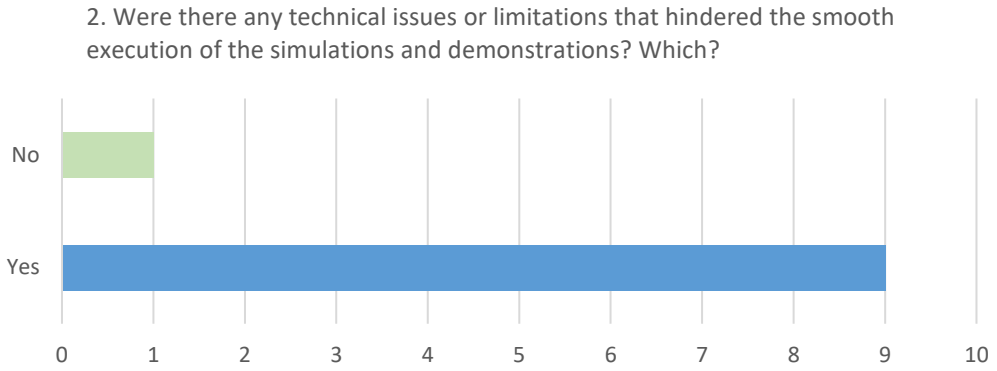

Figure 5-12: Technical-economic perspective - Question 2

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Observations: Reported issues were: delays in partner's developments, lack of flexibility markets, lack of accessible data and technological deployment difficulties (ex: blockchain)

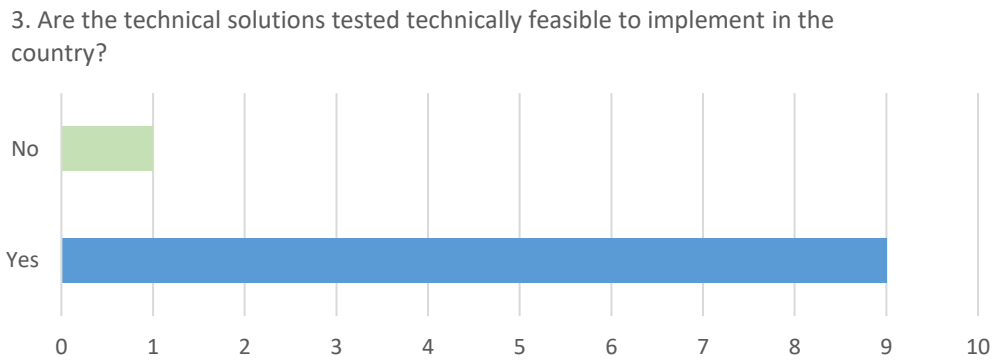

Figure 5-13: Technical-economic perspective - Question 3

Observations: Hard to scale.

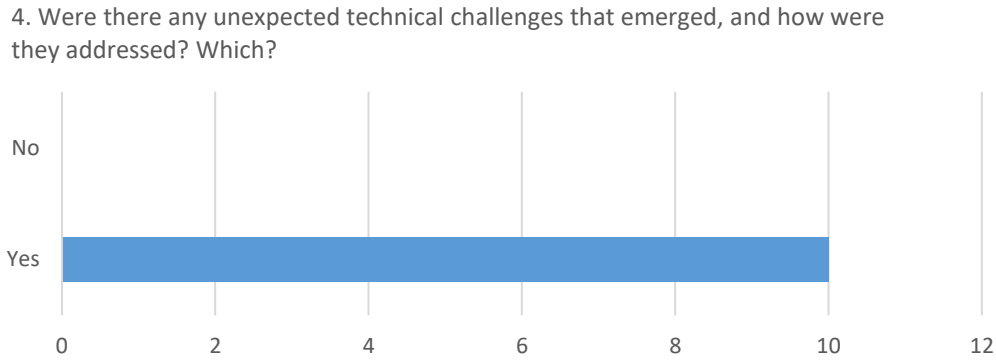

Figure 5-14: Technical-economic perspective - Question 4

Observations: Reported issues: Azure support, IT configurations of the Connector, difficulties in assessing flexibility activation, redefining the architecture during the project, technology performance. At least a half of the FSPs has no monitoring systems in order to make the most of the flexibility markets, in terms of bidding properly and adjusted to their consumption behaviour. In addition, the customer engagement was quite a barrier.

5. What improvements or enhancements would you suggest for the technical aspects you encountered?

- Suggestion to implement the Post method feature in a third-party service on the OneNet Connector;

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- Simpler Azure procedures
- Some organizations such as system operators have very strict firewalls and connection requirements, which will not allow the installation of .exe file such as the Local App file, which makes it difficult to use the Connector.
- Ease the IT configurations of the Connector
- Better understanding of Blockchain possibilities
- Better customer engagement strategies like cascading funding
- we suggest that it would be a good idea to have these FSPs also as partners in the project, because the engagement with no incentive at all has been very difficult. However, the participation of the final group of FSPs has been exemplary.
- Better understanding what the capabilities of the Connector were and its end goal.
- Claiming interoperability needs, should be justified by examples of lack of interoperability. The same applies for coordination. Those should be the base case, showing where the problem is, and then fix it with the tools we've developed. Lack of the problematic narrative might be missing in some cases, coordination and interoperability wise.

Communication

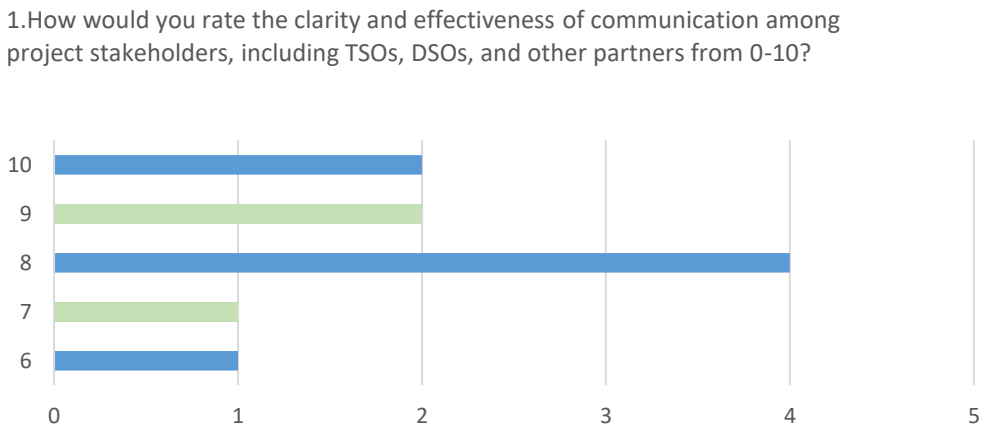

Figure 5-15: Communication - Question 1

Observations: One partner felt that more knowledge/experiences exchange would have been welcome, given the project size and number. of partners.

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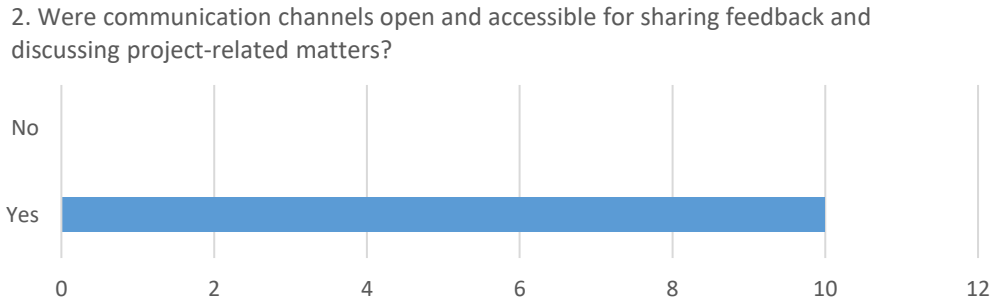

Figure 5-16: Communication - Question 2

Observations: Open meeting environment, email communication, reporting channels well established, share point repository, inviting environment

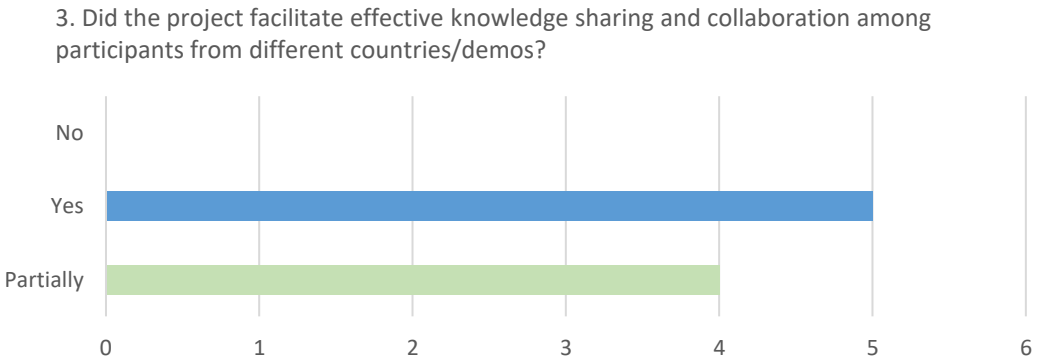

Figure 5-17: Communication - Question 3

Observations: More could have been done by partners to share experiences given the extraordinary set of skills, competences and knowledge from the group size. The communication of results of the Demos should have been higher.

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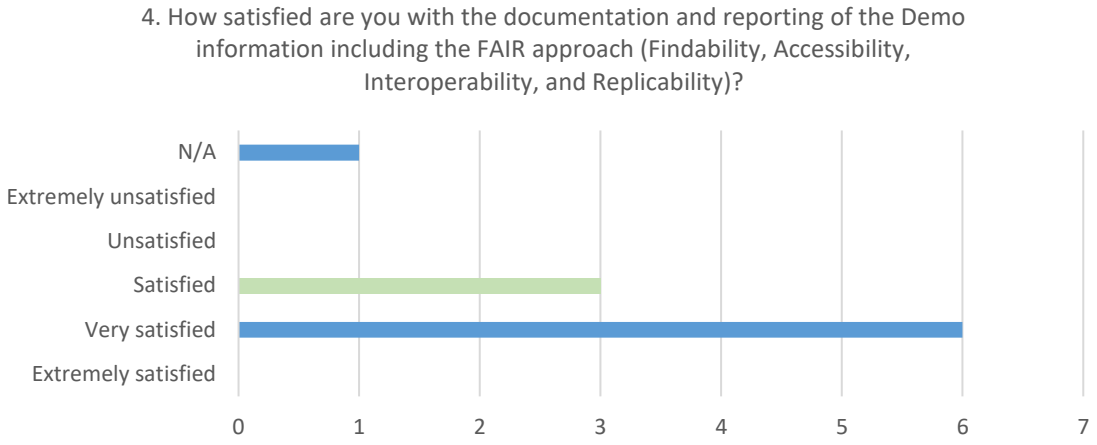

Figure 5-18: Communication - Question 4

Regulatory and business processes

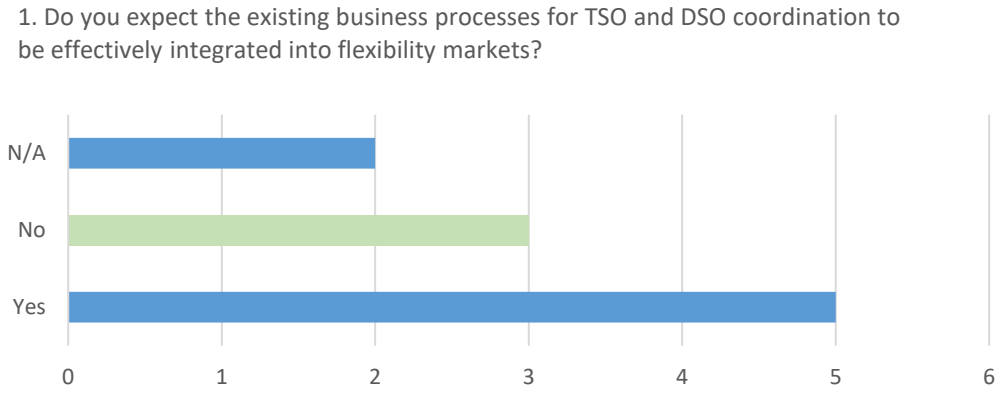

Figure 5-19: Regulatory and business processes - Question 1

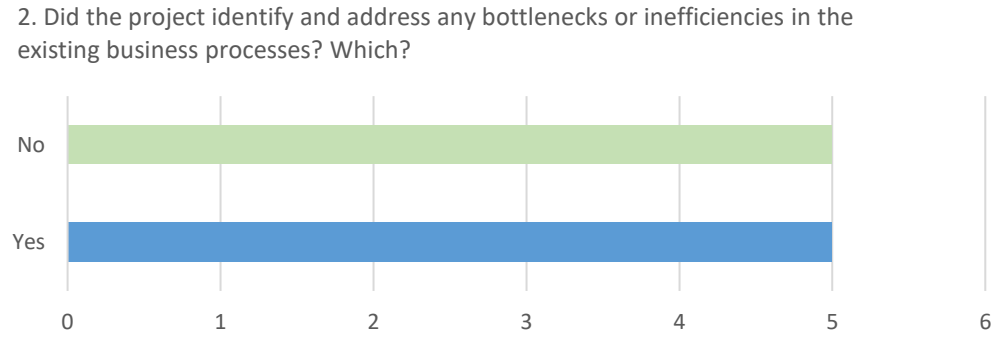

Figure 5-20: Regulatory and business processes - Question 2

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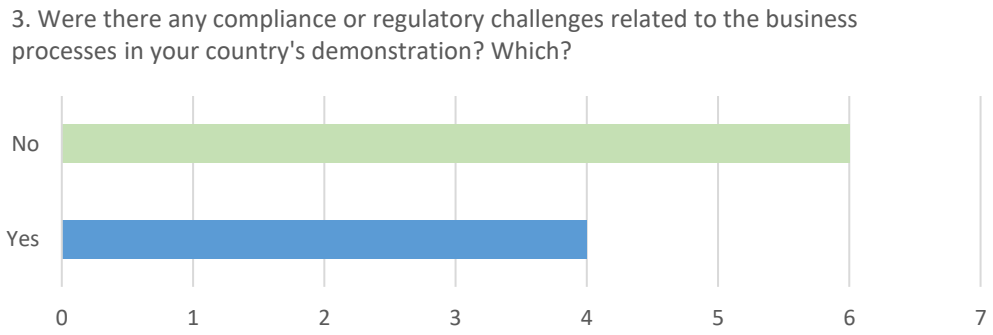

Figure 5-21: Regulatory and business processes - Question 3

4. What suggestions do you have for further improving business processes in the context of flexibility markets?
    - Baseline definition, activation process, aggregator, and flexibility monetization clarification to promote consumer participation.
    - Establishment of clear and pre-agreed data models for the interactions between the involved parties; define clear processes and roles; allow more frequent and regular interactions/data exchange between DSOs and TSOs, e.g., on the flexibility needs for each side.
    - Improve coordination among stakeholders, facilitate the consumer participation in the flexibility markets, regulatory frameworks
    - Improve coordination among stakeholders, facilitate the consumer participation in the flexibility markets, regulatory frameworks.
    - Finish pending issues on regulation
    - Develop the regulatory framework. In the meantime, regulatory sandboxes could be good tools
    - The MO could perform a key role in this process facilitating the negotiations in local flexibility markets and the prequalification through its platforms. Moreover, the MO will share the same platform's access to the different markets he managed. Thus, DERs could use the same IT developments to connect to the different electricity markets managed by MO.
    - Definition of roles and responsibilities
    - Further market procedures implementation
    - Incentives for DSOs to use flexibility
    - Customer engagement strategies

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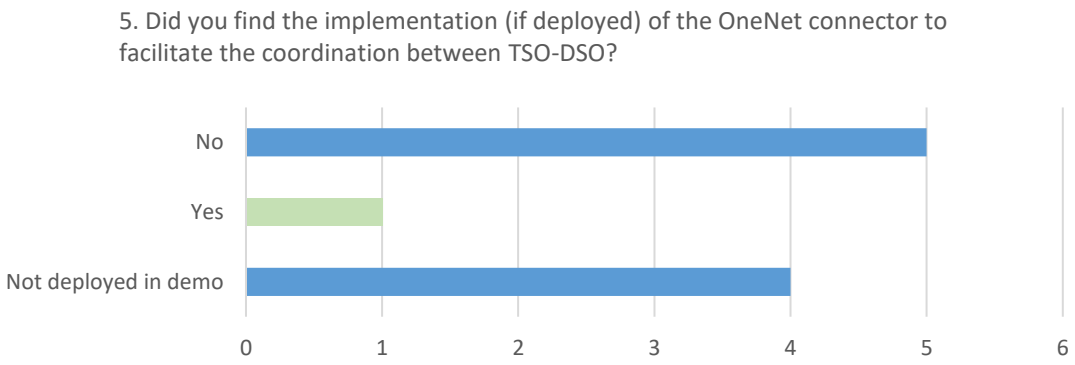

Figure 5-22: Regulatory and business processes - Question 5

Observations: Two Demos were able to deploy it (Portugal and France in a total of 3 partners).

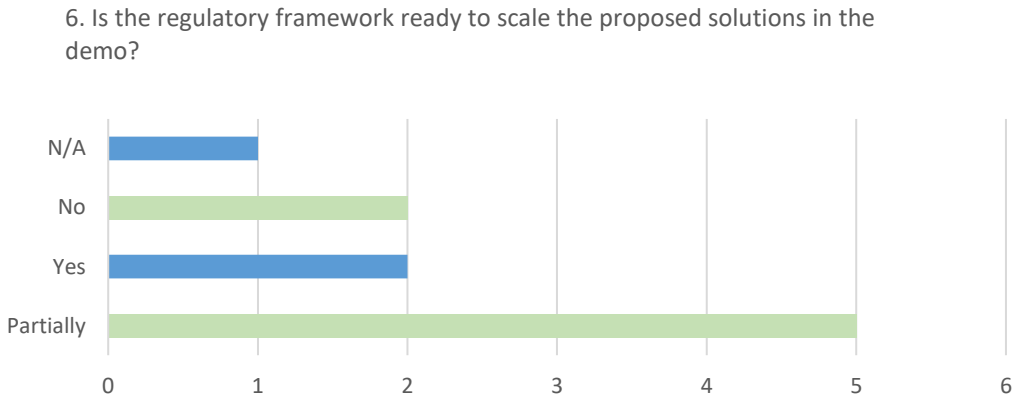

Figure 5-23: Regulatory and business processes - Question 6

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Requirements

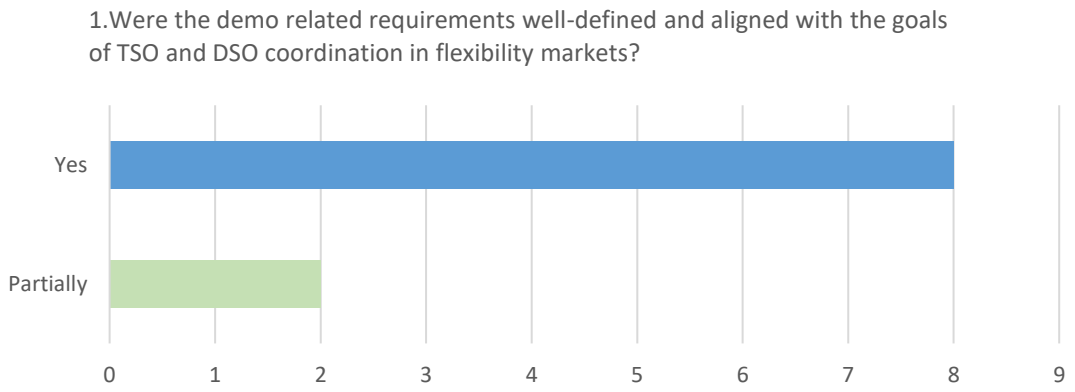

Figure 5-24: Requirements - Question 1

Observations: For a project this size more ambition could have been expected including the market phase of the coordination

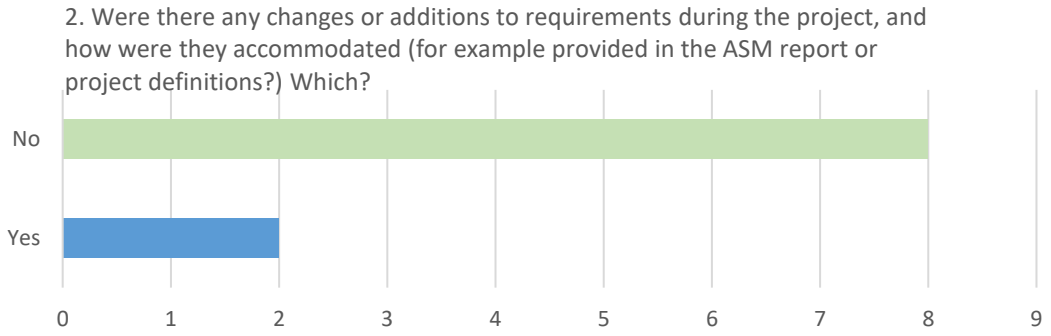

Figure 5-25: Requirements - Question 2

Observations: The "YES's" refer to Scope redefinition

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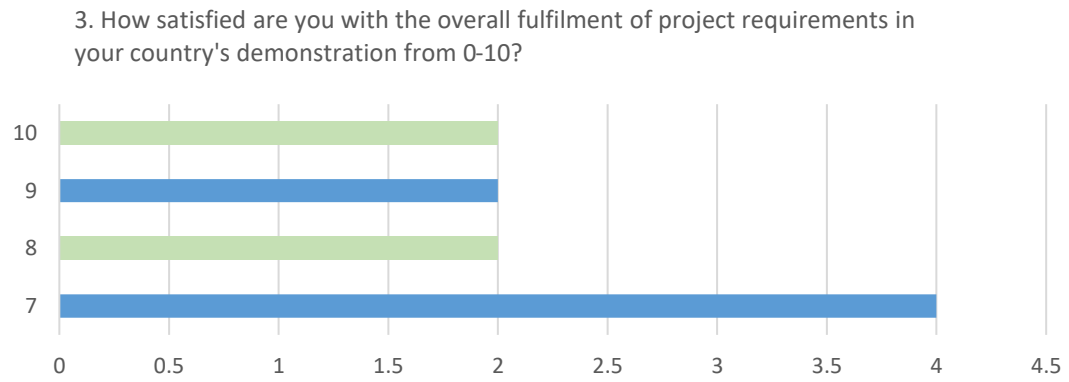

Figure 5-26: Requirements - Question 3

Observations: One partner reported for example that they missed the TSO participation in the markets for a global approach to flexibility markets in our demo.

Design and build

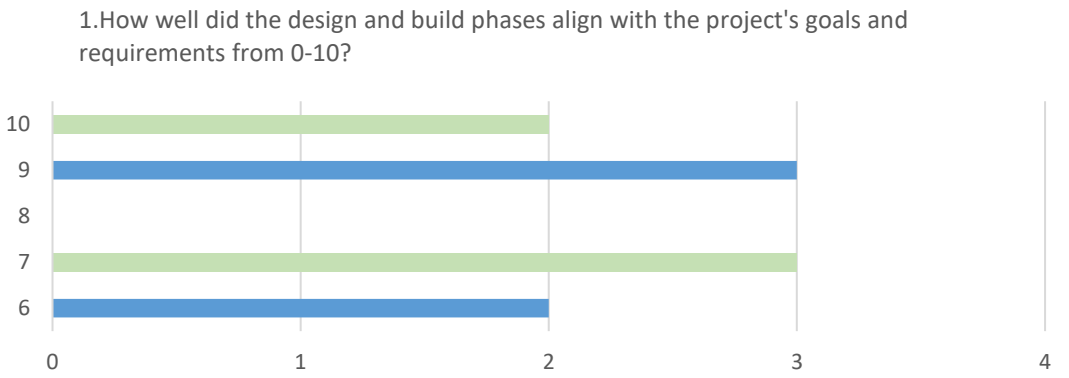

Figure 5-27: Design and build - Question 1

Observations: Could have been more ambitious to align with the project's goals aligning with the Active system management phases and also demonstrate market phase and monitoring and activation

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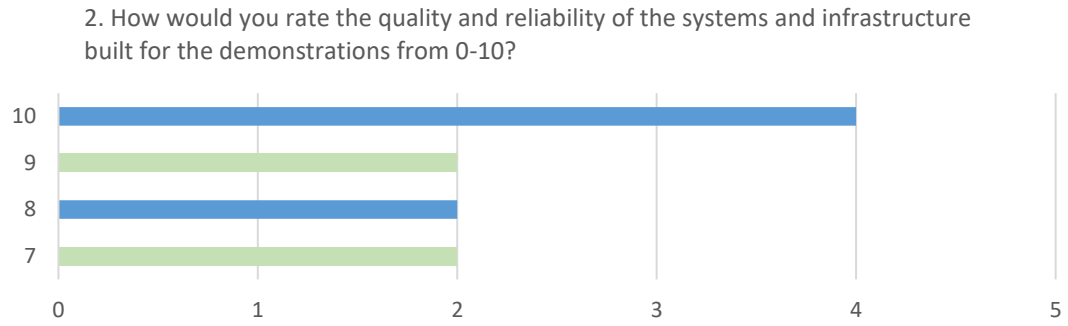

Figure 5-28: Design and build - Question 2

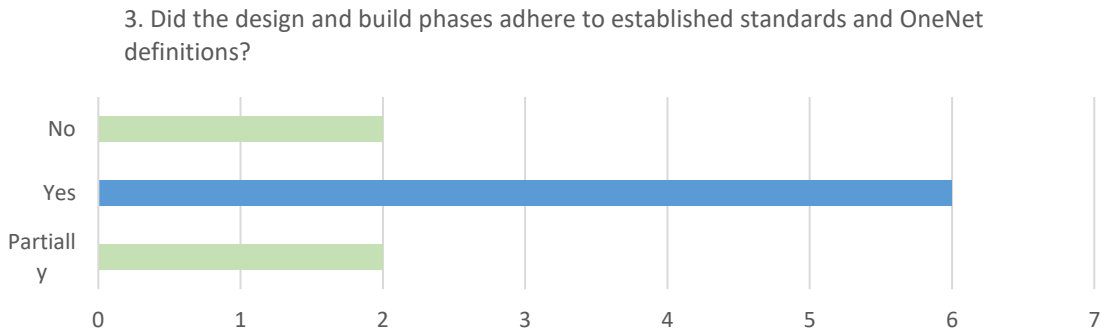

Figure 5-29: Design and build - Question 3

Observations: Not been able to use the Connector. Partially. We worked with a unified market system in Spanish demo developed by OMIE, but we didn´t use standards with other Demos, nor find it pertinent to use the Onenet Connector.

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Implementation/operational

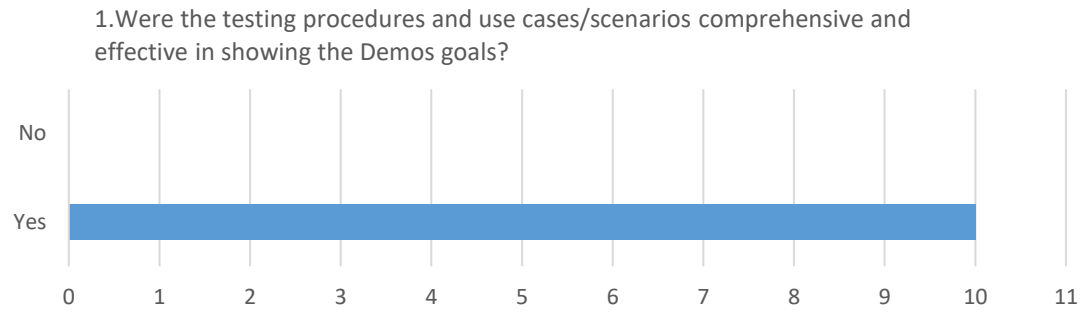

Figure 5-30: Implementation/operational - Question 1

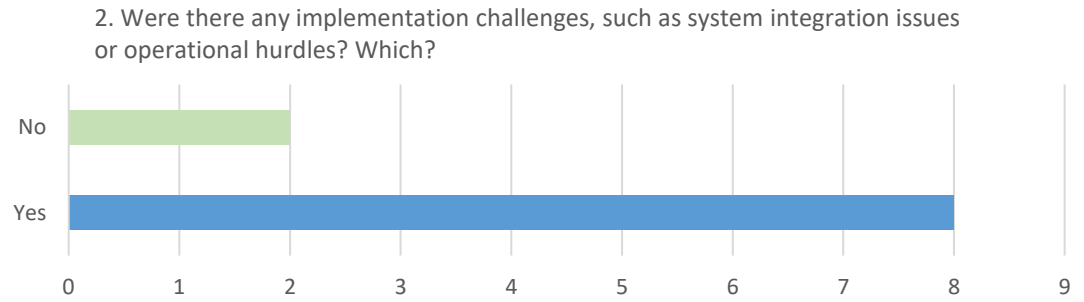

Figure 5-31: Implementation/operational - Question 2

Observations: 1 - Minor obstacles related to Data Availability; 2- Difficulties in communicating with resources (heating systems and control systems) 3- Difficulties deploying the OneNet Connector 4- Lack of timely development of the DSO platform 5- We had to agree on the availability of the FSPs for the tests, instead of the contrary, but we couldn´t ask for anything different as there were no incentives for them.

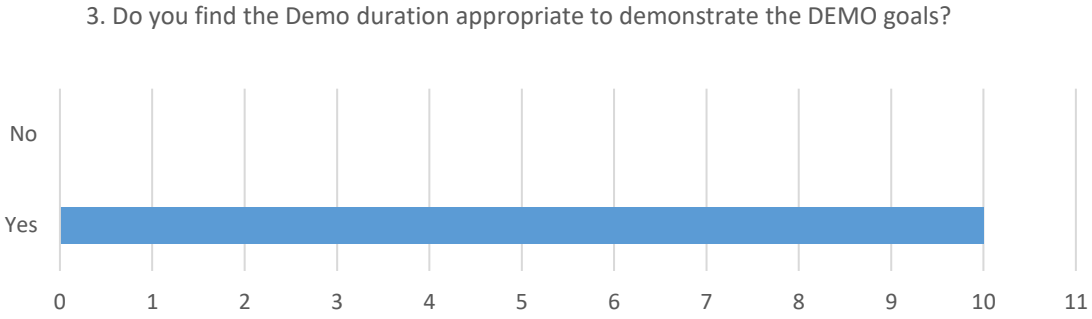

Figure 5-32: Implementation/operational - Question 3

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4. What lessons can be learned from the implementation phase for future projects in this domain?

- The Use cases could have been built around the OneNet Connector to highlight its features and developments. However due to the undefinitions of what the Connector would be lack of knowledge regarding the data spaces at the beginning of the project could not have been done differently.
- Accounting for the needed time for the deployment of the solutions is critical.
- Know well the cyber-security rules set by your company vs the cybersecurity requirements from any tool/service/development to be settled during the project.
- The architecture of blockchain solution should be well defined at the beginning considered data which should be in blockchain, and which data should be in "classic" database.
- Better aligning of objectives and prior evaluation of their adequacy with chosen technology.
- Customer engagement needs to start as soon as possible. Plan with enough time to have room for delays or in case you have to repeat some tests.
- Customer engagement strategies need to be further developed and customer-centric solutions.
- The participation of flexibility through a market-based approach and using the MO's market platforms makes more transparent, standardized, and easy both the negotiations and the IT connections with those platforms.
- Using buildings as loads leads to difficulties/resistances when activating demand response resources, especially when building managers' have the perception it can affect users' comfort.
- The traineeship of market participants (as DSOs, aggregators, etc.) in the use of local flexibility market platforms take some time, especially when these participants hadn't had contact with market trading before. Thus, enough time and resources should be schedule for this task.
- The methodology to assess the activation accomplishment by DERs is complex so enough time should be scheduled for this task.
- Customer engagement was the key factor to improve in general. As mentioned before, incentives need to be included, or having the FSPs as partners of the consortium.

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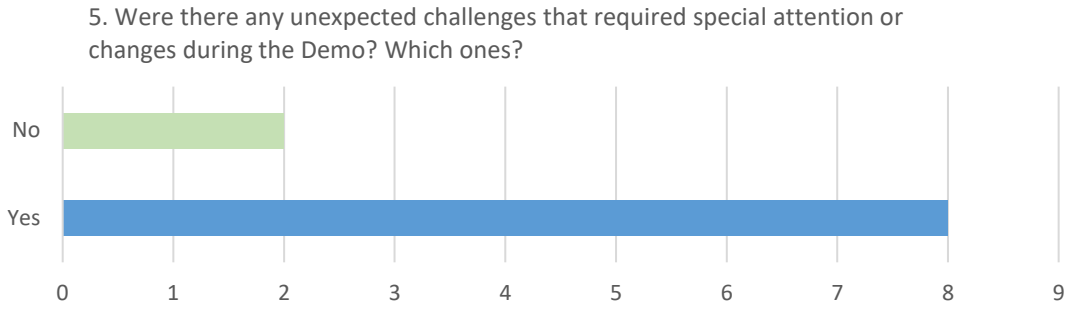

Figure 5-33: Implementation/operational - Question 5

Observations:

- Delays from one of the partners in the PT demo that faced a delay of one of the platforms to be tested required adjustments of scope, depth and timeline
- Due to delays in customer engagement, some tests were conducted in a forced situation during winter in Spain, and additional heating was required to test the cooling systems' flexibility capabilities, which were evaluated on Saturdays using the load before activation as baseline.
- Redefinition of the blockchain architecture due to difficulties in implementation and performance
- The availability of the FSPs has been a factor to be considered to program the tests. In a normal situation, the DSO should be the one to ask for a market due to a situation in the network that requires the help of flexibility.

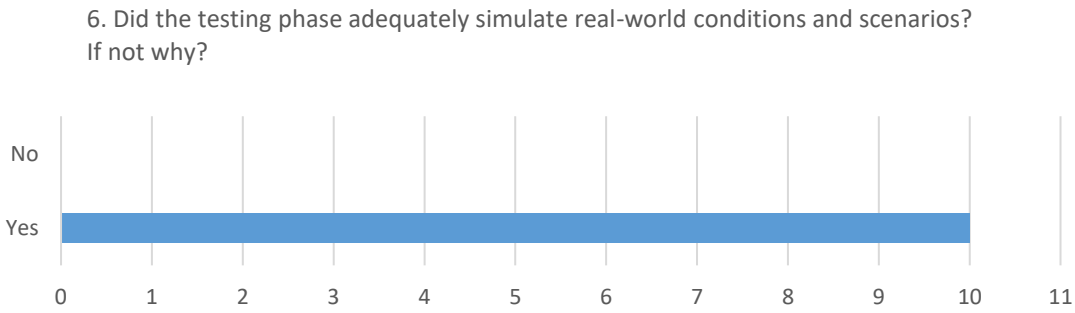

Figure 5-34: Implementation/operational - Question 6

Observation: Justified by the use of real resources, real data, real platforms from SO and roles played in the demonstrations

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Demo Recommendations and acknowledgements

Complementing the surveys and interpreting the results, several recommendations were provided in the course of the Demos.

Common feedback was that for the nature of the demonstrations, when consumer participation is required, strategies or mechanisms of incentives should exist, to promote engagement, such as open call. This could be done both for clarity or transparency but also to have wider access to data and participation. A related topic in promoting consumer engagement is the clarification of baselines establishment, so that all intervenient, but especially consumers, become aware of what was requested and expected from them.

Still regarding the consumer engagement, it was reported that all market organizations should be coordinated and aligned and only then consumers should be involved. An immature feeling by final consumers who get in touch with flexibility services for the first time, may lead to abandoning the concept before it starts.

Partners reported that pending regulation on flexibility was an added difficulty for the Demonstration. Whenever this happens easy access to sandboxes should be facilitated. Regarding the demo itself. Delays were observed to which a recognition of time to deal with subcontracting was noted. All partners should have been aware of the efforts in WP6, which despite all the workshops promoted did not reach many partners until the very end of the project and still some not at all. The potential visibility and replication that such a large project such as OneNet with over 70 partners could have to boost this particular dataspace Connector could have been taken advantage of. Regarding the use case specification themselves, a common observation was that, the use cases should have been aligned with the OneNet Connector. However due to lack of knowledge of its potential led to a miss alignment.

As a positive note, the Western Cluster partners reported to have been exposed to an excellent and stimulating environment in which definitions, products, market approaches and business models were matured and that this was the right group to do it, with such a rich participation and involvement of TSO, DSO, MO, companies, associations and research organizations. The coordination between system operators took a step forward in aligning understandings and defining procedures for future market cooperation, especially related to data exchange.

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5.2 Conclusions from the Demos

5.2.1 Spanish demo final take

The results showed that flexibility providers were able to deliver the contracted amount on time and for the duration set for almost all cases. The KPIs are computed and reported for each demo site test, showing in general positive results in terms of cost efficiency, accuracy of load forecast and asset load impact. However, some barriers were identified during the development of the Demos, including customer engagement challenges, maintaining customer comfort, baseline calculation, adjusting market production needs for industrial providers and lack of regulatory rules for incentives/penalties.

Lack of customer participation was identified as the biggest challenge, for that reason, demo site selection was motivated more by the feasibility to engage potential flexibility providers, in a trial framework than by network needs to be solved, which was simulated accordingly. To overcome the rest of the barriers, demo site dates (days and activation flexibility schedule) were explained in advance and selected in agreement with the engaged FSPs to avoid possible inconvenience to building users or production development in the case of industrial participants. In fact, the participation of the Market Operator in this demo assurance be under a real transparent a non-discriminatory market. Also helped to explain the market processes and coordinate all the information exchanged between the parties involved with the platforms. In addition, its contribution allows minimizing IT development barriers for participants since it allows them not only to understand the functioning of wholesale existing markets but also the integration them with local flexibility markets. It's true that maybe some of the value features detected during the test preparation in the platform, are still to be further developed, such as the absence of notifications to FSPs about the opening of an intraday market and the need for certain labels to provide complete information, but of course all the improvements will go hand in hand, with the regulation definition. Additionally, it is currently necessary to log onto in the long-term platform to consult information about which FSP has been awarded, as it is not available in the short-term platform.

Overall, the demonstrator highlights the potential of local flexibility markets to address network constraints detected by DSOs in a cost-effective manner. Nonetheless, further efforts are required to overcome the identified barriers and make these markets a reality. The demonstrator provides valuable insights into the challenges and opportunities of local flexibility markets and can inform future research and policy decisions in this area. The successful implementation of these objectives could pave the way for more widespread adoption of flexibility participation in the Spanish electricity market, leading to more resilient system and cost-effective solutions providing relevant inputs for the European development.

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5.2.2 Portuguese demo final take

The results from the Portuguese demo allowed for the calculation of the KPIs however this was partially attained for several reasons:

- Lack of further engagement of FSP to provide data. This was caused by the fact that at the beginning of the use case description, the substations were not identified, hence the areas from which FSP could be recruited from were unknown, and so the appropriate targeted recruitment initiatives were not possible.
- Disproportion in the size of the flexibility availability reported from the users and the Substation capacity. This happened because although the Demo used real that from FSP, the number of installations inside the flexibility perimeter defined were 3 to 10 stores. This caused the values offered as available flexibility (even though aggregated) to be order of magnitude lower that the HV substations.
- Lack of actual real congestion problems in the grid in the substations/lines used to be solved, resulted in some KPIs to be 0.
- Delay of the DDEP - DSO's Data Exchange Platform development did not allow for a full integration with the TSO side.

The delay of the DDEP however, meant that a second demo run had to be planned for December 2023. Nevertheless, and with this in mind, all the BUC and SUC chosen were demonstrated and the core goals of the Portuguese demo which revolved around the coordinated information specification and exchange for flexibility provision (including pre-qualification), grid operation and planning were achieved.

5.2.3 French demo final take

The results of the demonstration were a successful with a robust test coverage, carrying the planned tests and implementing production data. In a nutshell, the STAR platform was successfully designed to meet the requirements of the use cases' scenarios in terms of data model, shared governance and architecture. As envisioned, the blockchain technology helped achieve transparency and data uniqueness goals, and further analysis on pros and cons of the technology choices are described in D9.7 [3]. As all technical and functional tests were successfully executed, STAR has been running in experimental phase, focusing on registering automated and manual flexibility orders related to local congestion management.

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5.3 Western Cluster lessons

The Western Cluster Demos were complementary regarding the flexibility provision process. They provided use cases that dealt with message exchange for operational planning and flexibility needs identification and prequalification of FSP on one hand, and on the other the actual activation of flexibility both from loads and RES generation complemented with monitoring. As lessons learned from the Demos the following deserve to be highlighted:

- Feedback on 8 categories were collected: project management, resources, technic-economic, communication, regulatory and business processes, requirements, design and build, implementation/operational.
- All demonstrations achieved their goals. Successful project management and a collaborative environment was reported.
- More ambition was commonly identified as an opportunity for the project budget, size and partners (e.g.: mkt phase of the ASM report, actual SP prequalification test did not happen).
- All Demos faced challenged, adjustments in scope or delays.
- Delay in the definition and lack of understanding of the OneNet Connector's potential reach and vision was, harmfully impacted the shape of use cases, causing misalignment with what the actual project impact could have been.
- Lack of data access was reported a common difficult element to bring realism to the Demos.
- From the 10 partners, 4 deployed the OneNet Connector and 2 tested it exchanging demo data.
- Compliance with the FAIR approach.
- All partners reported enough and proper resources. Bad planning may have led to some delays.
- Costs of software and hardware for baselining, forecast and activations may hinder the flexibility business models with the foreseen low incentives.
- A common feedback was that for the nature of the demonstrations when consumer participation is required, strategies or mechanisms of incentives should exist to promote engagement such as open call. This could be done both for clarity or transparency but also to have wider access to data and participation.
- A related topic in promoting consumer engagement is the clarification of baselines establishment, so that all intervenient but especially consumers, become aware of what was requested and expected from them.
- Still regarding the consumer engagement is was reported that all market organizations should be coordinated and aligned and only then consumers should be involved. A feeling of immature business model by final consumers, may lead to abandoning the concept before it started.

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- Partners reported that pending regulation on flexibility was an added difficulty for the Demonstration. Whenever this happens easy access to sandboxes should be facilitated.
- Regarding the demo itself. Delays were observed to which a recognition of time to deal with subcontracting was noted.
- A common observation was that, the use cases should have been aligned with the OneNet Connector. However due the delay in the definition and lack of knowledge of its potential led to a miss alignment.

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6 Conclusions

The OneNet project provided an unmatched platform for cooperation, coming to an end with an impressive record of workshops, surveys, homogenization of concepts and dissemination of market related issues, in the context of system operator's coordination and flexibility services. To this purpose the Western Cluster provided valuable contributions to the project with its analysis, inputs, market flexibility procedures and use cases, visible from the interactions with ENTSO-E and E.DSO, and the sharing of experiences with different partners. Moreover, the Western Cluster successfully deployed 4 OneNet Connectors and tested it from different perspectives, enabling multiple recommendations to the OneNet Connector development teams.

The Western Cluster developed complementary BUCs, ranging from FSPs prequalification, information definition for operational planning, to actual load activation, generation curtailment and monitoring. From all the targets defined for the 40 estimated KPIs, 95% of them were reached. Not only all the KPIs were able to be estimated, but also the objectives of all BUCs were achieved.

For the Spanish demo, the results showed that flexibility providers were able to deliver the contracted amount on time and for the duration set for almost all case. All KPIs were assessed showing in general positive results in terms of cost efficiency, accuracy of load forecast and asset load impact. Lack of customer participation was identified as the biggest challenge. The demo ended up choosing the participants more willing to participate instead of choosing network areas with potential constraints. The Portuguese demo also reported difficulties in consumer engagement, reporting lack of diverse data to work with. It ended up choosing a supermarket chain with stores spread around the country which were used for the flexibility estimation. The Demo showed clear improvements when DSO-TSO coordination was promoted, especially in network operation clearly visible in the error forecast reduction, short circuit and values accuracy. The French demo also ended successfully, reporting a robust test coverage. The blockchain technology included in the demo was reported to have helped achieve transparency and data uniqueness goals but partners shared difficulties in the implementation. All demos were concluded within the lifetime of the project. Regarding the OneNet Connector deployment, partners reported common difficulties, especially related to assigning static IP addresses in their organizations and overcoming cybersecurity internal policies, restricting the use or installations of many of the OneNet Connector's requirements.

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Annex A Survey

Project Management:

Question	Answer
1.Have the overall goals, timeline and milestones been achieved during the demonstrations in your country? If not why?	
2. Did the project management/demo leader team effectively address any unexpected challenges or delays that arose during the project?	
3. Were project goals and objectives clearly communicated and understood by all involved partners?	
4. Were regular project status updates and communication channels effective in keeping you informed about project progress?	
5. How would you rate the project management/demo leader team's responsiveness to your concerns and feedback throughout the project from 0-10?	

Resources:

Question	Answer
1.Were the necessary resources from your side put in place to achieve demonstration goals effectively?	
2. Were there any challenges in securing the required human resources	

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(e.g., experts, technicians) for the project?	
3. Were the physical resources (e.g., equipment, infrastructure) sufficient and appropriate for the simulations and demonstrations?	
4. Did the project face any resource constraints or shortages that impacted the quality or outcomes of the demonstrations?	
5. How would you rate the allocation and utilization of resources in your country's demonstration from 0-10?	

Technical-economic:

Question	Answer
1.Were the technical solutions and tools used in the simulations and demonstrations effective in achieving the project's objectives? If not why	
2. Were there any technical issues or limitations that hindered the smooth execution of the simulations and demonstrations? Which?	
3. Are the technical solutions tested technically feasible to implement in the country?	

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4. Were there any unexpected technical challenges that emerged, and how were they addressed? Which?	
5. What improvements or enhancements would you suggest for the technical aspects you encountered?	

Communication:

Question	Answer
1.How would you rate the clarity and effectiveness of communication among project stakeholders, including TSOs, DSOs, and other partners from 0-10?	
2. Were communication channels open and accessible for sharing feedback and discussing project-related matters?	
3. Did the project facilitate effective knowledge sharing and collaboration among participants from different countries/Demos?	
4. How satisfied are you with the documentation and reporting of the Demo information including the FAIR approach (Findability, Accessibility, Interoperability, and Replicability)?	

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Regulatory and Business Processes:

Question	Answer
1.Do you expect the existing business processes for TSO and DSO coordination to be effectively integrated into flexibility markets?	
2. Did the project identify and address any bottlenecks or inefficiencies in the existing business processes? Which?	
3. Were there any compliance or regulatory challenges related to the business processes in your country's demonstration? Which?	
4. What suggestions do you have for further improving business processes in the context of flexibility markets?	
5. Did you find the implementation (if deployed) of the OneNet Connector to facilitate the coordination between TSO-DSO?	
6. Is the regulatory framework ready to scale the proposed solutions in the demo?	

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Requirements:

Question	Answer
1.Were the demo related requirements well-defined and aligned with the goals of TSO and DSO coordination in flexibility markets?	
2. Were there any changes or additions to requirements during the project, and how were they accommodated (for example provided in the ASM report or project definitions?) Which?	
3. How satisfied are you with the overall fulfilment of project requirements in your country's demonstration from 0-10?	

Design and Build:

Question	Answer
1.How well did the design and build phases align with the project's goals and requirements from 0-10?	
2. How would you rate the quality and reliability of the systems and infrastructure built for the demonstrations from 0-10?	

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3. Did the design and build phases adhere to established standards and OneNet definitions?	

Operational/ Implementation:

Question	Answer
1.Were the testing procedures and use cases/scenarios comprehensive and effective in showing the Demos goals?	
2. Were there any implementation challenges, such as system integration issues or operational hurdles? Which?	
3. Do you find the Demo duration appropriate to demonstrate the DEMO goals?	
4. What lessons can be learned from the implementation phase for future projects in this domain?	
5. Were there any unexpected challenges that required special attention or changes during the Demo? Which ones?	
6. Did the testing phase adequately simulate real-world conditions and scenarios? If not why?	

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