Regulatory and demo assessment of proposed integrated markets

D3.4

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About OneNet

OneNet 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.

The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "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)".

While the electrical grid is moving 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. For this reason, the two major associations of grid operators in Europe, ENTSO-E and EDSO, have activated their members to put together a unique consortium.

OneNet will see the participation of a consortium of over 70 partners. Key partners in the consortium include: already mentioned ENTSO-E and EDSO, Elering, E-REDES, RWTH Aachen University, University of Comillas, VITO, European Dynamics, Ubitech, Engineering, and the EUI's Florence School of Regulation (Energy).

The key elements of the project are:

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

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List of Abbreviations and Acronyms

Acronym	Meaning
API	Application Programming Interface
BA	Balancing
BRP	Balance Responsible Party
CCGT	Combined Cycle Gas Turbine
CACM GL	Capacity Allocation and Congestion Management Guideline
CEP	Clean Energy for all Europeans Package
CM	Congestion Management
CY	Cyprus
CZ	Czech Republic
DA	Day-ahead
DC NC	Demand Connection Network Code
DER	Distributed Energy Resources
DSF	Demand Side Flexibility
DSR	Demand Side Response
DG	Distributed Generation
DR	Demand Response
DSO	Distribution System Operator
EB GL	Electricity Balancing Guideline
EC	European Commission
ER NC	Emergency and Restoration network code
ES	Spain
EST	Estonia
EU	European Union
EV	Electric Vehicle
FI	Finland
FR	Flexibility Register
FR	France
FRO	Flexibility Register Operator
FWGL DR	Framework Guideline Demand Response
GCT	Gate Closure Time
GDPR	General Data Protection Regulation
GR	Greece
GRIFOn	GRId FOrum
GUI	Graphical User Interface

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HU	Hungary
HV	High Voltage
ID	Intraday
IMO	Independent Market Operator
IT	Information Technology
LV	Low Voltage
LV	Latvia
LT	Lithuania
mFRR	Manual Frequency Restoration Reserves
MO	Market Operator
MS	Member State
MV	Medium Voltage
NEMO	Nominated Electricity Market Operator
NOCL	NOrthern CLuster
NRA	National Regulatory Authority
NRT-P-E	Near-Real Time Active Power Energy product
PL	Poland
PT	Portugal
PV	Photovoltaic
RD&I	Research, Development and Innovation
RES	Renewable Energy Sources
RPU	Reserve Providing Unit
RPG	Reserve Providing Group
RUC	Regional Use Case
SLO	Slovenia
SO	System Operator
SO GL	System Operation Guideline
SP	Service Provider
TCM	Terms, Conditions and Methodologies
ToE	Table of Equivalences
TSO	Transmission System Operator
TTST	Transition Technologies-Systems Sp. z o.o.
UC	Use Case
UI	User Interface
VC	Voltage Control
vRES	Variable Renewable Energy Sources
WP	Work Package

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Executive Summary

This deliverable reports on several alignment activities that have been carried out in the context of OneNet Task 3.4. The activities focused on the alignment of the OneNet proposed concepts for integrated and coordinated electricity markets with the findings of the OneNet demonstrators and current and future regulatory aspects. Three types of alignment activities were carried out, namely a regulatory study, project-internal consultation moments, and an external workshop.

The regulatory study is set in the current regulatory context for demand response and the market-based procurement of non-frequency ancillary services and congestion management services at EU level. New EU rules are currently being developed jointly by the DSOs and TSOs and supported by a drafting committee based on the framework guideline published by ACER in December 2022. At the same time, several bottom-up initiatives and pilot-projects related to flexibility are ongoing across Member States, including in the OneNet demo countries. The regulatory study analyses three elements that are essential for the development of an EU regulatory framework, namely baselining, prequalification and local market operation. For each, we conduct a literature review, analyse the experience in the OneNet demo countries, and qualitatively discuss the regulatory options that exist based on a multi-question framework. The learnings from literature and experiences of the OneNet demos can provide relevant insights for the development of the new European rules. Also, the outcomes of deliverable will feed the OneNet roadmap developed in WP11.

For baselining, the relevant body of literature is organized according to three phases in the development of explicit demand response. The first dates to around the late 2000s to early 2010s and covers baseline experiences mostly related to wholesale-market administered demand reduction programs. The second dates to the mid-2010s and covers early thinking on how to include independent aggregators and other intermediaries in existing EU electricity markets dominated by incumbents. The third covers literature from around 2020 to today and analyses first implementation experiences with baselining in the context of flexibility markets

A taxonomy of the baseline methodologies is provided and the relationship between these methodologies and the principles of simplicity, accuracy, and integrity is discussed. No baseline can perfectly fulfil all three principles as all baselines are estimates, but those that balance the three principles are better than those that do not. The choice of which baseline methodology to adopt is not straightforward as it depends on several factors including the type of service or product provided, the characteristics of the service provider, the timeframe, and the related requirements and applicable rules.

The regulatory options for baselining were discussed based on a six-question framework: *(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? (6) Which product is baselining applied to?* For each

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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. 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.

For prequalification, regulatory options based on a four-question framework were qualitatively discussed: *(1) Does prequalification need to be a mandatory step? (2) Who is responsible for carrying out the prequalification process? (3) Where are the eligibility criteria for flexibility sources prequalification set? (4) How is the submission of the prequalification template done?* Contrary to the provisions in the framework guideline, most OneNet demonstrators currently do not consider ex-post verification as default option instead of ex-ante product prequalification. Regarding the above-mentioned question (1), it appears that more time is needed to study the method of ex-post verification and better understand the benefits it may bring. Regarding the above-mentioned questions (2) – (4), demo experiences are more differentiated. Of the different possibilities that exist for allocating the responsibility for carrying out the prequalification process, most demonstrators chose the system operator. Some demos also selected a combination of entities. Most demos chose to set the eligibility criteria at the platform level for reasons of simplicity and current lack of regulation at national level. While most demos choose automated submission of the prequalification template also for simplification and efficiency reasons, nonetheless, some still apply manual submission for certain phases of the process. As in the case of baselining, each design choice has advantages and disadvantages that need to be considered and clear winners could not be identified.

For local market operation, regulatory options based on a three-question framework were discussed: (1) *What are the implications when the procuring SO operates a local market for SO services? (2) What are the implications when a different SO operates a local market for SO services? (3) What are the implications when a third-party operates a local market for SO services?* All analyzed options have merits and disadvantages that carefully need to be considered in the analysis. Ultimately, the choice of whether to allocate the responsibility for market operation to the procuring SO, a different SO, or a third party depends on various factors, including the specific market design, the need for independence and neutrality, the level of coordination required, and regional considerations. There is no clear implementation trend as all three options are currently taken up in practice by OneNet demonstrators and other existing local market initiatives across Europe. A main finding is the need for new functions when a local market for SO services is implemented, such as the prequalification of SPs, the dispatch and activation of flexibility, the calculation of flexibility service needs, or the post-market evaluation and selection of the bids. In the existing local markets, these new functions have been assigned differently between the three MO options (i.e. the procuring SO, a different SO, or a third party who is not a SO), whereas the FWGL DR states that the selection and activation of the bids and control of delivered services remain the responsibility of the SO. Another finding is the need to decide if local MOs are allowed to recombine bids and if they are enabled to forward bids to other wholesale markets.

The project-internal consultation moments provided the opportunity for OneNet WP3 and demo partners to align the research and implementation work and lay out the status quo on specific market integration issues across countries related to the OneNet demonstration activities. T3.4 organised two consultation moments related to, first, barriers to integrated and coordinated markets, and second, efficiency, barriers, and consumer-centricity in TSO-DSO coordinated flexibility markets. At the time of the first consultation moment most OneNet demo countries did not have organized markets for congestion management or voltage control. Practices with regard to managing congestions and voltage control varied a great deal across countries. The consultation moment helped to highlight these varieties and served as basis for the comprehensive analysis of barriers to integrated and coordinated markets in T3.2. The second consultation moment allowed T3.3 and demo partners to align on the research carried out and provide feedback from practical implementation.

The external workshop was organized in the context of GRIFOn, an innovative concept developed by the OneNet consortium to receive feedback from stakeholders external to the OneNet consortium. The feedback from these stakeholders was used to improve the OneNet proposed solutions and market design concepts.

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1 Introduction

OneNet aims to define a common market design for Europe, including standardised products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers.

A common market design can, at best, be at the end of a harmonisation process. While the harmonisation process for European wholesale and balancing markets has been ongoing for many years, new markets for the procurement of non-frequency ancillary and congestion management services, in particular congestion management and voltage control, are emerging all across Europe. The design of these markets is different from initiative to initiative, however. New rules at EU level are currently being developed jointly by DSOs and TSOs that shall provide foundational elements for a harmonisation of the emerging markets at a later stage, including a common terminology and principles and common requirements for certain processes.

The process of harmonising market designs also requires the coordination and consensus of all relevant actors. System and market operators, flexibility service providers, customers, regulatory bodies and many others must come together to form a unified understanding and approach. This collaboration ensures that essential decisions are not made in isolation and that the emerging common market design represents the needs and interests of all stakeholders.

1.1 Scope of this deliverable (Task 3.4)

This deliverable covers the objective of work package (WP) 3 to ensure alignment between the developed concepts of market design, regulation and the OneNet demonstrators. This was one of the four objectives of WP3 (see Section 1.4) and was addressed in Task 3.4 (T3.4).

The aim of T3.4 was to dynamically integrate the market design concepts developed in T3.2 [3] with the findings in T3.3 [4] and the results from the demonstrators. The task also aimed at analysing and identifying the relevant regulatory issues at European Union (EU) level that could impact the proposed integrated market design. Three types of alignment activities were carried out in the framework of T3.4 and are reported in this deliverable: a regulatory study, project-internal consultation moments, and an external workshop.

The regulatory study. The regulatory study was carried out with the aim to make a link between the ongoing development process of new European rules on demand response, including the market-based procurement of system services by SOs, and relevant insights gained through the research and implementation work in OneNet. The new rules are being developed in the context of a second generation of network codes emerging from Regulation (EU) 2019/943 of the Clean Energy for all Europeans Package (CEP) published in mid-2019 [6]. In December 2022, ACER submitted the Framework Guideline (FWGL) on Demand Response (DR) to the European Commission (EC) as the basis for the development of a new network code or guideline [7]. At the time of writing

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this deliverable, the new rules are being developed jointly by TSOs and DSOs at EU level. Both the scope and development timeline of these new rules is well-aligned with the scope and timeline of the OneNet project.

The idea was to provide insights for the development of these new EU rules from the OneNet research and implementation efforts. An analysis of the regulatory options for three key elements from the FWGL DR was carried out, namely baselining, prequalification and ex-post verification, and local market operation. Insights from the OneNet demonstrator experiences were considered, where relevant. Subsection 2.2 provides a more detailed description of the methodology for the regulatory study.

The project-internal consultation moments. Ensuring coordination between the research carried out in the horizontal WPs and the demonstration activities in the vertical WPs was deemed essential for the progress of the OneNet project for three main reasons. The first reason was the aim of the project. OneNet is unique in that it aimed to reach consensus on integrated market and system operations beyond traditional barriers, as well as, beyond the limits of the consortium. The second reason was the size of the project. OneNet is unique in that it gathered more than 70 partners from all across Europe and included four demonstration clusters consisting of 15 different countries. The third reason was the COVID-19 pandemic, which required the OneNet consortium to work fully online for 19 out of 36 months (the first physical General Assembly took place in May 2022).

The consultation moments organised by T3.4 contributed to this mutual exchange among WPs. They were organised project-internally with the aim to lay out the status quo on specific market integration issues across countries involved in OneNet. Table 1-1 provides an overview of the countries involved in the four OneNet demonstration clusters.

Table 1-1: Overview of the OneNet demonstrators

OneNet demonstration cluster	Countries represented
Northern cluster	Finland, Estonia, Latvia, Lithuania, Sweden, Norway, Ireland
Eastern cluster	Czech Republic, Poland, Hungary, Slovenia
Southern cluster	Cyprus, Greece
Western cluster	Portugal, Spain, France

Two consultation moments with the OneNet demonstrators were organised during the project. Each consultation moment included a presentation by WP3 representatives to share the interim results of their research with the demonstrators. Subsequently, the demonstrators provided input (via e-mail or in real-time

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during the workshop) to provide missing information. The first consultation moment included a second workshop in which the demonstrators presented the status of their work. The workshops were designed to be inclusive and interactive through the use of online engagement tools.

The external workshop. The aims of the OneNet project to reach a consolidated view on market and system operation across Europe made it indispensable to gain feedback from external stakeholders beyond the project consortium. Despite the large size of the project consortium, it could not be guaranteed that all the different views and practices across Europe were covered in the project. The OneNet project thus organised a series of workshops in the framework of the GRId FOrum (GRIFOn), an innovative platform developed by OneNet to promote and facilitate a constant dialogue between all the actors.[1] In November 2021, WP3 participated in the first GRIFOn workshop to present interim results on the market design for a harmonised European electricity market [17].

1.2 Objectives per alignment activity reported in this deliverable

This deliverable reports on the three types of alignment activities that were carried out, a regulatory study, internal consultation moments, and an external workshop. Table 1-2 gives an overview of the alignment activities and their objectives.

Table 1-2: Overview of the alignment activities

Alignment activity	Scope	Frequency	Objective
Regulatory study	EU level with insights from the OneNet demonstrator countries, where relevant	Continuous	Link the new rules being developed at EU level with the OneNet market concepts and feed network code development process with insights from OneNet demonstrations, where relevant
Consultation moments	Project-internal with the OneNet demonstrators	Two consultation moments, each including presentations by WP3 and demo representatives	Lay out the status quo on specific market integration issues across countries related to the OneNet demonstration activities and, where possible, reach a consolidated view within OneNet
External workshop	External stakeholders	One external workshop with WP3 participation	Receive feedback on the developed OneNet market concepts, challenge the consolidated OneNet view where existent, and gain insights on alternative practices

[1] https://onenet-project.eu/grifon/.

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1.3 Outline of this deliverable

This deliverable is structured according to the three T3.4 alignment activities as follows. Section 2 presents the regulatory study. Section 3 reports on the project-internal consultation moments. Section 4 reports on the external workshop.

1.4 How to read this document

OneNet dedicated an entire work package, i.e. WP3, to the design of efficient, integrated and scalable markets for the procurement of system services by Distribution System Operators (DSOs) and Transmission System Operators (TSOs) with seamless coordination among all relevant players within and across countries.

The alignment activities of *Task 3.4 Challenging market concepts with demo results and current and future regulation* were carried out in close coordination with the other three tasks in WP3. The alignment activities built on the theoretical market framework for innovative market design options developed in *Task 3.1 Framework for coordination models and market set-ups* [2]. They were interlinked and running in parallel with the work on the market integration aspects in *Task 3.2 From markets in isolation to integrated and fully coordinated markets* [3] and the work on consumer-centric products and market distortions in *Task 3.3 Consumer-centric products and efficient market design* [4].

Note that two WPs in OneNet dealt with regulatory aspects at national and EU level. On the one hand, several tasks in WP11 included an analysis of national regulations relevant for the provision of system services and TSO-DSO-FSP-consumer coordination in the demo countries. Of those, the regulatory analysis in Task 11.2 [5] is the most relevant for the work in this report and to a large extent can be considered complementary to results presented here. On the other hand, T3.4 in WP3, and thus this report, focused on relevant European regulation.

Figure 1.1 gives an overview of the relationship between this and other deliverables in the OneNet project.

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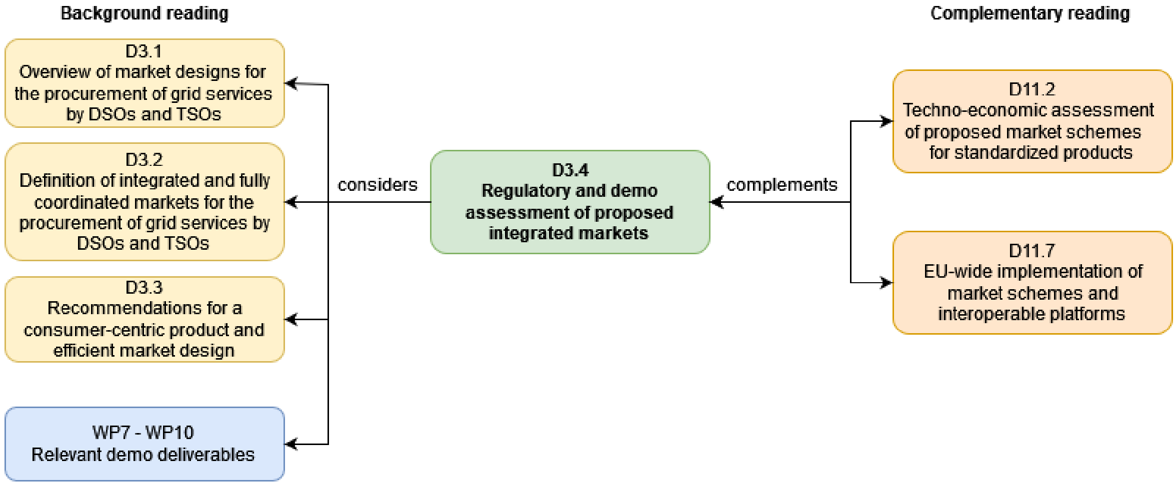

Figure 1.1: Relationship of this deliverable (D3.4) to other deliverables

The regulatory study in Section 2 analyzes three elements that are essential for the development of a European framework for demand response and the market-based procurement of system services. These elements are baselining, prequalification, and local market operation. It considers insights and learnings from the demonstrator work packages WP7-WP10. For the reader to obtain the comprehensive insight into the analysis, it is important to consider both the element-specific conclusion in subsections 2.4.4, 2.5.4, 2.6.4 as well as the overall conclusion in subsection 2.7.

Note also that the aim of the regulatory study is not to give recommendations. The practical experiences with the implementation of baselining, prequalification, and market operation in local flexibility markets, particularly in the OneNet demonstrators, is still limited. At the time of writing, the collected evidence is not sufficient to allow us to build general recommendations targeted at the EU level. Instead, we discuss a set of regulatory options for each element. These regulatory options may be considered in the currently ongoing process of developing new rules for demand response and the market-based procurement of system services at the EU level.

Other tasks in OneNet will build on the results of T3.4 and this deliverable and may choose to give selected recommendations based on their research. This is specifically the case for the national regulatory analysis in T11.2 and the OneNet roadmap developed in T11.7.

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2 Regulatory study

2.1 Introduction

The electricity sector in Europe is currently undergoing a profound transformation, driven by the EU's climate goals for 2030 and 2050 and the confluence of decarbonization, decentralization and digitalization [16]. To ensure the success of this transformation, a greater proportion of renewable energy sources (RES) must be seamlessly integrated into the electricity system. At the same time, the number of active consumers generating, storing, and selling their own electricity is steadily increasing. The majority of these new resources are being connected to the distribution grid. This poses challenges to the traditional way of planning and operating electricity networks, which has focused on network investment to ensure stability and reliability. The toolbox needs to be expanded and alternatives to system expansion are being explored, including the market-based procurement of system services (often referred to as "flexibility").

Numerous bottom-up initiatives related to flexibility have emerged all over Europe. A review of relevant European RD&I projects conducted by [2] highlighted the existing "*large variety of formalisations and set-ups that have been designed, proposed, adopted, and tested for flexibility procurement*" and showed that "*a unique way of general validity to procure flexibility does not exist*."

At the same time, Regulation (EU) 2019/943 [6] foresees the top-down establishment of new network codes, among them new rules in relation to demand response (DR), aggregation, energy storage, and demand curtailment (Art. 59(1)e). The development of these new rules is ongoing. The European Commission specified that a European framework for DR should ensure that no undue regulatory barriers hamper the participation of these new resources in any of the existing wholesale electricity markets. It should also enable their participation in the market-based procurement of services needed by the system operators (SOs), where applicable [9]. According to ACER, however, the benefits of defining a Europe-wide target model are not yet certain and more time is needed for experimentation with different models [10].

Therefore, the framework guideline demand response (FWGL DR) that ACER submitted to the EC in December 2022 [7] recommends the establishment of a common terminology and principles, common requirements for certain processes, and to define European processes for establishing further harmonisation, when and where necessary. This is to ensure coherence across all markets, processes and timeframes during this experimentation phase. The FWGL DR also stresses the importance of technology-neutrality and non-discrimination. It aims at removing all undue barriers for the participation of all resources in all wholesale electricity markets (incl. those for procuring SO services) and establishing European principles for the assessment of the need for, the procurement of and the use of local SO services.

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It is still unclear whether the new rules will have the form of network code or guidelines.[2] It will be important to find a consensus about what will be regulated at EU level and what will be left to national discretion. A balance needs to be struck between going towards a European target and respecting regional specifications.

A similar balance is required in the OneNet project, which is bringing together more than 70 partners from all over Europe and fourteen demonstrators organized in four geographical clusters. While OneNet is developing European target solutions for market design, system services and products, among others, the regional specifications of the demo countries also need to be respected.

This deliverable aims to analyze three selected elements that are essential for the development of new European rules on demand response and market-based procurement of non-frequency ancillary and congestion management services [7]. The three elements are baselining, prequalification, and local market operation. The aim of this deliverable is not to give recommendations but to discuss different regulatory options that exist for each of the elements. The idea is that the experience within OneNet, both in terms of research-oriented activities as well as demonstration-oriented activities, could provide insights that can inspire the development of the new rules at EU level.

This regulatory study is structured as follows: Section 2.2 provides an overview of the methodology applied to conduct this regulatory study. Section 2.3 summarises the relevant regulatory framework at EU level. Sections 2.4, 2.5, and 2.6 cover, respectively, baselining, prequalification and local market operation. Each section includes four subsections, consisting of a literature review, an overview of the OneNet demonstrators, a discussion of the regulatory options, and a topic-specific conclusion. Section 2.7 concludes the regulatory study.

2.2 Methodology

The FWGL DR represents the most recent legislative developments around market-based procurement of system services at the EU level. It also sets the broad framework for the regulatory study in Section 2 of this deliverable.

Three topics from the FWGL DR were selected to be analyzed in more detail, namely baselining, prequalification, and local market operation. This selection was done based on the expertise of the involved partners and the focus of their work within OneNet. Other important selection criteria were the alignment with the overall OneNet objectives and the focus of the OneNet demonstrators. To ensure the latter, T3.4 in collaboration with WP11 conducted a survey among the OneNet demonstrators in late 2022. The aim of the

[2] A detailed explanation of the differences and commonalities between network codes and guidelines is provided in [15].

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survey was to identify those demonstrators that focused on baselining, prequalification and/or local market operation in their activities (Table 2-1).

Table 2-1: Overview of which OneNet demonstrators address the topics of baselining, prequalification, and local market operation

Demo cluster	Demo	Baselining	Prequalification	Local market operation
Northern cluster[3] (NOCL)	-	X	X	X
Eastern	Czech Republic (CZ)	-	X	X
	Poland (PL)	X	X	X
	Hungary (HU)	-	X	X
	Slovenia (SLO)	X	X	X
Southern	Cyprus (CY)	X	X	X
	Greece (GR)	X	X	-
Western	Portugal (PT)	-	X	-
	Spain (ES)	X	X	X
	France	-	-	-

The methodology of the regulatory study consists of three steps per topic: First, a literature review was conducted. Second, the experience of the OneNet demonstrators was analyzed. Third, the regulatory options were discussed.

Another survey of the OneNet demonstrators in collaboration with WP11 was conducted in June 2023. It served to receive feedback on the research conducted thus far as well as on the approaches applied and challenges faced by the OneNet demonstrators with respect to the three selected topics.

Where relevant, the work in T3.4 considered results from other OneNet tasks and WPs. One example is the analysis of existing services and products and the development of new, harmonised OneNet products in [12]. Other examples are the deliverables resulting from the other three tasks in WP3 (see subsection 1.4). Note also the complementarity between the EU focus of the regulatory study conducted in the context of T3.4 (this deliverable) and national focus of the analysis conducted in T11.2 [5].

[3] The OneNet Northern cluster works on a common market solution.

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2.3 Regulatory framework for the market-based procurement of system services

Market-based procurement of system services refers to the practice by system operators of procuring the services they need to ensure the reliable operation of the electricity system through competitive markets rather than through administrative mechanisms. In the greater context of flexibility, providing services to system operators is one way of leveraging the flexibility of service providers (Figure 2.1). Flexibility can be understood as the "*ability of an electricity system to adjust to the variability of generation and consumption patterns and grid availability, across relevant market timeframes*" [14].

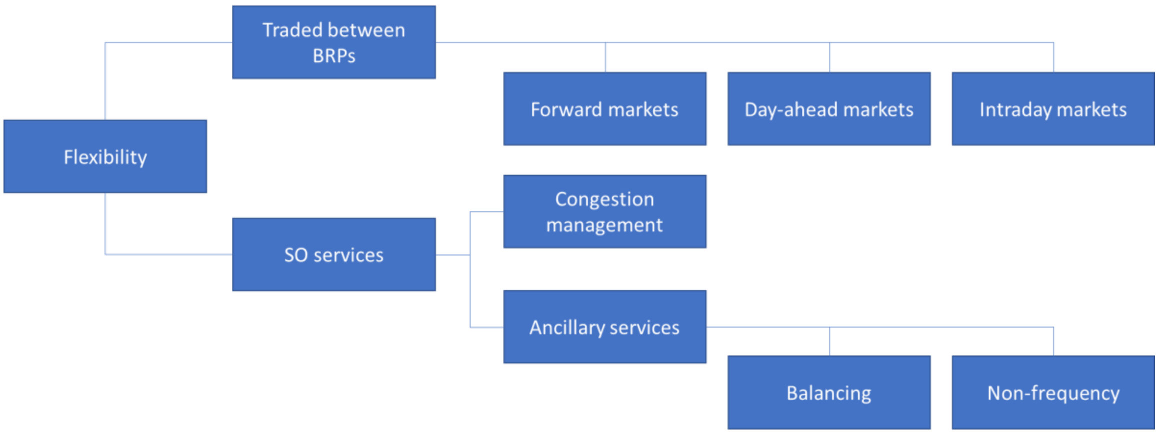

Figure 2.1: Categorization of flexibility, adapted from ACER, 2021 [13]

In the OneNet project, a system service is defined as "*the action (generally undertaken by the network operator) which is needed to mitigate a technical scarcity or scarcities that otherwise would undermine network operation and may create stability risks*" [1]. System services can generally be divided into ancillary services, comprising of balancing and non-frequency services, and congestion management. Projects such as OneNet often require a more detailed classification of system services since they focus on how the needs of system operators can be addressed. The OneNet classification distinguishes five groups of services: adequacy, frequency control, congestion management, black start and voltage control. The focus of the OneNet project, however, is on frequency control, congestion management and voltage control as these are the needs that most often arise in system operation and are also addressed by most of the OneNet demonstration projects. This is in line with the FWGL DR that defines "system operator services" as "*market-based procurement of balancing, voltage control and congestion management*" [7].[4]

[4] Note that the market-based procurement of voltage control and congestion management are further subsumed under the term "local system operator services."

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In the EU, the market-based procurement of system services is being promoted through the implementation of European energy legislation packages and network codes and guidelines. The first generation of network codes and guidelines that emerged from the third energy package addressed the transmission level [15]. In terms of system services, the Guideline on Capacity Allocation and Congestion Management (CACM GL) provides rules for the allocation of cross-zonal transmission capacity in a coordinated and market-based manner, which helps to reduce congestion and improve efficiency. It also regulates the use and coordination of remedial actions for congestion management, including countertrading or redispatching to deal with internal and cross-zonal congestion. The System Operation Guideline (SO GL) [102] establishes common rules for the operation of the electricity system, including the procurement of system services, such as congestion management or ancillary services, by TSOs from third parties when applicable. The Electricity Balancing Guideline (EB GL) [75] sets out an EU-wide set of technical, operational and market rules to govern the functioning of electricity balancing markets, including the procurement of balancing services.

The CEP opened a debate around flexibility services procurement at the distribution level. The Electricity Directive (EU) 2019/944 requires Member States (MSs) to set up regulatory frameworks to allow and provide incentives to DSOs to procure flexibility services as an alternative to network expansion. Art. 32(1) of that directive states that "*DSOs shall procure such services in accordance with transparent, non-discriminatory and market-based procedures unless the regulatory authorities have established that the procurement of such services is not economically efficient or that such procurement would lead to severe market distortions or to higher congestion*." Arts. 40(4,5) require TSOs to procure balancing services in a transparent and non-discriminatory way following market-based procedures. This also applies to the provision of non-frequency ancillary services by TSOs, unless the regulatory authority has assessed that the market-based provision of non-frequency ancillary services is economically not efficient and has granted a derogation.

A second generation of network codes and guidelines is now emerging from the CEP that targets both transmission and distribution level, where relevant. Pursuant to Article 59(1)(e) of Regulation (EU) 2019/943 one of the areas for the development of new EU rules is "*rules implementing Article 57 of this Regulation and Articles 17, 31, 32, 36, 40 and 54 of Directive (EU) 2019/944 in relation to demand response, including rules on aggregation, energy storage, and demand curtailment rules*." ACER submitted the FWGL DR to the European Commission in December 2022 [7]. The FWGL DR is a high-level document that includes objectives, principles, processes, definitions and high-level requirements. It is divided into horizontal chapters that include general requirements for market access, prequalification, and SO interaction and data exchange, and vertical service-specific chapters for congestion management and voltage control (Figure 2.2). The vertical chapters include elements that are only applicable to the specific service, such as products or pricing. Since the benefits of a European target model are currently uncertain, the idea is that the FWGL DR follows a two-stage process to maintain a balance between national/regional specificities and a possible European harmonisation (at a later

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stage). The first step is a clarification of the terminology and processes, and a definition of high-level principles and requirements at the EU level in the framework of a new network code or guideline. The second step will consist of further clarifications in national terms, conditions and methodologies (TCMs) developed by all SOs and approved by the National Regulatory Authority (NRA) at national level. Annex A provides a summary of the FWGL DR provisions relevant for baselining, prequalification and local market operation.

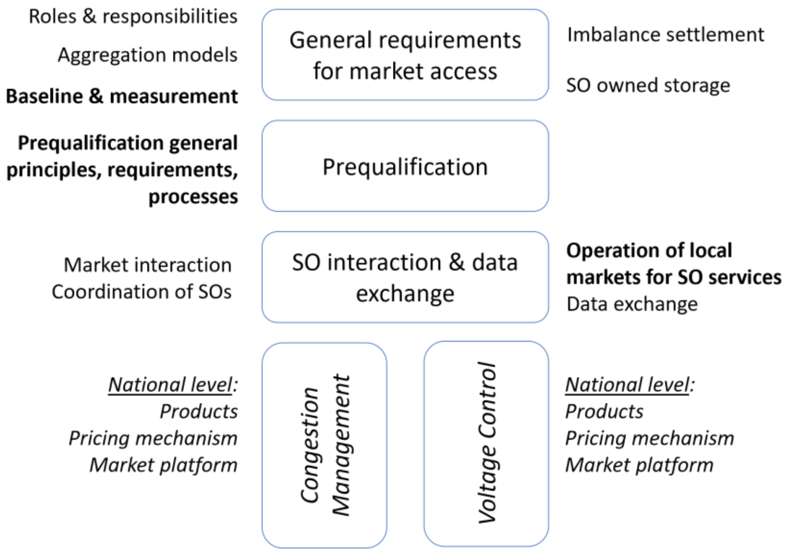

Figure 2.2: Structure of the FWGL DR); source: author's own elaboration

(bold font: elements that are treated in this deliverable; normal font: topics that will be tackled at EU level; italic font: topics that will be tackled at national level.

Following the official invitation by the European Commission, ENTSO-E and the EU DSO Entity have convened a drafting committee that is expected to submit a draft of the new rules based on the FWGL DR for revision to ACER within a period of twelve months [11]. These new rules will have strong links with the existing legal framework, namely the EB GL, CACM GL, SO GL, the Demand Connection Network Code (DC NC), and Regulation (EU) 2019/943. At the time of writing of this deliverable it is not yet determined whether the development of a European framework for DR should also include amendments of existing network codes and guidelines.

More recently, the proposal of the European Commission for an improved EU electricity market design of March 2023 emphasised, *inter alia*, the need to boost the use of non-fossil flexibility solutions such as demand response and storage [14]. The proposed measures require changes to the existing EU-wide framework for the electricity market design as set out in Regulation (EU) 2019/943 and Directive (EU) 2019/944. For example, the amendments to the regulation provide for new rules concerning the procurement by TSOs of DR in the form of a peak shaving product and rules allowing TSOs and DSOs to use data from submeters ("dedicated metering devices").

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2.4 Baselining

There is a large and growing body of literature related to baselining[5] in electricity markets. Most of this literature covers the technicalities of baselining methodologies and provides suggestions for how to improve these methodologies, often in the context of their application to specific electricity market products. The work conducted in the Horizon Europe project CoordiNet[6] is the most recent example: it provides an in-depth discussion of the various baseline methodologies that exist and puts forward concrete recommendations for which methodology to apply to the products used in the CoordiNet demonstrators [18].

This deliverable does not intend to duplicate the baselining research conducted in CoordiNet neither to update it as it is very recent. Instead, we complement it by focusing on baselining principles. This is aligned with the intention of the FWGL DR (see Annex A), which aims at setting general principles for baselining at EU level.

This section is structured as follows: Subsection 2.4.1 presents the literature review. Subsection 2.4.2 provides an overview of the OneNet demonstrators' baselining activities. Subsection 2.4.3 qualitatively discusses regulatory options for baselining based on a six-question-framework. The six questions are: *(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? (6) Which product is baselining applied to?* For each question, we provide a set of possible answers and discuss these options. Subsection 2.4.4 concludes the baselining workstream.

2.4.1 Literature review

The contribution of this literature review is twofold. First, we organize the existing body of baselining literature by identifying three relevant waves and contextualizing them. Second, we provide a taxonomy of the existing baselining methodologies.

2.4.1.1 Overview of the existing baselining literature

There is a large existing and growing body of literature on (experiences with) baselining in electricity markets. In the following, we identify three waves in the relevant literature that are related to three phases in the development of explicit DR (Table 2-2).[7] We contextualize the experiences with baselining by introducing the

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[5] In this deliverable, baselining is generally understood as what the customer would have consumed in the absence of a demand response event. The exact definition depends on the context, as is shown throughout this section.

[6] https://coordinet-project.eu/projects/project.

[7] Two types of demand response schemes exist [19]. Implicit ("price-based") demand response refers to consumers choosing to be exposed to time-varying electricity prices that reflect the value and cost of electricity in different time periods. Explicit ("incentive-based") demand response means that the result of demand response actions is sold upfront on electricity markets sometimes directly for large

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main policy or regulatory controversies per development phase. Note that we use the waves as a rough categorization in literature, and that their start and end are not always clear-cut.

Table 2-2: Overview of baselining literature reviewed in this deliverable

Number of wave	First	Second	Third
Timing	2000-2010	Mid-2010s	From 2020 to today
Integration of what?	demand reduction programs	independent aggregators and other intermediaries	active consumers and demand-side flexibility
In which markets?	existing US wholesale electricity markets	existing EU electricity markets	emerging (local) flexibility markets
Academic literature	[20], [22], [25], [26], [27][22]	[37]	[21], [30], [39], [40], [41], [41],[46], [47], [48], [49]
Stakeholder reports	[23], [24], [34], [43]	[19], [28], [29], [35], [36], [45]	[7], [31], [32], [33], [44]
Project deliverables	-	-	[18], [38]

First wave: demand reduction programs in existing US wholesale electricity markets

The first wave of literature dates to around the late 2000s to early 2010s. It covers baseline experiences mostly related to wholesale-market administered demand reduction programs that have been deployed in the US since the early 2000s [20].

At that time, the US electricity markets were characterized by a lack of retail competition and uniform pricing in many areas where utilities had a monopoly on the market. Consumers had limited options when it came to choosing their electricity supplier. It often also meant that all customers were paying the same price for electricity, irrespective of their actual demand patterns and the actual cost of electricity production, distribution, and transmission. This resulted in a lack of incentives for consumers to conserve energy during peak demand periods or for utilities to invest in energy-saving technologies, as they were not able to pass on the true cost of energy to consumers. 2000-2001 was also the time of the California energy crisis that exposed flaws in the wholesale electricity market structure and the need for a more flexible and responsive electricity market that could better balance supply and demand, reduce costs and increase security. In that context, there was an increased interest in DR programs that encouraged customers to change their behavior when demand reductions were needed to relieve stress on the grid [21] [50].

industrial consumers or through demand response service providers. While "demand-side flexibility" has recently become a more frequently used term than “demand response”, the concepts remain the same.

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A discussion emerged regarding the correct mechanism for incorporating DR in electricity markets [22]. Some argued that the wholesale market should be restructured to allow for explicit DR, which would give consumers more control over their energy usage and help balance the grid. Others believed that retail competition and variable pricing would be a better solution, as it would encourage energy providers to innovate and create new pricing models that reflect the true cost of energy production. Chao [26] was particularly convinced that the difficulties with baselining are one of the strongest reasons for preferring implicit over explicit demand response. Ultimately, the debate led to the inclusion of provisions in the Energy Policy Act of 2005 [51] and the Energy Independence and Security Act of 2007 [52] that, *inter alia*, encouraged the development of DR programs and the elimination of barriers to DR participation in energy, capacity and ancillary services markets. Notable subsequent decisions are FERC orders No. 719 of 2009 and No. 745 of 2011 that opened up US wholesale energy markets to the participation of DR resources [25].

The general principle when creating mechanisms for demand-side resources to participate in electricity markets is to make them subject to the same requirements as generation, to the extent practical. However, as [23] notes, "*there is a fundamental difference between load reduction and generation as resources: It is not possible to meter or otherwise directly observe load reductions. Rather, measurement of the performance of any demand-side resource necessarily means comparing observed load to an estimate of the theoretical load that would have occurred absent the resource's being dispatched—that is, compared to a calculated baseline*."

In other words, customers participating in demand reduction programs get compensated for reducing their electricity consumption level during the event. Since electricity that is not consumed cannot be measured, however, a baseline needs to be established. In this context, the baseline is a counterfactual that reflects what the consumer would have consumed in the absence of the demand reduction event. To calculate the demand reduction, the baseline is compared to the actual metered electricity consumption during the event.

Many methodologies to calculate baselines exist, and it was recognized that a certain level of harmonization was needed to accelerate the development of DR and reduce barriers for new entrants to electricity markets. The North American Energy Standards Board (NAESB) thus developed a set of common definitions and practices that were recognized by Federal Energy Regulatory Commission (FERC) Order no. 676-G of 2013. Note that, recently, FERC order No. 841 of 2018 regarding the participation of electric storage resources in the capacity, energy, and ancillary service markets generated new discussion on the topic of integrating DR into the markets [53].

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Second wave: independent aggregators and other intermediaries in existing EU electricity markets dominated by incumbents

The second wave of literature dates to the mid-2010s. It covers early thinking on how to include independent aggregators and other intermediaries in existing EU electricity markets dominated by incumbents. Baselining was discussed as one of the challenges for their integration.

At that time, the European energy system was already undergoing profound changes in pursuit of the (then-2020) climate goals. The increasing share of variable renewable energy sources (vRES) requires the electricity system to be operated more flexibly and efficiently, and electricity markets to be opened to new and smaller entrants. However, the EC [28] acknowledged that the market arrangements at the time did not provide adequate incentives for flexible solutions to be deployed. Retail energy markets were in most parts of the EU suffering from persistently low levels of competition, consumer choice and engagement, and energy markets generally did not sufficiently allow for the active participation of consumers.

In 2015, the EC [29] announced a new deal for consumers that included measures to integrate independent aggregators and other intermediaries in existing electricity markets and realize the value of flexibility through demand response. In the same year, [35] analyzed the regulatory framework for explicit DR in 16 EU Member States (MSs) and identified not fully enabled aggregation services and inadequate and/or non-standardized baselines to be among the main regulatory barriers.

Most consumers do not have the means to trade directly in the market and need to rely on a professional party that acts as intermediary. Incumbent suppliers can provide aggregation services but have been slow in taking up this role. The independent aggregator emerged as a new role in European electricity markets that acquires the flexibility from demand-side resources owned by industrial, commercial, and residential user, aggregates them into a portfolio, creates services based on the flexibility, and trades these services in wholesale, balancing and capacity markets. The independent aggregator is defined in Art. 2(19) of Directive (EU) 2019/944 as a "*market participant engaged in aggregation who is not affiliated to the customer's supplier*" [54]. A baseline is needed to quantify the performance of the user, and the performance of the independent aggregator towards the entity procuring the flexibility services (TSO, Balancing Responsible Party (BRP), or DSO). [36] provide several recommendations with respect to baseline design, calculation and distribution of related roles and responsibilities for different aggregator implementation models.

The actions of an independent aggregator also have an impact on the supplier as they cause an imbalance in the supplier's portfolio and a likely reduction in its revenues. [37] take stock of current practices in regulating the contractual relationship between the supplier and the independent aggregator and mention baselining as one of three open issues in the implementation of the perimeter correction and compensation models.

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Third wave: including active consumers and demand-side flexibility in emerging (local) flexibility markets

The third wave covers literature from around 2020 to today. Several academic papers and deliverables from EU Research, Development, and Innovation (RD&I) projects analyze first implementation experiences with baselining in the context of flexibility markets. Baselining is often not (only) applied to demand reduction but also to other types of resources such as distributed generation (DG) or storage.

In 2018-2019, the CEP was adopted. Article 32 of Directive (EU) 2019/944 defines the EU legal basis for the market-based procurement of flexibility from resources such as DG, DR, or storage when such services are cheaper than distribution grid expansion [54]. Consequently, flexibility markets have started to emerge across EU Member States and have been analyzed in several academic and stakeholder publications as well as in numerous EU RD&I projects such as CoordiNet, EUniversal, INTERRFACE or OneNet. [38] finds that, while there is no unique way to procure flexibility services, "*the market-based procurement through local flexibility markets that involve the DSO or the TSO, or both, utilizing auction-based markets is of primary interest.*" Based on their research, [39] conclude that there is potential to use flexibility services to save investments in distribution grids and discuss the options that DSOs have in contracting that flexibility. [30] discuss six controversies around the design of flexibility markets, analyzing four European pilot projects, and [31] examine the function and design characteristics of seven flexibility platforms.

CEER stresses that, independent of the specific market design, the establishment of baselines are a crucial aspect of flexibility products and their design [32]. Baselining is needed to quantify the performance of flexibility service providers (FSPs) towards the parties procuring the flexibility (TSO, BRP, DSO) and to compensate the FSP adequately [39]. When a service is delivered by an FSP, the amount of flexibility must be calculated by taking the meter reading at the connection point and comparing it to a baseline (or a schedule), and the flexibility must typically be paid for by the procuring party. In the case of downward flexibility, higher consumption can also be remunerated as a cost paid by the FSP to the procuring party. If the service is not delivered or does not respect the agreed parameters, a penalty is possible. For flexibility markets to flourish, the rules for baseline calculation as well as compensation schemes and responsibilities need to be clear and transparent and must not constitute barriers for new entrants [33].

The FWGL DR states that the FSP can either be the customer herself or an intermediary, i.e. an aggregator. When an intermediary is the service provider, two general fields of application of the concept of baselining exist. One is linked to the contractual relationship between the customer and the intermediary. The other is linked to the relationship between the intermediary and the SO. In the context of the FWGL DR, only the latter is relevant, i.e. the baseline is considered from the perspective of the SO in relation to the intermediary. Under this assumption, the baseline represents a "*counterfactual reference about what the allocated volume [of the FSP's*

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BRP] would be in the absence of the activation for the provision of the respective service, in order to quantify and measure the actual delivery of the service" [7].

2.4.1.2 Baselining principles and methodologies

In this subsection, we first introduce the baselining principles. We then provide an overview of existing baselining methodologies. Finally, we match the principles with the methodologies based on findings in the literature.

Baselining principles

No baseline is perfect as all baselines are estimates. However, baselines that balance several principles are better than those that do not [24]. The three principles that baselining should respect and that are typically mentioned in the literature are simplicity, accuracy, and integrity. Note that some reports add a fourth principle, for example alignment [34], efficacy [18] or replicability [33].

Simplicity means that the baseline calculation method should be sufficiently simple for stakeholders to understand, calculate and implement it. This includes final consumers. Simplicity is closely linked with transparency. A transparent methodology is one that is open and clear about its assumptions, inputs, and calculations. Typically, a simple methodology is more transparent as it is easier to understand, recalculate and verify by stakeholders, facilitating their trust in electricity markets.

Accuracy means that the calculated baseline should accurately estimate the level of consumption if the consumer (or the available flexibility) is not activated. Consumers or FSPs should be credited only for the service they provide. Under- or overestimation of the baseline can lead to, respectively, lower incentives for the consumer or FSP and higher costs for the party that is procuring the load reduction or the flexibility service.

Integrity means that a baseline method should be calculated in a way that does not encourage strategic behaviour and attempts to game the DR scheme. In turn, strategic behaviour and attempts to game the DR scheme should not influence the baseline calculation. In other words, a baseline with integrity minimizes the possibility for consumers or FSPs to game the system.

Baselining methodologies

Different baseline methodologies exist and are discussed in the literature.

Table 2-3 gives an overview of the main baselining methodologies. A description of the methodologies is provided in Annex B.

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Table 2-3: Overview of baselining methodologies

		Baseline methodology										
		High X of Y	**Regression**	**Comparable day**	**Rolling average**	**Statistical sampling**	**Meter before / meter after**	**Maximum baseload**	**Meter generator output**	**Machine learning techniques**	**Control groups**	**Self-declared**
Timeframe of data included	Historical	✓	✓	✓	✓	✓				✓	✓	✓
	Real-time		✓				✓	✓	✓	✓		
Type of data included	Interval meter	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Other*	✓	✓	✓	✓	✓				✓	✓	✓
Number of sites covered	Individual	✓	✓	✓	✓		✓	✓	✓			✓
	Multiple					✓		✓		✓	✓	✓
Type of profile created	Static						✓	✓				
	Dynamic	✓	✓	✓	✓	✓			✓	✓	✓	✓
Timing of baseline calculation	Ex-ante	✓	✓		✓			✓		✓		✓
	Real-time						✓		✓	✓		
	Ex-post			✓							✓	

*may include other data such as weather and calendar data

Baselines can be calculated based on historical or real-time data (or a combination of both), from interval meter readings and/or other data. Historical data typically includes a collection of measurements recorded over a specific period in the past. This can include data on hourly, daily, or seasonal patterns, as well as on long-term trends. Real-time data typically includes current measurements of electricity demand, weather conditions, market prices, and other relevant variables.

Some baselining methods require measurements and data from the site providing flexibility, others allow the baseline to be estimated based on data from nearby sites. These sites can belong to different FSPs. In other words, the idea is to use a kind of 'average' demand computed among various FSPs/customers.

The baselining calculation methods result in different types of profiles. 'Static' means that the baseline remains at one level during the entire activation period, while 'dynamic' refers to a profile that changes during the activation period.

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Baselines can be calculated before, in real-time or after the event. Ex-ante baselining refers to calculating the baseline before the demand reduction event or activation of flexibility resources. Real-time baselining involves continuously updating and adjusting the baseline demand during the event. The primary value of real-time baselining is the provision of immediate information about the activations, enabling, for example, real-time monitoring of the grid status. Ex-post baselining refers to calculating the baseline after the event.[8]

Interaction between baselining principles and methodologies

Several authors have discussed the interaction between baselining principles and methodologies. Some authors have assessed the suitability of certain baseline methodologies for specific products or services against the baselining principles. For example, [24] and [34] provide recommendations for resource adequacy/capacity and energy programs based on their experience with the participation of consumers and their resources in demand reduction programs in US wholesale and ancillary services markets. [18] puts forward concrete recommendations for which methodology to apply to the congestion management products used in the flexibility market demonstrators of the Horizon Europe project CoordiNet. [21] [38] reviewed the experiences with baselining methodologies in 23 Horizon Europe projects.

Other authors have proposed approaches to improve estimation of baselines applied to specific types of resources or customers. For example, [47] proposes a machine learning approach to apply to individual behind-the-meter distributed photovoltaic systems. [48] propose a method to address challenges in estimating load reductions of residential consumers who show large stochasticity. [49] discuss baselining in the context of the Danish Market Model 3.0 that aims to make the ecosystem for demand-side flexibility more attractive to the stakeholders involved. [46] are generally critical towards the use of baselining methodologies in flexibility markets for reasons of transparency and efficiency and favour the use of capacity limitation services[9] in distribution systems.

The experiences discussed by these authors show that no baseline methodology will fulfill all principles to the same extent. Improving on one principle is likely to cause a weakening of at least one other principle.

The experiences also show that there is no standard baseline methodology that fits all purposes. The choice of which baseline methodology is the best depends on several factors including the type of service or product provided, the characteristics of the service provider, the timeframe, and the related requirements and applicable rules.

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[8] Note that in case of ex-post baselining, the system operator may still need to calculate some form of ex-ante baseline to obtain a refence point for the expected operation state of its network without flexibility activation. This could be based on forecasts that consider the expected operation of the grid under various scenarios. As such ex-ante baseline relies on assumptions and modelling, it may not capture all the complexities and variations of the actual grid operation and may thus not be as accurate as an ex-post baseline that uses historical data. By continuously evaluating and refining the ex-ante baseline, though, the system operator can enhance its accuracy over time.

[9] Capacity limitation services can be understood as temporary absolute consumption caps for aggregators.

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Some conclusions can be drawn as to how methodologies generally score against the three principles simplicity, accuracy, and integrity. In Table 2-4, we report and extend the scoring table from the Horizon Europe CoordiNet project. Note, however, that there is likely not a single grade for a single methodology for all services or products. Each of the cells in the table can be discussed for each individual case and one could think of the "High X of Y" methodology scoring "high accuracy" for one product and "medium accuracy" for another product.

Table 2-4: Qualitative assessment of baseline methodologies against baselining principles, modified from [18] and extended with statistical sampling, control groups and self-declared baselines

Baseline methods	Accuracy	Simplicity	Integrity
High X of Y	Medium	High	Medium
Regression	High	Low	High
Comparable day	Medium	High	Medium
Rolling average	Medium	Medium	Medium
Statistical sampling	Medium	Medium	Medium
Meter before/meter after	Medium	High	Low
Maximum Base Load	Low	High	Medium
Metering generator output	Medium	Medium	Medium
Machine learning	High	Low	High
Control groups	Medium	High	High
Self-declared baseline	Medium	High	Low

High X of Y is a common baseline methodology. It is often chosen because it strikes an appropriate balance among the three principles of accuracy, simplicity and integrity. The overall performance of the method, in particular regarding accuracy and integrity, depends on the definition of its parameters. Simplicity, on the other hand, does not seem to be affected significantly by the design parameters.

Regression methods have a high accuracy as they consider multiple variables that influence load, but a caveat is the training data for the regression model. Accuracy can be affected if there are significant changes in consumption behaviour or if observations do not include extreme conditions. Due to their complexity, regression approaches have a small chance of being artificially modified, minimizing opportunities to game the system and increasing integrity. For the same reason, however, they lack simplicity and are challenging for stakeholders to understand.

Comparable day is an approach that is simple to communicate but requires a large pool of days to select from to ensure comparable days are found. Extending the time span from which data can be drawn may be needed to find a comparable day but increases the possibility of structural changes affecting the accuracy of the

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baseline. The selection of the comparable day is done after the event, and there are no objective selection criteria. In case the consumer or flexibility service provider is allowed to select the day, they may be incentivized to modify it to their benefit, negatively impacting the integrity of the approach.

Rolling average baselines can have high accuracy if there is sufficient representative data, and they are not complex to apply. Integrity can be enhanced by using a weighing factor that emphasizes previous days more and the current day less. At the same time, this could cause a drop in accuracy in cases where recent measurements are more representative. However, this approach may not be suitable for customers whose energy usage fluctuates between seasons or whose load level repeats every certain number of days, unless the periodicity of load is considered in selecting the days of the rolling window (which, in turn, decreases simplicity).

Statistical sampling methods offer simplicity because of their straightforward approach to selecting data points, which makes it easier to communicate to stakeholders. A caveat is that choosing representative data points necessitates knowledge of the statistics of the data set. Such complexity can be mitigated by simplifying the choice itself, for example by using simpler metrics. Accuracy can be an issue if the sample is not representative of the larger population, leading to errors in baseline estimation. This method can also be subject to gaming as consumers may alter their behaviour during the baseline period. To ensure integrity, the sample selection process must be transparent and unbiased.

Meter before / Meter after (MBMA) is considered a simple baseline method that is easy to communicate and apply. However, it can be subject to gaming by consumers offering DR services if they artificially increase their demand on high peak days to receive a higher compensation for decreasing their demand. This can be overcome if the FSP does not know in advance the direction of the flexibility it will be asked to provide. The accuracy of the MBMA method was found to be appropriate for estimating the response of DR resources in real-time dispatch conditions and is favoured for system services such as frequency regulation.

The **Maximum Baseload Methodology** is simple to implement and requires computation only once a season. It is less susceptible to gaming and provides little opportunity for participants to distort their baselines. However, it is less accurate and tends to overstate performance, particularly when based on non-coincident peak days.

The **Meter Generator Output** method scores medium in simplicity as it is not straightforward to communicate. [47] provides an analysis of the advantages and limitations of the possible meter configurations with a net meter only or with a net and a generation meter. The level of accuracy of the method depends on the option chosen. The "zero baseline" is considered the least efficient, as it only provides incentives for the DG generation and not for demand reduction. A mitigation measure could be its combination with another baseline method that considers both the level of the net load minus generation and the level of generation. The zero baseline also means increased complexity and cost as it requires the installation of a second meter, which is another reason for scoring medium in simplicity.

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Machine learning techniques have the potential to simplify the baseline calculation process through automation. They may increase complexity, however as data processing expertise is required to implement and finetune machine learning models. Also, transparency is reduced as models are often not easily interpretable, making it difficult for end users to understand and verify the (rationale behind the) resulting baseline. Subject to the availability and high quality of data, accuracy can be considered high as these techniques allow to capture complex relationships and patterns within large data sets and can adapt to changing conditions. Integrity can be considered high if techniques are designed to incorporate proper data governance practices, avoid biases in data selection, and promote transparent model development. The training data set needs to be carefully chosen as biases there can be perpetuated in the resulting baselines. Regular monitoring and validation of the machine learning models can help maintain the integrity of the approach.

Control groups offer an intuitive approach to baselining by directly comparing outcomes between treatment and control groups that is easy to understand also for non-experts. They promote accuracy by allowing for causal inference to isolate the effect of the event and controlling for confounding factors that could influence its outcomes. However, this requires a sufficient sample size and careful design of the study that ensures random assignment of participants to the groups and avoids selection biases. Integrity can be considered high as FSPs do not know who participates in the control group and can therefore not act to strategically influence the baseline calculation.

Self-declared baselines score high for simplicity but raise concerns regarding accuracy and integrity. Where the FSP has a good understanding of its resources and capabilities, it can calculate a baseline that is in alignment with the specific service provided. The accuracy of the baseline may vary depending on the FSP's expertise, data quality, and analytical methods. The integrity of a self-declared baseline is low due to conflicts of interest. As the FSP has a vested interest in the baseline estimation, there is a risk of bias or manipulation to maximize its own benefits. Clear guidelines and standards should be defined by the SO and/or NRA to govern the process of self-declaration, ensuring that baseline methodologies are robust and that the broader interests of the electricity system are considered. Independent verification or external oversight can help reduce the risk of biases and inaccuracies.

2.4.2 Overview of the OneNet demonstrators

Six OneNet demonstrators are implementing baselining in their activities, namely the Northern cluster, Poland, Slovenia, Cyprus, Greece, and Spain. In the context of two workshops organized in collaboration with WP11 in March 2023 and June 2023, several questions were asked to the demonstrators regarding baselining. In the following, we provide a summary of their answers.

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Which baseline methodology is applied for which products in your demo, and why?

The demo experience shows that only a limited number of the available baselining methodologies are used in practice (Table 2-5). Also, a clear preference in terms of methodology for a certain product cannot be deducted. The demo experience rather suggests that it is important to enable different approaches. Which methodology is ultimately used depends on the experience of the involved parties, existing requirements, already available tools and information, or the regulatory framework. Different methodologies for different types of FSPs or resources may be used. Where the default option is a self-declared baseline by the FSP, it seems important to have alternative solutions available in case the FSP chooses not to or fails to submit their baseline, as wells as verification and mitigation measures in place to ensure accuracy and integrity.

Table 2-5: Overview of baseline methodology per product used in the OneNet demonstrators

Product[10]	**Baseline methodology**			
	High X of Y	Comparable day	Meter before/ Meter after	Self-declared by FSP
aFRR	Greece			
mFRR	Northern, Greece		Poland	Northern
RR			Poland	
Corrective local active power	Northern	Spain	Slovenia	Northern, Cyprus, Spain
Corrective local reactive power	Greece			Cyprus
Predictive short-term local active power	Northern, Greece	Spain	Poland	Northern, Spain, Poland
Predictive long-term local active power	Northern	Spain		Northern, Spain

In the **Northern cluster**, both ex-ante schedules submitted by the FSP, and ex-post baselines calculated by the flexibility register (FR) are enabled. Also, both baselines based on main meter and submeter data are enabled. Different countries within the Northern cluster may decide for different of the abovementioned options. In many cases the FSP has a forecast of the resources' behaviour, in which case the option to use it also for verification is offered. A possible associated risk is the possibility for gaming, which could be minimized by

[10] [12] analyze the existing services and products in energy market and develop a set of standardized OneNet products for system services that are being used by all the OneNet demonstrators.

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comparing the ex-ante baseline to the metering data in the cases where there was no activation. High X of Y was chosen as a method because of its good reputation in the literature and its characteristics of being simple and easy to understand.

In the **Polish demo**, the TSO level is not considered as congestion is managed in the integrated scheduling process on the balancing market (central dispatch model). At the DSO level, the default option is the self-declared baseline by the FSP. This is especially the case for large customers that are already part of a DSR program and have a good knowledge and monitoring of their consumption. However, in case of small installations, e.g. prosumers and renewable distributed energy resources (DER), there is the risk of large deviations and forecasting errors due to frequent changes in weather-dependent generation. Also, prosumers typically do not have precise data and/or knowledge about their generation and consumption readily available. In such cases, the alternative method used is MBMA. The main motivation for these choices was simplicity and transparency. Other reasons were an overall lack of experience about baselining, and the level of access to smart meter data.

In the **Cypriot demo**, DSOs and TSOs use rolling average (for demand response) and regression methods (for FSPs with RES generation) to estimate the system state for the procurement of services three hours ahead of the flexibility event. Submetering is used to provide the baseline and to check the delivery by the FSP. The demo platform includes a response tool that evaluates whether the services was correctly provided based on actual measurements. The reasons for these choices are simplicity, accuracy and previous experience.

In the **Spanish demo** the FSP submits a self-declared baseline. The DSO checks the assets and the delivery by comparing the activation against the agreed baseline. To do so, the DSO uses the closest measurement point that is available. Smart meters are available for some (not all) FSPs involved in the demo. If the FSP fails to deliver a baseline, the DSO estimates the baseline using the comparable day method based on historical information. The reason behind these choices was that it could be done easily with the information and the tools that were available to the DSO. The FSP has information about the individual assets and their capabilities, while the DSO only sees the total load at the connection point.

In the **Slovenian demo**, there is no self-declared baseline by the FSP. In the first two years of OneNet, the aggregator provided the baseline, while in the third year the MBMA method was used (for households). Based on its three-year experience, the DSO defined the baseline as the last 15 min measurement before the announcement of the activation, and the baseline was kept constant during the activation period. This approach was chosen because of its transparency, simplicity, and suitability for estimating household response.

In the **Greek demo**, two different approaches based on the type of resource are used. For load, the SO calculates the baseline ex-post based on historical data. High X of Y was chosen due to previous experience and

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because it is the current practice used on the existing market. For RES and conventional units, the SO uses the set-point ex-ante (forecasted set point within the F-channel) of each unit based on the system requirements.

Who is responsible for setting the baseline?

In the OneNet demonstrators the responsibility for setting the baseline is either attributed to the FSP or the SO (Table 2-6). In some cases, the former is the default option while the latter serves as alternative.

Table 2-6: Overview of responsible for setting the baseline in the OneNet demonstrators

	System operator	Market operator	FSP	Independent third party, e.g. regulator	Flexibility register
Default option	Slovenia, Greece	-	Northern, Cyprus, Spain, Poland	-	Northern
Alternative	Spain, Poland	-		-	-

In the **Northern cluster**, two options are enabled depending on the product and the country. The FSP can self-declare a baseline before the gate closure time (GCT) of the market in question. In case the FSP has not provided its schedule in time or has generally decided not to provide a schedule, the flexibility register calculates the baseline ex-post for a specific period based on the available metering data. While it is important that the technical solution, i.e. the flexibility register, enables both options, the actual choice needs to be made in national legislations and may differ from one product to another. Regarding the operation of the flexibility register, the Northern demo defined a new role for the task, i.e. the Flexibility Register Operator, which needs to be delegated to a legal entity at the national level in the future.

In the **Polish demo**, the default is for the FSP to provide their schedule ex-ante. If a reliable and accurate baseline is available, it is used. Alternatively, the DSO calculates the baseline with real-time metering data using the MBMA method.

In the **Cypriot demo**, the default option is a self-declared baseline by the FSP.

The default option in the **Spanish demo** is an ex-ante baseline submitted by the FSP and checked by the DSO. The alternative is a baseline calculated by the DSO.

In the **Slovenian demo**, the DSO calculates the baseline. This is because the involved households cannot predict their consumption. In the future, it may be decided that large industrial FSPs may submit a self-declared baseline.

In the **Greek demo**, the system operator calculates the baseline.

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Which type(s) of FSP and resource is the baseline applied to? Is the baseline applied to individual or aggregated resources? Is submetering used?

The OneNet demo experiences show a large variety regarding the involved types of FSPs and resources as well as aggregators and use of submetering (Table 2-7). It can be observed that the involvement of an aggregator does not necessarily mean that the baseline is also calculated at the aggregated portfolio level. It is also observed that the use of submetering is only just starting, with some demos already having a clearer picture of the related technicalities (e.g. definition or granularity of the meters) than others.

Table 2-7: Overview of different demo characteristics: type of FSP(s) and resource(s) involved, involvement of an aggregator, level at which the baseline is calculated, use of submetering

	Type of … involved in the demo		Aggregator involved?	Baseline calculated at		Use of submetering ?
	FSP	Resource		individual asset level	aggregated portfolio level	
Northern	Residential, Commercial	Demand (heat pumps, water boilers, EV), PV	Yes (Estonia, Finland)	Yes		Yes
Poland	Industrial, Generators	PV, DSR, CCGT	Yes		Yes, at the level of scheduling units for balancing services	No
Cyprus	Household	Load reduction, RES generation, batteries	No	Yes (at metering point)		Yes
Spain	University, Industrial	Load reduction (air conditioning, heat pumps)	Yes		Yes	Yes
Slovenia	Household	Heat pump, battery, PV	Yes	Yes	Yes	No
Greece	Generators, Residential, Industrial	RES, conventional units, load reduction	No	Yes		No

In the **Northern cluster**, some real FSPs are participating in Estonia and Finland that are focused on residential flexibility coming from heat pumps, water boilers, electric vehicles (EVs) or other devices. While an aggregator is involved, each unit (resource) should have its own measurements and as such can have its own baseline. This is required for flexibility settlement from the perspective of the flexibility market, and imbalance settlement from the perspective of BRPs in wholesale market as resources in the same portfolio can have different supply side BRPs. The trades are settled on portfolio, more explicitly, on resource group level.

Baselines based on both main meter data and sub-meter data are enabled. A submeter is defined as any meter located behind the main meter of the connection point. It can be a dedicated meter of an asset but also of a group of assets. The latter would include the case of flat in an apartment building, where the main meter is installed on the level of the whole building only. At the time of writing, the granularity of the meters is not yet strictly defined for the demo. The technical configuration enables a wide range of granularities. The short-term active power energy (ST-P-E) product uses 15 min by default, which also aims to enable the participation of resources that only use smart meter measurements. The near-real time active power energy (NRT-P-E) product that is based on the mFRR product requires a granularity of one minute. A main advantage of such sub-metering is the observability on the individual device level. Whereas from the main meter data it may difficult to realise the impact/behavior of the flexibility, in particular when tens or hundreds of devices exist behind the same main meter. All measurements need to be available in the Flexibility Register where the verification of activated quantities takes place.

In the **Polish demo**, large industrial customer and large generation units, i.e. combined cycle gas turbine (CCGT), as well as photovoltaic (PV) are participating. The baseline is calculated on portfolio level, more concretely, for the scheduling units. This is because a baseline is mainly needed for the balancing services provided by the scheduling units (collection of FSP into one group). Submetering is not used.

The **Cypriot demo** includes household final customers using demand reduction, RES generation and batteries. The use cases in the demo consider the FSP-DSO chain. The baseline is calculated at the unit level based on submetering data available at the metering point. The submeter measurements are available to the FSP as well as DSO and TSO. A submeter is defined as a dedicated meter for the controllable and uncontrollable resources. The granularity of the meters is 30 seconds.

The **Spanish demo** includes a university and an industrial FSP, providing load reduction services mostly from air conditioning and heat pump systems. Some of the FSPs calculate the baseline at individual level and sum them up to receive the aggregated baseline. Others calculate the baseline at individual level. The FSPs ran resource tests individually to quantify their flexibility.

In the **Slovenian demo**, households participate with heat pumps, batteries, and PV. In the wintertime, the demo network suffers from overload, and load reduction is managed via heat pumps being turned off. However, it was realized that the flexibility resources behind the meter being activated are PVs and batteries. The baseline is applied at household level. If the customer herself is the FSP (without an aggregator), the baseline is calculated for the customer's measurement point. In case an aggregator is involved, the baseline is calculated at the aggregate level, i.e. all measurements of all resources are summed, and baseline is set based on the sum diagram. No submetering is applied. Only measurements from the main (billing) meter of the households are used for calculating the activated energy.

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The **Greek demo** includes only simulated FSPs, namely RES, conventional units, and consumers (load). Baselines are set at the individual level as portfolios are not yet applied in the Greek market (unit based). Submetering is not used.

2.4.3 Discussion of the regulatory options

Based on the literature review and the analysis of the demonstrators, we identified six questions that are relevant for the development of a regulatory framework for baselining (Table 2-8). The answer to each question includes several options. In the following, we discuss these options with a particular emphasis on the three baselining principles of simplicity, accuracy, and integrity. Where relevant, we refer to the experiences of the OneNet demonstrators. Note that we do not claim to be exhaustive and there may be other relevant questions. Note also that there is no hierarchy in the order of the questions.

Table 2-8: Six-question framework and related regulatory options for baselining

Question	Options that are discussed
Which relationship is the baseline methodology applied to?	• Customer <– > intermediary, i.e. aggregator • Intermediary <–> system operator
In which grid operational state is the baseline methodology used?	• Normal state • Emergency state
Who is responsible for setting the baseline?	• System operator • (Independent) market operator • FSP • Independent third party, e.g. regulator
Which type of customer is baselining applied to?	• Non-professional customers, e.g. residential customers or energy communities • Professional customers, e.g. (large) commercial or industry customers *
Which type of DER is baselining applied to?	• Isolated DER, e.g. heat pumps, PV/wind, back-up generation, combined heat and power, storage/batteries • Combined DER • Aggregated DER
Which product is baselining applied to?	• Frequency versus non-frequency product • Active versus reactive product • Short-term, long-term, and emergency (operational)

* in particular, where they do not have schedules set in other market segments

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Which relationship is the baseline methodology applied to?

In the context of DR, the service provider can either be the customer herself or an intermediary, for example an aggregator. In the latter case, there are two general fields of application of the concept of baseline.

The first field of application is linked to the contractual relationship between the customer and the aggregator. The relationship between these two parties is governed by private law[11]. It can be assumed that, as in other types of consumer-producer relationships, the usual principles of contractual transparency and fairness should apply to the rights and obligations defined in the contract. Adhering to these principles also helps to strengthen trust in the business of DR, which helps to increase the willingness and availability of final customers to offer their flexibility. Beyond this, upholding of the baselining principles is not relevant from the perspective of the electricity system.

The second field of application is linked to the relationship between the aggregator and the SO. Due to the critical infrastructure nature of the energy system, the (good) governance of this relationship is of public interest. Upholding the baselining principles is important as they support

- the effective functioning of the electricity system and markets. The SO is responsible for operating the grid and ensuring reliable electricity supply to consumers. To do so, the SO relies on accurate data provided by market participants including aggregators to effectively balance supply and demand and to make informed decisions regarding infrastructure investments. By upholding the baselining principles, the aggregator facilitates transparent and efficient communication with the SO, leading to streamlined processes, minimized errors, and reduced administrative burden.
- the efficient use of taxpayers' money, and overall safeguarding of consumers' interests. The SO must accurately measure and allocate volumes and related payments among BRPs. Inaccurate or unreliable data can lead to inefficiencies, increased costs, and potential disruptions in the energy supply. Adhering to baselining principles not only ensures efficiency, but also that payments are fair and transparent, consumers' electricity usage is accurately recorded, and consumers are billed correctly. It ensures that consumers are not overcharged or disadvantaged, also protecting them from potential disputes. In turn, inaccurate baseline estimates can cause biases in load reduction or flexibility provision estimates and lead to either overpayment or underpayment of incentives [43]. This can even result in the non-participation by consumers in future events.

Ultimately, upholding the principles helps to maintain public trust and confidence in the electricity system and markets. This, in turn, can encourage investments and promote the green and digital transition.

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[11] "Private" law as law that applies to relationships between individuals in a legal system, e.g. contracts and labor laws. On the contrary, "public" law applies to the relationship between an individual and the government, e.g. criminal law.

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In which grid operational state is the baseline methodology used?

In a normal operational state of the grid, it could be argued that keeping a baseline calculation as simple and transparent as possible is of the highest relevance, even if at times it is to the detriment of accuracy. A simple baseline calculation allows the interested parties to calculate it and understand what they are credited for, reduces the management costs of a program and can also increase its attractiveness among end-consumers [20] [34].

In an emergency state, however, it could be argued that accuracy and integrity outweigh simplicity. Commission Regulation (EU) 2017/2196 establishing a network code on electricity emergency and restoration (ER NC) [55] specifies that TSOs should ensure the continuity of energy transactions during emergency states and only suspend market activities and market's accompanying processes as a last resort. In the future, similar provisions could apply to markets at the distribution level. For flexibility and DR resources to be reliable resources in an emergency state, they need to guarantee the quality and accuracy of the service they provide. Integrity is equally important to maintain trust in the system before, during and after emergency events. Uncovering ex-post that certain players were able to use emergencies to their own benefit, for example by manipulating the baseline, would undermine public trust and confidence in the system.

In their TSO-DSO roadmap, [44] propose that any method for baseline calculation should be allowed if agreed so between the FSP and the SO. It could be worth thinking about whether two different types of baselines, one for normal operational state and one for emergency state, would support the further participation of DR in the market. It could also be the case that the increased cost and administrative burden due to the need to define two baseline methodologies outweighs the benefit.

Who is responsible for setting the baseline?

The responsible party for setting the baseline can be system operator, the market operator (MO), the FSP or an independent third party like the regulator [36]. Considering the architecture of a certain market and role allocation among the participating actors, actors may have different, sometimes conflicting, interests and incentives when it comes to the calculation of the baseline [32]. [45] point to the importance of setting a baseline in such way that all stakeholders can agree to it, as otherwise settlement becomes impossible or at least settlement disputes may arise.

In terms of integrity, taking up the neutral facilitator role for local markets is a more recent task for DSOs and they have yet to prove that they are up to the challenge.

The first option is the system operator. This option was chosen by two OneNet demonstrators as default option (SLO, GR) and by two OneNet demonstrators as fallback option in case the FSP did not provide the baseline (ES, PL).

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Where the SO is responsible for calculating the baseline, the default method is often based on historical measurement with or without day-of adjustments. Such approaches were chosen in NOCL, GR and ES. This increases the simplicity and transparency of the approach but is to the detriment of accuracy. Higher accuracy is likely needed in a future electricity system with increasing volumes of flexibility provided by distributed assets. System operators would be well placed to develop relevant methods as they have direct access to real-time data and insights about the system's performance, at least at the transmission level. Methods based on real-time data are used in PL and SLO. An open question raised by [42] is whether SOs should be mandated to develop more sophisticated methods for baselining (for example per connection point and/or flexibility asset), given the associated effort and cost.

The second option is the market operator. None of the OneNet demonstrators chose this option. In the EU, some markets are operated by SOs, such as markets for transmission capacity, congestion management, balancing, and some local flexibility markets. Others are operated by dedicated MOs, for example exiting spot (and forward) markets, and some local flexibility markets (see also subsection 2.6.1).

The European experience with flexibility platforms so far shows that there are different operational models. These platforms can act as marketplaces, performing the essential functions of market operation; they can act as an intermediary to procure flexibility services through established markets, and they can also take over a coordination role in an administrative flexibility scheme. [31] find that in cases where a platform acts as intermediary for an existing market, the baselining responsibility is often deferred to the MOs. The flexibility MO Piclo Flex negotiates baselines with the market parties guided by voluntary industry standards.

In setting the baseline, MOs may prioritize simplicity, making it easier for market participants to understand and comply with the rules and lowering entry barriers for new entrants. Accuracy is crucial for MOs who are interested in finding efficient market outcomes and properly valuing the contributions of different market participants base on their actual performance. Compared to SOs, however, MOs have less visibility and fewer data available on the system and its conditions which makes it challenging to calculate accurate baselines. Imposing stricter accuracy requirements may increase the complexity of the baselining process. Regarding integrity, independent MOs (IMOs), i.e. MOs separate from system operators, can provide checks and balances, reducing the potential for conflicts of interest and enhancing transparency and trust. Due to their lack of direct access to system information, however, MOs are reliant on the establishment of robust governance mechanisms and procedures for verification and prevention of manipulation. Also, a lack of coordination between the MO and the SO may lead to discrepancies in baselining, potentially undermining market integrity.

The third option is the FSP. This is the default option in four (NOCL, CY, ES, PL) of six demos that use baselining. Allocating the baselining responsibility to FSPs could, on the one hand, increase simplicity, and keep a moderate level of accuracy. [44] find that FSPs prefer not too complex, and sufficiently accurate, baseline

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methodologies. Moreover, they may not be willing to learn new and different baseline methodologies in each country/market but would prefer a certain level of stability and some uniformity between Member States to facilitate easy market access. For FSPs interested in value stacking, this could also result in an alignment of baseline methodologies for services provided to different SOs. On the other hand, integrity may be reduced for self-declared baselines due to the asymmetry of information between the FSP vis-à-vis the entity procuring the service. There is an increased possibility for FSPs to game by declaring distorted baselines that overestimate the actual flexibility provided. The SO needs to set up clear rules in advance as well as a verification method to check the delivery of the service. The self-declared baseline can also be complemented by a method defined by the MO or the procuring SO.

[31] report on mitigation measures that have been taken by various flexibility platforms to increase integrity by reducing incentives for strategic gaming by FSPs. These include market surveillance routines[12] (NODES) and allowing DSOs to enter long-term contracts or offer fixed prices, rather than run flexibility auctions (Piclo Flex). Inspired by good practices in other sectors, Piclo Flex is also considering introducing a 'data insights function' that includes FSP ratings (based on historical factors such as reliability and speed of response) and fraud detection (probabilities that actions taken by participants have been used to game the system) to further reduce FSP incentives for strategic gaming.

Many flexibility market platforms reviewed in [31] and [42] allow for both self-declared baselines by the FSP and calculated baselines by the market or system operator. Self-declared baselines are often preferred by large FSPs with dispatchable assets (including generation and storage) that have existing schedules for other (wholesale or balancing) markets. Externally calculated baselines are often preferred by smaller FSPs or those that offer mainly demand reduction services. These trends could be confirmed by the OneNet demonstrator experiences.

The fourth option is an independent third party such as the regulator. None of the OneNet demonstrators went for this option.

Allocating the responsibility to an independent third party could increase simplicity by establishing a standardized approach across the sector and transparency by also providing a basis for comparison. However, the involvement of a regulator may introduce additional bureaucracy and administrative processes, potentially making the process of defining the baseline more complex and time-consuming. Regulators often have access to industry data, a certain level of expertise, and enjoy enforcement powers, which can increase accuracy. The counterargument is the information asymmetry as also mentioned above. Due to the independence of the regulator, their setting of the baseline can enhance integrity of the baseline as well as trust among the market

[12] For example a review of the baseline forecast methodology of the FSPs, the comparison of FSP baseline declarations with historical measurements and statistical analysis.

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participants. Disputes may still arise in cases where concerns exist about the regulator's specific competence or expertise in this area.

Which type of customer is baselining applied to?

For non-professional customers, such as residential customers or even energy communities, simplicity is the most relevant baselining principle as it helps them understand and calculate the baselining methodology. As explained above, simple approaches are also likely to be more transparent and facilitate trust in the system. The choice for a simple approach applied to residential customers was confirmed in SLO and NOCL.

For professional customers such as (large) commercial or industry customers, accuracy may be more important due to the financial (compensation payments) and technical (industry processes, production downtimes, use of back-up systems) impact the provision of flexibility has on their business.

Integrity is most important for society as a whole, ensuring that possibilities to game the system are minimized.

The types of customers not only differ in their preferences for more simplicity or accuracy, but also in terms of their characteristics. For example, [41] and [48] highlight that baselines developed for commercial and industrial customers with large-scale predictable and controllable assets are not readily transferable to residential customers, as residential activities are more random and less predictable, and their assets are smaller scale and less controllable. A difference is also that DER at the distribution level do not generally provide schedules for the wholesale or balancing markets against which their change in consumption or generation, i.e. their provision of flexibility, can be measured.

Moreover, relevant data may be more readily available and in higher granularity for industrial or commercial customers that already have smart meters, which allows for baselines with a higher level of accuracy. For residential consumers, data could generally be available for those that already have smart meters, but the granularity is not always high enough and privacy concerns may be more immanent.

Which type of DER is baselining applied to?

Distributed energy resources (e.g. heat pumps, PV/wind, back-up generation, combined heat and power, or storage/batteries) can participate in different combinations in flexibility markets. They can participate in isolation or can be combined with demand reduction actions of an active consumer behind that consumer's main meter. They can also be aggregated into a larger portfolio consisting of multiple DERs managed by an aggregator.

In case of isolated DER, different baseline methodologies are rated differently in terms of the baselining principles for different types of DERs (Figure).

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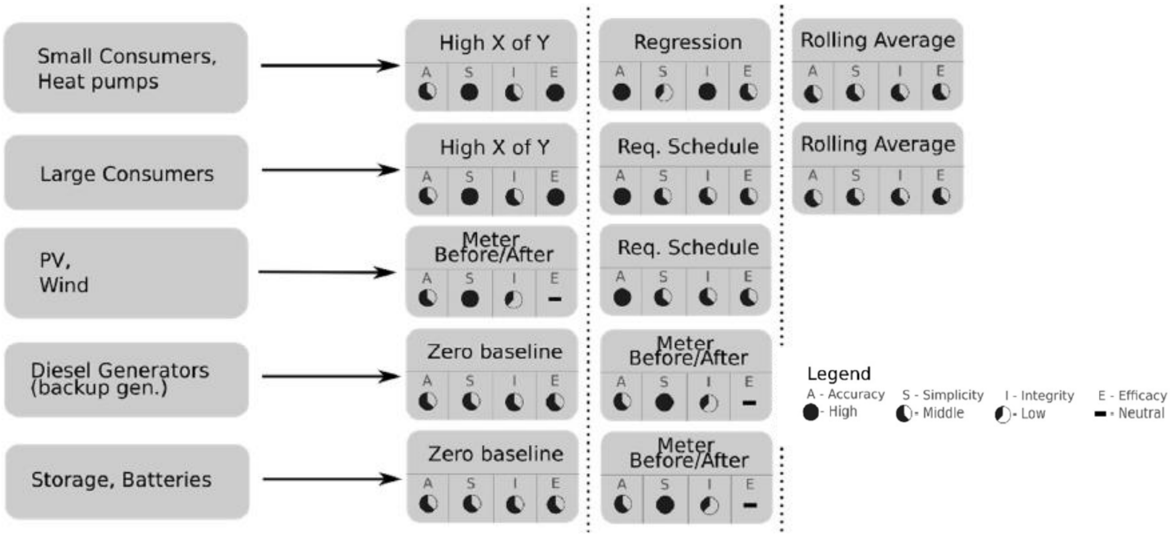

Figure 2.3: Assessment of selected baseline methodologies according to type of DER against the baselining principles of accuracy (A), simplicity (S), integrity (I), and efficacy (E), source: [18].

For combined DER, accuracy may be the most important baselining principle. Take a residential customer with solar photovoltaic behind the main meter offering flexibility that stems both from demand reduction as well the generation asset. The distributed generation asset adds volatility to the consumption profile of that customer. According to the accuracy principle, FSPs should only be credited for the service they provide as otherwise they would be over- or under-incentivized. In the long run, this may cause disinterest in participating in future events. [47] discuss the decoupling problem that emerges, namely the need to calculate the baseline by subtracting from the gross expected consumption the generation of the PV installation to make sure that the FSP is only compensated for the actual decrease in consumption.

Submetering is considered one of the methods to improve baselining, not only but especially in the case of combined DERs. [36] explain that submetering may be applied by the intermediary to separate the controllable asset used for the flexibility service from the other consumption assets at the customer site. This would allow the intermediary to better quantify the performance of the consumer. Similarly, it would allow the intermediary to better quantify their performance towards the entity procuring the flexibility. Alternatively, the aggregator could also not be at all responsible for the uncontrollable assets as submetering also allows for multiple suppliers or intermediaries being active behind the main meter. Submetering is used in the NOCL, ES and CY demos, where in the latter it is explicitly considered for all controllable loads with a metering granularity of 30 seconds.

In case of DERs aggregated into a larger portfolio, aggregated baselines can be calculated for the same type of DER or for different types of DER. For these types of baselines, it is difficult to argue that one principle would outweigh another principle.

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Where DERs of the same type are aggregated, [18] show that a simpler baselining approach can also mean a more accurate approach. Namely, calculating the baseline at the individual site level and summing those performances up to calculate the performance of an entire FSP portfolio is not only simpler but also leads to a more accurate outcome than calculating the baseline at the aggregate level and then assigning baselines to each customer. In the SLO demonstrator, the aggregated baseline is calculated by summing up the individual baselines of the resources. Note, however, that not all baseline methodologies lend themselves to such a summing up approach.

Where different types of DERs are aggregated under one portfolio, it is likely that different types of methodologies need to be applied to different types of DER. The related grouping of baselines can be done either by type of technology or by cluster [18]. Accuracy is of high importance, but not always straightforward to achieve. [48] found that customers may challenge baselines that are based on clustering rather than on individual demands. This is particularly true for customers that, due to random clustering, would get smaller payments when the baseline determined by the average demand of the clustered group is lower than the baseline for that individual customer. In turn, when clustering is formulated based on similar size and demand predictability rather than random clustering, it was found that the formulation will increase user understanding and appearance of fairness. An analogy would be the insurance system, where customer rates depend on group characteristics rather than individual characteristics.

For aggregated baselines, transparency and consistency in the calculation approach are also important to ensure integrity. [49] stress that, when 50 out of 200 assets in a portfolio respond to an event, the baseline should be estimated using exactly those 50 assets. Otherwise, the integrity of the approach may be compromised as aggregators may be prone to manipulate the baseline estimation to hide an insufficient response of the portfolio.

Which product is baselining applied to?

Different products or services may require different baselining *methodologies*, depending on their specific characteristics or requirements. On the contrary, it is hard to argue that a certain baselining *principle* is per se more important for one product than for another.

Several authors have discussed the suitability of a certain baseline methodology for specific products in a specific context with the objective to find the best methodology for that use case. To do so, methodologies are typically assessed against the baselining principles. For example, based on their experience with demand reduction programs in US wholesale markets, [24] provide recommendations for adequacy / capacity and energy programs. [34] add findings for ancillary services and for specific customers, for example those with highly variable loads. [18] have evaluated the different baseline methodologies to understand which is the best suited for the products used in the CoordiNet demonstrators, all the while balancing the baselining principles.

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Based on the experiences in the OneNet demonstrators, it seems that the choice of which baselining method to apply depends on several factors, not the least the previous experiences of the actor responsible for setting the baseline. Most often, the same baseline methodology is applied to all products used in the demonstrator. Where this is not the case, the differentiation is made based on type of resource participating in the demo (e.g. Cyprus).

In the OneNet project [12], products were classified according to three product classification drivers:

- frequency (balancing) versus non-frequency products,
- timing when the system need is addressed: short-term planning, long-term planning, and operational (day-ahead or intraday), and
- active versus reactive products.

In what follows we qualitatively discuss which baseline methods, if any, are better suited for the different options in each driver.

Firstly, frequency versus non-frequency products. Elia [58] found that, with reference to frequency products (in particular mFRR), MBMA and historical baseline methodologies outperform other methodologies as they perform well in terms of both simplicity and accuracy. Self-declared baselines also perform well in terms of accuracy, but less in terms of simplicity. Regression-based, control group and calculated baseline methodologies can achieve a high accuracy but are complex. Regarding congestion management products, as mentioned before, an extensive study was conducted in the CoordiNet project [18]. Congestion management markets can be cleared days, weeks or even years ahead of real-time, as opposed to balancing markets. Products can also vary, possibly being capacity or energy, and could have a variety of duration periods as well.

Secondly, the second classification driver of timing of the system needs and the planning associated with it (short-term, long-term, operational) is usually linked to the market timing and the type of product defined. Some baseline methodologies are heavy in data and computational needs while other, more static methodologies require less or no previous computation. These different needs have implications regarding which methodologies can be used in which type of planning and products. For instance, methodologies heavy in data and computational needs might be better suited for products with a longer timeframe for planning and procurement, while products with a shorter timeframe for planning and procurement might be better off with less data-heavy methodologies as these would require less or no previous computation. However, these more static baseline methodologies would be less suited for long activations, seeing they cannot be changed [18].

Moreover, as mentioned before, planning and procurement timing are linked to specific types of products, i.e. capacity and energy (or both) products, where longer-term planning usually coincides with capacity (potentially coupled with energy) products, and shorter-term planning with energy products. Capacity products only need a baseline to determine whether the service is being actually delivered. Indeed, as FSPs are

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remunerated only for providing capacity (e.g. FCR is a capacity-only product with automatic activation), the SO might want to verify that these automatic activations took place in reality. To be able to do this, a baseline is needed. Energy products, on the other hand, need a baseline for settlement as well as for verification [18]. This product characteristic does not necessarily influence the choice of baseline methodology in function of the principles but in terms of the number of baseline calculations that are necessary, i.e. one for capacity products versus two for energy products.

Other product characteristics that heavily impact the choice of baseline methodology are also related to timing. For instance, the activation duration of a product will impact the accuracy of the baseline, with long activation periods reducing the accuracy of certain methodologies such as MBMA. Then, the time between the activation request and start of the activation (i.e. preparation time) can affect the integrity of certain methodologies, especially the self-declared, MBMA and historical baseline methodologies, as FSPs could have incentives to impact or manipulate the baseline (if possible). Also, the activation frequency of a product impacts the data selection and, consequently, the accuracy of methodologies. For instance, for historical baselines such as comparable day it may prove challenging to obtain a set of reference days sufficiently close to the day of the activation for products with high frequency of activation. Finally, the metering resolution used for the validation of the service is also an important characteristic in terms of accuracy. High resolutions require methodologies with a high accuracy [58].

Finally, active versus reactive products. The products discussed above are primarily active products. However, other products, such as voltage control products, are reactive products. Not a lot of literature is available yet on baselining methods for reactive power. [59] state that there are clear differences between reactive and active power baseline accuracy and that more research is needed into the topic.

2.4.4 Conclusions for baselining

The contribution of this section on baselining is threefold. First, we organized the body of literature related to baselining in electricity markets by identifying three waves. The waves are aligned with three phases in the development of explicit DR and its integration in electricity markets from the early 2000s to today.

Second, we provided a taxonomy of baselining methodologies and discussed the relationship between these methodologies and the principles of simplicity, accuracy, and integrity. While no baseline can perfectly fulfill all criteria, baselines that balance the three principles are better than those that do not. At the same time, improving on one principle is likely to cause a weakening of at least one other principle. The reviewed experiences also show that there is no standard baseline methodology that fits all purposes. The choice of which baseline methodology is the best depends on several factors including the type of service or product provided, the characteristics of the service provider, the timeframe, and the related requirements and applicable rules.

Third, we qualitatively discussed six questions relevant for the development of a regulatory framework for baselining, based on the literature review and OneNet demonstrator experiences. The answer to each question includes multiple options. In discussing these options, we focused on the baselining principles of simplicity, accuracy, and integrity.

(1) Which relationship is the baseline methodology applied to? Where the FSP is an intermediary, two general fields of application of the concept of baseline exist. The first is linked to the contractual relationship between the customer and the intermediary, in which usual principles of contractual transparency and fairness should apply to the rights and obligations defined in the contract. The second is linked to the relationship between the aggregator and the SO. Due to the critical infrastructure nature of the energy system, the upholding of the baselining principles of simplicity, accuracy and integrity is of public interest.

(2) In which grid operational state is the baseline methodology used? While in a normal operational state of the grid, a simple and transparent baseline methodology may be of higher importance, an emergency state may have different requirements. Accuracy and integrity may rank higher due to the need to maintain trust in the system during and after the emergency event. Having separate baselines for normal and emergency state may increase cost and add administrative burden that may not outweigh the benefits. Quantitatively analyzing this question could be a step in future research on the topic of baselining.

(3) Who is responsible for setting the baseline? We identified four actors that could be allocated the responsibility for setting the baseline, namely the SO, (I)MO, FSP and an independent third party like the regulator. Trade-offs exist whichever actor is ultimately allocated this responsibility.

The trend in the OneNet demos is to allocate the responsibility to set the baseline either to the FSP or the SO. Where the FSP is made responsible, a fallback option in case of failure to deliver the baseline is typically implemented, as are monitoring and mitigation measures to ensure accuracy and avoid gaming. In some cases, both approaches are enabled. This combined approach is aligned with the preferences of FSPs themselves as large FSPs often prefer to self-declare the baseline, while small FSPs may prefer an externally calculated baseline.

Allocating the responsibility to the (I)MO or the regulator instead may have certain advantages like increased simplicity or a higher level of standardization. However, the responsible may also suffer from a limited system view in case of the (I)MO or information asymmetry in case of the regulator. Additionally, coordination between the baseline responsible and the SO is needed, likely increasing administrative burden and complexity.

(4) Which type of customer is baselining applied to? Non-professional customers such as households typically prefer simple baselines as it increases transparency and helps them understand and calculate the baselining methodology. Also, these customers typically do not engage directly but use intermediaries to participate in electricity markets. Professional customers such as (large) commercial or industry customers value accurate

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baselines that are, at the same time, not too complex. This tendency is also displayed in the demo choices, as all demos chose to use baselining methodologies that score high in simplicity and medium in accuracy.

(5) Which type of DER is baselining applied to? In case of DER participating in isolation in electricity markets, different baseline methodologies rate differently in terms of the baselining principles for different types of DER, as was shown by research in OneNet's predecessor project CoordiNet. For DER that are combined with demand reduction actions of an active consumer behind that consumer's main meter, accuracy may be the most important baselining principle as FSPs should only be credited for the service they provide and not be under- or over-incentivized. Submetering is considered one of the methods to improve baselining, in particular in the case of combined DERs but it is only at early stages of deployment. Some OneNet demos are already more advanced than others in defining the submeters and developing related specifications like metering granularity.

In case of DERs aggregated into a larger portfolio, aggregated baselines can be calculated for the same type of DER or for different types of DER. Where DERs of the same type are aggregated, a simpler baselining approach can also mean a more accurate approach. This is reflected in the experience of the Slovenian demo. Whereas, where different types of DERs are aggregated under one portfolio, it is likely that different types of methodologies need to be applied to different types of DER. The related grouping of baselines can be done either by type of technology or by cluster. However, for aggregated baselines it is difficult to argue that one baselining principle would outweigh another principle.

(6) Which product is baselining applied to? The reviewed literature suggests that different products or services may require different baselining *methodologies*, depending on their specific characteristics or requirements. On the contrary, it is hard to argue that a certain baselining *principle* is per se more important for one product than for another.

The choice of baseline methodology is not determined by the system need that is addressed (e.g. frequency versus non-frequency) but mostly by the following product characteristics: capacity/energy product, activation duration, preparation time, activation frequency and metering frequency. While the simplicity of the different methodologies is product-independent, the accuracy and integrity are determined by the chosen options/values for the product characteristics described above. The choice of baseline methodology when considering a specific product should hence be determined by a careful consideration of how a specific methodology scores regarding the baselining principles of accuracy and integrity.

This is however only partially confirmed by the demo experiences. Most demos apply the same methodology across all products used in the demo. The reason for the choice is often the experience of the involved parties, existing requirements, already available tools and information, or the regulatory framework. Some demos also differentiate methodologies based on the type of FSP or resource.

2.5 Prequalification

Flexibility markets have been gaining importance in recent years, due to the increased penetration of DERs in the electricity networks. The prequalification process is a key element for the proper functioning of those markets since it qualifies the flexibility products and the corresponding grids.

The prequalification is the ex-ante process that can be divided into FSP qualification, product qualification, and grid qualification. The first two consist of determining the ability of a particular FSP to deliver a particular product, according to the requirements set by the SO and addresses the abilities of both the FSP as well as its flexibility resources themselves [7] [60]. The third part of the prequalification process is to verify whether the electricity grid is technically capable of accepting the delivery of the flexibility product. The FWGL DR [7] introduces another concept, named ex-post verification, as a default procedure for specific balancing products, congestion management, and voltage control products. This is the process that verifies the compliance of an FSP with the technical requirements to deliver a certain flexibility product after the actual delivery.

This section analyses the prequalification and ex-post-verification processes by providing an overview of main findings from the literature, linking them with the implementations in the OneNet demonstrators, and discussing the main available regulatory options. Notice that the integration of the prequalified assets with the market is out of the scope of this section, which is structured as follows: Subsection 2.5.1 presents a literature review and discusses the findings from it. Subsection 2.5.2 provides an overview of the OneNet demonstrators' activities regarding prequalification and ex-post verification. Subsection 2.5.3 qualitatively discusses regulatory options for prequalification and post-verification.

2.5.1 Literature review

This section provides an overview of the key points mentioned in the literature regarding the prequalification and ex-post verification processes. This review aims to complement the main provisions defined within the FWGL DR (Annex A.2) and is based on various types of sources, namely stakeholder reports, academic literature, and project deliverables (Table 2-9).

Table 2-9: Overview of prequalification literature reviewed in this deliverable

Stakeholder reports	Academic literature	Project deliverables
[7], [57], [60], [61], [62], [31], [63], [64], [71], [42], [72], [74], [75], [76], [77]	[49], [70],	[65], [66], [67], [68], [69], [73]

The main findings retrieved from the literature can be divided into three areas: general principles and scope, roles and responsibilities, and format and process (including proposed simplifications).

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General principles and scope

The literature divides the prequalification process into three main steps: FSP, product and grid prequalification. **FSP prequalification** consists not only of ensuring that the FSP has a settlement account, enough financial liabilities and complies with legal provisions [60], but also the technical capabilities to deliver a service, by possessing the adequate communication tools or the data correctly registered together with the associated units [7]. **Product prequalification** consists of verifying if the FSP fulfills technical requirements to deliver a particular product. To check technical requirements, activation tests can be performed to ensure that the FSP can deliver the requested service [60]. **Grid prequalification** ensures that the service offered to the SO can be delivered in the involved grids (i.e. connecting, that means where the service is provided) and should include principles and criteria for SOs to set limits and re-examine the grid. The Active System Management (ASM) report [60] foresees two options for a more flexible grid prequalification, namely the dynamic grid prequalification and the conditional grid prequalification.[13] The latter is dependent on certain conditions clearly specified in advance, whereas the former may change over time, with the aim to increase the prequalified capacity as soon as new information on the grid is available. Note that these are not mutually exclusive options.

The activation tests that may be required during the product prequalification phase, consist of sending an activation signal to the FSP's assets, during normal operating conditions to ensure that, in case of need, (and upon a favorable market clearing) the resources can actually be activated, that their capabilities meet the product requirements and that the relevant data can be exchanged [7]. When an activation test is required, it should be done by a single SO, in cooperation with the concerned SOs. It is very important to clarify which SO performs the test, also when several SOs procure the same product [7].

Specific **activation tests** may consist of load shedding tests, voltage control tests and frequency response tests [31]. Those can be conducted to assess the ability of the power system to respond to changes in supply and demand, to identify potential vulnerabilities in the system and evaluate the effectiveness of specific flexibility measures. Based on the results of the activation tests, an individualized plan can be developed to address areas of weakness and improve the flexibility of the power system.

Overall, the prequalification process shall be **user friendly**, aiming to **minimize the different steps** and to **standardize them** wherever it is possible. This concerns especially technical prequalification criteria for asset or DER registration, making sure that no significant entry barriers are posed that could hinder market liquidity [57]. Product prequalification could take place on an aggregated/portfolio level if technically acceptable and [62] it is recommended to include qualified units in a national flexibility register to increase process transparency and

[13] Note that this distinction has evolved in TSO-DSO discussions since ASM report was published. The concept of grid prequalification echoes the conditional approach but does not mean it is fully static. The term ''temporary limits'' (applied in the short-term by the connecting or intermediate system operators) is now used to describe what ASM meant with the dynamic approach.

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efficiency. Grid prequalification must take into account any form of restriction on the grid connection, for instance, reverting congestions in the network shall be subject to financial compensation if the concerning FSP is not bound to a connection agreement with restrictions [62].

Another important aspect of prequalification process efficiency is **avoiding duplications** in the process. In the case of both the TSO and DSO being the buyers of the same product, the ASM report recommends the product prequalification process to be agreed between the SOs, to avoid the prequalification being done twice (for the TSO and the DSO) [60], [65]. In addition, ACER suggests that re-prequalification should be done only in case of significant changes in prequalified units or groups, with the aim to avoid unnecessary repetitions on the prequalification process [7].

There should be **minimum technical requirements** for the provision of congestion management or voltage control products and minimum harmonization levels shall be set at EU level in the steps and lead times in the prequalification processes. Nonetheless, specificities of the prequalification process and additional technical requirements may be defined at MS level and thus vary across countries [61]. To better understand how prequalification can be **harmonized across the different MS**, it would be interesting to find out whether prequalification process occurs cross-border and how different it is from performing prequalification at MS level. Limited literature was found addressing these questions, which may mean that this concept is not (yet) considerably developed or implemented in practice. [70] investigates a regional congestion management market framework in South-East Europe based on the cross-border use of DSF (demand side flexibility) resources. The study concludes that cross-border participation of flexibility in congestion management is more effective than in national level regarding required capacity of flexibility sources for the same level of congestion alleviation. Even though the study does not specify how the prequalification process takes place, it mentions that the FSP should be subjected to a prequalification process to participate in the market.

The actual delivery of a flexibility service shall be subjected to validation, regardless of the type of the product. This means that after the activation and delivery of an FSP, there is the settlement phase that includes the measurement of the flexibility delivered and the verification of compliance with the agreed parameters [60]. This verification can be performed by the contracting SO itself or by a third party on its behalf, but the contracting system operator will keep the legal responsibility for this activity. SOs are entitled to apply a penalty regime in case of non-compliance in the delivery [62]. This is a similar concept to what FWGL DR describes as **ex-post verification** (see Annex A.2), which is proposed as a default option, to replace the existing ex-ante prequalification of a specific balancing, congestion management, and voltage control product. However, the literature reviewed does not foresee the option of having the ex-post verification process actually replacing the ex-ante product prequalification for certain products, now foreseen in the FWGL DR, but it rather considers it under the settlement phase. On this note, the “ex-ante prequalification” is a more developed and more widely implemented concept.

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Roles and Responsibilities

Generally, TSOs and DSOs think that the party performing the product prequalification should be the SO that needs the flexibility product under analysis and will, eventually, be the buyer of that product. In this regard, the SO GL leaves the MSs an opportunity for finding suitable solutions on how the data might flow between grid users, DSOs and TSOs. Thus, the responsibilities for prequalifying the product shall be set accordingly. As explained above, in case several SOs are buyers of the same product, the product prequalification process should be agreed between the SOs wanting to buy this product to avoid the prequalification being done twice [60].

When it comes to the grid prequalification, TSOs and DSOs agree that the responsible party is the SO to which the grid unit is connected to and (where applicable) the intermediate DSOs[14] [60]. The reason for this is that, most of the times, only this specific SO knows what the grid is able to manage and when it is, or it is not possible, due to specific constraints [60].

To properly perform the prequalification of a potential FSP, it may be necessary to establish the **eligibility criteria** to provide assurance to potential procurers that the FSP can deliver the selected product. Those typically focus on technical requirements, compatibility with the communication protocols used by the platform, and adherence to any specific operational standards or guidelines established by the platform operator [62]. Those criteria for FSPs may be at product, asset, or company-level, typically requesting asset details, such as location, voltage, available capacity and ramping time. Most of the time, eligibility criteria implemented by the platforms reflect requirements of the adjoining markets or platform participants (SOs) [31].

Those eligibility criteria are often established at the platform level to ensure consistency and transparency. Note that those platforms refer to a specific system or infrastructure that facilitates the participation of flexibility assets in the market. For a single flexibility market, multiple platforms may exist to facilitate the participation of flexibility assets and enhance the granularity of the market. Each platform may have its own specific features, operational requirements and eligibility criteria tailored to address different aspects of flexibility provision [31].

Alternatively, the eligibility criteria can be set at market level, meaning that the market operator or regulator sets the eligibility requirements that apply to all participants across the flexibility market. On this note, it is also important to emphasize that there can be several flexibility markets established (e.g. central, local…) and operated by different entities, so criteria may also diverge at this level. These criteria are typically designed to ensure fair competition, reliability, and compliance with market rules. Market-level eligibility criteria for prequalification of flexibility assets may cover a broad range of aspects, including technical capabilities, performance standards, compliance with regulatory requirements, financial viability, and contractual obligations.

[14] "An intermediate DSO is the DSO between the grid of the buyer of the product and the grid the unit is connected to." [60].

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Moreover, a hybrid approach that combines market-level criteria with platform-level flexibility assessments could be considered [31]. The benefits and drawbacks of these different approaches are discussed in the subsection 2.5.3.

It is also important to ensure a more inclusive access to flexibility markets to ease the rules and requirements applicable the aggregators. For example, in the Danish Market Model 3.0, Denmark relaxed the previous condition of requiring each aggregator to be associated to a retailer and a BRP. In this case, the flexibility is provided to the TSO through ancillary services. For this new approach, the aggregator aggregates flexibility from multiple consumers with different retailers and BRPs and it must only pass the prequalification towards the TSO, not including the customer's BRP in the bidding, reservation, and activation phases [49].

Format and process

Harmonization or even standardization of prequalification processes at EU level could help to make the system fair and easier to interpret by the different stakeholders involved.

One measure is to introduce **standardized templates**, for example for the alignment of technical criteria for Asset/DER registration [57]. These templates can be submitted manually or automatically for each asset. Typically, aggregators or suppliers with larger portfolios find the manual submission difficult and time consuming. Also, closer to real-time procurement automated prequalification submission becomes even much preferrable [57]. Submission automation can be possible not only through a FR, but also via standardized application forms, online portals and data integration and machine learning models [61]. On the other hand, for small portfolios of assets, manual submission may be more efficient than setting up an automated system. Nonetheless, automated submission can bring more efficiency and scalability as it can handle large portfolios of assets. For e.g. in U.K, providers with large portfolios of assets can use an automated submission process, while those with smaller portfolios can use a manual submission process [57], [60], [61].

The **harmonization of telemetry requirements** for measurement, validation, and settlement can also be part of the prequalification process. Some countries are more advanced than others in this regard. For example, Energinet in Denmark has established a common platform for the exchange of telemetry data among market participants and National Grid in the UK has established a set of standard data formats and communication protocols that all market participants must follow when submitting telemetry data [42], [72].

SmartEn [61] suggests a single harmonized prequalification process that is valid for different technologies and aggregated pools, and that allows them to sell their flexibility in various markets and to different buyers (that might or might not be SOs). If local specificities prevent common prequalification processes from being a viable option, an alternative is to share a list of common principles for prequalification across the EU.

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Although **prequalifying aggregated units** may bring several advantages, such practice is still not possible in some MSs, depending on the specific requirements of SOs and market rules. While some TSOs make simplifications or exceptions to simplify and speed-up the prequalification of groups of units, a few other TSOs still require each individual unit to prequalify separately [63].

When it comes to balancing markets in EU, all TSOs allow providers to prequalify groups of assets for participation, but each individual asset within the group must meet the technical requirements. The majority of TSOs also distinguish between prequalification of generation and consumer/demand units, with different technical requirements and eligibility criteria for each. Hence, in many countries, generation and demand units are not allowed to be aggregated, which might represent an entry barrier for new market participants that aggregate multiple types of units, such as EVs, solar PV panels and household consumers [7]. An opposite example is National Grid in the U.K that is exploring the possibility of allowing aggregation of different types of assets within same group [31].

Another interesting example is the Danish TSO Energinet [64]. Prequalification tests are done in close communication with the FSP and the TSO itself must be allowed to be present during tests of new units/control concepts. The FSP may carry out follow-up tests independently as agreed and subject to the submission of detailed documentation. If the unit/aggregated portfolio of units is approved, a maximum threshold is set for the volume of power that the unit or aggregated portfolio of units can offer in a reserve capacity market. Subsequently, a portfolio of units will be tested and approved based on its overall performance in relation to the applicable requirements for the ancillary service it offers. The aggregated portfolio will be approved based on the same conditions as described for stand-alone units. During the tests of aggregated portfolios, Energinet would also like to see the response from a stand-alone unit, as well. The aggregator in charge of ensuring that underlying units are always aggregated, allowing them to comply with any system-related conditions for the provision of ancillary services. Energinet requests a concept description and results from the developed calculation when a unit or a portfolio of units is prequalified to deliver ancillary services. Those calculations must also be prequalified.

2.5.2 Overview of the OneNet demonstrators

Questions related to prequalification and ex-post verification were addressed to OneNet demonstrators that use these processes within their activity scope. Most demonstrators in the OneNet project address at least the prequalification step and are thus considered within this analysis: Northern cluster, Spain, Portugal, Cyprus, Greece, Hungary, Slovenia, Czech Republic, and Poland. The French demonstrator is out of the scope for this analysis.

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Considering the outcomes of the literature review, six questions were identified as having either diverging opinions within literature or as being under-developed topics that could benefit from further discussion (Table 2-10). These questions fit within the areas mentioned in subsection 2.5.1, i.e. roles and responsibilities, format, and scope and process.

Table 2-10: Main research questions regarding prequalification addressed to the OneNet demonstrators

Area	Research questions
General principles and scope	• *Do you consider prequalification a mandatory requirement in your demonstration? Please motivate your answer.* • *Are there any special considerations for cross-border participation in the prequalification process?*
Roles and responsibilities	• *Who is the responsible entity for carrying out the prequalification processes in your demo? And why did you choose this option?* • *Where are the eligibility criteria set in your demo? And why did you choose this option?*
Format and process	• *How are the results of the prequalification process communicated to market participants in your demo?* • *Do you use a manual or automated process for submitting the prequalification template in your demo? Please motivate your choice.* • *How is prequalification different for different types and sizes of assets, such as solar, wind, demand response or energy storage systems? Is any simplification of the process is envisaged for smaller assets? Can groups of units be prequalified?*

These questions are addressed below, identifying the main positions and adoption by the demonstrators, including an overall idea and tendency for each of the questions.

General principles and scope

Do you consider prequalification a mandatory requirement in your demonstration? Please motivate your answer.

This question seeks to understand whether the demonstrators consider the ex-ante prequalification process as mandatory, or if this can be replaced by an ex-post process, especially considering the provisions within the FWGL DR that set as standard procedure the ex-post verification. All OneNet demonstrators consider prequalification a mandatory process that cannot be replaced by an ex-post verification (Table 2-11).

Table 2-11: Overview of whether prequalification is a mandatory requirement in the OneNet demos

Prequalification is a mandatory requirement	Product prequalification can be replaced by an ex-post verification process
All OneNet demos	none

For the **Northern cluster**, the main reason pointed out for this choice was the fact that the recommendation from ACER foreseen in the FWGL DR [7] to apply the ex-post verification by default only came after the definition and implementation of the demonstrators, thus, it was not possible to address this option. The ex-post verification process is nonetheless adopted, but only as part of the settlement, by checking whether the service offered matches the actual delivery. As for the actual product prequalification in the demonstrator, it adopts a minimum prequalification process, comparing the resource group characteristics to the product requirements.

In the **Portuguese demo**, ex-post verification is not addressed, and it is considered that prequalification removes the need for it. In addition, it is also mentioned that if the prequalification does not happen, there is no way to verify the ability to provide the service, which could hinder the use of SO services for critical activities. The importance of an ex-ante process to guarantee security and reliance of supply and grid operation was pointed out from the **Czech demo**, allowing limits to be set for market participants.

From the **Polish demo** perspective, it is also considered as mandatory since the data about the network connection point is crucial for the local products auctions. For the **Slovenian demo**, the prequalification is only done if the DSO considers that the impact will be significant enough, which has not been the case so far, meaning that the registration is the only prequalification process foreseen, this being an ex-ante process for General Data Protection Regulation (GDPR) reasons.

The **Greek demo** considers prequalification the only way to guarantee the security of supply and the grid as there is no metering included in the demo and thus no other way to verify the ability of an FSP to provide the service. It is also relevant to notice that this demo mainly demonstrates grid prequalification.

The **Hungarian demo** uses products defined by capacity limit type, instead of baseline type. As it is a relatively new approach, the demo considers it is worth using ex-ante prequalification. However, the other important aspect is the location-dependency of the FSPs (or their assets) which differs from the aggregated approach (e.g. the location of aggregated DR capable assets is not important if they intend to participate in balancing market).

Are there any special considerations for cross-border participation in the prequalification process?

This question assesses whether there is any special consideration within the demonstrators for cross-border participation in the prequalification process, for which the responses can be seen in Table 2-12.

The **Portuguese demo** is the only one having special considerations for cross-border participation in the prequalification process. It fits within the developments of the demonstrator, to in this case, design the data exchange platform so it can communicate with external entities using the OneNet Connector. Namely, specific API endpoints have been created for that purpose. This is done under the Regional Use Case (RUC) from the Western Cluster, with participation of market parties from Portugal, Spain, and France [73]. Note that the negative answer from the **Spanish demo** to this question means it is not an activity directly foreseen within the

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scope of activities of the demo itself but of the entire cluster. It also includes the applicable for the **French demo**, which is outside the scope of this analysis.

Table 2-12: Overview of whether there is any special consideration for cross-border prequalification in the prequalification processes of the OneNet demonstrators

Cluster	Yes	No
Northern		Northern
Southern		Cyprus, Greece
Western	Portugal	Spain
Eastern		Poland, Hungary, Slovenia, Czechia

Roles and responsibilities

Who is the responsible entity for carrying out the prequalification processes in your demo? And why did you choose this option?

This first question addresses the responsibility for carrying out the prequalification process within the OneNet demonstrators, namely whether it is allocated to the SOs (either DSO, TSO or both), an IMO or other actors, such as the Flexibility Register Operator (FRO). Table 2-13 portrays the responses gathered. A general tendency can be observed towards having SOs as responsible parties to the prequalification process, varying between the DSO and TSO depending on the scope of the demonstrator and the services to be provided. Two demonstrators rely on the IMO for this role, mainly for product prequalification. The Northern cluster, including all the demos within it, allocates the responsibility to the FRO.

Table 2-13: Entities responsible for the prequalification processes in the OneNet demonstrators

Cluster	DSO	TSO	IMO	FRO
Northern	Northern (grid)	Northern (grid)		Northern (product)
Southern	Greece, Cyprus (grid)	Greece		
Western	Spain (grid), Portugal	Portugal	Spain (product)	
Eastern	Slovenia, Hungary, Czech, Poland	Slovenia	Poland	

A crucial component within the **Northern Cluster** is the FR, through which the product prequalification is performed, leaving the responsibility for this activity with the FRO. For the purpose of the demonstration activities, the role of the FRO is assumed by the TSOs in the countries of the Northern Cluster [66], [67]. The SO can conduct the grid qualification by itself or can test the connectivity and service availability with the specific FSP or resource.

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Following a similar approach to the Northern Cluster, the **Spanish demo** also opts for a division of responsibilities, leaving the grid prequalification in responsibility of the SO, in this case the DSO, and the product prequalification in the responsibility of the IMO (OMIE). The responsibility towards the DSO is related to the fact that the FSPs participating in the Spanish use cases are connected to MV and LV grids [68].

In the **Polish demo**, the responsibility for the prequalification is allocated to the MO, counting with the participation of the DSO whose network the given FSP is connected to. The product prequalification is carried out by the market operator based on the atFlex platform, which compares the technical attributes of the FSP technical resource with the technical attributes required by the product. This process is supported by the DSO who is responsible for confirming whether the right connection parameters and metering infrastructure are in place. Moreover, static grid prequalification is carried out by the DSO whose network the FSP resource is connected to.

On the opposite end of the spectrum are the remaining demonstrators (Cyprus, Hungary, Czech, Portugal, Greece, Slovenia), which leave the responsibilities solely to the SOs. This choice could be explained within the scope of these demos that are more focused on the technical coordination between SOs.

More specifically, the **Cypriot demo** defined the DSO as the responsible for the prequalification and only performs grid prequalification. This happens, since the flexibility service provision is only for frequency support and, thus, it is important to ensure that the power that leaves the DSO network does not generate any congestions in the network and does not cause any other issues to the distribution grid. Also, the **Hungarian and Czech demos** opt for having the DSO as responsible party.

In the **Hungarian demo**, the DSO is the responsible party for prequalification as set in national legislation. The Hungarian network code for DSO gives the DSO the right not only to operate the flexibility platform, but also to prequalify. The network code does not refer to any operator other than the one responsible for operating the DSO flexibility platform and thus for product and grid prequalification.

In the **Czech demo**, the reasoning for having the DSO as responsible party is due to non-frequency services. However, prequalification was not specifically the focus of this demo. Hence, standard prequalification processes were applied, meaning that grid prequalification is dependent on the connection point (TSO or DSO) and product prequalification is based on- the requirements of the entity purchasing the service (TSO or DSO).

The Portuguese, Greek and Slovenian demos allocate responsibility either to the DSO or TSO. For the **Portuguese demo**, the responsibility for the prequalification process depends on the prequalification phase being considered (product or grid prequalification), where the FSP is connected, and to which SO the FSP will provide the service. For instance, the product prequalification is done by the SO to which the FSP will provide the service and the grid prequalification by the SO to which the FSP is connected. This is related to the fact that the PT demonstration is solely focused on technical coordination between TSO and DSO, thus, not involving a

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market, nor an IMO [69]. Similarly, the **Greek demo** is mainly focused on the technical coordination, which is the responsibility of the SO. No MO is considered within this demo, that mainly focuses on grid prequalification.

Where are the eligibility criteria set in your demo? And why did you choose this option?

This second question is related to the definition of the eligibility criteria considered for the prequalification process, namely if this definition falls under the market platform itself or is determined in a broader stance, at the market level. For a matter of simplicity, a large majority of the demos set the eligibility criteria at the platform level, possibly also related to the fact that market level regulation within several countries is to be defined. The results are presented in Table 2-14.

Table 2-14: Overview of whether the eligibility criteria for the prequalification processes in the OneNet demonstrators are set at platform or market level

Cluster	Platform level	Market Level
Northern		Northern
Southern	Cyprus, Greece	
Western	Spain, Portugal	
Eastern	Hungary, Slovenia, Poland	

The **Portuguese demo** chose to set the eligibility criteria at platform level since no market is demonstrated and no technical regulation is in place. The eligibility criteria are determined and checked in the product prequalification phase and are defined by the entity responsible for the product prequalification – can be either the TSO or DSO, depending to which the service is to be provided.

The eligibility criteria defined in the **Greek demo**, also set at the platform level, are based on the requirements and constraints posed by SOs. This demo does not demonstrates any market and the eligibility criteria for the grid prequalification are set on the F-channel platform, widely used in this demo.

The **Cypriot demo** also uses a specific platform, ABCM, for the TSO and DSO, to set the eligibility criteria for grid prequalification.

The **Northern Cluster** sets the eligibility criteria on market level and it should be established in the law by the regulator or by the respective SO.

For the **Polish demo,** the prequalification process takes place on the atFlex platform, considering the operator of a virtual market (actually a platform that also hosts auctions) as part of the demonstrator. The eligibility criteria are embedded in the atFlex platform, but some activities are confirmed by the DSO and the supervisor of the atFlex platform.

Format and process

How are the results of the prequalification process communicated to market participants in your demo?

This question addressed how the prequalification results are communicated to market participants, which could be, for instance, through a dedicated platform, by e-mail or other means. The trend in the OneNet demos is to communicate the results through a dedicated platform (Table 2-15).

Table 2-15: Overview of how the results of the prequalification process is communicated to market participants in the OneNet demos

Cluster	Dedicated platform	OneNet System	E-mail
Northern	Northern		
Southern	Greece	Cyprus	Cyprus
Western	Portugal, Spain	Spain, Portugal	Spain
Eastern	Czechia, Slovenia, Poland		Hungary

The **Hungarian demo** exclusively uses e-mail for this purpose, whereas the **Cypriot and Spanish demos** use e-mail to complement the communication via the OneNet System and dedicated platform, respectively. The **Cypriot demo** is the only one that mentioned to use the OneNet System for the communication of prequalification results. However, this is also foreseen within the Western Cluster for cross-border prequalification as a cluster-wide activity, although not belonging to an actual demo. Also note that the connector itself does not replace a platform, as it is an instance that is installed in each system, to guarantee bidirectional data exchange. One of the layers of the OneNet Orchestration Workbench is indeed a Graphical User Interface (GUI), but it is more focuses on providing the status for the data exchange allowing exchange of information from different services and users.

In the **Portuguese demo**, both product and grid prequalification results are exchanged via the Data Exchange Platforms (DEPs) developed and are subject to an automatic format and schema validation (internal process in the DEPs) to verify if the data shared complies with the pre-agreed format and schemas. Once validated (grid prequalification), there is either an acknowledgement and the process finishes, or an error message is produced. The results are stored in the databases of each DEP [69].

The **Spanish demo** enables FSPs to register their flexibility resources to participate in Local Flexibility Markets, and once the local auction is on trading mode, they will be allowed to send their bids. After the auction, the results and other relevant information are published and shared through the platform. The IMO manages and controls all the processes using this platform, from the registration of new FSPs and resources to the settlement of the local auctions [68].

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The dedicated platform used for the **Northern cluster** relies on the FR as well as on the TSO-DSO Coordination Platform and respective UIs.

Do you use a manual or automated process for submitting the prequalification template in your demo? Please motivate your choice.

This question seeks to identify whether the demonstrators rely on an automated process to submit the prequalification template to be filled by the FSPs, or whether this is done manually. Table 2-16 shows that most chose the automated submission of the prequalification template due to the simplicity, efficiency, and speed of the automated approach. Nonetheless, three demos (still) have some non-automated processes for prequalification submission, also depending on the prequalification phase.

Table 2-16: Overview of type of submission template used for prequalification in the OneNet demos

Cluster	Manual	Automated
Northern	Northern (if not through FR)	Northern (FR)
Southern		Cyprus, Greece [15]
Western	Portugal (grid)	Portugal (product), Spain
Eastern	Hungary (initially), Poland (support from DSO)	Hungary, Poland, Czech

The demos in the **Northern cluster** submit the prequalification results automatically and registration through the FR. The basic product prequalification is automatic (comparing the resource characteristics to product requirements), but the SOs have a possibility to conduct manual checks if needed. In addition, the grid impact assessment is embedded into the bid optimization routine for market clearing.

For the **Portuguese demo**, the prequalification submission is manual for the grid prequalification, due to complexity of the process and the need for verification. After receiving the FSP information, the SO can proceed to the grid prequalification. On the other hand, the product prequalification is done automatically to increase overall efficiency of the process.

As for the **Hungarian demo**, the prequalification process is manual when an FSP is prequalified for participation on the platform. This is a business, technical and legal procedure that happens at the time an FSP embarks on a platform or has changed its asset structure, which does not need to be automated. From then on, every bid submitted by the FSP is prequalified automatically.

[15] If such activation may threaten the security limits of the network, the DSO may set a power limit for such a resource or prevent its activation at all.

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In the **Polish demo**, the overall process of submitting the prequalification template is automated, but with some manual support from the DSO. The grid prequalification is carried out by the DSO, taking into account the impact of potential activation of FSP resources. If such activation may threaten the security limits of the network, the DSO may set a power limit for such a resource or prevent its activation at all. The power flow calculation carried out in connection with this process is the responsibility of the DSO. During the Polish demonstration these calculations were done in a simplified way.

The **Cypriot, Greek, Spanish and Czech demos** opt for the fully automated approach, with the **Czech demo** basing the process on the grid condition in a given nodal area. For the latter, the SCADA system evaluates the grid condition based on planned outages/grid issues and the result is communicated through the environment to the relevant flexibility provider.

How is prequalification different for different types and sizes of assets, such as solar, wind, demand response or energy storage systems? Is any simplification of the process envisaged for smaller assets? Can groups of units be prequalified?

These questions aim to understand the simplifications foreseen in the process within the demonstrators depending on the size and type of assets, and whether a prequalification at group level is possible. Table 2-17 shows that most of the demos do not vary the prequalification process according to the type or size of the assets to be prequalified. The demos perspectives diverge on the question of grouping.

Table 2-17: Overview of how prequalification differs with different types and size of assets and whether prequalification by groups of units is implemented across demos

Simplification?			
	Same prequalification process	**Prequalification process may differ**	
Type	Northern, Spain, Portugal, Slovenia, Poland	Greece	
Size	Northern, Spain, Portugal, Slovenia, Poland	Cyprus, Czechia	
Grouping?			
	Standard procedure	**Allowed**	**Not allowed**
Aggregated units	Northern	Cyprus, Spain (but not tested), Portugal (if same type)	Slovenia, Greece

The **Northern cluster, Spanish, Portuguese, Slovenian, and Polish demos** apply the same prequalification process, regardless of the size and type of assets. On the contrary, prequalification in the **Greek demo** may differ according to the type of assets. In the **Cypriot demo**, the prequalification relies on the upward and downward

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capacity of the feeder, therefore the process may differ according to the size of the assets. In the **Czech demo** it is also the size of the assets that can influence the way the prequalification is performed.

The **Northern cluster** always applies the prequalification to groups of units, due to simplicity and because there is a minimum size to which assets can be prequalified.

The **Portuguese demo** allows groups of units to be prequalified if those are from the same technology type.

The **Spanish demo** does not group the flexibility units because of a lack of involved FSPs that results in each of the two aggregators having only one consumer. Therefore, the units are not grouped in this demo. In principle, though, the partners in the demonstrator do not foresee any issue in grouping the units to be prequalified in case this happens in the future.

In the **Cypriot demo**, grouping of units is allowed, while the **Slovenian and Greek demos** do not prequalify groups of units.

In the **Greek demo**, four types of products have been defined, and there is a difference between the types in terms of product prequalification. For example, a production limit type of product can be used by generators and storage, but not for consumers. At the same time, there is no difference in grid prequalification. Grouping is not supported by the DSO because the use of flexibility depends on the location.

The **Polish demo** allows for prequalification of groups of units.

The remaining demos have not answered the question regarding the possibility of prequalifying groups of units. However, the **Czech demo** highlighted that the prequalification shall be technology-neutral and respect the set of specific technical requirements for flexibility services which the aggregator or supplier must meet, such as reaction time, amount of available output and data connectivity.

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2.5.3 Discussion of the regulatory options

Considering both the results from the demonstrators' analysis and from the literature review, four main aspects were considered as relevant for the development of a regulatory framework for prequalification and ex-post verification. These can be found in Table 2-18, including the different options that can be identified for each question. Note also here that there is no hierarchy in the order of the questions and that we do not claim to be exhaustive and there may be other relevant questions.

Table 2-18: Questions and related regulatory options for prequalification discussed in this subsection

Question	Options that are discussed
Does prequalification need to be a mandatory step?	• Yes • No
Who is responsible for carrying out the prequalification process?	• SO (DSO, TSO) • Market Operator • Flexibility Register Operator • Combination of entities
Where are the eligibility criteria set?	• Platform level • Market level • Hybrid
How is submission of the prequalification template done?	• Automatic • Manual • Both

Does prequalification need to be a mandatory step?

This question serves to understand how ex-ante product prequalification is perceived, meaning whether it needs to be a mandatory process or can be replaced by ex-post verification. The views from the OneNet demonstrators are aligned, with all demonstrators supporting the prequalification. The demonstrators' perspectives thus go against the provisions in the FWGL DR that point to the replacement by default of the product prequalification towards an ex-post verification procedure.

Several reasons are pointed out by the demonstrators to support mandatory prequalification, in part related to system security and reliability reasons. Also, the absence of product prequalification could hinder the ability to verify the service's ability to provide critical activities, such as communications and protocol implementations. Additionally, removing product prequalification as the default step may pose challenges, especially within the period where the technical regulations (network codes) are to come into effect, thus, in this period there may not be a clear definition on the technical capabilities required to deliver a certain product. This latest point can in fact pose a challenge to the consideration of the technical capabilities of the unit for grid connection as prequalification criteria, as suggested by ACER [77], in this initial development stage.

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The input from literature, especially gathered from the responses to the public consultation on the FWGL DR [77], suggests that while ex-post verification may remove barriers for DER flexibility, ex-ante prequalification can be important for DSOs, since distribution level issues are local and specific.

The requirement for having activation tests is also an important aspect to tackle within this topic and was subsequently referred to in the responses to the public consultation. If indeed ex-ante activation tests are regarded as a requirement, they would fit within an ex-ante product prequalification process for standard balancing products and products for local SO services, or also within the verification process if defined at the national level for specific balancing products and products for local SO services. In a first glance, prequalification through the activation tests, was perceived to benefit both FSPs and SOs. It allows FSPs to secure the provision of services to the SOs and avoid penalties, since the compliance and capabilities to provide the service will be verified a priori. On the other hand, it enables SOs to verify the entire activation chain and ensure service reliability. Opinions also point to the fact that the need for certainty in the performance of the process may question the applicability of ex-post verification as the default approach, being probably more suited to fit under the settlement process, particularly for critical balancing services where TSOs need to ensure proper delivery and system stability. Nonetheless, the default option of deploying the ex-post verification instead of an ex-ante product prequalification can, in fact, lead to simplification of the overall process and removal of entry barriers, namely for smaller FSPs, that can move away from the ex-ante activation tests that can be perceived as burdensome not only to the FSPs themselves but to the SOs that need to verify compliance to a larger number of FSPs, which is especially impactful if activation tests are requested at the unit level, and move towards simpler certification processes. On this note, it is also important to mention that the framework guidelines open the door for having exemptions for ex-ante activation testing at the unit level for standard balancing products and products for local SO services, which conditions and adequate thresholds are to be defined in the new rules.

One other aspect that warrants careful consideration in this debate is the cost-sharing model for activation tests, which can significantly influence the feasibility and attractiveness of either an ex-ante prequalification or ex-post verification approach. If the costs are borne solely by the FSPs, this could be a significant entry barrier, especially for smaller players who might lack the resources for comprehensive tests. On the other hand, if SOs bear the cost, the cost-benefit of flexibility activation could be affected, especially when considering a large portfolio of small resources. A cost-sharing approach, where both FSPs and SOs share the financial burden, could offer a balanced solution but requires careful structuring to ensure fairness and efficiency. This topic has indeed been left open in the FWGL DR, leaving it for national decision.

Nonetheless, it is important to highlight that the FWGL DR foresees the possibility to deviate from the standard ex-post process to the ex-ante process under specific technical criteria [7]. Ultimately, the decision on whether prequalification should be mandatory and the balance between ex-ante product prequalification and ex-post verification depends on reliability considerations, regulatory requirements, and the specific needs of the

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grid and service providers. These specific needs and priorities may differ among the different actors. For instance, while the SOs prioritize reliability, security and quality of supply, an FSP may focus on the ease of market access. It is therefore important to balance these priorities from an impartial perspective, an activity that could be done by a neutral party, such as the regulator.

Who is responsible for carrying out the prequalification process?

The question on who is responsible for carrying out the prequalification process requires careful consideration. Possible options are the SO (either DSO, TSO, or both), the MO, the FRO, or a combination of entities. To evaluate the pros and cons of the different options, both input from the demonstrators and literature was considered, so that not only the theoretical and strategic approach is discussed, but also the actual applicability considering experiences from the demonstrators. The option regarding the FRO is not deeply analyzed as this role can in principle be assumed by any of the other three actors.

The first option is the SO. The implementations in the OneNet demonstrators show a tendency for having the SOs as responsible parties for the prequalification process. Some demonstrators also opt for splitting responsibilities between grid and product prequalification. In some cases, the latter responsibility is assumed either by a MO or by the FRO. Note that apart from product and grid prequalification, another step can be considered, which is the FSP prequalification, however, it was not specifically addressed by the OneNet demonstrators.

This tendency is clearly supported by the inputs received from the demonstrators on the evaluation of these options, which emphasized the significant role to be played by the SOs in prequalifying flexibility assets. Main arguments to support this are related to the fact that the SOs have, by default, access to the technical data, with some of which possibly being confidential and not accessible with certain degree of granularity to the MOs. Additionally, the SOs are tasked with the responsibility to ensure the reliable and secure operation of the grid, making them well-suited to establish criteria and requirements for assets to participate in flexibility markets. Also, TSOs and DSOs possess the necessary technical expertise and system knowledge to assess the capabilities of assets and their compatibility with grid requirements.

The latest argument related to the expertise is also supported by literature, pointing out the fact that SOs have a comprehensive understanding of the grid's technical requirements, thus being able to effectively evaluate whether a resource can provide the necessary flexibility in a reliable manner [74]. Supporting this option is also a best practice from the INTERRFACE project, which highlights the importance of starting the process within a TSO/DSO coordination platform for resources registration, after which the prequalification results can be sent to the market [65]. On the actual differentiation between DSOs and TSOs, from one side there is the fact that TSOs have more experience with existing ancillary services markets, allowing them to set up the prequalification process more easily, which also supports the previous discussion between SOs and IMOs

[75]. On the other hand, flexibility needs on the distribution level are more location-dependent and the respective data may be more difficult, for confidentiality purposes, to disclose [76].

The second option is the (independent) market operator (IMO). Supporting this option is the fact that IMOs are neutral entities and can conduct the prequalification process impartially. Although IMOs might lack the technical expertise to assess the physical characteristics of flexibility resources, they possess a deep understanding of market dynamics, pricing, and scheduling, which enables them to prequalify resources based on their potential market performance.

The third option is that the responsible entity for prequalification is a combination of entities. Such combinatory approach, which was observed in several demonstrations, ensures a collaborative effort that incorporates the strengths and knowledge of different entities.

Where are the eligibility criteria set?

The eligibility criteria for flexibility sources prequalification can be set at the market level or platform level. A clear winner from the demonstrators' perspective was identified, namely the definition at the platform level.

The first option to set the eligibility criteria at the platform level is also positively seen throughout the literature to ensure higher adaptability, allowing individual platform operators to tailor the criteria to match their specific needs and the requirements of the flexibility sources they aim to attract [57]. This adaptability can lower entry barriers, making it easier for a diverse range of resources to participate in the market. Also, this option still allows for consistency and transparency within the platform, promoting fair competition and a level playing field [62]. On the other hand, if several platforms are implemented, establishing its own criteria, could lead to market fragmentation, thus creating inconsistencies and inefficiencies across the broader market [71].

This last argument can be mitigated in the second option, i.e. the market approach. Setting the eligibility criteria at market level not only ensures a more cohesive and coordinated market structure, but also improves market efficiency by streamlining the entry process for flexibility sources [31]. Note, however, that this option does not completely remove the risk for fragmentation, especially when several markets are established. Setting the criteria at the market level can also help to avoid prequalification duplication, where flexibility sources would have to go through the same evaluation process multiple times for different platforms. On a more negative note, is of course the lower degree of flexibility foreseen in this option, where the criteria defined at the market level may not necessarily align with the different system needs.

A hybrid option between market level and platform level is also possible. This would allow for a balance between standardized requirements and tailored assessments that can capture the unique capabilities and characteristics of flexibility assets while maintaining overall market integrity and efficiency.

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How is the submission of the prequalification template done?

The submission of the prequalification template can be done manually or in an automated way. The demo experience here is more split compared to previous questions, although more demos opted for the automated approach.

According to the input gathered from OneNet demonstrators, automation leads to higher efficiency of the overall process, which was the general argument presented for choosing this approach. Also, this is perceived to be a good option for recurring processes, such as the product prequalification itself, where there is a clear need for automation to streamline the submission and evaluation of templates. However, for one-time processes, like registration of FSPs, manual submission may suffice as automation may not be necessarily more efficient in such cases.

Efficiency, as well as a higher potential for scalability are also arguments stated within the literature, especially for providers with large portfolios of assets. Automation allows for quick processing of large amounts of data and can easily accommodate a growing number of flexibility providers. For instance, aggregators or suppliers with larger portfolios find manual submission difficult and time-consuming, particularly when closer to real-time procurement. Hence, automated submission becomes much more preferable for these stakeholders. This automation can be achieved, for instance, through the implementation of a FR, enabling a streamlined and efficient submission process. However, it is important to consider that an automated system may be less flexible in accommodating non-standard submissions or complex scenarios.

Manual processes, on the other hand, although time-consuming and labor-intensive, can provide more flexibility in handling such cases. Also, for small portfolios of assets, manual submission may be more efficient than setting up an automated system. The complexity and cost associated with implementing an automated submission process may outweigh the benefits for these stakeholders.

Both views may be considered, for instance, providers with large portfolios can use an automated submission process, while those with smaller portfolios can opt for manual submission.

2.5.4 Conclusions for prequalification

We qualitatively discussed four questions relevant for the (further) development of a regulatory framework for prequalification, based on the literature review and OneNet demonstrator experiences. The answer to each question included multiple options.

(1) Does prequalification need to be a mandatory step? In the FWGL DR proposed by ACER in late 2022, a simplification to the prequalification process is foreseen, by applying an ex-post verification by default for specific balancing products, congestion management and voltage control products (replacing an ex-ante product prequalification). Nonetheless, according to the literature and responses obtained from the OneNet

demonstrators, the majority of entities responsible for the prequalification process do not feel prepared to apply an ex-post verification instead of an ex-ante prequalification. The main reasons pointed out are that ex-ante prequalification not only enables SOs to verify the entire activation chain and ensure service reliability, but it also allows FSPs to secure the provision of services to the SOs and avoid penalties, since the compliance and capabilities to provide the service will be verified a priori in specific activation tests. Moreover, since the proposed simplification was introduced recently, some SOs mentioned as reasons the lack of time to study and implement the concept. Nonetheless, some stakeholders see this replacement as an effective simplification of the process, since it would make it simpler for smaller resources to participate in flexibility markets, by avoiding performing so many activation tests, thus leaning towards their certification, especially if these are to be required at the unit level. Additionally, other aspects such as the cost sharing structure on the activation tests are important topics for further discussion, as from one side if put entirely under FSPs responsibility it can lead to increased entry barriers, if under SOs the cost-effectiveness of the flexibility offer may be affected. A balanced approach can of course be reached, taking into careful consideration the fairness and efficiency of the cost sharing structure.

In any case, on its FWGL DR, ACER also foresees the possibility for deviation from the proposed simplifications of the prequalification process, allowing the responsible entities to opt for an ex-ante process under certain technical criteria to be defined in the actual network codes. And even on the activation tests, the FWGL DR leaves the door open for the new rules to define exemptions for activation testing at the unit level, which would indeed end up being too burdensome when considering small FSPs (e.g. charging points). Even though harmonizing the prequalification processes at EU level is desired in the long term, at this initial stage it might be important to understand the different positions and, possibly, allow the use of different methodologies (ex-ante prequalification vs ex-post verification) for the different types of flexibility products. Thus, allowing for a transition period may facilitate the implementation of the ex-post verification.

(2) Who is responsible for carrying out the prequalification process? The main regulatory options for determining the responsible entity for carrying out the prequalification process include the SOs, coordinated efforts between TSOs and DSOs, the IMOs, and a combination of entities influenced by local regulators, market frameworks, and stakeholder engagement. Each option brings specific advantages, such as data confidentiality, technical expertise, system knowledge, market experience, neutrality, and understanding of market dynamics. The choice of the responsible entity should consider these factors to ensure fair competition, reliable market outcomes, and the effective evaluation of resources' capabilities.

The entities chosen for most of the demonstrators were the SOs (TSO or DSO, usually depending on the scope of the demo) with the DSO being more predominantly chosen. Some demos also selected a combination of entities, depending on the prequalification step, thus arriving at different parties responsible for different steps. A usual split landed in having the SO as the grid prequalification responsible, and the FRO/IMO as product prequalification responsible.

(3) Where are the eligibility criteria for flexibility sources prequalification set? The main regulatory options include the platform level, the market level or a hybrid option. Setting criteria at the platform level ensures consistency, transparency, and adaptability, which can help lower entry barriers. Conversely, setting criteria at the market level avoids prequalification duplication and promotes market efficiency. However, both options need to carefully consider the potential risks of market fragmentation. The choice of the appropriate level should consider the trade-offs between consistency and flexibility, duplication and efficiency, adaptability, and market fragmentation, while ensuring fair competition, transparency, and a reliable market outcome.

For a matter of simplicity, most of the demonstrators set the eligibility criteria at the platform level, possibly also related to the fact that market level regulation within several countries is to be defined.

(4) How is the submission of the prequalification template done? The main regulatory options include manual submission and automated submission. Automation brings higher efficiency and scalability, making it favorable for providers with large portfolios of assets and recurring processes like prequalification. 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. The choice of the submission method should consider the size of portfolios, 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.

Most of the OneNet demonstrators chose an automated submission of the prequalification template for a matter of simplicity, efficiency, and speed of this automation. Nonetheless, three demos have some manual processes for prequalification submission, according to the phase of the process.

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2.6 Local market operation

This section aims to analyse regulatory options for the operation of local markets for SO services based on the general principles established in the FWGL-DR (Annex A.3) and by examining existing local market solutions implemented in OneNet demonstrators and other relevant projects.

This section is structured as follows: Subsection 2.6.1 presents a literature review focused on the differences when a local market is operated by a third-party or a SO. Subsection 2.6.2 provides an overview of the OneNet demonstrators' activities regarding local market operation, and Subsection 0 qualitatively discusses regulatory options for local market operation.

2.6.1 Literature review

This subsection provides an overview of the key points discussed in the literature regarding the operation of local markets for SO services. This review is organized following the main aspects of the FWGL DR described in Annex A.3: i) Who is assuming the market operator role when a local market is implemented? ii) What are the responsibilities of a local market operator? and iii) What are the pros and cons when a local market for SO services is operated by a SO or a third party?

Before discussing how these key points have been identified in the literature, it is relevant to introduce the definition of a local market. The literature presents a variety of definitions and concepts concerning the term local markets. On a broader view, such as in [78], local markets include both the exchange of energy and/or network capacity as the provision of flexibility either for local portfolio balancing services or network management services since both types of trading activities can take place on the same platform. Similarly [79], through surveying 19 existing local markets, concluded that a local market could be defined as a marketplace that enables buyers and sellers to trade energy and/or flexibility within a limited geographical area. Furthermore, [80] states that a local flexibility market is generally a technology-neutral solution to incentivize different assets to compete to provide grid services. Although these definitions employ different terminology, they generally address three aspects that characterize local markets, i) the purpose, which is to address local needs through system services, ii) the product to be traded, and iii) market participants. These aspects align with the definition provided in the FWGL DR.

The new FWGL DR defines the local market for SO services (or local market) as a market where service providers offer products for local SO services [7]. In this context, the term "local SO services" refers to congestion management and voltage control. These services are mainly characterized by a certain geographical location, meaning that only service providers (SPs) connected to the given location in the electricity grid can provide the required service [81].

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2.6.1.1 Who is assuming the market operator role in local market solutions?

As stated in [30], the market operator role in the existing European electricity markets depends on the specific market. Generally, wholesale markets are operated by power exchanges, which are third-party entities that could be competitive or monopolistic. On the other hand, ancillary services and redispatch markets are operated by TSOs who act as market operator and single buyer.

Similarly, the current local market platforms in Europe are operated by either DSOs, TSOs, or third-party market operators. Table 2-19 provides a comprehensive overview of who is assuming the market operator role in the most relevant local markets for SO services that are currently implemented in Europe, except for the OneNet local markets that will be analyzed in Subsection 2.6.2 of this report. Since the FWGL DR establishes that a local market operator could be i) the procuring SO itself, alone or together with other SOs, ii) a different SO or different SOs, or iii) a third party who is not a SO [7], this classification is considered in our analysis.

Many of these initiatives have emerged from the European H2020 research program, including projects such as CoordiNet [82], EUniversal [83], EU-SysFlex [84], Interflex [85], and SmartNet [101]. These projects involve different partners across Europe implementing demonstrators in different locations. Other solutions have been developed by SOs, such as Flexible power [86] in the UK, GOPACS [87] in the Netherlands, and ENEDIS tenders [88] in France. Moreover, Enera [89] is a joint initiative between the German TSO TenneT DE, the German DSOs Avacon Netz and EWE NETZ, and the power exchange EPEX Spot. OMIE, the nominated electricity market operator (NEMO) for the Iberian peninsula, is developing a local flexibility market platform based on the work carried out in the IREMEL [90] and DRES2Market [91] projects. In addition, commercial solutions like NODES [92] and Piclo [93] offer marketplaces for the procurement of SO services in different projects across Europe. Most of these initiatives are either fully operational or completed except EUniversal and the OMIE local market, which are at the implementation stage at the time of research.

As illustrated in Table 2-19, most analyzed local markets are operated by a third party, including third-party commercial operators like NODES and Piclo or third-party regulated operators like OMIE or EPEX Spot. In the case of the GOPACs, it serves as an intermediary platform supporting the coordinated market-based procurement of congestion management services. Thus, it does not technically have a market operator. It depends on the ETPA (energy trading platform Amsterdam) power exchange. Furthermore, some companies have implemented local platforms to test use cases in research projects and act as market operators, such as N-Side [92] in the CoordiNet business use case (BUC-ES-1b Málaga) and the EUniversal Portuguese demonstrator and Centrica in the Cornwall local energy market [93].

On the other hand, in the ENEDIS and the Flexible Power projects, local services are being acquired using market platforms operated by the procuring SOs. Similarly, DSOs act as a market operator and a single buyer in some business use cases implemented in CoordiNet (BUC ES 1b/4 Murcia, SE/GR local markets), EU-Sysflex

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Finnish demo, Interflex, and SmartNet Spanish pilot as shown in Table 2-19. However, in the EU-Sysflex PT-FxH-RP use case the TSO aims to procure reactive power at the TSO-DSO connection point by using a local market operated by a DSO [84].

Table 2-19: Market operator role in relevant local markets for SO services in Europe

The procuring SO itself alone or together with other SOs	A different SO or different SOs	A third party who is not a SO
CoordiNet: - BUC ES 1b/4 local markets in Murcia: DSO - BUC SE/GR local markets for congestion management: DSO	**EU-Sysflex:** PT-FxH-RP local market for TSO: DSO	**CoordiNet:** BUC ES 1b local market in Málaga: N-Side
EU-Sysflex: FI-RP local market: DSO		**Cornwall** Local Energy Market: Centrica
ENEDIS tenders: DSO		**Enera Flexmarkt:** EPEX Spot
Interflex: NL demo: DSO		**EUniversal:** DE, PL demos: NODES PT demo: NODES and N-Side
Flexible Power platform: National Grid Electricity Distribution (NGED), SP Energy Networks, Northern Power Grid, Scottish and Southern Electricity Networks flexibility tenders using DNOs		**Intraflex, Minetz, NorFlex, Smart Senja, Sthlmflex** projects: NODES
		GOPACS: ETPA (Energy trading platform Amsterdam)
SmartNet: Spanish pilot: DSO		**IREMEL, DRES2Market**: OMIE
		UK Power Networks and Electricity North West flexibility tenders: Piclo flex

2.6.1.2 What are the responsibilities of a MO and a SO when a local market is implemented?

The traditional roles and interactions between market actors are altered in local market solutions. Authors in [79] highlight that although the core responsibilities of the local market operator remain similar to those of traditional market operators, local market operators may also take on additional functions. Table 2-20 provides and overview of market operator responsibilities in European local markets for SO services, including:

Develops & maintains an IT solution (market platform): The local market operator is usually responsible for designing, developing, and maintaining the market platform that facilitates the market operation. This includes creating the infrastructure, software, and IT tools necessary for market participants to interact and conduct bid transactions efficiently.

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Communication with the service providers: The MO acts as a link between the market buyers and service providers. MO facilitates effective communication channels (through the market platform) to address any queries, concerns, or issues raised by the SPs, ensuring collaboration and efficient market functioning.

Market-clearing: The market operator is responsible for conducting this process, which involves matching SO service needs and SPs' bids, considering market rules and constraints, and optimizing the overall market efficiency. It is important to highlight that in certain local market solutions, the MO is limited to providing a merit order list to the procuring SO based on a set of economic and/or non-economic criteria. Then the procuring SO assumes the responsibility of selecting and activating the bids outside of the market platform.

Communication of market results: After the market-clearing process, the market operator communicates the results to the system operators and market participants. This involves sharing information regarding the cleared prices, quantities, and other relevant market data. Clear and timely communication of market results is crucial for participants to make informed decisions and adjust their strategies accordingly.

Market settlement: Market settlement involves the financial transactions and obligations arising from the market's trading activities. The MO ensures or supports the exchange of information such that settlements are executed accurately and in a timely manner, facilitating the transfer of funds, assets, or other obligations between buyers and sellers based on the market outcomes.

As previously mentioned, local market operators often assume additional functions beyond the traditional scope of market operators. Some of these new responsibilities include:

Product and/or asset prequalification: The MO may be responsible for the prequalification process of assets that can participate in the market, see Section 2.5.3 of this report. This involves establishing criteria, assessing the eligibility of products/assets, and approving them for trading.

Determining network problems: The SO should identify and calculate the flexibility requirements needed to solve problems in its network. In case that the SO operates the local market, these needs could be automatically incorporated into the market clearing. Otherwise, these needs are shared with a third-party MO.

Dispatch/flexibility activation: The local market operator may have a role in dispatching resources or activating flexibility options. They can coordinate the activation of resources with SOs, to ensure a reliable and balanced system operation in response to changing conditions.

Looking at the existing European local markets for SO in services, the allocation of these responsibilities depends on the specific market design and whether the market operator role is assumed by a SO or a third party, as illustrated in Table 2-20.

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Table 2-20: Overview of market operator responsibilities in European local markets for SO services

Responsibilities	**FWGL-DR**	**The SO as market operator**					**Third-party market operators**					
		Coordi Net ES-1b	ENEDIS tenders	Flexible Power NGED	EUSysfl ex PT	Interflex NL	Cornwall LEM	EPEX Spot Enera	EUnivers al DE	NODES Intrafle x	OMIE Iremel	Piclo UKPN
Develops & maintains market platform	**MO**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Communication with the service providers	**MO**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Market-clearing	**MO**[16]	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Communication of market results	**MO**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Market settlement	**MO**	**X**	**X**	**X**	**X**	**X**	**X**			**X**	**X**	
Product and/or asset prequalification	**SO**	**X**	**X**	**X**	**X**		**X**		**X**	**X**[17]		
Dispatch/flexibility activation	**SO**	**X**	**X**	**X**	**X**			**X**		**X**		

For instance, in the UK Power Networks (UKPN) flexibility tenders [94], responsibilities are divided between the distribution network operator (DNO) - UKPN and Piclo that act as a third-party market operator. In order to participate, the SPs must complete an online dynamic procurement system application (company qualification) and a prequalification questionnaire using the Piclo Flex platform. Based on this information, the UKPN pre-qualify providers. The next stage involves a competition where pre-qualified SPs can bid on the Piclo platform, and the UKPN assesses the bids in accordance with an assessment criterion that considers meeting volume requirements at a cost that is within budget, as economically as possible. Competition results are announced through Piclo Flex. Moreover, UKPN will dispatch SPs under three dispatch principles, cost efficiency, security of supply, and operability.

In the EUniversal German demo, the DSO Mitnetz Strom is implementing a local market for congestion management and voltage control [95]. NODES performs the market operator role, while Centrica acts as a service provider (SP) offering flexibility services of one or multiple resources through aggregation. In this demonstrator, NODES executes a continuous market-clearing where the DSO launches a bid recommender tool at regular intervals. This tool analyzes and identifies the combination of bids that solves as many congestions as the lowest price, based on this analysis, the DSO will then be able to submit "buy" bids. NODES then sends a notification to the SPs regarding the accepted bids. Centrica is responsible for dispatching the accepted offers via individual assets and ensuring the service is delivered in real-time. Validation and settlement will not be tested during this use case.

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[16] The FWGL DR highlights that although the market-clearing should be performed by the market-operator, the selection and activation of the bids and control of delivered services remain the responsibility of the SO.

[17] In the Intraflex Project, both NODES and the procuring SO are involved in the pre-qualification process [42].

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Another relevant example is the CoordiNet BUC-ES-1b, which implemented a local congestion management market in the region of Murcia in Spain. In this case, the local market platform is part of the DSO's own platform, and the DSO acts as both a market operator and a single buyer. The DSO handles the prequalification, market clearing, the SPs' communication and activation, and settlement [96]. In addition, the market results are communicated to the TSO by the Common CoordiNet platform. As shown in Table 2-20, similar responsibilities are assumed by the SOs when they act as market operators in other local markets analyzed in this report.

2.6.1.3 What are the pros and cons reported in the literature when a local market is operated by a third-party or a SO?

This subsection aims to identify and analyze the advantages and disadvantages of operating a local market either through a SO or a third party. To gather insights, we have incorporated findings from notable studies on this subject, such as EUniversal D5.4 111 [97], INTERRFACE D3.2 [65], [98], and [99]. While we present the pros for both third-party (Table 2-21) and SO (Table 2-22), it is important to note that the cons are also implicitly addressed. For instance, the drawbacks of opting for a third-party MO can be seen as the corresponding advantages of having a SO as MO (Table 2-22), and vice versa.

Having a third-party operator for a local market for SO services offers several advantages (Table 2-21). For instance, it enhances transparency in bid matching and promotes neutrality between buyers (SOs) and sellers (SPs). To ensure transparency, authors in [98] highlight that the market operator must maintain complete independence of market activities. Neutrality is even more critical when the market scope involves multiple buyers competing to procure services in the same geographical area. An additional point supporting a third-party MO is that a specialized third party can allow for faster development of the procurement mechanisms of new services [65], [99]. The presence of a third-party operator also improves interoperability with other market platforms, fosters increased competition and provides easier access for customers.

On the other hand, having a SO as a local market operator offers several benefits (Table 2-22). Firstly, it reduces the need for extensive coordination efforts, mainly when there is a need to share grid information between SO and MO since it is sensitive to share it due to data protection (GDPR) and cybersecurity constraints. For instance, in the existing local markets, there is a permanent discussion on how to select the optimal bid when a local market is operated by a third-party and which information needs to be shared for this selection. Additionally, the cost of interface management between the SO and the local market could also be reduced, resulting in potential cost savings. Moreover, the involvement of fewer actors simplifies governance and regulation, as a single entity consolidates responsibilities for system and market operation. Lastly, in case SOs have access to their own flexibility resources (network reconfiguration, capacitor banks, OLTC, storage, etc.), it

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would be more efficient to optimize the combination of these resources with purchasing flexibility from SPs in a single optimization problem which considers the network constraints and managed by the procuring SO.

Table 2-21: Pros of having a third-party as a local market operator reported in the literature

Pros of having a Third-party as a local market operator	References
Improved transparency in bid matching	[97], [98], [99]
Improved neutrality between buyers and sellers	[97], [65]
Facilitate the procurement of flexibility for multiple buyers (TSOs, DSOs)	[97]
Improved interoperability with other market platforms	[97]
Increased competition and easier access for customers and aggregators	[97]
Improved communication and coordination between market players	[97], [99]
Faster development of the procurement mechanism of new services/products	[65], [99]
Improved clearing algorithms, data security due to the knowledge of MO	[97]

Table 2-22: Pros of having a SO as a local market operator reported in the literature

Pros of having a SO as a local market operator	References
Fewer coordination efforts are required	[97]
Less GDPR complexity	[97]
Cost savings of the interface management between the SO and local market	[97], [65]
Fewer challenges in terms of governance and regulation since the responsibility for the operation of the system is divided among fewer actors	[97]
SOs have access to their own flexibility resources. They can optimally combine these resources with purchasing flexibility from third parties.	NA

2.6.2 Overview of the OneNet demonstrators

This subsection is dedicated to examining the operation of local markets in OneNet demonstrators through the lens of the three questions explored in the preceding literature review, i.e. who is the MO entity and the corresponding responsibilities, and the justifications from the demonstrators for the selection of either a third-party or a SO as the local market operator. The analysis relies on the information obtained from a questionnaire and workshop organized in collaboration with OneNet WP11 in June 2023. The questionnaire targeted OneNet demonstrators that are implementing local market solutions or multi-layer/common markets where a local submarket is considered. A summary of the demonstrators and their corresponding use cases considered in the analysis is provided in Table 2-23.

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Table 2-23: OneNet BUCs that implement local markets for SO services

Demo	Business Use Case	Market Architecture	Services
NOCL	NOCL-01: Northern flexibility market	Common market TSO/DSO[18]	Service agnostic
CY	SOCL-CY-01: Active power flexibility	Multi-layer market TSO/DSO	Balancing, Congestion management
	SOCL-CY-02: Reactive power flexibility and power quality	Multi-layer market TSO/DSO	Congestion management, Voltage control
ES	WECL-ES-01: Long-term congestion management	Local market DSO	Congestion management
	WECL-ES-02: Short-term congestion management	Local market DSO	Congestion management
CZ	EACL-CZ-01: Nodal area congestion management	Local market DSO	Congestion management
	EACL-CZ-02: Reactive power overflow management	Local market DSO	Voltage control
	EACL-CZ-03: Voltage Control	Local market DSO	Voltage control
HU	EACL-HU-01: MV feeder voltage control	Local market DSO	Voltage control
	EACL-HU-02: HV/MV transformer overload	Local market DSO	Congestion management
PL	EACL-PL-01: Prequalification of resources provided by FSPs	Multi-layer market TSO/DSO	Service agnostic
	EACL-PL-02: Managing flexibility delivered by DER to provide balancing services to TSO	Multi-layer market TSO/DSO	Balancing
	EACL-PL-03: Event-driven P for congestion management and voltage control by the DSO	Multi-layer market TSO/DSO	Congestion management, Voltage control
	EACL-PL-04: Balancing service provider on the flexibility platform	Multi-layer market TSO/DSO	Balancing
SLO	EACL-SL-01: Congestion management in distribution grids under market conditions	Local market DSO	Congestion Management
	EACL-SL-02: Voltage control in distribution grids under market conditions	Local market DSO	Voltage control

As illustrated in Table 2-24, the answer to the question of who should be the MO in local markets is tailored to the specific market. Although most demos have opted for a third-party MO, some have selected a SO to operate their local markets. With regards to the MO responsibilities, it is evident that when a SO assumes the MO role most of the functions listed in Table 2-25 are performed by this entity, except for the dispatch and flexibility activation in the Northern cluster and the Hungarian demonstrator. In the OneNet local markets, the responsibilities of third-party operators remain similar to those of traditional market operators, which are also

[18] In the Northern cluster, there are cases where a SO may be the only entity interested in purchasing a particular product using flexibility connected only to its own grid (e.g. a DSO interested in purchasing the LT-PC/E product for resolving anticipated congestions in its own grid), in which case, the common market will turn into a single market for that particular SO, [100].

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specified as MO's functions in the FWGL DR. Some exceptions include the Spanish demonstrator, where OMIE is responsible for the final selection of the bids and performs the prequalification process together with the DSO. The virtual market operator in Cyprus is also in charge of the bid selection.

Table 2-24: Market operator role in the local markets for SO services in OneNet

The procuring SO itself alone or together with other SOs	A different SO or different SOs	A third party who is not a SO
EACL-SL-01/02: DSO	**NOCL-01**: Elering (TSO), Fingrid (TSO), AST (TSO), Litgrid (TSO)	**NOCL-01**: Piclo, Nord Pool
	EACL-HU-01/02: MVM and E.ON	**SOCL-CY-01/02**: Virtual market operator
		WECL-ES-01/02: OMIE
		EACL-CZ-01/02/03
		EACL-PL-01/02/03/04: TTST (Transition Technologies-Systems Sp. z o.o.)

Table 2-25: Overview of market operator responsibilities in OneNet local markets for SO services

Responsibilities	FWGL-DR	Procur-ing SO	Different SO		Third-party			
		SLO	**NOCL-01:** Elering, Fingrid, AST	**HU**	**NOCL-01:** Piclo, Nord Pool	**CY**	**ES**	**PL-03**
Develops & maintains an IT solution (market platform)	**MO**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Communication with the service providers	**MO**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Market-clearing	**MO**[19]	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Communication of market results	**MO**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Market settlement	**MO**	**X**	**X**	**X**		**X**	**X**	**X**
Dispatch/flexibility activation	**SO**	**X**						
Product and/or asset prequalification	**SO**	**X**	**X**	**X**			**X** [20]	
Bids selection	**SO**	**X**	**X**	**X**		**X**	**X**	
Evaluation of bid impact on delivering the services	**SO**	**X**	**X**	**X**				

[19] The FWGL-DR highlights that although the market-clearing should be performed by the market-operator, the selection and activation of the bids and control of delivered services remain the responsibility of the SO.

[20] Together with DSO

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Furthermore, to understand the selection of the entity acting as the local market operator in the OneNet solutions, the demonstrators were specifically questioned about their choices' motivations or justifications. The list of potential advantages of having a third party or a SO as MOs identified in the literature review was provided to facilitate the analysis. The motivations expressed by the demonstrators for opting for a third-party and a SO as market operators are delineated in Table 2-26 and Table 2-27, respectively. Additionally, demonstrators were encouraged to include any additional pros that they considered relevant to their decision. In the case of third-party MOs, the Northern cluster emphasized its preference for this option in certain local submarkets due to the prior expertise of the selected MO. The Spanish demonstrator indicated that the selected MO (OMIE) manages the Iberian Peninsula's day-ahead and intraday markets, facilitating the coordination of the local markets with the existing ones. Furthermore, the Polish demonstrator highlights that TTST is the developer and owner of the market platform. Thus, this third-party entity acts as MO in the business use cases analyzed.

Table 2-26: Pros of having a third-party as a local market operator according to OneNet demonstrators

Pros of having a Third-party as MO VS the procuring SO or a different SO	Demo
Improved transparency in bid matching	NOCL, CY, CZ, ES
Improved neutrality between buyers and sellers	
Facilitate the procurement of flexibility for multiple buyers (TSOs, DSOs)	NOCL, CY, CZ
Improved interoperability with other market platforms	NOCL, CZ, ES
Improved communication and coordination between market players	NOCL, CY
Faster development of the procurement mechanism of new services/products	
Improved clearing algorithms, data security due to the knowledge of MO	CY, ES

Table 2-27: Pros of having a SO as a local market operator according to OneNet demonstrators

Pros of having the procuring SO or a different SO as MO vs. a third-party	Demo
Fewer coordination efforts are required	HU, SLO
Fewer challenges in terms of governance and regulation since the responsibility for the operation of the system is divided among fewer actors	
SOs have access to their own flexibility resources. They can optimally combine these resources with purchasing flexibility from third parties.	
Cost savings of the interface management between the grid operator & MO	SLO
Less GDPR complexity	

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On the other hand, the selection of a SO in the local submarkets in the Northern cluster was justified by several factors. Firstly, as the TSO plays the role of balancing, there are synergies with near real-time products. Additionally, the limited availability of third-party MOs for these specific use cases further influenced their decision.

2.6.3 Discussion of the regulatory options

As highlighted in the academic literature and the analysis of the OneNet demonstrators, the answer to the question of who should be the market operator in local markets for SO services is tailored to the specific market, and these markets could be operated by the procuring SO, a different SO, or a third-party. Therefore, to develop a regulatory framework for the operation of local markets for SO services, the most relevant thing is to analyze what are the implications when these markets are operated by any of the three potential entities. The selection of these entities was determined by the classification framework provided by the FWGL DR, which effectively covers the diverse range of existing local market operators identified in previous subsections.

Several options are considered and presented in Table 2-28 to address this question. These options encompass the examination of market operator responsibilities, the potential advantages associated with each entity assuming the MO role, and the underlying market design principles. Furthermore, additional options are explored in the operation of local markets, including bid forwarding and the coordination of these markets with wholesale markets.

Table 2-28: Questions and related options discussed in this subsection

Question	Options that are discussed
What are the implications when the **procuring SO** operates a local market for SO services?	• Division of responsibilities (Market operator vs. System Operator) • Pros and Cons of the selected market operator • Additional considerations (bid forwarding and coordination with wholesale markets)
What are the implications when a **different SO** operates a local market for SO services?	
What are the implications when a **third-party** operates a local market for SO services?	

What are the implications when the procuring SO operates a local market for SO services?

As discussed in the preceding subsections, certain local market solutions consider the procuring SO as the market operator. In these solutions, the SO typically assumes the dual role of the single buyer and the MO. In this context, the responsibilities of the MO include functions that are traditional associated with MOs, such as the development and maintenance of the market platform, communication with service providers, execution of the market-clearing and settlement, and the communication of market results to SPs. Moreover, the procuring SO may undertake additional functions beyond the traditional scope of MOs, including the prequalification of assets for trading, the calculation of the flexibility needs, or the dispatch and activation of SPs.

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The academic literature and the OneNet demonstrator analysis identified several arguments in favor and against a procuring SO acting as the local market operator. Firstly, this scenario reduces the need for extensive coordination efforts between multiple actors, thereby streamlining the decision-making process of procuring SO services. For instance, it reduces challenges in terms of governance structures and regulatory compliance and mitigates the complexity associated with sharing sensitive data between SOs and MOs. Furthermore, under this approach, the procuring SO can optimally combine the flexibility provided by its own network assets (network reconfiguration, OLTC, capacitor banks, etc.) with the market-based procurement of services from third parties, since the full grid information could be integrated into the local market-clearing. Another notable advantage is the cost savings realized by eliminating the need for interface management between the SO and a third-party MO. On the other hand, the literature presents arguments against the notion of a SO acting as the local market operator. These arguments mainly focus on the lack of transparency, the limited market expertise of DSOs, the limited market innovation, and more difficulties to integrate the local market with other wholesale energy markets. However, it is important to highlight that there are SO market solutions that effectively address these concerns by transparently publishing volumes and prices, while also establishing interlinks with wholesale markets. Moreover, TSOs with specialized market departments further demonstrate their potential for efficient market operations.

What are the implications when a different SO operates a local market for SO services?

Local markets for SO services may be operated by a SO who is not the procuring SO in certain circumstances. This typically occurs in multi-layer markets with various SO buyers, and one of the SOs is selected to operate the local submarket. This also happens when a TSO aims to procure products in a local market operated by a DSO or vice versa. In this context, responsibilities could be divided between the procuring SO and the SO acting as MO. For instance, the procuring SO primarily focused on functions to ensure the reliable operation of the grid, while the SO acting as MO handles the market-related responsibilities mentioned before. This separation of duties can foster market competition and transparency. By contrast, clear protocols and mechanisms must be established to ensure effective coordination and information sharing between SOs.

What are the implications when a third-party operates a local market for SO services?

As shown in previous subsections, a third-party could also operate a local market for SO services. The third-party MO could be a regulated entity like a NEMO or a commercial market platform. In this scenario, there is also a clear separation of responsibilities between SOs and the MO. Both the literature and the OneNet demo analysis highlight that the functions of third-party MOs are primarily focused on the development and maintenance of the market platform, market-clearing, communication of market results, and settlement. However, in some existing local markets, a third-party MO also performs the prequalification process, dispatch and activation of flexibility, and the final bid selection. It is worth noting that the new rules of the FWGL DR state

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that the selection and activation of the bids and control of delivered services remain the responsibility of the SO, see Annex A.3.

Having a third-party as the local market operator offers several advantages. One notable benefit is that the division of the MO role from the buyer role promotes independence and neutrality, ensuring fair treatment and equal opportunities for all market participants, and it also facilitates the procurement of services for multiple buyers. In systems, with many small DSOs, to have a third-party market operator with a single common platform and defined standardized products could be an attractive market solution. Moreover, independent MOs can introduce new market products and technologies and foster market competition and innovation. However, when the local market is operated by a third-party, it is essential to establish effective information sharing between SOs and the MO. For instance, network-related information is typically treated as confidential by most SOs resulting in a market-clearing process that lacks a comprehensive representation of the network. Additional considerations come into play when a third-party operates a local market. For instance, the FWGL DR establishes that any third-party MO must be independent from all market activities, i.e. supply and demand in electricity markets. This ensures impartiality and prevents conflicts of interest.

Additionally, the FWGL DR highlights important points not extensively covered in the literature. For example, in the operation of local markets is critical to define if a MO, different from the procuring SO, is allowed to recombine bids to meet the SO's requirements. The FWGL DR emphasizes that the market operator should refrain from engaging in arbitrage during the bid regrouping process, which ensures fairness and avoids any manipulation of market outcomes.

Another crucial aspect to address is whether a local market operator (in any of the three options) is permitted to forward bids to other wholesale markets. The forward bids could be recombined or not, depending on the specific circumstances, and should be subject to the consent of the SPs. The compatibility of the concerned product with the target wholesale market also needs to be considered. In this regard, the market design should incorporate suitable requirements to uphold neutrality and transparency, particularly concerning the pricing mechanism and the selection of bids for forwarding. Similarly, the FWGL DR indicates that the new rules should indicate if the SOs are allowed to procure bids from other wholesale markets to use for local SO services.

2.6.4 Conclusions for local market operation

The contribution of this section to the operation of local markets for SO services is twofold. First, we analyzed how the operation of local markets is addressed in the academic literature, particularly experiences and conclusions from the existing local market solutions in Europe were collected, including OneNet demonstrators. Second, we qualitatively discussed what are the implications when a local market is operated by a procuring SO, a different SO, or a third party in order to establish a regulatory framework for the operation of these markets.

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When comparing the advantages of operating a local market through these options, they all have their merits and disadvantages. In general, third-party MOs enhance transparency, neutrality, and competition in the market. They can also facilitate faster development of procurement mechanisms and interoperability with other market platforms. Moreover, it can be an ideal solution to standardize products and simplify trading in systems with many small DSOs. However, as discussed in the previous section, efficient information sharing between SOs and the MO is crucial when a third-party operates a local market. For instance, one particular topic that requires attention is how to integrate network-related information during the market-clearing and/or the bid selection processes since the grid data is typically treated as confidential by SOs. Hence, it is necessary to propose solutions that guarantee that the local market outcomes do not violate the grid operational limits regardless of the entity acting as the MO . Moreover, it is important to highlight that the FWGL DR mandates that any third-party MO must be separate from all market activities, such as electricity supply and demand. This ensures fairness and avoids potential conflicts of interest.

On the other hand, having a procuring SO as the market operator reduces coordination efforts, simplifies governance and regulation, and allows for more efficient optimization of resources, especially when the SO has access to its own flexibility assets. Furthermore, the FWGL DR establishes market design principles applicable to all market operators, and they are aligned with the information reported before. These principles include ensuring neutrality towards SPs and how their offers are presented to SOs, providing equal treatment to all market participants regardless of technology, safeguarding confidential data received from the SPs and SOs, and publishing specific information such as market structure, section clearing details, gate closure times, and traded products.

Another key aspect analyzed in this study is the separation of responsibilities between the local market operator and the SO when a local market for SO services is implemented. When these markets are operated by an entity that is not the procuring SO, i.e. a third-party or a different SO, the division of responsibilities usually is clear. The MO primarily is focused on market-related functions, including market platform operation and maintenance, market-clearing, communication with SP, and settlement. By contrast, the SO is focused on its traditional tasks related to network operation. However, when a local market is operated by a procuring SO is evident that both market-related and grid operation functions are performed by the MO. As highlighted during the discussion section and literature review, new functions are needed when a local market for SO services is implemented, such as the prequalification of SPs, the dispatch and activation of flexibility, the calculation of flexibility service needs, or the post-market evaluation and selection the bids. Although these new functions have been assigned differently between the three MO options in the existing local markets, the FWGL DR states that the selection and activation of the bids and control of delivered services remain the responsibility of the SO.

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Furthermore, this analysis pointed out the need to decide if local MOs are allowed to recombine bids and if they are enabled to forward bids to other wholesale markets. In this context, the market design should provide appropriate requirements for neutrality and transparency, particularly concerning the pricing mechanism and the choice of bids to be forwarded.

Overall, as highlighted throughout this study, the choice between a procuring SO, a different SO, or a third party to operate local markets for SO services depends on various factors, including the specific market design, the need for independence and neutrality, the level of coordination required, and regional considerations. These three options are currently taken up in practice by OneNet demonstrators and the existing local markets in Europe, where responsibilities are divided between MOs and SOs depending on the selected MO entity.

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2.7 Overall conclusion

New rules in relation to demand response and the market-based procurement of non-frequency ancillary and congestion management services are currently being developed by TSOs and DSOs at EU level based on the FWGL DR published by ACER in December 2022. At the same time, numerous bottom-up initiatives and pilot projects related to flexibility are ongoing at the national level, including in the OneNet demo countries. While the benefits of defining a European target-model are not yet certain, there is consensus on the need for a common terminology and high-level principles for this current experimentation phase.

In this regulatory study, we analysed three elements considered in the FWGL DR that are essential for the development of a European framework for demand response and mark non-frequency ancillary and congestion management services. The three elements are baselining, prequalification, and local market operation. For each element, we conducted a literature review, analysed the experience in the OneNet demos, and discussed a set of regulatory options based on a multi-question framework. These different regulatory options together with the experience gathered in OneNet could inspire the development of the new rules at EU level.

This conclusion section must be read in conjunction with the element-specific conclusions sections for baselining (section 2.4.4), prequalification (section 2.5.4) and local market operation (section 2.6.4). Those give detailed insights into the regulatory options and other findings per element.

In general, the literature analysis highlighted the large variety of options that exist when it comes to determining roles and responsibilities, processes and procedures, and minimum technical requirements for baselining, prequalification and local market operation. It suggests that the choices made ultimately depend on various factors and regional specificities, including the specific market design, existing requirements, the level of coordination required, and the regulatory framework (where existent).

The demo experiences confirm this finding from the literature analysis. For most design choices there is no clear trend across demos. In several cases, a choice was made primarily based on the existing experience of the involved parties and the tools and information already available to them. One interesting finding was that all OneNet demonstrators consider prequalification a mandatory process. This is contrary to the FWGL DR that considers ex-post verification the default process. A reason for this divergence may be that the FWGL DR introduced this new concept of ex-post verification only after the OneNet demos had already started their work.

At the time of writing, the implementation experience is still limited in the OneNet demo countries. It allowed us to understand and compare choices across countries. However, it did not allow us to build general recommendations regarding baselining, prequalification and local market operation targeted at the EU level. This could be the next step in the analysis once more practical evidence will have been gathered at national level and could be taken up by a following research project.

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3 Project-internal consultation moments

This section reports on the two consultation moments organised over the duration of the OneNet project. Subsection 3.1 reports on the first consultation moment that focused on limitations and barriers to integrated and coordinated markets. Subsection 3.2 reports on the second consultation moment that focused on Efficiency, barriers, and consumer-centricity in TSO-DSO coordinated flexibility markets.

3.1 First consultation moment (T3.2): Barriers to integrated and coordinated markets

The first consultation moment focused on barriers to integrated and fully coordinated markets identified during the initial months of T3.2. The barriers were identified through an academic literature review and external stakeholder literature review. After obtaining insight into different barriers, a gap analysis was carried out to understand the steps needed to move from markets in isolation to integrated and fully coordinated markets.

At the time of the consultation moment in November 2021, T3.2 was in the midst of performing the gap analysis, which represented the second of four steps towards the development of integrated and scalable market concepts as shown in Figure 3.1. The aim of the consultation moment was to discuss the relevance of various barriers to the coordination and integration of markets that had been identified with the OneNet demonstrators and specific stakeholder groups and to understand the implementation status of specific markets (voltage control, congestion management) in the countries of the demonstrators. Note that a more detailed report of this consultation moment is provided in [3].

The workshop with the OneNet demonstrators consisted of two sessions. In the first session, T3.2 task leader ENTSO-E presented the status of the gap analysis. In the second session, representatives of each OneNet demonstrator presented the current approach to voltage control and congestion management in their countries.

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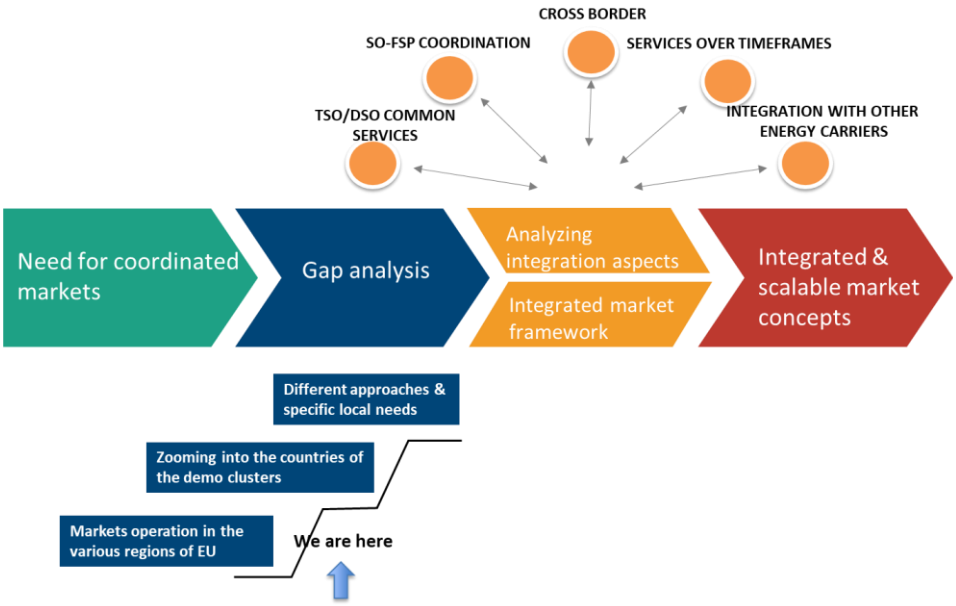

Figure 3.1: Status of the work in T 3.2 at the time of the first consultation moment

3.1.1 WP3 session

The goal of the different existing markets in the sequence of European electricity markets (day-ahead (DA), intraday (ID), balancing (BA), etc.) is different. Also, these markets create multiple opportunities for market actors. Since recently, Europe has seen the creation of new markets for flexibility. So far, in most cases these new markets are not (yet) linked or integrated with the existing sequence of electricity markets. In most of these new markets, the key buyers are likely to be the TSOs and DSOs. The coordination and integration of markets is important to enhance the efficiency of markets and leverage on synergies. Coordination and integration ensure that the allocative efficiency of flexibility used for different purposes is maximized and that, at the same time, flexibility trades by one market party do not create negative effects for other market parties.

Figure 3.2 shows the initial list of barriers to integrated and coordinated markets that had been identified in T3.2 at the time of the first consultation moment. They had been classified into three main categories: market coordination, market architecture and other limitations.

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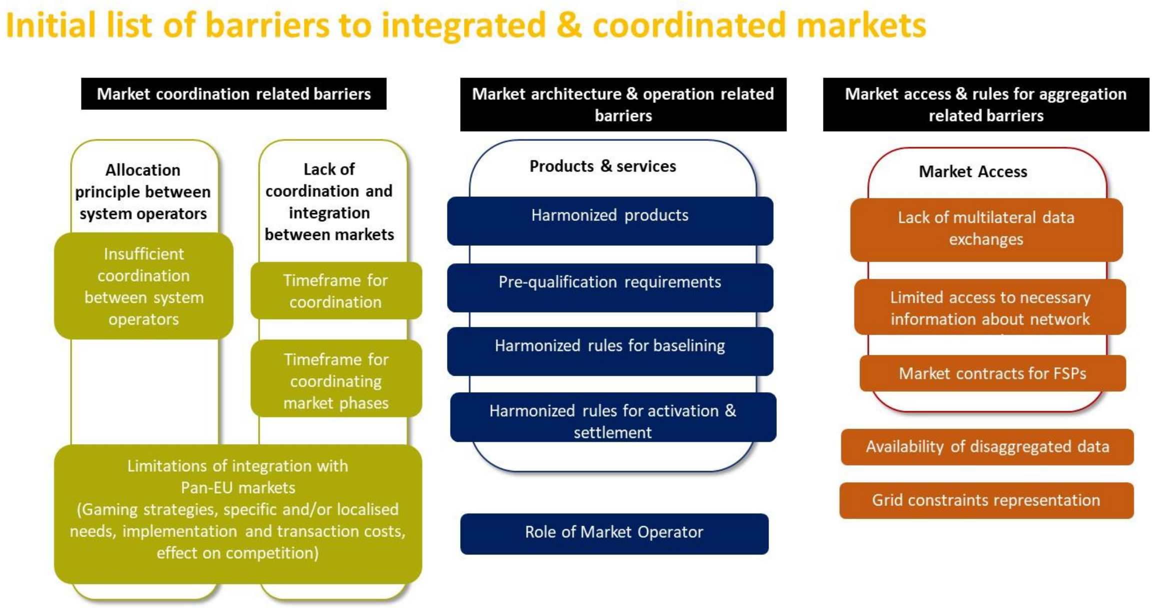

Figure 3.2: Initial list of barriers to integrated and coordinated markets identified in T3.2

A survey among a total of 41 workshop participants (10% Southern, 32 % Northern, 27% Western, 19% Eastern, 12% Horizontal WPs) was carried out, which aimed at identifying the relevance of each individual barrier. Figure 3.3 shows the scale of relevance used for the survey and Table 3-1 shows the results per cluster for those barriers that were deemed relevant or very relevant by the workshop participants.

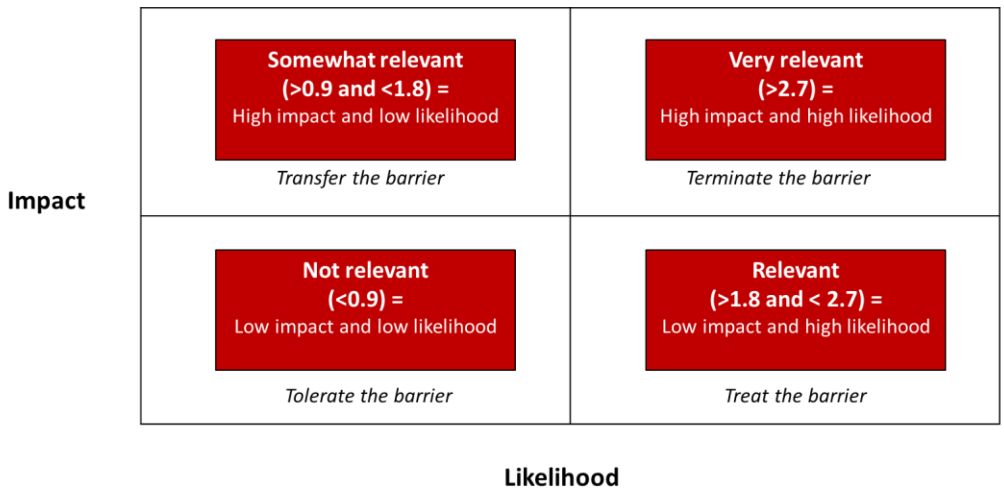

Figure 3.3: Scale of relevant for the identified barriers

The relevance for each barrier was measured for all countries within the demo cluster on a scale of 0 to 3 with indicators: 'impact' and 'likelihood' being taken into consideration, as shown in the simple matrix in figure above. On the horizontal axis 'likelihood' indicates the frequency as well as the probability of the barrier materializing. On the vertical axis 'impact' indicates the severity of the barrier.

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Table 3-1: Barriers identified as relevant or very relevant per demonstration cluster

	Barrier	Northern Cluster	Eastern Cluster	Western Cluster	Southern Cluster
Market coordination	Lack of communication between SOs on formal allocation of products and resources			x	x
	Lack of coordination between markets on timeframes (especially GOT, GCT and trading resolution of products)	x	x	x	
	Implementation of bid forwarding and adequate interfaces		x	x	x
	Missing uniform principles on implementation of interoperable flex resource register	x		x	x
Market architecture and operation	Lack of alignment of prequalification processes			x	x
	Lack of harmonization for products	x	x		x
	Lack of high-level principles of harmonization for market operation (e.g. market clearing type, pricing, procurement frequency ...)	x	x		
	Lack of harmonized rules for baselining and settlement	x			
	Lack of alignment in technical specifications (e.g. of submeters)	x			
	Ensuring appropriate cybersecurity for operators, market participants and consumers	x		x	x
Market access and rules for aggregation	Existence of exclusive market contracts that lock flexibility into one market	x			
	Lack of (harmonized) interfaces that enable market access for FSP value stacking across timescales and different markets	x	x		x
	Insufficient representation of grid constraints (in the light of more dynamic utilization of the grid)	x	x	x	x

During the workshop, the representatives of the demonstration clusters also raised additional barriers that were missing from the list in Table 3-1, namely customer engagement, market complexity, lack of implementation of Directive (EU) 2019/944, legal barriers, co-optimisation of local needs (TSO and DSO congestion management) and European needs (balancing), a single interface for FSPs, and common grid modelling.

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3.1.2 Demo sessions

The demo sessions aimed at identifying the status quo and future plans regarding the approaches to congestion management (CM) and voltage control (VC) in the countries of the demonstrators. Below is a summary of the questions that demo representatives addressed in their presentations.

- *What is the current approach used in your country when addressing congestion management and voltage control?*
- *What are the barriers to the integration of potential congestion management and voltage control markets into the sequence of the current energy markets (wholesale and balancing)?*
- *Which one of these barriers have you identified in the development of the work you are undertaking for your OneNet demo and how you are planning to overtake them?*
- *Do you plan to test potential congestion management and voltage control via a market-based process? For context, please clarify whether:*
    - *a DSO participates into congestion management market; and*
    - *demand facilities and aggregators will participate.*

In the following, a summary of the demonstrator responses per question is provided. Please note that the answers were provided in M14 of the project and can thus not be considered to represent the final view of the demonstrators in the project.

What is the current approach to congestion management in your country?

In most countries, the processes for congestion management at the time of inquiry were not market-based. Generally, different approaches can exist on TSO and DSO level. While market-based congestion management at TSO level did exist in FI, EST and PT, there was no OneNet country with market-based congestion management at DSO level at the time. In some countries DSO participation in congestion management markets was considered for the future. In Estonia congestion issues were identified due to the fact that small-scale assets cannot connect to distribution grid due to high connection fees.

Market-based approaches on TSO level included the use of mFRR bids (FI, EST), the use of bilateral agreements with customers in the form of commitment of must-run units at specific locations for local congestions (FI), or annual auctions for service providers (LT). The non-market-based approaches at TSO level included the use of technical possibilities such as limits considered in the planning process (HU), constraints imposed in the balancing mechanism (GR), static security assessments in day-ahead and real-time (GR), or topology changes (CY, PT) or central dispatching model to resolve congestions in transmission network with integrated scheduling process by activation of offers on the balancing market (PL). The curtailment of renewables was also considered (CY).

At the DSO level, non-market-based measures included considering CM in the planning stage (CY), network investments/reinforcements (ES, GR), the use of technical possibilities (PL, GR, PT, ES), or load curtailment (GR). Some countries (SLO) made use of tariff schemes and dynamic grid tariff pilots. Different approaches could be applied depending on the voltage level operated by the DSO (high voltage (HV), medium voltage (MV), and low voltage (LV)). For example, while DSOs in Poland used technical possibilities at HV and MV level, there was no action at LV level because of limited knowledge about network problems.

A separate category were countries that did not have an approach to congestion management due to the absence of congestion in the country (LV, LT).

What is the current approach to voltage control in your country?

No country reported to have a market-based approach to voltage control in place. In most countries, voltage control is implemented via requirements for generators (and storage) (FI, SLO, CZ), but can also be carried out with traditional system operator assets (LV, CY). In some countries, annual auctions for the selection of voltage control service providers are carried out (LT).

At the TSO level, some countries specify reactive power windows for all connections in the connection agreements (FI) or require large-scale RES to operate within a power factor range according to TSO set-points (CY). Others use technical possibilities such as tap changers of HV/MV transformers, or variable shunt reactors/capacitors (CY, GR, PT). Participation in dynamic voltage control can also be mandatory for different types of assets such as generators or storage (FI).

In most countries, DSOs use technical possibilities to manage their networks, such as using tap changer transformers or network improvements of lines feeders and transformers (PL, SLO, PT, ES). In many countries, inverters at DL are required to provide grid support via active and reactive power functions (CZ, SLO, CY). Approaches can also differ according to the voltage level. For example, in the Czech Republic, DSOs at the MV/HV level contract reactive power-based voltage control services from individual providers/units on a bilateral basis, while at LV level, grid support is provided through requested functions of inverters. Another example is Slovenia, where smart photovoltaic PV inverters are used at LV level, reactive power obligations for generators at MV level, tap changers on HV/MV transformers, and capacitor banks at HV level, where needed.

Which barriers have you identified in the context of your work in OneNet and how are you planning to address them?

The identified barriers vary from country to country. They include:

- TSO-DSO coordination (LT, PL, CY, GR, FR)
- Regulatory barriers (LV, PL, SLO, PT, ES)
- Lack of incentives for DSOs to use market-based solutions (LV, PL, PT, ES)

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- Lack of physical and/or digital infrastructure (e.g. platforms) and tools (e.g. forecasting) (LV, SLO, GR)
- Lack of market participants / market liquidity (LV, CY, ES)
- Insufficient harmonisation of products and services so far (FI, EST, GR)
- Data exchange and related issues such as privacy, consent, sub-metering etc. (EST, FR)
- Lack of qualified personnel to implement flexibility markets (SLO)

Some demos mentioned specific plans to overcome certain barriers. The majority, however, stated that the solutions to overcome these barriers would be developed in the OneNet project, including via the cascade funding. Some also referred to working groups that were set up at the national or regional level to address certain barriers. The Portuguese demo referred to the use of a simulation-based approach.

Do you plan to test congestion management and voltage control via a market-based process?

Market-based processes for congestion management and voltage control were planned to be tested in some, but not all OneNet demonstrators. Some countries of the Northern Cluster (FI, EST), all countries of the Eastern Cluster (PL, HU, SLO, CZ), both countries of the Southern Cluster (CY, GR) and one country of the Western Cluster (ES) aimed to test a market-based approach. Latvia and Lithuania said they would test the use of flexibility products in balancing markets but were not planning to set up a flexibility market. The French demo indicated that it was not going to implement a market-based approach, and the Portuguese demo aimed to work with a simulation-based approach.

3.1.3 Conclusions from the first consultation moment

Overall, the workshop revealed that in November 2021, most countries related to the OneNet demonstrators did not have organized markets for congestion management or voltage control. There is mostly no remuneration for counter actions due to the emergency character of the situation.

TSOs and DSOs used a combination of technical measures and other solutions. It was observed that central dispatch arrangements are used in some countries where TSOs determine the dispatch values based on the prices and technical parameters provided by resources as well as the whole network model. The TSO then constructs a schedule and issues instructions directly to resources.

Some countries did not face congestions at the national level and therefore did not consider the implementation of a market-based approach a priority. It also became clear that not all OneNet demos would be working on the implementation of a market-based approach. Some, like Portugal, would be concentrating on a simulation-based approach, while others, like France, would be focusing on data exchange.

While barriers varied widely across countries, the most commonly referred to were TSO-DSO coordination, regulatory barriers and a lack of incentives for DSOs to use market-based solutions.

Existing EU legislation on markets for congestion management is focused on cross-zonal congestions, while legislation on intra-zonal markets for congestion management and voltage control is still in a nascent stage. As more flexibility providers emerge, especially at the distribution level, and as both market parties and system operators require more flexibility to manage volatilities from renewable energy sources, a fit-for-purpose legal and regulatory framework will be needed to cover more markets and products.

For a more in-depth analysis of the first consultation moment, please consult [3].

3.2 Second consultation moment (T3.3): Efficiency, barriers, and consumer-centricity in TSO-DSO coordinated flexibility markets

3.2.1 Scope of the workshop and consultation moment

T3.3 organized a workshop and consultation moment, in March 2023, entitled "TSO-DSO Coordinated Flexibility Markets: Efficiency, Barriers, and Consumer-Centricity". The workshop and consultation moment focused on the different developments within T3.3, within the scope of TSO-DSO coordinated flexibility markets, consumer products, and efficient market design, all being a key focus of WP3, towards achieving its overarching objective of advancing "the design of efficient, integrated, and scalable markets for the procurement of system services by DSOs and TSOs with seamless coordination between the different actors involved".

The workshop focused on the development along three different subtasks within T3.3 covering:

1. TSO-DSO coordinated flexibility markets: Efficiency and sensitivity to entry barriers. This analysis is based on a developed set of TSO-DSO coordinated flexibility market models and simulation environment. It aims at analyzing and comparing different TSO-DSO coordinated market designs as well as analyzing their sensitivity to different aspects, such as: entry barriers, pricing of TSO-DSO interface flows, FSP bidding and strategic behavior, bid formats, etc.
2. Consumer-centricity in flexibility markets: The focus was on capturing how consumer-centricity can be defined in the scope of TSO-DSO coordinated flexibility markets.
3. Interconnection between markets: The focus here was on the linking of flexibility markets through bid forwarding and the technical and regulatory conditions and barriers that enable/hinder it.

In this respect, the goal of the workshop was to present the results of the developments within the task achieved to date and receive feedback from the different demonstration clusters and the general OneNet consortium. The entire OneNet consortium was invited to the workshop and consultation moment. In addition, the slides used in the workshop, providing an overview of the work, were provided to the demo clusters ahead of the workshop. Each demo cluster was asked to review the slides and select one representative to provide feedback during the workshop.

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During the workshop, ten interactive online polls in the form of multiple-choice questions were used to collect ad-hoc feedback from the audience on keys aspects of the developments within T3.3.

3.2.2 Feedback received

Each demo cluster provided feedback on the presented methodologies and interim results of T3.3. The demo clusters highlighted the positive complementarity between the research work and the practical implementations in the demos. Additionally, the importance of focusing on the engagement of consumers and the value brought to them by providing flexibility were mentioned, which are elements within the core focus of WP11.

The poll questions and results are presented next (Table 3-2), where the percentage of the attendees who chose each option is included followed by the number of responses in paratheses.

Table 3-2: Overview of the audience polls asked in the second project-internal consultation moment

Poll nr.	Question	Answers
1	What is the element you consider having the most impact on the efficiency of the TSO-DSO flexibility market procurement process?	○ TSO-DSO coordination scheme (i.e. market model, design, and clearing mechanism) → 88% (24) ○ Entry barriers → 3% (1) ○ Allowed bid formats → 0% (0) ○ Consumer centricity → 7% (2) ○ Strategic behavior → 0% (0) ○ Other → 0% (0)
2	What is the primary factor that renders a TSO-DSO coordinated flexibility market consumer-centric?	○ TSO-DSO coordination scheme → 15% (4) ○ Product definition and service delivery requirements → 57% (15) ○ Market entry requirements (e.g. aggregation rules) → 23% (6) ○ Baseline methodologies → 3% (1)
3	Which product attribute you consider having the most impact on the introduction/removal of entry barriers?	○ Minimum bid size entry requirement → 78% (22) ○ Bid granularity → 0% (0) ○ Available bid formats (simple, complex, etc.) → 7% (2) ○ Activation time → 14% (4)
4	What characterizes consumer centricity the most?	○ The focus on the value the consumer can get → 48% (14) ○ The inclusion of consumer's experience when developing a product or setting a rule → 31% (9) ○ The lowest fare for the consumer → 6% (2) ○ The understanding that consumers can be non-identical → 10% (3) ○ The ability for the consumer to choose what to consume rather than just how much → 3% (1)
5	Do you agree with our definition of a consumer-centric product?	○ Yes, it is fine and useful → 52% (10) ○ Yes, it is fine but not very operational → 36% (7) ○ No, I think the definition proposed misses some important elements → 10% (2)
6	Do you agree with our definition of a consumer-centric TSO-DSO flexibility market?	○ Yes, it is fine and useful → 52% (11) ○ Yes, it is fine but not very operational → 47% (10)

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		○ No, I think the definition proposed misses some important elements → 0% (0)
7	Do you see negative implications from more consumer-centric TSO-DSO flexibility markets?	○ Yes, physical constraints of the grid may be difficult to be respected → 18% (4) ○ Yes, simplified entry requirements can jeopardize the adequate provision of critical grid services → 18% (4) ○ No, more consumer-centricity incentivizes market parties and system operators to come up with new solutions for an efficient and secure functioning of the system → 50% (11) ○ It is difficult to say → 13% (3)
8	Which market participant should be responsible for forwarding unused bids from one market to another?	○ Market operator of the first market → 54% (12) ○ The FSP owning the bids in the first market → 9% (2) ○ An independent agent aggregating original bids from first market → 22% (5) ○ System operator(s) of the area of the first market → 13% (3)
9	Which of the proposed solutions [on bid forwarding] can be the most challenging one to implement?	○ Simplified prequalification (and re-prequalification) → 25% (5) ○ Definition of clear roles and responsibilities → 35% (7) ○ Technology-agnostic aggregation → 30% (6) ○ Adjusting market timing to facilitate coordination → 10% (2)
10	Can you identify any other relevant barrier to the bid forwarding process that we have not presented here?	○ Yes → 17% (3) ○ No → 82% (14)

In terms of the different concepts and drivers, the poll results were in line with the expectations of T3.3 partners, and the key elements taken up in their analyses. A reflection on the results and clarifications needed were also provided during the workshop. The feedback from the polls asking specifically about the presented definitions (e.g. polls 5 and 6) were considered in the further development of the corresponding subtasks in the remaining time within the task, hence, also fulfilling one of the main goals of the consultation activity.

3.2.3 Conclusion from the second consultation moment

In conclusion, the received feedback was positive on the different developments within T3.3. The consultation moment allowed T3.3 partners to present the development of their work to the demos and other OneNet participants and to receive their feedback and engage in a dynamic discussion. The overall goal was, in addition, to receive specific feedback, in terms of whether any of the demos or participants see any major elements or aspects that have not been considered so far in the analysis and should otherwise be considered. However, the overall feedback did not point out to any such missing elements, hence, achieving the overarching goals of the consultation moment.

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4 External GRIFOn workshop

GRIFOn is an innovative approach in generating European-wide consensus about OneNet proposed solutions by integrating external stakeholders in the development key solutions. GRIFOn is implemented via workshops on specific project-related topics.

In this section, we describe the contribution of WP3 to the first GRIFOn Workshop which took place on 5 November 2021 and focused (for the WP3 part) on services, products and market design for a harmonised European electricity market. Note that a complete report of the workshop is available in [17].

The workshop included presentations on the following topics:

- Frameworks for services, products and market frameworks;
- Best practices and challenges in market design;
- Challenges in market integration.

The presentations were followed by a panel discussion on:

- Options to solve local congestions in both transmission and distribution grids;
- Product design approaches;
- Mechanisms facilitating the engagement of FSPs;
- System services procurement approaches; and
- Co-optimization of energy and reserves.

After the panel discussion, the audience was polled to receive their feedback on specific topics. The poll questions were:

- There are multiple options to solve local congestions in both transmission and distribution grids. What is, according to you, the preferred solution in case regulation allows them?
- When defining flexibility products, it is possible to design products that serve multiple TSOs, multiple DSOs or a combination of TSOs and DSOs. Furthermore, it is also possible to design flexibility products that could be used to deliver more than one system service (e.g. a flexibility product that can be used to facilitate frequency and congestion management). Two potential approaches have been identified to deliver these products: A super product approach and a flexibility supermarket. What are the key elements when deciding on opting for super products or a supermarket approach?
- To reflect potential technical constraints, system operators specify a minimum amount of power (or change in power) that FSPs need to include in their bid when defining flexibility products. This minimum size of the bid limits the direct participation in the market of some consumers connected

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to the low voltage network. What are the mechanisms SOs should use to facilitate engagement with FSPs to determine that minimum size?

- System services can be procured via a centralized or decentralized approach. In a centralized approach TSOs and DSOs procure from FSPs the products for system services in a single (e.g. country-wide) common market. In a decentralized approach, multiple markets exist at local level and TSOs and DSOs may be single buyers in different markets. However, bids can be forwarded from one market to another. Which services fit better with the common TSO-DSO market model? Which services fit better with the local market model?
- Co-optimization refers to the simultaneous optimization of two or more different, yet related, resources. Currently, the procurement of reserves is separated from energy markets in Europe. Co-optimized markets allow for the generation capacity to be allocated for provision of energy or reserves enabling most valuable use of the capacity and potentially leading to lower costs. Co-optimization evaluates the lost opportunity costs and trade-offs when allocating products (energy, reserve). What are the pros or cons of implementing co-optimization of energy and reserves in the day-ahead timeframe as part of the future market design?

The WP12 leader together with the OneNet coordinator concluded that GRIFOn is a key concept of the OneNet project. The OneNet ambitions and project goals require a Europe-wide consensus about our proposed solutions. To strengthen the consensus about OneNet proposed solutions, GRIFOn is engaging as many external stakeholders as possible. The feedback from these stakeholders is used to improve the OneNet proposed solutions. In carrying out the first GRIFOn workshop, OneNet showed that the project can engage with many external stakeholders [17]. Taking the learnings from the first workshop, OneNet further developed the GRIFOn idea and particularly focused on improving the direct exchange with external stakeholders.

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Annex A A summary of the FWGL DR provisions with regard to baselining, prequalification and local market operation

A.1 Baselining

In the following, we first summarize the key elements regarding baselining from the FWGL DR. We then highlight the relevant points from the proposal for an electricity market design reform.

A.1.1 FWGL DR

In the context of baselining, the FWGL DR

- Sets the context in which baselining is considered and gives a definition of baselining in that context;
- Clarifies obligations for the use of baselining;
- Defines the relationship between the EU and national level;
- Sets objectives of the new rules to be developed; and
- Provides considerations for submetering and data exchange for settlement.

Baselining context and definition

The FWGL DR assumes that an aggregator is the service provider (as opposed to the customer herself). It thus covers the relationship between the aggregator and the SO (and not the contractual relationship between the consumer and the aggregator). In other words, the FWGL DR considers the baseline from the perspective of the SO in relation to the service provider.

In this context, the baseline is defined as the counterfactual reference about what the allocated volume of the service provider's balance responsible party (BRP)[21] would be in the absence of the activation for the provision of the respective service, to quantify and measure the actual delivery of the service.

Baselining obligations

The FWGL DR clarifies that it shall not be mandatory to use the baselining approach for validating the activation. The SO can implement alternatives such as taking the final position of the service provider's BRP as the baseline, to be used as reference for the delivery of the service (known as "buy your BL" principle).

[21] BRP (as defined in Art. 2(7) of the EB GL) means a market participant or its chosen representative responsible for its imbalances.

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Relationship between EU and national level

The FWGL DR clarifies the relationship between the EU and national levels in specifying baselines. Where baselining is used, general principles for its establishment shall be defined at EU level, while the details shall be established at national level.

In the short term, it is not necessarily the aim to set a harmonised European methodology for baselining. In the long term, subject to the assessment of benefits, a further harmonization across Member States may be possible. It is also clarified that the baseline could be different depending on products and timeframes. At the same time, the target is not necessarily to have one baseline per product and per timeframe.

Objectives of the new rules

The new rules at EU level shall establish high-level principles for the baseline methodology following commonly known criteria. The baseline shall be easy to implement, transparent and accurate, and the opportunity for gaming based on a manipulation of the baseline shall be prevented. The FWGL DR also expresses a preference for an objective calculation method to make the baseline replicable and non-manipulable. Alternatives such as a forecast by the service provider shall also be possible if there is a procedure for an ex-post check for accuracy.

The new rules shall define the minimum content to be included in the terms and conditions for service providers regarding the baseline methodology and the processes for its definition, calculation and validation. They shall provide a clear framework for the validation of the baseline, which could include ex-post analysis by the SO or ex-ante adjustment coefficients based on real-time measurements. The validation is important to ensure that the baseline is as consistent as possible with the actual profile of the resources.

Considerations for sub-metering

The FWGL DR specifies that at least (but not only) where the deployment of smart meters is delayed, the new rules shall specify the conditions for the usage of sub-meters for the measurement of the provision of the service. They shall provide a definition of sub-meters, set up principles for the use of the data to avoid manipulation, and include provisions on roles, data collection, verification, and compliance with relevant standards including interoperability rules.

Data exchange for settlement

For settlement, the new rules shall include provisions covering the data exchange between service provider and SO related to the provision and validation of the service, including data related to baselining. This includes the definition of which data is to be communicated and related roles and responsibilities.

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Overall, the new rules shall ensure consistency among volumes involved, position of the BRPs, imbalance adjustment, and the service provided. They shall also ensure that there is no uncertainty on measurements and allocation of corrections, especially when the aggregator and the BRP are different entities.

A.1.2 Proposal for an electricity market design reform

The European Commission's proposal for a reform of the electricity market design includes, among others, new rules concerning the procurement by TSOs of demand response in the form of a peak shaving product and rules allowing TSOs and DSOs to use data from submeters ("dedicated metering devices") [14].

The peak shaving product may be designed and procured by TSOs to enable demand side response to contribute to decreasing peaks of consumption in the electricity system at specific hours of the day. The product aims to ensure the efficient integration of electricity generated from variable RES and to reduce the need for fossil-fuel based electricity generation in times when there is high demand for electricity combined with low levels of electricity generation from variable RES. The procurement of the peak shaving product should take place in such a way that it does not overlap with the activation of balancing products. To verify volumes of activated demand reduction, the TSO should develop and use a baseline reflecting the expected electricity consumption without the activation of the peak shaving product.

Where smart meters are not yet installed and where they do not provide for sufficient level of data granularity, TSOs and DSOs should be able to use data from dedicated metering devices for the observability and settlement of flexibility services such as DR and energy storage. This aims to facilitate the active participation of the consumers in the market and the development of their DR. The use of data from these dedicated metering devices should be accompanied by quality requirements relating to the data.

A.2 Prequalification and ex-post verification in the FWGL DR

In the context of prequalification and ex-post verification, the FWGL DR:

- provides the context and definition for "ex-ante prequalification" and "ex-post verification";
- sets out general principles, requirements and processes;
- aims to simplify the prequalification processes at EU and national level;
- provides basic principles for the definition of requirements for efficient and standardized data exchange processes at national level.

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Prequalification and ex-post verification context and definition

The provision of flexibility services by FSPs envisages the compliance of certain eligibility criteria, to check if the required technical requirements are met and whether the activation will not cause additional congestions. For that purpose, two processes are defined within the FWGL DR [7] to check this compatibility, namely:

- **'ex-ante prequalification'** is the **ex-ante** process to check the compliance of a potential FSP with the technical requirements set by the SO for the provision of a specific product (product prequalification) and where applicable, the process to verify the ability of the grid to technically accept the delivery of this product (grid prequalification). In the product prequalification, the SO may require the potential FSP to overcome activation tests[22].
- **'ex-post verification'** is the process that checks the compliance of a qualified FSP with the technical requirements set by the SO for the provision of a specific product based on the service delivery and on certain verification criteria set by the SO.

General principles, requirements and processes

Overall, the prequalification process shall be user-friendly, non-discriminatory, fair, objective, transparent, using minimum and standardized steps. In that sense, the requirements should be limited to the technically necessary to ensure system security and grid operation and should lower entry barriers. If testing is technically needed to ensure system stability and operation, it shall be conducted by the contracting SO in cooperation with the connecting SO. In case several SOs procure the same products, the rules should clarify who should execute the test. It is also important to ensure a balance between the size of the assets and the extension of the prequalification process, meaning that the burden of the process shall be proportionate to the size of the SPUs or SPGs, as well as its impact on the system security and grid operation in case of non-delivery.

Three concepts are introduced for prequalification:

- **Grid prequalification** - aims at verifying that the delivery of a service can be technically supported by the connecting grid and any intermediate grids. The new rules shall clarify the concept of conditional or long-term grid prequalification and shall define the principles and criteria allowing SO to set limits under this type of grid prequalification. These criteria shall be public, transparent, verifiable and accurate.
- **FSP prequalification** – to verify its capability to deliver a service, having the adequate communication tools or the data correctly registered together with the associated units.

[22] In these activation tests, the SO sends an activation signal to the FSP's assets under normal operating conditions, to verify if these can actually be activated when needed, if they meet the product requirements and whether the relevant data can indeed be exchanged.

- **Product prequalification –** to verify the compliance of the asset(s) of the FSP to the technical requirements of the service. When appropriate, SOs may perform an activation test to confirm that the FSP has the adequate assets to deliver the requested product.

Simplification of prequalification processes at EU and national levels

With the aim to simplify the process of prequalification, for standard balancing products, a unique and common prequalification process shall be defined at EU level per product for different situations with same steps, lead times and technical requirements. The first-time prequalification of potential RPUs and RPGs shall be simplified if they comprise units similar to other prequalified RPUs and RPGs for the same product. Only the relevant changes in prequalified RPUs and RPGs for the service provision shall be submitted to a new prequalification process. For that purpose, the new rules shall define criteria to consider changes as relevant. The prequalification processes required after significant changes in prequalified RPUs and RPGs shall be simplified, including a reduction in the steps and lead times. Moreover, the prequalification activation tests shall be minimized, particularly for small units.

For specific balancing, congestion management and voltage control products, an ex-post verification process shall be required by default, consisting of qualifying the FSP to ensure it has a settlement account, financial liabilities and legal provisions. The ex-post verification based on service delivery and verification criteria should be defined at Member State (MS) level, and if the FSP participates in multiple SO products it shall submit only one application.

The new rules shall establish the technical criteria that will allow SOs to deviate from the ex-post product verification process and thus perform an ex-ante product prequalification process at SPU or SPG level as a prerequisite to provide the product.

An overview of these processes can be found in Figure A.1.

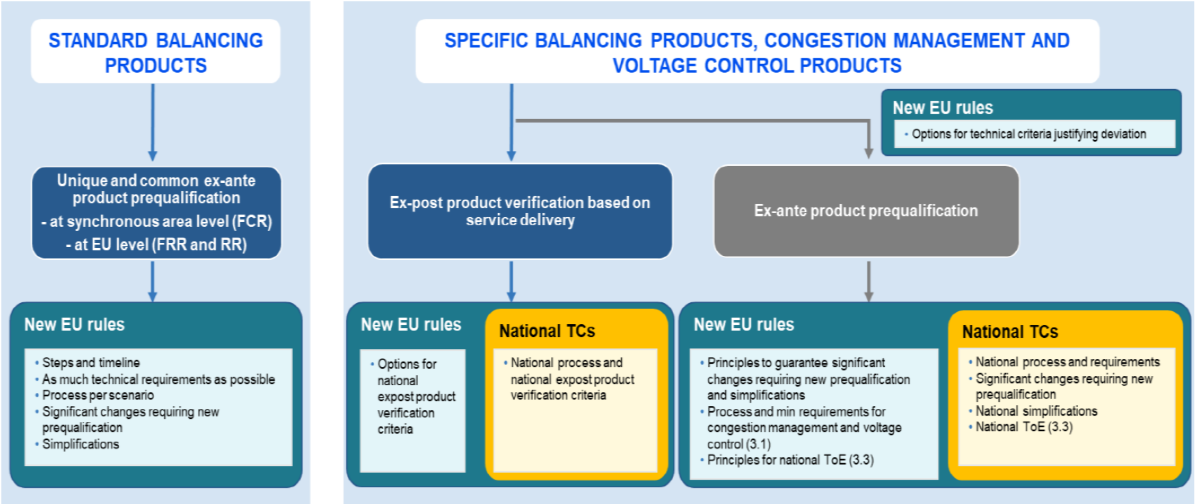

Figure A.1: Overview of the ex-ante prequalification and ex-post verification process proposed to access the different SO products, source: ACER [7]

Principles and processes should be applicable for all SOs in each MS, to propose common national terms and conditions or a methodology to define all ex-post verification and prequalification processes for SOs services. Principles and requirements shall be designed with the view of minimizing effort, resources and time from FSPs when an ex-ante prequalification process is required at service providing unit or group of units. The FWGL DR advises ENTSO-E and EU DSO to propose an EU methodology for further harmonization of prequalification processes.

Avoid duplications in product prequalification processes

Duplications in prequalification processes should be avoided by only requiring prequalification to happen once if multiple SOs procure the same product. Principles and requirements for SOs should be defined with a ToE between minimum technical requirements of each product requiring prequalification and procured within each MS. It is also a best practice to establish, at MS level, TCMs to propose the first concept of the ToE, by mapping all minimum technical requirements, common and comparable attributes, minimum technical requirements that cannot be comparable or ranked or that are unique for each SO. In the end, a procedure to avoid duplicates in the prequalification processes shall be defined by accepting existing prequalification in one product as prequalification for another product, if the ToE indicates that the existing prequalification is more challenging.

A.3 Local market operation in the FWGL DR

The FWGL DR outlines that local SO services may be procured in dedicated local market for SO services, or through bids in other wholesale markets (DA, ID, BA). In this context, the FWGL DR:

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- Provides comprehensive directives regarding the operation of local markets for SO services considering their coordination with wholesale markets;
- Indicates the different entities that could assume the market operator role in local market solutions;
- Defines the responsibilities that market operators must undertake;
- Describes the principles applicable to all market operators; and
- Highlights various considerations that come into play when a local market is operated by a third-party.

Local market for SO services definition and operation

According to the FWGL DR, a local market for SO services (or local market) is defined as a market where service providers offer products for local SO services, these services are referred to the market-based procurement of congestion management or voltage control. Furthermore, the FWGL DR emphasizes that SOs can procure local SO services from a local market operated by:

- The procuring SO itself, alone or together with other SOs
- A different SO or different SOs
- A third-party who is not a SO

Market operator responsibilities

The new rules shall provide that the national terms and conditions (TC) for the design of local markets for SO services outline the roles, responsibilities, and interactions between SOs, market operators, and wholesale markets. Additionally, the FWGL DR highlights the following local market operator responsibilities:

- The development and maintenance of the IT solution (market platform).
- Communication with the service providers (SPs).
- The settlement and clearing of the bids.

However, the selection and activation of the bids and control of delivered services remain the responsibility of the SO.

Market design principles applicable to all market operators

The FWGL DR also defines market design principles that apply to all MOs:

- The MO should be neutral regarding all SPs and technologies and how their offers are presented to SOs.
- The market should be accessible to all market participants, who should be treated equally whatever their technology.
- The MO shall protect confidential data received from the SPs and SOs.
- The new rules shall require that the MO to at least publish the following information: structure, number and clearing of market sections, gate closures times, and product traded.

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- Furthermore, the FWGL DR indicates that the SOs shall share the following information with market participants through all relevant platforms. For instance, for the market-based procurement and activation of congestion management products SOs shall publish:
    - The TC for local SPs, standardized products, and pricing mechanisms
    - Requirements for becoming a SP, including prequalification requirements
    - Information on the area of delivery (network points), forecast about the expected number of events, the timing of events and the resulting need for congestion management, bid selection criteria, and reserve price (if applicable).
    - Market results and activation, including information on volumes, price, bids

Third-party market operator considerations

The FWG DR includes several considerations that come into play when a local market is operated by a third-party:

- The national TC shall define whether a MO, different from the procuring SO, is allowed to recombine bids to suit the needs of an SO. The MO shall not perform any arbitrage in the bid selection. Moreover, the national TC shall indicate whether a MO is allowed to forward bids to other wholesale markets, recombined or not, subject to the SP's consent and when the concerned product is compatible with the concerned wholesale market.
- The new rules shall provide that any third-party MO must be independent from all market activities, i.e. supply and demand in electricity markets, with the potential exception of the regrouping of bids mentioned above.
- The new rules shall establish a process enabling the SOs to ensure the independence of a third-party MO providing common principles for a governance model for third-party operators of local markets to be further developed in the national TC for the overall market design.

Market interaction and SO coordination when a local market is implemented

The new rules shall establish:

- Principles for coordination of local markets with other wholesale markets promoting good coordination between SOs and ensuring coherence in the interaction across different markets and timeframes.
- If the SOs are allowed to procure bids from other wholesale markets to use for local SO services.

Each SO is responsible for solving congestion and voltage control issues on its own grid. Thus, the cost for local SO services are allocated to this SO, independently of the grid to which the activated resources are connected.

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Annex B Description of baselining methodologies

High X of Y: From an original pool of the last Z calendar days, the last Y days are selected after applying the exclusion rules (e.g. exclude the weekend days if the service is needed on a weekday; exclude the days in which the service was provided). The Y days are ranked according to their daily load from the highest to the lowest, after which the highest X days are selected. The estimated load of the event day is the average of the load of the same hour for the X days. There are also several variations possible for this type, such as the Mid X of Y method, or the Last Y days (all Y days are used) method.

Regression: These methods use past consumption data together with other relevant characteristics (e.g. type of consumer, temperature, season, day of the week) to generate a baseline function for every FSP. This function is estimated by the use of regression techniques and is used to generate the baseline for every flexibility activation.

Comparable day: This method identifies a representative day in the past, to be taken as a reference for the computation of the baseline, using historical meter data. To select days with similar load characteristics, match-day criteria based on load or temperature can be used.

Rolling average: This method uses historical meter data from many days (e.g. 30 past days) on a moving average fashion, but gives greater weight to the most recent days.

Statistical sampling: This method can be used when data from individual sites is not available, but data from a meter that aggregates or is representative of several sites is available instead. The meter data can be used to create a baseline for a group of sites, followed by the application of a method to allocate the load to specific sites. It is used in cases where statistical interference is needed to estimate the electricity consumption of an aggregated demand resource because not all consumers are provided with a smart meter. With the increase in numbers of (residential) smart meters, the need for these types of methods is likely to decrease [18].

Meter before/meter after (MBMA): This is a static method that uses the metered value instants before the activation of the flexibility and the metered data during the activation period.

Maximum base load (MBL): This is a static method that first identifies the maximum power usage expected of each customer. It then sets a specific level of electricity usage that is equal to the maximum level, minus the committed capacity of the customers. This method uses historical meter data to obtain the MBL considering previous year's peaks, either coincident or noncoincident, i.e. using peak hours of the previous year based on system load peaks or determined by individual load behaviour.

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Meter generator output (MGO): This method is used when a generation asset is located behind the customer's main meter, where the demand reduction value is based on the output of the generation asset. Depending on the configuration of the meter(s) (i.e. net meter only or additional generation meter), different options for baselines exist. One option mentioned more often in the literature is the "zero baseline" for backup generators. [18][18] refer to this option as "*generation offset only*." Assuming the existence of an additional generation meter, it means that the baseline is effectively zero, and any generation by the asset behind the generation meter is considered as "demand reduction" for the purpose of determining the level of the system service.

Machine learning techniques: Such methods use advanced algorithms to estimate baselines. An example are neural networks of interconnected layers of nodes that learn patterns from data. They can capture complex relationships and make accurate baseline predictions. Another example are unsupervised learning techniques that help identify patterns and structures in data without the need for labelled examples.

Control groups: This approach involves creating a control group with a very similar load pattern to that of the treatment group but does not participate in the flexibility market. The baseline is then defined by assuming that the control group and the treatment group would have had a similar power consumption in the absence of the activation.

Self-declared baseline: Instead of calculating the baseline based on metered data, the (D)SO requests the FSP to submit a consumption/generation profile before activation. The FSP may use any of the above methods to estimate its own baseline if the required input data for calculation is available. To avoid gaming, the (D)SO can set mechanisms to check how representative the baseline submitted is. The submission by the FSP is the basis for calculating a baseline for settlement. There is typically a penalty in case deviation is substantial.

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