Review on markets and platforms in related activities

D2.1

Authors:

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About OneNet

OneNet will provide 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 E.DSO, 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 E.DSO, Elering, EDP Distribuiçao/E-REDES, RWTH Aachen University, University of Comillas, VITO, European Dynamics, UBITECH Energy, 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
aFRR	Automatic Frequency Restoration Reserve
BRP	Balancing Responsible Party
BSP	Balancing Service Provider
BaU	Business as Usual
BUC	Business Use Case
CIM	Common Information Model
DSF	Demand Side Flexibility
DSO	Distribution System Operator
ESCO	Energy Service Company
FSP	Flexibility Service Provider
FCR	Frequency Containment Reserve
HERM	Harmonized Electricity Role Model
ICT	Information and Communications Technology
mFRR	Manual Frequency Restoration Reserve
MO	Market Operator
PCI	Projects of Common Interest
RES	Renewable Energy Sources
RR	Replacement Reserve
SUC	System Use Case
TSO	Transmission System Operator

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Executive Summary

Power markets are being completely transformed by the massive entry of Renewable Energy Sources and the electrical grid is moving towards being more decentralized. As a result, the consumer role is evolving towards a more active one. The mission of OneNet is to create the conditions for a new generation of grid services able to fully exploit demand response, storage and distributed generation while creating fair, transparent and open conditions for the consumer. WP2 aims to define the products and services in support of OneNet by building on the information of previous EU pilot projects and European policy frameworks. In this context, this report is related to the Task 2.1 "Review of best practices in markets and platforms from initiatives, national and EU projects on TSO-DSO-consumer coordination" which aims to define the starting point for building the OneNet concepts. The report provides the outcome of the review performed as part of Task 2.1 of the OneNet project. In total 15 H2020 projects have been reviewed, which were selected based on criteria such as their call ID and topic, their maturity level, and the coordination scheme (TSO-DSO-consumer). Furthermore, 4 national initiatives due to their affinity to OneNet project were also analysed. The main findings of this review process are stated below:

- A common feature among various projects is that regarding system services definition, they all consider addressing a scarcity/need by the network operator as the driver of the service. However, although they all consider different definitions of products, they all indicate that products are the means network operators use to solve the scarcities they face.
- The delivery of frequency control services, mainly provided by TSOs, includes a set of well-established products that are considered in almost all projects evaluated, while for non-frequency control services there appears to be more heterogeneity among the products definitions where all projects adopt their own product definitions.
- Congestion management, frequency control and voltage control are the services most frequently addressed within the reviewed projects. From a total number of 13 projects that have identified the services that they consider, 12 of them consider congestion management, 11 of them consider frequency control, while 10 of them consider voltage control.

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- As pointed out by the analysis of the reviewed projects, several mechanisms have been explored for the procurement of the grid services required by the DSOs or TSOs. This analysis also shows that the majority of the projects address the coordination among main actors TSOs and DSOs and the arrangements or contracts of them with FSPs. However, a relevant share of reviewed projects concerns the joint coordination of TSO, DSO, and flexible service providers.
- IEC-62559-2 is the most commonly used methodology among the 15 projects regarding the Business Use Cases (BUCs) definition, which is also the methodology that the OneNet project will use.
- Most of the projects use the Smart Grid Architecture Model (SGAM) approach to link the developed use cases with ICT infrastructures and to define the interface's boundaries and functionalities among market operator and grid operators.
- Further digitalization, handling data management and security issues, as well as standardization, were the challenges that most of the projects faced and should be addressed at the European level.
- From the national projects, OneNet can utilize mature concepts from flexibility marketplaces and platforms regarding assets prequalification process, data exchange architectures, developed interfaces among actors in the energy value chain, and innovative services directly provided by standardized products from existing wholesale markets.

Based on the findings of this review the starting point for building OneNet was defined.

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1 Introduction

The Energy System is facing an incredible revolution. The end target is the creation of a new energy scenario widely dominated by renewable energy sources and mostly based on distributed energy generation. In this context, the Clean Energy Package for all Europeans seeks to establish a modern design for the EU electricity market, adapted to the new realities of the power system– more flexible, more market-oriented, more consumer-centric and better placed to integrate a greater share of renewables. Since market integration is a keyway to deliver on Europe's energy goals, OneNet aims to provide a seamless near real-time integration of all the actors in the electricity network across countries to create the conditions for a synergistic operation that optimizes the overall energy management while creating an open and fair market structure.

OneNet will develop an open and flexible architecture to transform the actual European electricity system, which is often managed in a fragmented country- or area-level way, into a pan-European smarter and more efficient one, while maximizing the consumer capabilities to participate in an open market structure. To this end, WP2 will set up the stage of the project defining and evaluating a new standardized set of products and services that are considered the key elements to enable a customer-oriented operation in a European integrated grid.

As it is illustrated in Figure 1.1, a high number of interdependencies between the different work packages exist in OneNet. WP2 will collect all the necessary information and relevant experience gained in previous H2020 as well as national projects and transfer it to the horizontal work packages to provide the starting point for their activities. In particular, WP2 will look back at the market solutions and digital platforms presented so far by other EU pilot projects, revisit European policy frameworks, summarize their contributions and benefits, and build on this information to sketch the new products and BUCs proposed in the OneNet approach.

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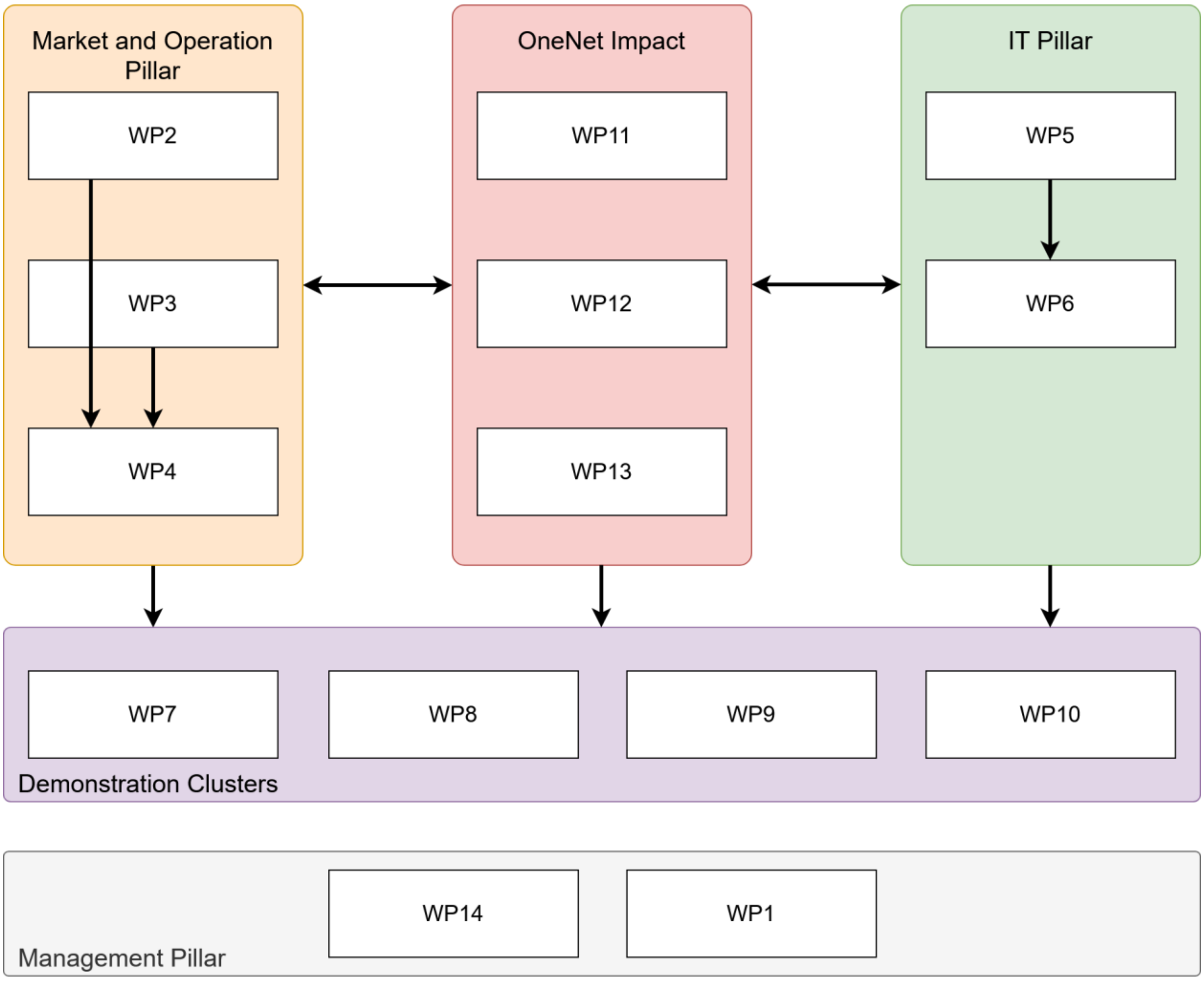

Figure 1.1: OneNet overall work plan structure

The scope of Task 2.1 is to present a detailed review of the best practices related to TSO-DSO-consumer coordination. More specifically, recommendations related to system needs, system services, product design, market design, ICT architecture, grid operation and business models will be analysed. The aim will be to:

- highlight the important achievements so far,
- identify significant scalable technologies and practices implemented on the field, and
- define the starting point for building the OneNet concepts developed in WP2, WP3, WP4, WP5, WP6 with the active participation of the demo clusters through an iterative process and demonstrated in WP7, WP8, WP9 and WP10.

Task 2.1 by forming OneNet starting point will provide input to the tasks illustrated in Figure 1.2.

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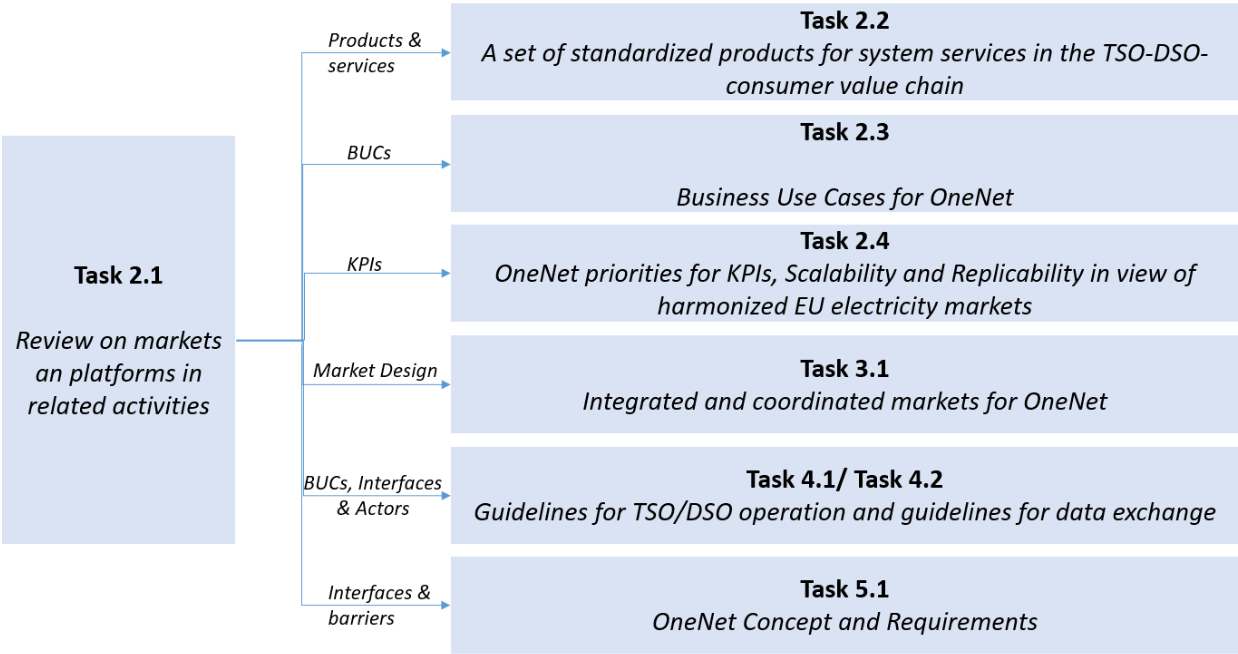

Figure 1.2: Utilization of Task 2.1 outcome to the other OneNet tasks.

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2 Methodology

This report provides the outcomes of Task 2.1 based on a literature review, which was carried out in the first 6 months of the project. The review was performed across a wide variety of energy systems H2020 projects, which were selected based on criteria such as their call ID and topic, their maturity level, and the coordination scheme (TSO-DSO-consumer) they proposed to ensure their relevance to Task 2.1 objectives. Given the fundamental role coordination schemes play in achieving OneNet objectives, the list of projects reviewed included not only projects that focused on DSO-FSP and DSO-TSO coordination, but inter-TSO and inter-DSO cooperation as well. In addition, some projects were reviewed because of their focus on consumer participation in the electricity market since enabling a real citizen inclusion by developing products and services and then coherently markets with the customers at the centre is one of the main cornerstones of the OneNet project.

The methodology that was adopted for the review process is described below:

1. A list of 15 H2020 projects was selected to form the basis for the review. The projects were clustered based on the topic each one addressed. The complete list of reviewed projects is shown in Table 2-1.
2. A questionnaire was circulated to be filled in for each project to gather all the necessary information. The received answers in addition to the available projects' deliverables were studied and the important achievements and proposals on product design, market design and BUCs of each project were reported. The circulated questionnaire can be found in the ANNEX I.
3. In addition to that, four national projects, and collaboration initiatives among several stakeholders in energy sector based on their affinity to OneNet project are analyzed (DA/RE, GOPACS, NODES, and Piclo Flex). Important elements of these projects are presented, providing OneNet valuable information based on which can build upon on.
4. Relevant EU publications and research papers were studied to supplement the findings of the core projects.
5. The major findings were analysed and the starting point for building OneNet was defined.

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Table 2-1: List of H2020 reviewed projects

Call number	Topic	Project name
LC-SC3-ES-5-2018-2020	TSO – DSO – Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation	INTERRFACE
		CoordiNet
LC-SC3-ES-1-2019	Flexibility and retail market options for the distribution grid	Platone
		EUniversal
LC-SC3-ES-2-2019	Solutions for increased regional cross-border cooperation in the transmission grid	FARCROSS
DT-ICT-10-2018-19	Interoperable and smart homes and grids	InterConnect
DT-ICT-11-2019	Big data solutions for energy	Synergy
LCE-04-2017	Demonstration of system integration with smart transmission grid and storage technologies with increasing share of renewables	EU-SysFlex
		Osmose
		Flexitranstore
		CROSSBOW
LCE-05-2017	Tools and technologies for coordination and integration of the European energy system	TDX-Assist
LCE-02-2016	Demonstration of smart grid, storage, and system integration technologies with increasing share of renewables: distribution system	InteGrid
		InterFlex
LCE-06-2015	Transmission grid and wholesale market	SmartNet

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3 Review of best practices related to TSO-DSO-consumers coordination

In the 35th European Electricity Regulatory Forum, the importance of cooperation between DSOs and TSOs [1] on both operation and planning of their networks, as well as the need to reinforce this cooperation in a more structured way at the European level in line with the Electricity Regulation, were underlined. Enhancing this cooperation is a heavily discussed topic across Europe and it has created several relevant actions, such as the establishment of the EU DSO Entity which interacts directly with ENTSO-E at the board level ensuring the close cooperation of these two entities in the sphere of network codes elaboration [2].

In this context, TSO, DSO and consumer cooperation is a key point for OneNet development, and it was taken into consideration through the project review process conducted within WP2. Table 3-1 presents an overview of the agents' coordination schemes that were considered in the reviewed projects. The term "agents" refers to transmission system operators (TSOs), distribution system operator (DSOs), flexibility service providers (FSPs) and market operators (MOs).

Table 3-1: Overview of the coordination schemes explored in the H2020 reviewed projects. Parentheses indicate an indirect exploration of the respective coordination schemes.

Project name	TSO-DSO	TSO-TSO	DSO-DSO	TSO-FSP	DSO-FSP	TSO-MO	DSO-MO
INTERRFACE	X	X			X		
CoordiNet	X		X	X	X		
Platone	X				X	X	X
EUniversal					X		X
EU-SysFlex	X	X	X		X		X
Osmose	X			X			
Flexitranstore	X	X		X	X		
CROSSBOW	X	X			X		
FARCROSS		X				X	
InterConnect					X		
Synergy	X	X	X	X	X		
InteGrid	(X)				X		(X)
InterFlex			X				
TDX-Assist	X	X					
SmartNet	X				X		X

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3.1 Summary of reviewed H2020 projects

In this section, a brief description of the objectives and expected outcomes of the reviewed projects are provided to highlight their relevance to achieving WP2 objectives. From the 15 reviewed projects, 4 were completed (InterFlex, InteGrid, Smartnet and TDX-Assist). For the completed projects, the major outcomes are reported. A more detailed description for the reviewed project can be found in ANNEX II.

3.1.1 INTERRFACE

Starting date	**Ending date**
January 2019	December 2022

Status:

2019												2020												2021												2022											
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12

Brief description:

The INTERRFACE (TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system) project fundamentally aims at supporting greater coordination between TSOs and DSOs facing common challenges for the procurement of distributed flexibility [3]. The INTERRFACE project will design, develop, and exploit an Interoperable pan-European Grid Services Architecture (IEGSA) to act as the interface between power networks (TSO and DSO) and the customers and allow the seamless and coordinated operation of all stakeholders to use and procure common services.

Role within OneNet concept:

Since the definition of a common IT architecture is one of the key elements of OneNet project, the IEGSA architecture which is being developed within INTERRFACE can play, along with CoordiNet, an important role in defining the starting point of OneNet concept.

3.1.2 CoordiNet

Starting date	**Ending date**
January 2019	June 2022

Status:

2019												2020												2021												2022					
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6

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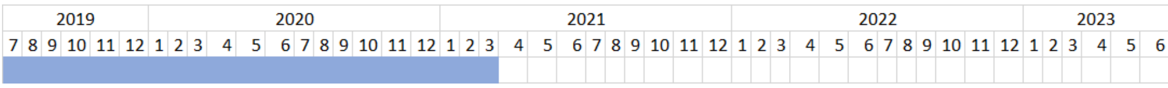
Brief description:
The key objective of CoordiNet is to demonstrate how DSOs and TSOs shall act in a coordinated manner and use the same pool of resources to procure and activate grid services in the most reliable and efficient way through the implementation of large scale "TSO-DSO-Consumer" demonstrations, in cooperation with market participants (and end users). [4]
Role within OneNet concept:
Given that CoordiNet is the twin project of INTERRFACE and that it has already made significant progress towards presenting the best practices on TSO-DSO interaction, its significance for defining OneNet starting point is self-explanatory. Both INTERRFACE and CoordiNet play a crucial role in defining the interactions between TSO and DSO level, as well as between DSO and customer level within OneNet.

3.1.3 Platone

Starting date	Ending date
September 2019	August 2023
Status:	



Brief description:
PLATONE - "PLATform for Operation of distribution Networks –aims to develop an architecture for testing and implementing a data acquisitions system based on a two-layer approach (an access layer for customers and a service layer) that will allow greater stakeholder involvement and will enable an efficient and smart network management. [5]
Role within OneNet concept:
PLATONE focuses on developing innovative tools for DSOs, thus its contribution to OneNet concept lies mostly on providing data models and architecture details for the various platforms that are being developed within the project at DSO level.

3.1.4 EUniversal

Starting date	Ending date
February 2020	July 2023

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Status:

2020												2021												2022												2023						
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7

Brief description:

The primary goal of EUniversal is to implement the Universal Market Enabling Interface (UMEI) concept by bringing forward a universal, open, adaptable and modular approach to interlink active system management with electricity markets and foster the provision of flexibility services, also acknowledging the activation needs of and the coordination requirements with other commercial parties and TSOs. A set of market-oriented flexibility services from DERs will be implemented to answer DSOs' needs in a cost-effectively way, supporting the energy transition [6].

Role within OneNet concept:

EUniversal focuses on the development of market-based flexibility solutions, in accordance to the system requirements, notably the ones from DSOs, and offers a universal solution for interfacing system operation with market platforms

3.1.5 EU-SysFlex

Starting date	**Ending date**
November 2017	October 2021

Status:

2017												2018												2019												2020												2021							
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8

Brief description:

The aim of the EU-SysFlex project is to identify issues and solutions associated with integrating large-scale renewable energy and create a plan to provide practical assistance to power system operators across Europe. This should ultimately lead to identification of a long-term roadmap to facilitate the large-scale integration of renewable energy across Europe [7].

Role within OneNet concept:

EU-SysFlex is on its last year of activities making it one of the most mature of the ongoing projects that were reviewed in WP2. Its major contribution to OneNet concept lies on the product and services definition

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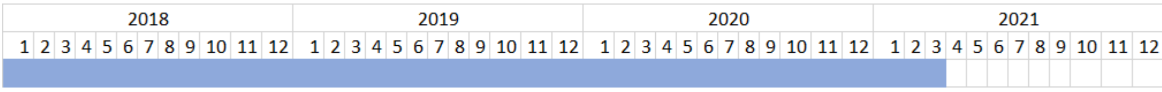
that has been already performed, as well as on linking the regulatory barriers or market design options to product characteristics.

3.1.6 Osmose

Starting date	Ending date
January 2018	December 2021
Status:	



Brief description:

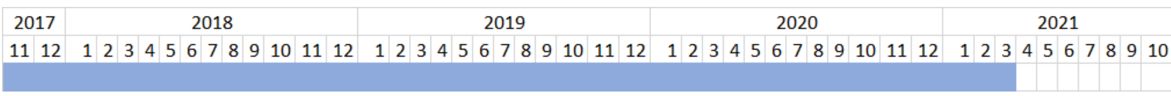
Osmose project aims for the development of flexibilities which can be used for a better integration of RES. The approach chosen is global as it considers at the same time, the increased need of flexibilities in the system (mainly improved balance of supply and demand in electricity markets, provision of existing and future system services and allowance of a dynamic control of electricity flows) and the sources of flexibilities (RES, demand-response, grid and new storages). Osmose approach addresses all system requirements to capture the synergies proposed by the different solutions to avoid stand-alone solutions that might be less efficient in terms of overall efficiency [8].

Role within OneNet concept:

Osmose contribution to OneNet concept lies on the flexibility solutions it proposes both on a market and a more technical level with a special focus on the transmission grid.

3.1.7 Flexitranstore

Starting date	Ending date
November 2017	October 2021
Status:	



Brief description:

FLEXITRANSTORE (An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources) aims to contribute to the evolution

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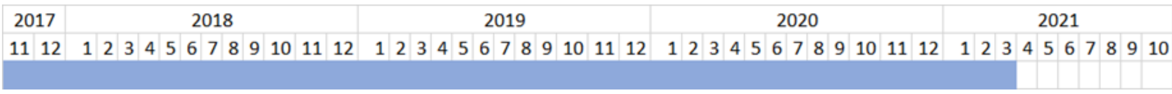
towards a pan-European transmission network with high flexibility and high interconnection levels. In addition, the project aims to develop a next generation Flexible Energy Grid (FEG) platform which can be integrated into the European Internal Energy Market (IEM), through the valorisation of flexibility services. Novel smart grid technologies, control and storage methods and new market approaches will be developed, installed, demonstrated and tested introducing flexibility to the European power system [9].
Role within OneNet concept:
FLEXITRANSTORE is another mature project which is in its last year of activities. It will provide as key input to OneNet the product and system services definitions, as well as the specification of the IT system integration that were produced in the context of developing the FEG platform.

3.1.8 CROSSBOW

Starting date	**Ending date**
November 2017	October 2021
Status:	



Brief description:
CROSSBOW will propose the shared use of resources to foster cross-border management of variable renewable energies and storage units, enabling a higher penetration of clean energies whilst reducing network operational costs and improving economic benefits of RES and storage units. The objective is to demonstrate a number of different, though complementary, technologies, offering Transmission System Operators higher flexibility and robustness through: 1) A better control of exchange power at interconnection points; 2) new storage solutions – distributed and centralized; 3) better ICT and Communications; 4) the definition of a transnational wholesale market, proposing fair and sustainable remuneration for clean energies though the definition of new business models supporting the participation of new players [10].
Role within OneNet concept:
In CROSSBOW a wholesale and ancillary market toolset and a cooperative ownership of flexibility assets platform are being developed. The market design and IT architecture behind these two solutions can provide valuable inputs for OneNet concept.

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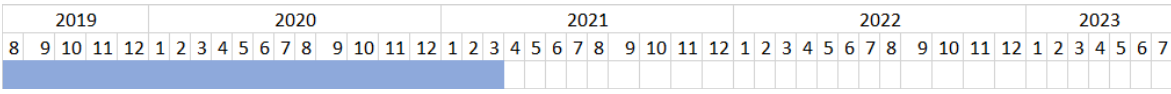
3.1.9 FARCROSS

Starting date	Ending date
October 2019	September 2023

Status:



Brief description:

FARCROSS aims to connect major stakeholders of the energy value chain and demonstrate integrated hardware and software solutions that will facilitate the "unlocking" of the resources for the cross-border electricity flows and regional cooperation and will enhance the exploitation/capacity efficiency of the transmission grid assets. It proposes state-of-the-art digital technologies into the power system, in order to enhance and optimize the coordinated effort between TSOs and between TSOs-energy producers and establishes a next generation electricity market which will operate on a regional basis and will benefit from disperse assets and increased presence of RES, thus creating incomparable economic benefits to the stakeholders of the chain. [11]

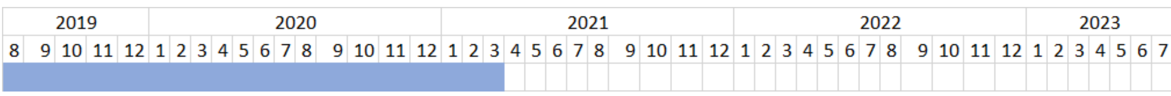
Role within OneNet concept:

FARCROSS will add to OneNet concept a more TSO oriented perspective by providing information about how the coordination between TSOs can be enhanced and what kind of tools and platforms OneNet should consider on the TSO level.

3.1.10InterConnect

Starting date	Ending date
October 2019	September 2023

Status:



Brief description:

InterConnect project aims to bring energy management within reach of the end-users by interoperable solutions connecting smart homes, buildings and grids. The solutions developed within the scope of InterConnect will allow a digitalisation of homes, buildings and electric grids based on an Internet of Things

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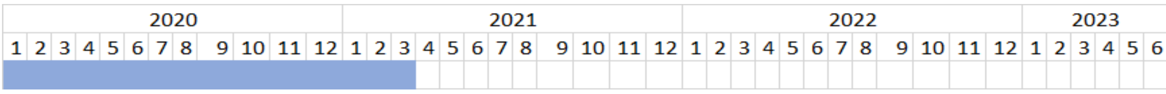
(IoT) architecture. By including digital technologies (artificial intelligence, Blockchain, Cloud and Big Data) based on open standards, such as SAREF, it will guarantee the interoperability between equipment, systems and privacy/cybersecurity of user data. [12]
Role within OneNet concept:
InterConnect importance for OneNet concept lies on bringing the end customer into the picture. This project focuses on how customers can really become active players, through the standardisation of the communication with their own devices, in the future energy system and its key contributions are expected in the area of data modelling.

3.1.11 Synergy

Starting date	**Ending date**
January 2020	June 2023
Status:	
	
Brief description:	
SYNERGY introduces a novel reference big data architecture and platform that leverages data, primary or secondarily related to the electricity domain, coming from diverse sources (APIs, historical data, statistics, sensors/ IoT, weather, energy markets and various other open data sources) to help electricity stakeholders to simultaneously enhance their data reach, improve their internal intelligence on electricity-related optimization functions, while getting involved in novel data (intelligence) sharing/trading models, in order to shift individual decision-making at a collective intelligence level. To this end SYNERGY will develop a highly effective a Big Energy Data Platform and AI Analytics Marketplace, accompanied by big data-enabled applications for the totality of electricity value chain stakeholders (altogether integrated in the SYNERGY Big Data-driven EaaS Framework). [13]	
Role within OneNet concept:	
Synergy project started in January 2020 and therefore its early stage of development does not allow an exhaustive review of the solutions it proposes. Nevertheless, because it is an ICT oriented project it can provide valuable input regarding the more technical aspect of OneNet project regarding data interoperability and big data reference architecture.	

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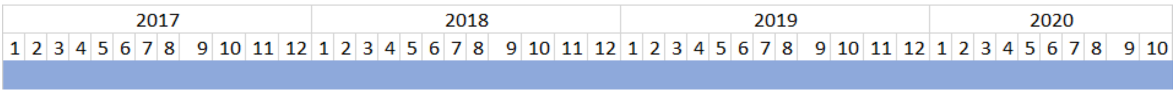
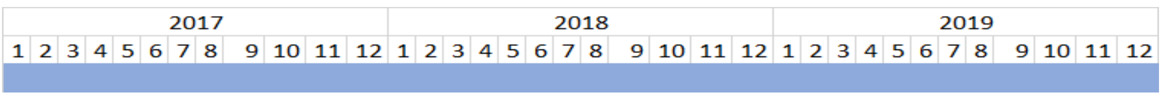
3.1.12 InteGrid

Starting date	**Ending date**
January 2017	October 2020
Status:	
	
Brief description:	
InteGrid's vision was to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services, hence expanding from DSOs distribution and access services to active market facilitation and system optimisation services while ensuring sustainability, security and quality of supply. [14]	
Role within OneNet concept:	
InteGrid focused on the DSO interactions with different stakeholders, stakeholders, and on developments to be made by DSOs to make their operation more aligned with flexibility use, which in addition to the solutions demonstrated should be considered within the OneNet network of platforms.	

3.1.13 InterFlex

Starting date	**Ending date**
January 2017	December 2019
Status:	
	
Brief description:	
InterFlex aimed to demonstrate that combining network automation with the local generation and/or consumption flexibilities (including the coupling between electricity, gas, and heat distribution networks) can make local energy systems more competitive and more reliable [15]. InterFlex was completed in 2019 and the project use cases provided input for the 5 main innovation streams of (1) Local flexibility market, (2) demand response and customer empowerment, (3) smart functions and grid automation, (4) cross energy carrier synergies, (5) multi-service storage and islanding.	
Role within OneNet concept:	

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InterFlex, like InteGrid, focused on the developing tools and systems that would be integrated on distribution grid level. Its contribution to OneNet concept lies in extracting valuable information regarding the market design and systems architecture it demonstrated.

3.1.14TDX-Assist

Starting date	**Ending date**
October 2017	September 2020
Status:	

2017			2018												2019												2020								
10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9

Brief description:
The objective of TDX-Assist was to design and develop novel ICT tools and techniques that would facilitate scalable and secure information systems and data exchange between TSOs and DSOs. The three main novel aspects of the ICT tools and techniques to be developed in the project were as follows: scalability – the tools and techniques will be able to deal with new users and increasingly larger volumes of information and data; security – the tools and techniques will ensure that overall system operation is protected against external threats and attacks; and interoperability – the information exchange and communications between the system operators will be based on existing and emerging international smart grid ICT standards [16].
Role within OneNet concept:
Given that TDX-Assist was an ICT oriented project, its outcomes on data interoperability, information models and cybersecurity tools will be relevant for defining the OneNet starting point mainly in this sphere, notably the direct interaction between TSOs and DSOs for both planning and operational activities.

3.1.15SmartNet

Starting date	**Ending date**
January 2016	June 2019
Status:	

2016												2017												2018												2019					
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6

Brief description:

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The SmartNet project aimed to provide optimised instruments and modalities to improve the coordination between the system operators at national and local level (respectively the TSOs and DSOs), including the exchange of information, for the acquisition of ancillary services (balancing, voltage control, congestion management) from subjects located in the distribution segment (flexible load and distributed generation) [17].
Role within OneNet concept:
SmartNet plays an important role in defining OneNet's starting point because it explores several different coordination schemes involving DSOs and TSOs, thus serving as a relevant knowledge base for leveraging the flexibility services to be implemented and tested within OneNet.

3.2 Analysis of reviewed H2020 projects

3.2.1 Assessment of system services and product designs

The selected projects have considered different challenges and, as a result, they used different methodologies when considering services and products. This section considers the main characteristics of these approaches and identifies the lessons learnt that will be relevant for OneNet. More concretely, this section considers the definitions used for services and products as well as the main characteristics of these services and products.

Many of the projects evaluated in this document do not provide explicit definitions of services or products. Furthermore, there appear to be significant differences even among those that provide these definitions. To compare the definitions of system services, those definitions identified are presented in the table below:

Table 3-2: Definitions of the term "service" in reviewed projects

Project name	Definition of service
CoordiNet	Services provided to DSOs and TSOs to keep the operation of the grid within acceptable limits for the security of supply and are delivered mainly by third parties.[1]
EUniversal	A service is defined as a specific strategy to help satisfy one or several system needs, where the service providers have to comply with the service technical requirements, designed according to the needs they are focused on, to be able to participate. [2]

[1] CoordiNet, D 1.3 "Definition of scenarios and products for the demonstration campaigns " p.23. Available in https://private.coordinet-project.eu//files/documentos/5d72415ced279Coordinet_Deliverable_1.3.pdf

[2] EUniversal, D1.2, "Observatory of research and demonstration initiatives on future electricity grids and markets" p.29. Available in https://euniversal.eu/wp-content/uploads/2021/02/EUniversal_D1.2.pdf

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EU-SysFlex	A system service is defined as the physical action, be it the provision of active or reactive power and/or energy, which is needed to mitigate a particular technical scarcity or scarcities.[3]
Flexitranstore	System services are defined as a need from the system operator that can be supplied by the market participants by bidding their flexibility capacity in the flexibility market.

Table 3-2 shows that a common feature of these definitions is that they all consider addressing a scarcity/need by the network operator as the driver of the service. Based on those findings, a system service will be defined in this project 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.

As for products, the main definitions from previous projects are presented in the following table:

Table 3-3: Definition of the term "product" in reviewed projects

Project name	Definition of product
CoordiNet	Products can be grouped into standard products and specific products. Standard products are defined as "harmonized products for the exchange of grid service(s) with common characteristics across Europe (i.e., shared by all TSOs or by all DSOs or by all TSOs and DSOs)". [...] Specific Products are "products different from standard products". (Location)-specific situations could call for the need to define specific products. [4]
EUniversal	A product is the specific commodity that is negotiated and delivered by the service providers to provide a particular service, which can be described by a set of technical attributes. [5]
EU-SysFlex	A product, contrary to the service, is the "option" that is purchased and remunerated, where the service is what is actually delivered, and the service defines exactly what is needed once a particular option is called upon. For example, manual frequency restoration reserve (mFRR) is a product, while the covered system service is the

[3] EU-SysFlex, D3.2 "Conceptual market organisations for the provision of innovative system services: role models, associated market designs and regulatory frameworks ", p. 23. Available in https://eu-sysflex.com/wp-content/uploads/2020/06/EU-SysFlex_Task-3.2-Deliverable-Final.pdf

[4] CoordiNet, D 1.3 "Definition of scenarios and products for the demonstration campaigns "p.23. Available in https://private.coordinet-project.eu//files/documentos/5d72415ced279Coordinet_Deliverable_1.3.pdf

[5] EUniversal, D1.2, "Observatory of research and demonstration initiatives on future electricity grids and markets" p.29. Available in https://euniversal.eu/wp-content/uploads/2021/02/EUniversal_D1.2.pdf

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	provision of active power to restore the system frequency following a frequency deviation. [6]

These projects have used significantly different definitions of products, but they all indicate that products are the means network operators use to solve the scarcities they face. As a result, in OneNet, a product is defined as a tradable unit that the network operator acquires from flexibility providers and that entails the option to deliver a service in case of activation (this activation can be automatic). The characteristics of the technical scarcity mitigated by the relevant service will determine the attributes of the tradable unit.

Once the definitions have been considered, the next stage is to identify the main services those projects consider.

Table 3-4: Services considered in each project.

Project name	Congestion management	Frequency control	Voltage control	Others
INTERRFACE	√	√	√	
CoordiNet	√	√	√	√
Platone	√	√	√	√
EUniversal	√		√	√
Osmose	√	√	√	√
Flexitranstore	√	√	√	√
CROSSBOW	√	√		
FARCROSS		√		
InterConnect	√	√		
Synergy	√		√	√
InteGrid	√	√	√	
InterFlex	√	√	√	√
TDX- Assist	√	√	√	√

[6] EU-sysflex, D3.2 "Conceptual market organisations for the provision of innovative system services: role models, associated market designs and regulatory frameworks ", p. 23. Available in https://eu-sysflex.com/wp-content/uploads/2020/06/EU-SysFlex_Task-3.2-Deliverable-Final.pdf

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Table 3-4 shows that congestion management, frequency control and voltage control are the services that receive more attention. This would appear consistent with the relevance these scarcities would have in the stability of the system.

In terms of products, it becomes apparent that products can be separated between frequency control and non-frequency control products. The delivery of frequency control services, mainly provided by TSOs, includes a set of well-established products that are considered in almost all projects evaluated. This homogeneity is the result of several factors including the existence of European initiatives for the development of homogenous products (e.g., PICASSO or MARI). [7]

For non-frequency control services (mainly voltage and congestion management) the issue appears to be quite different. For these services, there appears to be more heterogeneity among the products definitions with no two projects using the same product definitions. As a result, it is obvious that in those services there is a bigger margin for the development of standardised or harmonized products. However, one important issue to consider is that contrary to frequency management services, these services are likely to be required by both TSOs and DSOs. As a result, different products could arise given the differences between these users. This topic will be considered in more detail in Task 2.2.

When considering issues of standardisation, however, the INTERRFACE project has an interesting contribution. This project indicates that the main argument in favour of standardised products is to allow for a sufficient level of liquidity (i.e., standardized products allow for building up a merit order to organize competition). As a result, with standardized products price transparency is promoted. However, there are also factors against standardisation. The first argument against standardised products is that with standardised products it is hard to meet the very specific flexibility needs of network operators. A second argument against standardised products is that a catalogue approach allows that unique characteristics of certain flexibility providers (e.g., reaction time or emissions) are valued. Flexibility providers can customize their offers and ask for premiums when an asset has valuable attributes which would otherwise not be valued if they were not part of the product definition. Therefore, it will be important to consider these two effects before higher degrees of standardisation are required.

When defining its products, each project uses a set of attributes or characteristics that differ between projects. In some cases, those attributes not only include characteristics of the tradable unit that the SO acquires but they also include characteristics of the procurement process (e.g., price-setting mechanism) and external factors (e.g., the elasticity of demand). The figure below shows the most commonly used attributes:

[7] Additional information about these initiatives can be found in https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/NC%20EB/entso-e_balancing_in%20_europe_report_Nov2018_web.pdf

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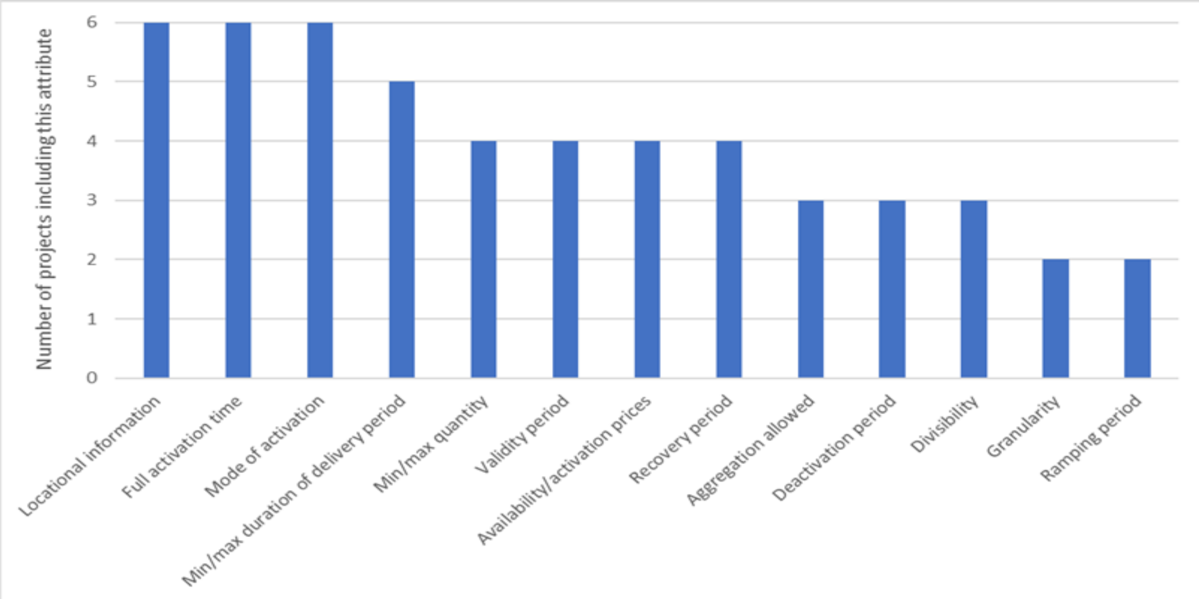

Figure 3.1: Number of projects considering most commonly used attributes.

This figure shows that the attributes being considered to cover a large number of characteristics of these products. Special attention seems to go to factors concerning the timing of the products (e.g., full activation time, the maximum duration of the delivery, recovery period), the inclusion of locational information (a must-have requirement for the delivery of some of the services such as congestion management) and the characteristics of the bid (e.g., divisibility or validity period). Therefore, it seems important to consider a large range of potential attributes when developing product definitions.

An attribute that requires special attention and that, in many cases, is implicitly considered, is the commodity traded. This attribute is composed of two main dimensions. The first one of these dimensions is whether the product reserves capacity or activates flexibility. This attribute could not only affect the operation of the product but also in the incentives to invests that providers of flexibility will be receiving.

A second dimension is whether the product considers active or reactive power. A standard division is that active is used for frequency management and congestion control while reactive energy will be used in voltage control. However, some of these projects (e.g., CoordiNet) also consider voltage regulation by using active power flexibility.

3.2.2 Assessment of mechanisms for acquiring grid services

In a liberalised electricity sector, the operation of the transmission and distribution system is considered as a natural monopoly and demanded to regulated entities, the transmission, and the distribution system operator (TSO and DSO, respectively) [18]. Both transmission and distribution systems can be divided into several areas

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operated by the relevant system operator. Considering the transmission system of a country, it can be operated by one or more TSOs; each TSO is responsible for the operation of the corresponding part of the transmission system. Similarly, considering the distribution system of a country, it can be formed by several areas operated by different DSOs. In general, the role of both TSO and DSO is to operate the respective part of the power system by ensuring the reliability of the electricity supply and the non-discriminatory network access to third parties [19], [20], [21], [22]. The operation of the power system requires coordinating the grid use and solving expected and unexpected grid problems. To accomplish the grid operation, the system operators resort to grid services: actions and measures which include, among others, network congestion, voltage control, balancing, rotor angle stability, system restoration. The need for grid services can be satisfied by the system operator by resorting to own or third-party resources. In the former case, the need for grid service is fulfilled by exploiting resources that belong to the system operator; while, in the latter case, the need for grid services is addressed by the contribution of the resources owned by third parties which operation is adapted to respond to the received signals sent by the relevant system operator to accommodating the power system operation requirements [23].

The system operators can exploit several mechanisms to acquire grid services from third parties (e.g., distributed generators, prosumers, customers, aggregators); a non-exhaustive list of market and non-market-based mechanisms for acquiring grid services is composed of flexible connection and access agreements, dynamic network tariffs, flexibility markets, bilateral contracts, cost-based mechanisms, and obligation [24]. Table 3-5 describes these main mechanisms. Each can be considered elementary since the corresponding features make it a unique process to acquire grid service from third parties [24]. More complex mechanisms are obtainable by combining the features of the mentioned mechanisms. To illustrate, a complex procurement mechanism can be formed by the combination of local flexibility markets and obligation, the provision of the grid service can be to some extent mandatory as a connection requirement condition, additional service provision capability can be acquired on a voluntary basis from the connected resources using a local market mechanism [24].

Table 3-5: Description of the market and non-market-based mechanisms for acquiring grid services.

Mechanism	Description
flexible access and connection agreements	The flexible access and connection agreements (or dynamic grid connection agreements) mechanism concern the formalisation of an agreement between the system operator and the service provider. The flexibility of the connection means that the power exchange at the interface with the network can be reduced according to the grid operator needs. Generally, flexible access and connection agreements are exploited for new connections.

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dynamic network tariffs	The dynamic network tariffs mechanism is characterised by the differentiation of network tariffs on temporal and spatial bases. As a consequence, the third parties provide grid services by adapting their electric behaviour according to the received price signal.
flexibility market	The flexibility market mechanism concerns the definition of a market dedicated to the exchange of flexibility. The market can be local or system-wide according to the type of flexibility traded. Flexibility markets can be characterised by the presence of a unique buyer (TSOs and DSOs) and multiple sellers (FSPs and market parties). In a single buyer scheme, an auction procedure is used for clearing the market; the service provider offers their flexibility through bids, which the buyer accepts according to the volume of the need and the related willingness to pay.
bilateral contract	The bilateral contract mechanism pertains to the definition of a binding agreement between two parties, the TSO or DSO and the service provider. In the contract are stated the agreed terms for the service provision found during the bilateral negotiation process. Generally, the bilateral contract mechanism is exploited for existing connected resources and constrained situations.
cost-based	Within a cost-based mechanism, the service providers are remunerated for the actual cost of providing the service. In general, cost-based mechanisms require auditing the providers' costs and defining an adequate margin for providers' return.
obligation	The obligation mechanism represents a non-market solution in which third-parties are obliged to provide the grid service when required by the system operator and without any remuneration.

As pointed out by the analysis of the reviewed projects, several mechanisms have been explored for the procurement of the grid services required by the DSOs or TSOs. First, it is important to mention that the surveyed projects mainly concern network congestion management and voltage control, which are characterised by a local dimension. Frequency control, and then balancing, is the other grid service mainly addressed by the reviewed projects. TSOs are in charge of managing frequency control, while network congestion management and voltage control are activities that both TSO and DSO address in the operated network area. Since the exploitation of third-part flexibility involves at least two different power system actors (the flexibility acquirer and the flexibility provider), adequate coordination between the parties involved is fundamental. Coordination is investigated considering its broad meaning, the act of making all the people involved in a plan or activity work

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together in an organized way [25]. Therefore, in the context of flexibility service procurement, a scheme for at last one two-sided coordination between the power system actors can be observed. However, more coordination schemes are required if more than two actors are interested by the process of flexibility provision (e.g., it is the case in which the TSO exploits the FSPs connected to the distribution system). The analysis of the projects points out that the majority regards the bilateral coordination of the three main actors TSOs, DSO, FSP. However, a relevant share of reviewed projects concerns the joint coordination of TSO, DSO, and flexible service providers.

The review of the projects is addressed considering as relevant blocks for the design of the procurement mechanism (as described in Table 3-5), the pricing method, the procurement timeframe, and the spatial extent of the area of the mechanism (bidding zone). Other relevant aspects surveyed are the interaction with existing markets, the number of markets utilised for buy flexibility, and the priority of access to the resources.

As shown in Figure 3.2, the analysis of the projects reveals that the general interest in the flexibility markets. As described in Table 3-5, the flexibility markets represent the procurement mechanism that best fits with the principles of a liberalised electricity sector. The flexibility markets that have been of interest for the reviewed projects have a monopsonistic and weak oligopsonistic structure. In monopsonistic markets, the sellers offer their flexibility to a unique buyer (the TSO or the DSO), while in the weak oligopsonistic markets, the buyers are both the TSO and the DSO. Flexibility markets consist of an auction procedure characterised by a tendering process in which the sellers offer their flexibility by submitting bids. According to the actual need for grid service, the bids are accepted, and the auction cleared. The clearing mechanism involves the price asked for the service provision. In some cases, technical aspects such as the expected effectiveness of the flexibility resource are also of interest [26], [27]. For example, the merit order of the received bid can be based on the corresponding price and the sensitivity coefficient related to the point of connection of the flexibility resources [26], [27]. The sensibility coefficients provide a measure of the effectiveness of the service provision. In fact, to illustrate, depending on the network parameters and operating point, the same amount of reactive power provided from two different locations can have a different impact on the voltage magnitude of the observed node [28] [29]. The use of Optimal Power Flow calculation also introduces technical aspects in the pricing mechanism [30]. The remuneration for the service provided depends on the particular pricing method adopted. In the reviewed projects, Figure 3.3 shows that in auction-based mechanisms, both the pay-as-cleared and pay-as-bid mechanisms are used. In the pay-as-cleared pricing, the remuneration is the same for all the sellers and equals the highest winning bid. In the pay-as-bid pricing, the remuneration for the sellers is equals to the price asked in the submitted bid, and therefore, the price paid is not uniform among the accepted sellers. Figure 3.2 shows that only a small share of the reviewed projects also investigates more regulated mechanisms such as bilateral contracts, cost-based schemes, and flexible connection and access agreements. These mechanisms involve an

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auction-based process for collecting offers, and therefore, the pricing method for remunerating the service providers is based on procedures such as agreed, dynamic, or fixed tariffs, nodal pricing, pay-as-cleared or pay-as-bid by node or prize zone, and compensation for the loss of opportunity cost. Figure 3.3 shows the occurrences of these pricing mechanisms in the BUCs of the reviewed projects.

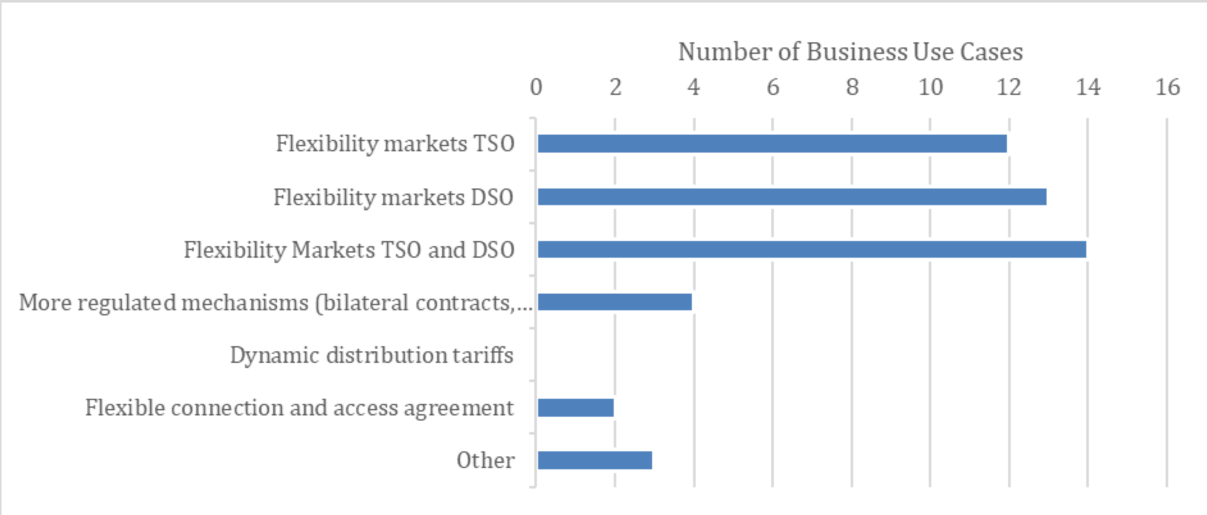

Figure 3.2: Overview of the procurement mechanisms addressed in the reviewed projects.

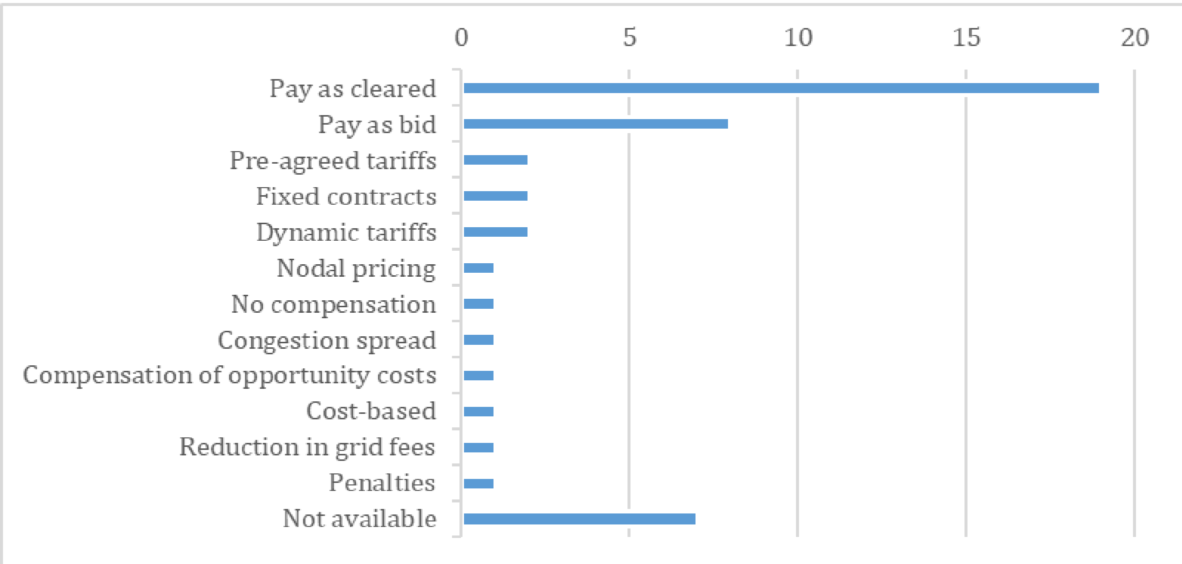

Figure 3.3: Overview of the pricing mechanisms addressed in the reviewed projects.

The procurement timeframe is an attribute that describes the temporal dimension of the procurement mechanism. This attribute describes the size of the time window that can be used for procuring the grid service. It is measured in terms of the time in advance in which the agreement with the parties is found and the moment of the expected service provision. It represents a relevant attribute since it also influences the product used to

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fulfil the need for grid services and influence the temporal size of the procurement process. In Figure 3.4, the procurement timeframe adopted in the BUCs of the reviewed projects is depicted. The availability for the provision of grid service can be procured long-term in advance. In these cases, the procurement timeframe can be on an annual, monthly, or seasonally basis. In the case of short-term procurement, the procurement timeframe can be day-ahead, intraday, near-real-time. This classification is not prescriptive; intermediate designs are possible (i.e., procurement on a weekly basis). The reviewed projects mostly focus on day-ahead, intraday, and near real-time (15-minutes ahead) and real-time (automatic activation) procurement timeframes.

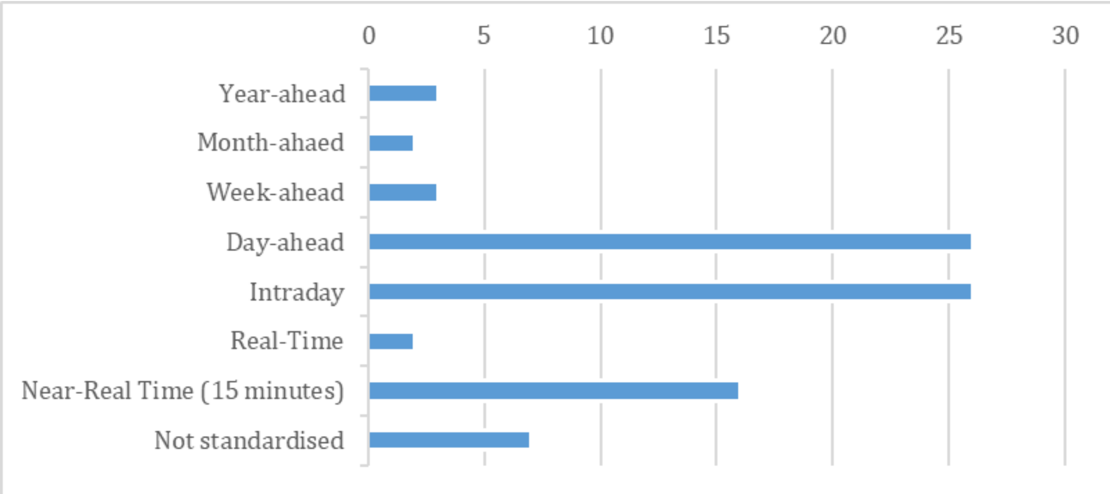

Figure 3.4. Overview of the procurement timeframe addressed in the reviewed projects.

The geographical scope of the procurement mechanism represents the spatial dimension of the procurement process. Depending on the characteristics of the need for the grid service, if this need can be satisfied by any resource connected to the system (system-wide need, it is the case of balancing) or only by a set of resources localised in a certain area (local need, it is the case of congestion management and voltage control). In the case of local needs, the dimension of the procurement areas depends on the network characteristics. Only the resources which show adequate effectiveness belong to the procurement area. In the case of system-wide needs, the geographical scope of the procurement mechanism can be national, transnational, or regional. In the case of local needs, the geographical scope is reduced to delimited areas of the transmission and the distribution grid. Figure 3.5 shows the geographical scope of the procurement mechanisms adopted in the BUCs of the reviewed projects.

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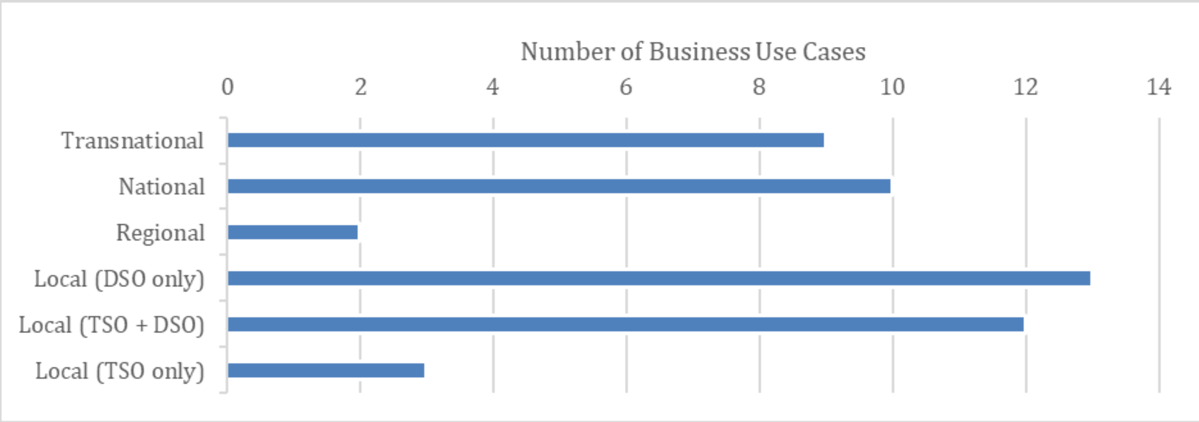

Figure 3.5. Overview of the geographical scope of the procurement mechanisms addressed in the reviewed projects.

A relevant aspect considered by the reviewed project is represented by the possible interaction between the existing markets and the novel procurement mechanism adopted. Figure 3.6 shows an overview of the market interaction addressed in the BUCs of the reviewed projects. Depending on the particular set-up of the adopted procurement mechanism, the corresponding outcome can influence the following sessions of the existing markets or introduce constraints in the actors' participation. Until recently, this interaction has been of interest to the energy markets (day-ahead and intraday energy markets) and the service markets (balancing, congestion management at transmission level).

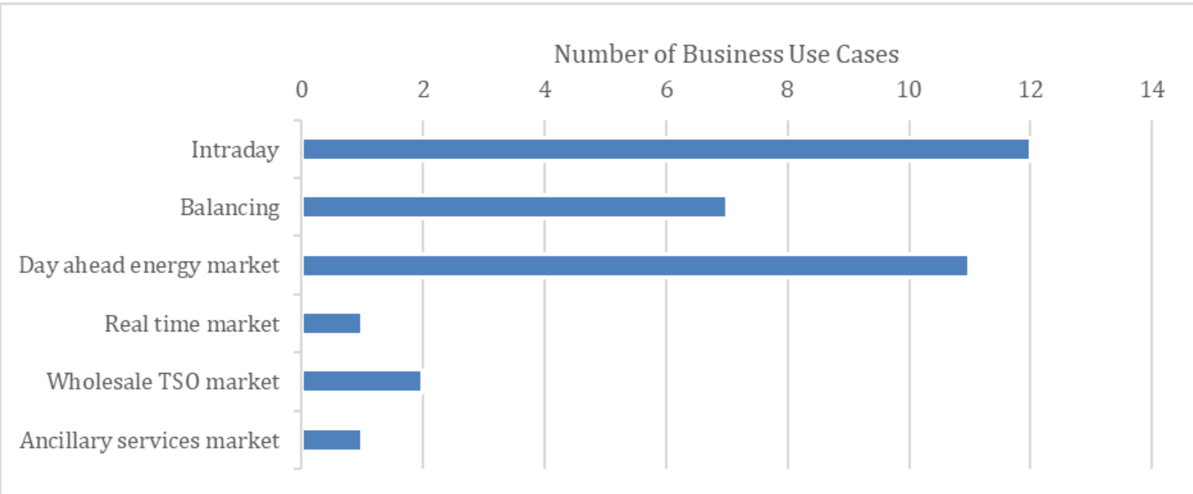

Figure 3.6. Overview of the interaction existing with the mechanism for procuring grid service proposed in the BUCs of the revised projects and the existing electricity markets of the corresponding country.

Both TSOs and DSOs can be interested in resorting to the flexibility offered by the third parties service providers for solving their needs. Therefore, the exchange of flexibility can be both be based on separated markets or on a unique market in which all system operators are buyers. In multiple markets, there will normally

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be only one buyer per market, the zonal system operator with exclusive access to the sellers' resources. Conversely, in the case of a unique market in which several system operators compete for buying flexibility, it is of interest to define clear and reliable rules which allow the TSO to exploit the flexibility of the resources connected to the distribution system without negatively interfering with the DSO activities. This rationale can be extended to all cases in which one system operator require to exploit the resources connected to the grid operated by a different system operator. This peculiarity of the power system represents a challenge for market design and influence the final structure of the procurement mechanism that can be devised. Several of surveyed projects concern the interaction between TSO and service providers and the possibility for the TSO to access the offers submitted to the DSOs but not used by them. The number of business use cases in which the TSO has access to the assets connected to the distribution level is 28 over 48. The number of business cases in which the TSO has access to the bids submitted to the DSO but not selected 16. The different coordination schemes between TSO and DSO are explored in detail in Task 3.1.

3.2.3 Classification of demonstrators' activities

The projects review process revealed a wide variety of different technologies that were implemented and demonstrated across Europe. The nature of these solutions varied from actual energy assets installed at different locations of the power system, equipment installed on overhead lines, as well as ICT infrastructures to facilitate the communication and data exchange among systems and market actors. In Figure 3.7, the demonstrators' location in each project per country is shown, where the geographical diversity of the different demos even within the same project becomes obvious. For the examined projects, as depicted in Figure 3.8, Greece is the country that has the highest number of different demonstrators, followed by Italy.

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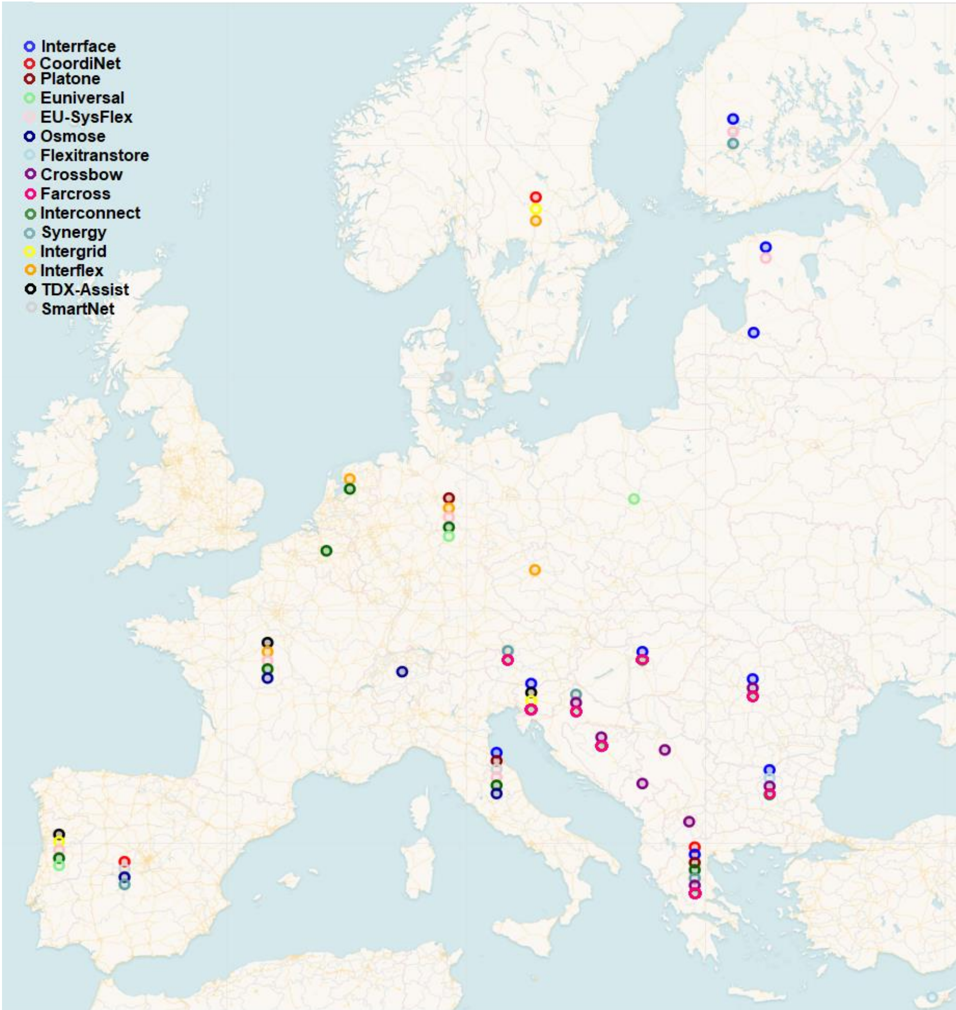

Figure 3.7: Map of demonstrators per country for the concerned projects.

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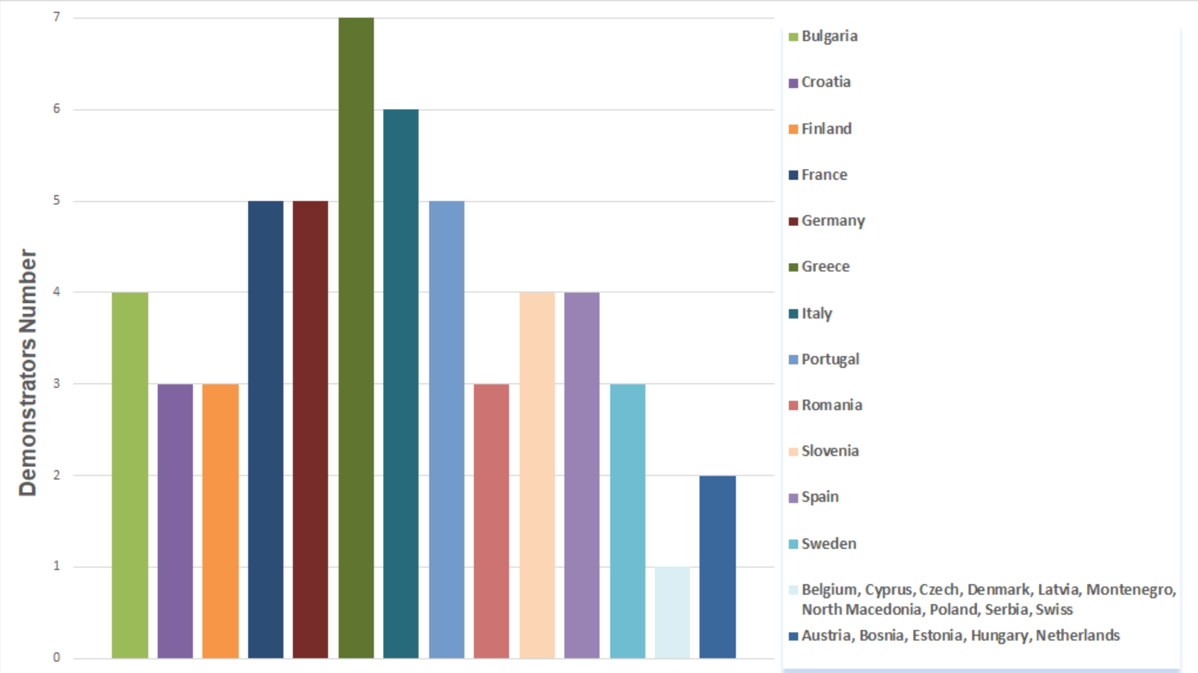

Figure 3.8: Number of demonstration activities conducted per country for the concerned projects.

Because each Demonstrators' location is highly related to specific installed/utilized resources, it is important to conduct a mapping of these. In our analysis, we consider an asset a physical installed entity that can provide flexibility services to the operators alleviating their problems. Through the thorough scanning of the 15 reviewed projects, the flexibility resources clustered in the following categories:

- **Conventional Units**: The term is applied to incorporate the production from coal, oil, and natural gas. In the examined demonstrator's setup diesel generators, gas turbines and fuel cells utilized as flexibility assets (e.g., *SmartNet, CoordiNet*).
- **Renewable Energy Resources**: This term is used to describe the plants that use natural resources or processes to generate power that are constantly replenished. Wind Farms, Photovoltaic (PV) power plants, Hydroelectric power plants, and Combined Heat and Power (CHP) or cogeneration plants are identified in the concerned projects (e.g., *CoordiNet, INTERRFACE, EUniversal*).
- **Storage**: This term applies to different storage technologies identified in the concerned projects. Storage can be either stationary or mobile (EVs) regardless of the used technology. Moreover, storage assets can be installed either Behind-The-Meter (BTM) at the edge of the distribution grid or at a utility-scale on higher voltage levels. The storage assets of the concerned projects were classified based on the technology it was used. Hence, the storage assets identified are:
    - Mechanical: pumped storage hydropower (e.g., *CROSSBOW*).

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- Electro-chemical or batteries (BSSs): lithium-Ion battery, lithium-titanate-oxide battery (e.g., *Osmose, CoordiNet, INTERRFACE, Flexitranstore*).
- Electrical: supercapacitors (e.g., *Osmose*).

- **Demand-side**: This term is used to describe all the demand-side flexibility regardless of the voltage level and the capacity size. Demand response (DR) on a household, tertiary (public sector and commercial) and industrial level is demonstrated in the different examined projects (e.g., *Osmose, InterConnect, CoordiNet, INTERRFACE*). In addition, in some projects, DR is demonstrated on a higher granularity than a household, where flexibility from IoT-enabled smart appliances (boiler, wet appliances etc.) is leveraged (e.g., *InterConnect, InterFlex* and *Synergy*).
- **Non-wire solutions:** Under this category, the non BaU grid installations that have as a primary goal to increase system flexibility, are encapsulated. These solutions may either directly increase transmission line capacity or transfer load to another line. For example, Phase shifting transformers (PST) which are already used in the planning process of the TSOs are not considered. The identified technologies are Dynamic Line Rating (DLR) solutions for grid management and Static Synchronous Series Compensators (SSSC) for power flow control (e.g., *Flexitranstore* and *FARCROSS*).

In each of the aforementioned categories, indicative projects that demonstrate the identified resources are included. For readability purposes, not all the projects per resource are included.

3.2.4 Overview of developed interfaces

In this section of the deliverable, the interfaces developed and under-development within the concerned projects between the grid operators, i.e., TSOs and DSOs, and the market operators are reviewed. This overview can be considered as an initial contribution to OneNet project and especially to WP4, in which new market and operational interfaces based on IEC standards (CIM, 61850) will be developed. Based on a rigorous analysis, interfaces in 10 projects were identified and reported in the following table.

Table 3-6: Interfaces developed per project.

Project name	Interface description
INTERRFACE	INTERRFACE project will design, develop, and exploit an Interoperable pan-European Grid Services Architecture (IEGSA) to act as the interface between the power system (TSO and DSO) and the customers and allow the seamless and coordinated operation of all stakeholders to use and procure common services. The IEGSA concept aims to fulfil the vision of the EU to "promote the network operators procure services (such as

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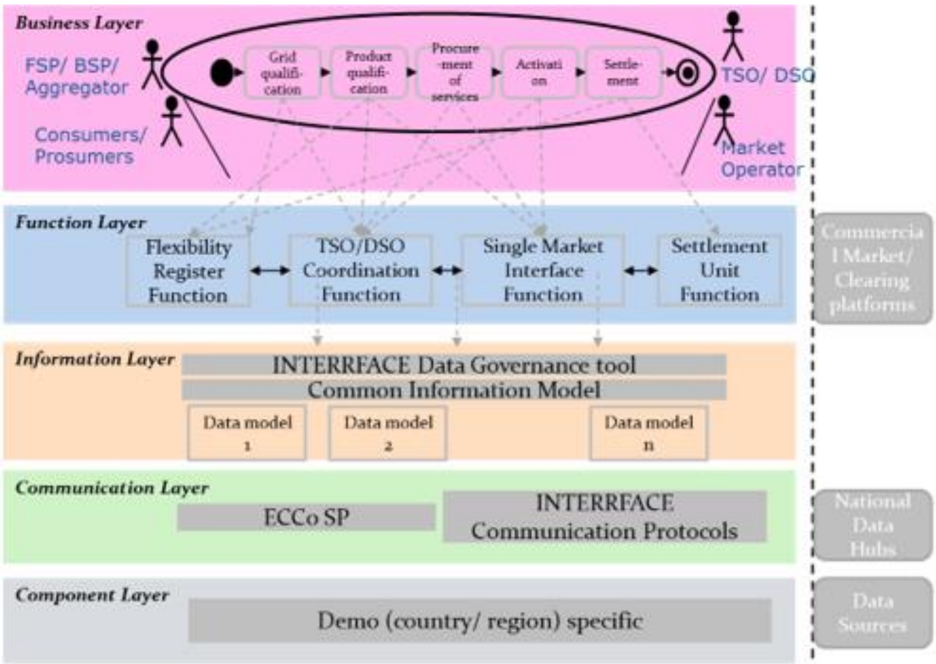
	balancing, congestion management and ancillary services) from assets connected to the network both at transmission and at the distribution level, in a coordinated way".  *Figure 3.9: ISGAM architecture of the IEGSA approach.*
CoordiNet	The CoordiNet platform is intended to form an interface that manages different interactions between the TSO, DSOs and FSPs and coordinates the different functions necessary to perform the use cases. The consideration of ownership of the platform and the governance structure is out of the scope of the CoordiNet project. The focus of CoordiNet is to define the roles and functions that such a platform may have. Some of the relevant functions to be performed by the platform include data exchange between actors related to market bids, technical limitations on networks, market-clearing functions, communication of market results, submitting activation bids to service providers and grid operators. The CoordiNet platforms will be implemented in all demos in Greece, Spain, and Sweden.

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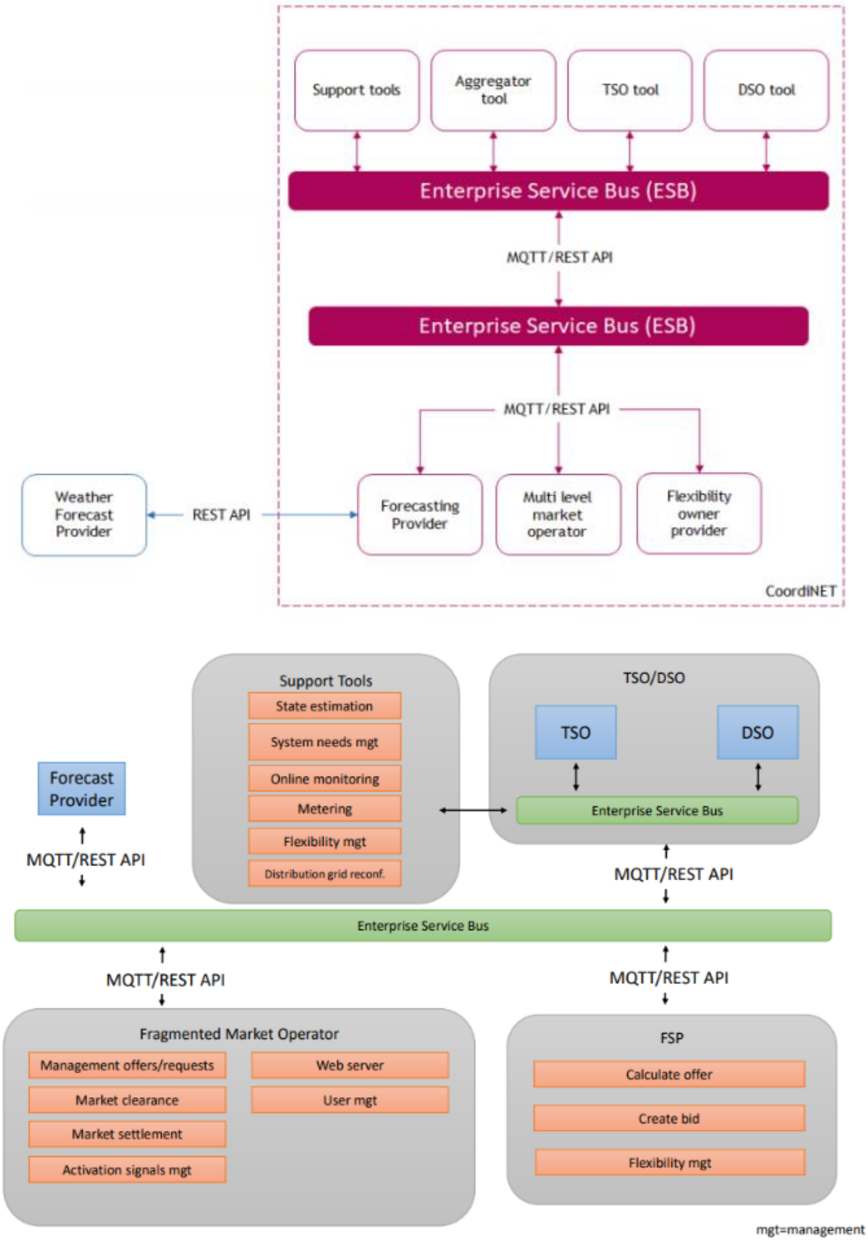

Figure 3.10: Interfaces developed in the context of CoordiNet in the Greek Demonstrator.

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	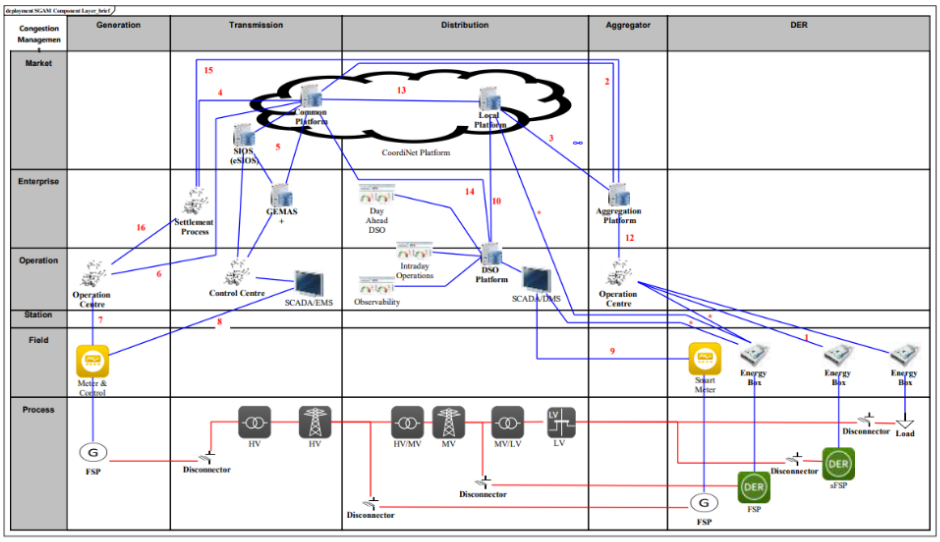 *Figure 3.11: SGAM diagram of the Spanish Demonstrator.*
Platone	Three different developed platforms are identified: • **Market platform:** Virtual marketplace where the requests for flexibility are matched with the offers. Thus, an interface between market operator and the marker participants is developed (figure below depicts the location of market platform in Platone architecture). • **DSO technical platform:** A Distribution Grid management system performs grid state estimation and forecasting of production and consumption. It defines the flexibility requests for DSO's grid. The platform exchanges data with SCADA and distribution grid operation systems. • **Blockchain access platform:** A software-based platform that certifies using Blockchain technology the data provided by end customers, which is used for purposes of flexibility management and grid observability.

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	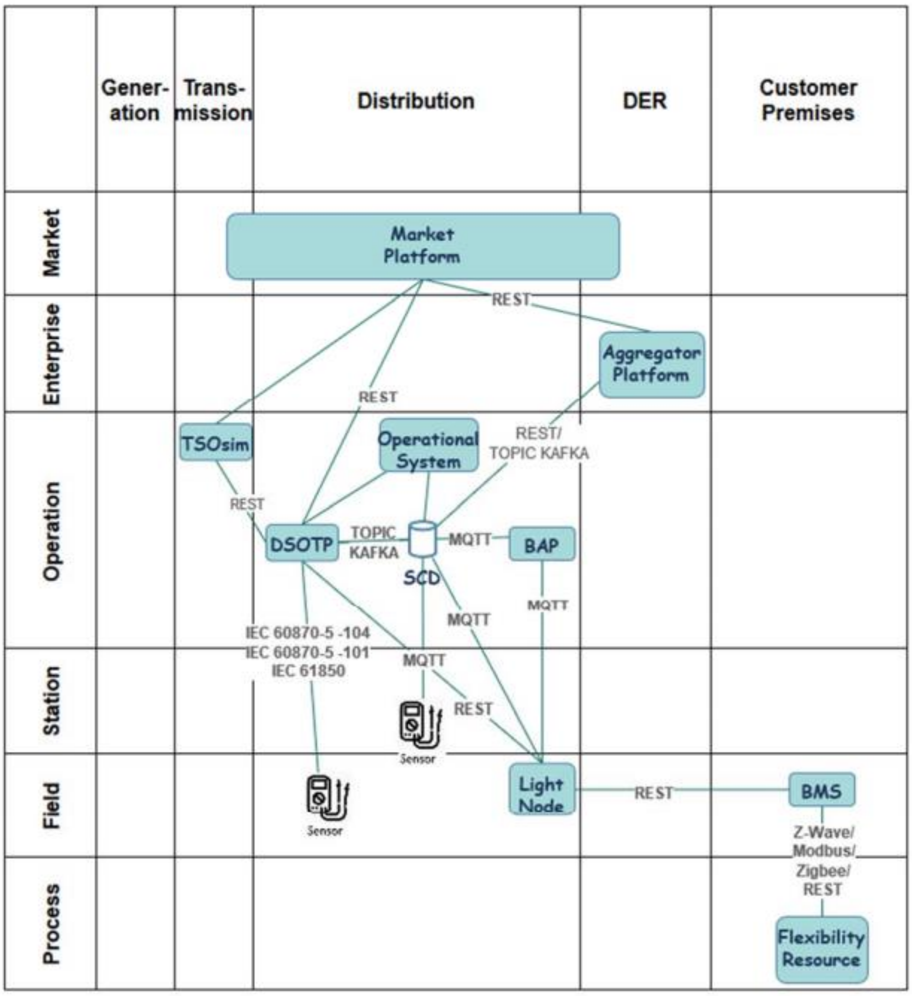 *Figure 3.12: Communication platform of SGAM architecture for Platone project.*
EUniversal	The primary goal of EUniversal is to implement the Universal Market Enabling Interface (UMEI) concept by bringing forward a universal, open, adaptable, and modular approach to interlink active system management with electricity markets and foster the provision of flexibility services, also acknowledging the activation needs of and the coordination requirements with other commercial parties and TSOs. The interface is API based. However, further information cannot be given at the time of the questionnaire's distribution because it is still under development.
EU-SysFlex	• **Customer – aggregator interface:** A demo called "Affordable Tool" investigates sub-meter data collection from customers as well as activating customers by the aggregator.

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	• **Flexibility provider – Flexibility Platform interface AND System Operator – Flexibility Platform interface:** Flexibility prediction can be split into three timeframes: 1. Investment planning (3+ years ahead). 2. Operation planning (days to years ahead). 3. Real-time Planning (Intraday operation). There are two options for baselines: 1. Market participant must declare its power schedule (baseline) ex-ante. 2. Market operator (TSO or DSO or Flexibility Platform Operator) calculates the baseline ex post based on meter data. Prequalification of the Flexibility Service Providers and the bidding process ending with the merit order of flexibility bids. Both steps include grid impact assessment, initiation of flexibility activation by SO, and final grid impact assessment by Flexibility Platform before forwarding activation request to FSP. Actual flexibility delivered is calculated as the difference between baseline and metered consumption/generation of FSP. The verification takes place by comparing the delivered flexibility and flexibility requested by SO. • **Data Exchange Platform:** All data management SUCs demonstrated take the advantage of using a DEP. This is especially beneficial for private data sharing.
Flexitranstore	In general terms, the proposed architecture for the FEG platform is firstly subdivided in two distinct main components. The first one presents the FEG Central Component that acts as the global registry of FEG installations and integration hub, and the second one is the FEG local component that represents the ready-to-use toolbox - installed within System Operators' and Flexibility Providers. Secure data handling requirements have been considered. The open architecture of the FEG Platform provides ease of integration within the operators' software environments and facilitates bi-directional communication with external systems, thus adding a high degree of flexibility and adaptability even in extreme brownfield situations.

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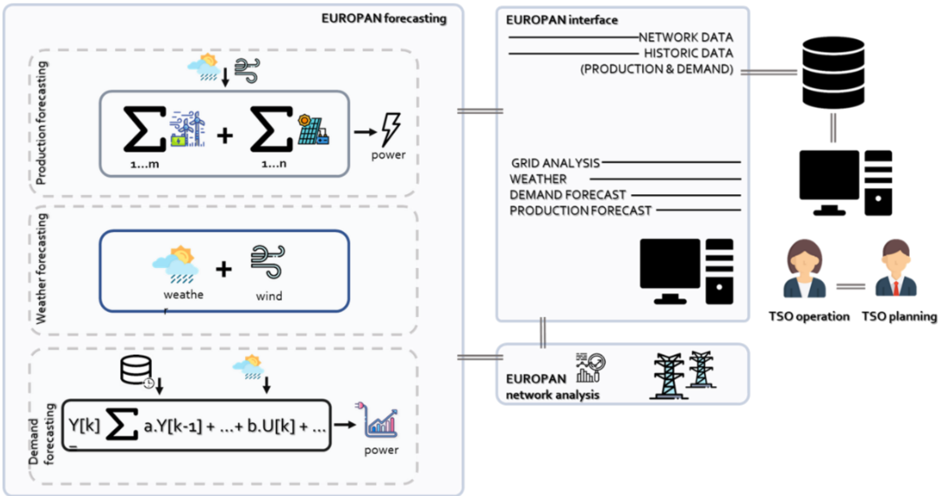
FARCROSS	In the context of EUROPAN platform demo, the depicted interface to create a communication link between different TSOs is developed to enhance efficiently grid operation.  Figure 3.13: EUROPAN platform components.
Synergy	Common interface for DSOs and TSOs to facilitate common operational scheduling, considering multi-diverse (and possibly conflicting) flexibility requirements of the two types of power networks.

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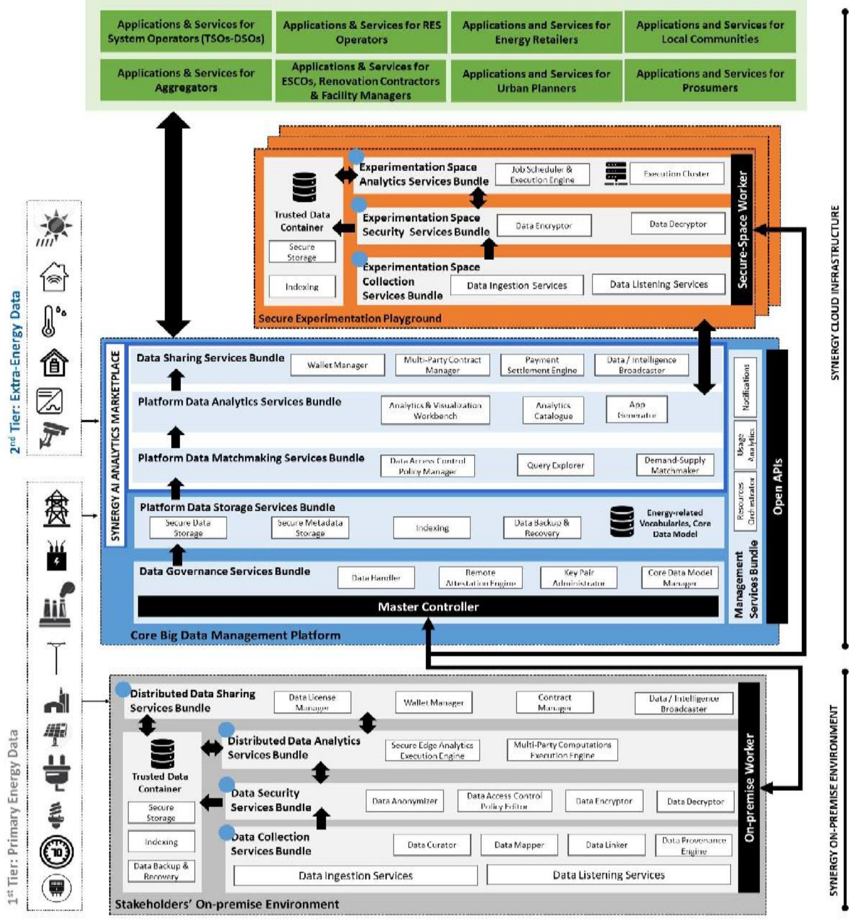

Figure 3.14: Interfaces developed in the context of Synergy project [13].
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<td>InteGrid</td>
<td>The main interface is the GM-HUB, located at the enterprise zone of the DSO domain. It interacts with the other DSO systems at the operation and station zones, such as the traffic light system, MPOFP, forecasting tools etc. It also interacts with the FSP systems (DER control, energy optimization, LocalLife etc.)</td>
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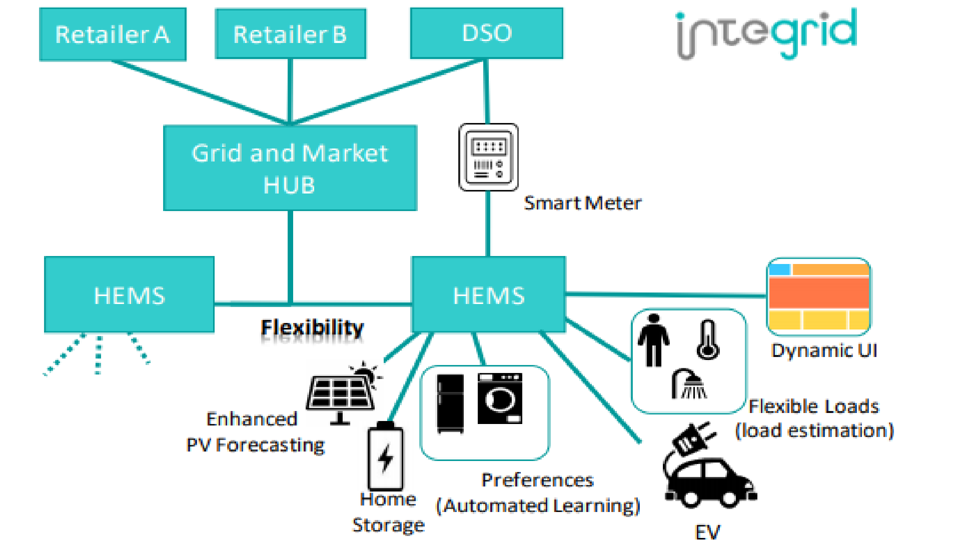

Figure 3.15: Actor's interactions in InteGrid project.
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<td>SmartNet</td>
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The demos develop a simulation platform for these three countries. This simulator includes three main layers:

- Market Layer: representing the mFRR market

- Bidding Layer: representing aggregation and disaggregation processes

-Physical Layer: physical network including controls and protections and aFRR regulation

The structure for these simulations is as follow:

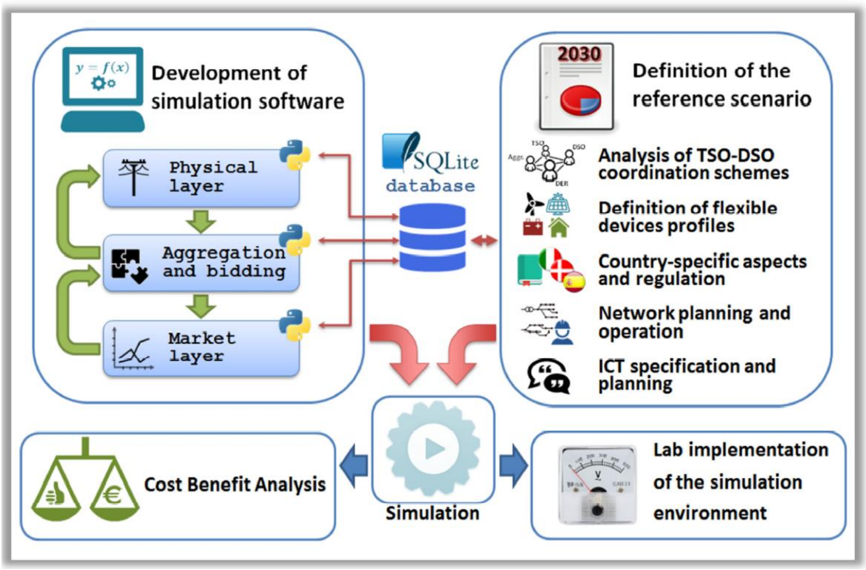

Figure 3.16: SmartNet project high level presentation.

A more detailed description of the process to develop the models is presented below:
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The project used an iterative and incremental process to capture ICT requirements and to elaborate ICT architecture design (see Figure below). The work required several analysis cycles and close collaboration with partners involved in the energy market activity.

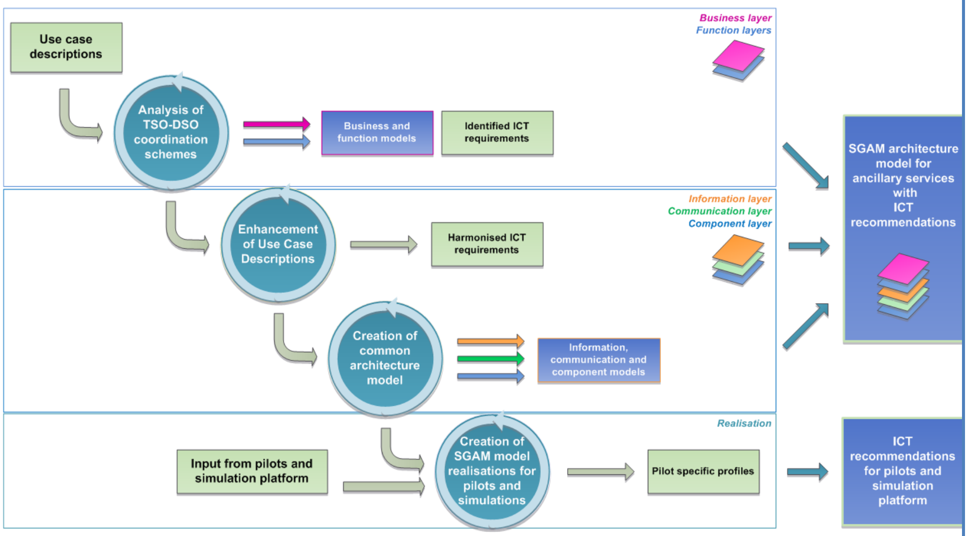

Figure 3.17: Use cases development in SmartNet project.

The first analysis cycle was done together with partners specifying the TSO-DSO coordination schemes as it requires a more profound understanding of involved business/system actors, interactions between systems, and exchanged data to be able to identify ICT requirements. During this cycle, the use case descriptions were updated together to fill discovered ICT related gaps. The use case descriptions were refined and extended with ICT requirements for each data exchange event. The requirements were collected in a table format that was added at the end of each use case description document. The project utilised the use case template, common definitions, and terms specified in the ELECTRA project. This helped them to align the specifications in both energy market and ICT viewpoints.

During the second iteration cycle, the project compiled the use of case-specific ICT requirement tables into an all-in-one ICT requirement table. It was a compressed presentation including all ICT interactions between system components, identified exchanged data objects, and ICT requirements covering networking, security, latency, data protocol, and communication technology properties. After the compilation, the

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number of ICT requirements exchanged data objects and even system components were too high to be used for the SGAM modelling.

An additional iteration cycle was needed to harmonise the use of case descriptions and associated ICT requirements. To make the number of ICT requirements manageable, the project grouped the ICT requirements into classes, and only the classes were used with information exchanged events. They focused on the four core processes of the ancillary service operations (see figure below): prequalification, procurement, activation, and settlement.

After the compilation of the all-in-one ICT requirement table, the project still validated the harmonised use case specifications and the ICT requirement table against the original energy market use case specifications to ensure that all interactions, system components, and requirements in the selected ancillary services were correctly taken into account.

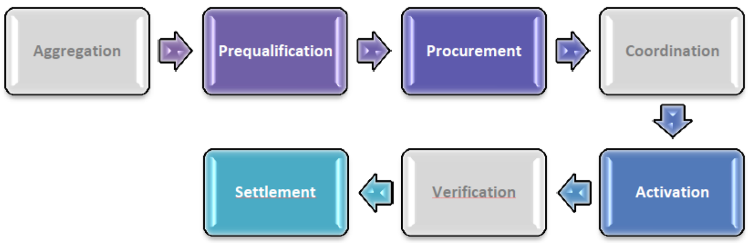

Figure 3.18: Sequence diagram of flexibility procurement.

The third analysis cycle included the creation of a common architecture model. The architecture model was created with the Enterprise Architect tool and the SGAM Toolbox extension. As a background for modelling, they used the modified use case specifications, all-in-one ICT requirement table, and to some extent the results from the study focusing on existing energy and communication architectures and enabling ICT technologies. Their goal was not to create an entirely new architecture, but to elaborate the existing one in order to fulfil the requirements set by the five TSO-DSO coordination schemes. The existing business and function layer SGAM models created in the first analysis phase were updated and complemented with information, communication, and component model layers. Figure 3.19 depicts the transition from business actors and relationships to communication and component layers with associated ICT requirements.

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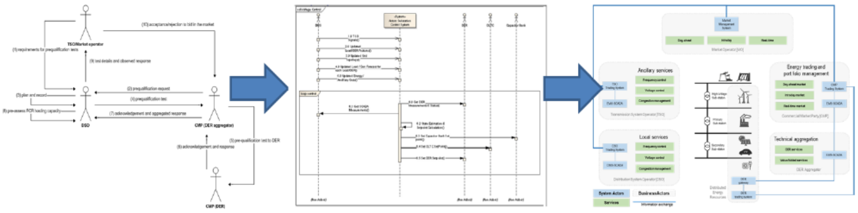

Figure 3.19: From BUCs to ICT requirements.

The final ICT SGAM model included use case diagrams, system/component and interface charts, and sequence diagrams associated with ICT requirements. This model is well-suited for studying the common architecture design and for modifying it further for a system realisation, but it requires the direct use of the Enterprise Architect tool. The last analysis cycle involved the creation of SGAM model realisations for pilots and simulation platform. The derived model focuses on the design of a specific ICT system implementation. The derived model is called profile, and it maps the common ICT architecture design and communication requirements of a specific coordination scheme to a SmartNet pilot system. The analysis and design procedure followed the same steps that they used for capturing ICT requirements for the common architecture design including:

- Creation of a layered overview of the system components.
- Creation of information exchanged sequence diagrams.
- Creation of communication interface profiles using the all-in-one ICT requirement table.

The creation of profiles is used as a feedback loop to verify the common architecture design and its flexibility to cover four different system realisations. Interactions between system components, the content of exchanged data objects, and ICT requirements were assessed and refined. During the analysis, latency, reliability, security, and cost were taken as the most critical requirements. They analysed those properties from trading and resource management viewpoints. The reliability aspects were assessed by studying the most actively utilised communication links requiring a higher level of reliability and resiliency. In general, latency and security requirements dictate whether a wireless or wired connection could be used. The data amounts in trading and resource control are

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	not restrictive. The cost is multi-facial property including investment and operation costs.

As can be seen, most of the projects use SGAM approach to link the developed use cases with ICT infrastructure to define the interface's boundaries and functionalities among market and grid operators with the rest participants in the energy data stream. A more thorough analysis of the developed interfaces will be presented within WP4, where the possible overlaps of different interfaces and existing gaps will be further explored.

3.2.5 Assessment of BUCs

Use cases are the first building blocks for projects in software engineering and describe the developed system and its functionalities in static as well as dynamic aspects. The static view is given through the presentation of actors that are related to the system, the dynamic view is described through the relation between actors and the system by use cases. Defining the Use Cases that will be addressed within the scope of a project is very important step towards achieving its objectives.

It should be noted that a BUC is different from a system use case. The building of use cases is usually based on an abstract business case with no technical details. A use case realizes the description of the business goals in different layers of granularity and can be differentiated into high-level use case (BUCs) and specific use cases (system use cases) [31].

Through the projects review process, all the available BUCs and SUCs were mapped and reported. In almost all the projects, the use case development methodology used was IEC-62559-2. A more thorough analysis of this topic will be conducted within WP2 and WP4 in relation with the development of the BUCs methodology that will be followed in OneNet. In this section, the BUCs of each reviewed project are reported forming the knowledge baseline needed for T2.3 work.

Table 3-7: INTERRFACE defined BUCs

Name	Scope
SO-Supplier	To provide flexibility using power production from programmable DG system (CHP plant)
LV regulation Power quality	Use of battery storage and DR program to optimally exploit the local production of renewable energy

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Local Energy Community	Exploit the synergies among energy network in a municipal scale multi-energy microgrids to maximize the self-consumption of locally produced renewable energy
Aggregated CM to TSO/DSO Balancing mFRR to TSO Non-frequency services to TSO/DSO	To provide CM service to the TSO/DSO by using part of the power/energy capacity of one (or more) Battery Energy Storage Systems (BESS) installed in multi-user buildings (or group of homes) with PV and particular loads, such as EV and data centres.
mFRR demonstration: Single Flexibility Platform	mFRR – Estonia, Latvia, Finland
aFRR demonstration: Single Flexibility Platform	aFRR – Estonia, Latvia, Finland
FCR demonstration: Single Flexibility Platform	FCR – Estonia, Latvia, Finland
Congestion management short-term demonstration: Single Flexibility Platform	Congestion management short-term – Estonia, Latvia, Finland
Congestion management long-term demonstration: Single Flexibility Platform	Congestion management long-term – Estonia, Latvia, Finland
Distribution grid users participating in P2P local market	Enable the market participation of small consumers: mainly households but the P2P local market concept enables the market participation of any low voltage and medium voltage users – consumers, prosumers, distributed generators, storage).
Flexibility services for DSO congestion management and allowing more renewable connection without unreasonable DSO network investments	The use-case is to be demonstrated in Bulgaria and/or Romania with our TSO-DSO partners (Bulgaria – CEZ, ESO and Romania – DEO, Transelectrica)
Regional inter-zonal provision of Balancing (FCR, aFRR, mFRR) services in South-East Europe	Market design of the regional inter-zonal provision of Balancing (FCR, aFRR, mFRR) services in the South-East European system. The Use-Case describes the algorithm to be developed for the optimal power market reserves clearing for the provision of FCR, aFRR, and mFRR services.
Regional inter-zonal provision of Congestion Management services in South-East Europe	Market design of the regional inter-zonal provision of Congestion Management services in the South-East European power system. The Use-Case describes the algorithm to be developed for the optimal power market reserves clearing for the provision of Congestion Management services, supplementary to the Balancing (FCR, aFRR, and mFRR) services clearing

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	described in the previous use case for Regional Balancing services. Congestion Management services are enrolled as mFRR, amended with zonal information, to enhance coherence with balancing services. The CM bids are to be added to energy and other ancillary services bids towards providing a distinct price signal for each service.
Direct participation of local flexibility on the wholesale market using a single auction-based market platform	To introduce spatial dimension into the existing wholesale market design. To develop a market tool that facilitates TSO-DSO coordination. To use an auction-type market platform that enables incorporating complex constraints. Locational information of the participating bids included – additional aspect to enhance the social welfare attainable. Still, not a multi-zonal approach, but a hierarchical one to enable connection to the existing wholesale market – one single bidding area to cover the whole zone, containing multiple and stacked local areas with flexibility sources

Table 3-8: CoordiNet defined BUCs [32]

Name	Scope	Objectives
BUC ES-1a	Congestion Management – Common Market Model - Spain	The main objective is to procure flexibility from the resources connected at both TSO and DSO level networks in a coordinated manner to solve transitory congestions that can occur in both networks.
BUC ES-1b	Congestion Management – Local Market Model - Spain	The principal objective is to procure flexibility from resources connected at the DSO LV networks to solve transitory congestions that can occur at the DSO LV networks.
BUC ES-2	Balancing Services for TSO – Central Market Model - Spain	This BUC evaluates how to improve the coordination between the TSO and DSOs when the activation of energy resources including DER providing balancing services to the TSO increases. This might result in constraints in the DSO network. The process description would apply for both manual Frequency Restoration Reserves (mFRR) and Replacement Reserves (RR).
BUC ES-3	Voltage Control – Common Market Model - Spain	This BUC will implement a market mechanism to procure voltage control services by using new and available technologies besides traditional investments.
BUC ES-4	Controlled Islanding – Local Market Model - Spain	The objective of this BUC is to operate part of the distribution network in an islanding mode during outages or programmed maintenance services.

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BUC GR-1a	Voltage Control – Multi-level Market Model - Greece	Flexible resources connected to the transmission and distribution system can provide flexibility to system operators to eliminate voltage violations through a market mechanism. Active and reactive power control is considered.
BUC GR-1b	Voltage Control – Fragmented Market Model - Greece	The flexible resources connected to the transmission system can provide flexibility only to the TSO and the flexible resources connected to the distribution system can provide flexibility only to the DSO. The TSO and DSO cooperate to decide on the power exchange between them. In order to do so, the TSO and DSO take into account the voltage level of the bus bars in the transmission and distribution system, respectively.
BUC GR-2a	Congestion Management – Multi-level Market Model - Greece	Flexible resources connected to the transmission and distribution system can provide flexibility to system operators to eliminate congestions through a market mechanism.
BUC GR-2b	Congestion Management – Fragmented Market Model - Greece	Flexible resources connected to the transmission system can provide flexibility only to the TSO and the flexible resources connected to the distribution system can provide flexibility only to the DSO, to eliminate congestions.
BUC SE-1a	Congestion Management – Multi-level Market Model - Sweden	In the first stage, local and regional congestion management markets are run. The remaining bids are transferred to the TSO's balancing market (BUC SE-3).
BUC SE-1b	Congestion Management – Distributed Market Model - Sweden	It is a peer-to-peer market between generators buying flexibility and DER providing it. This market will take place in situations where there is congestion, in which a generator would be curtailed. To avoid that, they can buy extra flexibility, provide by other generation or demand, in the peer-to-peer market.
BUC SE-2	Balancing – Local Market Model - Sweden	This BUC describes the actions that are carried out when the regional and local DSOs want to use flexibility for system services for power quality and security of supply.
BUC SE-3	Balancing – Multi-level Market Model - Sweden	This BUC describes the actions that are carried out when unused bids after the DA and ID market that meet the conditions for the balancing service mFRR (e.g., minimum bid size of 1 MW is foreseen for the CoordiNet pilot) are transferred to the TSO balancing market.

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Table 3-9: Platone defined BUCs [33]

Name	Scope	Objectives
UC-IT-1	Voltage management in transmission and distribution systems	– To support the TSO in using the flexibility provided by the resources connected to the distribution system for voltage violation, respecting the distribution system constraints. – To ensure an inclusive and non-discriminatory access to the market to all the actors that provide grid services. – To empower coordination between system operators. – To activate flexibility to solve voltage violations in the distribution grid.
UC-IT-2	Congestion management in transmission and distribution systems	– To support the TSO in using the flexibility provided by resources connected to the distribution system for congestion management, respecting distribution system constraints. – To ensure inclusive and non-discriminatory access to the market for all actors that provide grid services. – To enable and empower coordination between system operators. – To activate flexibility to solve congestions in the distribution grid.
UC-GR-1	Improvement of measurement data reliability	– To improve confidence in actual measurement data obtained throughout the network as well as available load forecasts. – To capture the real-time operational network state.
UC-GR-2	PMU data integration into SE tool	– To reinforce network observability and controllability via improved state estimation performance. – To ensure smooth incorporation of synchronised measurement data derived from PMUs into the pre-existing system of conventional measurements.
UC-GR-3	Distribution network limit violation mitigation	– To use network tariffs in order to incentivise a more efficient operation of the network while respecting operation limits (voltages, lines).
UC-GR-4	Frequency support by the distribution network	– To keep the distribution network within physical limits (line and voltage) with appropriate actions in the case of a frequency restoration reserve activation request by the TSO
UC-GR-5	PMU integration and	– To increase network observability.

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	data visualization	– To integrate data coming from different sources in the Platone DSO Technical Platform.
UC-DE-1	Islanding	– Maximize consumption of local generation/Minimize demand satisfied by public grid. – Islanding of local grid by making use of flexible loads and storages. – Maximizing duration of islanding operation UC-DE-1 is prerequisite for UC-GE-2-3-4
UC-DE-2	Flexibility provision	– Maintain a fixed non-zero power exchange between energy community and the distribution network for a limited duration.
UC-DE-3	Bulk energy supply	– Enabling temporary islanding even in times of energy deficit of the local community. – Forecasting of residual energy demand of an energy community. – Forecasting of residual energy generation of an energy community. – Execution of power exchange schedule for the energy community for the grid connection point LV/MV (time and power of load exchange). – Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule. – Execution of defined power exchange between energy community and the distribution network.
UC-DE-4	Bulk energy export	– Enabling temporary islanding even in times of energy deficit of the local community – Forecasting of residual energy demand of an energy community – Forecasting of residual energy generation of an energy community. – Execution of power exchange schedule for the energy community for the grid connection point LV/MV (time and power of load exchange).

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		– Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule. – Execution of defined power exchange between energy community and the distribution network.

Table 3-10: EUniversal defined BUCs

Name	Scope	Objectives
PT BUC 1 - Congestion Management	Congestion Management in MV grids for the day-ahead market (or between 1 to 3 days in advance	– Using the market participation of distributed generation and industrial consumers – Based on the generation and load forecast for the next days – Engagement of MV customers with the ability to provide flexibility (depend on the industrial process)
PT BUC 2 - Voltage control	Voltage control in MV and LV grids for the day-ahead market (or between 1 to 3 days in advance)	– Integrated Approach (MV and LV) – Using the local resources (MV and LV) – Considering the Phase Balancing
PT BUC 3 - Contracting Flexibility Services for Voltage Control and Congestion Management	Contracting Flexibility Services for Voltage Control and Congestion Management during planned actions in distribution grids (days in advance)	– Related to the congestion management and voltage control. – Optimal scheduling of DER for planned works
PT BUC 4 - Flexibility Services for medium- and long-term planning	Flexibility Services for medium- and long-term planning through market mechanisms	– Identifying voltage or congestion violations that occur only in certain periods of the year. – Quantify the costs of the flexibility service vs upgrade network costs (investment deferral) – Bilateral contracts as a possible solution. – Considering generation and load forecast for medium and long term. – New connection of loads and generation

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PL BUC - Congestion Management & Voltage Control with market-based active power flexibility	short term network operation divided into a day ahead and an intraday process. theoretically applicable for all voltage levels. However, the focus is on medium voltage. The UC explains how active power flexibility in distribution grids can be procured through a market platform	– Easing Physical Congestions (overloading of lines/transformers, voltage band violations) with market-based active power flexibility in a cost-efficient way – Ensure that flexibility activation of market bids (local market) will not create grid constraints
DE BUC AP - Manage market-based active power flexibility to support congestion management and voltage control in the German demo	Manage market-based active power flexibility to support congestion management and voltage control in the German demo in compliance with regulated processes	– Easing Physical Congestions (overloading of lines/transformers, voltage band violations) with market-based active power flexibility in a cost-efficient way. – The process must be compatible with mandatory processes e.g., Redispatch. – The DSO is responsible for ensuring a secure network operation and therefore and takes the decision on the activation of flexibility. – Ensure that flexibility activation of market bids (local market) will not create grid constraints
DE BUC RP - Manage market-based reactive power flexibility to support voltage control in the German demo	Manage market-based reactive power flexibility to support voltage control in the German demo in compliance with regulated processes	– Easing Physical Congestions (particularly voltage band violations) with market-based reactive power flexibility in a cost-efficient way. – The process must be compatible with mandatory processes e.g., Redispatch. – The DSO is responsible for ensuring a secure network operation and therefore and takes the decision on the activation of flexibility. – Ensure that flexibility activation of market bids (local market) will not create grid constraints.

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Table 3-11: EU-SysFlex defined BUCs [34]

Name	Scope	Objectives
Manage active power flexibility to support mFRR/RR in the Finnish demo	The aggregator (Helen) uses distributed resources to participate to the manual balancing power market (mFRR/RR) of the TSO (Fingrid).	– Bring the frequency back to the required value: The system frequency after the resources activation should be back within the values defined in the regulation. – Increased revenue: The Aggregator wishes to improve its revenue by better utilizing the resources it has available.
Manage reactive power flexibility to support voltage control in the Finnish demo	Creation of a new market for reactive power at the distribution level. The market is operated by the DSO and would be open to all the resources connected to the network which satisfy to the requirements. In the demonstration however, only one aggregator will be participating to the market.	– Avoid penalties: The DSO wants to avoid penalties for reactive power exchanges being outside of the allowed PQ-window determined by the TSO. – Increase revenue: The Aggregator wishes to increase the revenue it gets from operating its resources by providing reactive power services to the DSO
Manage active power flexibility to support congestion management and voltage control in the German demo	This use case will explain how active power flexibilities from distribution grids can be used to solve congestions in transmission grids, while respecting distribution grid constraints on the one hand and solving congestions in distribution grids on the other hand. The timing of this use case lasts from day ahead to intraday. Active power flexibilities are activated based on schedules.	– Reducing counteractions by TSOs and DSOs: Establishing a coordination process on a schedule basis to reduce counteractions. Therefore, frequency reserve activations by TSOs (caused by DSO's real-time curtailments) and DSO's counteractions (due to TSO's frequency reserve activation or redispatch) are reduced. – Improving TSOs flexibility selection process: Offering further flexibility options for active power management to TSO by activating flexibilities in the distribution grid under consideration of

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		sensitivities. Therefore, the TSO's congestion management costs can be reduced.
Manage reactive power flexibility to support voltage control and congestion management in the German demo	This use case will explain how reactive power flexibilities from the distribution grid can be used to support reactive power management in the transmission grid, while respecting the distribution grid constraints on the one hand and using reactive power management in the distribution grid on the other hand. The timing of this use case in EU-SysFlex lasts from day ahead to real-time. Reactive power flexibilities are activated with operating signals to units.	– Offering further reactive power flexibility options for voltage control and congestion management to TSOs by activating flexibilities in the distribution grid.
Manage active power flexibility to support mFRR/RR and congestion management in the Italian demo	Provide active power flexibilities from distribution grid for mFRR/RR and congestion resolution services to the Transmission Network in real-time operations. The market operator manages a local flexibility market, collects and aggregates flexibility offers from customers and aggregators and provide them to the centralized market operator. The distribution system operator can exploit flexibilities to solve congestions in distribution grid; it cannot use its own assets (ex: Battery Storage) for participating to the centralized transmission ancillary services (mFRR/RR market), but only for distribution system management and for solving imbalances (counter-activations in case of activation of flexibilities for local congestion management).	– Manage a local flexibility market and provide aggregated flexibilities at Primary Substation interface, guaranteeing secure operations of the distribution grid. Increase the participation of distributed energy resources in the transmission network mFRR/RR market.

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Manage reactive power flexibility to support voltage control and congestion management in the Italian demo	Manage the reactive power exchange at Primary Substation interface for voltage control and congestion management in real-time operations of the transmission network. The fulfilment of these services is performed by the Distribution System Operator through suitable optimization processes, exploiting reactive power flexibilities connected to the distribution network. These flexibilities come from distributed resources connected to the distribution network and from the Distribution System Operator own assets (i.e., Battery Energy Storage Systems, STATCOM, other). These mixed flexibilities portfolio may, potentially, drive to a broader capability area in order to constantly guarantee the provision of the agreed reactive power exchange between the distribution and transmission networks.	– Manage and optimise the distribution network in real-time, allowing the Distribution System Operator to procure the contracted reactive capability from flexible distribution resources. – Provide a broader reactive power capability area at Primary Substation interface, through the exploitation of a portfolio of flexible resources. – Manage the flexibilities portfolio, exploiting the reactive power flexibilities from private resources connected to the distribution grid.
Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo	This BUC proposes an extension of the current Portuguese replacement reserve market (tertiary reserve market) to make it more flexible, allowing generation and loads to provide this service, making it closer to real-time, and allowing resources connected at the distribution network as aggregated replacement reserve (active power) providers, but guaranteeing that no distribution network constraints are violated	– Inclusion of new types of active power providers: Inclusion, as aggregated reserve providers, of new providers that could aggregate load and generation resources connected at the distribution networks. – TSO-DSO coordination: TSO-DSO coordination mechanism to allow the participation of distributed network resources, but guaranteeing that, for those bids involving resources connected to distribution networks, its

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		activation does not violate any distribution network constraint. – Close to real-time TSO active power market: Extension of the current replacement (tertiary) reserve market to make it more flexible, allowing generation and loads to provide the service, and making it closer to real time.
Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo	This BUC is for providing reactive power to the TSO at the TSO-DSO connection point for voltage control, by using the resources connected to the distribution network managed with a distribution network local market. This local market could also be part of a larger regional market (out of the scope of this BUC) where the TSO could select reactive power from different local sources, such as other distribution networks or any other type of local reactive power resource	– Proper timing design: Use proper time periods, delivering time, and simple and complex (if feasible) bids to allow for a sufficient and flexible reactive power control but avoiding excessive switching and degradation of assets. – Create local reactive power market: Establish a local market mechanism to incentivize private agents' participation to complement DSO resources, so that the DSO can use its own resources and the commercial ones to comply with TSO Q requirements. – Provide reactive power from the distribution grid: Use DSO and private resources connected to the distribution network to provide reactive power in response to TSO requirements, guaranteeing that no distribution network constraints are violated.
Provide active distribution grid dynamic model for transmission operator in the FlexHub	This BUC sets the rules for providing active distribution grids' dynamic response models to be delivered to TSOs for dynamic stability studies for planning purposes. The distribution grid dynamic model that is here	– Voltage and frequency dynamics: The dynamic model should represent the dynamic behaviour in terms of voltage and frequency variations.

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Portuguese demo	described is intended to be a basic tool to help the DSO on defining the set of parameters that describe the available technologies, as well as its combined response to frequency and voltage. This model framework will be then delivered to the TSO, which will substitute the actual load model with this new DSO dynamic model. On the framework of the EU-SysFlex project, the DSO dynamic model is a service that DSOs could provide to TSOs and is included in the Flexibility Hub (FlexHub) platform, with the benefits of the existing interaction layers.	– Derive a simplified dynamic model of the distribution network: The objective is to derive simplified distribution grid dynamic model to be delivered to the TSO.
Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo	In the context of the Portuguese Demo WP7 a Virtual Power Plant (VPP) will be tested and coordinated, by a market agent of flexibility provided from centralized resources including pump storage plants (PSP) and wind power plants connected to the transmission level providing aFRR services (aFRR - automatic frequency restoration reserve).	– Real-time management of the storage and generation portfolio: based on mathematical models including short term balancing operations. – Market bidding suite for the different markets: (day ahead, intraday, system services) respecting long term strategies for storage management. – Enhanced computational management system: integrating forecasting modules for prices, energy supply and demands. – Renumerate the Wind Power Plants: that in the future will lose the feed-in-tariffs. – Aggregation of mixed resources: for the efficient management of a portfolio, the hydro could compensate the deviations for the wind power plants.

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Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo	In the context of the Portuguese Demo WP7 a Virtual Power Plant (VPP) will be tested and coordinated, by a market agent of flexibility provided from centralized resources including pump storage plants (PSP) and wind power plants connected to the transmission level providing regulation reserve services (mFRR/RR - manual frequency restoration reserve / regulation reserve).	– Enhanced computational management system: integrating forecasting modules for prices, energy supply and demands. – Real-time management of the storage and generation portfolio: based on mathematical models including short term balancing operations. – Market bidding suite for the different markets: (day ahead, intraday, system services) respecting long term strategies for storage management. – Remunerate the Wind Power Plants: that in the future will lose the feed-in-tariffs. – Aggregation of mixed resources: for the efficient management of a portfolio, the hydro could compensate the deviations for the wind power plants.

Table 3-12: CROSSBOW defined BUCs [35]

Name	Objectives
HLU1 Regional Operation Centre	Demonstrate how the current services of the existing RSC in the region (SCC) can be enhanced by improving the supporting calculation methodologies and extending the provided services to other countries, define and incorporate new services and functionalities associated with short-term operation tasks, thus demonstrating how an RSC centre can evolve to a ROC.
HLU2 Cross-border RES management	Develop, deploy and test a Regional Coordination Centre for RES and support RES in becoming an actor that can provide other services to the grid operator in order to better and more environmentally-efficiently operate the grid. In other words, this centre should help intermittent energy sources turn into service providers at the same level as the other conventional energy sources

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HLU3 Cross-border storage of RES production/output	Develop a flexible mechanism that should enable storing excess RES energy in any available storage facility and allow access to all relevant actors while considering market operations and network constraints.
HLU4 Distributed storage for system stability and energy quality control	Achieve a more efficient operation of the grid at a lower cost by using distributed storage units while maintaining grid stability through the development of advanced algorithms that would allow the optimal management and coordination of distributed, cross-border storage units participating in STO-CC.
HLU5 Virtual Storage Plants	Propose a framework for different stakeholders to promote and adopt the use of VSP, by offering the System Operators specific services to use VSP as primary and secondary reserve and congestion management and transmission and distribution deferral, on the hand, and by enabling energy producers and retailers to use VSP to mitigate imbalance, store energy surplus and modulate market offers.
HLU6 Transnational Demand Side Management	Demonstrate the usage of DSM to increase RES penetration, namely in scenarios when the demand of a specific country cannot be covered with cheap and green energy units and big consumers are requested to modulate their consumption instead of activating expensive and polluting production units.
HLU7 Hybrid RES Dispatchable Plants	Demonstrate the capacity of hybrid power plants for providing energy and services in a similar manner to a conventional generator when required by the System Operator. This solution will meet the requirements imposed by System Operator to be considered as a dispatchable, firm and fully flexible power plant, and also will provide the needed tools to the generators in order to maximize revenue from selling electricity.
HLU8 Cooperative Ownership of Flexibility Assets	Establish a Cooperative Flexibility Platform that will enable flexibility providers (e.g., prosumers, consumers and distributed generation) to organize themselves and, independently from conventional electricity players like retailers, offer aggregated flexibilities at national balancing or other suitable electricity markets.
HLU9 Transnational Ancillary and Wholesale Market	Propose unified types of balancing services, dimensioning, procurement and settlement of balancing reserves and standard products (including balancing energy measurement). Examine cross-border balancing principles for common usage of balancing reserve and exchange of balancing energy and imbalance netting.

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Table 3-13: FARCROSS defined BUCs

Name	Objectives
Enhanced grid operations and energy forecasts from increased resolution	TSO Users shall have the ability to obtain RES production, Load, OHL rating, ice and storm forecast, with the option to integrate into existing TSO EMS environment and further used for short term planning analysis inside DACF, 2DACF and capacity calculation processes, or reliability studies and maintenance/outage scheduling. This capability will be made possible as an extension to current TSO tools, although a dedicated interface to the EUROPAN platform shall be formed to provide access to connected users - not interfering with currently live systems. The EUROPAN platform's GUI, shall provide a grid presentation on the GIS based grid map through a stack of layers providing information and relevant alarm signals.
High Spatio-temporal resolution	TSO Users and other Users will be able to choose customized aggregation of the modelled entities to be shown on the GIS based grid map together with the weather forecast series and visualized weather conditions map layer (showing cloudiness, precipitation, temperature, wind speed for the whole region not only for selected set of POIs). High-resolution weather forecasts besides being directly presented on the GIS based grid map, through a dedicated layer, will also be used by the internal EUROPAN's tools for additional calculation: production forecast, load forecast, OHL rating forecast, ice forecast and storm forecast explained in BUC 2. EUROPAN's relevant functionalities: – High-resolution weather forecasting (500m to 1 km grid coverage), – High-resolution deep grid modelling that allows customized aggregations
Enhanced inter and intra-TSO operational planning and analysis	EUROPAN will actively support inter and intra TSO collaboration by creating standardized interfaces for data exchange based on the CGMES format, making it a standalone power system analysis application for a certain group of users. All the Grid data and analysis output data will be available on a EUROPAN's screen as a separate data layer of a GIS based grid map. Additional communication channels shall be formed (messaging & file exchange systems) shall provide EUROPAN users with the interactivity for online interaction. EUROPAN's functionalities: Forecasting analysis (secondary, EUROPAN internally uses its forecasts to produce additional analysis): 1. CGMES I/O functionality

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	2. Power system analysis using interface towards existing TSO tools or internal tool, consisting of: i) Congestion forecasting (Load flow + Contingency analysis + Contingency statistics + mitigation measures and OTDF matrix calculation), ii) Capacity calculation (ATC evaluation / re-evaluation through PTDF matrix, closer to the real-time operations) iii) Reserves forecasting (reserves evaluation / re-evaluation, closer to the real time operations) iv) Grid losses calculations 3. Emergency state of the grid forecasting
Optimized market data and trading portfolio analysis	EUROPAN shall be able to produce estimates of the market supply and demand curves that can be further used by market players as input to market simulation tools for improved decision making on different time horizons. EUROPAN shall also be used as a market prediction tool, using its load and production forecasting capabilities and - being connected to the market data base - can improve market predictions and serve as an ancillary tool for market analysis and market price forecasting. EUROPAN shall be able to make the full coupling of available market and network data, checking the consistency of an external market simulation tool solutions, against foreseen grid capabilities and current situation in the network. TSO user shall be able to get market simulation inputs and further use them inside their market simulation tools and market database. EUROPAN's functionality: Market and network data coupling.

Table 3-14: InteGrid defined BUCs [36]

Name	Objectives
HLUC01	Operational planning (from hours to week-ahead) of MV distribution network to pre-book available flexibility
HLUC02	Distributed monitoring and control of LV network using available flexibilities
HLUC03	Perform asset health diagnostics for preventive maintenance
HLUC04	Operations centre plans repair of unplanned outages based on sensors and remote diagnostics and historical data

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HLUC05	Manage the impact of flexibility activation from resources connected to the distribution network
HLUC06	Provide data management and exchange between DSO and stakeholders
HLUC07	Procure and manage regulated flexibilities from DER to optimize operation and costs
HLUC08	Manage internal processes' flexibility to minimize energy costs according to market-driven mechanisms and system operators' requests
HLUC09	Perform energy management to maximize self-consumption and self-sufficiency
HLUC10	Aggregate and communicate multi-period behind-the-meter flexibility from LV prosumers
HLUC11	Engage consumers in demand-side management programs considering contextualized (environmental, price, peak load reduction) feedback mechanisms
HLUC12	Aggregate geographically distributed third-party (multi-client) resources to offer ancillary services to TSO (frequency) and DSO (non-frequency)

Table 3-15: TDX-Assist defined BUCs [37]

Name	Objectives
Activation of DSO-connected resources for balancing purposes in market environment	– Improve the system security. DSO provides balancing service for TSO using demand response mechanism. – Validate information exchange between TSO and DSO necessary for activation of DSO-connected resources for balancing purposes in market environment. – DSO participate at balancing service market.
Coordination of distributed flexibility services in a marketplace	– Investigate different strategies for TSO-DSO coordination that will maximise usage of flexibility services. – Test different solutions to validate the flexibility offers both by TSO and DSO. – Achieve competitiveness of flexibility resources in a common pool and obtain market liquidity. – Take advantage of increasing amount of flexibility resources connected in the distribution grid for providing services for the benefits of the overall power. Improve the system security.
Optimize active power management by the System Operator for congesting management purposes	– Define the interactions between TSO and DSO and the exchange of information to achieve to an optimal management of congestion situations.

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TSO and DSO coordination of reactive power management to voltage control purposes	– Improve the system security Improve the quality of electricity supply. – Control the voltage level at the TSO/DSO interface areas.
Coordination of operational planning activities between TSO and DSO	– Anticipate and solve transmission grid constraints. Enhance the scheduled/forecasted information exchanged in TSO-DSO interface to improve programming of TSO operation. – Enhance the scheduled/forecasted information exchanged in TSO-DSO interface in order to improve programming of DSO operation. – Application of state of the art, standardized technological means to perform operational planning data exchange between TSO and DSO. Reduce DER curtailment. – Improve quality of service. – Anticipate and solve distribution grid constraints.
Optimize work programs (TSO, DSO, and SGU works)	– Maximise renewable energies production Program as many works as possible in coordination with other parties. – Validate the Works proposed by the TSO, Producers and by the DSO. – Optimisation of the works planning taking into account the expected technical constraints. – Prepare a sequence of operations to be performed by the operator in the control room.
Coordination between TSO and DSO for distribution network reconfiguration	– Improve the quality of electricity supply. – Limit DSO congestion constraints during a network reconfiguration. – Optimise DSO Network Operation. – Optimise TSO and DSO work planning Improve the system security.
Coordination of long-term network planning between TSO and DSO	– Ensure long-term power networks stability and robustness. – Standardize network planning information exchange. – Improve investment planning based on improved long-term plans. – Development of scenario preparation mechanisms Improve long-term network planning considering modern challenges
Improve system real-time supervision and control through better coordination (TSO, DSO and SGUs)	– Ensure regular review of observability areas of both TSO and DSO to accommodate any substantial structural change in network configuration over time. – Solve transmission grid constraints.

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	– Increase observability areas of both TSO and DSO on each other networks, expanding the set of signals (measurements, states …) exchanged in real-time, as well as improving data exchange structure/normalization. Reduce DER curtailment Enlarge real-time data exchanged between TSO and DSO for improved supervision and control of their networks. Solve distribution grid constraints
Improve fault location close to the TSO-DSO interface	– Reduce the needed time for fault information exchange between the TSO and DSO. – Improve the accuracy of fault location at distribution lines through enhanced levels of real-time information exchange between TSO and DSO. – Reduce the needed time to locate a fault by DSO's operational teams and, ultimately, minimize downtime of electricity distribution lines, at the border with the transmission network, in face of a fault.

The review process of the use cases defined in the 15 projects revealed that IEC-62559-2 is the most commonly used methodology and that defining the use cases is a unique process that should take under consideration each project's objectives and individual characteristics. Nevertheless, some projects present common characteristics among the defined BUCs. INTERRFACE, CoordiNet, EUniversal and EU-SysFlex defined BUCs focusing on testing different system services and system products being procured in different timeframes. CROSSBOW, FARCROSS, Synergy and InteGrid focused on testing different functionalities of the tools each one developed. TDX-Assist focused on testing the TSO-DSO coordination process in various market designs.

3.2.6 Mapping of KPIs defined on demonstrators

From the 15 projects, in 10 of them, KPIs had already been identified. These projects are namely: CoordiNet, INTERRFACE, TDX-Assist, Platone, InteGrid, CROSSBOW, InterFlex, EU-SysFlex, Osmose, and FARCROSS. In SmartNet project KPIs were not identified. In the rest four projects, KPIs had not been defined at the questionnaire's distribution[8]. As can be seen in Figure 3.20, InteGrid project has defined the highest number of KPIs (64), followed by CROSSBOW (44) and CoordiNet (38). Figure 3.21 depicts a mapping of the KPIs defined in the concerned projects onto four main categories: economic, technical, environmental, and social. Approximately three-quarters of the defined KPIs quantify and assess a technical perspective of the projects. A fifth of the defined ones, evaluate the financial benefits of the approaches applied in each project. The rest KPIs

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which account for less than 10% of the total number, focus on the measurement of project success regarding environmental and social objectives.

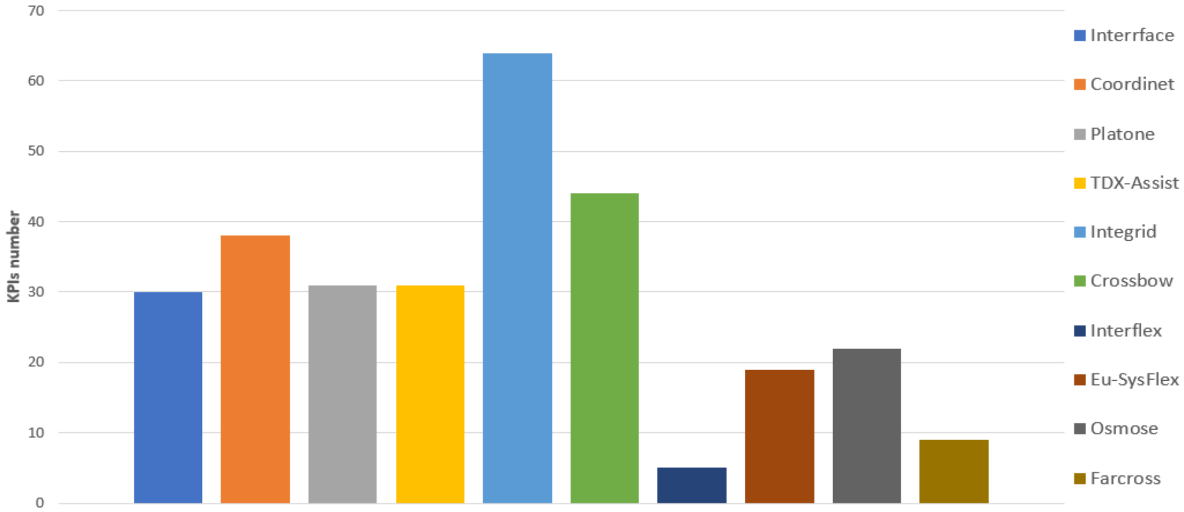

Figure 3.20: Number of KPIs defined per concerned project.

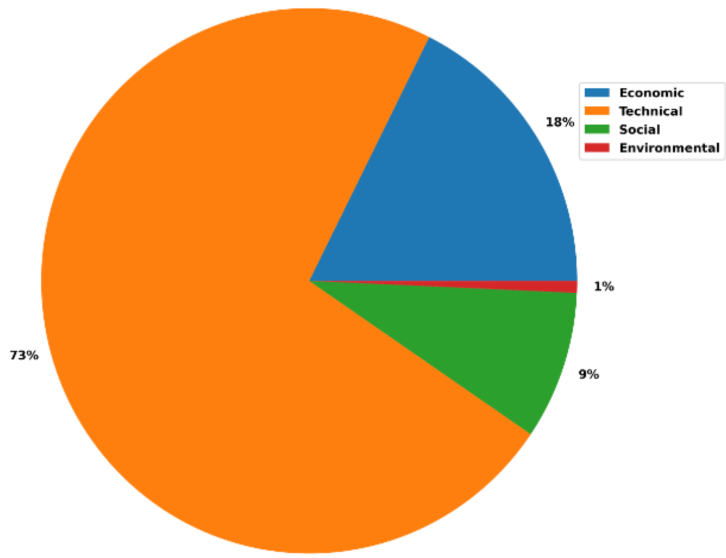

Figure 3.21: KPIs categorization on the concerned projects.

Due to the close affinity of OneNet project with CoordiNet and INTERRFACE (participation in the same call[9], we further analyse the KPIs introduced in those two projects. As Figure 3.22 illustrates, both projects mainly

- [9] LC-SC3-ES-5-2018-2020 - TSO – DSO – Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation. Available in: https://cordis.europa.eu/programme/id/H2020_LC-SC3-ES-5-2018-2020

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introduce technical KPIs for the quantification and assessment of the objectives' progress. Those KPIs mainly quantify the operation and performance of developed tools (e.g., state estimation performance, forecasting accuracy, data reliability ratio), the solutions' effect on the grid condition (e.g., decrease in congestion, number of islanding hours, voltage variation, increase in hosting capacity) and technical characteristics of the market (e.g., amount of provided flexibility, the total amount of offers). Besides the technical ones, a significant amount of economic KPIs is introduced. Within the INTERRFACE project, economic KPIs have a share of more than 30% compared to the total introduced in the project number of KPIs. Economic KPIs used mainly to quantify the increase in liquidity in wholesale and local markets, the calculation of operational expenses (OPEX) for service procurement, ICT cost of the developed tools, improvement of BESS turnover due to the participation in the markets and average cost per service for the demonstration period. In addition to the above mentioned KPIs, CoordiNet defines social and environmental ones trying to quantify the user engagement (i.e., active participation in the market, participant recruitment) and the environmental benefits (i.e., the share of fossil-based activated energy, reduction in RES curtailment).

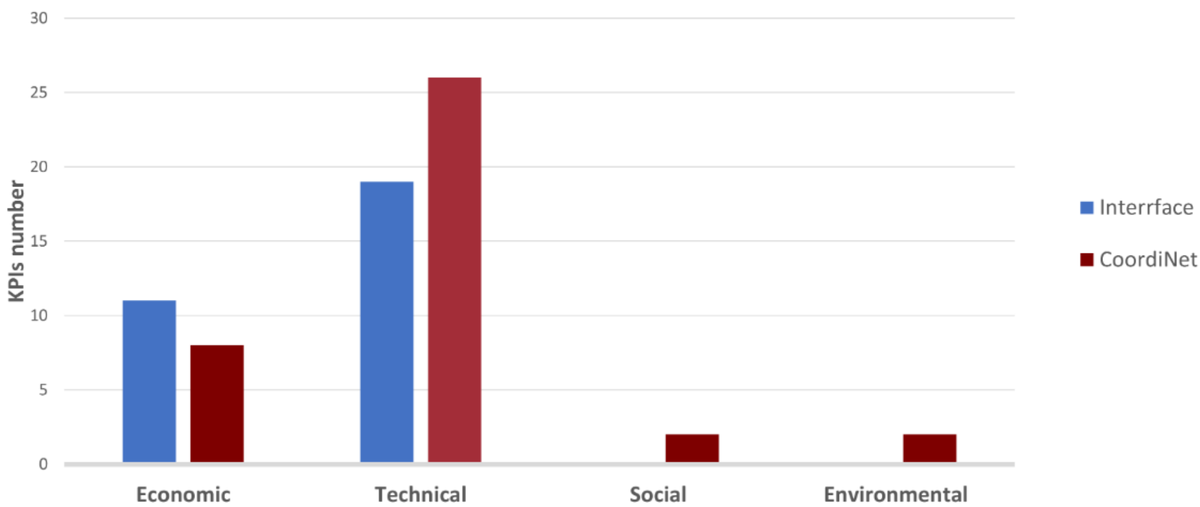

Figure 3.22: KPIs categorization in CoordiNet and INTERRFACE projects.

3.2.7 Assessment of identified barriers

Identification of the barriers is a common activity within H2020 projects, since it provides valuable information regarding the actions that should be considered to better facilitate the objectives of each project. Most of the barriers are identified from the demonstrators' feedback on the difficulties they faced, while complementary a high number of projects conduct regulatory analysis for the countries where the demonstrators are carried out.

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Many of the projects evaluated in this report do not provide detailed lists of barriers because their demonstrators are still active, and barriers will be identified at a later stage. Figure 3.23 depicts the number of barriers that were identified within the concerned projects clustered as legal/regulatory, economic, technical, and social.

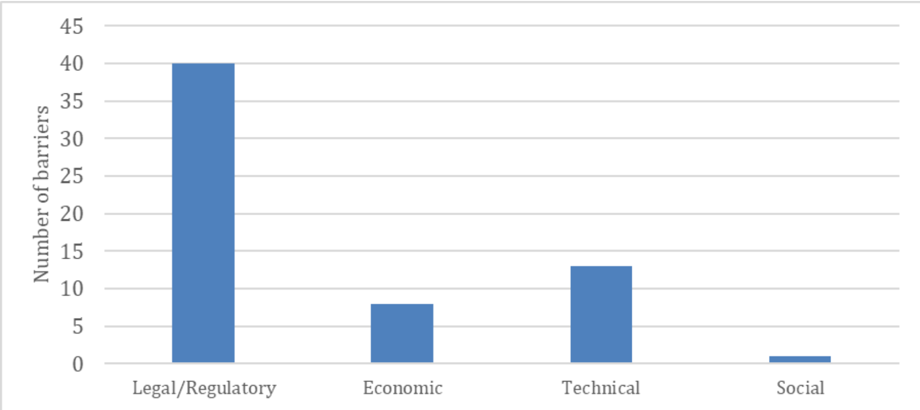

Figure 3.23: Identified barriers categorization within the reviewed projects.

InteGrid project is the one that provided most of the barriers that are considered in the regulatory section by identifying 31 regulatory barriers in the five target countries [38]. These barriers are presented in Table 3-16.

Table 3-16: Regulatory barriers identified within InteGrid project.

Topic	Sub-topic	Identified barrier
DSO Economic regulation	Revenue regulation	Lack of incentives for DER flexibility procurement due to asymmetries between the treatment of CAPEX and OPEX which favour the former over the latter.
		Lack of incentives to extend the useful life of network assets beyond their regulatory lives.
		DSO revenue regulation does not remunerate the cost of new "distribution services" i.e., management of the grid using flexibility.
		Allowed revenues based on past investment/costs only, without considering future investment needs, including DER.
		DSO are not required to submit long-term investment plans and/or it is not clear how these are reflected in their allowed revenues.
		New smart grid technologies, beyond pilot projects, are not considered in the remuneration of DSOs.
	Other output-based incentives	Incentives for the reduction of energy losses are not in place or provide weak incentives (low-powered incentive, dead-bands, non-symmetric designs, cap, and floors).

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		Output-based incentives for continuity of supply are not in place or provide weak incentives (low-powered incentive, dead-bands, non-symmetric designs, cap, and floors).
		Energy losses incentives do not consider the impact of DER and smart grid technologies.
		Reference values for reliability indices based exclusively on historical values, cost-benefit analyses that allow continuous improvements are not being carried out.
		Equal treatment of planned and unplanned interruptions or stringent requirements to qualify as a planned interruption.
		Lack of incentives for innovation and experimentation, including the possibility of requesting regulatory sandboxes.
Other roles of DSOs	Network access and connection	System users do not have appropriate information regarding expected expansions or upgrades due to new connections (degree of detail of the expansion plans). Lack of transparency on available grid capacity for new DER.
		Deep connection charges are a barrier to the connection of DG, particularly small units.
		Lack of transparency in the calculation of grid connection charges.
	Ownership of storage	Unclear regulation on the ownership of storage systems by DSOs.
Local flexibility markets/services	Mechanism to provide local flexibility	Mechanisms for local flexibility procurement and provision (local markets, non-firm access, agreements DSO-DER) are not implemented
		Lack of regulation for the coordination between TSO and DSO for the provision of ancillary services by DER
Balancing Markets	Balancing services	Balancing markets are not open to demand, included the one connected at distribution level, or balancing products not suited for demand-side resources
		Balancing market access and product definition not suited for DER (minimum sizes, design of deviation penalties, upwards and downwards allocated together, dual imbalance pricing)
		Barriers to the development of the aggregation activity
		Barrier for the aggregation of different DER types
		Barriers to independent aggregation (e.g., balancing responsibility)
Tariffs and self-consumption	Retail tariff design (regulated charges)	Regulated charges show no or little time discrimination; structure inappropriate to promote flexibility
		Tariff design: high share of taxes and other regulated costs may kill other price signals
		Self-consumption not permitted or facing relevant barriers (administrative, economic, technical)

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	Self-consumption and metering	Inefficient incentives for self-consumption that hamper flexibility: net-metering permitted; a large share of regulated costs charged through a volumetric component
		Insufficient smart meter capabilities
		Lack of a clear framework for the deployment of smart meters (technical requirements, accessibility)
Data Management	Data Management	Lack of definition on the data-management model
		Barriers to grant access to metering data to third parties, whilst complying with GDPR requirements

From the rest of the reviewed projects, the barriers that were identified are reported in Table 3-17.

Table 3-17: Identified barriers from the reviewed projects (excluding InteGrid) [39] [40]

Project	Barriers	Characterization
CoordiNet (from the Swedish demo)	The liquidity in terms of competition among bids though was not good enough with a lower level of bids available than hoped from some flexibility providers. Several flexibility providers underestimated the effort and time needed for preparation to provide flexibility. This resulted in fewer bids than the DSOs than they had hoped for.	Technical
	Few flexibility providers are willing to participate in a market with only free bids today.	Technical
	Privacy and security improvement processes were not easy and there is no standard way to perform the security assessment for the information exchanged between flexibility providers, companies providing services in the market infrastructure and DSOs.	Technical
EUniversal	Limited experiences with smart flexibility technologies and enabling products at commercial level. Current technologies and solutions must be scaled up to prove their replicability in making the expected impact. In addition, the enhanced operational capability enabled by flexibility requires changes in internal operating processes and a revision of relationships with customers.	Technical

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	Current regulatory frameworks limit potential benefits from the use of flexibility services in grid operation. Issues such as flexibility use for investment deferral, innovation on smart grids, data handling, market regulation, etc.; should be properly addressed.	Regulatory
	Societal and high-level leadership concerns that integrate a range of governance, financial and technical barriers: lack of standards, insufficient government/societal endorsement, consideration of social acceptance and customer usage of technologies, etc.	Social
	Lack of funding sources	Economic
SYNERGY	Potential restrictions in data usage and sharing, due to privacy, legal and ethical concerns may hinder the business potential of energy big data platforms.	Legal
	Reluctance of stakeholders to transform their established business models.	Economic
	Inability to open up existing silos due to proprietary data formats and APIs.	Legal
	Independent Demand-Side Flexibility aggregators are currently hindered from entering the market and a clear regulatory framework is missing.	Regulatory
	Roll-out of smart meters needs to accelerate.	Technical
	User acceptance of smart appliances and intelligent energy management systems is low.	Economic, Technical
InterFlex	Local availability and reliability of flexibilities: The demonstrators highlighted that flexibility sourcing remains a critical element. Especially at the early stage of the market development when flexibility value is low and the DSO's flexibility demand remains sporadic and not easy to predict,	Economic, Technical, Legal

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	there is high risk of experiencing fragile aggregator business models and a lack of liquidity on the market. In the current situation, conditions are not yet met in the demonstration areas to set up durable business models for local flexibility markets, as the distribution grid presents a very small number of constraints.	
	Financing of control infrastructure and technical implementation of direct-control solutions for demand response: Financial incentives do not always meet the customers' expectations, considering both the lack of maturity of the flexibility market, particularly in the B2B and residential segment.	Economic
	Data privacy and General Data Protection Regulation (GDPR): Under the current rules the customer consent forms that need to be signed prior to any access to metering data have to specify in a very detailed way all services the data will be used. As a result, the complexity of those consent forms is too high for residential customers.	Legal
	Cost effectiveness of the stationary battery storage business models: Despite considerable progress, most stationary battery storage business models are not yet economically viable.	Economic
	National and local administrative hurdles for the usage of battery storage systems and PV installations: Important national and local administrative hurdles have been experienced during field implementation (risks, authorizations, environmental & fire protection). The same applies for PV installations.	Legal

As mentioned in section 3.2.3, i.e., Classification of demonstrators' activities, demand response was considered in a high number of projects. For that reason, it was deemed necessary to include, at this point, the barriers regarding demand-side response which were presented in the Florence Forum [2].

Main barriers / regulatory gaps identified at wholesale/transmission level:

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- Absence of EU frameworks for aggregation and prequalification processes.
- Some level of harmonization required to enable DSF (directly or through aggregation) to access the benefits of cross border trade.
- Harmonization mainly to be reflected in the SOGL, EBGL and CACM.
- Main barriers / regulatory gaps identified at the distribution level:
- Absence of EU regulatory framework for the development of a (local) congestion management market.
- High level principles exist, but key design features need to be clarified in network codes.

Based on the collected information the following conclusions can be drawn:

- One strong request from flexibility providers was further digitalization.
- One of the more difficult and time-demanding issues was handling data management and security.
- Standardization has an important impact on interest in investments and market competitiveness. With an increasing number of technologies being connected to the grid, interoperability is becoming a true challenge. Regulation update is also required for addressing the new era and actors of the smart grid.
- Current technologies and solutions must be scaled up to prove their replicability in making the expected impact. In addition, the enhanced operational capability enabled by flexibility requires changes in internal operating processes and a revision of relationships with customers.
- An integrated smart grid solution requires addressing the cost (capital and operating) for deploying and integrating solutions. Thus, favourable funding sources should be available e.g., government incentives, lending mechanisms, etc.
- Incentives for Local Energy Communities and collective self-consumption could be a more effective solution for the participation of residential prosumers.

3.3 Analysis of national projects

In this section of the deliverable, four national projects, and collaboration initiatives among several stakeholders in energy sector are presented. The analysis conducted in the following projects is not as thorough as in the before mentioned projects due to the lack of excess information and the differences in the projects' structure compared to the Horizon 2020 projects. However, OneNet project can leverage important elements documented in this section and build upon on that.

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3.3.1 DA/RE

DA/RE project [41], i.e., data exchange and redispatch, initiated by TransnetBW and Netze BW, aims to develop an IT platform that supports TSOs, DSOs, generating plants and storage assets to exchange data and coordinate in an efficient manner, facilitating the participation in the mandatory "Redispatch 2.0" decentralized congestion management scheme. In 2019, the Federal Ministry for Economic Affairs and Energy adopted an amendment to the Grid Expansion Acceleration Act (NABEG 2.0), introducing a new redispatch regime in which all generation and storage assets with a capacity greater than 100kW and controllable assets in lower voltage levels of the distribution grid, shall participate. This mandate will be in effect as of October 2021.

DA/RE implements an administrative redispatch procedure with cost-based reimbursements, and thus there are no specific product definitions. One of the main functionalities that DA/RE platform offers is various connection options for data exchange among network operators. Data can be exchanged via XML files leveraging four different communication architectures: an Application Programming Interface gateway (API), a Secure File Transfer Protocol (SFTP), an Email Adapter (EA), and a web Graphical User Interface (GUI). For the redispatch procedure, an optimization algorithm calculates the dimensioning parameters for energy redispatch in order to alleviate congestion issues. Time series forecasted data are used as an input to DA/RE, communicating to the platform the redispatch requirements per network operator in Day-Ahead time frame. By considering network constraints of all operators (TSOs and DSOs) in the optimization process, congestion issues are alleviated without transferring the problem in different locations of the network while maximizing flexibility potentials from different voltage levels of the grid. The redispatch results are reported and sent to the involved parties, i.e., network operators and plant owners, to activate flexibility.

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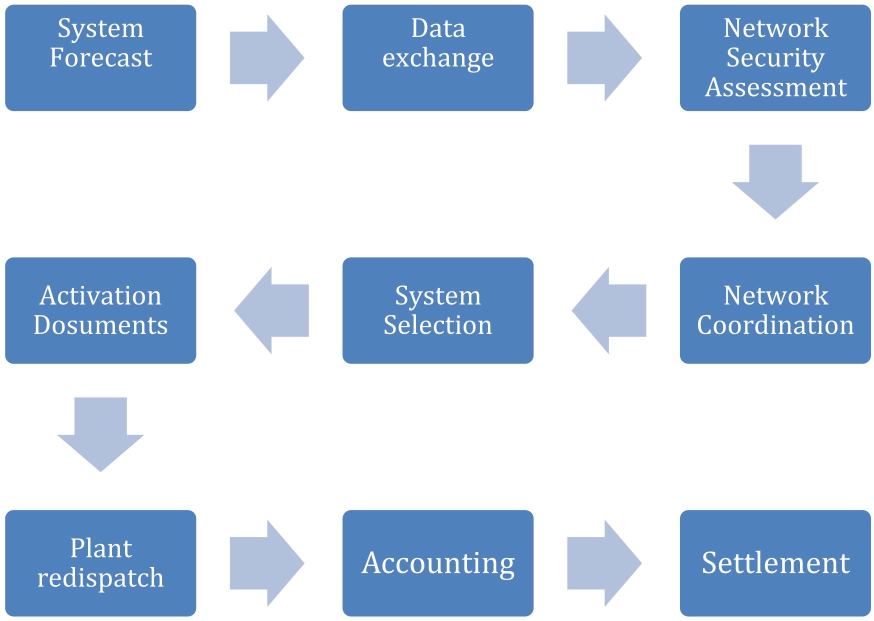

Figure 3.24: DA/RE platform redispatch procedure. Adopted and translated by [42].

OneNet project can utilize the data exchange architecture of the DA/RE project, regarding the vertical communication of network operators and flexibility. In addition, the process used for flexibility procurement, activation and settlement can be used by Demonstrators as an initial framework to build upon on that.

3.3.2 GOPACS

GOPACS (Grid Operators Platform for Congestion Solutions) is a market platform owned and operated by the Dutch-German TSO (TenneT) and four DSOs (Stedin, Liander, Enexis Groep and Westland) [43]. The platform (launched in January 2019) acts as an intermediary between the needs of network operators and markets with the aim to alleviate grid congestion in an efficient manner. The coordination achieved through the platform (TSO-DSO coordination) prevents the congestion to shift to different branches in the network and aggravating another grid operator's problem. GOPACS is not a market platform itself, but it is connected to a national Intraday platform, Energy Trading Platform Amsterdam (ETPA), which is operational in the Netherlands. At this moment, flexibility is provided solely by assets connected to the transmission grid. In the near future, also flexibility from assets connected to low voltage levels, such as from Electric Vehicles, is expected to participate.

GOPACS enables grid operators to procure standardized products from existing Intraday markets, in which a locational tag, called European Article Numbering (EAN) code, is added to define flexibility within local perimeters to alleviate congestion issues. GOPACS algorithm identifies the assets that offer the most cost-efficient solution while the grid balance is maintained. The GOPACS platform defines the Intraday Congestion Spread (IDCONS) product which is a combination of two offers in opposite directions, an ask and a bid, having

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the same starting time and duration. The orders have similar format as Intraday wholesale order and a time span of 15 minutes, 1 to 6 hours. There are no minimum or maximum prices or volumes defined for IDCONS. For each congestion notification issued on GOPACS, participants on the intraday market that are located within the congested area submit an energy sell or buy order, and those located outside of the congested area can submit an opposite (i.e., buy or sell) direction order. Direction of offers is based on the characteristics of the congestion. The network operator who initiated the request pays the difference between these two prices, i.e., spread, to enable the transaction to take place and solve the congestion issue.

OneNet project can thorough investigate to utilize as an input from GOPACS a congestion management product, i.e., IDCONS, which is a standardized product already procured in the Intraday market.

3.3.3 NODES marketplace

The marketplace NODES is a joint project between Norwegian Utility Adger Energi and the European Power Exchange Nord Pool, established in 2018 [44]. Main objective of NODES platform is the valorisation of flexibility and the opportunity provision to buyer to alternate its consumption/production according to a contract. NODES creates a marketplace for both DSOs to purchase local flexibility to solve local grid problems, and TSOs who are unable to leverage flexibility existing at in the distribution grids. Figure 3.25 presents the roles in the market design after the integration of NODES marketplace.

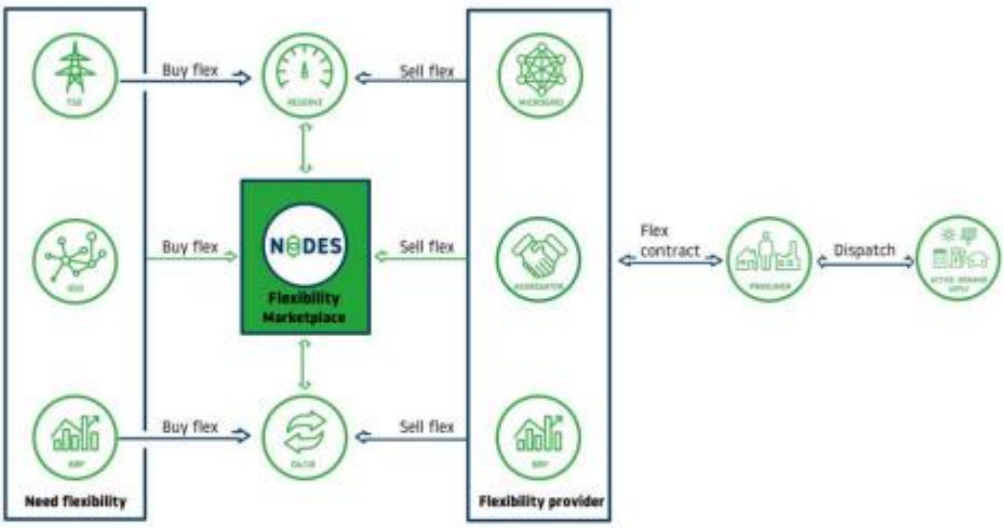

Figure 3.25: Roles identified in the market design encompassing NODES marketplace [44].

Several Use Case and projects are already demonstrated in the Northern Europe using the NODES marketplace; In Germany, with the region of the DSO Mitnetz Storm, NODES marketplace was leveraged to

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manage excess renewable energy production situations, by saving investment and operational costs. In Norway, the NorFLEX project is a 3-year pilot for local flexibility procurement established by the Norwegian TSO Statnett and DSOs Agder Energi, Glitre Energi, and Mørenett, based on NODES and the technology-provider Enfo. Three demonstrators will test various technological solutions to enable local flexibility to be made available at the distribution system initially, and potential later to be made available on the existing TSO's reserves market. Launched in 2020 by Western Power Distribution (WPD), the IntraFlex project is a DSO-led trial of flexibility procurement using NODES marketplace. IntraFlex is testing the use of a continuously clearing marketplace that operates from a few days ahead to close to real-time for the procurement of flexible generation and consumption, adding to WPD's existing flexibility procurement system 'Flexible Power'. Figure 3.26 depicts the system overview of the Intraflex project, along with the interfaces developed for data exchange and communication among the different actors in the project.

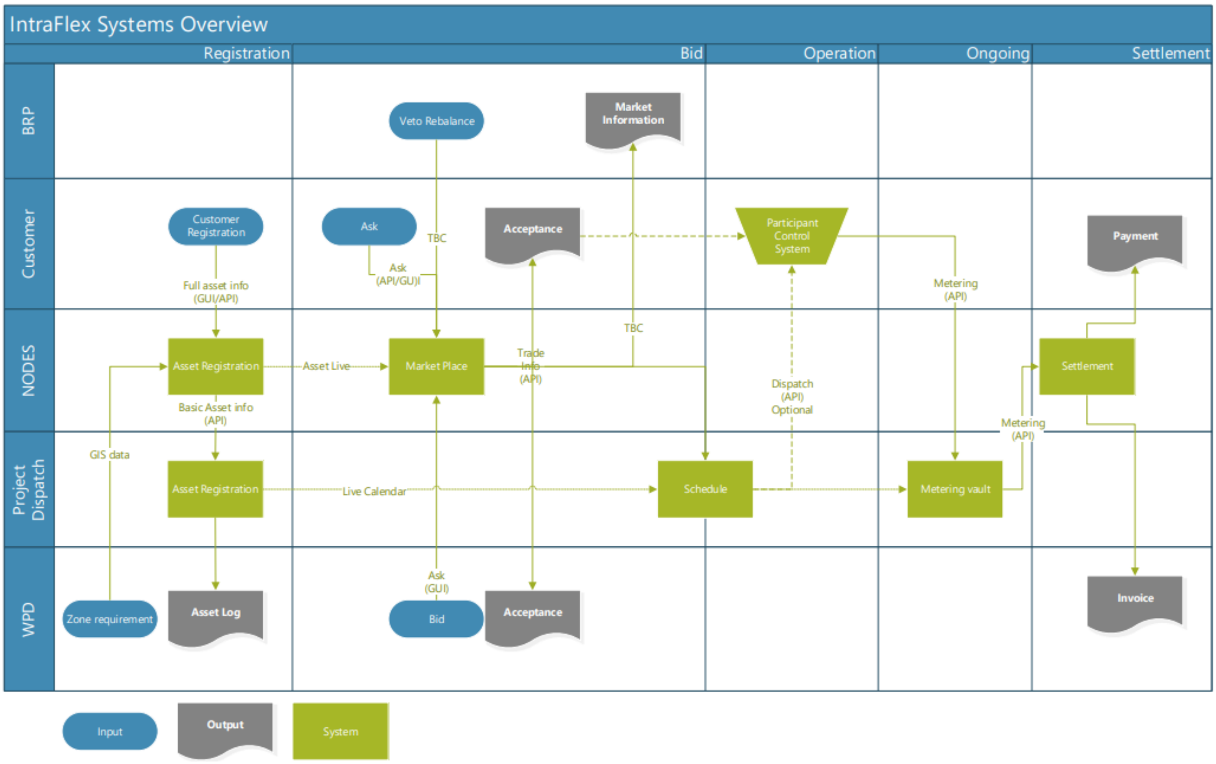

Figure 3.26: IntraFlex project system overview [45].

OneNet project can acquire valuable information by NODES marketplace and its different demonstrated projects and Use Cases, mainly regarding the integration of flexibility marketplaces in wholesale markets and the creation of interfaces for data exchange among the actors in the flexibility value chain.

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3.3.4 PICLO FLEX

Piclo Flex is an independently operated marketplace that enables energy and availability trading between FSPs and DSOs [46]. Its trial operation started on 2018, and the commercial offering was launched at mid-2019. Piclo is an independent software company which piloted its decentralised flexibility market platform in June 2018 with funding from the UK Government. In February 2019, following a trial period with all six Distributed System Operators (DSOs) in the UK, Piclo Flex was commercially launched via procurement contracts with UK Power Networks (UKPN), Scottish and Southern Electricity Networks (SSE) and Western Power Distribution (WPD).

Currently Piclo is solely used by DSOs. However, when a DSO activates a resource for congestion management must notify the TSO. Piclo's cloud-based platform can facilitate the following steps in the procurement of flexibility by DSO; provision of an online trusted and independent marketplace, automation of dispatch signals facilitating real-time operation, and post-event settlement process by automating data communications as well as validation and settlement calculations. Piclo operates a Dynamic Purchasing System (DPS) register that enables DSOs to set the duration that a FSP remains qualified to bid for flexibility services. When DPS exists, Piclo performs an automatic qualification assessment for every competition for each DSO. The criteria that considered during the prequalification phase are depicted in Table 3-18.

Table 3-18: Automatic technical qualification of assets assisted by Piclo [46].

Information	Description
Area	Whether the asset is located inside the main area that the flexibility service shall be provided.
Zone	Whether the asset belongs to the buffer zone of the system operator (if exists).
Voltage level connection	Whether the asset is connected a voltage level in which flexibility can be provided fulfilling the needs of the competition.
Compatibility	Whether the asset is able to provide compatible capacity for the specific needs of the flexibility competition.
Deadline	Whether the asset was uploaded before the qualification close deadline for each particular flexibility competition.
DPS approval	Whether the FSP has been approved by the DPS.

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In Piclo Flex, standardized defined flexibility products on UK are used by the DSOs to procure flexibility services. Table 3-19 presents the active power services defined by Energy Networks Association (ENA).

Table 3-19: ENA-defined active power services [47].

Active Power Service	Definition
Sustain	The Network Operator procures, ahead of time, a pre-agreed change in input or output over a defined time period to prevent a network going beyond its firm capacity.
Secure	The Network Operator procures, ahead of time, the ability to access a pre-agreed change in Service Provider input or output based on network conditions close to real-time.
Dynamic	The Network Operator procures, ahead of time, the ability of a Service Provider to deliver an agreed change in output following a network abnormality.
Restore	Following a loss of supply, the Network Operator instructs a provider to either remain off supply, or to reconnect with lower demand, or to reconnect and supply generation to support increased and faster load restoration under depleted network conditions.

Piclo is a partner of OneNet project, and thus can further increase the functionalities of its existing marketplace during the course of the project. On the other side, OneNet project can benefit from the developments in Piclo marketplace, by get inspired from the procedure used for prequalification in each flexibility competition and the concept of DSP.

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4 Conclusions

4.1 Important key points and achievements so far

Building upon the experience gained in previous H2020 and national projects is the cornerstone for achieving the strategic objectives and widest possible impact of such an ambitious project as OneNet. While a single solution, a single platform across Europe, is not feasible and not even reasonable, OneNet plans to demonstrate that a system of systems approach is possible and can be built on top of commercial and proprietary solutions thanks to an open IT approach. And the first step to do that is to define new and standardized products and services, as well as to identify the appropriate market structure starting from the experience of past and on-going projects. In this section, the conclusions drawn from the projects' assessment process, as well as the important achievements of the reviewed projects are highlighted.

In the context of new standardized products and services definitions, a common feature among various projects is that regarding system services definition, they all consider addressing a scarcity/need by the network operator as the driver of the service. However, although they all consider different definitions of products, they all indicate that products are the means network operators use to solve the scarcities they face. Moreover, the delivery of frequency control services, mainly provided by TSOs, includes a set of well-established products that are considered in almost all projects evaluated, while for non-frequency control services there appears to be more heterogeneity among the products definitions with no two projects using the same product definitions. The lack of standardization which was observed within the reviewed projects highlights the need for OneNet to contribute to that challenge.

Regarding the market structures in support of the defined products and services, the surveyed projects mainly concern network congestion management and voltage control which are characterised by a local dimension. Frequency control, and then balancing, is the other grid service mainly addressed by the reviewed projects. Furthermore, the analysis of the projects points out that the majority of them addresses the coordination among main actors TSOs and DSOs and the arrangements or contracts of them with FSPs. However, a relevant share of reviewed projects concerns the joint coordination of TSO, DSO, and flexible service providers. In addition, the exchange of flexibility can both be based on separated markets or on a unique market in which all system operators are buyers. In multiple markets, there will normally be only one buyer per market, the zonal system operator with exclusive access to the sellers' resources. Conversely, in the case of a unique market in which several system operators compete for buying flexibility, it is of interest to define clear and reliable rules which allow the TSO to exploit the flexibility of the resources connected to the distribution system without negatively interfering with the DSO activities. This rationale can be extended to all cases in which one system

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operator require to exploit the resources connected to the grid operated by a different system operator. This peculiarity of the power system represents a challenge for market design and influence the final structure of the procurement mechanism that can be devised. This challenge will be further investigated within OneNet project, where various market designs will be explored in different regions of Europe.

In the context of reviewing the BUCs defined in the considered projects, it was concluded that IEC-62559-2 is the most commonly used methodology, which is also the methodology that OneNet project will use. Furthermore, using the SGAM architecture reference and the HERM in the process of defining the BUCs seems to be quite important. OneNet will focus on ensuring the interoperability across multiple platforms and through this process new roles can be proposed to be considered in next role models, as well as in extending the HERM.

The assessment of the barriers identified within the considered projects showed that further digitalization, handling data management and security issues, standardization, as well as the need to look for open and flexible solutions were among the challenges that most of the projects faced and should be addressed in a European level. In this context, OneNet through its research and demonstrators will work towards the standardization of energy data management processes and the relevant cybersecurity strategies.

Finally, the information gathered from the presented national projects and collaboration initiatives showed that OneNet can utilize mature concepts from flexibility marketplaces and platforms regarding assets prequalification process, data exchange architectures, developed interfaces among actors in the energy value chain, and innovative services directly provided by standardized products from existing wholesale markets.

4.2 The starting point for building OneNet concept

This deliverable can be considered as a starting point for the creation of the OneNet concept. The progress that has been made in previous concluded and on-going Horizon 2020 projects is investigated and documented in this deliverable. This valuable information from different innovative activities across Europe must be leveraged to create adequate strong foundations on which the OneNet concept will be built upon.

The horizontal WPs 2 to 6, which follow the work done in this task, can utilize the information documented in this deliverable as follows:

- Task 2.2 can utilize the innovative market products and services (section 3.2.1) defined for different operators (Transmission and Distribution) to build upon that the foundations of OneNet' products and services. Harmonization and interoperability among the demonstrators' activities and the outcomes of WP2 shall be achieved to create standardized products on an EU wide perspective.

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- Market designs already implemented in the different projects are reported in sections 3.2.2 and in 3.3. These designs mainly concern the smooth operation of local markets for flexibility procurement and their proper integration in wholesale markets by applying different coordination schemes between operators (TSO and DSO) and consumers in multiple timeframes. WP3 shall use this input as a first step for the definition of fully integrated and coordinated markets in the context of OneNet project, regardless of the coordination schemes among market actors and cross-countries exchanges.
- WP4 can leverage the information documented regarding the BUCs definition in the different projects (section 3.2.5) along with the developed interfaces for communication between the market operator and the grid operators.
- WP5 and WP6, which are responsible to develop an open IT Architecture for OneNet and reference IT Implementation, can use the information regarding developed interfaces (section 3.2.4) and barriers identified in previous projects (section 3.2.7), to integrate either already developed architectures or important components of them and act proactively eliminating the possibility to meet obstacles that make difficult the implementation of the desirable outcome on a pan-European level. In addition to that, information from national deployed market platforms could provide valuable input regarding data exchange among actors.

Work packages 7 to 10 which are associated with the demonstration activities in the four defined clusters, can utilize the information reported in both sections 3.2.3, and 3.2.5. Specifically, information regarding the DER used for flexibility provision in previous demonstrators around Europe and the implemented BUCs shall be used from the different demo partners as a baseline and build upon on that their demo scenarios and customer engagement practices. Furthermore, procedures used for assets prequalification and registration considered from already developed initiatives presented in section 3.3.

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Appendix

ANNEX I

This section includes the questionnaire's template used for the data acquisition for the purposes of this deliverable.

Background information			
[Project Name]	Starting date		
	Ending date		
What is the objective of the project under review? *[provide a brief explanation of the main objectives of this project]*			
Has the project been completed?	*[Y/N]*		
If yes, what are its major outcomes?			
If no, what are its expected outcomes?			
What are the agents that the project is aiming to coordinate? *[e.g., TSO-DSO, TSO-TSO, DSO-DSO, DSO-MO, DSO-FSP]*			
Do they define system services?	*[Y/N]*		
If yes, which definition do they use? *[e.g., 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 put the stability of the operations of the network at risk.]*			
Do they define system products?	*[Y/N]*		
If yes, which definition do they use? *[e.g., a product is a tradable unit that the network operator acquires from flexibility providers and that entails the option to deliver a service in case of activation (this activation can be automatic if the product deals with the acquisition of energy). The characteristics of the technical scarcity mitigated by the relevant service will determine the attributes of the tradable unit.]*			
Product definition			
What are the services being considered? *(multiple answers possible)*			
• Frequency control (balancing)	☐		
• Voltage control	☐		
• Rotor angle stability	☐		
• Network congestion management	☐		
• System restoration	☐		
• System adequacy	☐		
• Islanded operations	☐		
• Others	☐		
• If others, which ones?			

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What are the products being considered? *[add lines as necessary]*		
Name	Description	
What are the attributes that have been considered when defining the products? *[add lines as necessary]*		
Attribute	Description	
What are the values for each one of these attributed for each one of the considered products? *[add lines and products as necessary]*		
[Name of the product]		
[Attribute 1]	*[Value chosen for quantitative attributes /description for qualitative requirements]*	
[Attribute 2]		
Barriers to integration		
Does the project identify characteristics of the market (e.g., characteristics of the network or differences in regulation) that affect the definition of the products and/or could affect the capacity to develop standard European products?		*[Y/N]*
If yes, what are these characteristics, what are the products affected and what is the effect they would have on the selection of the attributes of the products?		
Have these barriers affected the choice of products for the demos? If so, in what way?		
Market design definition		
What are the markets domains being considered within the project? *(multiple answers possible)*		
• Balancing market	☐	
• Congestion management market	☐	
• Other non-frequency ancillary services (in addition to congestion management) market	☐	
• Others	☐	
• If others, which ones?		
Does the project define a new market model?	*[Y/N]*	
If yes, which definition is being used? *[e.g., a market is defined as a Merit Order List (MOL) combining specific products for a specific timeframe.]*		
What is the need that the new market model covers?		
• Central	☐	
• Local	☐	
Who is the primary buyer of the flexibility?		
• TSO	☐	
• DSO	☐	
• TSO & DSO	☐	
• TSO & DSO & External Stakeholder	☐	

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• Peers	☐
• If others, which ones?	
How many markets are utilized to buy flexibilities?	
• 1	☐
• ≥1	☐
Does the TSO have access to assets on the distribution level?	*[Y/N]*

Demo review			
What are the demonstrations of the project under review? *[Provide the name of each demo and a brief explanation of its main objectives]*			
What is the location, status and assets used within each demo? *[add lines as necessary]*			
Demo name	Country	Demo status	Assets
		☐ ongoing ☐ completed	
		☐ ongoing ☐ completed	
Where platforms developed within the project?		*[Y/N]*	
If yes, what are the services and actors considered within each platform? *[Enumerate the specific services offered within each platform as well as the actors that have access to each one, add lines as necessary]*			

Platform name	Offered Services	Actors involved

Interfaces	
Where any specific interfaces between markets and grid operators developed within the project?	*[Y/N]*
If yes, provide a brief description or picture of each interface's architecture with a reference to the SGAM model.	
Were forecasting tools developed in relation with the above-mentioned interfaces?	*[Y/N]*
If yes, what are these forecasting tools? *[Provide a short description of forecasting tool functionality, add lines as necessary]*	
Forecasting tool	Description

Business use cases definition		
Have BUCs been defined for the reviewed project?	*[Y/N]*	
If yes, provide the name and a brief description of the scope and objectives of each BUC with a reference to IEC 62559.		
Name	Scope	Objectives

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KPIs definition		
What are the identified KPIs for each one of the project's demo? Characterize them based on their qualitative targets and report the demo name for which the respective KPI was calculated. *[e.g. a KPI can be economic, social, technical, environmental, add lines as necessary]*		
[KPI 1 name]	*[KPI characterization]*	*[Respective demo name]*
[KPI 2 name]		
Identified barriers within the project		
What are the identified barriers in the context of accomplishing the project's objectives? Characterize them based on the sector they were identified for and report the proposed mitigation actions for each one of them. *[e.g., a barrier can be economic, legal, technical, regulatory, add lines as necessary]*		
[barrier 1]	*[Barrier characterization]*	*[Proposed mitigation action]*
[barrier 2]		
Relevant references		
What are the websites/deliverables/ documents used in order to provide the relevant information? *[provide the titles and the respective links where it is possible, add lines as necessary]*		

Title	Link

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ANNEX II

This section includes a more detailed description for the projects which were reviewed within Task 2.1.

INTERRFACE

The INTERRFACE (TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system) project fundamentally aims at supporting greater coordination between TSOs and DSOs facing common challenges for the procurement of distributed flexibility [3].

The coordinated procurement of balancing, congestion management, and other ancillary services at both the transmission and distribution level will enable more efficient and effective network management and will increase the level of demand response and the capacity of renewable generation. Digitalization is a key driver for coordination and active system management in the electricity grid, enabling TSOs and DSOs to optimize the use of distributed resources and ensure a cost-effective and secure supply of electricity but also empowering end-users to become active market participants, supporting self-generation and providing demand flexibility.

To support this transformation, the INTERRFACE project will design, develop, and exploit an Interoperable pan-European Grid Services Architecture (IEGSA) to act as the interface between power networks (TSO and DSO) and the customers and allow the seamless and coordinated operation of all stakeholders to use and procure common services. State-of-the-art digital tools based on blockchains and big data management will provide new opportunities for electricity market participation and thus engage consumers into the INTERRFACE proposed market structures designed to exploit Distributed Energy Resources.

The main expected outcome is the development of a common architecture namely the Interoperable pan-European Grid Services Architecture (IEGSA), which will enable the connection, data, and information exchange with existing data hubs across Europe, where TSOs, DSOs, market participants and customers will be connected. Expected benefits are greater TSO-DSO coordination for the procurement of flexibility, the development of common standards and processes across borders, the demonstration of innovative solutions for maximizing the flexibility potential from DERs, and empowering energy communities.

Since the definition of a common IT architecture is one of the key elements of OneNet project, the IEGSA architecture which is being developed within INTERRFACE plays an important role in defining the starting point of OneNet concept.

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CoordiNet

The key objective of this project is to demonstrate how DSOs and TSOs shall act in a coordinated manner to procure and activate grid services in the most reliable and efficient way through the implementation of three large-scale demonstrations (Spain, Sweden, and Greece). CoordiNet is looking to address the following challenges [4]:

- To demonstrate to which extent coordination between TSO/DSO will lead to a cheaper, more reliable, and more environmentally friendly electricity supply to the consumers through the implementation of three demonstrations at large-scale, in cooperation with market participants.
- To define and test a set of standardized products and the related key parameters for grid services, including the reservation and activation process for the use of the assets and finally the settlement process.
- To specify and develop a TSO-DSO-Consumers cooperation platform starting with the necessary building blocks for the demonstration sites. These components will pave the way for the interoperable development of a pan-European market that will allow all market participants to provide energy services and opens up new revenue streams for consumers providing grid services.

The expected outcomes of CoordiNet project are:

- To contribute to a smart, secure and more resilient energy system through demonstrating cost-efficient model(s) for electricity network ancillary services that can be scaled up to include networks operated by other TSOs and DSOs, that will be replicable across the EU energy system, and provide the foundations for the further implementation of the already approved and future network codes, particularly on demand-response and storage.
- To open up significant new revenue streams for consumers and generators to provide grid services.
- To increase the share of RES in the electricity system

Given that CoordiNet is the twin project of INTERRFACE and that it has already made significant progress towards presenting the best practices on TSO-DSO interaction, its significance for defining OneNet starting point is self-explanatory. Both INTERRFACE and CoordiNet play a crucial role in defining the interactions between TSO and DSO level, as well as between DSO and customer level within OneNet.

Platone

Platone - “PLATform for Operation of distribution Networks – aims to develop an architecture for testing and implementing a data acquisitions system based on a two-layer approach (an access layer for customers and a service layer) that will allow greater stakeholder involvement and will enable efficient and smart network

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management. The tools used for this purpose will be based on platforms able to receive data from different sources, such as weather forecasting systems or distributed smart devices spread all over the urban area. These platforms, by talking to each other and exchanging data, will allow collecting and elaborating information useful for DSOs, transmission system operators (TSOs), customers and aggregators. In particular, the DSO will invest in a standard, open, non-discriminating, economic dispute settlement blockchain-based infrastructure, to give to both the customers and to the aggregator the possibility to become flexibility market players more easily. This solution will see the DSO evolve into a new form: a market enabler for end-users and a smarter observer of the distribution network. By defining this innovative two-layer architecture, Platone removes technical barriers to the achievement of a carbon-free society by 2050, creating the ecosystem for new market mechanisms for a rapid roll-out among DSOs and for a large involvement of customers in the active management of grids and the flexibility markets [5].

The project's objectives include the definition of new sustainable business models aiming to remove the barriers to the commercialization of the Platone solution, among others. In addition, recommendations for energy policymakers will be drawn based on the project outcomes.

Platone focuses on developing innovative tools for DSOs. Thus, its contribution to the OneNet concept lies mostly in providing data models and architecture details for the various platforms that are being developed within the project at the DSO level.

EUniversal

The primary goal of EUniversal is to implement the Universal Market Enabling Interface (UMEI) concept by bringing forward a universal, open, adaptable and modular approach to interlink active system management with electricity markets and foster the provision of flexibility services, also acknowledging the activation needs of and the coordination requirements with other commercial parties and TSOs. A set of market-oriented flexibility services from DERs will be implemented to answer DSOs' needs in a cost-effectively way, supporting the energy transition [6].

In this project the following developments are expected:

- UMEI (Universal Market Enabling Interface);
- Flexibility solutions - techno-economic optimization framework;
- Smart grid solutions - operation and planning strategies;
- Smart grid solutions - improved observability and control;
- Smart grid solutions - Resilience based planning and operation;
- Flexibility market mechanisms, products, and platforms;

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EUniversal focuses on the development of market-based flexibility solutions, in accordance to the system requirements, notably the ones from DSOs, and offers a universal solution for interfacing system operation with market platforms.

EU-SysFlex

The EU-SysFlex project aims to identify issues and solutions associated with integrating large-scale renewable energy and create a plan to provide practical assistance to power system operators across Europe. This should ultimately lead to the identification of a long-term roadmap to facilitate the large-scale integration of renewable energy across Europe [7].

The project's expected outcomes are to:

- identify the long-term needs as well as the technical scarcities of the future power system.
- incentivise the necessary flexibility and solutions to enhance the market and regulatory framework.
- identify and demonstrate new types of system and flexibility services:
- The demonstration consists of different BUCs in seven field tests at all system levels and across Europe. They provide evidence of how the timely provision of system services will be achieved using new approaches to coordinate the resources, actors and new technology mixes that will be present in the future European system. This involves testing new concepts, tools and a wide range of flexibilities including centralised pump storage plants, batteries, wind and photovoltaics (PV), heat loads, electric vehicles (EV) and super-capacitors. The interaction between the system layers and actors and the replicability of concepts and approaches is also addressed.
- create a long-term roadmap of actions for Europe to facilitate the large-scale integration of new technologies and capabilities.

EU-SysFlex is in its last year of activities,18 making it one of the most mature of the ongoing projects that were reviewed in WP2. Its major contribution to the OneNet concept lies in the product and services definition that has been already performed, as well as in linking the regulatory barriers or market design options to product characteristics.

Osmose

The project aims at developing flexibilities that can be used for better integration of RES. The approach chosen is global as it considers, at the same time, the increased need for flexibilities in the system (mainly improved balance of supply and demand in electricity markets, provision of existing and future system services and allowance of dynamic control of electricity flows) and the sources of flexibilities (RES, demand-response, grid and new storages). Osmose approach addresses all system requirements to capture the synergies proposed

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by the different solutions to avoid stand-alone solutions that might be less efficient in terms of overall efficiency [8].

The main expected outcomes of Osmose project are presented below:

- Quantify the needs of flexibilities in different long-term scenarios, define the most adequate sources of flexibilities in these scenarios and create advanced tools and methodologies to analyse flexibility.
- Explore and propose some market-based solutions for the development of an optimal mix of flexibility sources in Europe and create advanced tools and methodologies for market design analysis.
- Develop a Master Control System to integrate different flexibility solutions, coordinate their operations and identify possible control strategies.
- Develop a smart management system integrating flexibility sources of market players together with flexibility sources of the TSO's infrastructure.
- Assess cross border exchange capability in real-time, with a view to identify and utilize post market gate closure residual cross-border capacity.
- Design, develop, demonstrate, and validate a novel near to real-time cross-border flexibility energy (FlexEnergy) dispatching while relying on a market-based mechanism to find an optimal solution for the release of energy constraints on generation units.
- Adapt and integrate Energy Management Systems already in place in conventional centralized generation and large hydro storage to maximize their participation in cross border FlexEnergy market.
- Develop an integrated yet replicable cross-border FlexEnergy market platform, which will be able to seamlessly manage necessary interactions among the involved parties and demonstrate cost-effective operation of storage systems on the FlexEnergy market.
- Provide an optimization framework considering different time scales for voltage control on the DSO grid in coordination with the TSO and demonstrate the tool and its benefits in a demo in real-time simulation.
- Develop methods and tools for BEDD design and control for a decrease of Levelized Cost.

Osmose contribution to OneNet concept lies on the flexibility solutions it proposes both on a market and a more technical level with a special focus on the transmission grid.

Flexitranstore

Flexitranstore (An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources) aims to contribute to the evolution towards a pan-European transmission network with high flexibility and high interconnection levels. This will facilitate the transformation of the current energy production mix by hosting an increasing share of renewable energy

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sources. Novel smart grid technologies, control and storage methods and new market approaches will be developed, installed, demonstrated and tested introducing flexibility to the European power system [9].

Besides the accomplishment of the 8 demonstrators, the project aims to develop a next-generation Flexible Energy Grid (FEG) platform which can be integrated into the European Internal Energy Market (IEM), through the valorisation of flexibility services.

Flexitranstore is another mature project which is in its last year of activities. It will provide, as a key input to OneNet, the product and system services definitions, as well as the specification of the IT system integration that was produced in the context of developing the FEG platform.

CROSSBOW

CROSSBOW will propose the shared use of resources to foster cross-border management of variable renewable energies and storage units, enabling higher penetration of clean energies whilst reducing network operational costs and improving the economic benefits of RES and storage units. The objective is to demonstrate several different, though complementary, technologies, offering Transmission System Operators higher flexibility and robustness through 1) better control of exchange power at interconnection points; 2) new storage solutions – distributed and centralized-, offering ancillary services to operate Virtual Storage Plants (VSP); 3) better ICT and Communications -e.g. better network observability, enabling flexible generation and Demand Response schemas; 4) the definition of a transnational wholesale market, proposing fair and sustainable remuneration for clean energies though the definition of new business models supporting the participation of new players –i.e. aggregators - and the reduction of costs [10].

CROSSBOW is a TSO driven project with two interrelated and equally important strategic goals: on the one hand, it aims at the successful deployment in the market, within a 24 months horizon after project completion, of a set of technological solutions which enable increasing the shared use of resources to foster transmission networks cross-border management of variable renewable energies and storage units, making possible a higher penetration of clean energies whilst reducing network operational costs and improving economic benefits of RES and storage units. The achievement of these strategic goals will involve the four aspects addressed by LCE-04-2017, since the project will demonstrate many different technologies offering TSOs increased grid flexibility and robustness through:

- A better control of cross-border balancing energy at interconnection points.
- new storage solutions – distributed and centralized-, offering ancillary services to operate Virtual Storage Plants (VSP).

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- better ICT and Communications -e.g., better network observability, enabling flexible generation and Demand Response schemas.
- the definition of a transnational wholesale market, proposing fair and sustainable remuneration for clean energies though the definition of new business models supporting the participation of new players –i.e., aggregators- and the reduction of costs.

In CROSSBOW a wholesale and ancillary market toolset and a platform for cooperative ownership of flexibility assets are being developed. The market design and IT architecture behind these two solutions can provide valuable inputs for the OneNet concept.

FARCROSS

FARCROSS aims to connect major stakeholders of the energy value chain and demonstrate integrated hardware and software solutions that will facilitate the "unlocking" of the resources for the cross-border electricity flows and regional cooperation and will enhance the exploitation/capacity efficiency of the transmission grid assets [11].

FARCROSS proposes state-of-the-art digital technologies into the power system, in order to enhance and optimize the coordinated effort between TSOs and between TSOs-energy producers and establishes a next-generation electricity market which will operate on a regional basis and will benefit from dispersing assets and increased presence of RES, thus creating incomparable economic benefits to the stakeholders of the chain. Its main objectives are to:

- Successfully integrate large amounts of renewable generation. These resources are intermittent and there are advantages to geographic dispersion. FARCROSS proposed solutions can be used to increase cross-border flows allowing other countries from importing clean energy and to maximise EU-wide renewable generation.
- Reduce the need to build new infrastructure by first optimising the existing network, whereas at the same time to achieve reduced environmental impact compared to alternative options and minimise total costs to customers.
- Shorten connection lead-times, as FARCROSS solutions can be installed in relatively short timeframes, can minimise the grid modifications needed to integrate new sources of generation or serve as a bridge solution.
- Test the state-of-the-art digital technologies, installed on the power grid and communication infrastructure, such as power flow controllers, dynamic line rating sensing systems and wide area monitoring systems (WAMS), for optimally exploiting and maximising the capacity and security of transmission corridors.

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- Develop advance software solutions, including capacity allocation and reserve optimisation tools, as well as advanced forecasting of energy production and demand response platform, to increase the cross-border capacity and the potential of cross-border grid services.
- Propose a robust set of technical and market codes (pathways) that would enable the building up of the harmonisation of the network codes, and subsequently to the integration of national electricity markets -possibly via a regional route.

FARCROSS will add to the OneNet concept information about how the coordination between TSOs can be enhanced and what kind of tools and platforms OneNet should consider on the TSO level.

InterConnect

InterConnect project aims to bring energy management within reach of the end-users by interoperable solutions connecting smart homes, buildings and grids. The solutions developed within the scope of InterConnect will allow a digitalisation of homes, buildings and electric grids based on an Internet of Things (IoT) architecture. By including digital technologies (artificial intelligence, Blockchain, Cloud and Big Data) based on open standards, such as SAREF, it will guarantee the interoperability between equipment, systems and privacy/cybersecurity of user data.

The main objectives of InterConnect project are [12]:

- Design an interoperable marketplace toolbox supported by a novel IoT reference architecture that defines the interconnection between different digital platforms and aligning existing standards and ontologies like SAREF, to allow different stakeholders to focus on the development of innovative services towards a human-centric energy ecosystem.
- Demonstrate, through large-scale pilots, the implementation of a digital marketplace composed of different platforms and showcase the satisfaction of energy users needs with cost-effective solutions, allowing different market agents to create their value, and simultaneously ensure high levels of cybersecurity and data privacy.
- Co-creation, involving citizens, to design energy and non-energy services and applications that foster active participation in new business models and grid operation, while ensuring comfortable, efficient, sustainable, and healthier living environments.

Related to system operators, most outputs will focus on DSO and will be:

- Grid-centric uses cases.
- Global smart energy interoperable IoT reference architecture definition.

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- Design and implementation of the Standard DSO Interface (API interface for connecting the DSO to the energy-related market platforms).
- Specification and implementation of a DSO flexibility market enabling new standardized flexibility services provided by aggregators, energy communities and microgrids for distribution grids.
- Implementation of distributed control architectures for the operation of MV and LV distribution grids, particularly involving energy communities.
- Demonstrations of some services in some of the pilots.

InterConnect importance for OneNet concept lies on bringing the end customer into the picture. This project focuses on how customers can really become active players, through the standardisation of the communication with their own devices, in the future energy system and its key contributions are expected in the area of data modelling.

Synergy

Synergy introduces a novel reference big data architecture and platform that leverages data, primary or secondarily related to the electricity domain, coming from diverse sources (APIs, historical data, statistics, sensors/ IoT, weather, energy markets and various other open data sources) to help electricity stakeholders to simultaneously enhance their data reach, improve their internal intelligence on electricity-related optimization functions, while getting involved in novel data (intelligence) sharing/trading models, to shift individual decision-making at a collective intelligence level. To this end, Synergy will develop a highly effective Big Energy Data Platform and AI Analytics Marketplace, accompanied by big data-enabled applications for the totality of electricity value chain stakeholders (altogether integrated into the Synergy Big Data-driven EaaS Framework). Its main objectives are [13]:

- To deliver a novel Big Data platform powered by energy-related data that effectively address the complexity of the energy/ electricity sector value chain interactions and allows for the delivery of innovative Energy-as-a-Service offerings, through central as well as federated experimentation with big data analytics, service composition, data sharing, assets reuse and business value generation.
- To integrate existing big data technologies, tools, and libraries, with energy sector legacy systems and ICT enabled assets and components to accelerate the data management and analysis cycle for powering the Synergy platform, turning the 4 Big Data V’s into Stakeholder Value.
- To deliver an innovative, secure, privacy preserving and IPR respecting multi-party data exchange and sharing framework, propelling the creation of a joint venture of data owners and analytics providers.
- To enable the delivery of added value services that satisfy emerging energy sector stakeholders needs and effectively contribute to the short-, mid- and long-term targets for a cleaner, more sustainable, and

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more efficient energy system characterized by maximized RES integration, increased Energy Efficiency, enhanced Consumer Empowerment and Democratized Energy Markets.

- To bring forward novel collaborative business models driven by big data sharing and analytics services, benefiting the whole value chain of actors relevant to the electricity domain.
- To deliver a reference big data platform architecture and implementation for the electricity data value chain, validated through a set of representatives, large-scale and long-lasting demonstrators.
- Promote the adoption of the Synergy solution as a next-generation Big Data Platform for data sharing based EaaS applications through intense dissemination and knowledge transfer of the project's outcomes towards the targeted stakeholders, reaching out to international audiences within and beyond the EU.

Synergy project started in January 2020 and therefore its early stage of development does not allow an exhaustive review of the solutions it proposes. Nevertheless, because it is an ICT oriented project, it can provide valuable input regarding the more technical aspect of the OneNet project regarding data interoperability and big data reference architecture.

InteGrid

InteGrid's vision was to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services, hence expanding from DSOs distribution and access services to active market facilitation and system optimisation services while ensuring sustainability, security and quality of supply. The main objectives of the project were [14]:

- To demonstrate how DSOs may enable the different stakeholders to participate in the energy market activity and to develop and implement new business models, making use of new data management and consumer involvement approaches.
- To demonstrate scalable and replicable solutions in an integrated environment that enable DSOs to plan and operate the network with a high share of DER in a stable, secure, and economic way, using flexibility inherently offered by specific technologies and by interaction with different stakeholders.

InteGrid is another one of the reviewed projects that have been completed producing as main outputs:

- Demonstration of 12 High-Level Use Cases (HLUCs) distributed in three different countries (Portugal, Slovenia, and Sweden). Each HLUC represents a solution for a certain main actor. The main functionalities demonstrated are:
    - The use of DER flexibility by DSOs at the operational planning. Both resources at the MV and LV participated in the demonstration.
    - Demonstration of improved methods of predictive maintenance and fault location

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- Development and demonstration of the "grid and market-hub" (gm-hub) concept, a market-enabling platform.
    - Development and demonstration of demand response tools. On one hand, a Home Energy Management System (HEMS) was developed. On the other, a behavioural demand response tool was also developed called LocalLife (a form of a social platform with behavioural signals only, no price signals.
    - Demonstration of energy management tools and flexibility provision for industrial consumers.
    - Demonstration of the Virtual Power Plant concept, aggregating resources to provide services to both DSO (technical VPP) and TSO (commercial VPP).
- Besides developing and demonstrating the concepts above, the project also:
    - Identified innovative business models enabled by the functionalities tested.
    - Identified regulatory barriers and provide recommendations on how to overcome them.
    - Studied the scalability and replicability of the proposed solutions.
    - Carried out a Cost-Benefit Analysis for the different HLUCs.

InteGrid focused on the DSO interactions with different stakeholders, stakeholders, and on developments to be made by DSOs to make their operation more aligned with flexibility use, which in addition to the solutions demonstrated should be considered within the OneNet network of platforms.

InterFlex

InterFlex aimed to demonstrate that combining network automation with the local generation and/or consumption flexibilities (including the coupling between electricity, gas, and heat distribution networks) can make local energy systems more competitive and more reliable [15].

InterFlex was completed in 2019 and the project use cases provided input for the 5 main innovation streams of (1) Local flexibility market, (2) demand response and customer empowerment, (3) smart functions and grid automation, (4) cross energy carrier synergies, (5) multi-service storage and islanding. InterFlex main achievements were:

- Flexibility mechanisms have been successfully set up, defining the roles of the respective stakeholders. IT tools have been developed, including forecasting engines, market platforms and aggregator interfaces, some of them based on open protocols (USEF, EFI or CIM). Concerted efforts on the market design of the traded products allowed to define formats to match the DSO's requests with the aggregator offers, while identifying adequate time frames for the activation process.

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- InterFlex demonstrated the successful implementation of direct DSO-control and local flexibility platforms and their technical functionalities. The ex-post validation of the flexibility activation has been obtained through dedicated service check routines. Demand Response experiments and solutions provided tools to facilitate the development of Citizen Energy Communities (CECs). Indeed, InterFlex successfully attracted a large number of pilot customers for these DR solutions. Other features included an end-user platform that has been developed to display household energy balances, and a real-time simulated P2P market where citizens could trade privately produced energy with their neighbours.
- Successful implementation of smart function related to the control of the islanding switch designed to perform seamless MV islanding for enhanced power quality for local customers; Increased hosting capacity close to zero equipment or marginal cost, allowing also to establish recommendations for global replication and large-scale implementation, as well as for an integration of the results in the regulatory framework or grid code. This can also be a valuable contribution to standardize new autonomous functions, for example in the field of EV Smart Charging.; delivered blueprint for the operational integration of grid control and a smart meter infrastructure.
- Successful implementation of innovative equipment and IT-solutions for a global cost optimisation beyond the electric system. For this aim, thermal networks were integrated to work side by side with the electric system, for example, to absorb DER production peaks. In particular, efficient tools for load peak shaving, and market-ready solutions for certain small-scale district heating sectors were developed, thereby sustaining the decarbonisation of the heating sector. Also, hybrid residential and commercial assets fuelled by both electricity and gas were tested and have shown their performance. The gas resource provided easily controllable flexibility as an alternative to batteries or curtailment.
- Two local microgrid batteries operated by DSO: Seamless MV islanding by the DSO to reinforce the resilience of areas where power supply is critical; Citizen Energy Community: maximizing village self-consumption while the grid serves as a back-up - virtual islanding & active customer involvement (P2P) to reduce battery sizing; Ancillary services in grid-connected mode.

InterFlex, like InteGrid, focused on developing tools and systems that would be integrated on the distribution grid level. Its contribution to the OneNet concept lies in extracting valuable information regarding the market design and systems architecture is demonstrated.

TDX-Assist

The objective of TDX-Assist was to design and develop novel ICT tools and techniques that would facilitate scalable and secure information systems and data exchange between TSOs and DSOs. The three main novel aspects of the ICT tools and techniques to be developed in the project were as follows: scalability – the tools

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and techniques will be able to deal with new users and increasingly larger volumes of information and data; security – the tools and techniques will ensure that overall system operation is protected against external threats and attacks; and interoperability – the information exchange and communications between the system operators will be based on existing and emerging international smart grid ICT standards [16].

TDX-Assist project has been completed and its major outcomes include the:

- Definition of BUCs and Systems Use Cases compliant with current IEC standards for the exchange of data between TSO and DSO.
- Development of new Profiling and UML based on CIM CGMES standards, providing network model CIM profiles appropriate for IEC approval. IEC experts were involved.
- Description of CIM Profiling tools and validation of RDFS XML test model generation.
- Establishment of an automated testing procedure to simulate a variety of TSO/DSO scenarios, including demos to simulate data exchange through CIM.

Given that TDX-Assist was an ICT oriented project, its outcomes on data interoperability, information models and cybersecurity tools will be relevant for defining the OneNet starting point mainly in this sphere, notably the direct interaction between TSOs and DSOs for both planning and operational activities.

SmartNet

The SmartNet project aimed at providing optimised instruments and modalities to improve the coordination between the system operators at a national and local level (respectively the TSOs and DSOs), including the exchange of information, for the acquisition of ancillary services (balancing, voltage control, congestion management) from subjects located in the distribution segment (flexible load and distributed generation) [16].

Different TSO-DSO interaction schemes were compared based on national key cases (Italy, Denmark, and Spain); where physical pilots were developed to monitor transmission's distribution parameters and investigate modalities for the acquisition of ancillary services from specific resources located in distribution systems.

Smartnet was successfully completed in 2019 and its main findings can be summarized in the following eleven points [17]:

- Traditional TSO-centric schemes could stay optimal if distribution networks do not show significant congestion not unlikely in near-future scenarios, since distribution grid planning was (and still is) affected by the fit-and-forget reinforcements policy. In the first period, costs to implement monitoring and control systems within distribution networks could result higher than the effect of over-investments inefficiencies due to the old fit and forget philosophy. This could engender resistance in

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some DSOs to consider flexibility as a value. This could also call for a revision of present remuneration schemes for DSOs' investments, so that they can claim OPEX and not only CAPEX.

- More advanced centralized schemes incorporating distribution constraints show higher economic performances, but their performance could be undermined by big forecasting errors, which could bring them to take wrong decisions. As a distributed generation, constituting a good share of the possible service providers in distribution, is mainly composed of RES generation (e.g., PV power plants, mini hydro…) it is important that the gate closure is shifted as much as possible toward real-time and forecasting techniques are improved. Such techniques can be better for some generation technologies (PV) but much worse for others which are strongly influenced by local factors (mini hydro).
- Technical reasons and high ICT costs disadvise to give balancing responsibility to DSOs. Nonetheless, the sheer economic performance of such shared responsibility schemes is not always bad (sometimes separating transmission and distribution markets could prevent high prices in one area to be spread to the other).
- Decentralized schemes are usually less efficient than centralized ones because the two-step process introduces undue rigidities. Scarcity of liquidity and potential impact of local market power, along with extra constraints introduced to avoid counteracting actions between local congestion market and balancing market (e.g., increasing system imbalance while solving local congestion) furthermore negatively affect economic efficiency of decentralized schemes.
- Decentralized schemes request to put in place further coordination actions between TSO and DSO: resources that are bid in both sequenced markets should not be selected twice (a "common marketplace" mechanism should be implemented).
- Local congestion markets should have a "reasonable" size and guarantee a sufficient number of actors compete to prevent scarcity of liquidity and exercise of local market power. For that, small DSOs should pool-up to create a common congestion management market: too many small local markets would increase ICT costs and reduce competition, with detrimental effects.
- Intraday markets should bring gate closure as close as possible to real-time. However, it is not feasible to overlap a real-time session of the intra-day market with a services market: this solution would create uncertainty in the operators (TSO and DSO) in charge of purchasing ancillary services because they would be no longer sure of how many resources are needed (i.e., the real amount of congestion and imbalance). For this reason, the fifth coordination scheme ("Integrated flexibility market model") is strongly dis-advised.
- Balancing and congestion markets should have, as a target, not to optimize system social welfare (that is, by contrast, the goal of energy markets) but just to buy the minimum number of resources to get

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the needed ancillary services while perturbing, the least possible, the results of the energy markets. This advices against allowing the award of sets of balanced upward and downward bids just to reduce total costs ("market arbitrage") even whenever this could reduce total system costs.

- Ensuring a level playing field in the participation of distributed resources (especially industrial loads) to the tertiary market means to be able to incorporate into the market products some peculiarities of such resources (loads or generators) without which it is nearly impossible for them to participate. This could imply enabling complex bids or other sophisticated products.
- Reaction to commands coming from TSO or DSO in real-time of the control loops which were initially planned for real-time services provision can be too slow. So, testing is needed to ensure compatibility with the requested reaction times.
- ICT costs are nearly never an issue: independent of the implemented TSO-DSO coordination scheme, the economic performance depends on wide and large operational costs. For all coordination schemes, ICT costs stay one order of magnitude lower than operational costs.

SmartNet plays an important role in defining OneNet's starting point because it explores several different coordination schemes involving DSOs and TSOs, thus serving as a relevant knowledge base for leveraging the flexibility services to be implemented and tested within OneNet.

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