one network for Europe

EU wide implementation of market schemes and interoperable platforms
D11.7

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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.

Table of Contents

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

List of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

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List of Abbreviations and Acronyms

Acronym	Meaning
AB	Advisory Board
API	Application Programming Interface, which is a set of definitions and protocols for building and integrating application software
BRP	Balance Responsible Party
BSP	Balancing Service Providers
BUC	Business Use Case
CIM	Common Information Model
DER	Distributed Energy Resource
DSO	Distribution System Operator
EHV	Extra High Voltage
EU	European Union
FCR	Frequency Containment Reserve
FR	Flexibility Register
FRO	Flexibility Register Operator
FSP	Flexibility Service Provider
GCT	Gate Closure Time
GUI	Graphical User Interface
HEMRM	Harmonised Electricity Market Role Model
HV	High Voltage
ICT	Information and Communication Technology
IDS	International Data Spaces
IMO	Independent Market Operator
IT	Information Technology
LMS	Local Management System
LT-P-C	Long-term capacity
LT-P-C/E-res	Long-term capacity/energy for reservation stage
LT-P-C/E-act	Long-term capacity/energy for activation stage
LV	Low Voltage
MARI	Manually Activated Reserves Initiative
MO	Market Operator
MV	Medium Voltage
NCDR	Network Code Demand Response
NGSI	Next Generation Service Interface
NGSI-LD	Next Generation Service Interface – Linked Data
NOCL	Northern Cluster

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NRT-P-E	Near real-time active energy
PICASSO	Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
RES	Renewable Energy Sources
SCADA	Supervisory Control and Data Acquisition
SDO	Standards Development Organizations
SO	System Operator
ST-P-C/E	Short-term active capacity/energy
TERRE	Trans European Replacement Reserves Exchange
TLS	Traffic Light Scheme
ToE	Transfer of Energy
TSO	Transmission System Operator

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Executive Summary

OneNet aims to develop solutions to reach the objective of consumer-centric, coordinated and integrated markets, and interoperable platforms. An initial step is to define what is meant with a consumer-centric, coordinated and integrated market. OneNet defines consumer-centricity as the practice or ability of putting the consumer at the centre of all the decisions made by a firm, a regulatory authority, or a policymaker, including (1) the identification of the value for the consumer, (2) assessment of how the consumer experiences its participation to the market, (3) considering different consumer preferences. Coordination is defined as the activities related to processes and interactions between stakeholders while integration focusses on aspects related to fair and equal inclusion of technologies, flexible sources, and stakeholders in the market.

The goal of a consumer-centric, coordinated, and integrated market design, supported by the emergence of interoperable platforms, can be achieved by the realization of **8 objectives**, summarized in Figure 0. The objectives are grouped according to the 3 main OneNet pillars: (1) Consumer-centricity, (2) Common Market Design, and (3) Common IT Architecture. Four objectives are related to Coordination and four objectives are related to Integration.

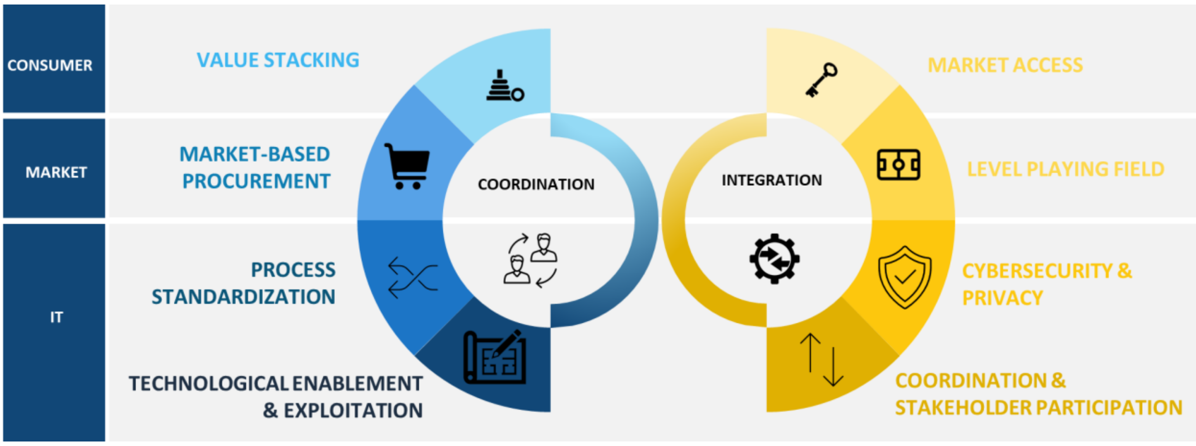

Figure 0.1.1: Objectives of Consumer-centric, coordinated and integrated markets.

This document presents the OneNet solutions to achieve a consumer-centric, coordinated, and integrated market in a comprehensive way, clustered according to two main axes: (1) Market Design and (2) Interoperability. Coordination. For each topic, key messages, main solutions, and recommendations are formulated. Each of the topics supports multiple objectives as presented in Figure 0.1.1.

The implementation of the OneNet solutions is a necessary condition to progress towards a wider European coordination and integration. However, several economic, regulatory, and technical barriers exist that hinder the adoption and implementation of the OneNet solutions. To resolve barriers that block implementation or to leverage more on possible enablers, regulatory intervention is needed. Regulatory intervention can take place

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at European level, national level or local level, dependent on the trade-off between European harmonisation or a more tailored local approach.

Today, many barriers block large-scale **consumer engagement and market participation**, even though this is indispensable to ensure sufficient flexibility is available at lower voltage levels. On top of the solutions discussed below, OneNet highlights four additional overarching solutions to boost consumer engagement, ranging from setting up consumer-engagement strategies by offering operational guidelines to tackle all identified barriers, and developing business models from a multi-stakeholder perspective, to offering insights on consumer centricity in different TSO-DSO coordination schemes and facilitating aggregation while accounting for local grids' limitations. To implement all these solutions properly, OneNet recommends initiating more bottom-up consumer awareness and information creation campaigns and to take away financial and economic uncertainties by clarifying incentive mechanisms. A stakeholder analysis at local level is needed to identify who should be in charge of different responsibilities, and who should be targeted and incentivized.

New flexibility **products and services** are needed to address upcoming challenges for system operation. In particular, services for congestion management and voltage control require new products. To maximize market participation and coordination between system operators, a harmonized product approach at EU level is needed. OneNet developed a product framework that allows a standardized classification of product attributes. Next, OneNet proposes six harmonized products for system operation, spanning multiple time frames, based on both active or reactive power, applicable to both frequency and non-frequency products. Product harmonisation is hindered due to different stages of national market development, different requirements between platforms or different grid conditions. However, a common terminology is addressed in the new Network Code for Demand Response (NCDR). Yet, a balance is needed between harmonisation and customization to address local needs and allowing a stepwise process considering different maturity and liquidity levels of DSO and TSO markets.

Clearly defined **roles and responsibilities** are a cornerstone in the (new) tasks and activities that emerge in the new market design. The Harmonised Electricity Market Role Model (HEMRM) outlines relationships and responsibilities among various electricity system actors. However, certain roles, such as DSO, TSO, FSP, Local Management System, Flexibility Register Operator, and Optimisation Operator, are not adequately addressed. This gap has resulted in complexities, particularly in modelling TSO-DSO markets for system services. OneNet provides a thorough assessment and definition of new roles, giving special attention to roles responsible for bid forwarding, ensuring grid safety in the process. The draft NCDR also addresses roles and responsibilities in various aspects, however, initial investments in infrastructure and technology may impede the adoption of new or adapted roles. Additionally, market innovations may potentially render OneNet definitions outdated. Therefore, ongoing review and adaptation of definitions are essential to address emerging gaps.

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As the flexibility is increasingly expected to be provided from all grid voltage levels for services that can be delivered to both TSOs and DSOs, the advancement of **TSO-DSO coordinated flexibility markets** becomes ever more essential to (i) maximize the value stacking potential of flexibility, and (ii) ensure the secure operation of all grids involved during flexibility procurement and activation. OneNet worked on the advancement of different fundamental TSO-DSO coordinated market models exhibiting different efficiency levels and sensitivities to various driving parameters. This is simulated in the OneNet flexibility markets simulation environment, while accounting for FSP strategic behaviour. In general, the common or multi-level markets would be recommended, due to their efficiency and participation benefits. However, this would require the set-up of joint or coordinated market platforms requiring the exchange of network information. Through the different demo activities, OneNet has implemented and tested such market mechanisms, enabling their further scalable implementation.

The ability to use flexibility to (i) reliably meet the grid service's needs, ensuring grid safety in the process, while (ii) reducing the barriers for FSP participation, requires adequate, coordinated, and harmonized **Prequalification** mechanisms. OneNet has focused on addressing entry barriers such as: the non-harmonized resource registration and settlement processes, the miscoordination of the prequalification phases when considering similar products traded in different markets, the timing of the prequalification phases with respect to the time gap with the trading phase, and the limited alignment on the use of baseline methodologies. In addition, OneNet has established flexibility register tools capable of streamlining resource registration, information access and coordination between different stakeholders (FSPs, SOs, IMOs). As such, the flexibility register can act as a single point of contact for SOs, MOs and FSPs, further harmonizing and simplifying the prequalification process while not compromising on grid safety and the reliability of service delivery. The setting up of flexibility registers and the coordination/harmonisation of prequalification mechanisms can face economic, regulatory, and technical challenges stemming from the initial costs of development and implementation, the perceived difficulty in changing current processes as part of a collaboration among a multitude of partners, non-clarity regarding the requirements of the new prequalification processes, and privacy concerns when sharing data. However, demonstration and pilots such as the ones set up in OneNet address those challenges, taking into account the perspectives of all key stakeholders, and provide first steps to scalable implementation of these solutions.

Advancing coordination, participation-boosting, and efficiency mechanisms in the **Procurement** phase play a primary role in enabling the efficient and reliable functionality of flexibility markets. OneNet has introduced theoretical market frameworks acting as a blueprint for establishing novel flexibility markets and the integration between markets. In addition, OneNet has introduced and implemented TSO-DSO coordinated market platforms, supporting the effective coordination between TSOs, DSOs, FSPs, and IMOs in the procurement of flexibility. OneNet has also introduced an optimization-based market clearing engine (market clearing algorithms), allowing the optimal and grid-safe clearing of flexibility markets. This market clearing engine allows meeting the TSOs and DSOs flexibility needs at minimum cost simultaneously, while supporting the trading of

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different types of products and ensuring that operational constraints are respected. OneNet has also introduced a concept of bid forwarding, whereby flexibility bids, when not cleared in an initial market in which they were participating can be automatically forwarded to subsequent markets. The introduction of these solutions can face (i) economic challenges due to the perceived high costs of setting up and operating flexibility markets and procurement platforms, (ii) regulatory challenges due to differing market set ups and services needs for different SOs in different countries, and (iii) technical challenges pertaining to the technical requirements of developing the needed platforms, tools, and algorithms, and the network models which can be required. However, regulatory support is needed to support the integration and coordination between markets to enable bid forwarding mechanisms and other forms of multi-market participation of flexibility resources. OneNet has demonstrated the technical feasibility of the developed solutions (market platforms and market clearing engines/algorithms). The next step would consist of scaling up those solutions, looking at either repeated/interoperable implementation instances, or pan-European applications, and the introduction of any regulatory gaps to support their wide-scale implementation.

Baseline methodologies play a crucial role in determining the actual volume of flexibility delivered and utilized during activation control and settlement processes. Choosing the appropriate baseline methodology for **settlement and baselining** is therefore of paramount importance, considering factors such as simplicity, accuracy, and integrity. Within the OneNet project, a six-question framework is introduced to elucidate regulatory options regarding baseline methodologies. This framework addresses questions about the application scope, grid operational states, responsibility for baseline setting, customer and DER types, and product specifications. OneNet also offers an overview of baseline definition methods, enriched with insights from demonstration projects for practical implementation. The framework underscores the need for flexibility in methodology selection, which hinges on various factors including stakeholder expertise, regulatory parameters, and technical characteristics of the service.

Ensuring **SO's needs** continue to be met as focuses shift to consumer-centric models is essential for efficient network and market operation. As prosumers and DERs entering networks grows, the ability to predict system states and communicate between SOs becomes more complicated and necessary. OneNet has developed tools that address these needs and were tested within the demonstrations. Many of these tools provide more accurate forecasting of the network status and flexibility needs in both the short- and long-term and include weather impacts in their predictions, while others focus on data exchange between SOs and provide clear indications to FSPs about the impacts of their flexibility. While it is true that the problems of network visibility and data sharing can be solved in the long-term via full deployment of smart, or sub-meters, for the former, and the adoption of a uniform data structures along with updated data privacy policies for data sharing between SOs, the solutions presented by OneNet here are easily implemented in the short- and medium-term.

Now on the interoperability pillar, OneNet has made substantial strides in **process standardization**, by fostering interoperability, scalability, and data ownership. The project integrates recommendations from IDS and FIWARE, utilizes standards like CIM, and introduces the OneNet Information Model based on the NGSI-LD standard. This collective approach ensures seamless interaction among OneNet participants, promoting a high level of standardization crucial for scalable and interoperable solutions.

Recognizing the paramount importance of **cybersecurity and privacy**, OneNet has developed comprehensive strategies to enhance the resilience of data exchange tools and infrastructure. It proposes a suite of recommendations, tools, and frameworks to bolster cybersecurity measures and privacy protections, addressing the sector's growing threats and concerns.

The project underscores the importance of scalable and replicable solutions to enhance **technological enablement and exploitation** across the energy sector. By advocating for standardized data models and investing in adaptive IT infrastructure, OneNet facilitates the integration of various stakeholders, fostering a decentralized data space concept that promises greater interoperability and efficiency.

To empower **stakeholder participation and enable efficient coordination**, OneNet emphasizes the implementation of standards and transparent data use. Recommendations include clear role definitions, duty separation, and the adoption of scalable, user-friendly architectures, which are essential for the seamless integration of new market parties.

The OneNet project's innovative solutions significantly contribute to the sector's digitalization and energy transition. However, the adoption of these solutions hinges on overcoming identified barriers and leveraging enablers at both national and EU levels. The project outlines a comprehensive roadmap detailing specific solutions, barriers, and enablers, emphasizing the importance of regulatory and economic considerations in fostering the adoption of interoperable solutions.

The feedback from the GRIFOn event underscores the necessity of addressing technical, economic, and regulatory aspects to enhance interoperability. The consensus points towards the crucial role of clear role definitions, user-friendly interfaces, and a regulatory framework that supports flexible and inclusive market participation.

In summary, the OneNet project sets forth a visionary framework for the energy sector's future, proposing 24 key recommendations across four main pillars for interoperability. These recommendations aim to standardize processes, enhance cybersecurity, enable technological advancements, and foster stakeholder engagement, thereby facilitating a more integrated, secure, and efficient energy landscape.

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1 Introduction

The European energy system is transitioning towards a more decarbonized, decentralized and consumer-centric system to achieve the ambitious EU Climate objectives. The decarbonization of the electricity supply requires amongst others increasing the electrical energy generated by renewable energy sources (RES) which requires the power system to operate in a more flexible and adaptive way to capture the intermittency of RES while safeguarding security of supply and grid stability at a reasonable cost. In that perspective, the role of new flexibility services, including all novel regulation, tools and processes, are a central topic of attention. 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. As a result, while creating one network for Europe, the project aims to build a customer-centric approach to grid operation. This ambitious view is achieved by proposing new markets, products and services and creating a unique IT architecture.

OneNet presents a large array of solutions to reach the overall objective to move from fragmented markets in isolation towards consumer-centric, coordinated and integrated markets, and interoperable platforms. The objectives are summarized in OneNet D3.2. The goal of a consumer-centric, coordinated, and integrated market design, supported by the emergence of interoperable platforms, can be achieved by the realization of **8 objectives**. The objectives are grouped according to the 3 main OneNet pillars: (1) Consumer-centricity, (2) Common Market Design, and (3) Common IT Architecture. Four objectives are related to Coordination and four objectives are related to Integration. Coordination is defined as the activities related to processes and interactions between stakeholders while integration focusses on aspects related to fair and equal inclusion of technologies, flexible sources, and stakeholders in the market.

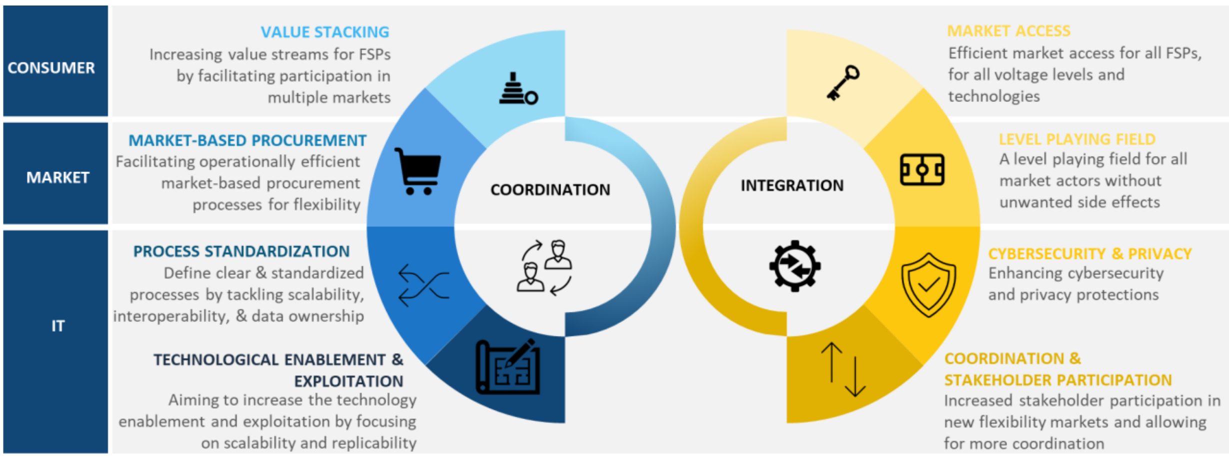

Figure 1.1: Objectives of Coordinated and Integrated Markets and Platforms

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The work presented in this deliverable will focus on how we can ensure that the OneNet solutions, developed to reach the overall objective of coordinated and integrated operable platforms, will be adopted, implemented and scaled-up within Europe. Consequently, recommendations are developed that should eliminate existing barriers for implementation and which enablers could be used to accelerate the uptake of the OneNet solutions.

1.1 Description of WP11 and Task 11.7

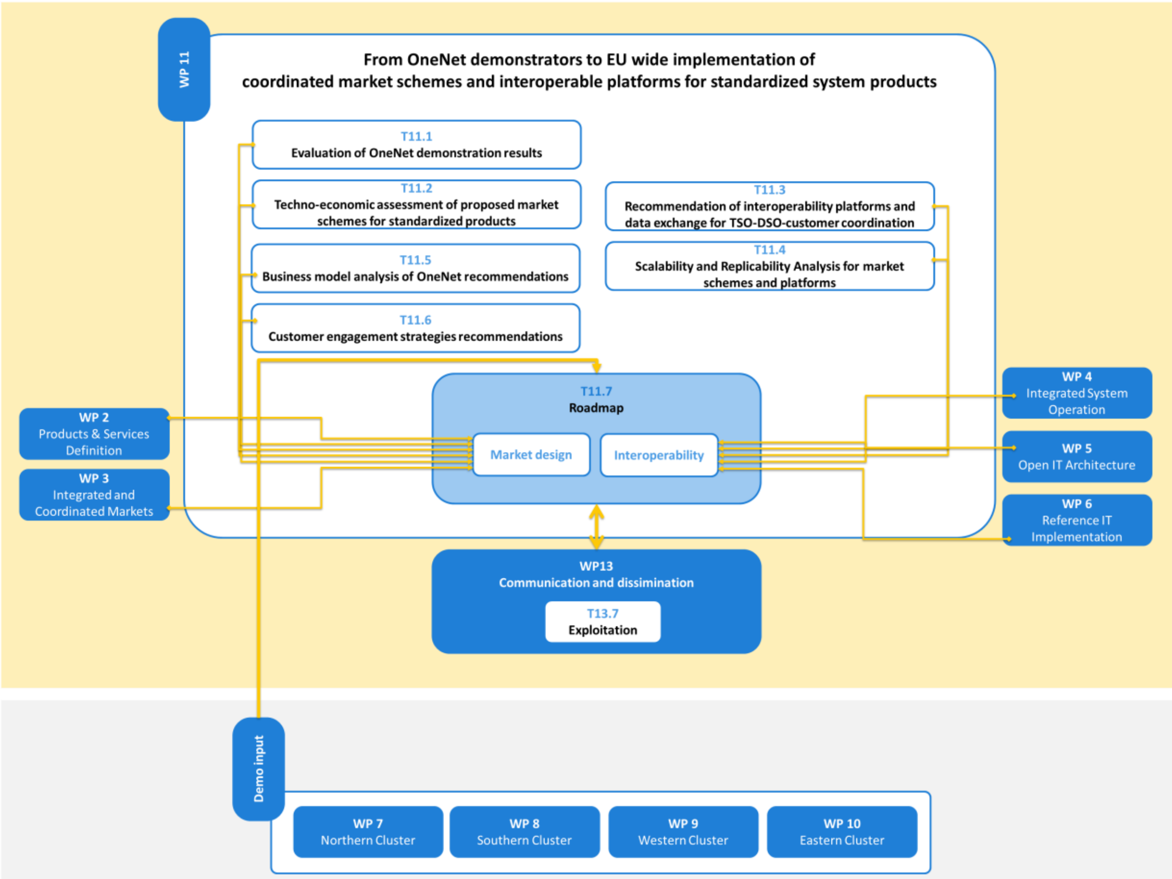

Figure 1.2: Relation between T11.7 and other OneNet WPs

This document presents the results of Task 11.7 'EU wide implementation challenges of market schemes and interoperable platforms. T11.7 is the final task of Work Package 11 (WP11). WP11 summarizes the main conclusions coming from the different demonstrators and research activities within OneNet, including 1) the quantified results of the demonstrators (T11.1), 2) techno-economic assessment of the OneNet market schemes (T11.2), 3) recommendations on interoperability and data exchange (T11.3), 4) replicability and scalability assessment for market schemes and platforms (T11.4), 5) business model analysis of OneNet solutions (T11.5), 6) recommendations for customer engagement strategies (T11.6). T11.7 concludes WP11 and is also one of the final deliverables of the OneNet project. It provides an overview of the technical, economic, and regulatory challenges to implement the OneNet solutions, and consequently proposes relevant policy recommendations

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to overcome these implementation challenges and to achieve wide implementation and scaling-up of the OneNet solutions.

T11.7 relies on input from several other tasks and activities within OneNet. An overview of the structure of T11.7 is provided in Figure 1.2. T11.7 is composed of two distinct work streams: 1) **market design** and 2) **interoperability.** The conclusions from these two work streams also represent the final result of 2 main OneNet documents: 1) Market Design for OneNet and 2) Interoperability Strategy for OneNet.

1.2 Outline of the Deliverable

This deliverable is composed of 6 chapters.

- Chapter 1 introduces the deliverable, highlighting the role of the work within the context of OneNet, including the relation between other tasks and OneNet activities.
- Chapter 2 describes the methodology that has been used to analyse the solutions presented across all OneNet's deliverables and demos. This chapter further details how these solutions have been grouped by common themes to simplify their dissemination. It also explains how each of the thematic areas is structured within the report.
- Chapters 3 and 4 present these thematic areas for the OneNet topics of **Market Design** (chapter 3) and **Interoperability** (chapter 4), respectively.
- Chapter 5 presents the main conclusions of the work. Chapter 6 contains the references.

1.3 How to Read This Document

The information presented in this document assumes the readers has prior knowledge regarding certain topics. With the topics presented in the Market Design portion, an understanding of European electricity and flexibility markets, and their current regulation landscapes, is presumed. Likewise, the Interoperability topics

anticipate knowledge surrounding such topics as information systems, network security, and existing communication protocols.

This deliverable is a summary of the OneNet solutions. As a result, it only provides an overview of the main messages from OneNet. More details surrounding what is presented in this document can be found in the OneNet deliverables referenced throughout the text.

2 Methodology

The objective of T11.7 is to propose recommendations to support a wide-scale adoption, implementation and scaling-up of the OneNet solutions. The methodology is summarized in Figure 2.1

- Initially, the list of OneNet solutions has been summarized and organized into 2 large work streams: 1) **market design** and 2) **interoperability.** The work stream on market design focusses on the OneNet pillars for **Consumer-centricity** and **Common Market Design**, while the workstream on interoperability focusses on the third pillar, i.e., a **Common IT Architecture** (see also section Introduction). Each of these work streams has been further sub-divided into a selection of key messages. All of the OneNet deliverables have been reviewed to collect, assess and cluster the developed solutions.
- Following this categorization, we conducted an in-depth analysis to identify both **enablers and barriers** associated with the implementation of the solutions within each thematic area separately. Enablers are factors that facilitate success and implementation of the OneNet solutions, while barriers are factors that may hinder their progress. The enablers and barriers were collected via surveys and workshops with OneNet partners. We examined these factors from **regulatory, economic, and technical perspectives** to gain a comprehensive understanding of the challenges and opportunities present.
- Furthermore, we identified the **level of impact or appropriate level of intervention** for each barrier and enabler. This categorization included considerations such as whether the intervention should be at **the local (L), national/country (C), or European level (E)**, as well as the **applicable timeframe**, which we categorized as Short-term (S before 2025), Medium-term (M, between 2025 - 2030), or Long-term (L, beyond 2030). The assessment of both the timeframe and level of intervention is based on stakeholder surveys within OneNet, workshops with OneNet partners combined with relevant expert views.

The table below is an illustration of this assessment. The level of implementation and the applicable timeframe are in **yellow-bold.** For some enablers and barriers, multiple implementation levels or timeframes are possible.

Enablers/Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E(conomic)	Explication of an economic enabler/barrier	L **C** E **S** M L

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R(egulatory)	Explication of a regulatory enabler/barrier	L **C** **E** S **M** L
T(echnical)	Explication of a technical enabler/barrier	L **C** E **S** M L

- To ensure that we captured **diverse stakeholder perspectives** on the identified barriers and enablers, we organized a GRIFOn [1] /BRIDGE workshop on 27/02/2024 with the involved stakeholders. This allowed us to gather insights from various viewpoints and ensure comprehensive coverage of potential challenges and opportunities. Additionally, the recommendations have been shared with both the OneNet advisory board (AB) and external stakeholders via a dedicated public consultation process to gather opinions from a broader range of stakeholders. This inclusive approach aims to incorporate feedback from all relevant parties and enhance the robustness of our analysis and recommendations.

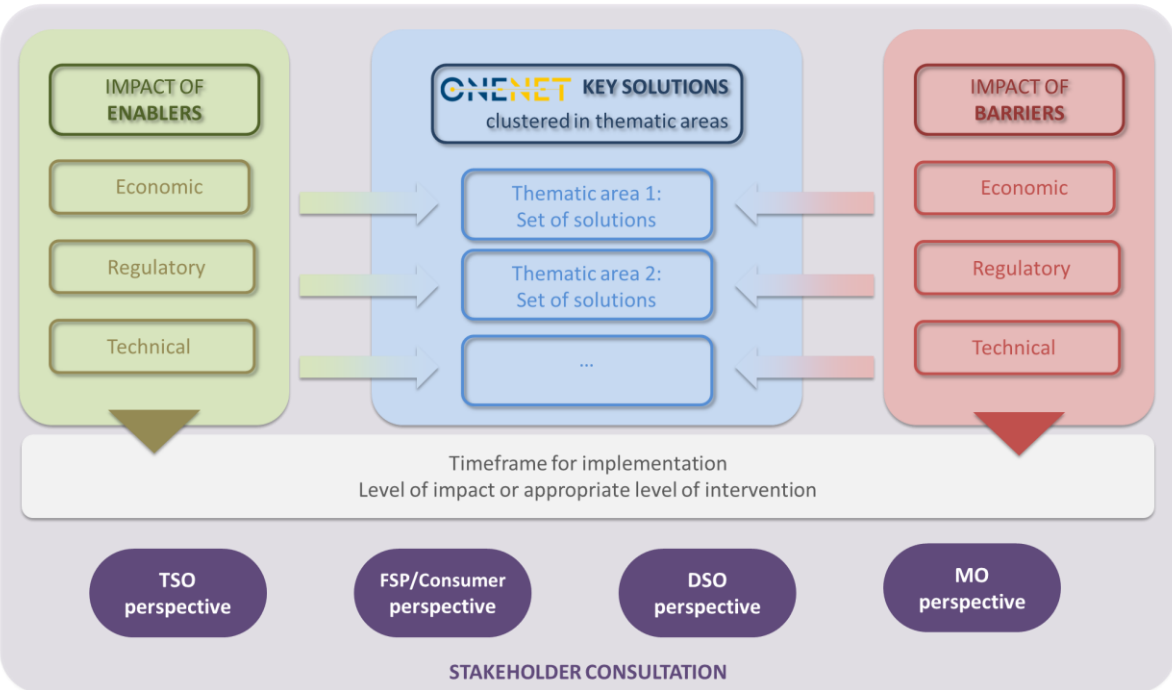

Figure 2.1. Schematic of the solutions framework utilized in T11.7.

[1] European GRID Forum: an initiative developed within OneNet to engage with stakeholders on a continuous basis.

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3 Market Design

As the European system transitions from a centralized to a decentralized design, the need for improved coordination and integration between TSOs and DSOs becomes all the more necessary to unlock flexibility.

The objectives focussing on Market Design (including both the OneNet pillars for **Consumer-centricity** and **Common Market Design)** are presented in Figure 3.1.

Figure 3.1: The distinct objectives of coordinated and integrated markets

To reach these objectives, OneNet analysed the main challenges within WP3 to overcome and for which accordingly, solutions needed to be developed. The overview of challenges to move towards consumer-centric, coordinated and integrated markets are presented in OneNet D3.2.

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Figure 3.2: Overview of the barriers that are addressed by each objective of coordinated and integrated markets.

OneNet developed multiple solutions that will enable to tackle the listed challenges and to reach the objectives of coordinated and integrated markets. The solutions are clustered into 8 key messages, including main barriers and enablers for implementation. Each key message concludes with policy recommendations how implementation of the solutions could be maximally supported. Table 3.1 provides an overview how the key messages contribute to the realisation of the 4 initial objectives of coordinated and integrated markets linked to the consumer and market pillar. The objectives are listed on the Y-axis.

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Table 3.1: Mapping between OneNet key messages and the objectives of coordinated and integrated markets that are targeted by the project.

	ONENET KEY SOLUTIONS clustered in thematic areas	Value Stacking	Market Access	Market-Based Procurement	Level Playing Field
Market Design	Market Participation & Consumer Engagement	●	●	●	●
	Products & Services	●	●	●	
	Roles & Responsibilities	●	●	●	●
	TSO-DSO Coordination Schemes	●	●	●	●
	Prequalification	●	●	●	
	Procurement	●		●	
	Settlement & Baselining		●	●	●
	SO's Needs	●	●		●

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3.1 Market Participation & Consumer Engagement

KEY MESSAGE:

With the transition from a centralized to a decentralized energy system, all SOs face a growing need for flexibility at grid lower voltage levels to support their safe and efficient operation. Given the fact that many new grid needs relate to local issues (congestions, voltage problems), it is not economically efficient for SOs (both DSOs and TSOs) to have own assets in each location to resolve them. In addition, the increase in renewables beats the speed of grid reinforcement. A wide-scale engagement and participation of consumers, located in these grids, is therefore needed to ensure sufficient liquidity is available to deliver the needed flexibility in the lower voltage grids.

Unfortunately, today, markets for flexibility provision at lower voltage levels are less developed compared to the flexibility provision for TSOs: there continue to be numerous economic, behavioural, legal and technical barriers that block wide-scale consumer participation, thus leading to insufficient liquidity in flexibility markets and large volumes of unused flexibility potential.

OneNet helps tackling these barriers by focusing on four dimensions of solutions:

- Consumer-engagement strategies in flexibility markets, by offering operational guidelines to tackle identified economic, behavioural, legal and technical barriers;
- Consumer-supportive business models by analysing different use cases from a multi-stakeholder perspective;
- Consumer-centric TSO-DSO coordinated flexibility markets, by giving insights on the participation opportunities for consumers in different TSO-DSO coordination schemes.
- Consumer participation facilitated by aggregation, by developing a grid-safe bid aggregation method that ensures local grids' limitations are also accounted for when forwarding aggregated bids and by

Solutions:

The table below gives an overview of all OneNet Solutions directly linked to Market Participation and Consumer Engagement. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 3.2: OneNet solutions for Market Participation and Consumer Engagement

Solution	OneNet Deliverable(s)
Operational guideline for consumer engagement strategies	D3.3, D3.4, D10.1, D11.5, D11.6
Use Case Business Models	D11.6
Consumer-centric TSO-DSO coordinated markets	D3.3, D11.5, D11.6
Aggregation Add-ons	D3.3, D7.2

The OneNet demos created an environment to enable broader and more active cooperation of grid users by taking a two-step approach: first of all, all economic, behavioural, legal, and technical barriers were identified. Second, targeted guidelines are worked out to overcome these barriers. These guidelines are based on demo insights as in total 4 OneNet demos had real customers in their tests (the Northern Demo (in Estonia and Finland), the Greek demo, the Cyprus demo, the Slovenian demo, and the Polish demo). All other demos included only commercial or industrial parties or utilized simulations. On top of demo insights, insights from other European projects and literature were accounted for, leading to tangible recommendations for regulators, governments, TSOs, DSOs, service providers, and other key stakeholders that enable them to address each barrier. These aspects are briefly summarized next.

Key **economic barriers** to consumer engagement are linked to the absence of viable business models which leads to a limited value of flexibility for end consumers; the high level of risk and uncertainty linked to the high upfront investments with uncertain returns; and challenges related to market and product design such as the limited value stacking options across markets. As elaborated in the sections below, OneNet proposes solutions to resolve these challenges. First of all, to improve value stacking by developing products and services that reduce investment costs needed to enter different markets (section 3.2), and by facilitating coordination between TSOs and DSOs (section 3.4). In chapter 4, we also make several recommendations linked to promoting interoperability of devices through standards and open data as this will facilitate market access and switching between flexibility service and energy providers which supports flexibility engagement. In section 3.5, we further detail how standardizing the registration and prequalification process also further support efficient participation in flexibility delivery. Finally, the guidelines to remove economic barriers zoom in on vulnerable consumer groups, indicating they suffer from perceptions of difficulty and lower levels of trust in the market due to the previous banking and energy crisis. Having simple and proportionate regulatory frameworks with incentive schemes that take away risks and with more information easily available to reduce uncertainty and concerns will benefit all consumers. In addition, to take away uncertainties, investing in research into advanced customer profiles to assess costs and benefits of solutions more accurately is recommended. We discuss this in more detail in the next OneNet solution in this section.

The OneNet guidelines for behavioural **components** are to improve knowledge of customers, promote flexibility markets awareness, and utilize effective and clear communication for flexibility-related offers. This is needed as consumers have limited understanding of benefits and how flexibility is present in their daily energy usage habits.

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OneNet also identified numerous **legal barriers** that lead to exclusion of certain customers and market operators from flexibility markets, which increase administrative and contractual constraints, that complicate data sharing due to privacy and data access issues and that block standards and interoperability. Nevertheless, art. 32 and art. 40 of EU 2019/944 specify non-discriminatory market-based procedures and the NCDR is also implementing principles of non-discrimination and technology neutrality. These principles should then be applied by the Member States and followed in the national terms and conditions for flexibility services of the member states. OneNet offers several recommendations linked to establishing fair and robust energy and flexibility contracts that enable switching, promoting best practices, minimizing ambiguities in standards, and promoting digitalization, all leading to more inclusive flexibility markets.

Market participation is also frequently hindered by **technical barriers** such as a lack of (data and IT) infrastructure, leading to data exchange challenges and communication issues. The OneNet demos tackled these challenges by preparing dedicated IT environments to facilitate market-based procurement through the creation of a more open and transparent way for participation in flexibility market providing information on bids/offers to wider amount of market participants – replacing existing way of flexibility procurement through bilateral contracts (D10.1). However, to properly succeed, it is recommended to further equip smart meters with robust functionalities, enabling two-way communication between system operators and customers. More detailed recommendations related to tackling these challenges are linked to unifying data models and protocols, open-source solutions, good communication and providing user-friendly interfaces. These are discussed in chapter 4.

A second type of **technical barriers** that OneNet explored are barriers induced by different flexibility products attributes as these can block certain consumers and their assets to access markets (for instance in balancing markets. A key proposed OneNet recommendation to tackle this is to set up supporting aggregation mechanisms to enable the participation of small-scale resources without requiring strict modifications to the products characteristics (thus enabling consumer participation while not jeopardizing the reliable delivery of services). Another recommendation is to add additional local market layers to enable small-scale resources to contribute their flexibility for local grid needs, which would have otherwise not been able to participate when there are technical barriers. This is because the latter would likely lead to more stringent product and services requirements which may be difficult to meet by small-scale resources without aggregation.

Business Models for OneNet Solutions

To facilitate implementation of flexibility markets and services, it is important to achieve engagement of the most critical stakeholders by (1) identifying key stakeholders, and (2) ensuring they benefit from the implementation, but also by (3) creating awareness about these benefits. The stakeholders most critical for the implementation of flexibility markets are NRAs and governments, local consumer associations and interest groups, BRPs and retailers, SOs, FSPs, conventional and large utilities and sectoral associations. For each demo, a multi-stakeholder analysis was made, setting up a stakeholder engagement strategy for each of them, indicating how these stakeholders should be involved and managed. This differed between the demos due to different local interests and concerns of stakeholders, differences in regulation and influence of different stakeholder groups. OneNet developed one Business Model for each stakeholder, applied to different use cases (D11.5) to exemplify that the business model itself is influenced by different circumstances (regulation, local economic incentives…). For each business model, the 9 main building blocks of the Osterwalder's Canvas were completed: Key partnerships, Key activities, Value proposition, Customer, Customer relationships, Key resources, Channel, Cost structure, and Revenue stream.

All business models were then quantitatively assessed in D11.6 to provide estimates on the quantitative impact of the implementation of flexibility solutions for the services targeted in the different use cases. As such, OneNet shows how different business model services can provide economic benefits to both SOs and consumers. OneNet shows that the right business model is dependent on local circumstances and conditions and can lead to significant cost savings and efficiency improvements. In what follows, it is now important to properly communicate these benefits to further create awareness on the economic and system value of flexibility from the perspective of different stakeholders. This is necessary as the right business models will encourage stakeholders to enter flexibility markets which they perceived to be less interesting in the past due to unclear business opportunities.

Consumer-Centric TSO-DSO Coordinated Markets

Consumer-centricity is often described as a requirement for electricity and flexibility markets. However, a clear definition of what consumer-centricity entails was missing. OneNet defined consumer-centricity as follows: *Consumer centricity means taking the point of view of the consumer, and not solely that of the producer, the regulator or the whole system, when developing a product, designing a market mechanism, or elaborating a public policy. This entails, among others, (i) starting from the identification of the value that the consumer can receive by consuming the good or the service under consideration, (ii) the way the consumer would experience his/her participation in the market, and (iii) capturing the fact that consumers are not all the same and may have different preferences and needs, and, as a result, may not attribute the same value to a certain good or service with specific characteristics. Ultimately, consumer centricity entails giving the consumer the concrete possibility to choose what to consume rather than just how much.*

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This definition was then applied to different TSO-DSO coordinated market models to investigate their level of consumer-centricity. For readers not familiar with this topic, we refer them first to section 3.4 where the different coordination schemes are explained. In TSO-DSO coordination schemes, the level of consumer-centricity is contingent upon their ability to allow increased participation opportunities for consumers. This is influenced by certain elements. For instance, some markets (e.g., disjoint central markets) exclude the participation of certain consumers (e.g., distribution-level resources) which therefore decreases their level of consumer-centricity. Other markets allow participation of distribution-level resources, but only for DSO usage which still decreases the participation scope of end-consumers. Alternatively, there are markets that allow all resources to deliver flexibility to all SOs. This highly increases consumer-centricity. However, in case the market is based on joint procurement by all SOs, the central system flexibility requirements, when harmonized for the complete market, can be stringent for local resources, thus leading to a reduction of consumer-centricity. This is the case for a common market, while it is not the case for a multi-level market. Given the multilevel market structure, which is composed of a local DSO-level market layer followed by a TSO-level market – it allows the first market layer to consider the needs of local flexibility resources more closely than in the joint common market. Thus, small-scale resources which otherwise may not have been able to participate in the common market, can potentially participate in the local layer of the multilevel market. This has a positive impact on the consumer-centricity level of the multilevel market. However, the fragmentation of the market can lead to a lower overall efficiency than the common market, leading to additional costs to be borne by consumers as part of their electricity bills, which would negatively impact the consumer-centricity level of the multilevel market.

Aggregation add-ons

Aggregation dictates whether multiple units can be grouped and offered in a single bid, facilitating participation for consumers who may not meet individual market requirements. This can be done ex-ante the bidding process, through resource aggregation where FSPs join to respect product attributes defined during prequalification. Or it can be done ex-post the bidding process in the context of bid forwarding where multiple bids are aggregated when being forwarded to another market. In OneNet, resource aggregation is being implemented in the demos in WP7, while in T3.3 bid aggregation is tackled.

Aggregation is a crucial factor in determining consumer centricity as aggregation allows consumers to participate according to their preferences and needs, alleviating the necessity for each consumer to adhere strictly to product requirements. Proper aggregation rules therefore have a large influence on consumer engagement and market participation.

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One of the challenges that aggregation faces is that, indeed, individual consumers do not need to respect all constraints and standards set by product requirements. In that regard, it is crucial to recognize that certain products may have limitations on the types and locations of units that can be aggregated, as under specific circumstances, aggregation might only yield private benefits rather than system-wide advantages. For instance, when offering balancing services with distribution-level connected units, and the capacity of the distribution system is constrained, it is important that distribution level constraints are considered to ensure flexibility is delivered in a grid-safe manner. This would limit the possibility of wide-scale aggregation.

To facilitate aggregation, OneNet developed a bid aggregation method that specifically takes into account the local grids' limitations in the form of residential supply functions (which are aggregated functions from individual bids), which are then forwarded instead of the individual bids. OneNet demonstrates that the new bid aggregation method can theoretically lead to a maximized efficiency and improved grid safety, especially when the aggregation mechanism and the prices of aggregated flexibility, captured in the residual supply function, are well-designed (which can pose technical challenges). More details can be found in section 3.4 where the solution is discussed in more detail. Furthermore, OneNet also allows for flexible resource group management in the flexibility register. In doing so, the flexibility register provides the capability to automatically define suitable resource groups that qualify for a product. More information can be found in D7.2.

Enablers & Barriers:

Table 3.3: Table of Enablers for Market Participation & Consumer Engagement. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	Product harmonisation is an important enabler for consumer engagement and market participation as it facilitates implementation of the OneNet business models and aggregation method. For more in depth recommendations on products, we refer to section 3.2.	L **C** E **S** M L
R	Supportive policies from regulatory authorities can encourage market participation and innovation in flexibility markets, which creates the right mind-set to implement the OneNet guidelines on consumer engagement strategies.	L **C** **E** S **M** L
R	The NCDR is emphasizing the need for aggregation, paving the way for innovate solutions such as the OneNet Grid-Safe Bid aggregation method. Transposition at national level is, however, still required.	L **C** E **S** M L

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R	Current market landscape lacks sufficient mechanisms to engage end-consumers (introductory market trainings, knowledge of benefits, etc.) that inhibits customer engagement and market access. There is no clear role defined to take up this responsibility which slows down the implementation of the OneNet guidelines and business models. Nevertheless, it seems that local governments are starting to take up this task (e.g., in Belgium, campaign of "make your meter smart").	L **C** E S **M** L
T	Many of the solutions to enable market participation require an easy way to access and share data by different stakeholders. In chapter 4, OneNet proposes a key solution and enabler for this: the Unified Market Platform.	L **C** E **S** M L

Table 3.4: Table of Barriers for Market Participation & Consumer Engagement. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Unclear and inconsistent compensation and penalty mechanisms for flexibility provided by FSPs leads to uncertainty in revenue streams, and uncertain returns on investments for flexible devices and adoption of flexible technologies. It negatively affects implementation of the different business models.	L **C** E **S** M L
R	The OneNet business models highlight the importance of engagement of all influential and critical stakeholders. However, this also implies that regulations for Transfer of Energy (ToE) should be set up. Currently, ToE is not widely used across Europe, even though the NCDR is indicating the need for a financial compensation.	L **C** **E** S **M** L
E/R	To boost the implementation of the OneNet solutions linked to consumer participation, it is important that there is an easier access to information on flexibility and its different options. A lack thereof results in a lack of clarity regarding the potential valorisation value, on how to deliver flexibility, and the overall transparency of the process, which negatively impacts market participation.	L **C** E **S** M L
T	To ensure grid-safe aggregation, additional calculations are needed. The computational burden of these methods might be higher and there are regulatory challenges linked to the entity that would take up this role.	L **C** E S **M** L

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Recommendations:

The reform of the EU electricity market design (March 2023) emphasizes the need for more consumer engagement. Throughout the next sections, OneNet offers many solutions related to interoperability and market design that need to be improved to further empower consumers. The next sections all show that many solutions are available, yet still need to be implemented. With the upcoming NCDR, many steps will be taken in the right direction. These supportive policy initiatives are important to fasten up the roll-out of market-based flexibility procurement and the enablement of smaller consumers in flexibility markets.

The following recommendations are proposed with respect to products and services:

Bottom-up creation of a positive mind-set: For proper transposition of the European regulation, it is important that this positive mind-set is not only imposed top-down. Instead, bottom-up initiatives are needed to create awareness among consumers. The OneNet consumer engagement strategy guidelines give many suggestions, ranging from market trainings, to brochures, information campaigns… Yet, before making this work, policy makers at local level should identify an entity to take up this responsibility. Depending on cultural and local differences, the organization involved might differ. In this regard, it is important to emphasize that the entity responsible for creating greater consumer awareness should be one that supports the development of market-based flexibility and is a trusted party for consumers. (Target: Policy Makers, FSPs)

Compensation mechanisms creation to ensure economic benefits: Before this entity can properly convince and encourage consumers, policy makers at national and/or regional level and/or regulators have to ensure that a clear, sustainable and transparent compensation mechanism exists to encourage consumers to offer their flexibility. The key incentive for all stakeholders is linked to economic benefits and returns. The OneNet business models indicated that this should not only be facilitated by commercial parties that provide consumers with compensations. Cost-reflective grid tariffs that incentivize consumers behaving in line with system needs are also a very promising way to acquire flexibility while compensating consumers properly. Grid operators should also create more transparent mechanisms for FSPs. Harmonisation of such incentive schemes is very hard as there are significant differences across Europe. It is therefore indispensable that each country identifies which entity is responsible for which type of incentives so that there are also no conflicting incentives. A clear vision should be worked out regarding these incentives, specifying the incentive mechanisms and how long they will be in place. This will build up trust and take away uncertainty with stakeholders. (Target: Policy Makers, System Operators, NRAs, FSPs)

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Stakeholder-analysis at country-level to identify involved stakeholders: Both these two recommendations imply that a proper stakeholder analysis needs to be done at country level by local policy makers to identify all involved stakeholders. This will clarify (1) who should be targeted during the awareness creation programs, (2) who is responsible for setting proper incentive mechanisms and (3) who should oversee awareness creation programs. This will facilitate the implementation of the above recommendations. In addition, a proper stakeholder analysis should also shed lights into the concerns that specific stakeholders might have. It is recommended to always check the validity of these concerns in light of new innovate solutions that take away possible conflicts of interest. For instance, possible blocking elements to implement aggregation mechanisms are the concerns that grid constraints are not always properly accounted for. However, OneNet offers solutions linked to grid-aware bid aggregation as discussed in section 3.4. Throughout the OneNet project, explicit attention is devoted to aggregation to capture its effect on opening up markets for small-scale FSPs, and the impact thereof on the efficiency of TSO-DSO coordinated flexibility market models. As a result, it is imperative for aggregation roles and remuneration mechanisms to be enshrined in regulations for all markets. (Target: Policy Makers)

Setting-up data management between multiple stakeholders: Finally, market-based flexibility leads to more market stakeholders which inherently increases the amount of data that must be managed by FSPs, aggregators, and other SOs. In tandem, the new roles require new channels for information sharing that must be managed efficiently. OneNet has proposed several solutions that address these, such as the Flexibility Register, a bid optimization tool, and a traffic light scheme to name a few. These are described in more detail in later sections of this roadmap. Moving forward, it is important that any future solution or market development aimed at improving consumer-centricity and increasing market participation should be sure to anticipate the infrastructure needs and design solutions for each type of user that encourage user-friendly interfaces and facilitate communication between relevant parties. (Target: DSOs, Policy makers, NRAs)

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3.2 Products & Services

KEY MESSAGE:

New and adapted products and services for system operation are needed to address challenges due to increased uptake of RES and further electrification. Both frequency (balancing) and non-frequency services (congestion management and voltage control) need to be addressed. In particular for non-frequency services, few products exist today which requires further product design innovation and development that allow the inclusion of locational information.

The increase in flexibility products and services entails a risk of further fragmentation of flexibility markets, leading to low liquidity and non-competitive prices. Moreover, a wide fragmentation of different flexibility products with diverging rules, attributes limit the ability for FSPs to develop a positive business case and is as such an important barrier for market participation (see also section 3.1). To maximize participation of Flexibility Service Providers to these new services, a harmonised product approach at EU level is needed, i.e., different flexibility products are defined according to a harmonised set of product attributes.

OneNet contributes to the area of product design by proposing a framework that allows a homogeneous classification of existing and new flexibility products. In addition, OneNet develops a set of harmonised products, including locational information. Finally, OneNet presents recommendations how further harmonisation between flexibility products could be realized in the coming years.

Solution:

The table below gives an overview of all OneNet Solutions directly linked to Products & Services. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 3.5: OneNet solutions for Products & Services

Solution	OneNet Deliverable(s)
Theoretical framework on products	D2.2
Development of 6 harmonized products for system operation	D2.2, D3.2, D11.2
Framework for product harmonisation, including assessment of entry barriers induced by different product attributes	D3.3, D11.2

Theoretical Framework on Products and Services

SOs use flexibility products to address long-term and short-term system needs. Figure provides an overview of the system services in OneNet, classified according to the actual use and timeframe. Multiple flexibility

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products exist or will be developed in the coming years, providing both frequency and non-frequency flexibility services. The OneNet theoretical framework for products defines a harmonized set of product attributes, including the range of values, which are needed to describe a flexibility product used for a specific system service.

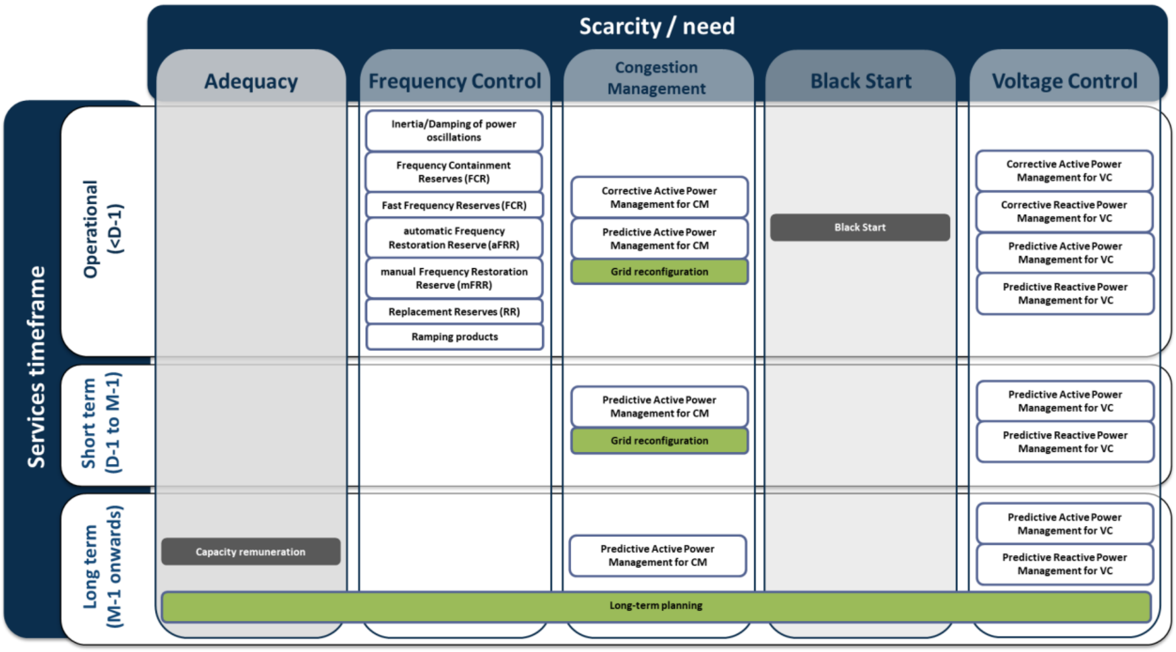

Figure 3.3: OneNet overview of System Services (D2.2)

The OneNet theoretical framework for products defines a harmonized set of product attributes, including the range of values, which are needed to describe a flexibility product used for a specific system service.

	Objective of the product					
	Technical dimensions			Bid related dimensions		
	The network operator aims to operate the network efficiently and reduce the overall cost of network operation and planning. To achieve this, the network operator will define technical requirements for the traded products and the market mechanism.			The bid related dimension of a flexibility product reflects the rules introduced in the bid as part of the procurement process.		
	Definition of the good traded	Timing for delivery	Communication	Technical rules for the bid	Settlement rules
	Characteristics of the "good" being acquired by the SO	Description of the timing in the delivery of the product	Methodology used to communicate between SO an FSP	Limitations in the structure of the product	Measures linked with the way that companies will be paid
Choices SO/MO do in attributes	Capacity / energy	Maximum preparation period	Required mode of activation	Minimum quantity	Baseline methodology
	Active/reactive energy	Maximum ramping period		Divisibility (Y/N)	Measurement requirements
	Location information required (Y/N)	Maximum full activation time		Granularity	Penalty for non-delivery
	Certificate of origin (Y/N)	Duration of delivery period		Maximum and minimum price	
	Minimum level of availability	Maximum deactivation period		Availability price (Y/N)	
	Symmetric/asymmetric product (Y/N)	Maximum recovery period		Activation price (Y/N)	
	Validity period of the bid	Maximum number of activations		Aggregation allowed (Y/N)	

Figure 3.4: OneNet framework for product harmonisation - overview of attributes (D2.2)

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Development of Six Harmonized Products for system operation

OneNet designed 6 common and harmonized products for system operation. These products include a locational component and can be used for non-frequency services (both congestion management services and voltage control), but also allow to be used for frequency services. The harmonised products differ in timing (long-term, short-term, real-time) and in the use of active or reactive power. The products are (i) corrective local active product, (ii) predictive short-term local active product, (iii) predictive long-term local active product, (iv) corrective local reactive product, (v) predictive short-term local reactive product and (v) predictive long-term local reactive product. Detailed attributes are defined for each product, Figure provides an illustration of the corrective local active product.

Attributes	Values
Capacity/energy	Capacity, energy or both
Location required (Y/N)	Yes
Maximum full activation time	<60 min
Minimum required duration of delivery period	A multiple of 15 minutes up to 1 hour
Maximum deactivation period	Defined in terms and conditions for FSPs
Maximum recovery period	Defined in terms and conditions for FSPs
Maximum number of activations (per day, week…)	
Required mode of activation	Automatic or manual (if compliant with FAT)
Minimum quantity	1 MW for TSOs 0.01 MW for DSOs
Divisibility (Y accepted / Y required /N)	Divisible and indivisible bids are allowed
Granularity	1 MW for TSOs 0.01 MW for DSOs
Maximum and minimum price	
Availability price (Y/N)	If required, in €/MW
Activation price (Y/N)	Yes, in €/MWh
Symmetric/asymmetric product (Y/N)	No symmetry required
Aggregation allowed (Y/N)	Allowed

Figure 3.5: Attributes for Corrective Local Active Product (D2.2)

Framework for Assessing Entry Barriers Induced by Different Product Attributes

In the future, additional products for system services will be developed. To allow policy makers to assess the impact of specific design attributes on the participation of market participants and flexibility service providers, a detailed 4-step methodology has been developed to assess these entry barriers and to link them with the TSO-DSO coordination schemes to facilitated integrated markets. In addition, a general framework is proposed to continuously evolve towards more harmonised products for system services for both existing and novel services.

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The evolution towards a more harmonised approach for flexibility products is challenging and the demonstrators within OneNet reported on several main barriers as presented in Figure 3.6.

Barrier name	NOC	CYP	GRC	FRA	PRT	ESP	CZE	HUN	POL	SVN
Structure of the grid	Y	N	N	Y	Y	Y	Y	Y	N	Y
SO market maturity	N	N	Y	Y	Y	Y	Y	Y	Y	N
ICT challenges	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Unclear product needs	N	N	N	N	N	N	N	N	N	N
Diverging requirements	Y	N	Y	N	N (TSO) Y (DSO)	Y	N	N	N	N
Economic development	N	Y	N	N	Y	N	N	N	N	Y
Product life cycle stage	N	N	N	N	N	N	N	N	N	Y
Competition/ liquidity	N	Y	N	Y	N (TSO) Y (DSO)	Y	Y	Y	N	Y
Political choice	Y	N	N	N	N	N	N	N	N	N
Regulatory limitations	Y	Y	Y	N	Y	Y	N	N	N	N
Contextual differences	N	N	N	N	N	Y	N	N	N	N

Figure 3.6: Overview of relevant barriers to product harmonisation for the different OneNet demos (D11.2)

Enablers & Barriers:

Table 3.6: Table of Enablers for Products & Services. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)*
E	Stage of market development: A higher need for flexibility will lead to a more mature local flexibility market and consequently a higher need for more advanced and harmonised flexibility products	L **C** **E** S **M** L

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E	Increased cross-border procurement for flexibility (MARI, PICASSO) supports harmonisation of flexibility products at EU-level.	L C **E** **S** M L
R	A network code for Demand Response will provide clear guidance on definition of products and services, terminology, design requirements and harmonisation guidelines.	L C **E** **S** M L
R	Joint incentive signals for TSOs and DSOs would support harmonisation and coordination activities, including harmonisation of products and services.	L **C** **E** S **M** L
T	The existence of common/joint or interoperable market platforms across multiple countries will provide leverage for harmonised products within and beyond national borders.	L C **E** S **M** L
T	Increased information sharing between TSOs and DSOs on flexibility needs, including a dedicated communication platform supports further harmonisation of flexibility services and products.	L C **E** **S** M L

Table 3.7: Table of Barriers for Products & Services. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Compatibility with product requirements from other platforms (e.g., MARI) to allow bid forwarding (value stacking) require adapted product design	L C **E** **S** M L
E	Low liquidity in local markets and limited availability of FSPs capable to follow the harmonised product requirements	**L** C E S **M** L
R	National grid code or technical regulation puts specific limitations or requirements on flexibility services and products	**L** C E **S** M L

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E	Remuneration for system operators (TSOs and DSOs) is not aligned, resulting in different incentives for flexibility use between transmission and distribution, impacting the speed and design of flexibility services.	L **C** E **S** M L
T	The structure/technology of the grid in a specific market area imposes restrictions on the values of certain attributes or the use of certain products or makes harmonisation unnecessary	**L** C E S M **L**
T	Diverging technical/grid requirements for different services for different SOs make harmonisation impossible.	**L** C E S M **L**

Recommendations:

The following recommendations are proposed with respect to products and services:

Product design as enabler for flexibility market development: Product harmonisation is important to support the uptake of flexibility markets, in particular due to the availability of harmonized products, more value can be attributed to the same flexibility offer as it can potentially provide multiple services in different markets. The increased value stacking potential will support the individual business cases of flexibility and accelerate the participation of flexibility in the market. Consequently, harmonized products are an enabler for coordinated and integrated European markets. (Target: Policy makers, NRAs and System Operators)

Product harmonisation to be applied on both existing and novel products: Product harmonisation is applicable to existing flexibility products but should also be addressed when defining new flexibility products. In particular for services related to congestion management and voltage control, new products should be designed, including a locational component. To ensure maximum value creation from the start, the design of these new products should be maximally harmonized with existing frequency products. (Target: Policy makers, NRAs and System Operators)

Common terminology is needed as a basis for product harmonisation : To support the process of harmonisation , a common terminology and classification of attributes is needed that allow a similar description of product attributes for multiple services. This common terminology will be addressed in the new Network Code for Demand Response. The draft NCDR explicitly proposes in this respect common requirements for definitions of products for congestion management and voltage control, a common EU list of attributes used for congestion management and voltage control, including a process for establishing standardized products. However, the definition of the products itself will be at national level. The OneNet demonstrators highlighted that even at EU-level, common EU products could be defined as main barriers

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for EU harmonisation were not linked to the country-specific grid or RES conditions but were linked to infrastructure and market maturity. Both infrastructural challenges and market development are factors that might require temporary national supporting measures but in the long run, do not pose any objection to determine an EU-wide approach for flexibility products. (Target: Policy makers, NRAs and System Operators)

A balance should be considered between local needs and harmonisation : Despite the important benefits of a harmonized product range, a balance should be found to address local specific needs with flexibility products that have specific local characteristics. This local need could be due to the individual characteristics of the local flexibility source or could be driven by a specific technical grid challenge. (Target: Policy makers, NRAs and System Operators)

Product harmonisation will be a gradual process: Although product harmonisation entails several benefits, it should be accepted that product harmonisation will be a stepwise process due to the actual different maturity and liquidity levels of local DSO markets and national TSO markets. The kick-start of local products and markets could in some cases require adapted product design. (Target: Policy makers, NRAs and System Operators)

3.3 Roles & Responsibilities

KEY MESSAGE:

The OneNet project recognizes the urgent need for clear roles and responsibilities for the (new) tasks and activities that emerge in the new market designs. This is indispensable to pave the way for a more inclusive and adaptable energy market, providing a leverage for future innovation projects. The definition of roles in the exchange of data is, for example, fundamental to ensure that data will be exchanged between the correct players in the electricity market. Moreover, to enable market efficiencies, like the process of forwarding unused bids between buyers of flexibility, requires the establishment of new roles.

The initiative of the Harmonised electricity market Role Model (HEMRM), a document proposed and maintained by ENTSO-E, ebiX and EFET is used to describe the relationship and responsibilities among the various actors in the electricity system. However, certain roles have not yet found their place in the current 2020 HRM version (e.g., DSO, TSO, FSP, Local Management System, Flexibility Register Operator and Optimisation Operator). This has, for example, led to complexities in the correct modelling of TSO-DSO markets for system services.

OneNet contributes by delivering a comprehensive assessment and definition of new roles within the energy sector, serving as a cornerstone for business model development, data exchange efficiency, and platform standardization. OneNet ensures uniformity and clarity in role definitions, facilitating seamless information exchange and enhancing market efficiency. Special attention is dedicated to the role responsible for forwarding bids, and making sure this happens in a grid-safe manner. The framework of definitions can be used as a guideline, yet continuous review of the roles remains required in the fast-emerging market environment.

Solution:

The table below gives an overview of all OneNet Solutions directly linked to Roles & Responsibilities. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 3.8: OneNet solutions for Roles & Responsibilities

Solution	OneNet Deliverable(s)
New or adapted role definitions	D2.5, D3.4, D3.3, D11.2
Role definition to ensure grid-safe bid forwarding	D3.3

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New or Adapted Role Definitions

In the context of the evolving landscape of market participants, new functions, tasks and responsibilities are required. In the development of flexible and open architectures to transform the European electricity market, correct and clear definition of the data exchange between different involved stakeholders is essential. For a market that exchanges data with stakeholders from multiple countries, a standardisation process must respect common rules, so it ensures the quality and the possibility to accommodate participants. This necessitates an ongoing review of the HEMRM to address emerging gaps. For one key gap (namely the correct modelling of TSO-DSO markets for system services), OneNet proposed new roles and responsibilities. Guidelines on both adapted roles and new roles are provided to accommodate the changing market dynamics. New definitions of roles are for example, flexibility register operator (FRO), local management system (LMS) and weather forecast provider. The FRO is defined as the party that stores information about flexibility assets, results of qualification (both product and grid), market results, grid information as well as perform flexibility verification and settlement, aggregates flexibility information, allocates access rights to the various actors and controls the level of access. The LMS is defined as the IT system allowing planning of charging patterns according to expected grid conditions and RES production. The weather forecast provider is considered the Unit inside the TSO/DSO or contracted outsourced weather forecast provider company responsible for weather forecasts for selected weather parameters and selected locations in the grid.

The guidelines on definitions of roles are indispensable to shape business models, to structure the data framework and ensure smooth flow of data among stakeholders. In addition, they play a pivotal role in achieving robust standardization of digital platforms, as seen in initiatives within the OneNet project. The exercise of defining roles and responsibilities is integral to delineating the use cases for each country and demonstration. With the OneNet guidelines and role definitions, future innovation projects can leverage this exercise early in their development to ensure alignment with European Commission codes and guidelines for the market data exchange, promoting optimal coherence and effectiveness.

Role Definition to Ensure Grid-Safe Bid Forwarding

In the context of TSO-DSO coordinated market models and their efficiencies, the analysis takes a key focus on the linking between flexibility markets through the forwarding of flexibility bids. This mechanism is defined to capture a process through which flexibility bids in one market (which have been unused in that market) for a specific service can be forwarded to another subsequent market for potentially delivering other services. Bid forwarding is crucial in the evolving energy landscape due to the increasing availability of flexibility across

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different grid levels and increased need for flexibility from different buyers. It is crucial for enhancing the efficiency and value stacking potential of flexibility markets. This mechanism is particularly relevant in scenarios where markets are not directly connected. Grid-safe bid forwarding is a complex process, which intention it is to mitigate the risk of network issues stemming from forwarded bids. To guarantee the grid-safe bid forwarding innovative solutions are necessary. As part of the research to provide insights into the process of bid forwarding, OneNet offers a comprehensive framework to describe the responsibilities of the entity tasked with ensuring the grid-safe bid forwarding. Overall, having an overseeing entity ensures that bid forwarding processes are conducted transparently, safely, and in compliance with regulations, thereby fostering trust in flexibility markets and promoting efficient utilization of flexibility resources.

Enablers & Barriers:

Table 3.9: Table of Enablers for Roles & Responsibilities. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	Attractive and harmonized market products and services can provide economic incentives to participate in multiple services, seeking for value stacking. This provides a market trigger to implement a clear role definition for the entity providing grid-safe bid forwarding.	L **C** E S **M** L
R	Supportive policies from regulatory authorities (enabling independent aggregation or the participation of LV flexibility for example) can encourage market participation and innovation in flexibility markets, driving adoption of new roles and processes by providing incentives or removing barriers for participation of flexibility.	L **C** **E** **S** M L
R	Aggregation models (including roles, responsibilities, interactions) are proposed in new draft NCDR. They should be transposed to regional regulation.	L **C** **E** S **M** L
T	Trainings and presentations for (new) market participants which need to take up new roles and responsibilities in which they might have little or no experience.	L **C** E **S** M L
T	Dedicated platform to facilitate communication between TSOs and DSOs	L **C** E **S** M L

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Table 3.10: Table of Barriers for Roles & Responsibilities. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	Implementing new roles and bid forwarding mechanisms may require initial investments in infrastructure and technology, posing a barrier for some market participants.	**L** C E **S** M L
R	Market innovations can lead to evolutions in the roles and responsibilities of certain market participants potentially making the OneNet definitions inaccurate or necessitates ongoing review of the definitions to address emerging gaps.	L **C** E **S** M L
R	Complex or ambiguous regulations governing flexibility markets (e.g., requiring a contractual relationship between a BRP and an FSP) may create barriers to entry for new market participants and this can delay the adoption of standardized role definitions and bid forwarding mechanisms.	L **C** E **S** M L
R	Uncertainty regarding future regulatory changes or requirements may deter market participants from investing in new roles and responsibilities, leading to slow adoption and implementation.	L **C** E **S** M L
T	Integrating new and adapted roles and responsibilities, including an entity for bid forwarding, within existing grid infrastructure and market platforms may pose technical challenges related to compatibility, data synchronization, and system reliability, delaying implementation and adoption.	L **C** **E** **S** M L

Recommendations:

The definition of roles is essential from multiple perspectives. Firstly, it moulds business models, particularly crucial in energy flexibility markets where these models serve as the nexus between technical innovations and economic feasibility. Additionally, in the realm of data exchange, roles and responsibilities are foundational. A well-defined framework ensures that data flows appropriately among stakeholders in the electricity market. Moreover, clear role definitions are pivotal for achieving robust standardization of digital platforms, as exemplified in initiatives like the OneNet project. This clarity facilitates seamless information exchange among participants, thereby enhancing overall efficiency. The drafting exercise of the NCDR acknowledged the establishment of clear and streamlined processes, roles and responsibilities on a European level to facilitate the integration of DR.

The following recommendations are proposed with respect to products and services:

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Start role identification early in the project development: OneNet accurately defined all necessary roles in the market processes and efforts were made to harmonize them, ensuring uniformity across all demonstrations. This harmonization enhances understanding and streamlines data exchange processes. Moving forward, OneNet advises that future innovation projects undertake similar exercises early in their development, aligning role definitions with European Commission mandated documents for optimal coherence and effectiveness. In addition, by leveraging these definitions and assessments, regulatory authorities can enact changes that promote the development of services outlined by the Business Use Cases (BUCs). Striving for harmonized definitions of roles and responsibilities further fosters the integration into European markets. (Target: Project partners research projects)

New and adapted roles are needed: Aligned with discussions held within BRIDGE and the Harmonisation Group, including ENTSO-E, ebIX, and EFET, the OneNet project has introduced adaptations to existing roles, such as TSOs and DSOs, and developed new roles as well (such as the FRO). However, the analysis of these new and/or adapted roles must be thorough, ensuring avoidance of overlapping roles or deviation from EU codes and guidelines for market data exchange. The OneNet gathered insights in the evolving roles and responsibilities can support, for example, in the drafting process of the new NCDR. Clear roles and responsibilities can assist in the scoping of the thematic areas of aggregation models, data exchange, market operations and prequalification. (Target: Policy makers, NRAs, System Operators, Market Operators, Flexibility Service Providers)

Continual refinement and expansion of role definitions is indispensable: The evolving landscape of market participants, necessitates ongoing review of the HEMRM to address emerging gaps in use cases. The OneNet project brings attention to notable proposals, like the Weather Forecast domain, underscoring the need for inclusion of additional roles at the distribution level, not currently addressed in the HEMRM. Simultaneously, the project underscores the importance of defining the entity responsible for ensuring grid-safe bid forwarding. These insights emphasize the imperative for continual refinement and expansion of role definitions to effectively capture the evolving dynamics of the energy market. (Target: Policy makers, NRAs, System Operators, Market Operators, Flexibility Service Providers)

Clarify accountability for non-delivered flexibility: In our examination of roles and responsibilities, determining accountability for non-delivered flexibility emerged as a significant concern among most project partners. Nevertheless, the OneNet project concluded that this issue is likely to diminish in importance over time as experience is accrued and trust-based relationships develop between SOs and FSPs. (Target: Policy makers, NRAs, System Operators, Market Operators, Flexibility Service Providers)

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3.4 TSO-DSO Coordinated Flexibility Markets

KEY MESSAGE:

The volume of available flexibility from all grid levels is increasing and expected to continue this upward trend in the coming years. Simultaneously, the need for flexibility at the TSO and DSO levels is also increasing, aiming at procuring different services, such as balancing, congestion management, voltage control, etc. In this respect, TSO-DSO coordination in the procurement of flexibility is of key importance to ensure: 1) maximizing the value stacking potential of flexibility (minimizing procurement costs), through which flexibility procured can concurrently meet the needs of multiple SOs, and 2) that the procured flexibility from the different grids can be safely activated (especially considering situations where an SO procures flexibility from a grid outside its direct area of control, such as the case of a TSO procuring distributed flexibility). As such, TSO-DSO coordination is of key importance to ensure the efficient and grid-safe procurement of flexibility.

Previous European projects, such as H2020 CoordiNet, have proposed novel TSO-DSO coordination schemes and resulting market models, while analysing their efficiencies. However, there remains a need to systematically identifying key factors that directly impact the efficiency of these models and their sensitivity to them. OneNet has aimed to go further by refining these TSO-DSO coordination mechanisms (while introducing concepts such as bid forwarding from one market to a subsequent one to maximize the potential use of flexibility) as well as by identifying and analysing the impact of key dimensions on the efficiency of different TSO-DSO coordinated market models.

OneNet addresses those coordination challenges between system operators by building upon these previously developed TSO-DSO coordination schemes to advance TSO-DSO coordinated flexibility market models together with a developed simulation environment to analyse their efficiency and its sensitivity to different key dimensions such as the pricing of TSO-DSO interface flexibility exchange, FSP sequential bidding processes, FSP strategic bidding and gaming potential, entry barriers, and allowed bid formats, among others. As such, the TSO-DSO coordinated flexibility markets are able to maximize the value-stacking potential of flexibility and return consistent and transparent valorisation opportunities to FSPs/consumers, and to ensure that the flexibility is delivered in a grid-safe manner for all participating grids.

Solution:

The table below gives an overview of all OneNet Solutions directly linked to TSO-DSO Coordinated Flexibility markets. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

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Table 3.11: OneNet solutions for TSO-DSO Coordinated Flexibility Markets

Solution	OneNet Deliverable(s)
TSO-DSO coordinated flexibility markets	D3.3, D11.2
Framework and simulation environment for the Analysis of the Efficiency of Different TSO-DSO Coordinated Flexibility Market Models	D3.3
Framework and simulation environment for the Analysis of the Impact of FSP Strategic Bidding on the Efficiency of TSO-DSO Coordinated Flexibility Markets	D3.3

TSO-DSO Coordinated Flexibility Market Models

To be able to meet the different SOs' needs and grid characteristics, OneNet has developed several TSO-DSO coordination processes and derived flexibility market models through which flexibility from different grid levels can be procured to meet service needs of TSOs and DSOs. They differ in the way the TSO-DSO provision of flexibility resources is coordinated, such as how flexibility resources are accessed and/or shared between the different SOs, the market sequence that exist, and if priority access to local resources is given to certain SOs. This gives rise to several TSO-DSO coordinated market models spanning from fully disjoint markets (disjoint distribution and disjoint transmission level markets) to fully common TSO-DSO joint markets, while considering sequential market set-ups formed of local DSO-level market layer followed by a central transmission-level layer. The 4 fundamental market models are described as follows (D3.3):

- **Disjoint markets**: the **disjoint transmission-level (central) market** and the **disjoint distribution-level (local) market** are flexibility markets models in which each SO runs its own market (independently from other SOs) to procure flexibly solely from resources connected to its own grid with no permitted modification to cross-grid flows. This represents a setting in which cross-system flexibility is not used and no impact of one market operation (flexibility procurement and activation) of one system on the other is present, requiring minimal forms of coordination, at the cost of minimized value stacking potential of flexibility and decreased system efficiency.
- **Common market**: The counterpart of disjoint markets is a common market, in which TSOs and DSOs jointly procure flexibility, in a co-optimized manner, from a common pool of flexibility resources (pool of bids submitted by flexibility resources connected at the different participating grids). Such a mechanism requires a high level of coordination and cooperation among the participating SOs, not only to communicate their flexibility needs but also to ensure that all grid limitations of all grids involved are considered in the market clearing process, thus guaranteeing the safety of all participating systems.
- **Multi-level Market**: within the spectrum of TSO-DSO coordination mechanisms, bounded at one end with disjoint markets and on the other end with the common market, the multi-level market is a sequential market setting composed of a local distribution-level market layer followed by a

transmission-level market layer. In this mechanism, the DSO would use distribution-level flexibility resources to solve its own grid needs before such flexible capacity is made available to the transmission system. In the second layer, the TSO would access the forwarded flexibility from the distribution system as well as transmission level flexibility to solve its own flexibility needs. As distribution-level flexibility is used, network limitations of the DSOs should be accounted for when clearing the transmission-level market. The multi-level market provides priority access to DSOs to local flexibility resources, while still enabling the TSOs to access distributed flexibility, even if only at the second stage. Such a setting can represent a combination of local and centralized markets and holds the advantage that the local market layer (Layer 1) can be more easily adaptable to the local grid and local FSPs needs, thus enabling the participation of small-scale resources, which might find the requirements of central system services challenging to meet prohibiting their participation in the common market (assuming this aspect cannot be resolved through aggregation). However, this market fragmentation, as compared to the joint market, can lead to sub-optimal use of flexibility. Thus, the trade-off between the two must be considered to enable the efficient and accessible use of TSO-DSO coordinated flexibility markets.

- **Fragmented market**: Similar to the multi-level market, the **fragmented market** is formed by the same two sequential market layers. However, the fragmented market does not enable the participation of distribution-level resources in the transmission-level layer (Layer 2). This encompasses settings in which the services traded are not yet open to the participation of aggregated resources (expected to be gradually phased out in the coming years), or settings in which the grid-safety of the distribution grid cannot be guaranteed when distributed flexibility is cleared in the transmission-level market (either due to limitation on the ability to consider the network constraints of the distribution system in the transmission-level market clearing formulation, or due to having stressed operational conditions on the distribution system level preventing any further use of distributed flexibility).

Different variants can be considered to these fundamental market formulations, especially when considering the extent up to which distribution network constraints can be taken into account when clearing transmission-level or common markets. For example, the work in OneNet has introduced **bid forwarding** as a particular form of multi-level markets through which distribution level bids can be forwarded to the transmission-layer markets, allowing the transmission system to acquire distributed flexibility but without the need for the transmission-level market to consider the network constraints of the distribution system. To guarantee grid safety, grid-checks are performed to enable the grid-secure forwarding. This can be achieved through forms of prequalification (grid checks before bid forwarding), correction mechanisms (implemented ex-post to correct for any cleared grid-unsafe distributed flexibility) or bid-safe aggregation mechanisms (aggregation of distributed flexibility to be forwarded as residual supply functions to the transmission-level markets). These mechanisms are further highlighted and clarified in the bid forwarding solution description in Section 3.6.

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Framework and Simulation Environment for the Analysis of the Efficiency of Different TSO-DSO Coordinated Flexibility Market Models

The structure of the different TSO-DSO coordinated flexibility market models can induce varying impacts on the efficiency of the procurement process, in terms of market clearing costs, grid-safety requirements, and entry barriers and participation potential, as well as consumer-centricity. In addition, within each TSO-DSO coordinated market model, various key aspects can drive the efficiency of each. OneNet has developed a framework considering all the TSO-DSO coordinated market models aiming at analysing them with respect to these key aspects. In this respect, the different conceptualized TSO-DSO coordinated market models are developed mathematically and implemented into code leading to a simulation environment using which a structured comparison between the performances of different TSO-DSO coordinated flexibility market models can be carried out. As such, the developed framework is able to quantitatively investigate the efficiency levels of flexibility procurement under each TSO-DSO coordinated market as well as their sensitivity to several key factors such as: (i) the interface flow pricing (capturing the way in which the exchange of flexibility between TSOs and DSOs – captured through changes to their interface flows – can be priced), (ii) FSPs' bidding processes (capturing the way FSPs can bid in sequential flexibility markets – namely, the multi-level market – depending on whether they have the capacity to observe previous market outcomes before deciding on their biddings strategies in subsequent market stages), (iii) entry barriers (which can materialize due to product attribute requirements such as, e.g., minimum bid sizes, and their differing levels of applicability when comparing local to central market schemes), and (iv) bid formats (capturing the different types of simple and complex bid types that could be used in flexibility markets). This allows SOs to select the best-suited TSO-DSO coordination model for their settings.

Framework and Simulation Environment for the Analysis of the Impact of FSP Strategic Bidding on the Efficiency of TSO-DSO Coordinated Flexibility Markets

As different flexibility market formulations and TSO-DSO coordinated market models can open space for differing FSPs' strategic bidding processes, OneNet introduced a framework and a simulation environment to identify potential FSPs' strategic bidding behaviours and analyse their impact on the efficiency of the TSO-DSO coordinated flexibility markets. The methodology used is based on a developed game-theoretic setting. In this regard, for each TSO-DSO coordinated flexibility market model, the strategic bidding processes of the FSPs participating in the market is formulated as a noncooperative game. This enables the characterization and the simulation of the optimal bidding strategies of each FSP in face of the opponents' potential strategies. This

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strategic interaction yields different bidding behaviours by each FSP. For each TSO-DSO coordinated market model, the developed framework compares the truthful bids and the strategic ones and quantifies their impact on the market efficiency. Then, a comparison between the results of each TSO-DSO coordinated market allows identifying any structural difference in terms of their sensitivity to strategic behaviour.

As such, the analysis captures the way in which each TSO-DSO coordinated flexibility market model can provide incentives for different levels of strategic bidding as well as quantifies the sensitivity of each market model to such strategic behaviour. The analysis has captured, for example, the way in which relevant information on the market design parameters and previously submitted bids by opponents can result in different bidding prices than their marginal costs, as deviations from truthful bidding can result in improved revenues. This effect was shown to materialize more strongly in fragmented market schemes (such as in the case of fragmented markets and disjoint markets), as these markets face reduced liquidity and a higher ability for FSPs to exert market power.

Enablers & Barriers:

Table 3.12: Table of Enablers for TSO-DSO Coordinated Flexibility Markets. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)*
E	Pricing the interface flexibility exchange between TSOs and DSOs adequately can increase the efficiency of sequential TSO-DSO coordinated market models, thus further supporting their implementation	L **C** E S **M** L
E	Clear cost allocation methods among SOs when jointly procuring flexibility (ensuring transparency and fairness) would support the implementation potential of common and joint flexibility market concepts, as well as incentivize further collaboration and coordination between SOs	L **C** **E** S **M** L
R	Common types of products at both TSO and DSO levels facilitates setting up joint or coordinated TSO-DSO markets	L **C** E S **M** L
R	Standard products and coordination mechanisms at the national level provide common rules for DSO participation, especially in setting in which a large number of DSOs exist	L **C** E S **M** L
T	Observable and reliable communication systems, compatible with SOs internal systems, facilitate the implementation of TSO-DSO coordinated flexibility markets	**L** **C** **E** S **M** L

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T	Development of collaboration protocols where a common visibility is warranted without compromising the rights of protected data, especially for bid selection and bid optimisation	L **C** **E** S **M** L

Table 3.13: Table of Barriers for TSO-DSO Coordinated Flexibility Markets. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Non-clarity regarding cost allocations between TSOs and DSOs when jointly procuring flexibility.	L **C** **E** S **M** L
R	Different types of products at both TSO and DSO levels, with differing requirements, hinder the coordinated or joint procurement of flexibility.	L **C** E S **M** L
R	Misalignment in participation requirements for the service delivery of different SOs may require different (pre)qualification steps, which can hinder the success of TSO-DSO coordinated markets.	L **C** E S **M** L
R	Co-optimisation across local and system services (i.e., a common market joining congestion management and balancing), requires EU-level alignment due to the pan-European nature of balancing markets	L C **E** S **M** L
R	In some countries, DSOs are constrained by national regulation preventing the establishment of flexibility markets.	L **C** E S **M** L
T	Low compatibility between data exchange requirements for local and national actors can hinder the implementation of TSO-DSO coordinated flexibility markets, especially if the developed platforms do not include data translation layers transforming the different data formats that can be provided as inputs to a commonly used format.	**L** **C** E S **M** L
T	Different market timings (e.g., day-ahead, balancing, local congestion management) can impact the feasibility of TSO-DSO coordinated flexibility markets.	L **C** E S **M** L

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T	Requirements on network information sharing can hinder the participation of SOs in TSO-DSO coordinated flexibility markets.	L **C** E S **M** L

Recommendations:

The proposition and evaluation of different TSO-DSO coordinated flexibility markets have resulted in several key insights on the adequacy of the different market formulations, leading to the following recommendations:

Joint TSO-DSO market models are preferred if the goal is procurement efficiency: OneNet identified that a common market model, in which TSOs and DSOs jointly procure flexibility, can achieve the maximum possible theoretical efficiency, as it allows a joint and co-optimized procurement of flexibility by all SOs from a common pool of flexibility resources while abiding by all the network constraints of all the grids involved. (Target: System Operators, NRAs)

Multi-level TSO-DSO markets remove entry barriers for small-scale FSPs: although more efficient, the joint (common) TSO-DSO market setting can lead to entry barriers for small-scale FSPs, which may not be able to meet the harmonized product requirements of a joint TSO-DSO market (e.g., balancing markets). If this challenge cannot be met through aggregation, complementing the common market by a local market layer, giving rise to a multi-level market, can help overcome such entry barriers and improve market participation levels. However, this market fragmentation can lead to an overall decrease in efficiency due to possible suboptimal market clearing results, giving rise to a trade-off that must be balanced. (Target: System Operators, NRAs)

The interface flow between TSOs and DSOs needs to be priced in sequential markets: one blocking efficiency factor in sequential TSO-DSO coordinated market models (such as fragmented and multi-level), is the pricing of the interface flexibility exchange between TSOs and DSOs. Those sequential markets involve levels of separation between transmission and distribution procurement, but, in reality, the systems are interconnected through interface components (substations). As such, what happens in one market level can (negatively) impact the needs of another market level (due to modifications in interface flows). OneNet shows that pricing the interface flow between transmission and distribution systems can increase the efficiency of sequential TSO-DSO coordinated market models (such as fragmented and multi-level), to the point that those markets reach solutions as efficient as in the common market (without the need of a joint procurement, which includes direct sharing of resources and possibly confidential information). (Target: System Operators, NRAs)

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Allowing aggregation of small-scale resources is key to increase TSO-DSO markets' efficiency: entry barriers (such as minimum bid requirement) can hinder the efficiency of the TSO-DSO coordinated markets, impacting their consumer-centricity. OneNet recommends that, for instance, if minimum bid size requirements are too high (e.g., 1 MW) but mandatory (e.g., in transmission-level markets), a first market layer for small-scale resources should be added (e.g., multi-level market) or aggregation conditions should be in place to allow meeting such requirements. (Target: System Operators, NRAs)

Bid formats allowed/required in the TSO-DSO markets have an impact on their efficiency: OneNet recommends to carefully consider which bid formats to allow/require in the TSO-DSO coordinated markets as these can also impact the market efficiencies. For example, including partially divisible bids (i.e., with a minimum clearing requirement) or even fully indivisible bids can have a negative impact on flexibility markets, as they may require purchasing larger volumes of flexibility than needed. The joint TSO-DSO market is less prone to that impact because as it considers a larger pool of resources than other markets and larger flexibility needs (i.e., it is easier to replace bids that can become increasingly expensive due to their minimum clearing constraint). It is important to note that these bid formats would be in place to enable meeting the technical requirements of different flexibility assets. Hence, even though they can lead to a theoretically negative impact on efficiency, their removal may prevent flexibility resources from participating leading to a more pronounced negative consequence. (Target: System Operators, NRAs)

Separating TSO and DSO markets should be avoided: the structure of the TSO-DSO coordinated markets can (more or less) incentivize FSPs strategic bidding. Market fragmentation (such as in disjoint and fragmented markets) is the aspect leading to a higher negative impact due to strategic behaviour. As such, OneNet recommends avoiding market fragmentation (e.g., separate transmission and distribution markets) if possible. (Target: System Operators, NRAs)

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3.5 Prequalification

KEY MESSAGE:

The ability to use flexibility to deliver system and grid services is limited by (i) the technological constraints of the flexible assets used, (ii) the communication infrastructure imposed by the SOs and/or adopted by the FSP, as well as extent of their ability to participate in the markets' platforms, and (iii) the grid operational state and its safety. The ability to use flexibility to deliver system and grid services is limited by (i) the technological constraints of the flexible assets used, (ii) the communication infrastructure imposed by the SOs and/or adopted by the FSP, and the extent of their ability to participate in the markets' platforms, and (iii) the grid operational state and its safety. Prequalification is the process used to test, before being granted the ability to participate in a flexibility market, whether (i) the FSP is capable to deliver the service required fulfilling the criteria for market access (known as Service Provider qualification), (ii) the FSP fulfils the communication and ICT requirements, as well as the technical requirements to participate in the market and service delivery (known as Product Prequalification), and (iii) the FSPs' participation does not endanger the reliability of the grid operation (known as Grid Prequalification). The FGDR and the draft NCDR introduced Product verifications as the default option for congestion management, voltage control and specific balancing services, which is an alternative to Product Prequalification, in which the compliance with the delivery of a certain flexibility service is done ex-post instead of ex-ante. The prequalification process may also include checking the ability of the FSP to abide by the verification and baselining methodologies in place.

When considering the existence of different flexibility markets and products, the existence of disparate, non-coordinated prequalification measures and processes (including non-harmonized resource registration and settlement processes) can hinder the participation of aggregated distributed flexibility.

In this regard, OneNet addresses barriers related to insufficient coordination and alignment of the prequalification phase, lack of appropriate baseline methodologies, and absence of uniform registration platforms by (i) establishing flexibility register tools that act as single points of contact with flexibility providers, in which prequalification and baseline activities are performed, and (ii) proposing regulatory and harmonization frameworks for prequalification. Those solutions enhance market alignment and support the efficient participation in flexibility delivery.

Solution:

The table below gives an overview of all OneNet Solutions directly linked to Prequalification. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

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Table 3.14: OneNet solutions for Prequalification

Solution	OneNet Deliverable(s)
Flexibility register	D3.2, D7.2, D10.1, D10.3, D10.4
Framework for regulatory options for prequalification	D3.4
Framework for harmonising prequalification	D11.2

Flexibility Register

A flexibility register (FR) stores, manages, and shares all relevant information on flexibility resources participating in flexibility markets. In OneNet, the FR, which has been implemented as a software tool in some of the demos, performs different key functions including contract management, prequalification, and verification and settlement processes. Indeed, resources, resources groups, and FSPs are registered in the FR (along with their technical details), which then also performs their prequalification according to predefined requirements. The FR can also perform other functionalities related to different market phases (e.g., baselining, verification, and settlement[2]). For instance, the baselining methodology can be implemented directly in the FR, given that the data needed from FSPs can be available in the FR (same for verification and settlement).

A common flexibility register, acting as a common interface (i.e., a single point of contact) with pooled information of all flexibility assets, can support standardized, coordinated, and – when possible – harmonized prequalification processes for FSPs. The FR enables the creation of standardized and shared processes for different products, thus simplifying and streamlining the prequalification of resources. In general, the FR can support the interconnection between markets and improve access to flexibility.

The FR can be integrated with an overarching TSO-DSO coordination platform (as is the case, e.g., in the Northern demo cluster in OneNet, which aims at coordinating the need and communication between the different SOs) or independent market operator platforms (as is the case in the Eastern demo cluster of OneNet) to support the functionality of those markets. Two demo clusters have implemented a formally defined type of flexibility register in OneNet: the Northern and Eastern clusters. The Northern demo establishes its flexibility register as the single point for product prequalification, prequalifying FSPs' resources and resource groups according to the harmonised products' requirements (in addition to functionalities relevant to baselining and verification as well as contract management). The Eastern demo has implemented a format including a database comprising the FSPs and their relevant information, enabling a common procedure for the registration of assets and their participation in the market, helping the coordination between TSOs and DSOs in the procurement of

[2] Baselining, verification, and settlement are discussed in Section 3.7

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flexibility (e.g., orderbooks from FR in the Hungarian demo), and supporting the implementation of a traffic light concept method (e.g., Czech demo), for the grid safe use of distributed flexibility.

Framework for Regulatory Options for Prequalification

OneNet proposes a four-question framework relevant for the (further) development of regulation for prequalification. Questions are related to (i) whether prequalification should be mandatory, (ii) who the responsible party is, (iii) where the eligibility criteria are set, and (iv) how the submission of the prequalification template should be done. The framework was applied to the OneNet demonstrators.

For the first question, all the demonstrators considered prequalification a mandatory process that cannot be replaced by an ex-post verification, yet the coupling of prequalification with ex-post verification can help decrease the strictness of the requirements in the Grid Prequalification stage. Although the Draft of the Network Code on Demand Response discussed the default use of Product Verification for specific products (e.g., non-standardized balancing products), the different demos have opted for a prequalification step, due to concerns regarding the reliability of service delivery. For the second question, the actor responsible for the prequalification process varied, i.e., DSO/TSO (for grid prequalification) and FRO (for product prequalification) in the Northern demonstrator, TSO/DSO for Greece and Portugal, TSO for Slovenia, IMO/DSO for Spain and Poland (where for Spain, the IMO is responsible for product prequalification, and the DSO for grid prequalification), and the DSO for Cyprus, Hungary, and the Czech Republic. Thus, different responsible parties in the same demo can be responsible for different types of prequalification (product or grid) as can be seen from the provided list of implementations. In addition, the choice of prequalification responsibility was also driven by the nature of the service demonstrated and the actors involved (e.g., DSO services, TSO services, or TSO-DSO services). For the third question, most of the demonstrators defined eligibility criteria at platform level for reasons of simplicity and current lack of regulation at national level. Only the Northern demo set those at market level, mentioning that they should be established in the law by the regulator or by the respective SO. For the last question, a trend is seen among the demonstrators to use a dedicated platform to submit and evaluate templates to/of market participants (i.e., developed platforms in the Northern, Greece, Portugal, Spain, Czech, Slovenia, Poland demos, as well as the common OneNet System in Cyprus, Spain, and Portugal). However, other means were also used, as e-mail (i.e., Cyprus, Spain, Hungary).

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OneNet assessed the potential for harmonising the prequalification phase in the demonstrator solutions. In a first step, principles and practices for the design of the prequalification procedure were defined and scrutinised, which involved the analysis of external recommendations for simplifying and streamlining the prequalification step such as:

- Use of ex-post product qualification (product verification) when applicable and when it does not pose reliability risks (relying on ex-post tests and penalties for non-compliance to reduce upfront administrative burdens of FSPs and SOs),
- Sharing the burden of prequalification according to the size and risk of the resource, and taking into account the resource's size and associate risks in setting the prequalification requirement,
- Adopting common pre-qualification for the same product, even when procured by different SOs, to reduce redundancies, where such common prequalification processes would require the assignment of a prequalification responsible party,
- Shifting prequalification stages closer to the trading phase (while also exploring, e.g., embedding grid prequalification within the trading/procurement/market clearing step),
- Streamlined prequalification processes for FSPs delivering services to different SOs,
- Managing the steps needed (by creating clear criteria) regarding when some units within an FSP portfolio change. The focus here would be on assessing when prequalification updates (re-prequalification) are necessary and when they are not needed, which captures whether or not such changes negatively impact the technical capabilities of the cumulative aggregated units by that FSP endangering its ability to deliver the service (along the product and grid prequalification). The Draft of the Network Code on Demand Response defines certain criteria for reassessment of product prequalification and product verification (change in capacity, change in communication system or technology, errors in the provision of the service),
- Creating scalable prequalification techniques which can be adapted for different market structures and sizes, etc.).

Then, an analysis of the prequalification procedures in the demonstrators within OneNet was performed, highlighting the implementation within the demos of different forms of prequalification (in the three dimensions defined below). For each dimension, the proposed framework defined the benefits, threats, and requirements for implementation:

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- The harmonisation of prequalification procedures for multiple products (i.e., a common prequalification process for different products), where steps have been taken in multiple demos to harmonize the requirements for balancing, congestion management, and voltage control.
  - Benefits: reduced administrative burden, value stacking maximization of flexibility (benefiting FSPs and SOs)
  - Threats: risks of lowering product standards to achieve harmonisation , complexity stemming for merging differing service criteria
  - Requirements: pilot testing, standardized technical requirements, unified regulatory framework, interoperable IT systems, fairness and neutrality in the prequalification processes.
- The harmonisation of the prequalification processes for multiple SOs (i.e., a common prequalification process for a set of different SOs).
  - Benefits: enhanced coordination between SOs, optimized utilization of flexibility, and a reduction in administrative burden.
  - Threats: conflicts of objectives between SOs, complexity of agreement on harmonisation standards, complexity/costs of implementation/change in already implemented procedures.
  - Requirements: interoperable platforms for implementation, shared data repositories, and uniform prequalification criteria
- The harmonisation of the prequalification processes of FSPs (i.e., collective prequalification processes for a group of FSPs) at unit and group levels (i.e., prequalification of aggregation).
  - Benefits: market accessibility for small-scale flexible customers through supported aggregation and induced benefits with respect to risk diversification and versatility brought in by a portfolio of small controllable resources
  - Threats: standardization challenges when considering assets with disparate technical features, operational challenges of maintaining service requirement over extended periods
  - Requirements: advanced monitoring and control systems, adaptable/dynamic portfolio management frameworks, detailed asset documentations within the aggregated portfolio.

In this respect, the barriers for large scale adoption of OneNet solutions on harmonised prequalification procedures were investigated within OneNet highlighting: (i) conflicts between the operational objectives of different SOs, (ii) complexity of reaching an agreement on common prequalification processes, (iii) implementation challenges stemming from the need for changing existing processes and implementing new/common ones, (iv) sharing of information between entities, which face confidentiality/privacy challenges as well as data storage and processing challenges, (v) risks of lowering product standards due to the need for harmonisation , and the related consequences on the quality of service, (vi) risks of dampening innovative prequalification mechanisms due to harmonisation , and (vii) inefficiencies stemming for the harmonisation efforts of possibly disparate products/service requirements. In addition, the demo design drivers for large scale harmonised prequalification procedures adoption were analysed, highlighting the benefits of (i) enhanced coordination between SOs, (ii) optimized utilization of flexibility resources, and (iii) reduction in administrative burdens for SOs and FSPs, (iv) supporting the value stacking potential of flexibility, (v) improved market accessibility for all type of resources, enabling a versatile and flexible response.

Enablers & Barriers:

Table 3.15: Table of Enablers and Barriers for Prequalification. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Economic benefits from the implementation of replicable shared procedures and tools (e.g., flexibility register) enable their further implementation by decreasing the marginal cost of their application.	L **C** **E** S **M** L
R	Regulatory support in terms of clear mandates from regulatory authorities (e.g., Draft of the Network Code on Demand Response) for the proposition of adaptable frameworks capable of dynamically adjusting as technologies and markets evolve, while ensuring reliable and secure operation	L **C** **E** **S** **M** L
R	Harmonisation of functionalities and requirements of the flexibility registers would standardize their development and implementation efforts, thus enabling their scalability and interoperability.	L **C** **E** S **M** L
R/T	Developing transparent procedures for the implementation and running of common flexibility prequalification platforms and mechanisms, supporting the participation potential of SOs and FSPs. This is coupled with a clear definition of transparent and uniform procedures across services at national level (in line with EU guidelines), including prequalification specifications in network codes and the definition of local flexibility markets	L **C** **E** S **M** L
T	Test beds and pilots enabling the initial testing of solutions and platforms (such as the flexibility register) to support the adaptation of these initiatives and minimize the risk and barriers facing their wide scale implementation.	L **C** **E** **S** **M** L
T	The creation of digital twins enabling the testing of the proposed harmonisation solutions (technical solutions such as the flexibility register, and general shared prequalification procedures) in a grid-safe manner.	L **C** **E** **S** **M** L

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T	Advanced IT systems that process large datasets, employ analytics, provide insights on the entire portfolio, and are compatible with SO systems would support the efficient integration and functionality of a flexibility register and a streamlined prequalification process.	L **C** E S **M** L
T	Embedding grid qualification in bid optimization processes, in a way that the most adequate information about the grid impact of the combination of selected bids is considered, renders its application more dynamic and applicable to the state of the grid.	L **C** **E** S **M** L

Table 3.16: Table of Barriers for Prequalification. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Initial anticipated costs for the implementation of common procedures and their required technical platforms can be perceived as an economic barrier.	L **C** **E** **S** M L
E	Perceived non-clarity regarding the process of cost allocation within common prequalification structures (e.g., among SOs) can be considered as an economic barrier.	**L** **C** E **S** **M** L
E	Resistance to change renders a move from current practices to harmonized processes and tools challenging. This is exacerbated by a perceived complexity of integrating procedures for the prequalification processes among different services, FSPs, and SOs, which reduced the incentive of their application	**L** **C** E **S** **M** L
R	Conflicting mandates leading to differing requirements and standards among services and their prequalification needs.	L **C** **E** **S** **M** L
R	No defined governance between TSO/DSOs for flexibility register, as well as agreeing on governance of regional/cross-border registers.	L **C** **E** S **M** L
R/T	Data privacy concerns related to the sharing of network and user consumption information when considering harmonized/common processes and prequalification platforms.	L C **E** **S** M L

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T	Differing objectives between system operators rendering the drive for the development and implementation of common prequalification initiatives less appealing. This applies at TSO-DSO level, but also among different DSOs, as the large number of existing DSOs within a country or at the European scale renders aligning on common rules for prequalification more challenging.	L **C** **E** **S** M L
T	If prequalification integration procedures are perceived to be too complex, it might be considered more efficient to keep them separate, especially for DSOs in the short term	**L** **C** E **S** **M** L
T	Data privacy concerns related to the sharing of network and user consumption information when considering harmonized/common processes and prequalification platforms.	L C **E** **S** M L

Recommendations:

The proposition of flexibility register tools together with a framework for the harmonisation of prequalification have resulted in several key insights:

Flexibility register tools are key to simplify and harmonize prequalification processes: as a single point of contact between the market and the FSPs, the flexibility register contains all the needed information for prequalification procedures, which can be automatically performed for the resources interested in providing flexibility, which can be performed concurrently for multiple system services. Moreover, with the inclusion of harmonised steps for the prequalification of resource groups, smaller units can be aggregated to reach product specification/attributes (such as minimum size), enhancing the liquidity, consumer engagement, and consumer-centricity of such markets. (Target: System Operators, NRAs, Market operators)

Choosing the entity responsible for combined prequalification processes must consider several key aspects: combined prequalification processes put significant responsibility on the choice of the prequalification responsible entity. Options are an SO, coordinated efforts between TSOs and DSOs, the IMOs, and a combination of entities influenced by local regulations, market frameworks, and stakeholder engagement, depending on the market setting and service in place. Each option brings specific advantages, such as data confidentiality, technical expertise, system knowledge, market experience, neutrality, and understanding of market dynamics. As such, the OneNet project recommends that the choice of the responsible entity should consider these factors to ensure fair competition, neutrality, reliable market outcomes, and the effective evaluation of resources' capabilities. (Target: System Operators, NRAs, Market operators)

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Prequalification needs to be carefully designed in the network codes, allowing for both ex-post verification and ex-ante processes: The OneNet project identified that most entities responsible for the prequalification process do not feel prepared to apply an ex-post verification instead of an ex-ante prequalification. In the draft network code on demand response, ex-post verification is recommended as a default method, especially for congestion management, voltage control, and specific balancing products. Although interesting to increase consumers' participation, decrease administrative burdens (for both FSPs and SOs) and to harmonize the prequalification of specific products, this ex-post product qualification (product verification) can be perceived by the SOs to jeopardize service reliability leading to non-delivery of procured services (resulting in FSPs' penalization). As such, the OneNet project recommends a careful design of the prequalification process in the network codes, showcasing the benefits and reliability of ex-post verification when applicable, while allowing the responsible entities to opt for an ex-ante process in cases where ex-post verification is deemed non grid-safe. (Target: policy makers)

Embedding grid prequalification in the trading phase is recommended, if possible: some of the OneNet demonstrators proposed the option of embedding grid prequalification in the trading phase to address the timing issue when coordinating markets. This approach can make the process more dynamic, allowing for adjustments based on real-time grid conditions and validation processes, leading to a more efficient system. A form of grid prequalification coupled with grid qualification during market clearing can coexist, reducing initial risks, while avoiding the filtering out of large volumes of flexibility at the prequalification level (e.g., when running worst case grid scenarios). Indeed, a traffic light concept can be in place, regulating the level of conservativeness of the prequalification process, and how much can be left to the procurement phase, in which the dynamic changes in the grid states can then be considered. (Target: System Operators, NRAs, Market operators)

Setting the level of prequalification criteria must consider key requirements (e.g., competition, transparency): setting the level at which participation criteria are defined is also a key factor in the prequalification process. Indeed, eligibility criteria for flexibility sources can be set at the flexibility register platform level, TSO-DSO coordination platform level, the market operator level, or a hybrid option. Setting criteria at the platform level (e.g., flexibility register or TSO-DSO coordination platforms) can support consistency, transparency, and adaptability, as updated resources and grid information can dynamically be considered. Conversely, setting criteria at the market level avoids prequalification duplication and promotes efficiency. As such, the OneNet project recommends considering both options while grounding the decision process in different key requirements such as: consistency of the processes and their efficiency, adaptability, fair competition, transparency, reliable service delivery, and efficient market functioning. (Target: System Operators, NRAs, Market operators)

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Choosing a prequalification submission method must consider key market aspects (e.g., size of portfolios, scalability): the OneNet frameworks identified two main regulatory options for the submission of the prequalification template: manual and automated. Automation brings higher efficiency and scalability, making it favourable for providers with large portfolios of assets and recurring prequalification processes. Manual submission may be more efficient for stakeholders with small portfolios or one-time processes. While automation offers advantages in terms of efficiency and scalability, manual submission provides more flexibility to accommodate non-standard submissions and complex scenarios. As such, the OneNet project recommends that the choice of the submission method should consider the size of portfolios, number of FSPs, size of assets, recurring or one-time processes, efficiency requirements, scalability needs, and the ability to handle non-standard scenarios. Indeed, enabling both approaches depending on the size of the portfolio can also be an option. (Target: System Operators, NRAs)

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3.6 Procurement

KEY MESSAGE:

EU regulations advocate for a market-based approach to procuring flexibility for system services. The success of this approach is contingent upon the development of efficiently functioning flexibility markets, which can reliably deliver the needed flexibility at minimized costs. This necessitates having:

(1) **Well-structured and coherent market designs** that serve as blueprints for establishing flexibility markets, enabling replicability, and thereby reducing implementation costs,

(2) **Development of TSO-DSO coordinated market platforms** which enable the participation of the different stakeholders in the market and the coordination of the procurement process between TSOs and DSOs to maximize the value stacking potential of flexibility and minimize the risks of unintended network issues arising from flexibility activation from grids outside an SO's area of control,

(3) **Cost-effective system and grid flexibility needs' fulfilment**, guaranteeing that the system and grid needs are met reliably and at minimum costs, while ensuring fair remuneration to FSPs, and

(4) **Effective coordination among flexibility markets and with existing wholesale markets**, which supports the operation of the different markets, enabling the SOs to more accurately estimate the needs of their systems at different time stages and FSPs to participate efficiently in different markets, thus improving their flexibility valorisation potential and enhancing the volume of available flexibility to SOs.

These core aspects are a primary focus within OneNet for which concrete solutions have been developed and implemented.

Solutions:

The table below gives an overview of all OneNet Solutions directly linked to Procurement. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 3.17: OneNet solutions for Procurement

Solution	OneNet Deliverable(s)
Theoretical market framework for existing and novel market design	D3.1
Market (TSO-DSO coordination-enabled) platforms	D9.4, D7.4
Optimization-Based market Clearing Engine	D7.4
Gate closure coordination	D3.2, D3.3, D11.2
Bid forwarding processes analysis	D3.3, D11.2

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To support the design of an efficient, integrated, and scalable market for the procurement of system services, OneNet proposes a theoretical market framework for existing and novel market design options aiming at classifying/categorizing different flexibility market concepts and facilitating the communication on these concepts.

The market framework development has built upon previous market concepts and coordination models defined in previous European projects. The framework is based on five key pillars as shown in Figure 3.7.

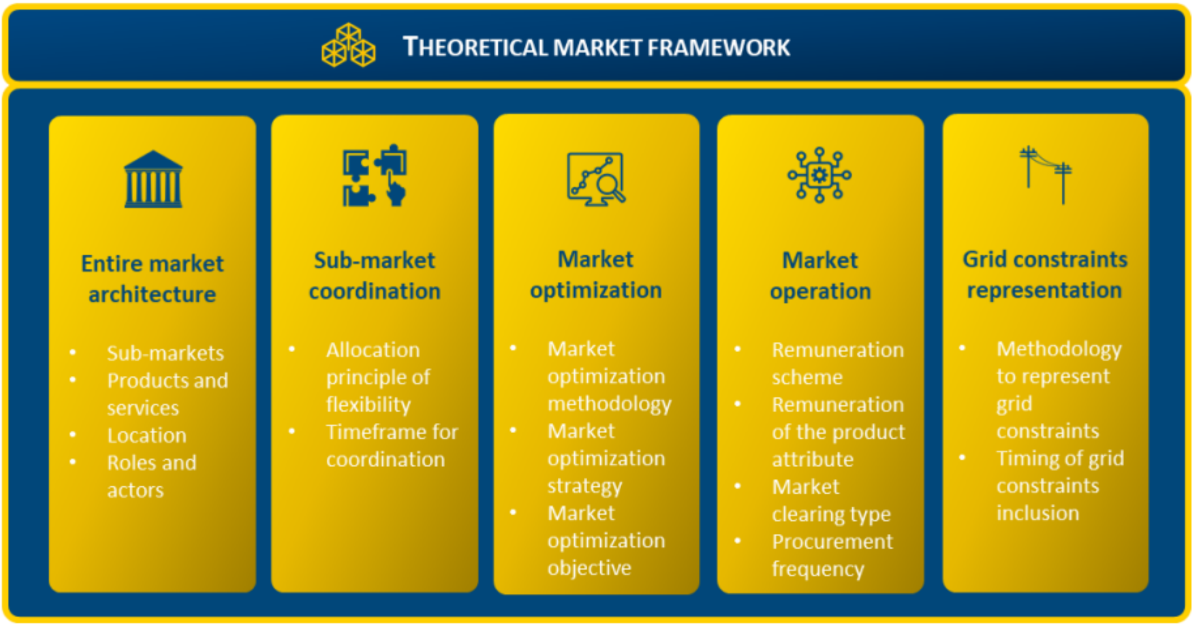

Figure 3.7: Theoretical Market Framework (D3.1)

The development of those pillars aims at classifying the interconnection and interaction that can take place between different submarkets leading to a comprehensive architecture capable of describing the various elements of flexibility market settings. Pillar 1 explores the complete market architecture, while Pillar 2 focuses on the coordination between the sub-markets. Pillar 3 focuses on the optimization for market clearing purposes, while Pillar 4 focuses on market operational dimensions. Pillar 5 focuses on the representation of grid constraints within the market.

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OneNet has developed several market coordination platforms. These platforms provide an interface to the different actors to act in the market (system operators, flexibility service providers, market operators, flexibility register operators, etc.), submitting their information to the market (e.g., bids, flexibility needs, purchase offers, etc.), and receiving the market outcomes (and at instances activation requests) through the platform. These platforms can act as a market platform within a single market operator or can be coordination platforms allowing multiple MOs to connect to and use the platform. The platform can also either integrate different functionalities such as the flexibility register or can connect to modules at the SOs, MOs, FSPs/aggregators, and optimization operators' sides. Different demos in OneNet have adopted different platforms. However, cross-interconnection is made possible through the interconnection of these platforms to the OneNet middleware, supporting interoperability/scalability and the role of OneNet to advance interconnected, harmonized solutions. Next, two examples of platforms developed within OneNet are highlighted, one from the Western demo cluster consisting of a local market platform and one from the Northern demo cluster consisting of a transmission-distribution coordination platform.

Example from the Western demo cluster:

In the Spanish demo of the Western demo cluster, OneNet has developed a local market platform enabling the DSO to procure flexibility from locally connected resources. The platform is run by an independent market operator and serves as an interface for the different market participants. The local market platform receives the flexibility needs of the DSOs, the bids from the FSPs, clears the market, and communicates the results to the different stakeholders. The platform would open a flexibility market session in an event-based manner, depending on the arising need at the DSO side. The traded products are active/power energy products and correspond to predictive short-term local active product, a predictive long-term local active product, and a corrective local active product, including reservation/availability and activation dimensions, with different remuneration mechanisms for flexibility and activation.

The local market platform also acts as a flexibility register allowing the DSOs to know the number and types of flexibility resources that are available, in addition to their location and other technical information.

Demonstrated as part of the Spanish demo, the LMP then:

- Enables stakeholders to interface with the local market,
- Allows DSOs and IMO to determine resource availability and relevant technical information thereof,
- Enables flexibility procurement by DSOs, by opening a market session when needed,
- Collects FSPs bids and DSOs flexibility needs,

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- Clears the market and communicates market results to the stakeholders.

Example from the Northern demo cluster:

In the Northern demo cluster, a transmission-distribution coordination platform was developed to support TSO-DSO coordination for the procurement of flexibility services (congestion management, with the option to take into account the imbalance position) through the trading of different flexibility products (long-term, short-term, near real-time, as well as capacity and energy products).

The platform provides several key functionalities, such as:

- Enables the coordinated procurement of flexibility between TSOs and DSOs and supports the run of a joint flexibility market as well as local markets,
- Provides initial flexibility resources grouping and their grid qualification,
- Enables SOs to initiate call for tenders,
- Develops and integrates flexibility register functionality (flexibility register as an integrated component),
- Receives FSPs' bids, system operators' needs/system models, and purchase offers needed for the market runs,
- Coordinates and integrates those inputs to be then sent to the market clearing engine for running a joint, common flexibility market (i.e., the optimization module),
- Receives the market outcomes from the optimization module and sends the market results to the SOs, MOs, and FSPs leading to sending activation signals to flexibility resources,
- Enables connection to a market clearing engine (i.e., the optimization module),
- Provides connection possibility with the OneNet middleware,
- Provides connection possibility with EU platforms (e.g., MARI).

This ICT platform enables the successful trading of different flexibility products in the Northern demo cluster in OneNet, in which TSOs and DSOs from Finland, Estonia, Latvia, and Lithuania have run specific use cases in support of their systems. The platform enabled connection to the optimization module/market clearing engine operated by VITO, as well as to market platforms such as NordPool and PicloFlex, in addition to a connection to system operators participating in OneNet and to Flexibility Register.

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OneNet highly focusses on joint TSO-DSO procurement of flexibility products by developing a bid optimization tool that matches flexibility bids and purchase offers in the most economical way, taking into account not only each bid's price, but also its impact on each network component.

Indeed, OneNet developed a market clearing engine, dubbed "**optimization-based market clearing module**" which enables jointly meeting the flexibility needs of TSO and DSOs, maximizing the flexibility value stacking potential and minimizing flexibility procurement costs. The module maximizes procurement efficiency (minimizes procurement costs, equivalently, maximizes the social economic welfare), while meeting the grid operation limits and abiding by the submitted bids technical needs. The optimization module aims at not only resolving the grid/system flexibility needs (e.g., congestion management) at least possible costs, but also ensures that the cleared flexibility, when activated, does not cause grid operational constraint violation in any of the grids involved. The module takes as inputs:

a. The set of flexibility bids submitted and their technical requirements (accepts different types of simple and complex bids – in harmonisation with MARI bid requirements – namely, fully divisible, fully indivisible, partially divisible, multipart (parent/children), and exclusive set bids),
b. The system operators' network information (highlighting the network configuration, power transfer distribution factors, expected power flows, and line limits), and
c. A purchase offer containing fundamental information provided by the SOs to launch the market clearing process and the procurement of flexibility, while indicating limits on the impact congestion management can have on the system balancing state.

The key outputs of the module include:

a. The portion of each bid to be cleared/purchased,
b. The total flexibility procurement costs, and
c. The updated network state including flexibility activation (i.e., the updated power flows, imbalance position),
d. among others.

The module enables the optimal trading of different flexibility products (of the Northern demo), namely:

a. Near real-time active energy (NRT-P-E),
b. Short-term active energy (ST-P-E),
c. Short-term capacity (ST-P-C),
d. Long-term capacity (LT-P-C),

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e. Long-term capacity with activation stage (LT-P-C/E-res is the product for the reservation stage and LT-P-C/E-act is the product for the activation stage).

It is automatically usable and accessible through a developed API. For the NRT-P-E product, the module also allows linking with MARI for the forwarding of flexibility bids from the regional flexibility platform to MARI. The forwarding of bids undergoes first a **MARI check** and a **grid check** filtering process to ensure, respectively, that the forwarded bids abide by MARI's bid requirements, and that the forwarded bids do not risk causing constraint violation to the local grids, from which they originated, if activated by MARI.

The optimization module has been thoroughly and successfully tested and demonstrated in the Northern demo cluster. The module reliably returned the market clearing results in a very short period of time (<0,25 s in all tested demo cases, in Finland, Estonia, Lithuania, and Latvia), ensuring an achieved minimum procurement cost and ensuring grid safety given the available sets of flexibility bids made available to the market.

Gate Closure Coordination

As highlighted by several OneNet demo clusters, gate closure time (GCT) incoordination is a main barrier for flexibility market integration.

Market gate opening and gate closure times directly impact whether FSPs can have the chance to use their flexibility in subsequent markets in case they were not cleared in preceding flexibility markets. In addition, having significantly early GCT can result in large uncertainty for the FSPs coupled with significant forecast errors, which influences their participation and the reliable service delivery to the grid, which in turn impacts the flexibility needs in subsequent markets. Indeed, improper coordination among GCTs has been identified by the OneNet as one of the main barriers facing bid forwarding.

OneNet highlights that gate closure times of flexibility markets must be coordinated properly, while taking into consideration existing energy markets, to (i) better estimate the evolving network state and flexibility needs, which in turn can be accommodated by flexibility products, and (ii) to allow transparent market participation for FSPs, enabling them to valorise their flexibility, thus achieving increases in revenues and/or cost reductions, while concurrently benefiting the system. Indeed, coordinated GCT enables FSPs to maximize the value stacking potential of their flexibility by enabling them to subsequently bid in different markets.

GCT coordination can capture:

- Coordination among the gate closure times of the flexibility and services markets in place.
- Coordination with existing energy markets (e.g., day-ahead and intraday markets)

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Different demos in OneNet have followed different approaches in coordinating the GCTs of their implemented markets. Some examples, among others, are highlighted next to showcase different variants:

- In the Northern demo: a GCT coordination is established to support the effective trading of the different flexibility products, considering the flexibility services that these products provide (i.e., coordination of the trading of the different flexibility products from long-term, to short-term, and near real-time). This coordination also considers coordination of the flexibility markets with respect to the wholesale markets (DA and ID) and balancing markets (e.g., MARI). For example, the Northern demo adopts a coordinated trading of its short-term active energy product (ST-P-E) with the wholesale intraday market. This is readily possible as the ST-P-E trading is integrated within the intraday market trading of Nordpool through what is referred to as locational intraday trading (intraday energy exchange with locational information enabling SOs to purchase ID bids for flexibility procurement). The GCT of ST-P-E trading is fixed at 2 hours before real-time. On the other hand, the GCT for the near real-time active energy product (NRT-P-E) is much closer to real-time operation and is set at 25 minutes ($T_0 - 25$) before real-time (T_0). This enables the operator to have a more complete knowledge of the network state (e.g., power flows), which considers the activations resulting from the ST-P-E product trading, hence allowing a better use of the NRT-P-E product. In addition, the 25 minutes GCT coincides with the balancing service providers' (BSPs) GCT within the MARI platform. As such, at T_0-25min, the BSP would in any case send their flexibility bids to the TSO, so this can be done in a joint manner where flexibility can be used for congestion management first (if desired by the FSP) before it is being considered for balancing within the MARI platform. Moreover, the bids to be forwarded to MARI in the NRT-P-E case, must be forwarded latest 12 minutes before real time (T_0-12min). This has the goal to have those bids considered for scheduled activation (SA) by MARI, whose GCT for TSOs is at T_0-10min.
- The Polish demo has established a setting in which all bids related to congestion management and voltage control at the distribution grid level are to be submitted and cleared before the gate closure time for balancing capacity.
- In the Cypriot demo for FCR products, bids are first cleared in the TSO market. The remaining active power flexibility from FSPs connected in the distribution grid can then be traded subsequently in the local DSO near real-time market.

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The coordination between the gate closure and opening times of the markets enables flexibility providers to effectively participate in the different possible markets to maximize their valorisation potential. This can be further supported by an automatic forwarding of bids from one market to the other, i.e., when bids of an FSP are not cleared in one market (e.g., a local congestion management market), they will be automatically forwarded to a following market to be considered for market clearing there (e.g., in a balancing market). This concept is referred to as “bid forwarding”, which can enhance the revenue stacking of service provides and the market liquidity. Bid forwarding would then require compatibility between the two markets, in terms of their products (and their attributes) traded and the bid formats allowed. OneNet introduced a definition of bid forwarding and proposed a methodology to analyse different bid forwarding processes through which one can effectively assess the bid forwarding potential and address hindering barriers for its implementation in energy and flexibility markets. The analysis has led to various observations. For example, the elimination of capacity reservation conditions for participation (keeping capacity reservation when needed, but complementing it with the allowed participation of free bids, thus providing a reduction in entry barriers in subsequent markets), the ability to participate using aggregated resources, the alignment in market timings, and the development of harmonized/coordinated prequalification methods in subsequent markets are key dimensions to enable the bid forwarding process.

In addition to compatibility in traded products, bid types, participation requirement, and market timing, a requirement for bid forwarding is to have mechanisms in place aimed at ensuring that the forwarded bids are grid-safe for the grid from which they originate. In other words, since when considering forwarding bids to subsequent flexibility or energy markets and as such markets may not be able to have constraints in place to limit the market clearing results in such a way to ensure that the local or regional grid constraints are not violated, a grid checking mechanism must be in place to ensure that only grid-safe bids are to be forwarded. For example, when considering forwarding bids from regional congestion management markets to MARI, the internal constraints of such grids would not be available to the MARI market clearing process to be able to ensure that the cleared flexibility, when activated, would not cause operational grid constraint violations within those networks. To address this challenge, OneNet has proposed three different methods to enable grid-safe bid forwarding:

- Bid prequalification: in these mechanisms, before bids are forwarded, they are checked against the grids from which they originate, and they are filtered out accordingly to make sure that only grid safe bids are forwarded.

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- Correction mechanisms: in this mechanism, bid forwarding takes place without initial checks, but the solution of the subsequent market is then checked (ex-post) with respect to the grids from which the cleared flexibility originated, to make sure that the market clearing result is safe. When any network violations are identified, a correction mechanism through local market layers is then run to address these violations.
- Bid aggregation: this mechanism mandates a party (e.g., the DSO) to create a bid safe flexibility function (known as residual supply function), which constitutes a stepwise function (where each step indicates an additional volume of flexibility that can be provided and its corresponding price. This residual supply function can then be submitted to the subsequent market layer, ensuring that any step when cleared can be dispatched locally in a grid-safe way.

In addition, a comparison framework has also been developed to compare between the efficiency, grid-safety guarantee, and computational complexity of each approach, in addition to their level of alignment with current regulatory settings. For example, the bid aggregation method can theoretically lead to grid safety and a high level of efficiency. However, it faces computational challenges as well as regulatory difficulties due to the new role assumed to be carried out by the DSO (acting as a market participating entity) or other independent entities that would require access to the distribution network grids to compute the required supply function. On the other hand, the correction mechanisms and bid prequalification are to a large extent in line with current regulations. The bid prequalification's grid safety relies on the sophistication of the grid checking and filtering process. The method also highlights a trade-off between grid-safety and market efficiency, since a stricter checking mechanism can guarantee grid safety but at the cost of discarding a large volume of flexibility (some of which would have been grid safe) leading to suboptimal solutions. The correction mechanism requires a low computational load, but its performance depends on the assumption of high liquidity in the ex-post flexibility market runs in which the correction actions are to be scheduled.

Enablers & Barriers:

Table 3.18: Table of Enablers for Procurement. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	Several demo activities have already run in Europe, which provide a background experience and available solutions for implementing flexibility market procurement processes leading to reduced costs. Continuous support for these demo activities, focusing on scalable and replicable solutions, at the European, national, and regional scales can support the continuous decrease in development and implementation costs.	**L** **C** **E** **S** M L

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E	Implementation of optimization-based market clearing mechanisms (which not only consider the costs of the bids submitted, but also their impact on the different grid elements and their ability to effectively contribute to the flexibility need) can achieve minimized costs to the SOs and fair and transparent remuneration for the FSPs. This acts as an economic enabler for the implementation of these mechanisms as compared to simple merit-order based clearing that only considers the bid costs. In addition, engagement mechanisms to support the widescale participation of FSPs in those markets, would help such market schemes achieve their potential.	L **C** E **S** M L
R	There is a general regulatory support for market-based procurement of flexibility, and the efficient functioning of markets, and for making the systems and markets ready to integrate demand side flexibility, as seen by the ongoing process to develop a network code on demand response. Hence, a reassessment of regulatory mechanisms at the member state level, in accordance with EU regulation, would support the realization of these initiatives.	L **C** E **S** M L
R	There is a general support for harmonisation potential between markets at the European level, when feasible. These efforts can aim to address when harmonisation or coordination would be beneficial and when not, which can support the coordination between different flexibility markets. The rise of European platforms for balancing services, and the ongoing integration of EU wholesale markets, provides a common reference for the timing of those markets and their coordination, which can then be used for the design of local/regional markets for other flexibility services (e.g., congestion management) to ensure the possible coordination among those markets.	L C **E** S **M** L
R	Enabling the use of "free bids", i.e., bids from capacity not previously reserved, in addition to bids from reserved capacity can enable the use of bid forwarding.	L **C** E S **M** L
R	Implementation of coordinated or common prequalification mechanisms for different markets can support the participation potential of an FSP in all these markets while reducing the organizational burden. This, as a result, enables the implementation of bid forwarding between markets.	L C **E** S M **L**
T	There is a large technical knowhow in the different European counties on setting up flexibility market procurement processes/platforms, which is gained through several demonstration projects and local/national initiatives. In addition, the coordination between different flexibility markets has also been addressed in OneNet, where common platforms were also developed. Such coordination can be facilitated through support at the European level, thus enabling the implementation of coordinated and interconnected flexibility procurement processes and platforms. Support in platform development enabling the unlocking of economies of scale when setting up a common market platform can also provide incentives for different SOs and MOs to join forces, while reducing the perception of additional complexities or costs.	L C **E** **S** M L

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T	Technical support and engagement with the operational and planning departments of the SOs would be needed to support the generation of the required network representations and models to be integrated in local, central, or TSO-DSO coordinated market clearing formulations.	**L** C E **S** M L
T	Optimization linearization/convexification techniques and computationally efficient methodologies are widely available and can be implemented to support the efficient and timely market clearing, targeting computational complexity challenges that such markets can face, when considering very large systems and the introduction of complex bids.	**L** C E S **M** L

Table 3.19: Table of Barriers for Procurement. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	High costs of development and implementation of market platforms which can at instances disincentive flexibility market implementation as compared to other flexibility procurement options or grid investments. Even though the costs are decreasing due to gained experience and replicability potential, the costs for different operators can still be perceived to be high. Short to medium term support on the European scale through demonstration projects can contribute to driving down such implementation prices. High implementation costs can imply high participation costs for stakeholders, which can be a deterrent for participation.	L C **E** S **M** L

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Recommendations:

The market-based procurement of flexibility for system services requires the development of efficiently functioning flexibility markets, capable of delivering the needed services reliably and at minimum costs. The following key recommendations enable achieving those goals:

Previous experiences together with BRIDGE initiatives, common workshops and/or direct cooperation around Europe is needed to reduce the perceived high investment costs in flexibility markets: flexibility markets, and market platforms therefore, can be perceived to be a new type of markets for SOs and solution providers, which implies additional complexity and costs of implementation. These implementation costs can be prohibitive and can disincentivize the setting up of these markets when compared with other flexibility options and grid investments. However, several flexibility markets have already been implemented in demonstration activities (in European and national projects) and are in actual operation across Europe. These previous experiences can enable the replicability/scalability of those solutions or can, at minimum, provide guidance on how to set up those markets so that is not needed to start from scratch with every new flexibility market initiative. As such, making use of previous experiences, and supporting this transfer and build-up of knowledge through BRIDGE initiatives, common workshops, and/or direct cooperation between the partners in European projects would help reduce the perceived high investment costs as well as the complexity of implementation and operation of flexibility markets and their platforms. (Target: representatives of pilot projects, BRIDGE, policy makers)

TSO-DSOs coordinated market platforms must seamlessly interact: setting up TSO-DSOs coordinated market platforms support the coordination and concurrent participation of different stakeholders (buyers of flexibility, such as TSOs and DSOs, market operators, FSPs, flexibility register operator, market optimization operator, etc.). This enables a common interface for these actors as well as the coordinated and grid-safe procurement of flexibility between TSOs and DSOs, and the maximization of the value stacking potential of flexibility. However, this does not always mean that a single market platform should be set up. Different platforms can be set up to accommodate the needs of different SOs and their service requirements, and the practical setting of the grids for which these markets are implemented. However, these market platforms should be enabled to seamlessly interact, thus enabling access to a wider pool of flexibility, as well as coordination between SOs to align on the flexibility needs and minimize the risks of unintended grid consequences stemming from flexibility activation. (Target: System Operators, NRAs, Market operators)

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Intelligent optimization mechanisms for market clearing are key to enable efficiency: the implementation of intelligent optimization mechanisms for market clearing enables clearing the flexibility market while ensuring minimum costs for the SOs, fair remuneration for FSPs (maximization of social-economic welfare), and FSPs' impact on the operation of the grid, developers are encouraged to make use of the wealth of solutions available in the operations research literature and in practice, and which are capable to reduce the possible computational load of these mechanisms. More specifically, the optimization models capture: 1) the impact of FSPs on resolving available grid issues for which the market is set up, and 2) ensure that this flexibility procurement does not lead to additional issues in any of the grids involved. Hence, including the grid aspect in the market clearing process (going beyond simple merit-order lists for market clearing) is essential to capture these elements, thus achieving a truly optimal market output. OneNet has demonstrated the success of using such optimization-based market clearing mechanisms (e.g., through the optimization module developed and tested in the Northern demo cluster). The implementation of these optimization mechanisms can act as enablers for participation as it brings benefits to both SOs and FSPs. Here, in case computational complexity of these techniques becomes challenging, developers are encouraged to make use of the wealth of solutions available in the operations research literature and in practice, and which are capable to reduce the possible computational load of these mechanisms. (Target: System Operators, NRAs, Market operators)

Platform developers must support SOs in generating the data needed for market clearing, as well as consider the data models used by SOs in their software development: the implementation of TSO-DSO coordinated markets, and the integration of grid representations, can constitute a participation challenge for SOs due to the need to generate the grid models/representation required and the sharing of this information. Here, it is recommended for platform developers as well as the developers of market-clearing engines to support the operational and planning departments of system operators in generating the needed data and its communication following standardized data models (e.g., CIM). In addition, security and confidentiality guarantees should be in place to secure the shared data. In addition to cybersecurity and encryption measures, abstracted forms of grid data can be used if the flexibility needs of the system allow it. For example, if an area of the grid is known and guaranteed to have overcapacity without any risk of congestions and voltage issues, the representation of that grid section in the market clearing formulation can be abstracted. (Target: System Operators, System developers, Platform developers)

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Engagement processes of FSPs are needed to the successful implementation of flexibility market platforms: to maximally capitalize on the use of these TSO-DSO coordinated flexibility market platforms and the benefits introduced through optimization-based market clearing mechanisms, the engagement of FSPs is needed to support and sustain a high level of liquidity in those markets. As such, engagement processes to highlight the benefits of valorising flexibility is essential to engage FSPs and incentive their participation in the markets. Transparent and efficient market functionality brought forward through these platforms and market clearing mechanisms are also a main incentive for FSP participation. (Target: aggregators, NRAs, policy makers, System Operators, Market operators)

Coordinating different flexibility markets is essential for their real implementation: in addition to the coordination within market platforms, coordination between the different flexibility markets that are set up is also essential to enable the SOs to define their flexibility needs more clearly (taking into account the effects of flexibility activations in other markets), and for FSPs to maximize the valorisation potential of their flexibility through the ability to participate in different markets. Essential elements therefore consist of coordinating, as much as possible the temporal sequence of these markets, e.g., their gate opening and closing times, as well as coordinating their participation requirements, enabling FSPs to more easily participate in those different markets. For example, coordinating different markets through bid forwarding requires compatibility of the products (and their attributes), compatibility of the bid's formats, as well as reducing the requirement on capacity reservation for participation (i.e., supporting the use of free bids), and the harmonization/coordination of the prequalification processes (i.e., through joint or common prequalification processes among different compatible markets), enabling FSPs to participate in those different markets through a simple bid forwarding mechanism. As such, coordinating different markets through bid forwarding requires compatibility of the products (and their attributes), and bid attributes, as well as a mechanism to ensure that the bids forwarded, when cleared in the subsequent markets, would not cause network violations in the grids where they are located. As such, mechanisms to check the impact of clearing bids on the grids from which they originate must be implemented to support bid forwarding. In this regard, a general support on the EU level exists for harmonization between markets, when this harmonization brings tangible benefits. In addition, the development of European-scale balancing platforms (i.e., MARI, PICASSO, TERRE), and the ongoing integration of EU wholesale markets, sets a common reference allowing the alignment of newly developed flexibility markets to ensure their possible coordination with those markets. In addition, existing markets are also encouraged to take into account the arising flexibility need in the European grids (transmission and distribution) and adapt their processes in support of flexibility procurement. For example, OneNet explored the introduction of locational granularity in intraday wholesale markets enabling SOs to purchase bids from those markets that are deemed to support their grid (the ability to provide that support is reflected through the bid's locational dimension). (Target:, NRAs, EU-policy makers, System Operators)

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3.7 Settlement & Baselining

KEY MESSAGE:

OneNet emphasizes the importance of selecting the right baseline methodology for flexibility services, considering simplicity, accuracy, and integrity. Baselining methods are identified as a pivotal solution area by the project, as they are required to determine the volume of flexibility delivered and used as part of the activation control and correct settlement. The current baseline methodologies implemented have been chosen in a pragmatic way and frequently based on suggestions of stakeholders, with the idea that these baseline methodologies could be reviewed in a later stage.

Objectively analysing the performance of the baseline methodologies currently in place and possible opportunities for improving the existing baseline methods or introducing new baseline methodologies still requires attention. Moreover, efforts are still needed on the harmonization, standardization, or coordination across different voltage levels and markets. Alignment across different settlement and baselining methods is crucial to streamline processes and ensure accurate measurement and settlement of flexibility, particularly in emerging markets and at the low voltage level. Ultimately, the selection of a methodology depends on various factors, including stakeholder expertise, regulatory parameters, and available resources.

OneNet offers practical insights and a framework for this analysis and selection process.

Solution:

The table below gives an overview of all OneNet Solutions directly linked to Settlement & Baselining. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 3.20: OneNet solutions for Settlement & Baselining

Solution	OneNet Deliverable(s)
Framework for regulatory options for baselining	D3.4, D11.2
A concrete method to define the baseline	D3.2

Framework for Regulatory Options for Baselining

A comprehensive taxonomy of baseline methodologies reveals their varying performance across the three pivotal principles of baselining: simplicity, accuracy, and integrity. While no baseline can perfectly embody all three principles due to their inherent nature as estimations, those striking a balance among them are deemed superior. Consequently, selecting the optimal baseline methodology is a nuanced process, contingent upon

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factors such as the type of the provided service or product, characteristics of the service provider, timeframe, and relevant requirements and regulations. Introducing a six-question framework within the OneNet project elucidates regulatory options concerning baselining methodologies: (1) Which relationship is the baseline methodology applied to, (2) In which grid operational state is the baseline methodology used? (3) Who is responsible for setting the baseline, (4) Which type of customer is baselining applied to, (5) Which type of DER is baselining applied to, and (6)Which product is baselining applied to. For each question, we provide a set of possible answers and discuss these options with a specific focus on the baselining principles. While the first two questions are discussed in general terms, the other four questions consider the experiences of the OneNet demonstrators. Each question in the framework is accompanied by a range of potential answers, deliberated with a keen focus on the baselining principles and its objectives of accurate verification and settlement. These insights, gleaned from the OneNet demonstrators, furnish a practical framework for evaluating the most suitable option. The analysis shows that there is no clear trend in the choices taken by the demonstrators. They often depend on the existing experiences of the involved actors and the tools and information that are already available to them. In several cases, the choice also depends on the preference of the FSP itself. When allocating the responsibility for setting the baseline, trade-offs between the baselining principles of simplicity, accuracy and integrity must be considered.

A Concrete Method to Define the Baseline

A precise definition of a baseline is crucial for verifying the provision of flexibility services. With numerous methodologies available for calculating baselines, it is acknowledged that a degree of harmonisation is essential to expedite DR development and lower barriers for new entrants in electricity markets. The OneNet project offers an overview of baseline definition methods, enriched with insights from demonstration projects for practical implementation. Both the Northern and Spanish demos rely on historical data information to define the baseline, with the latter haven't yet defined specific rules for baseline definition but is currently undergoing some studies on different ways to calculate the baseline using historical information from smart meters or asset monitoring devices. However, the Northern demo foresees two different approaches for baseline calculation, either ex-ante provided by the FSP, or ex-post baseline, the latter based on historical data and centralises this process via its flexibility register, through which the settlement process is also done. The Northern demo resorts to the ex-post process in case the FSP doesn't provide an ex-ante baseline until the predefined deadline. Diverse settlement methods can lead to inefficiencies and increased costs for FSPs, navigating multiple procedures with underlying uncertainty regarding future collected revenues from flexibility delivery, emphasizing the need for alignment to streamline processes and ensure accurate measurement and settlement. Forecast-based solutions are also implemented. In the Cypriot demo LV prosumers separate loads between controllable and

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uncontrollable, having two different smart meters installed, for each of these categories, and a load/generation forecasting scheme is applied solely to the controllable loads, for which forecasting errors calculated by the FSPs are corrected by a storage system installed by the prosumer. The Greek demo relies on its F-Channel to do realistic assessments of weather conditions and based on that, provides dispatch setpoint instructions for FSPs, and uses the common baseline load calculation provided for in the existing balancing market. The Slovenian and Polish demos also adopt similar practices done in TSO markets, with the latter using the same baselining method used in capacity markets. The Hungarian demo adopts a different approach from other demos, addressing the baselining barrier via product design, namely through the use of capacity limitations instead of ordered deviations, thus, no requirements are defined in the demo regarding baseline as it is not directly connected to a specific provision schedule. While different services may have unique baselining requirements, the options presented within the OneNet project allow for seeking synergies between markets and potentially mitigating these discrepancies.

Enablers & Barriers:

Table 3.21: Table of Enablers for Settlement & Baselining. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	Level of Intervention (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
R	Regulatory framework for baselining is proposed in new network code demand response (draft NCDR). This should be transposed to regional regulation.	L **C** E **S** M L
R	Allowing submetering and both ex-ante and ex-post baselining will facilitate data access and availability to required baselining data.	L **C** **E** S **M** L
R	Practical insights from demonstration projects enrich the overview of baseline definition methods, enabling stakeholders to understand real-world applications and benefits, which can encourage adoption.	L **C** **E** **S** M L
T	Appropriate measuring devices implemented for baseline calculation.	L **C** E **S** M L
T	Advances in digital technologies and data analytics enable the development of automated baselining and settlement systems, reducing manual errors and improving accuracy and efficiency.	L **C** E **S** M L

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T	Adoption of interoperability standards and protocols for data exchange and communication can facilitate seamless integration of systems and facilitate the definition of baselines.	L **C** **E** **S** M L

Table 3.22: Table of Barriers for Settlement & Baselining. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Without transparent baseline methodology, the revenue stream for FSPs is uncertain.	L **C** E **S** M L
E	The need to upgrade systems and infrastructure to accommodate standardized baselining and settlement processes may incur initial implementation costs for market participants (which can be FSPs and/or SOs), especially smaller entities with limited resources.	L **C** E **S** M L
R	Large number of DSOs makes aligning on common baselining rules difficult.	L **C** E **S** M L
R	Variability in market practices (e.g., products and services and roles and responsibilities) across different regions or countries due to the absence of universally agreed approaches can hinder the adoption of standardized baselining methodologies.	L C **E** **S** M L
T	Lack of standardized data formats and protocols for baselining and settlement can hinder data exchange and interoperability between different systems and platforms, leading to inefficiencies and errors.	L **C** **E** **S** M L
T	Integrating distinct systems and platforms for baselining and settlement can be technically complex and costly, requiring careful planning and coordination among market participants and technology providers.	L **C** E **S** M L
T	Stochasticity of residential consumption and data availability limitations, can impede the establishment of baselines at the low voltage level.	L **C** E **S** M L

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Recommendations:

Baselining methods play a pivotal role for the breakthrough of flexibility markets as they determine how FSPs can be compensated properly. The OneNet project offers an insightful overview of baseline definition methods, enriched with practical insights from demonstration projects to facilitate implementation. A thorough taxonomy of baseline methodologies sheds light on their diverse performance across the critical principles of baselining: simplicity, accuracy, and integrity.

The following recommendations are proposed with respect to Settlement & Baselining:

Further research is needed to establish proper baselining methods, especially at lower voltage levels: While established services often benefit from well-defined methodologies, emerging markets frequently lack a universally agreed approach, resulting in varied practices across Europe. The emergence of new flexible resources, particularly at the low voltage level, poses challenges in quantifying flexibility due to factors like stochastic residential consumption, data availability limitations, and the disparity in the type of flexible technologies that can be aggregated. Harmonizing procedures across all voltage levels is essential, with a particular emphasis on LV due to its current challenges in baseline methodology and market access for flexibility providers. Nonetheless, best practices for establishing LV flexibility baselines are currently lacking, underscoring the need for further research and standardization in this critical area. In addition, harmonization can potentially be performed at the level of definition of attributes of each method, as well as on the choice of which methods can be viable. Research along these two dimensions is required to identify the level of harmonization or coordination needed, to provide clarity to the FSPs while not limiting their participation due to the absence of baseline methods that can suit their technologies and metering structures. (Target: R&D, policy makers, NRAs, FSPs, System Operators)

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Harmonisation between different baseline solutions is important to facilitate FSPs: While no baseline can perfectly embody all three principles of simplicity, accuracy, and integrity due to their inherent nature as estimations, those striking a balance among them can provide a higher level of adequacy depending on the use case considered (e.g. market structure, services considered, technologies considered, aggregation mechanisms permitted, etc.). Consequently, selecting the optimal baseline methodology is a nuanced process, contingent upon a multitude of factors. As different settlement and baselining methods exist, causing inefficiencies and increased costs for FSPs navigating multiple procedures, alignment becomes crucial. Across the demonstrations, some recurrent solutions were identified, particularly concerning baselining methods. However, despite their recurrence, these solutions lack full harmonization due to specifications dependent on factors such as the country of the demo, network topology, digital and infrastructure maturity, and the level of flexibility market implementation. Alignment is essential, which can focus on the definition of attributes within each method rather than solely on the selection of a single method as the latter can constitute a barrier for some technologies, to streamline processes and ensure accurate measurement and settlement of flexibility. While different services may necessitate varying baselining requirements, seeking synergies between markets could mitigate these differences. (Target: EU-policy makers, System Operators)

Diverse baselining methods should be allowed, enabling adaptation to different circumstances: The framework developed to assess baseline methodologies highlights that, in practical demonstrations, only a limited subset of available baselining methodologies sees active use. Rather than a broad adoption, the demonstration experience underscores the importance of fostering diverse approaches. Ultimately, the selection of a methodology hinges on several factors: the stakeholders' expertise, existing requisites, tool availability, informational resources, regulatory parameters, as well as on the technical characteristics of the service to be delivered, the market mechanisms in place and rules regarding aggregation, and the specification of the diverse set of flexible technologies. In cases where the default option entails a self-declared baseline by the FSP, it becomes imperative to offer alternative solutions should the FSP opt out or fail to submit their baseline. Verification and mitigation measures must also be in place to uphold accuracy and integrity. (Target: R&D, policy makers, NRAs, FSPs, System Operators)

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3.8 SO’s Needs

KEY MESSAGE:

As the energy landscape continues to evolve, with ever more DERs entering the grid and more frequent severe weather and geopolitical events, SOs are faced with a growing number of challenges from numerous sources that impact their network management. These include an increased frequency of congestion events, over/under voltages, and frequency deviations that threaten grid stability; natural disasters that can damage existing network infrastructure; and an increasingly complex market environment that complicates communication channels. SO’s currently do not have the visibility necessary to adequately address these needs and, as a result, must provision flexibility without fully understanding their needs, knowing how much flexibility is available, or how its activation will impact the grid.

Many solutions have been proposed to counter these challenges from grid visibility (via smart meter roll-out) to standardizing the use of the CIM data format across all energy markets and system operators. However, these permanent fixes and transitions take time to implement and as a result do not solve the problems in the short-term.

OneNet presents solutions that address the lack of clarity for flexibility needs. This is accomplished by improving forecasting capabilities and communication channels for SOs to obtain knowledge on the needs of the network as well as the impact of flexibility activation. Using these tools, SOs can efficiently procure flexibility when and where it will be needed. These solutions also facilitate market participation by giving FSPs insights into the impact their flexibility can provide, increasing the number and quality of bids generated.

Solution:

The table below gives an overview of all OneNet Solutions directly linked to SO’s Needs. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 3.23: OneNet solutions for SO's Needs

Solution	OneNet Deliverable(s)
TSO flexibility needs evaluation and FSP flexibility provision simulation tool	D3.2, D9.5, D11.1
F-channel forecasting module	D3.2, D8.2, D8.4
Short-circuit levels forecast tool in TSO-DSO substations	D9.1, D9.2. D9.5
Traffic light scheme	D3.2, D10.2, D10.4, D10.5
Single Flexibility Platform	D3.2, D7.4, D7.6

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TSO Flexibility Needs Evaluation and FSP flexibility provision simulation Tool

With the increase in penetration of DERs into the electricity network, it is anticipated that TSOs and DSOs will experience a rise in the number of congestion events within their networks. The ability to adequately forecast these constraints becomes imperative to ensure that the appropriate quantity of flexibility is procured in the locations that it is needed. Without this foresight, the FSPs lack the relevant information to offer flexibility where it is needed. Additionally, given the inherent stochastic nature of energy supply and demand within a network, obtaining an accurate forecast of potential flexibility needs has proven to be difficult.

To address this need, OneNet developed a solution that empowers SOs and other relevant parties to evaluate the flexibility needs of any network for a given timeframe and provides FSPs with a set of flexibility dispatch solutions that address these potential constraints. This tool is composed of two modules: one that computes the TSO nodal flexibility needs in the TSO/DSO transformers (EHV/HV) and another that provides the FSPs' optimal dispatch that solves the TSO's flexibility needs. The tool can be used for single or multi-period studies and can run a stochastic analysis. It allows the TSOs to identify the grid flexibility needs profile, taking into consideration different levels of demand uncertainty as input.

This tool was tested within OneNet in the Portuguese demo. In this, the tool was used on the EHV network operated by the Portuguese TSO, REN. Due to the limited number of consumer participants within the Portuguese demo, the available dataset was limited. This, combined with the robust Portuguese grid that was designed to avoid congestion incidents, resulted in no congestion events being forecast or occurring during the period of the demonstrations. However, as mentioned previously, with the increase in DERs into the networks, this tool and the problems it helps to avoid will become more necessary in the near future.

F-channel forecasting module

The ability to accurately predict weather patterns becomes increasingly critical for network management as the frequency of severe weather events increases and as the use of DERs continues to increase across Europe. In the short term, inaccurate predictions could lead to outages caused by weather damage that are anticipated and as a result take longer to recover from. Additionally, it could cause congestion or voltage concerns due to increased demand or DER generation. In the long term, these inaccurate understandings of the network condition could lead to inefficient investments in grid infrastructure.

OneNet has developed the F-channel forecasting module as a forecasting and data analysis tool to forecast weather data and energy production and consumption, for enhancing grid observability and reliability for DSOs

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and TSOs, and for network planning through providing greater confidence and coordination when making strategic investments (Figure 3.8). It is capable of identifying flexibility resources more precisely and simultaneously for both DSO and TSO grid levels, focusing on the lower voltage levels prosumers, which are usually not covered by detailed energy predictions, in a much more precise manner and over a longer time period than it is being done today.

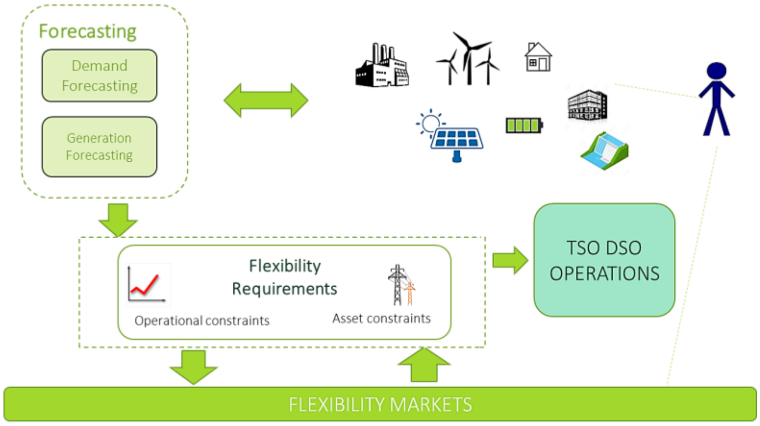

Figure 3.8: F-channel platform's expected role in the flexibility market (D8.2)

This tool was developed for and demonstrated in the Greek demo within OneNet, specifically on the interconnection between Peloponnese and the island of Crete. In the demonstrations, the F-channel achieved a higher level of forecasting accuracy using the artificial neural network (ANN) than current techniques. It also successfully predicted over 27.000 severe weather conditions in a simulated environment that covered the majority of western Europe.

Short-Circuit levels forecast tool in TSO-DSO substations

The short-circuit current is one of the most important security operational parameters. With the increased penetration of DERs, it is crucial to frequently and periodically monitor short-circuit levels, ideally every 24 hours and with high granularity (e.g., 30 minutes), to ensure that they do not exceed the short circuit current.

This OneNet solution computes day-ahead three-phase short-circuit levels for the 63kV bus bars that are the interconnection TSO/DSO transformers (EHV/HV). It uses the grid data and forecasted generation/load profiles known after the wholesale market results to perform these calculations with a granularity of 30 minutes. Obtaining this information gives TSOs and DSOs day-ahead short-circuit forecasts that enable them to improve operation planning activities to avoid surpassing the short circuit current level of their networks.

Like the TSO Flexibility Needs Evaluation and FSP Flexibility Provision Simulation Tool mentioned previously, this forecasting tool was also developed for and tested in the Portuguese demo. This tool was tested successfully

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within the first Portuguese demo phase at the Pocinho and Batalha demo sites and within the second demo phase at the Zêzere, Pocinho, Batalha, Mourisca, and Portimão sites.

Traffic Light Scheme

A common barrier for both existing and potential prosumers offering their flexibility on the market is a lack of information surrounding whether the flexibility they are offering would positively impact the network.

OneNet designed a traffic light scheme (TLS) to address this point. This scheme provides information on grid availability through a User Interface, where users can check if they can activate their flexibility without negatively impacting the grid. As such, the TLS offers crucial information on the availability of the grid to registered flexibility providers to ensure the system is transparent and accessible to all stakeholders. The TLS informs the market that a distribution grid area has constraints in the use of flexibility of the consumers connected to that grid area. This solution allows the FSPs to optimize their portfolio and business case for flexibility provision. In some of the demo implementations the results suggest that the number of FSPs has increased considerably since the commencement of the project and the introduction of the Network Traffic Light system in early 2022. An additional benefit concerns access to a more accurate time schedule of planned grid outages for FSPs. A screenshot of the GUI for the TLS is shown in Figure 3.9.

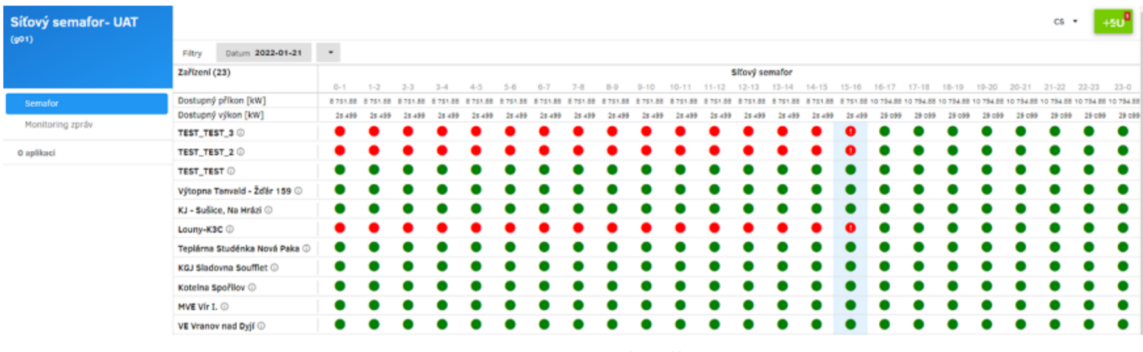

Figure 3.9: The traffic light system – flexibility resource overview ([D10.4](D10.4))

Within OneNet, the TLS was tested within the Czech demo. The implementation of the TLS resulted in an increase in FSP units provisioned, a reduction in time flexibility is blocked due to outages, and an increase in the flexibility available for non-frequency services. This scheme was successfully integrated into the SCADA systems of all major Czech SOs and has since continued to be used by the Czech TSO and DSOs for their flexibility provisioning. It is currently expected to be included in the new flexibility exchange platform that is being discussed for the new Czech Energy Act.

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To estimate this impact of flexibility on the network, proper network representation is needed to ensure there are no network violations and to avoid inefficient flexibility procurement. A key challenge here is that flexibility can be sourced from the grid of one system operator (e.g., the DSO) to support the grid of another system operator (e.g., the TSO), thus requiring proper estimation of the impact of flexibility activation by and on other actors. However, many SOs utilize different data formats, such as the EU standard CIM or a proprietary format, making it difficult to exchange necessary information between them.

This was especially relevant within the Northern cluster, which, unlike the other demos, included seven countries operating under a single demo. To address this, a common network model used by both the DSO and the TSO, developed within the Northern cluster, is proposed by OneNet. This ensures a common representation of the network, disclosing topology, network limitations, forecasted baseflows and power transfer distribution factors. The conversion of the DSO network representation is done based on an open-source data converter format allowing for efficient, improved communication in the event that a common format does not exist between two or more entities.

This common data format was successfully utilized within the Northern demo by allowing the different operators to input data within their standard formats and receive a converted data file in a uniform format. In addition to data format conversion, the NOCL Single Flexibility Platform was able to interface with the OneNet Connector to receive and send common CIM format messages.

Enablers & Barriers:

Table 3.24: Table of Enablers for SO's Needs. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	A DSO remuneration mechanism that incentivizes the use of flexibility compared to grid investments when this is the most efficient solution is important to benefit from the lower financial and time investments that the OneNet solutions offer (compared to the investments needed with the roll-out of a full metering infrastructure)	**L** C E **S** M L
R	Local flexibility markets are being encouraged by EU legislation. This increases demand for and incentivizes the development and deployment of tools that facilitate flexibility procurement.	L **C** E S **M** L
R	National regulators and DSOs are exploring alternatives for complying with the EU Directive mandate.	**L** C E S **M** L

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T	Trainings and presentations for the users of the new forecasting solutions to explain to them how to use new tools would lower the entry-level knowledge requirement and facilitate new users.	**L** C E **S** **M** L
T	The possibility of inclusion of DER with less uncertainty about their impact on the grid stability encourages SOs to use the forecasting tools.	**L** C E S **M** L
T	Digitalization facilitates forecasting and communication tool deployment and development.	L **C** E **S** **M** L

Table 3.25: Table of Barriers for SO's Needs. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Currently, SOs still favour grid investments to resolve their needs. Doing so does not incentivize them to forecast flexibility needs properly as the current method favours robust physical networks over efficient operation to avoid problems.	L **C** E S **M** L
E	Market recessions and the energy crisis blocks certain investments by leading MOs to adopt more cautious behaviours to avoid excessive economic risks. This, in turn, inhibits the development and widespread adoption of new tools.	L C **E** **S** M L
R	Data sharing between SOs is not (always) allowed, making estimating the impact of flexibility hard as the information needed to properly forecast is split between the TSOs and DSOs.	L **C** E **S** **M** L
R	Data sharing between market participants is not (always) allowed, making estimating the impact of flexibility hard.	L **C** E **S** **M** L
T	Heterogeneity in distribution grids makes it hard to standardize tools, blocking their large-scale roll-out. More details on product harmonisation and OneNet's recommendations regarding the topic can be found in section 3.2 of this document.	**L** C E S M **L**
T	Data availability / access blocks further innovation and/or usage of the tools. (In some regions the metering infrastructure is not managed by the grid operator, or data is not readily available in the right format)	L **C** E **S** M L

Recommendations:

To establish flexibility markets, being able to identify and signal system operators' flexibility needs is indispensable. Without this, market participants do not know which services they should offer to resolve network problems and grid operators would not know what to order on a market.

OneNet proposes the following recommendations regarding SO's Needs:

Promote homogeneity, where possible, and remove data access barriers to facilitate stakeholder access to forecasting solutions: One key challenge here is that there is a very limited grid visibility in distribution grids today. OneNet steps in by offering more accurate forecasting solutions which help to determine SO flexibility needs more accurately, both in the short- and long-term for both weather and flexibility volumes (D3.2). It turned out that the forecasts were successful in following the real-life production patterns (D8.2). In addition, OneNet proves that, even in case there are only low levels of smart meter deployment and only 50% LV supervision, no additional LV monitoring is needed with the developed and tested solutions (see for instance Czech demo) (D11.4). In the short run, it is therefore recommended to continue rolling out these solutions to further increase visibility and monitoring in the distribution grid. This is further enabled by the fact that regulation pushes for flexibility markets and that the energy transition has increasing flexibility needs. Nevertheless, it needs to be acknowledged that stakeholders need to become aware of these forecasting solutions, including on how to use them. However, in the medium run, it is important to remove the heterogeneity in monitoring (deployment of smart meters, LV supervisors, sub-metering…) in both LV and MV grids. Not only would this increase scalability and replicability of the OneNet solutions, but it would also be beneficial for baselining and settlement. In addition, the higher the data availability, the more performing the forecasting tools can become. In this regard, barriers to data access need to be removed, as depending on who manages the metering infrastructure, grid operators do not always have access to all required data. (Target: NRAs, System Operators, technology developers/suppliers)

Remove restrictions to data sharing between SOs to enable clear definitions of boundaries between TSOs & DSOs: Once it is clear how much flexibility is needed, one needs to ensure that flexibility activations stay within the limits of the grid. To estimate this impact of flexibility on the network, proper network representation is needed to ensure there are no network violations and to avoid inefficient flexibility procurement. A key challenge here is that flexibility can be sourced from the grid of one system operator (e.g., the DSO) to support the grid of another system operator (e.g., the TSO), thus requiring proper estimation of the impact of flexibility activation by and on other actors. To ensure this, a common network model used by both the DSO and the TSO is proposed by OneNet, which ensure a common representation

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of the network, disclosing topology, network limited, and forecasted baseflows (D3.2). In order to achieve this, TSOs and DSOs need to agree on connecting points (i.e. the boundary points that define the TSO-DSO border) which calls for a discussion between TSOs and DSOs to clarify and agree upon this, and to see what kind of system will be used to agree, maintain, and exchange such information (D5.4). The key challenge to overcome here are data sharing restrictions between stakeholders. (Target: NRAs, System Operators)

Sufficient implementation of TLS at asset level to ensure sufficient network representation is achieved: Finally, OneNet proposes a traffic light solution to communicate information on grid availability to the users through a user interface. As such, after having calculated flexibility needs (facilitated through the forecasting solutions and the common network representation model), the state of the distribution grid needs to be signalized (e.g., congestions, voltage profile violation) (D10.2). OneNet proves that the TLS is mature enough to be implemented in a real environment – therefore the TLS developed in the project was upgraded with a data privacy and security solution and the whole scheme was integrated into the SCADA systems of all major system operators in the Czech Republic. An important attention point remains the definition of the granularity of the TLS to represent the network. The TSO traffic light indicates the status of the whole TSO control area while the DSO traffic light indicates the status of a given network area or element (e.g., a transformer). Also, the DSO breaks down the network issue to network assets (generators and loads) and assigns them a sensitivity factor that indicates the degree that the network issue can be resolved by. This implies that the traffic light logic should be applied at asset (or unit) level, thus the physical network can be sufficiently represented (D10.4). (Target: NRAs, System Operators)

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4 Interoperability

With the development of new flexibility markets and introduction of new market parties and roles, there is the increasing need to guarantee a seamless communication between different systems that currently meet different standards and are not interoperable. Hence, expanding interoperable solutions across borders would promote the establishment of a common and coordinated market for flexibility services. OneNet makes a strong effort in the promotion of interoperable and replicable solutions[3], aiming to reach the following objectives for increased interoperability:

1. Process standardization: Establishing uniform procedures and protocols to streamline operations and enhance compatibility across different systems.
2. Cybersecurity and privacy: Implementing robust security measures and privacy policies to protect sensitive data and systems from cyber threats and ensure user confidentiality.
3. Technological enablement and exploitation: Ensure the necessary scalability and replicability of the solutions developed, so that they are easily and effectively implemented and scaled up within and across different countries.
4. Stakeholder participation and coordination: Facilitating collaboration and communication among all market participants, including providers, consumers, and regulators, ensuring a smooth information exchange between them.

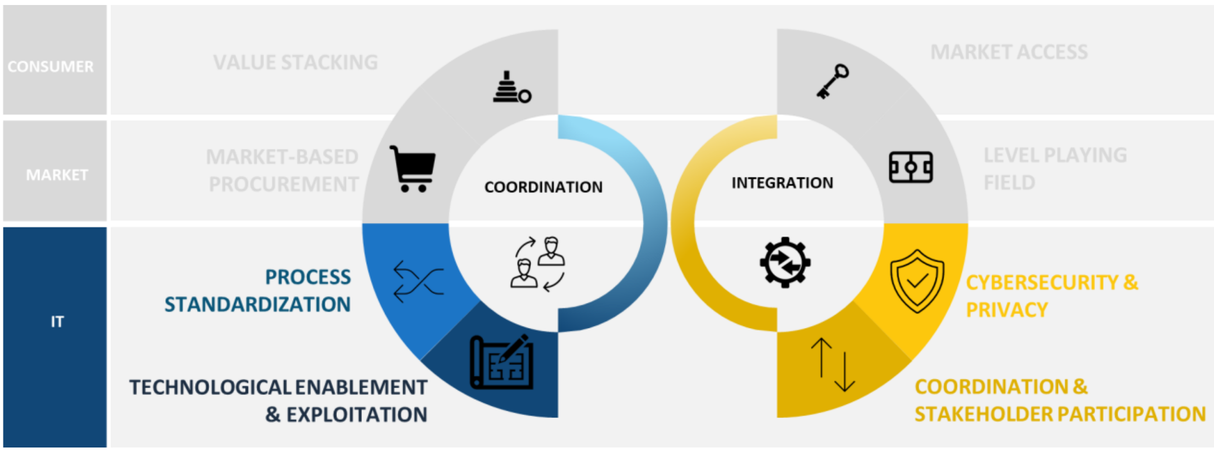

Figure 4.1: OneNet's Interoperability Objectives

The following sections will explore the main solutions developed within the OneNet project to promote the achievement of these objectives, exploring the different enablers and barriers that can exist for the effective

[3] The solutions within each objective are presented from the most to the least relevant, as identified by the comments to the public consultation.

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implementation of these solutions, the level of intervention for these enablers and barriers required and concludes with a series of recommendations for an effective roll-out of interoperable solutions.

The approach taken for the Interoperability followed the core methodology of T11.7 (see also Methodology). As the work progressed this scope was narrowed to focus on the four key objectives and five categories of solutions, whose referred solutions originated mainly from WP 4, 5, and 6 and documented in WP11, also comprising solutions from the demonstrators, as represented in Figure 4.2. (The colour scheme used in the figure represents the impact of OneNet's solutions for each matrix cell, with red indicating the most impactful and green indicating the least impactful).

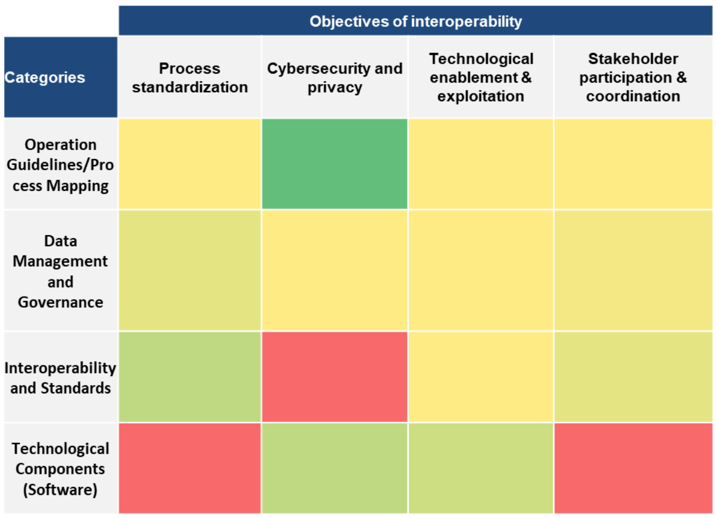

Figure 4.2: Interoperability Solutions Matrix

4.1 Process Standardization

KEY MESSAGE:

The OneNet project contributes significantly to process standardization within the energy sector by tackling interoperability, scalability, and data ownership. It incorporates recommendations from widely recognized initiatives such as IDS and FIWARE, uses standards such as CIM, and it developed a set of cross-platform services. This approach facilitates the integration and cooperation among OneNet participants through the OneNet system, ensuring that diverse platforms can interact seamlessly. It also proposed the OneNet Information Model that adopts the NGSI-LD standard, promoting a high level of standardization and reuse, which is crucial for the scalable and interoperable implementation of decentralized middleware and connectors.

Solutions

The table below gives an overview of all OneNet Solutions directly linked to Process Standardization. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 4.1: OneNet solutions for Process Standardization

Solution	OneNet Deliverable(s)
OneNet Decentralized Middleware and Connector	D5.2, D6.1, D6.2, D6.5, D6.8
Business Object List	D5.6, D6.4
OneNet Information Model	D5.5, D6.3

OneNet Decentralized Middleware and Connector

The OneNet Decentralized Middleware is a key part of the OneNet system, designed with a decentralized architecture using widely recognized standards like IDS and FIWARE. This approach promotes the integration and cooperation among OneNet participants, supporting cross-platform market and network activities. It emphasizes scalability, interoperability, and data ownership. The OneNet Connector, designed for easy deployment and integration with existing platforms, provides user-friendly REST APIs and GUIs for data exchange. It also includes a predefined list of Cross Platform Services, Business Objects, and Data Profiles to facilitate semantic and data interoperability.

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Business Object List

Business Object List defined to tackle the multiple cross-platform services of OneNet, which provide their semantic definition on standard profiles such as CIM and CGMES.

OneNet defined 43 business objects, and through an analysis of the semantic description of business objects, it was concluded so far that they can be generally addressed by IEC profiles such as IEC 62325 (ESMP), IEC 61970 (CGMES), IEC 61968 (CDPSM) and potentially by their subsequent enhancements.

OneNet Information Model

NGSI-LD information model that raises a hybrid solution using both standard models for implementing the OneNet Decentralized middleware and the OneNet Connector. The usage of IDS Connector and FIWARE Context Broker was identified as the best solution to be adopted for ensuring a high level of standardization, interoperability, scalability and reuse of OneNet solution.

Enablers & Barriers

Table 4.2: Table of Enablers for SO's Needs. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)*
E	Cloud services for individual energy data measurements and possibly aggregation that could be used by a FSP through an API	L C **E** S **M** L
E	Definition of standards/ontologies that are easily applied between DSOs, TSOs and other market parties that allow an adequate degree of flexibility for adaptation	L **C** **E** S **M** L
E	Promote the uptake of the dataspace concept, particularly the energy data space	L C **E** S **M** **L**
R	Lower costs for new players to participate in existing/new markets	L **C** E S **M** L
R	Usage of open-source solutions	L **C** E **S** **M** L

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T	Harmonized schedules for data exchange in the market process and structured processes	L **C** **E** S **M** L

T	Use of smart contracts, streamline of settlement and activation processes	L **C** E S **M** L
T	Establishment of harmonized reference processes	L **C** **E** S **M** L
T	Clear integration guides for user about how to connect to a data space like system	L C **E** S **M** L
T	Promote the use of open-source standards	L **C** **E** **S** **M** L

Table 4.3: Table of Barriers for SO's Needs. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	Implementation of proprietary solutions for data exchange	L **C** E S **M** L
E	Non-existent interoperability between standards for certain operations	L **C** **E** S **M** L
E	Complexity of existing standards	L **C** **E** S **M** L
E	The shift to other SO interoperable solutions may require several adaptations to their internal processes/systems/tools	**L** **C** E S **M** L
R	Technical and budget limitations by some parties (e.g., smaller DSOs that operate in LV grids only)	L **C** **E** S **M** L
R	Cost to adapt existing systems may be high and difficult to retrieve from tariffs	L **C** **E** S **M** L

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R	Cost splitting of interconnecting the trans-national systems	L C **E** S **M** L

T	Missing governance for pan-European data exchange, including reference models	L C **E** S **M** **L**
T	Missing submetering regulation	L **C** **E** S **M** L
T	Access to standards is not free	L C **E** S **M** L
T	Missing governance models	L **C** E S **M** L

Recommendations

- **Promotion of CIM and HEMRM**: Support the adoption to ensure interoperability in the energy sector. This approach makes communication and data exchange more uniform, simplifying collaboration for all market participants. (Target: Policy Makers, System Operators)
- **Easy integration with data spaces for market parties**: Integration with data spaces should be straightforward for market participants, enabling easy access to shared data resources and services, and supporting innovation and efficiency. (Target: Dataspaces participants, Policy Makers)
- **Standardization of workflows and data exchange models**: Develop standardized workflows and data exchange protocols for consistency and operational efficiency across stakeholders. This reduces errors and inefficiencies, facilitating smoother transactions. (Target: Market Operators, System Operators, SDOs)
- **Data standards and models' definition**: Establish clear standards and models for data exchange, storage, and analysis among stakeholders to ensure data integrity, security, and reliability, supporting better decision-making. This also includes to work on ontologies, namely on a common framework based on an ontology, which can allow operators and actors to use their own developments to avoid previous investments and without disclosing their technologies. (Target: SDOs, System Operators)

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- **Adopt semantic interoperability:** Using ontologies as a standard protocol to ensure neutral and compatible communication across various. (Target: Market operators, System Operators, and Market Participants)
- **Modular and flexible architectures adoption**: Utilize modular and flexible architectures to allow for easy system and service integration or modification, meeting evolving market needs and technology changes and taking into account the social dimension. (Target: System Developers, Market Participants)
- **Participation in standardization bodies and consortia**: Engage in standardization bodies and consortia related to the energy sector to contribute to the development of interoperability standards and guidelines, improving process standardization across the market. (Target: System Operators, Market Participants)
- **Implement data governance methods**: Establish clear policies and procedures for data governance, including data ownership, data quality management, and access controls, helps maintain trust and integrity in the shared data environment. (Target: Policy Makers, NRAs)
- **Facilitate Collaboration and invest in programs to enhance knowledge:** Encourage collaboration among industry stakeholders, regulators, and standards organizations to develop interoperable solutions, share best practices, and address common challenges. (Target: Policy Makers)

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4.2 Cybersecurity & Privacy

KEY MESSAGE:

The OneNet project places a significant emphasis on cybersecurity and privacy, recognizing these aspects as crucial to the integrity and resilience of the data exchange tools and infrastructure. Through its various initiatives, OneNet aims to address the growing concerns around cybersecurity threats and the need for robust privacy measures in the energy sector. The strategies and tools developed under OneNet offer a comprehensive approach to enhancing cybersecurity and privacy protections, but providing a set of recommendations, tools and frameworks.

Solutions

The table below gives an overview of all OneNet Solutions directly linked to Cybersecurity & Privacy. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 4.4: OneNet solutions for Cybersecurity & Privacy

Solution	OneNet Deliverable(s)
Energy Sector Security Framework	D4.4
OneNet Cybersecurity Recommendations	D5.8
OneNet Monitoring and Analytics Dashboard	D6.6

Energy Sector Security Framework

OneNet D4.4 provides the Energy Sector Security Framework, detailing the integration of cybersecurity measures within the European energy sector. It covers the implementation of the cybersecurity network code, adherence to the NIS 2 Directive, and the application of cybersecurity standards. It serves as a guideline for ensuring cybersecurity resilience, offering a structured approach for the sector's stakeholders to protect infrastructure and data against cyber threats, in alignment with current regulations and standards.

OneNet Cybersecurity Recommendations

A comprehensive framework designed to enhance the security posture of grid operators within the smart grid ecosystem. These guidelines encompass a broad spectrum of security measures, including access control, system and communication protection, incident response, and risk management. Tailored to align with the

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NISTIR 7628 Smart Grid Cyber Security standards, they emphasize the importance of maintaining the confidentiality, integrity, and availability of the network infrastructure. By integrating these recommendations, grid operators can proactively address cybersecurity threats, ensuring a resilient and secure smart grid environment.

OneNet Monitoring and Analytics Dashboard

The OneNet Monitoring and Analytics Dashboard is designed to enhance cybersecurity within the OneNet infrastructure. It integrates features for real-time and historical data monitoring, employing machine learning algorithms for anomaly detection. Through its comprehensive logging and analysis capabilities, the dashboard supports the secure and efficient operation of the grid, highlighting the critical intersection between operational technology and cybersecurity in modern energy systems.

Enablers & Barriers

Table 4.5: Table of Enablers for SO's Needs. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	R&D Investment	L C **E** **S** **M** L
E	Continuously pen-test existing and new systems	L **C** **E** **S** **M** L
E	Develop and adopt data sovereignty tools	L **C** **E** S **M** L
E	Economies of Scale	L C **E** S **M** L
E	Build upon industry de facto standards	L **C** **E** S **M** L
R	Investment in Advanced Technology	L **C** E **S** **M** L

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R	Cyber Insurance	L **C** E S **M** L
R	Information being exchange in a secure way generate new business opportunities	L **C** **E** S **M** L
R	Cost-Benefit Analysis for Security Measures	L **C** **E** **S** **M** L
R	Create smooth tools and processes enabling FSPs to comply with GDPR requirements	L **C** **E** **S** **M** **L**
T	Financial Incentives and Subsidies, including Compliance and Audits	L **C** **E** **S** **M** L
T	Funding for Compliance and Audits	L **C** **E** S **M** L
T	Separation of duties, establishment of data sharing reference process	L **C** **E** S **M** L
T	Stabilization of regulation	L **C** **E** **S** **M** L

Table 4.6: Table of Barriers for SO's Needs. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European)* *(S – Short, M – Medium, L – Long)*
E	System Integration Challenges	**L** **C** E **S** **M** L
E	Intellectual Property Concerns	L **C** E S **M** L
E	Lack of interoperability in existing systems	L **C** **E** **S** **M** **L**

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E	Supply Chain Risks	L C **E** S **M** L
R	High Costs of Implementation	L **C** **E** S **M** L
R	Limited Return on Investment	L **C** E S **M** L
R	Budget Constraints	L C E S **M** L
R	Awareness of end-customers and small FSPs about GDPR requirements	L **C** **E** **S** M L
T	Regulatory Lag incompatible with risks and threats	L **C** E S **M** L
T	Enforcement Challenges	L **C** E S **M** L
T	Diverse set of available Standards	L **C** **E** S **M** L
T	Lack of trusted entity, or set of entities, for decision making and monitoring	L **C** **E** S **M** L

Recommendations

- **Balance between security requirements and costs**: Find a middle ground in security requirements and implementation costs to maintain effective security measures without excessive spending.
- **Consent management for private data**: With the increase of private data collection, including from sub-meters, ensure proper consent management practices are in place. In addition, regarding privacy, it is needed to implement a flexible approach to enable actors to choose and change the level of privacy.
- **Regularly conduct security testing on existing systems**: Regularly test security of tools/platforms and integrated systems to identify and address potential vulnerabilities, taking into account the different dependencies that can exist between the different platforms.

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- **Software updates and patches**: Keep software components up to date and apply patches to fix known vulnerabilities and protect against new cyber threats.
- **Data encryption**: Encrypt sensitive data to prevent unauthorized access or interception.
- **Alternative solutions for cybersecurity measures**: In instances where cybersecurity measures block necessary functions, like the OneNet Connector issue due to public static IP requirements, find alternative solutions such as deploying in cloud environments.
- **Invest in ongoing programs and efforts for cybersecurity:** Not to focus on further policy development but to invest in ongoing programs and efforts to implement current cybersecurity policies and regulations (NIS2, NCCS, CRA, RED)
- **Implement risk analysis:** It is important to use a risk-based approach to implement cybersecurity solutions and perform a risk assessment to understand what risks these solutions might introduce to the grid.
- **Information mechanism to communicate cyberattacks:** Incorporate an information mechanism to ensure transparency for all stakeholders once a cyberattack is detected.

The recommendations mentioned above should target all types of stakeholders who implement critical business and operational systems, including Market Participants, System Operators, and Market Operators.

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4.3 Technological Enablement & Exploitation

KEY MESSAGE:

OneNet puts a strong effort on the scalability and replicability of the solutions developed, aiming to increase the technology enablement and exploitation. It achieves this through the implementation of open standards and development of solutions based on a decentralized Data Space Concept, which is the case of the OneNet system, which allows integration across multiple stakeholders and countries. As main recommendations to these solutions are the prioritization of standardised data models and the investment in scalable and adaptive IT infrastructure.

Solutions

The table below gives an overview of all OneNet Solutions directly linked to Technological Enablement & Exploitation. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 4.7: OneNet solutions for Technological Enablement & Exploitation

Solution	OneNet Deliverable(s)
Adopt a decentralized Data Space Concept through the OneNet System	D5.2, D5.3, D5.7, D6.1
Implement industry-standard protocols and utilize open standards	D4.1, D4.2, D4.3, D5.6, D11.3

Adopt a decentralized Data Space Concept through the OneNet System

This is done through the implementation of the OneNet Framework developed, which seamlessly connects different flexibility platforms and energy stakeholders, allowing various stakeholders to exchange reliable and trusted data with one another through a secure and smooth process. OneNet relies on a decentralized data interoperability mechanism that serves the purpose of facilitating data exchange and allowing to achieve scalability and real-time data integration across multiple stakeholders and countries.

Implement industry-standard protocols and utilize open standards

It will allow to ensure system-wide compatibility and integration through industry-standard protocols between different systems and devices, while also facilitating the integration of new technologies and systems from various vendors through the usage of open standards.

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Enablers & Barriers

Table 4.8: Table of Enablers for Technological Enablement & Exploitation. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	Level of Intervention (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	**Cost and Economic Viability:** a) clear and attributable division of costs; b) targeted funding and grants; c) incentives for interoperable solutions.	L **C** **E** **S** **M** L
E	**Data Space Utilization:** a) Quantify value for stakeholders; b) Definition of UCs; c) Incorporate signals in the data space.	L **C** **E** S **M** L
E	**Market Access and Innovation:** a) Access to new markets and business models	L **C** **E** S **M** L
R	**Regulatory Innovation and Flexibility:** a) Performance-based regulation; b) Regulatory experimentation; c) Regulatory support for advanced management and response tools.	L **C** **E** S **M** L
R	**Standards and Compliance for Expansion and Security:** a) Promote the adoption of open standards; b) Compliance with national and international standards; c) Set industry-wide standards that promote consistency and security	L **C** **E** S **M** L
R	**Stakeholder Collaboration and Market Fairness:** a) Stakeholder engagement and exchange of best practices; b) Regulations ensuring consumer data privacy and security	L **C** **E** S **M** **L**
T	**Standardization and Efficiency:** a) Standardized interfaces and data models; b) Adopt plug-and-play solutions for easy integration	L **C** **E** S **M** **L**
T	**Support and Scalability for Market Participants:** a) Technical assistance and capacity building for smaller market parties; b) Modular and scalable system designs	L **C** **E** S **M** **L**
T	**Real-time Data and Grid Management:** a) Access to real-time data and ability to participate in DR programs; b) Enhanced capabilities for monitoring, control real-time response.	L **C** E S **M** L

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Table 4.9: Table of Barriers for Technological Enablement & Exploitation. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** *(L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)*
E	**Cost and Economic Viability:** a) Profitability of business model (high initial costs for infrastructure and device upgrades risks of high R&D expenditure); d) Complexities in quantifying benefits and balancing regulatory cost implications	L **C** E S **M** L
E	**Technical and Resource Limitations:** a) Technical and budget limitations, particularly for smaller players	L **C** E S **M** L
E	**Market Dynamics and Risk Management:** a) Risk aversion towards new solutions; b) Interest in maintaining market share and control over data use	L **C** E S **M** L
R	**Regulatory Knowledge and Framework Limitations:** a) Regulators' limited technological knowledge; b) Regulatory framework not supportive of riskier investments; c) Lack of an overarching EU regulatory body to harmonize standards and practices across MS	L **C** **E** S **M** L
R	**Regulatory Divergence and Complexity:** a) Diverging regulatory frameworks between MS; b) Navigating diverse and changing regulatory environments across different markets is complex and resource intensive	L **C** **E** S **M** **L**
R	**Standards, Compliance, and Consumer Awareness:** a) Compliance with complex and varying standards and protocols; b) Lack of understanding or awareness among consumers regarding their rights and protections	L **C** **E** S **M** **L**
T	**System Compatibility and Integration:** a) Integrating legacy systems with new, interoperable technologies (existing ones are tailor made and with high security standards); b) Developing universally compatible and scalable solutions that can adapt to various operational needs	L **C** E S **M** L
T	**Technical and Financial Constraints:** a) Existing technical and budget limitations faced by smaller parties	L **C** **E** **S** **M** L
T	**Operational and Regulatory Adaptation:** a) The necessity for several adaptations to internal processes, systems, and tools when shifting to interoperable solutions; b) Challenges in understanding and interacting with advanced energy management systems	**L** **C** E S **M** L

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Recommendations

Standardization of data models, roles and interfaces: To enable a smooth and seamless technological integration, standardized interfaces data models need to be adopted to exchanges between stakeholders involved in flexibility markets and for system operation. Emphasizing data-driven services, such as data harmonization and data quality, will further facilitate the agnostic integration of pre-existing components. This approach is key to achieving efficient interoperability across various systems and platforms. The need for standardized approaches isn't restricted to data models, with the introduction of new market players, harmonized role models (e.g., HEMRM) need to be defined to promote scalability and replicability. (Target: Policy makers, NRAs, System Operators, SDOs)

Conduct a Comprehensive Trade-Off Analysis for Flexibility Solutions: Grid operators should undertake a thorough trade-off analysis to evaluate the benefits and drawbacks of advanced, and potentially more economically efficient, flexibility solutions that rely on advanced monitoring technologies, compared to other alternatives like traffic-light systems. This analysis should encompass various critical factors such as cost-effectiveness, scalability, deployment speed, and long-term benefits. Such a comprehensive assessment will enable grid operators to make well-informed decisions that balance immediate needs with long-term strategic goals. (Target: System Operators, NRAs)

Invest in Scalable and Adaptive Infrastructure: Infrastructure investment decisions must prioritize scalability and flexibility to ensure that systems can grow and adapt with evolving technological landscapes and market demands. This means choosing solutions that are modular, scalable and can be easily upgraded or expanded, for example, through the implementation of middleware solutions, such as the OneNet system and APIs, to enable interoperability and communication between different systems and platforms. It also means building in the capability to integrate emerging technologies, such as renewable energy sources, energy storage, and electric vehicles, without extensive overhauls. A forward-looking infrastructure strategy considers not just current needs but also anticipates future developments. (Target: System Operators, NRAs)

Utilize Advanced Data Analytics and AI for Informed Decision-Making: System operators should invest in advanced data analytics tools, which are vital in managing the increasingly complex and voluminous data generated by modern grids. These tools should be capable of integrating data from disparate sources to provide a holistic view of the grid's operations. By applying sophisticated algorithms, machine learning and other AI techniques, operators can extract valuable insights for more informed decision-making. These insights can lead to improvements in operational efficiency, more precise demand forecasting, and better customer service. (Target: System Operators, NRAs)

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Forge Synergistic Partnerships for Shared Success: There should be close collaboration between system operators, technology providers, other utilities, and stakeholders, to leverage collective expertise and achieve economies of scale. Partnerships can take various forms, from joint ventures to research collaborations, and should be aimed at sharing risks and rewards equitably. By pooling resources and knowledge, organizations can accelerate the development of interoperability solutions and drive innovation. Collaborative efforts also provide a platform for setting industry benchmarks and best practices. (Target: Market Operators, System Operators, Technology providers, Utilities, Project Consortia, Industry Associations, European Commission)

Incentivization and targeted funding for interoperable solutions: The investment and exploitation of interoperable solutions are generally hindered by the profitability of the business models for these such solutions, usually involving high initial costs for infrastructure and device upgrades and risks of high R&D expenditure. This, together with existing complexities in quantifying the benefits gathered from these solutions, leads to high risk of investment, emphasizing the need to allocate incentives and to create targeted funding and grants to boost the adoption. (Target: Policy Makers, NRAs, European Commission)

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4.4 Stakeholder Participation/Coordination

KEY MESSAGE:

For an increased stakeholder participation in new flexibility markets and to allow coordination between them, it is imperative to ensure interoperability between the different systems, through implementation of standards and by reinforcing the transparency of the data collected and used by the market parties. As main recommendations, OneNet proposes to have clear role definitions and duty separation and to adopt scalable, adaptable and user-friendly architectures and interfaces for easy integration of new market parties.

Solutions

The table below gives an overview of all OneNet Solutions directly linked to Stakeholder Participation/Coordination. More extensive explanations on each solution can be found in the indicated deliverables and a summary of each solution can be found under the table.

Table 4.10: OneNet solutions for Stakeholder Participation/Coordination

Solution	OneNet Deliverable(s)
Extension of the CIM Model	D5.6, D6.3, D11.3
Transparency in Data Collection and Usage	D6.2, D6.6, D6.4

Extension of the CIM Model

This extension should include consumer aspects, allowing their seamless participation in the several energy markets. To ensure this, the CIM data model should incorporate a more extensive set of standardized data exchange models tailored to both large and small FSPs, facilitating seamless communication across diverse energy systems.

Transparency in Data Collection and Usage

Articulate and publicize the types of data collected from consumers and FSPs, detailing how this data contributes to grid optimization and individual benefits. Specific access rights need to be defined for different stakeholders, including utilities, aggregators, and consumers, while implementing robust privacy measures to protect sensitive information. Finally, provide comprehensive disclosures regarding the purposes for which data is used, including system management, market operations, and personalized services, ensuring consumers are fully informed.

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Enablers & Barriers

Table 4.11: Table of Enablers for Stakeholder Participation/Coordination. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Enablers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	**Economic Incentivization:** a) Developing incentive schemes to encourage participation and investment; b) Remunerating stakeholders for data access.	L **C** E S **M** L
E	**Benefit Distribution:** a) Implementing value sharing mechanisms to ensure equitable distribution of economic benefits.	L **C** E S **M** L
R	**Technological Advancements and adoption of open solutions**: a) Speed up the introduction of smart meters across Europe; b) Remove vendor lock-in solutions and shift towards open solutions.	L **C** **E** **S** **M** L
R	**Transparency and Enhanced Communication:** a) Transparency and reporting requirements, making operations more understandable and trustworthy; b) Raising customer awareness about business parties, data access rights, and the implications of the electricity market.	L **C** E S **M** L
R	**Harmonisation and Standardization Initiatives:** a) Data exchange harmonisation on EU level; b) Harmonisation of rules, roles and processes.	L C **E** S **M** L
T	**Standardization and Data Integration:** a) Implementation of a Common European Data Space for Energy; b) Standardization of data exchange protocols and adoption of standardized data models such as the CIM, including its extension to customer and small FSP aspects; c) Development of standardized interfaces and data models.	L **C** **E** S **M** L
T	**Knowledge Exchange and Best Practices:** a) Encouragement of knowledge sharing and the exchange of best practices.	L **C** **E** S **M** L
T	**Technical Simplification and User Experience:** a) Automation of processes to address the technical complexity of tools and platforms; b) Design and implementation of user-friendly interfaces.	L **C** E S **M** **L**

Table 4.12: Table of Barriers for Stakeholder Participation/Coordination. Topics are grouped into Economic (E), Regulatory (R), and Technical (T) topics.

Barriers		
	Topic	**Level of Intervention** (L - Local, C - Country, E - European) (S – Short, M – Medium, L – Long)
E	**Economic Disparities and Integration Costs:** a) Cost of integration can be high and the impact can be "experienced" differently amongst different stakeholders; b) varying economic capacities among stakeholders.	L **C** **E** S M L

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E	**Valuing Non-Quantifiable Benefits:** Economic difficulty in quantifying certain benefits of interoperability.	L **C** E S **M** L
E	**Mismatch Between Business Models and Market Demand:** Service acquisition business models do not align with the actual needs and preferences of the customers.	L **C** E S **M** L
E	**Economic Risks of Data Sharing:** Data provision may be a risk especially for companies.	L **C** E **S** **M** L
R	**Regulatory Harmonisation and Data Governance:** a) Missing governance for pan-European data exchange; b) Diverging and divergent regulatory frameworks and standards across MS; c) Missing regulation concerning customer data ownership and access.	L **C** **E** **S** **M** L
R	**Technical Integration and Financial Allocation Challenges:** a) Communication requirements and the associated high costs for smart FSPs to connect with other market players; b) Challenge of how to distribute ICT costs due to its interrelation with regulatory aspects	L **C** E S **M** L
R	**Customer Engagement and Market Literacy:** a) Customer unwillingness to understand or engage with electricity market implications.	L **C** **E** S **M** **L**
T	**Data Access and Privacy:** a) Limited availability of grid data from SOs; b) Data security and privacy concerns.	L **C** E **S** **M** L
T	**Technological and Infrastructural Challenges:** a) Technological heterogeneity across stakeholders; b) Technical complexity of tools and platforms; c) Lack of standardization in data exchange and the slow adoption of standardized data models like CIM.	L **C** **E** **S** **M** L
T	**Market Participation and Aggregation Issues:** a) FSP aggregation primarily focused on industrial FSPs; b) Restrictive market participation conditions for residential load aggregators (consumers), such as the requirement for a minimum bid of 1 MW.	L **C** E S **M** L
T	**Expertise and Knowledge Gaps:** a) Lack of technical expertise among varied stakeholders.	L **C** E S **M** L

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Recommendations

Implement Structured Role Definitions and Duty Separation: It's recommended to rigorously define roles and responsibilities within the operational framework. This step involves establishing clear, distinct job descriptions and a separation of duties, aimed at eliminating conflicts of interest and ensuring operational integrity. This approach not only promotes accountability and efficiency but also aligns with best practices for interoperability by clarifying interfaces and interactions among different roles. Such structured role clarity is vital for maintaining streamlined, conflict-free processes, essential for achieving optimal interoperability in complex operational environments. (Target: Policy Makers, NRAs)

Promote stakeholder involvement and knowledge exchange: Promote workshops and initiatives to create consumer awareness about the importance of their participation in the existing/upcoming flexibility markets and empower stakeholders to effectively utilize and integrate technological components, maximizing the benefits of interoperability. The involvement of stakeholders should also be extended to the aim of defining data models and data exchange protocols adequate to the several market parties. In addition, there should be an identification of groups of consumers with different levels of knowledge and engagement to address potential resistance or specific concerns. (Target: Market Operators, System Operators, Technology providers, Utilities, Industry Associations, European Commission, Market participants)

Adoption of adaptable and user-friendly architectures and interfaces for easy integration: Adopt modular and flexible architectures that allow for easy integration of new stakeholders, facilitating integration of systems and applications used by different stakeholders. Use of a GUI to show up the analysis and data gathered for the different UCs, to give visibility to the different stakeholders involved. (Target: Market Operators, System Operators, SDOs)

Implementing value sharing mechanisms: Through the implementation of value sharing mechanisms, it is possible to ensure an equitable distribution of economic benefits to the different stakeholders involved. This would further promote participation from stakeholders who initially don't identify or quantify any benefits from shifting to these solutions. (Target: Policy Makers, NRAs)

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5 Conclusions

OneNet presents an extensive set of solutions, developed jointly by 72 partners and 16 field pilots, to reach the objective of consumer-centric, coordinated and integrated markets and interoperable platforms. This document provides a comprehensive overview of the OneNet solutions (tools, frameworks and methodologies) and related policy recommendations to ensure implementation, clustered according to two main work streams: Market Design and Interoperability. The combination of large-scale technical demonstration with wide consultation between all relevant stakeholders (TSO, DSO, FSP, MO, Regulator…) allows to ensure technical feasibility, scalability and replicability of the OneNet solutions.

However, although replicable in theory, there still exist important barriers that hinder the OneNet solutions to be effectively implemented. These barriers can be technical, economic or regulatory by nature and require regulatory intervention. Feedback from the stakeholder consultation on market design and interoperability indicated for example that stakeholders consider enablers and barriers across technical, economic, and regulatory aspects significant to the uptake of interoperability solutions.

Regulatory barriers relate to **existing regulation**, but also **market rules, technical requirements** or **administrative procedures**, which are often **different across EU countries** and regions, that hinder the implementation of innovative solutions. In addition, the **absence of regulation** to stimulate the uptake of a specific solutions is, in some cases, considered a major barrier. Important topics mentioned by stakeholders were clear role definitions and user-friendly interfaces for integrating new market parties. Economic barriers are often linked to these aspects that have a negative impact on the **value or business case of flexibility**. Other important economic barriers mentioned are the **additional costs** for stakeholders to install the needed **infrastructure** or adapt existing **operational processes** in order to adopt or make use of the OneNet solutions. Finally, several technical barriers exist that pose restrictions on the wide roll-out of the OneNet solutions. Some technical barriers are hard to solve, for example the diverging grid conditions across Europe. Other require a European approach, for example the governance for European data exchange. However, other **technical elements** could be an **enabler** to overcome these barriers, supporting the adoption of the OneNet solutions. Examples are the **development of tooling** (both related to **grid operation and market operation**, such as market platforms or data platforms) or the uptake of interoperable interfaces and scalable data models to support implementation.

Regulatory intervention can take place at local, national or European level. The adoption of the **Network Code Demand Response** and adoption and transposition of the **Electricity Market Directive** aim to remove several barriers for implementation. Moreover, several EU action plans, like the **Digitalisation for Energy Action Plan, the Data Interoperability Implementing Acts** and the **Grid Action Plan**, will be important enablers to

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support further implementation of the OneNet solutions. However, additional regulatory intervention will still be needed.

Most of the recommendations of the OneNet project are largely aligned with the FGDR and the draft NCDR. There are however some OneNet recommendations which foresee a higher level of EU intervention compared to what is currently put forward in the draft NCDR. The draft NCDR for instance provides principles for the coordination of markets for local services with other wholesale markets and for the design of these markets, but the actual market design choices are left to the MS, while the OneNet project recommends an increased level of harmonisation of both the design and the coordination at EU level. Similarly, the draft NCDR proposes to develop nationally standardized congestion management products using an attribute list agreed and maintained at EU level, while OneNet supports further harmonisation of products (harmonized product range). Next, related to prequalification, the FGDR and the draft NCDR introduced the concept of Product verifications as the default option for congestion management, voltage control and specific balancing services as an alternative to Product Prequalification, while the OneNet demonstrators are in favour of an ex-ante product qualification step, due to concerns regarding the reliability of service delivery in case of product verification. Finally, the draft NCDR foresees the adoption of a flexibility register with a 'common front-door' at member state level, while OneNet stresses the importance of further harmonisation of the register at EU level.

Although many barriers should be tackled at European level, in some cases, national or even local regulation needs to be amended and updated. Not only differences between existing national regulation requires a nation-specific approach, also different levels of maturity with respect to flexibility, different climatical and grid conditions, or different consumer attitudes ask for a more tailored approach. In addition, OneNet proposes several frameworks that support further harmonisation (e.g., product harmonisation, market harmonisation, etc.), i.e., illustrating how policy makers could ensure that differences between countries might disappear over time where appropriate and feasible. From the input gathered from the demos, there was a general preference addressing the enablers and solving the barriers at national level and in a medium-term timeframe. However, when speaking about regulatory barriers for process standardization, there is a general inclination towards an EU wide approach. Similarly, the technical and economic enablers for cybersecurity should also be addressed at EU level, aside from the country level, in part related to existence of funding and incentives for the adoption of interoperable solutions. The economic and regulatory barriers for technological enablement should also be addressed at EU level, complemented by national actions. Short-term barriers and enablers were also identified, namely related funding and incentivization, system integration and cost of integration, customer awareness and data privacy.

Table 5.1 summarizes the main recommendations for **Market Design:**

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Table 5.1: OneNet recommendations for Market Design

Market Participation & Consumer Engagement	Products & Services	Roles & Responsibilities	TSO-DSO Coordinated Flex Markets
Bottom-up creation of a positive mind-set	Product design as enabler for flexibility market development	Start role identification early in the project development	Joint TSO-DSO market models are preferred if the goal is procurement efficiency
Compensation mechanisms creation to ensure economic benefits	Product harmonisation to be applied on both existing and novel products	New and adapted roles are needed	Multi-level TSO-DSO markets remove entry barriers for small-scale FSPs
Stakeholder-analysis at country-level to identify involved stakeholders	Common terminology is needed as a basis for product harmonisation	Continual refinement and expansion of role definitions is indispensable	Price interface flow between TSOs and DSOs in sequential markets
Setting-up data management between multiple stakeholders	A balance should be considered between local needs and harmonisation	Clarify accountability for non-delivered flexibility	Allow aggregation of small-scale resources
	Product harmonisation will be a gradual process		Bid formats allowed/ required in TSO-DSO markets impact efficiency
			Avoid separating TSO & DSO markets

Prequalification	Procurement	Settlement & Baselining	SO's Needs
Simplify and harmonize prequalification via flexibility register tools	Utilize cooperative efforts across Europe to reduce high investment costs of flexibility markets	Further research into proper baselining methods	Homogenize grid monitoring (especially in LV and MV grids)
Clearly define entity responsible for combined prequalification processes	Facilitate seamless coordination between TSO-DSO market platforms	Seek baselining synergies between markets	Clarify TSO-DSO boundary points and data sharing protocols
Carefully design network codes to include ex-post and ex-ante prequalification processes	Enable efficiency via intelligent optimization mechanisms for market clearing	Allow diverse baselining methods	Apply TLS at asset/unit level for optimal network visibility

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Embed grid prequalification into the trading phase	Support development of platforms for generating data needed in market clearing
Carefully consider certain criteria when setting the level of prequalification	Develop processes for engagement of FSPs
Carefully select prequalification submission method	Coordinate different flexibility markets

Table 5.2.summarizes the main recommendations for **Interoperability**:

Table 5.2: OneNet Recommendations for Interoperability

Process standardization	Cybersecurity & Privacy	Technological Enablement & Exploitation	Stakeholder Participation/Coordination
Promotion of CIM and HEMRM	Balance between security requirements and costs	Standardization of data models, roles and interfaces	Implement Structured Role Definitions and Duty Separation
Easy integration with data spaces for market parties	Consent management for private data	Conduct a Comprehensive Trade-Off Analysis for Flexibility Solutions	Promote stakeholder involvement and knowledge exchange
Standardization of workflows and data exchange models	Security testing	Invest in Scalable and Adaptive Infrastructure	Adoption of adaptable and user-friendly architectures and interfaces for easy integration
Data standards and models definition	Software updates and patches	Utilize Advanced Data Analytics and AI for Informed Decision-Making	Implementing value sharing mechanisms
Modular and flexible architectures adoption	Data encryption	Forge Synergistic Partnerships for Shared Success	Implementation of a Common European Data Space for Energy
Participation in standardization bodies and consortia	Alternative solutions for cybersecurity measures	Incentivization and targeted funding for interoperable solutions	Standardization of data exchange protocols
Facilitate Collaboration and invest in programs to enhance knowledge	Invest in ongoing programs and efforts for cybersecurity	-	-
Data governance	Implement risk analysis	-	-
-	Information mechanism to communicate cyberattacks	-	-

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The recommendations provided by OneNet will support a further evolution towards more consumer-centric, coordinated and integrated EU markets and platforms. However, more research is needed the coming years to complement the work done in OneNet. Four main areas of further development are observed: 1) more research is needed to extend the solutions focused on the electricity system towards a **multi-energy system** solution, integrating multiple energy carriers (e.g. gas, heat, Power-to-X, hydrogen, biofuels,…); 2) additional research is needed to complement the OneNet work on explicit flexibility markets with solutions that focus on **implicit flexibility mechanisms** (e.g. flexible connection agreements and tariff methodologies); 3) OneNet proposes a set of guidelines to engage consumers, this work should be extended with the **development of the needed digital tools for consumers** to bring their renewed engagement in practice. Moreover, market tools need to be developed (e.g. platforms for peer-to-peer and energy sharing) to facilitate the participation of end consumers both in individual and collective settings; 4) a wide set of data models and guidelines for interoperability are presented, this should be further extended with the emergence of a **Common European Data Space** and the refinement of relevant use cases, developed and implemented as part of the initiative of the creation of a **European Digital Twin.**

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6 References

D2.2 A set of standardized products for system services in the TSODSO- consumer value chain

D2.5 Recommendations for the Harmonised Electricity Role Model

D3.2 Definition of integrated and fully coordinated markets for the procurement of grid services by DSOs and TSOs

D3.3 Recommendations for Consumer-Centric Products and Efficient Market Design

D3.4 Regulatory and Demo Assessment of proposed integrated markets

D4.1 Guidelines for TSO operation and guidelines for data exchange

D4.2 Guidelines for DSO operation and guidelines for data exchange

D4.3 Guidelines for TSODSO-Consumer system integration plan

D4.4 Cybersecurity requirements for Grid Operators

D5.2 OneNet Reference Architecture

D5.3 Data and Platform Assets Functional Specs and Data Quality Compliance

D5.5 Report on Technical specifications for data models/platform agnostic middleware

D5.6 Report on Extended Data, Platform and Service Interoperability

D5.7 Report on Data Enforcement Policies Design for Sovereignty preserving data access

D5.8 Report on Cybersecurity, privacy and other business regulatory requirements

D6.1 Report on decentralized edge-level middleware for scalable platform agnostic data management and exchange

D6.2 Cross stakeholder Data Governance for Energy Data Exchange

D6.3 Extended Interoperability and Management with FIWARE

D6.4 AI, Big Data, IoT Orchestration Workbench

D6.5 OneNet Reference Platform First Release

D6.6 Tools for Legal, Regulatory, Privacy and Cybersecurity Compliance

D6.8 OneNet Framework and Components Final Release

D7.2 Flexibility register description and implementation

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D7.4 TSO-DSO Coordination module description and implementation

D7.6 Final Northern Cluster demonstrator evaluation report

D8.2 Development and implementation of the “F-Channel” platform

D8.4 Evaluation of Demonstrations Results in Greece and Cyprus

D9.1 Specifications and guidelines for Western Demo

D9.2 Validation and results of concept test – Portugal

D9.4 Validation and results of concept test – France

D9.5 Demo results assessment and data collection report – Portugal

D10.1 Report on customer engagement

D10.2 Report on selection of services

D10.3 Report on development of integral market platform

D10.4 Report on demonstration

D10.5 Report on lessons learned

D11.1 Evaluation of OneNet demonstrators

D11.2 Techno-economic assessment of proposed market schemes for standardized products

D11.3 Recommendation of interoperability platforms and data exchange for TSO-DSO-customer coordination

D11.5 Customer engagement strategies recommendations

D11.6 Business model analysis of OneNet solutions

EUDSO & ENTSO-E, EUDSO Entity and ENTSO-E DRAFT Proposal for a Network Code on Demand Response, 2023, EUDSO Entity and ENTSO-E DRAFT Proposal for a Network Code on Demand Response (entsoe.eu)

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