Report on development of integral market platform

D10.3

Authors:

Nermin Suljanović (EIMV)

Amila Dervišević (EIMV)

Dominik Falkowski (EOP)

Péter Márk Sőrés (BME)

Bálint Hartmann (BME)

Vaclav Janoušek (Cez Distribuce)

Boris Turha (EL)

Rok Lacko (GEN-I)

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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 EDSO, have activated their members to put together a unique consortium.

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

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services that 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
ADRP	Aggregated Data Retrieval Profile
aFRR	automatic Frequency Restoration Reserve
API	Application Programming Interface
BSP	Balancing Service Provider
BUC	Business Use Case
CIM	Common Information Model
CIS	Common Interface Specifications
CM	Congestion Management
CSV	Comma Separated Values
CZ	Czech Republic
DA	Day Ahead
DAM	Day Ahead Market
DEP	Data Exchange Platform
DSO	Distribution System Operator
EA	Enterprise Architect
ESMP	European Style Market Profile
FCR	Frequency Containment Reserve
FPO	Flexibility Platform Operator
FRO	Flexibility Register Operator
FSP	Flexibility Service Provider
GID	Generic Interface Definition
HRM	Harmonized Role Model
HU	Hungary
HV	High Voltage
ID	Intra Day
IDM	Intra Day Market
IMP	Integral Market Platform
JSON	JavaScript Object Notation
LD	Linked Data
LT	Long-Term
LV	Low Voltage
mFRR	manual Frequency Restoration Reserve
MO	Market Operator
MV	Medium Voltage

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NRT	Near-Real-Time
OIDC	OpenID Connect
PL	Poland
RDF	Resource Description Framework
RR	Restoration Reserves
SDAC	Single Day-Ahead Coupling
SI	Slovenia
SIDC	Single IntraDay Coupling
SO	System Operator
SUC	System Use Case
TD	Transmission and Distribution
TLS	Traffic Light System
TSO	Transmission System Operator
VC	Voltage Control
WP	Work Package
XML	Extensible Markup Language
XSD	XML Schema

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Executive Summary

The electricity directive states the hat flexibility market is a key factor in the uptake of renewable energy[1]. Furthermore, distribution system operators (DSOs) should procure flexibility services "in order to improve efficiencies in the operation and development of the distribution system", by transparent, non-discriminatory, and market-based procedures. On the customer side, all customer groups should have access to the market to trade their flexibility. Market places that facilitate flexibility trading in EU countries are, however, in the early stage of development. This also can be observed in the status description of flexibility markets in the countries participating in the OneNet Cluster East (Czech Republic, Hungary, Poland, and Slovenia), which is provided in the last chapter of this report.

This deliverable is the outcome of the task T10.3 "Integral market platform development" and describes the framework for the development of the Integral market platform (IMP) for flexibility product trading. The framework is generic and takes into account the specificities of the national demos in the Cluster East. In other words, market platforms deployed by the demonstrators are aligned with the IMP framework. Since this report is focused on the development of the integral market platform, the current status of national flexibility market platforms in the Cluster East is provided in the last chapter of the document.

The Eastern Cluster demonstrator aims to develop an interoperable network of flexibility platforms to support the utilisation of various flexibility services, service integration, and interaction, as well as the related data exchange. Demo coordinators will perform pilot testing of flexibility services. The alignment of each national demonstrator is two-fold.

First, the general OneNet nomenclature and planning methodology is used to describe the details. Moreover, the defined business and functional layer of the Integral Market Platform aggregates the requirements of each market and creates a common set of business processes and functional modules. This facilitates the WP objective of establishing a combined and digitalized TSO-DSO flexibility process for balancing and grid services, commonly procured, and activated to deliver services for TSOs and DSOs. Second, the IMP framework presented covers a wider scope of the functionalities, that are not necessarily in the full scope implemented in each demo. Every national demo applies this concept according to their needs and national regulatory framework in their local development.

[1] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market for electricity and amending Directive 2012/27/EU, 5 June 2019

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The integral market platform has layered architecture, in which each layer contains specific functionalities. Deployment of IMP in accordance with the proposed framework, therefore, requires implementation of all layers:

- User layer,
- Service layer,
- Market layer,
- Data governance layer,
- Data interoperability layer,
- Data source layer.

The user layer is on the top of the architecture. This layer identifies IMP users and defines procedures for how users can access the market platform. In the Eastern Cluster, users are identified from the available business use cases (BUCs) for each demo listed and explained with all details in this report. Demos of this cluster commonly use a web interface for user access to the platform.

The service layer aims to define standard flexibility products and harmonise flexibility services procured by flexibility users such as TSO, DSO, and balancing responsible parties. Definition of services heavily relies on the results of tasks in WP2. All services are further evaluated against demonstration and a catalogue of flexibility services that will be deployed and demonstrated is provided.

The market layer is a key layer of the IMP. Generalization of market players introduced by the Service layer has been done to find the common anchors to connect individual national demonstrations to the common OneNet approach. In order to handle complexity, this layer is further divided into two sublayers: business sublayer and functional sublayer. The business sublayer of IMP defines the common market structure for flexibility services market-based (i.e., dynamic pricing and compulsory/voluntary bidding based) procurement. Business concept, process, and key elements are identified that are necessary to compose services and products, along with an emphasis on business roles and interactions. The role of the functional layer is based on the high-level architecture model for the BRIDGE report 'European energy data exchange reference architecture', using the already laid out and overarching OneNet Concept and Requirements. Functional elements in the Cluster East demos are overviewed.

The data governance layer enables data control and ensures high data quality. Governance models of data management are provided by key EU documents such as the Electricity directive, GDPR, and Data Act. This layer states the importance of data privacy and describes the procedures needed to implement it. Details on how the market platform in each demo implements these principles are provided in this report.

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The data interoperability layer is crucial to facilitate interoperability between different platforms and provide uniform communication interfaces for making seamless integration and standardised data exchange. IMP assumes usage of CIM IEC 62325-based API enabling data operability among marketplaces across Europe. CIM standard analysis for information instances exchanged within national demos in the Cluster East is provided.

The data source layer lists the main data sources important for the flexibility training in an electricity system, as well as commonly used data formats. Besides using semantic data models, it is important to define which data formats (serialisation of data models) are supported by IMP.

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1 Introduction

This report describes a framework for the integral market platform (IMP), aimed at the flexibility of product trading for DSOs and TSOs. Since flexibility services can be traded at different marketplaces, the provided design supports harmonised flexibility products and data exchange interoperability. IMP has a layered architecture in order to facilitate all identified functionalities that such a platform should enable. This layered architecture is explained in the second chapter of the deliverable. It is important to emphasize that IMP is validated through four national demos in the Cluster East (Czech, Slovenian, Polish and Hungarian). IMP encompasses all functionalities of the national market platform (as a generalisation) and specific implementations are described for each national demo.

In the market platform design it is very important to identify the roles and users of the platform, as well as to investigate possible user access to the platform. This topic is treated in Chapter 4 of this document.

Flexibility services and the corresponding products are another aspect important for the interoperability among market platforms. Chapter 5 provides a comprehensive overview of flexibility services leveraging the work done in the OneNet project and provides a service catalogue for the demos in Cluster East. This layer enables standard flexibility products.

The market layer is the core layer of IMP and is described with many details in Chapter 6. This layer is divided into two sublayers, business sublayer, and functional sublayer. The business sublayer of IMP defines the common market structure for flexibility services market-based (i.e., dynamic pricing and compulsory/voluntary bidding based) procurement. This description also includes regional BUC, which is demonstrated by all demonstrators in the Cluster East.

Chapters 7 and 8 are devoted to data and information exchange. Data governance, including data access, privacy, and data quality are described in Chapter 7. This chapter also includes a description of how each demo in the Cluster East deployed the data governance process. Chapter 8 is focused on semantic data interoperability and CIM (Common Information Model) as a semantic model used for information exchange in the flexibility market. All business objects included in the SUCs that are demonstrated in national pilots are processed and standard analysis is done. A semantic data model (CIM profile) for the regional SUC, that will be demonstrated in the Cluster East, is given in this chapter (XSD and XML sample files).

Chapter 9 lists major data sources, feeding IMP, and common data formats. The last chapter, Chapter 10, provides an overview of the current status of national flexibility markets in Cluster East and targeted functionalities that will be established before the end of the OneNet project.

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2 Methodology

The methodology used for the development of the Integral Market Platform (IMP) aims to define a layered architecture that will put the flexibility market platforms developed in the national demonstrators in the Cluster East into a common framework. The final aim is to enable interoperability between flexibility services and products in East Cluster demonstrations as well as data interoperability between all stakeholders in the flexibility market. Furthermore, the specifications of the platform developed in Task 10.3 is harmonized with the deliverables and results of OneNet WP2, WP3, and WP5.

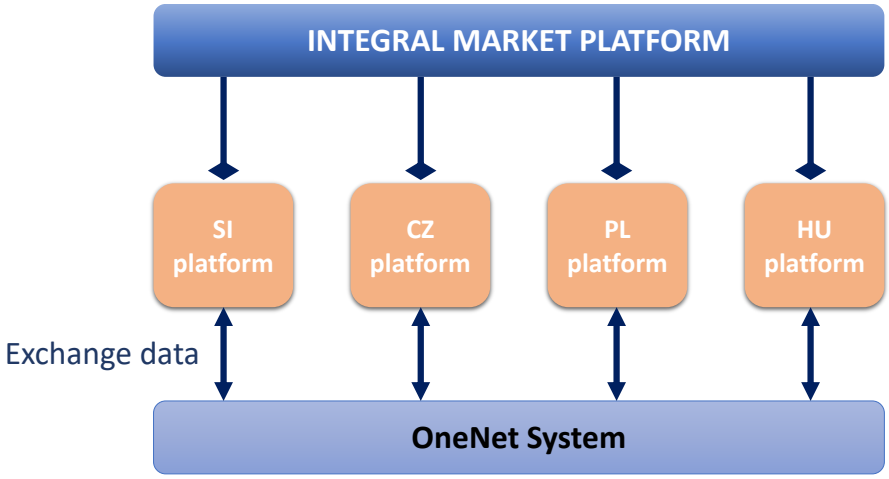

Figure 2-1 Positioning of Integral Market Platform.

An Integral market platform is a framework that describes the architecture and common functionalities of the national flexibility market platforms in the Cluster East. In other words, integral market platform concept aggregates and generalises all functionalities of the national market platforms. This approach is depicted in Figure 2-1. IMP development is founded on the following principles:

- a technology-agnostic approach (general design not locked to any particular technology),
- an open definition of APIs,
- a common standardised contextual information model (IEC CIM),
- a common context information representation (e.g., JSON-LD, XML) – for harmonized interfaces.

The layered architecture enables a technology agnostic approach. In a collaboration with task T10.2, a catalogue of harmonised flexibility services and corresponding products, that will be demonstrated in the Cluster East, is prepared. The core of the framework is the Market layer, which describes business processes that flexibility market platform facilitates as well as business functionalities that should be included in the platform. Development of the market layer leverages outcomes of OneNet WP2 and WP3, such as market mechanism and

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common definition of the flexibility products. IMP framework covers the wider scope of the functionalities, that are not necessarily in the full scope implemented in each demo. Every national demo adapts this concept according to their needs and national regulatory framework.

The principles of an open definition of APIs, using a common standardised contextual information model (IEC CIM) and application of common context information representation (e.g., JSON-LD, XML, …) have been addressed by the Data interoperability layer of IMP. This report includes a standard analysis of business objects exchanged within SUCs describing each national demo as well as detailed semantic data modelling (CIM) for the data exchange within the regional system use case (SUC) that is demonstrated by all national demos in the Cluster East. Furthermore, approaches how to ensure high quality of data, enable data control, and how to manage data in general to meet data privacy principles, have been implemented by the Data governance layer. The definition of these two data-related layer functionalities is harmonised with the results of OneNet work packages WP4 and WP5. Data interoperability and information exchange have been described in the example of the Cluster East Regional business use case (BUC) “Flexibility market data aggregation”.

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3 Integral Market Platform architecture

3.1 The concept and role of the Integral Market Platform

The role of the integral market platform is to provide a framework that will enable TSOs, DSOs, and other grid flexibility users (e.g., balancing responsible party) to procure and use flexibility services through harmonised flexibility products and to orchestrate data exchange in a standard way among all market participants. In the same time, it enables flexibility service providers to offer harmonized flexibility products. This effort is aligned with the Digitalisation in Energy Action Plan and the "opportunity to create a market for data-driven energy services and develop seamless data exchange across all layers of the energy system, considering the enablement of local energy markets and the procurement of demand-side flexibility as a central service".

The concept of the IMP is implemented through the layered architecture, in order to facilitate a design of various market processes through the independent layers. With a such approach complexity of the overall IMP design is reduced. Each layer design is compared with the corresponding national demo implementations. General design is followed by additional details of national demos.

3.2 Integral market platform hierarchical architecture

Figure 3-1 represents the layered architecture of the integral market platforms. The architecture includes six layers:

- ***User layer***: identification of users and user access to the integral market platform.
- ***Service layer***: catalogue of services and description of products.
- ***Market layer***:
    - *Business sublayer*: determination of business processes, identification of business roles and interactions between actors in business processes, the definition of the flexibility market structure.
    - *Functional sublayer*: definition of flexibility market functionalities and functional components; SUCs are used to describe functionalities with more technical details.
- ***Data governance layer:*** how to manage data, enable data control and ensure high data quality.
- ***Data interoperability layer***: identification of interfaces for data exchange, use CIM to enable semantic data interoperability.
- ***Data sources layer***: identification of data sources and stakeholders, and available data formats.

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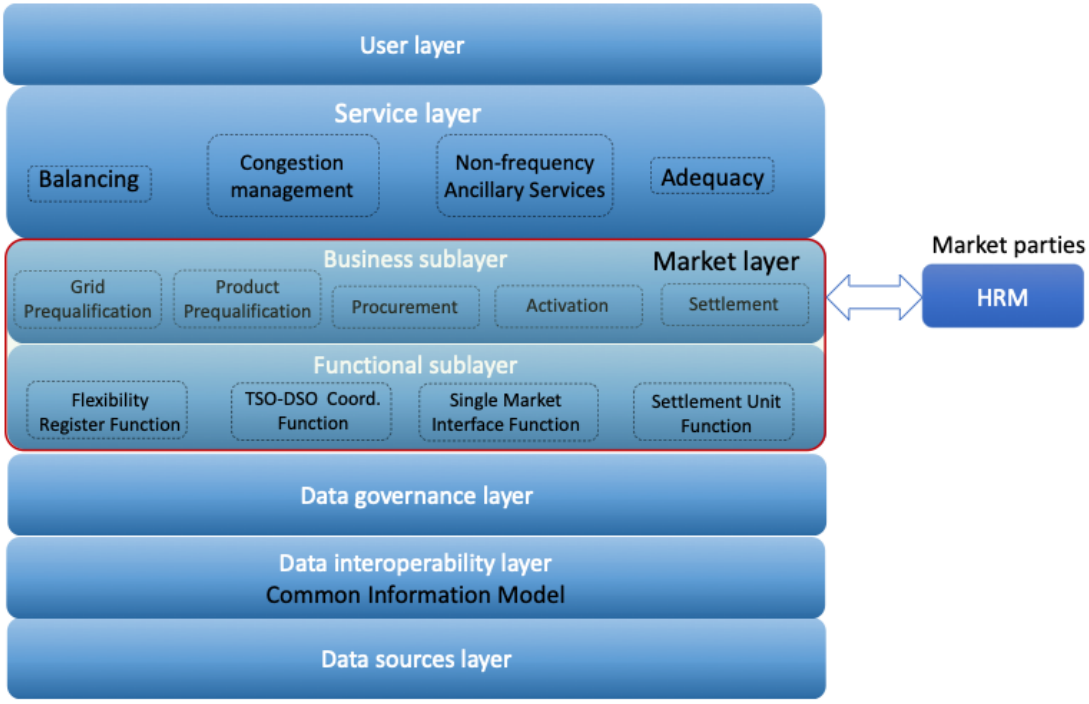

Figure 3-1 Layered architecture of Integral Market Platform.

Each layer is described in detail in separate chapters of this document.

3.3 Integration with the OneNet system

Each demo in Cluster East will demonstrate at least one SUC that utilises information exchange over the OneNet platform. All demos will also implement regional BUC/SUC (explained in this report in detail) that will exchange data through the OneNet system.

Since the development of the OneNet system is still in progress, this report lacks detailed information how integration of national market platforms with OneNet system will be implemented. Based on the available information provided by deliverables in WP5 (in particular D5.2, D5.4 and D5.5 [1, 2, 3]), OneNet system users (in our case national market platform) will communicate using OnNet connector, which is a decentralised instance of the OneNet middleware. High-level block scheme that shows how market platform is integrated with the OneNet system, on the example of the regional SUC, is given in Figure 3-2. Market platform in Figure 3-2 denotes national market platforms in the Cluster East, aligned with the IMP functionalities.

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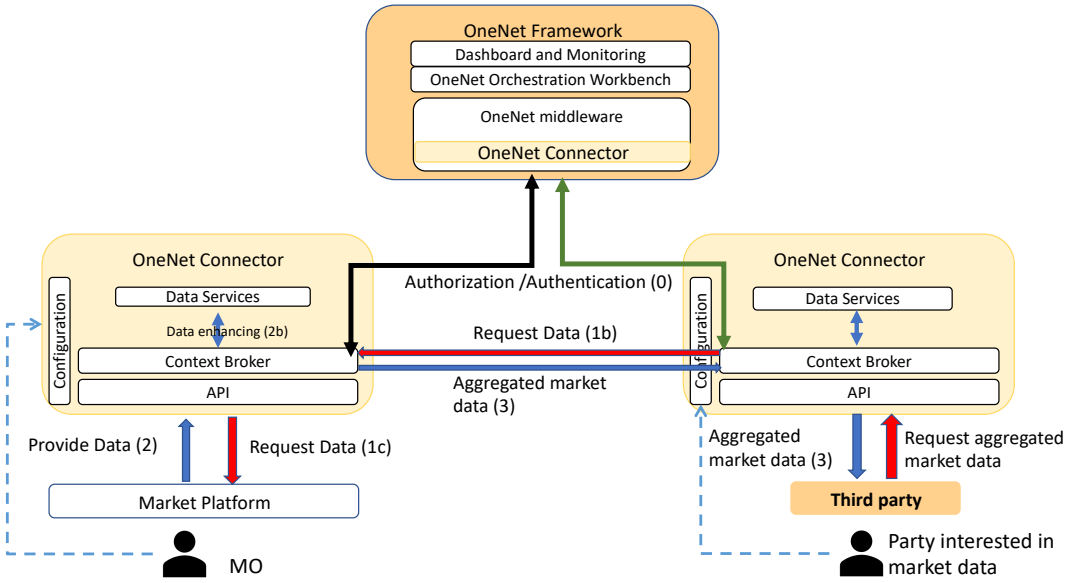

Figure 3-2 Integration of demo with OneNet system.

OneNet middleware facilitates user authentication and authorisation, and enables secured data exchange. Both sides use API provided by the OneNet connector to exchange data. Once OneNet connectors are registered in the system, data is exchanged between them (as peer to peer).

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4 User layer

During the design of the demo scope and development of BUC, each partner from the Eastern Cluster identified the main actors who take part in business processes happening on market platforms. Demonstrations carried out as part of the OneNet project have a different scope and focus on solving various problems related to the management of the transmission and distribution network. Each demo identified the most important users that are required to conduct a demonstration in each country. Therefore, the range of users has been limited to the minimum required for the demonstration of the designed solutions as a part of the OneNet project scope. Identifying the main actors and users also allowed for the determination of all dependencies between individual market participants at all stages of the market process. For each developed BUC, the main actors were identified along with the definition of its role and a short description.

4.1 Identification of users

As part of the work on BUC, three main groups of users were identified in the Eastern Cluster:

- System Operators group,
- Market Operator,
- Flexibility Services Provider group.

These three actors form a fully complete (but minimalistic) system operator – market platform – customers chain needed for the market solutions.

Depending on the way of defining a given role in the demo from the Eastern Cluster, different entities can be assigned to particular groups.

In the case of System Operator, the Distribution System Operator and Transmission System Operator were identified, which are entities purchasing flexibility services from suppliers on the market. Main activity of the DSO and TSO on the market platforms are defining the products related to network and system needs and calling an auction for specific product as needed. System Operators are also involved in the process of prequalification of FSP and performing grid analysis for grid impact assessment. In the Eastern Cluster, the DSO is also responsible for the metering data (acts as a meter data operator).

Market Operator is also referred to as Flexibility Platform Operator and is a single entity group. Market Operator is an entity that is responsible for managing the market platform. The scope of Market Operators responsibilities may be very wide depending on how the market in each country functions. The scope of activities include organizing auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers, managing and operating the platform for trading, clearing the market, and communicating auction results.

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The Flexibility Service Provider group includes all entities that provide services for DSO and TSO. It includes individual Flexibility Service Providers, Aggregators and Balancing Service Provider. The last one appears only in the Polish demo, which is the only one in the Eastern Cluster that is focusing on the balancing of the power system by TSO as a part of the OneNet project. Within this group, there may be different relationships between the various actors. It depends on the way the market functions in a given country and the scope of services provided on the platform.

The method of interaction between the different groups of actors on the flexibility platform in each demonstration is described below.

4.1.1 Czech demo

The goal of the CZ demo is to demonstrate a market for non-frequency flexibility services to be used by grid operators and other grid users. Basically, there are several DSOs, TSO and two aggregators (FSPs) as main actors in the CZ demo and all of them should interact and communicate with each other.

A two-phase authentication/authorization access system for the new FSPs will be implemented. At the first phase DSO will serve as an interface between FSP and the market platform. Each new unit (FSPs) needs to be evaluated on its ability to provide relevant services to the grid in terms of required amount and quality.

When the first registration phase is successfully completed, FSPs enters the second phase in which system operator helps the FSPs/aggregator to engage more flexibility units integrated in the system to provide flexibility services.

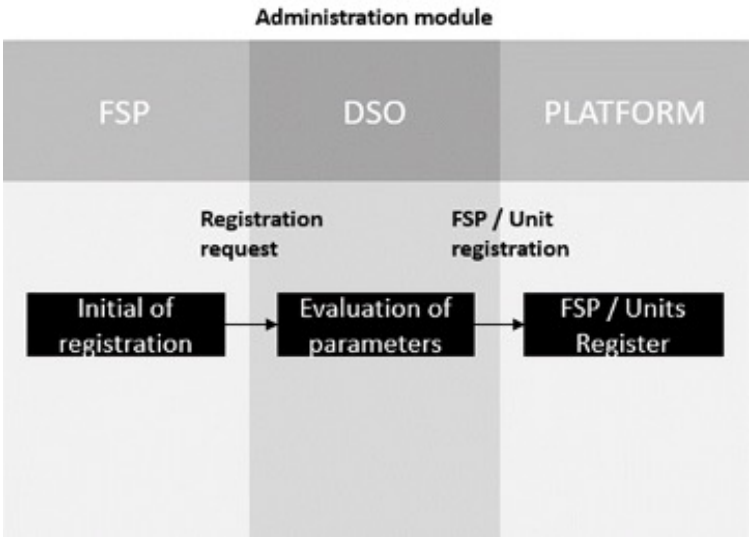

Figure 4-1 Administration module of the Czech market platform.

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4.1.2 Hungarian demo

The key users are the SOs (TSO and 2 DSOs involved), who will serve as market operators as well as currently the Hungarian Grid Code describes. The demonstration does not have FSP market participants, bidding will be simulated via the use of bid generators.

4.1.3 Polish demo

In order to ensure broad access to the flexibility services platform in the Polish demo, each market participant can access the platform through a dedicated website. The platform allows for the exchange of information between individual market participants during all market stages: pre-qualification, bidding, delivery, settlement. Information between participants is exchanged by the notification system on the platform. The platform also provides the ability to export basic information by individual participants. The scope of available information varies for different groups and is defined by the market operator.

The market platform operator has full rights and the ability to create an access account for network operators who decide to participate in the flexibility services market. Other market participants, i.e., individual customers, aggregators, and balancing service providers, can set up an account and register on the platform. After the correct registration of the user, it is possible for the users to carry out further actions depending on the function of the given user on the market.

FSPs and Aggregators can register flexibility service resources and decide what types of services they want to provide using the above resources. Entities wishing to provide balancing services for TSO on the balancing market must cooperate with the BSP because only BSP has the right to submit offers on the balancing market. The FSP that successfully passes the product prequalification process for balancing products must establish cooperation with the BSP, which then includes the resource in its scheduling unit. DSOs are responsible for certifying flexibility resources connected to their network that are reported by FSP during the prequalification process.

Using the platform, system operators can create and modify products for individual types of flexibility services, i.e., balancing, congestion management and voltage control. Every product has more or less complex requirements to fulfil by every energy resource, dedicated to a given flexibility service. The System Operator verifies and certifies the given resource during product prequalification.

Based on specific products, System Operators can run an auction for specific services that FSPs and aggregators can participate in if they have the flexibility resources that have been declared for the product.

DSO is involved in the grid impact assessment analysis for both DSO and TSO auctions where resources connected to MV, and LV network owned by DSO are involved. Depending on the scenario, the grid impact

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analysis can be done directly by the DSO based on the auction data or by the market platform based on the network data received from DSO (model, network topology, measurements, etc.).

4.1.4 Slovenian demo

Since there is no flexibility market platform for DSO in Slovenia, the web portal *mojelektro.si* [4] will be used instead. This web portal is part of the common system access to metering data (SEDMp). In it, users from entire Slovenia have the opportunity to observe their energy consumption or production from their own metering points, regardless of DSO (there are five DSOs in Slovenia). Each DSO has an independent metering centre for data collection from smart meters, but they are all connected to the web portal *mojelektro.si*. Beside *mojelektro.si*, which is a costumer portal, SEDMp has a business user portal (central electro-energy portal CEEPS) which is used for sharing metering data to business objects such as TSO, energy suppliers and aggregators.

The authorization management function enables customers to grant access to their data to third parties (suppliers, aggregators, etc.) through B2C web access. The additional B2B data services for suppliers, aggregators, energy service providers, distribution companies, and regulatory authorities are in testing procedure. To cover uniform access to imbalance settlement (in 1h and 15 minutes intervals), a service for suppliers and power market operator was established.

SEDMp is a system merged from different components, briefly described below, and covers data services as shown in Figure 4-2.

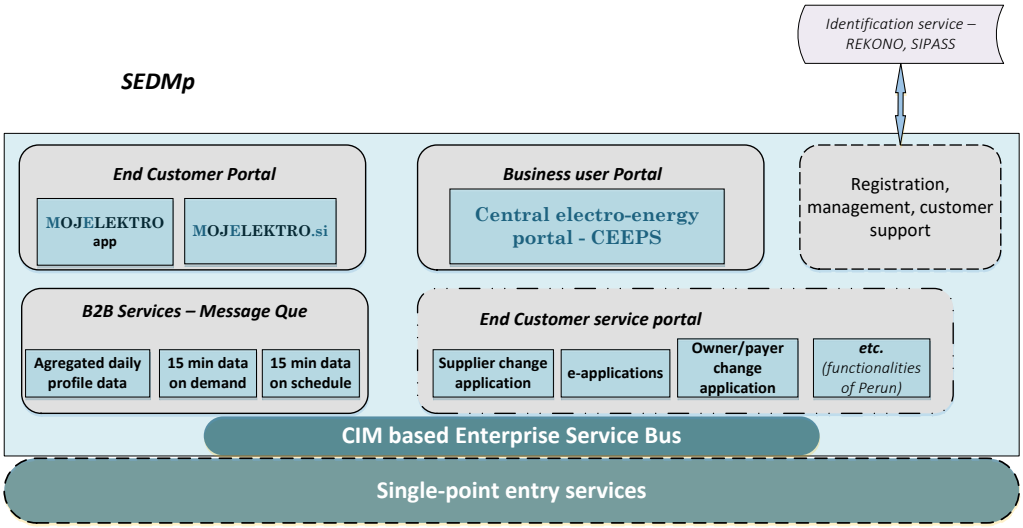

Figure 4-2 Market platform access in Slovenian demo.

End Customer web portal and mobile app – *Moj Elektro* has many functionalities. Listed below are the most useful ones, that will be upgraded with flexibility functionality:

- Daily and monthly metering data,

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- 15 minutes metering data (for technical equipped metering points), so consumer can check measurements D-1 after activation of flexibility,
- Monthly billing data (the same as on bills), upgraded with billing data for providing flexibility service,
- Authorization process for metering points access for third party, with this feature end consumer can authorize third party-aggregator to bid their flexibility on DSO tender.

Business to Business Services:

- 15 minutes data for metering points above 43 kW,
- 15 minutes data and calculation of provided flexibility energy in case of aggregators,
- 15 minutes data for batch of metering points (on demand),
- Monthly billing data for providing flexibility service,
- System for flexibility procurement, settlement system for flexibility.

DSOs will publish tenders for flexibility services procurement on the portal and exchange other information with stakeholders. In case of activation DSO will send activation message to aggregators over the portal. The aggregator will have to confirm the reception of an activation with a response message (xml format). After successful activation, settlement data will be sent to the aggregator.

End consumers will use the web portal or mobile app to register their flexibility. There are different levels of prequalification depending on the needs of particular product. The first level is registration itself. For the prequalification process secure access will be used (with certificate or SMS authentication), so every consumer can register flexibility only for their own metering place/points only. As all information about metering points are in the system (contracted power), consumers cannot insert flexibility higher than its contracted power. Also, by registering, the consumer has to agree to the terms and conditions for providing service and proceed with adequate prequalification required for the offered services. They can place bids as Independent Flexibility service Providers or can offer their flexibility to an aggregator. At the end of the month, they can see the performance of each activation and how much energy they provided.

Aggregators will have the ability to exchange information with DSOs (inserting bids, exchange activation messages, exchange settlement data and restrictions of using flexibility – traffic light system TLS[2]). TSO will receive restrictions of the distribution network – TLS. Any FSP involved in flexibility provision receives TLS information on grid availability concerning planned outages/overloads including location (nodal area) and duration. If FSP wants to offer services to DSO it has to register in SEDMp. If FSP wants to offer the same fallibility to TSO (balancing products), it must apply to the TSO tender, which is separated form DSO. From FSP perspective

[2] DSO uses traffic light system (TLS) to limit activation of flexibility resources (e.g. for the balancing market) which would degrade state of the distribution system.

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it would be easier if DSO and TSO tenders would be somehow merged in one place. If TSO would exchange proper data with SEDMp, then SEDMp could be used for DSO and TSO.

4.1.5 Overview of actors in East Cluster demos

For a more complete picture, an overview of actors is provided for each national demo from the East cluster.

In a case of the Czech demo, for the three developed BUCs, a total of three business actors were determined:

Table 4-1 Key actors in the Czech demo.

Actor name	***Actor type***	***Actor description***
Distribution System Operator (DSO)	Business	A natural or legal person who is responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity
Aggregator	Business	A natural or legal person who is a market participant providing flexibility services to any electricity market that represents and aggregates the capacity of the entities that own a distributed energy resource (DER).
Unit/Flexibility provider (flexibility resource owner)	Business	Single units (part of the portfolio of the aggregator) providing flexibility to the distribution grid operator.

In the case of the Hungarian demo, for the two developed BUCs, a total of five actors were identified for which a more detailed actor type was indicated:

Table 4-2 Key actors in the Hungarian demo.

Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***

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DSO	• Grid Access Provider • Data Provider • System operator	Active actor Responsible for maintaining service quality (e.g., EN 50160) and quantifying flexibility service needs Participates in energy auctions and energy activations	In the BUCs, the DSO is responsible for the operation of the distribution network and all related technical matters.
TSO	• System Operator • Data Provider	Passive actor Receives information on capacity auctions and energy activations	In the BUCs, the TSO is informed on the results of the flexibility service market and the actions of DSOs and FSPs. The TSO considers this information in the operation of the transmission system and all related technical matters.
FSP	• Flexibility/Balancing Service Provider • Resource aggregator • Producer / Consumer • Party connected to the grid • Flexibility service provider being aggregator	Provides services for the DSO Provides information to the TSO in case of activations through schedules	In the BUCs, the FSP is technology-independent; potential assets include photovoltaic plants, energy storage, B2B demand-side response, etc.
Market operator	• Market operator • Data Provider • Merit Order List Responsible	Responsible for market clearing	In the BUCs, the market operator aggregates the supply bids in the order book and

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			carry out market clearing process.
OneNet common platform	• Flexibility register provider // consent administrator • TSO-DSO coordinator platform provider // coordinated cap. calculator • Market interface provider / market information aggregator	Responsible for the necessary TSO-DSO coordination	In the present BUC, the common coordination platform carries out TSO-DSO and DSO-FSP coordination steps, including: DSO demand finalization, flexibility registration and bid prequalification, and market result broadcasting.

In the case of the Polish demo, a total of nine business-type actors were defined for four BUCs:

Table 4-3 Key actors in the Polish demo.

Actor name	***Actor type***	***Actor description***
Distribution System Operator (DSO)	Business	A natural or legal person who is responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity
Flexibility Service Provider (FSP)	Business	A natural or legal person who is a market participant providing flexibility services to any electricity market who owns at least one distributed energy resources

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Market Operator (MO) or Flexibility Platform Operator (FPO)	Business	A natural or legal person who organizes auctions (continuous auction, discrete auctions, call for tenders) between buyers and sellers of electricity-related products in the markets. Manage/operate the platform for trading (where bids and offers are collected). Clear the market and communicate results.
Transmission System Operator (TSO)	Business	A natural or legal person who is responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity.
System Operator (SO)	Business	Transmission System Operator or Distribution System Operator
Balancing Service Provider	Business	A market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSO or a market participant providing either or both balancing energy and balancing capacity to transmission system operators
Flexibility Service Provider being Aggregator (FSPA)	Business	A natural or legal person who is a market participant providing flexibility services to any electricity market that represents and aggregates the capacity of the entities that own a distributed energy resources (DER).
Metered Data Responsible	Business	A party responsible for the establishment and validation of measured data based on the collected data received from the Metered Data Collector. The party is responsible for the history of metered data for a Metering Point.

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Metered Data Collector	Business	A party responsible for meter reading and quality control of the reading.

In the case of the Slovenian demo for two BUCs, four actors were defined:

Table 4-4 Key actors in the Slovenian demo.

Actor name	***Actor type***	***Actor description***
Transmission System Operator (TSO)	Business	According to the Article 2.4 of the Electricity Directive 2009/72/EC (Directive): "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity". Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area.
		Source: EU Commission Task Force for Smart Grids, EG3
Distribution System Operator (DSO)	Business	A natural or legal person who is responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.

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		Defined in the European Union Internal Electricity Market is legally defined in Article 2(29) of the Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market in electricity (recast),
Flexibility Service Provider (FSP)	Business	Defined as any legal entity that offers flexibility services in the market, based on acquired (aggregated) capabilities, usually from third parties.
Market Operator	Harmonised Role	A market operator is a party that provides a service whereby the offers to sell electricity are matched with bids to buy electricity.
		Additional Information:
		This usually is an energy/power exchange or platform.
		The definition is based on Regulation on the internal market for electricity (EU) 2019/943.

4.2 User access to the market platform

4.2.1 Czech demo

The system provided by CZ demo has the ambition to ensure reliable exchange of information on the availability of the grid to all other market participants including FSPs. This is implemented in a standardized and transparent manner. Within the platform (at this stage relevant for traffic light scheme) there is an administration module allowing access of the units into the system. This system enables gathering information on unit capacity, topology as well as information on organizations/aggregators to which the relevant units belong.

For the unavailability of the grid market participants (as a part of registration procedures) the operator of the platform allows access through ECP. For that purpose, an ECP communication network was created, based on general used standards defined and developed by ENTSO-E.

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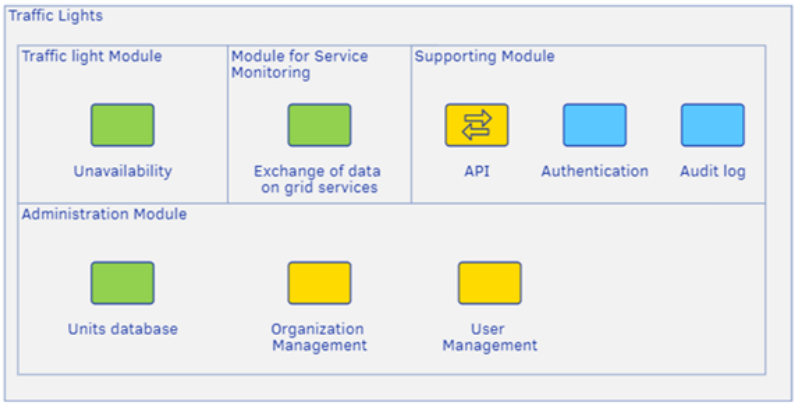

Figure 4-3 Traffic light system concept in the Czech demo.

4.2.2 Hungarian demo

During the Hungarian demonstration, the users can connect to the simulation environment on the OneNet platform. The key users are the SOs (TSO and two DSOs involved), who will serve as market operators, which is currently described in the Hungarian Grid Code. The DSOs will have access to the environment, and take the following steps:

- upload and update of the grid environment,
- electrical attributes, topology, load, and generation data,
- information about the FSPs,
- analyse the pilot sites according to the defined use cases,
- check the sensitivity factors, elaborate on the effectiveness,
- scenario analysis, input for strategic planning and the ongoing pilot platform development.

As the bidding will be generated using Monte-Carlo simulations, there is no need to create FSP role connections to the platform (also, the Hungarian demonstration does not have FSP contributors). The TSO and the two DSOs will have specific access assigned to a company e-mail address, while there will also be a connection for the developers of the functionalities to support the tests. The users will have the possibility to evaluate the results via graphical user interface and export the data for further assessment as well. This data structure will enable the development of the Hungarian flexibility platform as a generalized dataset.

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4.2.3 Polish demo

Access to the market platform takes place via the website after an account for the specific market actor is created (FSP or SO).

In the case of the service provider group, the entity that wants to play a role in this group of actors (FSP, BSP, Aggregator) creates an account that is linked to a specific email address. During registration, the customer must complete a form providing basic information and attach all the required documents to the application on the platform. The market operator verifies the data and attached documents and creates an account or asks for completion of missing information or rejects the request to create an account for formal reasons. After creating an account, actors from the service provider group can carry out further activities on the platform, i.e., pre-qualification, bidding, etc.

In the case of system operators, the market operator also creates accounts linked to a specific company e-mail, at the request of a given user, but no additional information is required by the user. The market operator determines to which group of actors a given user should be assigned: DSO or TSO. The registration of this type of user is also verified to prevent unauthorized access to the platform.

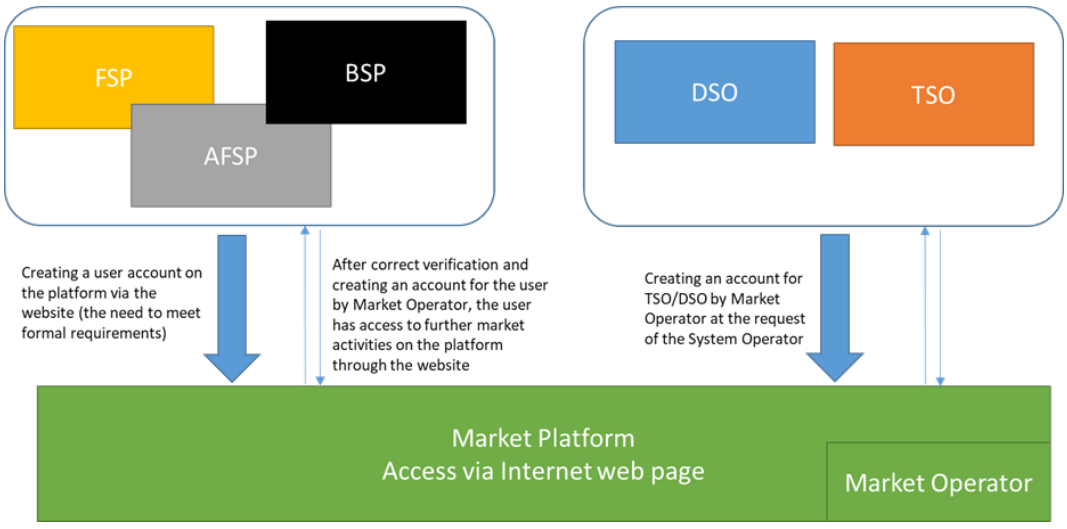

Figure 4-4 Market platform access in Polish demo.

4.2.4 Slovenian demo

In the Slovenian demo, end consumers will use the web portal *mojelektro.si,* which is described in Chapter 4.1.4.. There are five DSOs in Slovenia and each one has its own Advanced Metering center. Single-point entry

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services enable the end consumers to register only once and be able to see their measurement data regardless to the local DSO.

Since all information about end consumers and measurements from the metering points are available in the web portal *mojelektro.si*, it will be upgraded with the functionality "registration of flexibility". If the end consumer wishes to register their flexibility, an account has to be created in the web portal *mojelektro.si*. After creating an account, the end consumer can insert the amount of power on their metering points and method of notification in case of DSO's tenders for procurement in the area, where his flexibility source is located. If DSO calls for tender, end consumers which registered their flexibility, receive a notification (SMS or e-mail), that they can place their bids. End consumers have two options to place a bid: they can place a bid (price for flexibility) by themselves as Individual Flexibility Service Provider or could authorizes an aggregator to place a bid. In case of placing bids via aggregator, the end consumer has to sign a contract with an aggregator. The aggregator must confirm that flexibility at the particular metering point is offered to the DSO. Each metering point can only have one aggregator for DSO product and this is managed in the SEDMp system, which allows only one active aggregator on each metering point at a time.

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5 Service layer

The service layer is a catalogue of services and products that will be demonstrated within the OneNet project by the Eastern Cluster. This catalogue originates from the OneNet deliverable D10.2 “Selection of services and other design elements of the integral flexibility platforms” [5], which includes an extended demo description from the East cluster.

A key element to build any open solution is common understanding of basic elements. The development of standard definitions is necessary for communication and mutual understanding among all stakeholders involved in the Integral Market Platform for the provision of the flexibility service. It is extremely important in the case of cross-country solutions. A clear definition of a services at the layer level is the basis for further work on integration and building a common energy market. The Service layer description contains a catalogue of harmonized services and products defined in the OneNet project and a detailed description of services and products defined by the demos of the Eastern Cluster.

5.1 Concept of the service layer

OneNet Work package WP2 focused on identifying the flexibility services that were planned to be used in each demo as part of the pilot installations. As part of the T2.2 task, definitions for the flexibility services for the OneNet project were developed based on and using information from the previous projects, e.g., COORDINET, EUSysflex, etc. During the analyses, the main problems faced by system operators were identified in the OneNet project. The basic needs are related to voltage control, monitoring of the load flows in the network and frequency regulation. The key parameter needed to develop standard services was to define the time horizons of the functioning of individual services. The Eastern Cluster demos define two main timeframes for tested services:

- Short term - the period between the day-ahead and the month before activation of the service.
- Long term planning - all activities that are undertaken in a period longer than a month before activation.

None of the demo decided to use flexibility service in the operational (intraday) timeframe.

Based on the established standard service list and identified technical needs of each System Operator a list of products was developed by each of the demos. As part of the design work, an analysis of those products was performed under the task T2.2. As a result, OneNet project provided a set of harmonized/standardized products for congestion management and voltage control. These identified products have been described with specific features: predictive/corrective, active/reactive power, short/long-term. For products related to frequency control, the standard products used by TSOs today were indicated (FCR, RR, aFRR and mFRR). A full list of the

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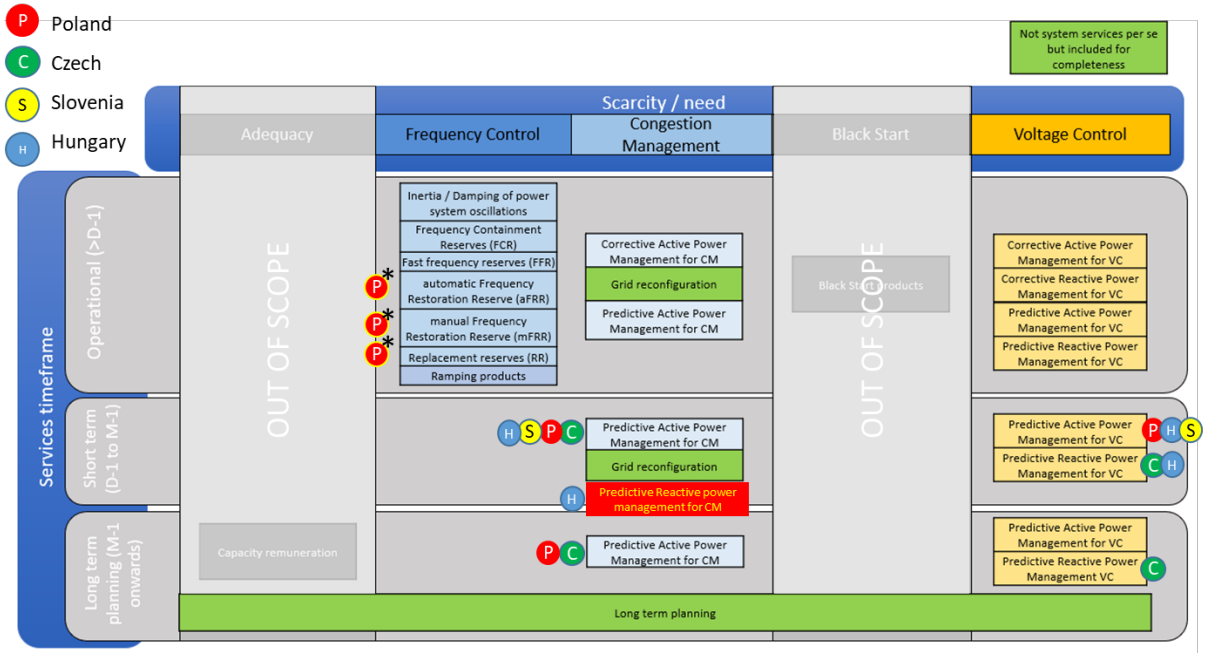
products, definitions and parameters are described in the deliverable D2.2 “A set of standardised products for system services in the TSO-DSO-consumer value chain” [6].

5.2 Services and Products in the Eastern Cluster

Based on the defined business needs described in Business Use Cases, which was developed to solve technical needs by network operators, groups of services have been selected by the demo to test it during the demonstration, including the demo from the Eastern Cluster. All demos from the Eastern Cluster are focusing on the congestion management and voltage control services. Polish demo is also testing possibility of using flexibility resources for frequency control and balancing. Services like Adequacy or Black Start are out of scope for the OneNet project. Figure 5-1 represents the matrix developed in the scope of task T2.2 with the main areas of interest of each demo being marked.



** Provided that the relevant regulations in Poland will be implemented. Otherwise, the service products will be tested in the form of simulations.*

Figure 5-1 Matrix correlated harmonized services with the demonstrators [5].

Despite the provision of services from the same service catalogue, e.g., congestion management or voltage control, the scope and attributes of the services differ for each country. This is due to the different needs of each of the network operators involved in the implementation of a given national demo. It is related to the voltage level of the network in which there are problems, the practical possibility of influencing the network, different approaches to contracting services and the planned time frame for purchasing services.

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5.2.1 Congestion management services

Congestion management services tested as a part of demonstration in in the Eastern Cluster will be based on the active power management. In case of the Hungarian demo congestion management with use of reactive power management is also in the scope of the OneNet Project.

It is assumed that all national demos will use predictive service, mainly in the short-term horizon. In the case of the Czech and Polish Demos, long term horizon is also foreseen. In the Slovenian demo, procurement process is performed in the long-term but activated in operational timeframe. A different approach to the design of congestion management services can be noticed within the Eastern Cluster. It results from different needs of system operators carrying out demonstrations in each country. More detailed information is given in the deliverable D10.2 [5].

Table 5-1 presents basic parameters for the congestion management services developed by the demos from the Eastern Cluster in the OneNet project.

Table 5-1 Correlation of congestion management service demonstration with the service parameters.

	CZ DEMO	**PL DEMO**	**SL DEMO**	**HUN DEMO**
Active/Reactive power	Active power	Active power	Active power	Active and reactive power
Voltage level of the network where service will be use	MV and LV	HV, MV and LV	MV/LV (transformer) LV network	MV network
Corrective/predictive	Predictive	Predictive	Predictive	Predictive
Capacity/energy	Capacity	Capacity and energy Energy (others)	Capacity and energy	Capacity and energy
Time frame	Short term and long term	Short term and long term	Short term (procurement) Operational (activation)	Short term

5.2.2 Voltage control services

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For voltage control services, all demos (except Czech demo) are expected to use active power management-based services. In the case of the demo from Hungary and the Czech Republic, it is also planned to use reactive power management for voltage regulation.

All demonstrators assumed that the solution will be used with predictive activities in mind, mainly in the short-term perspective. In the case of the Czech Republic and Poland, services in the long-term perspective will also be demonstrated. The biggest difference is in the network cases and situations when the Voltage control service is to be used. In the case of the Czech Demo, the idea is to protect the HV and MV network. Polish Demo plan to use it for protection of the MV and LV network. In the case of the Hungarian demo, it is planned to use the customers from the MV network to protect HV/MV transformers. Slovenian Demo is focusing on using LV network resources to protect equipment in the MV/LV substation.

Table 5-2 shows basic parameters for the voltage control service used by each demo in the Eastern Cluster as a part of the OneNet project.

Table 5-2 Correlation of congestion management service demonstration with the service parameters.

	CZ DEMO	**PL DEMO**	**SL DEMO**	**HUN DEMO**
Active/Reactive power	Reactive power	Active power	Active power	Active and reactive power
Voltage level of the network where service will be use	MV and LV	MV and LV	MV/LV (transformer) LV network	HV/MV (transformer)
Corrective/predictive	Predictive	Predictive	Predictive	Predictive
Capacity/energy	Capacity and energy	Capacity and energy	Capacity and energy	Capacity and energy
Time frame	Short and Long term	Short and Long term	Short term	Short term

5.2.3 Frequency control services

The Polish demo is the only one that plans to test the purchase of flexibility services from resources connected to the distribution network for frequency regulation. The purchased services will be standard in case of balancing energy, currently purchased by TSO in Poland only from central dispatchable units to balance the power system. In the case of balancing capacity, the scope of the tests will depend on the implementation of

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regulations enabling this on the Polish balancing market (work is currently underway). In the case of balancing products, the scope of the tests will depend on the implementation of regulations enabling this on the Polish balancing market (work is currently underway).

Detailed information about flexibility services demonstrated in the Eastern Cluster is available in the deliverable D10.2 “Selection of services and other design elements of the integral flexibility platforms” [5].

5.3 Products in the demo

Each national demo in the Eastern Cluster defined a list of products that will be tested in order to tackle the problems in the distribution and transmission network. The product catalogue was created as a result of this activity and is presented in Table 5-3. Despite similar needs identified by system operators and the common approach to solving grid operation problems, products developed by individual demos differ. At a very high level of generality, the products are greatly similar to each other. Further analysis of their underlying assumptions with more details detects some differences within these products. The full description of the products in the Eastern Cluster can be found in the D10.2 [5].

Table 5-3 List of products that will be demonstrated in Eastern Cluster.

Demo	Service	Product	Products according to WP2 definition
Czech	Congestion Management	Local congestion management of active power (-)	Predictive short and long term local active product
	Voltage control	Voltage control	Predictive short and long-term local reactive
		Reactive power management	Predictive short and long-term local reactive product
Poland	Congestion Management	Change in active power (+/-) also includes Active energy balancing (RR)*	Predictive short and long term local active productActive energy balancing (RR)*
	Voltage control	Change in active power (+/-)	Predictive short and long term local active product
	Frequency control	Balancing capacity for mFRR*	Balancing capacity for mFRR*
		Balancing capacity for RR*	Balancing capacity for RR*
		Active energy balancing*	Active energy balancing*
Hungary	Congestion Management	P increase/decrease in MV network	Predictive short term local active product
		Q increase/decrease in MV network	Predictive short term local reactive product
	Voltage control	P increase/decrease in MV network	Predictive short term local active product

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		Q increase/decrease in MV network	Predictive short term local reactive product
Slovenia	Congestion Management	Congestion management via aggregator through a market platform	Predictive short term local active product
	Voltage control	Congestion management via aggregator through a market platform	Predictive short term local active product

** Provided that the relevant regulations in Poland will be implemented. Otherwise, the service products will be tested in the form of simulations.*

5.3.1 Czech demo

The Czech demo is focusing on solving problems with voltage violation, reactive power management and congestion management in the DSO network. In the demo, three products were proposed for tackling DSOs needs:

- For congestion management in the LV network an active power management product, delivered by the EV power station,
- Reactive power control for voltage control services in the network,
- Reactive power control for reactive power flow management between TSO and DSO network in the common coupling points (same as the product above but used for a little different purpose).

The congestion management product is dedicated to short term, predictive and local problems. DSOs plan to contract capacity for congestion management product. The reactive power products are developed as long-term products for solving predictive and local problems. The goal is to contract capacity that will be activated when needed on the DSO call. This solution is seen as an alternative tool for the long-term operation of the distribution network. The services are used both for disturbances and normal operation. In the demo, there is a plan to use a traffic light scheme for the coordination between different System Operators. The traffic light scheme is described in the detail in the Chapter 5 in the deliverable D10.2 [5].

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Table 5-4 Flexibility products in Czech demo.

Products proposed by Czech Republic demo	**Description**	**Harmonised Products**
CZ1: Local congestion management of active power	Flexibility is provided through active power management of fleet charging stations of EV.	Predictive short-term local active
CZ2: Voltage Control by Q management	This product aims to regulate the Voltage according to the requirements of DSO in order to achieve voltage stability of part of the distribution network.	Predictive long-term local reactive
CZ2: Reactive Power Management	This product aims to regulate the Reactive power according to the requirements of DSO in order to achieve voltage stability of part of the distribution network.	Predictive long-term local reactive

5.3.2 Hungarian demo

The Hungarian demo will demonstrate resolving congestion and voltage violation problems with the use of active and reactive power-based products. The demo includes two similar products in terms of activation time and ramping to meet DSOs needs. Both products are characterized as predictive and local products, because there are targeting local needs of DSO e.g., overload of HV/MV transformer or violation of standard voltage bands on selected MV lines due to high generation from RES connected to MV network. For both products, the auction will take place in two steps: capacity for ensuring availability of FSP in advance and energy when the need for such service will be noticed in the network. Capacity auctions will be driven by the technical needs of the DSOs, which are determined every week based on weekly maintenance plans. Energy bids can be submitted between W-1 Monday 0:00 and D-1 6:00. The early gate opening supports the procurement of services that are expected to be necessary with probability. The gate closure on D-1 allows SOs to procure services based on day-ahead predictions and network calculations. Combined bidding of those products for a selected problem is of interest for the Hungarian demo.

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Table 5-5 Products demonstrated in Hungarian demo.

Products proposed by Hungarian demo	**Description**	**Harmonised Products**
Change in active power (P) (CM & VC)	P products of the flexibility market will have the same attributes, which are designed in a way to maximize the number of potential bidders, thus no certificate of origin will be necessary, and products will not be separated based on the technology behind the bid. This practically allows generation units (P), storage units (P), demand-side (P) to participate in the same market. The products will be capacity+energy products.	Predictive short-term local active
Change in reactive power (Q) (CM & VC)	Q products of the flexibility market will have the same attributes, which are designed in a way to maximize the number of potential bidders, thus no certificate of origin will be necessary, and products will not be separated based on the technology behind the bid. This practically allows generation units (Q), storage units (Q), reactive power providers (Q) to participate in the same market. The products will be capacity+energy products.	Predictive short-term local reactive

5.3.3 Polish demo

The Polish demo is focusing on the active power management products for balancing, congestion management and voltage control services. Nowadays in Poland, there is no flexibility market, and no flexibility services or products are acquired by DSO. TSO has access to standard balancing products on the dedicated balancing market, but the requirements are very strict and prevent small service providers from participating in the balancing market. A new approach to provide balancing services by the flexible service providers is developed in the Polish demo. The main idea is to give small and medium customers the possibility to provide in the day ahead market balancing services to TSOs. The customer will be able to provide standard balancing products like aFRR, mFRR, RR, etc. to TSO alone or with the help of an aggregator. New services, dedicated to DSO needs, will be tested during the project for congestion management and voltage control based on active power management. The same product will be used in the day ahead and medium/long term time frame. Those services will be acquired by the DSO in the event-driven approach, which means the auction will be only called when the need for such services will be identified. In the day ahead market it may be a result of the change in the forecast or some events that result from the network reconfiguration. Medium/long term auctions will be used for the planned works, that are scheduled by the DSO. In that case, the DSO will pay first for the capacity and then, after activation for energy (if this will be still needed). The auction will be called a few weeks ahead, and the activation will take place in the day-ahead timeframe.

Table 5-6 Products demonstrated in Polish demo.

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Products proposed by Polish demo	Description	Harmonised Products
Change in active power (+ & -) (CM + VC for DSO)	The volume of active power resulting from an increase and decrease in the demand or decrease generation at the connection point, in reference to the baseline profile.	Predictive short-term and long term local active energy
Balancing capacity for FRR*	Acquired as a standard product.	FRR
Balancing capacity for RR*	Acquired as a standard product.	RR
Active Energy Balancing*	Product used for balancing and congestion management. Active energy balancing product solves firstly congestion management and next balancing issues. FSP's need to meet technical requirements, especially in terms of time activation.	FRR, RR

** Provided that the relevant regulations in Poland will be implemented. Otherwise, the service products will be tested in the form of simulations.*

5.3.4 Slovenian demo

The Slovenian demo is focusing on the active power curtailment of heat pump supply according to the activation calls from the DSO to solve the congestion and voltage problems of the MV/LV transformers substation in the demo area.

One product is proposed for congestion management and voltage control to fulfil DSO's needs in the network. The product is characterized as corrective and local, due to the nature of the problem. As the demonstration takes place in a low voltage network and in a limited network area, the risk of a problem in the TSO network as a result of activation of the flexibility service by DSO is negligible. There is no cooperation between DSO and TSO established for Slovenian demo on the product or service layer, but the curtailment of the active power can be utilized for mFRR at the balancing market.

One of the procurement cases concerns the use of predefined windows for the activation of flexibility. The response time after the call for activation is 30 minutes (to reach the 100% of service provision). The procurement happens several weeks before to ensure capacity for the need and only the delivered energy is paid.

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Table 5-7 Products demonstrated in Slovenian demo.

Products proposed by Slovenian demo	**Description**	**Harmonised Products**
SL: Congestion management and Voltage control via aggregator through a market platform	Locational congestion management service of existing congested secondary MV/LV transformer (substation) Flexibility (capacity) is procured from aggregated demand response (heat pumps) – active power curtailment.	Corrective local active

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6 Market layer

Following the top-down approach of defining the IMP, the Market layer describes the general realization of market processes that essentially follow the necessary core business functions of the Eastern Cluster demonstrated flexibility markets. The business sublayer consists of the main elements, mostly executed step-by-step to realize the market-based approach of grid service provision, according to the BUCs. This chapter of the Eastern Cluster IMP further clarifies the market design/process dilemma stated in OneNet Deliverable 3.2 [7] by creating a unified approach of the demonstrators concerned, focusing on the market/FSP bid selection process via merit order and the necessary pre-conditioning, qualifying and post-processing functionalities. The layers of business and functional components are organized following OneNet Concept and Requirements (Deliverable D5.1 [8]) architecture of interoperable layers consisting of components, based on the high-level architecture model for BRIDGE report 'European energy data exchange reference architecture'.

Generalization of market players introduced in Chapter 4 of User layer is necessary to find the common anchors to connect individual national demonstrations to the common OneNet approach. Revision, harmonization of the roles-actors shall be further completed, thus the already defined, ENTSO-E Harmonized Role Model (HRM) shall be updated. IMP roles are aligned to the HRM, with necessary updates of it, according to the OneNet Deliverable D2.5 [9] finalized along with this current deliverable.

The chapter further leverages the outcomes of WP2, WP3, WP5 of the OneNet project and the INTERRFACE project's IEGSA conceptual architecture to define the core functional elements of the market platform [10].

The two sublayers are concluded with the description of national demonstrators and IMP connections and the necessary differences, also including a separate chapter, Chapter 6.1.5, detailing the Eastern Cluster cross-border BUC for the business sublayer.

6.1 Business sublayer

Business sublayer of IMP defines the common market structure for flexibility services market-based (i.e., dynamic pricing and compulsory/voluntary bidding based) procurement. Business concept, process, and key elements that are necessary to compose services and products are identified, along with an emphasis on business roles and interactions.

6.1.1 Key challenges in the integrated market and requirements of the national markets

Deliverable 3.1 [11] extensively explored the four OneNet Clusters' flexibility markets and mapped them to a general framework. The four Eastern Cluster demonstrations are, though varying in timing, services, and

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actors, all are market-based schemes with DSO and/or TSO-DSO coordination. Thus, three key elements of the IMP are identified: SO (TSO+DSO), FSP, and the market itself, operated by a designated MO.

For the sake of the clarity, hereby the sections follow the theoretical framework of OneNet deliverable D3.1 [11], following its aim to harmonise flexibility market concepts and the related vocabulary.

The generalized market can have different timings, different FSP grid connection, product type and can work with both availability/activation delivered products. This general approach is necessary, as the four Eastern Cluster demos have a significantly different flexibility market setup, as seen in Figure 6-1.

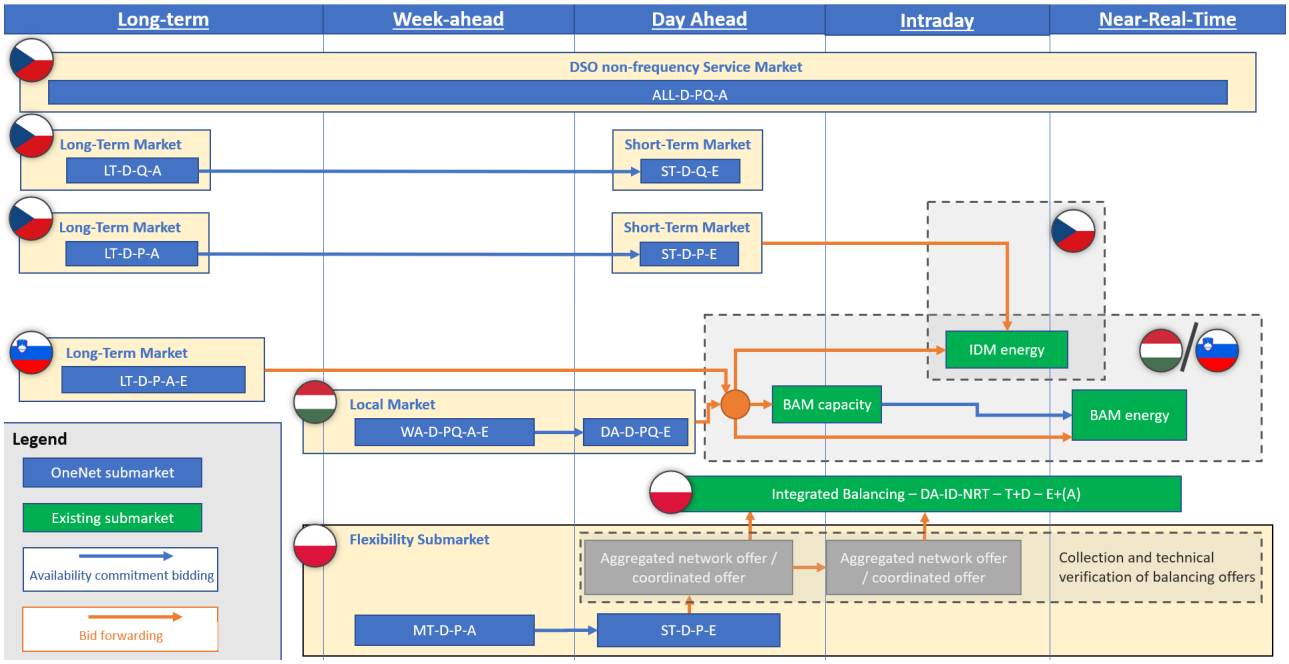

Figure 6-1 Market setup of Eastern Cluster demos – combined market process flow, based on OneNet D3.1.

Practically, a single IMP shall cover all OneNet submarkets in Figure 6-1, denoted by blue boxes.

Thus, a generalized market shall be defined. According to the methodology applied in WP3, markets consist of five main pillars, each having different features – giving a reference model, including submarkets and their interaction:

1. structure and scope of market process
    - Market architecture,
    - Submarket coordination.
2. pillars of market clearing/bid matching
    - Market optimization,
    - Market operation,

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- Grid representation.

The key challenges are also described in the theoretical market framework of OneNet deliverable D3.1 [11], highlighting the key design problems/variables of the IMP, also describing a product/service design to market design approach, suitable for defining the market layer.

1. Market architecture:
    - Number of submarkets that are connected to products and services catalogue.
    - Procurement area (locational representation) to be aligned with service requirements.
    - Clear market roles to be defined, especially with market operation, market management, grid management – thus MO – DSO distinction.
2. Submarket coordination:
    - Allocation principles between parallel buyers of products/services – formal allocation rules and secondary/propagational effects of flexibility activation (e.g., balancing consequences).
    - Allocation principles between submarkets (bid forwarding, market making, timing, common market phases, energy, and ancillary/local grid service coordination).
3. Market optimization:
    - Methodology vis-á-vis the submarket structure,
    - Submarket optimization strategy,
    - Inclusion of the grid representation in the market optimization.
    - Overall procurement economic efficiency.
4. Market operation:
    - Remuneration (pricing) scheme, and product remuneration rules,
    - Market clearing type,
    - Timing for flexibility service procurement.
5. Grid representation:
    - Completeness of the grid representation,
    - Comprehensiveness of market phases/timing vis-á-vis grid representation.

For the catalogued products and services, the following options for each of the four core market dimensions shall be part of the IMP business requirements.

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Table 6-1 Required options on market dimensions on IMP Based on the OneNet formalised sub-market nomenclature.

Market dimensions	Timing	FSP grid connection	Variable related to the product traded	Availability or activation of the flexibility to be provided
Options	ALL (All timeframes)	D (Distribution)	P (Active power)	A (Availability)
	LT (Long-Term)	TD (Transmission and Distribution)	Q (Reactive power)	E (Activation)
	ST (Short-Term)		PQ (Active and reactive power)	A-E (Availability and activation)
	WA (weeks ahead)			
	DA (Day-ahead)			
	ID (intraday)			
	NRT (Near-Real-Time)			

6.1.2 Generalized market features

As the key pillars, design variables and the necessary services, products are identified, the generalized market's main attributes can be derived from the national demonstrators. The approach is based on finding the minimum necessary feature set to cover all demonstrators. Some demonstrators will not use specific features, e.g.: TSO participation is only enabled at PL demonstrator.

Key elements of IMP:

- **Timeframe**: across the complete timeline, **not a decisive market feature** – timings can be modified in a specific instance of the general market platform.
- **Products**: practically all needed, P + Q and A + E – both active and reactive, and both capacity and energy based.
- **Objective**: cost minimization of procurement - uncleared bids can be forwarded. At least initially no possibility for SO demand curtailment in the markets: global, TSO-level constraints, balancing cannot be relaxed, local, DSO-level congestions can be solved with operational-technical intervention if no market – relaxing of constraints can be a feature of interest there.
- **Market type:** Pay-as-bid auction markets, for both congestion management and voltage control services.

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- Sequential markets, first capacity type (if applicable) then energy type with compulsory bid forwarding – market maker contracts from the availability product allocation.
- Bids can be automatically priced (SI) but generally free bidding is allowed.

- **Roles:** IMO is needed, DSO can assume this role in HU and SI demonstrators.
- **Triggers:** regularly run market, normal progress (gates of the market) can be suspended – skipped – if no network issue identified.

6.1.2.1 Market architecture

Four features are identified comprising the architecture of IMP.

Sub-markets are widely varying in the Eastern Cluster (Figure 6-1). Thus, IMP shall handle up to (at least) three individual sub-markets with up to two OneNet demonstrated and up to two targeted market for bid forwarding chained in a single process, step-by-step timed. Also, up to three parallel market processes are required (note Czech demonstration) in a single demonstration zone. (Note: further parallel markets/auctions may be required – but not derived from the business architecture, but from a technical necessity: the reduction of the optimization problem by cutting up the auction's optimization vector space to disjunctive sets of optimizations.)

As the timing is widely varied, different settings, parameters shall be setting the time limit, e.g., bid submission deadlines. The complexity of temporal links of different sub-markets is however limited, as only sequentially structure of sub-markets is necessary.

One common design variable of each demonstrator is the type of sub-markets. Auction based markets can be used as there is a definite single buyer for a specific product/service (demand is not curtailed nor substituted with another SO's need). Note that, however, multiple similar products with different delivery zones – e.g., DSO1 CM capacity + DSO2 CM capacity products can be parallel, even allowing a single FSP to bid for multiple demanded products jointly – a cross-product matching feature.

Product and services in the IMP shall include all cluster products. As it can be derived from Chapter 5 multiple services (CM, balancing, voltage regulation) and multiple products (reactive and real, both scheduled and optional activation) with a wide range of timing is necessary (Table 6-1) Thus the general approach requires handling different services simultaneously. This multitude of products in the catalogue require flexibility of the platform in defining the products – thus a market/product pre-qualification – configuration steps. The common parameters are set by the deliverable D2.2 [6] of OneNet, the range, options for each 'parameter field' to be set by SO/MO parallel to what FSP shall state its qualified capabilities (technical and bid related dimensions). This requires a well-configurable pre-qualification step in the business process, also for product registration by SO.

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Location representation can be applied differently to each sub-market. Granularity in product definition, but this shall be aligned with the data model, the allocation and clearing rules, let alone with other coordination (non-market) steps in the business process. Nodal/zonal representation, along with grid constraint definition shall be aligned with the location representation of the market. The IMP thus consider a general delivery zone as the measure of location, that can:

- set by the service procuring SO,
- be identical of a specific network node, thus realizing nodal pricing,
- be identical of a finite section of the network (e.g., a MW feeder, or a HV/MW substation aggregated),
- have multiple assets/resources connected to each zone,
- hence multiple bids can be submitted for each zone, every 'pieces' of location (and multiple FSPs can be involved in bidding for a single delivery zone).

Market competition and price interaction also influences, along with grid representation and service point of delivery requirement from the SO. This creates additional requirements on the data model, as the different asset, node, location (delivery zone), congestion zone, congestion element, metering, etc. IDs have to be mapped to each other. Grid qualification step is thus necessary and requires a complex registration process.

Roles and actors involved in each sub-market are not fully aligned in each national demo, generally, SOs, FSP and MO are the actors, with limited participation of TSO in most sub-markets (e.g., CZ, HU, SI). Specific access control of FSPs to each sub-market is enabled via pre-qualification of resources (product qualification). Another aspect is that voluntary participation is handled by IMP, as compulsory registration cannot be enforced without off-platform legal bounds. The roles are described in more detail in Section 6.1.3.

6.1.2.2 Submarket coordination

The previous section concluded that IMP should have multiple sub-markets with bid forwarding in a step-by-step process, so the coordination of them is a necessary business requirement.

Allocation principle of flexibility describes the resource allocation division rules, not only in a single sub-market, but also in coordination of different – in case of IMP – subsequent markets. Buyers of flexibility are SOs. Priority of buyers are not pre-defined, but based on economic efficiency, thus priced demand curves in IMP. This enables a market specific parametrization of flexibility demand. Though only the Polish demonstrator covers both DSO and TSO demand (in one sub-market), in case of the DSO-only CZ, HU and SI demos multiple DSO areas can be easily part of the market domain, hence the prioritization of allocation shall be possible.

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Coordination issues in activation also stipulates a market design task, as multiple/overlapping activation of a single resource from different sub-markets are possible (even resulting a cross-activation – with opposite effect on a specific network variable). This necessitates in the IMP that either a complete update of the underlying grid/system representation is run before each sub-market bid matching, or the grid effect is carried over (activations from the previous sub-markets) autonomously – preferentially via flexibility register.

Bid forwarding is explicit in multiple demos, thus IMP shall provide this feature. This can require a post-matching process step for automated/FSP-gated feedforward of unmatched bids. However, other, non-technical means can result in the coordination of sub-markets (e.g., market maker conditions in market rules, other legal commitments).

Sub-market timing coordination is necessary in case of overlapping trading time periods, i.e., a market timeline with multiple bid submission gates open (e.g., with multiple, differently parametrized instances of a general market processes). CZ demo stipulates such parallel sub-markets. The conflict of committing a single resource, however, is recommended not to be resolved within the IMP, as it would require the integration of the complete organized, wholesale market result, with additional information on the commitments from bilateral, non-registered trades. Only enforcing the full feasibility of some parallel sub-markets still does not ensure complete feasibility. However, for the sake of simplicity and sub-market liquidity different resources/products shall be in the focus of parallel sub-markets – as it is done in CZ demo.

Order of market phases are strict in IMP, with defined gate opening and closing time. The bid forwarding requires full conclusions of earlier sub-markets to enable bidding in the subsequent market.

Coordination of different products' market timeline is not an explicit IMP functionality, as demonstrators not covering the total sub-market plane. Implicit alignment is possible with proper gate timing settings.

Concluding this section, of the three general coordination schemes, **IMP delivers bottom-up coordination**, as the first sub-markets are starting with distribution-level optimization, and through bid-forwarding and/or actual market realization further markets (general wholesale energy markets (DAM/IDM) and/or specific TSO+DSO level flexibility service markets) are demonstrated.

6.1.2.3 Market optimization

Market optimization methodology is decentralized in IMP as resources can enter the market using other, non-SO centric marketplaces as well. This underlines the importance of added (non-technical) measures to ensure proper strategies able to avoid double procurements, double payments to FSPs, and discourage gaming - in line with D3.2 [7] recommendations. Also, centralized optimisation would require one algorithm that considers all voltage levels, including both transmission and distribution levels in a single process.

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Decentralized markets and the sequential **sub-market optimization** are the direct consequence of the step-by-step sub-markets. In case of the CZ timeline, independent optimization is carried out (no joint optimization of different services). IMP thus handles sub-market optimization individually, with no connection of variables, objective function, etc.

Grid representation in the market optimisation is clearly a mandatory function, with the emphasis of local flexibility services (see Sections 5.2 and 6.1.2.5).

Overall procurement economic efficiency is based on **(sub-) market optimization objective function(s).** IMP operates fully SO centric markets, with hard grid constraints and firm services demand. Hence cost minimization is the basis of objective function, with possible penalty function for any necessary other prioritization of services demand (if applicable). This is also underlined in D3.2 [7], as there is generally no defined or complete information about buyer-side willingness to pay, so cost minimization is an alternative instead of maximizing social welfare.

6.1.2.4 Market operation

Remuneration scheme in IMP is pay-as-bid, in the market process. Further fine-tuning of the price/cost results of the flexibility service procurement can be added, in the pre-qualification, bid-qualification process. Regulated prices, price caps and general price limits can narrow the range of bid prices, thus in pay-as-bid, the pay-outs, the necessary remuneration. This setup can deliver no remuneration (with zero bid price) and cost-based pay-outs as well, with parameter settings.

Methodologies to define the remuneration of the products: IMP shall have features to enable both energy and availability (capacity) based remuneration calculation, and of both active and reactive power. This, however, only requires flexibility in market bid dimensions and settlement vs. metering calculations, but it does not necessitate general overhaul of the market framework.

Market clearing type is based on discrete, auction-typed bid matching, with regular or trigger-based auctioning. Discrete intervals (e.g., hours) can be auctioned in batch (e.g., days, weeks) thus enabling not-only multi-period bid types (e.g., spanning consecutive hours), but also a more convenient market schedule for FSPs.

Frequency of flexibility procurement is varying in Eastern Cluster. IMP shall have flexible, configurable gate-timing set. IMP not only spans long, medium, and short timeframes, but e.g., weekly auction not necessarily coincides with each other, nor it is mandatory to be harmonized (as IMP considers primarily grid services). Actual gate open/closure timing are subject to individual parametrization due to regulation, and even depending on the national holiday schedules.

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6.1.2.5 Grid representation

Grid constraints, the resulting market clearing rules and optimization constraints are a complex topic in the Eastern Cluster. CZ demonstration uses conditionally set limits, depending on the topology switch/connection states (50%/70% of built-in capacity, non-normal states: up to 100% of loads). This requires handling the network state in detail. SI demonstrations uses full representation, including full metering data covering complete MV/LV section in both demonstration locations. HU demo uses comprehensive grid data, however the connection point and network constraint interaction are represented with the use of sensitivity factors. PL demo also handles full network representation in contained parts of HV/MV/LV grids, using detailed state estimation, prediction for full network state.

Comprehensiveness of the grid representation is a general full representation in IMP, however, 1:1 connection to the actual grid assets might have to be relaxed and parts of the network simplified and aggregated. The IMP shall contain a complete load flow – state estimation function, resulting a full network descriptor calculation, including diverse grid phenomena. The results shall be able to be interpreted using (linearized) sensitivity factors for market optimization. Bid selection process shall include full granularity of the underlying network, with point-to-point cross-sensitivities. Zonal representation can be also realized with the complete topology, using either simplified, reduced grid inputs and/or equalized sensitivity factors.

Grid representation in market phases – IMP requires to fully consider the grid as per to its individual connection points (e.g., with POD descriptors) throughout the qualification, bid matching, activation, and settlement steps. These are all specific to location, even including various individual FSP details in the qualification and metering-settlement steps.

However, the details of the network considered is different throughout the BUC scenarios, as Figure 6-2 shows. Pre-qualification, especially grid pre-qualification necessitates a complete representation of the grid, on connection point (POD) level to ensure all DERs can be mapped. Further calculation steps, especially the market constraints are generally aggregated into larger zones, but if one zone contains only one node, than the full representation is ensured. Linearization of grid constraints are required to result in a computationally tractable market algorithm. Generalization of NTC-based (zone-to-zone, flow gate typed), and flow-based (sensitivity factor based coordinated zonal/nodal) constraint definitions are fully compatible with a wide range of networks constraints, including the DSO relevant voltage limitations.

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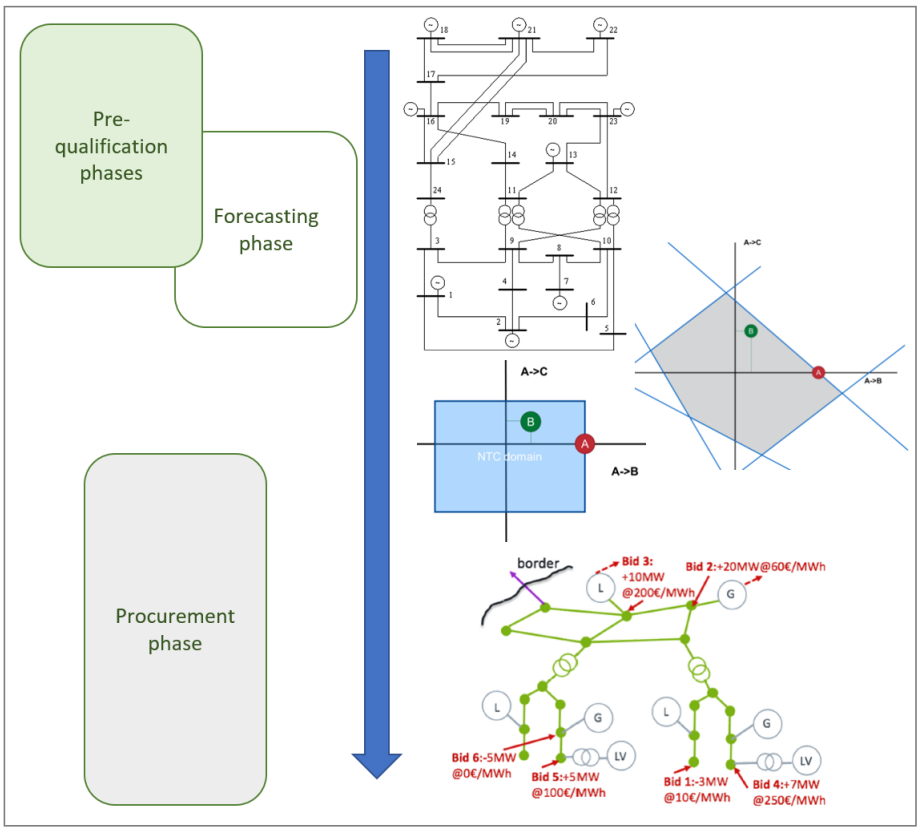

Figure 6-2 Grid representation of IMP – from full with linear constraints. Figure adapted from [12] [13] [14].

6.1.3 Roles in the integral market platform

IMP considers three generalized actors:

- System Operator (DSO, TSO) – buyer of the flexibility services, responsible for grid operations, calculations, metering.
- Flexibility Service Provider (FSP) – market participant that submit resources' capabilities to the IMP.
- Market Operator (MO) – operator of the IMP, manager of the market process, monitors, supervises the market results, and performs settlement.

General actors however can perform multiple roles. Main roles identified by the demonstrators: Flexibility Market Operator, Flexibility Service Provider, Flexibility Service Provider Aggregator, TSO, DSO, Balancing Service Provider.

OneNet WP2 efforts resulted in an elaborated business role list, compatible with ENTSO-E Harmonized Role Model (HRM), also with BRIDGE – Harmonised Electricity Market Role Model (HEMRM) and amended it where it deemed necessary. The IMP relevant roles are presented in a hierarchical structure, depicted by Figure 6-3.

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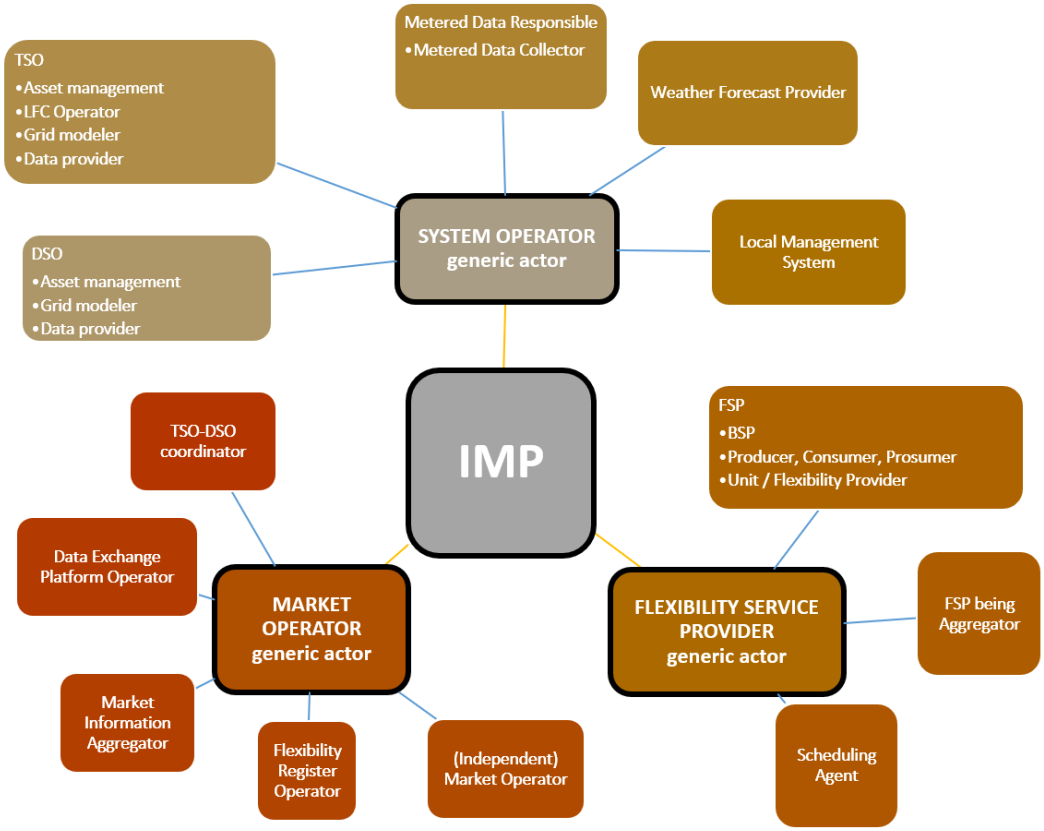

Figure 6-3 Roles in the Integral Market Platform.

The details are summarized in the following list, connected to the generalized actors. Already standardized HRM roles are underlined, and **new roles proposed in OneNet** are in bold, according to Deliverable 2.5 (Recommendations for the Harmonised Electricity Role Model) [9].

- System Operator generalized actor
  - **Distribution System Operator (DSO)** – *including asset management and microgrid scheduling sub-roles, grid access and data provision*
  - **Transmission System Operator (TSO)** – *including asset management, network modelling & calculation, forecasting, capacity management and RES scheduling sub-roles, data provision*
    - LFC Operator – *qualification, balancing for TSO*
  - Metered Data Responsible – *meter data validation, aggregator*
    - *including* Metered Data Collector – *meter reading, data acquisition*
  - **Weather Forecast Provider**
  - **Local Management System (Operator)** – *managing grid a RES forecasts, enabling pattern planning*

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- Flexibility Service Provider generalized actor
    - **Flexibility Service Provider (FSP)**
        - extension of Balancing Service Provider (BSP)
        - *including Producer, Consumer,* ***Prosumer,***
        - *including* **Unit / Flexibility Provider** – *single units, part of aggregated portfolios of FSPs that is an extension of Resource Provider*
    - Flexibility Service Provider being Aggregator (FSPA)/ **Aggregator**
        - extension of Resource Aggregator that only aggregates for BSPs
    - Scheduling Agent – *schedule information responsible for BSP*
- Market Operator generalized actor
    - **Independent Market Operator (IMO)** – *including Platform 'roles'*
    - **Flexibility Register Operator (FRO)** – *manages flexibility register*
    - Market Information Aggregator
    - TSO-DSO coordinator
        - generalization of TSO-only Capacity Calculation Coordinator
    - DEP operator – *manages data exchange platform*

  Platform as a separate role/entity is directly mentioned in CZ and HU BUCs, in both Local and OneNet Market/Information Platform uses. WP2 recommends merging these mentions into Market Operator, as this role is rather a function and connected to the System Use Cases. However, Local Management System in CZ demo is more connected to the grid planning functions. Data exchange platform operator role is a direct part of the Eastern Regional Business Use Case.

The definition of each key role is presented in Section 4, and in OneNet Deliverable 2.5 [9].

The connection of roles and demonstration use cases, and the interaction of various sub-roles, quasi-roles, and the ongoing extension of HRM is challenging to be mapped in full extent. The differentiation of each demonstrator with the relevant roles are summarized in Table 6-2.

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Table 6-2 Connection of IMP roles and demonstrators – asterisk marks and implicit relevance of the role.

	CZ	HU	PL	SI	Eastern RBUC	Notes
System Operator generic actor						
Distribution System Operator (DSO)	x	x	x	x		
Transmission System Operator (TSO)		x*	x	x		TSO is only a passive actor in HU demo
Metered Data Responsible			x			
Weather Forecast Provider	*	*	*	*		Necessary for grid planning
Local Management System Operator	x	*	*	*		Implicitly in all network calculation
Flexibility Service Provider generic actor						
Flexibility Service Provider (FSP)	x	x	x*	x		PL: BSP and FSP explicitly differentiated
FSP being Aggregator (FSPA)/ Aggregator	x	x	x			
Scheduling Agent			x			
Market Operator generic actor						
(Independent) Market Operator (IMO)	*	x	x	x	x	HU: including merit order list responsibility
Flexibility Register Operator (FRO)	*	*	*	*		Necessary for grid, product and bid qualification
Market Information Aggregator	*	x	*	*	x	HU: role via OneNet platform
TSO-DSO coordinator		x				HU: role via OneNet platform
DEP operator	*	*	*	*	x	

6.1.4 Business process steps in the integral market platform

The Integral Market Platform of Eastern Cluster is a specialization of the OneNet general platform, of its business processes and use cases developed in WP2, WP3 and WP4 (Figure 6-4).

Business functionality details are derived from the IMP market design, architecture and features presented in Section 6.1.2. Thus, the market platform process steps are derived from OneNet general BUC, with the required alignment to be fully compatible with the IMP market features.

WP2 developed the OneNet General Business Use Cases in a top-down approach. Currently details of the specific data exchanges and descriptors of each scenario/step is yet to be finalized – within WP4. However, the main structure is defined, and the alignment can be specified, based on the national demonstrator use cases.

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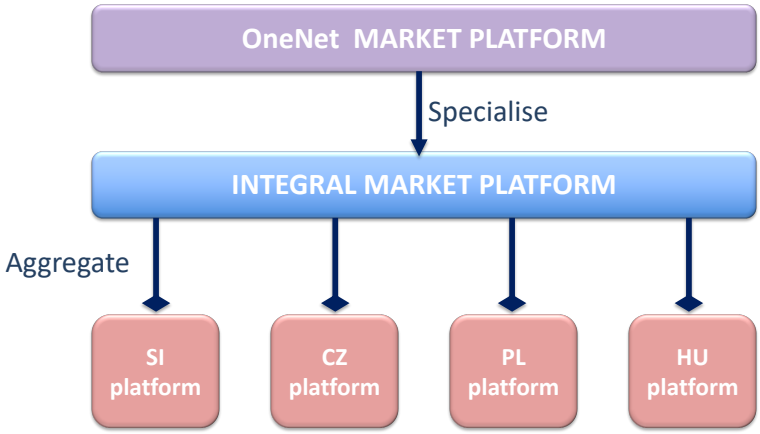

Figure 6-4 Position of the Integral Market Platform – Specialisation of OneNet business processes and functions.

Figure 6-5 presents the results of the alignment of WP2 and WP10 efforts. For the sake of the integrated process further, implicitly required scenario steps are identified for each demo. E.g., measurement & settlement cannot be performed without delivery processes and the associated data acquisition there. Thus, for the continuous stream, these are also required to be not only in the aggregated instance of IMP (a template for each national marketplace), but also in the specific instances of IMP, representing a single national demonstration.

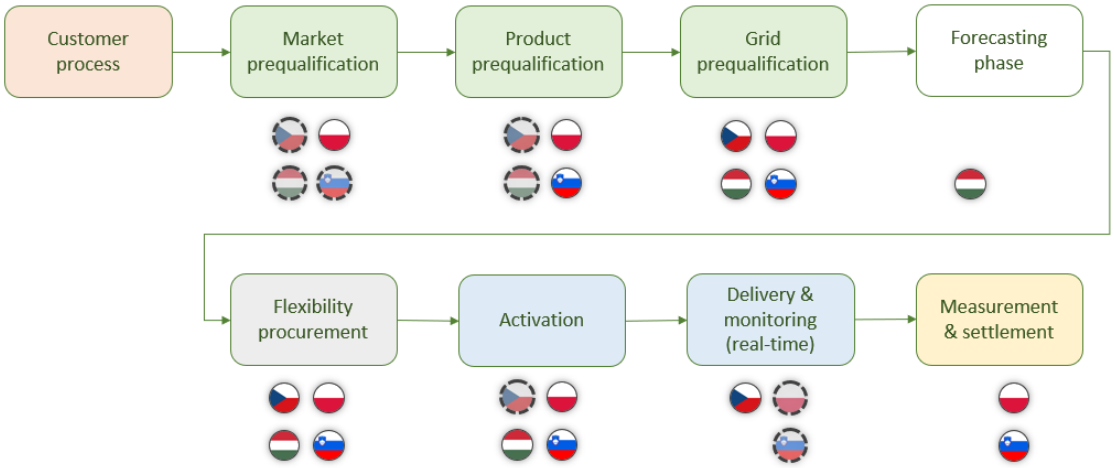

Figure 6-5 OneNet General BUC steps and the scope of the Integral Market Platform – explicit and implicit use cases in the Eastern Cluster demonstrations.

Description of the IMP BUC scenarios, based on the OneNet General Business Use case follows:

- **Customer process**: This is not a required part of any IMP instances. Basically, this step describes the end-user (customers aggregated and represented by FSPs) perspective of the market process, starting with contracting, data sharing, activation consenting and registration. In IMP, the relevant

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parts (e.g., location and capability registration) are integrated on an aggregated level, represented by FSPs, as part of the corresponding qualification steps (e.g., grid pre-qualification).

- **Preparation of market optimization – pre-qualification**
  - registration of market participants;
  - specification of products in the IMP;
  - market participant pre-qualification as Flexibility Service Providers,
  - FSP resource prequalification for specific products;
  - and grid assessment of the flexibility product ('grid prequalification').

  Detailed procedures of pre-qualification are interlinked to each other in these three steps. It is necessary to differentiate between single and recurring processes in qualification.

  Single, registration-typed pre-qualification steps:

  1. configure the general IMP to specify its details to various products, timing and market architecture,
  2. assign specific users with the necessary roles and authority to perform the market function in use cases,
  3. also, for the FSPs, the (asset/portfolio) specifics of flexibility resources are registered in the flexibility register, managed by the Flexibility Register Operator.

  Recurring qualification steps are part of the market phase, as all bids must be checked against the registered datasets, constraints and descriptors, identifiers. Thus, **bid-qualification** is based on the databases compiled in pre-qualification phases. Also, any update, revision deemed necessary requires a reiteration of the pre-qualification steps. Mostly this is required and initiated by FSPs if their resources' availability changes.

- **Forecasting phase**: Based on the aggregated datasets, grid constraint forecasting is part of the IMP. Some demonstrators skip this step and base their market phase on pre-calculated forecasts, grid capacity measures performed by system operators/local management systems.
- **Market phase**: The core step of IMP, delivered by the market operator, with several sub-processes for preparing, performing the auction, then for the notification:
  - collection of SO demand, grid parameters from forecasting phase and/or from SOs, with coordination between TSO-DSOs using e.g., traffic light concept;
  - collection of fixed bids from FSPs based on Flexibility Register data and/or – if applicable – bids forwarded from previous sub-markets;

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- notification of FSPs on posting the auction (regular of trigger-based), gate configuration and market opening, including posting general auction details (e.g., necessary flexibility products, congestion zones and price limits);
- continuous bid submission from FSPs and instantaneous bid qualification by MO and FRO – bid validation or rejection;
- closing of bid submission, collection of order book and merit orders;
- selection of bids required, bid matching, market clearing optimization to solve the flexibility demand for network constraints by a cost-minimum optimum – allocation of bid acceptance variables;
- verification of results and communication of results to FSPs and all related parties;
- publication of public results of the auction, through market information aggregator and data exchange platform operator;
- the results can be also feedforwarded for TSO-DSO coordination to form a basis for a subsequent network services decision / calculation / sub-market opening.

Note, that the market phase can be parallel or iterated if multiple sub-markets are part of the complete process.

- **Activation phase**: The market allocated and required energy bids are firmly, while the availability bids are voluntarily called in this process, taking into account any further grid limitation and actual requirements
- **Delivery and monitoring phase**: This scenario focuses on monitoring the flexibility delivery.
- **Measurement and settlement phase**: In this step, the financial settlement is prepared, based on meter and other measurement data acquisition, considering baseline methodologies and validation of service delivery. Financial settlement steps (certificate of delivery/service completion, invoicing) are not part of IMP.

6.1.5 Regional business use case realization

East Cluster within OneNet project developed and demonstrated regional business use case (BUC) “Flexibility market data aggregation”. The scope of this BUC is sharing aggregated market data on individual national flexibility platforms via the OneNet system. The business use case defines how external entity can retrieve market data from national market platforms through OneNet system, in a standardised way and in a standardised data format. The overview of the regional BUC is given in Figure 6-6. It is related with the systems use case (SUC) “Aggregated data retrieval”.

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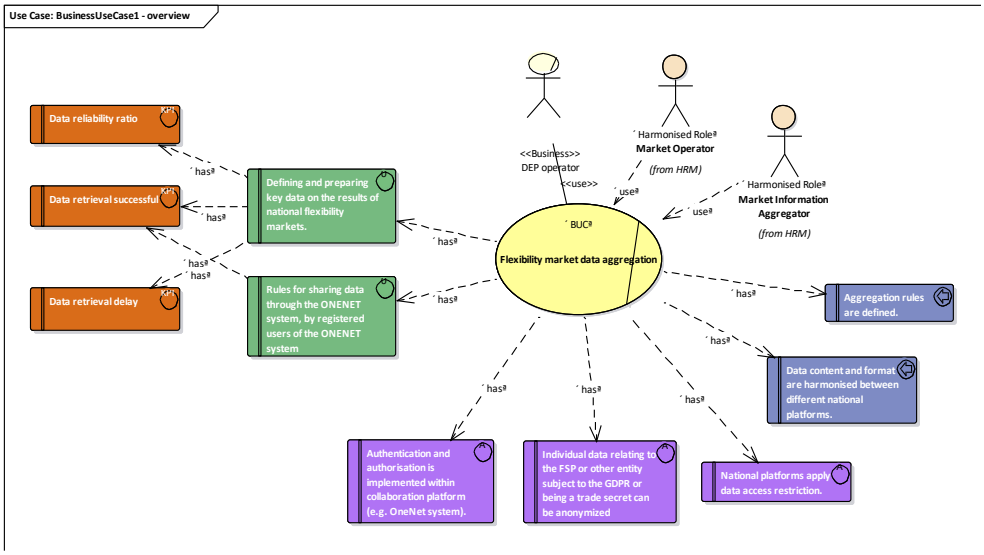

Figure 6-6 Overview of East Cluster regional BUC.

Figure 6-7 shows activity diagram, that contains role participating in the BUC and information instances exchanged. It is assumed that an entity authenticated in the OneNet system and authorised to obtain aggregated market data can send the request through the OneNet system (DEP operator role).

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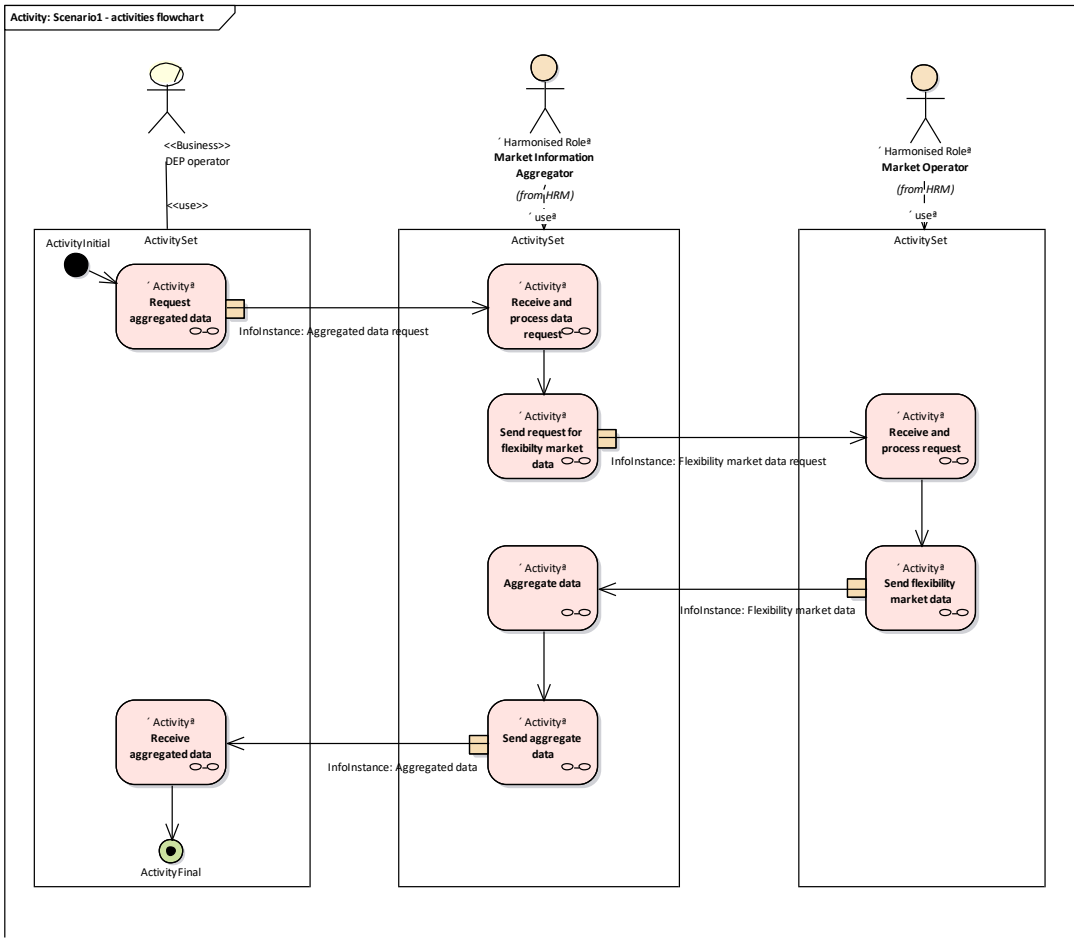

Figure 6-7 Activity diagram for RBUC "Flexibility market data aggregation".

More technical information is given in the regional SUC "Aggregated data retrieval". Common data exchange platform (OneNet system in our case) forwards the request for aggregated data to the data aggregation application. Data aggregation application retrieves market data from the data source and runs aggregation algorithm. Aggregated data are sent back through the data exchange platform in the format that enables data interoperability. Aggregated data can not contain any sensitive commercial or personal data. Activity diagram that describes this process is presented in Figure 6-8. Business objects that represent exchanged information is presented in the activity diagram, while standardized data models (CIM) used to represent this information are described in Chapter 8.

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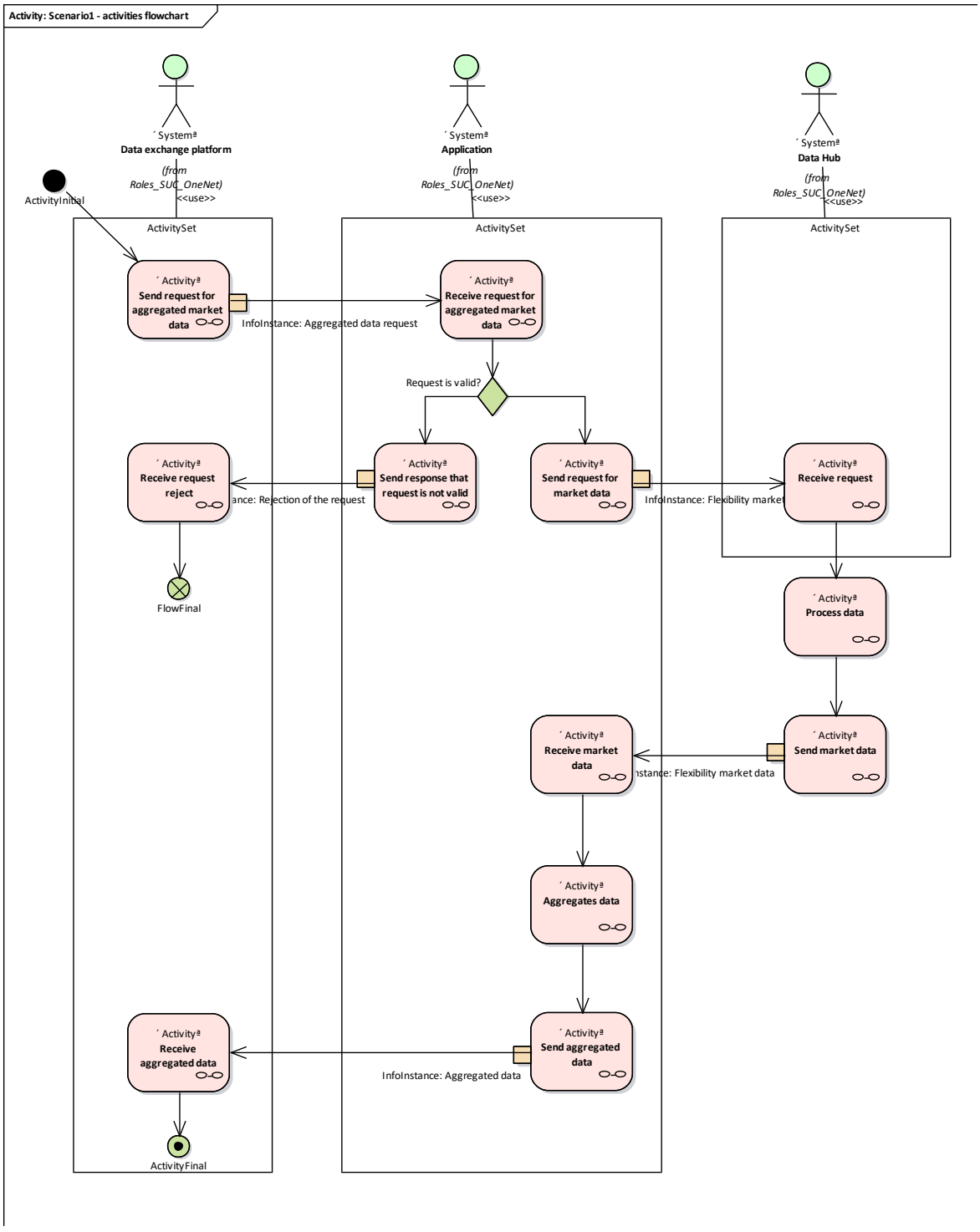

Figure 6-8 Activity diagram for RSUC "Aggregated data retrieval".

All four national pilots in the Cluster East will demonstrate this regional BUC, with enabled connectivity of national flexibility market platforms through the OneNet connector.

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6.2 Functional sublayer

In this subsection the functionalities and functional modules of IMP are described. The role of the functional layer is based on the high-level architecture model for BRIDGE report 'European energy data exchange reference architecture', using the already laid out and overarching OneNet Concept and Requirements (Deliverable D5.1 [8]) This concludes that the system can be divided into five main layers, moving from the lower to the higher syntactic layer:

1. Components layer,
2. Communication layer,
3. Information layer,
4. Functions and relations layer,
5. Business layer.

Following a further bottom-up and top-down combined approach, similarly as in Section 6.1 for the business layer, first the national demonstrators key components and requirements are summarized, then the general OneNet Platform is specialized and forms the basis of the IMP functional layer, connecting the business and information layer as one interoperable set of components.

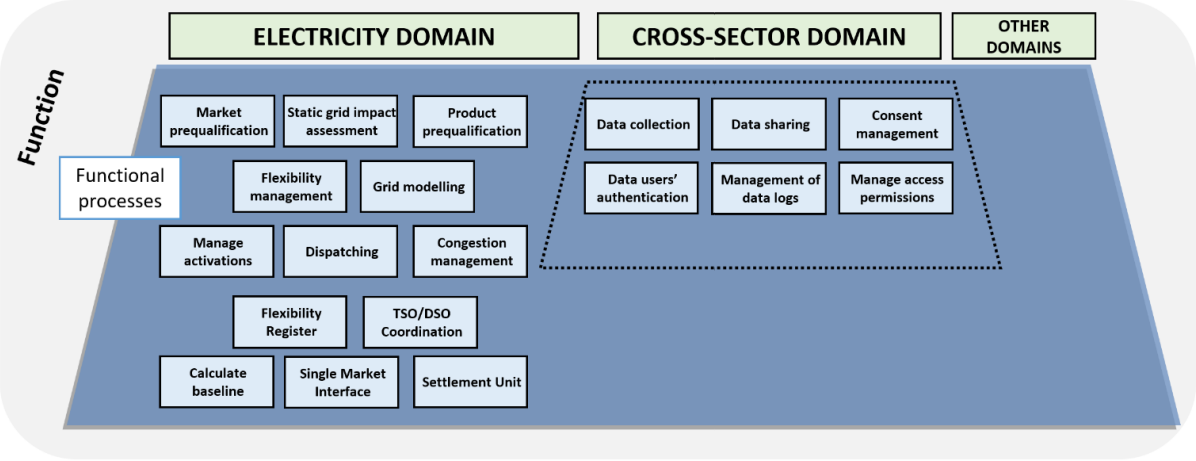

Figure 6-9 Functional layer of the BRIDGE Reference Architecture for the complete Eastern Cluster and IEGSA – aggregation of Deliverable 5.2 results.

6.2.1 Functionalities of an auction-based market platform

The general functionalities of an auction-based market platform (such as the IMP) are illustrated using INTERRFACE's IEGSA, as it has advanced demonstrators and further consolidated results of building an integrated platform for grid services.

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IEGSA stands for Integrated pan-European Grid Services Architecture, with key elements like OneNet general BUCs, as well as important complementary features.

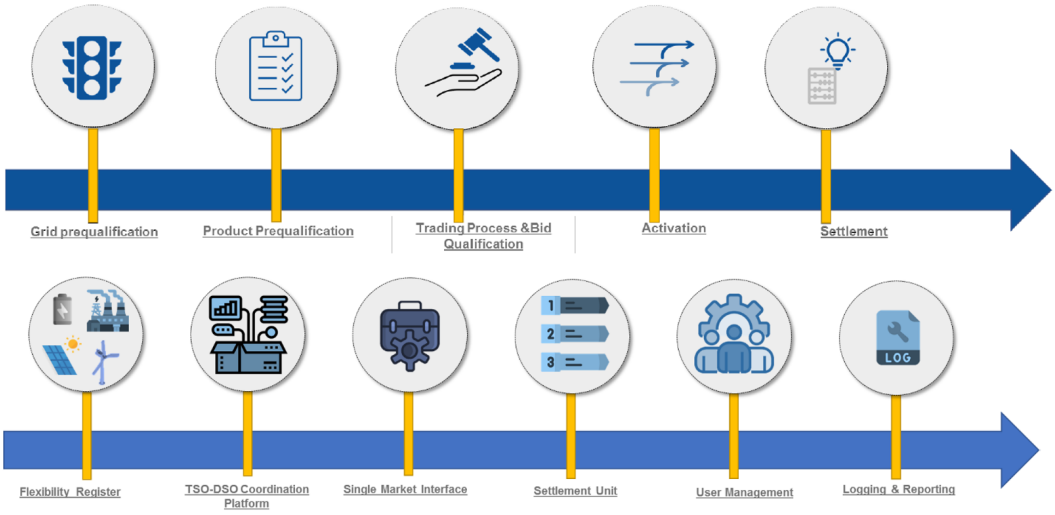

Figure 6-10 INTERRFACE's IEGSA core and complementary functions.

Though both core and complementary functions in Figure 6-10 are in the electricity domain (of the reference architecture), the former one is realized via specific use cases, thus are aligned with the business layer. The complementary functions however outline critical functions, components to be considered in a mature flexibility platform, as follows:

Flexibility Register module is the "back office" of the **pre-qualification** process. FSPs register their capabilities in Flexibility register to access one or more flexibility market. It stores resources and their qualification results from grid qualification, through product qualification ending to bid qualification. It stores metering data FSPs, allowing to store information about resource availability, thus forming a basis to settlement. The module also stores metering data from SOs, and trading results received from MOs via the Single Interface to Market module. Grid models and related data can be part of the register.

TSO-DSO Coordination Platform is the gateway through which the system operators can access the IEGSA platform. It allows data exchange with operators through well-defined and interoperable APIs to support realization of the qualification process, communicating to SOs.

Single Interface to Market is an API-based data exchange gateway to various market platforms (thus IEGSA does not form a single platform for the market phase of the flexibility markets). It communicates the flexibility needs of the operators to the market and returns and stores market results to the flexibility register. Special use cases allow the integration of grid constraints and topology information, or even complete grid models to be communicated via this interface.

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Settlement Unit module is responsible for calculating the settlement, deciding the delivery status, and realized quantities of services. The module is connected to various other components (e.g., Flexibility Register, markets, system operators) to perform data aggregation, calculation and publish settlement results to participants, markets and in the Flexibility Register.

Privacy Protection Framework is in the cross-sector domain, focusing on data privacy, authorisation, based on Role-Based access control.

Logging and Reporting is a standard function in the cross-sector domain for software platforms.

6.2.2 Functional elements in Cluster East demos

6.2.2.1 Overview of the functional elements of the Czech demo

The administration module in CZ demonstration gathers and handles the registration data of the market participants – both FSPs and SOs. This includes the collection of all the relevant data (nominal values, location etc.) and the validation procedure by the SO, covering the **authentication and authorization** steps for the key users as well as some of the **resource pre-qualification**. This step includes cross-sector domain functions as the users (FSP and SO) share data, while the MO verifies and permits the users based on this.

The market module is responsible for collecting the bids (**Market participation**) and the flexibility demand (**forecasts**) from the participants with all the relevant attributes, such as the location, time and type of service. The considered business use cases are nodal congestion management, reactive power overflow management and voltage control services centered. Hereby the SO uses **measurement & monitoring information and grid models** to perform **long-term grid assessment**, then share the results through the platform.

The traffic light concept ensures the security and quality of supply in this demonstration. During this step, the platform calculates that the planned activities would cause any congestion on the grid (analysis by location, knowing that which FSPs are offering capacity to either flexibility or ancillary service market), taking into account the planned outages in the concerned locations. This includes a communication task to the market participants about the result as well. During the activation phase, **system service activations** and unit activation **(resource control)** happen based on the available information and restrictions of the traffic light concept. Flexibility register collects the **measurement & monitoring** information.

External data exchange provides opportunity for OneNet participants to reach **report** data about the Czech demonstration. This includes management of data logs as a cross-sector domain activity.

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6.2.2.2 Overview of the functional elements of the Hungarian demo

In the Hungarian demonstration, participants (SOs) have access to a simulation tool where the operation of flexibility markets can be tested. To access the platform**,** users require **authentication & authorization**, which includes cross-sector domain functions such as consent management, data collection and user authentication. In the data access layer, the **resource pre-qualification is possible** as FSPs can be added to the demonstrator**.**

SOs then define their service needs through the simulation tool, which uses **grid models, measurement & monitoring data and forecasts** to compose flexibility demand **as simulation results**. The FSP activity is created by Monte-Carlo simulations and the **market participation** can be evaluated based on the results.

The flexibility register handles **measurement and monitoring** data created during the simulations. **System service activations** and **resource control** only happens virtually during the simulations. This includes **reports** on the effects of the services. The data from the simulations will be accessible for the OneNet participants, which includes cross-sector domain functions such as data log management.

6.2.2.3 Overview of the functional elements of the Polish demo

A prequalification process includes the registration of the flexibility potential of Distributed Energy Resources (DER). In this case the flexibility platform offers a standard communication and process handling for the SOs and FSPs, fulfilling the functions of **authentication & authorization**. This is considered as a cross-sector domain activity due to the data collection, consent management and user authentication. The data is provided to the platform by the FSPs or FSPAs, as they send the registration form, and the platform collects and validates the data. The market prequalification end with an accepted certification by the SO. Then the FSPs can request the creatin their flexibility register object, shares data about the flexibility potential. This process ends with the **pre-qualified resources** from the SO. In case of FSPAs, a new sub-portfolio also can be added in the same certification process. The registration is also available for the Balancing Service Providers (BSPs).

The platform operates an auction procedure to enhance the FSPs access to the balancing market, congestion management (CM) and voltage control (VC) services (**market participation**). During the creation of an auction, SO defines **forecasts** for:

- the need for energy-only and capacity-energy needs in the case of balancing markets,
- the need for CM and VC services.

For forecasting, the DSO uses **measurement & monitoring** information and **grid models** to carry out **simulations** and share the results. Then, FSPs can submit bids, which are collected by the platform. These bids can be sent to the balancing market after a verification. The result of the auction then can be published on the platform.

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During the activation procedure, FSPs send the activation plan to the platform, where the DSO receive it and can check if the plan is feasible to realize. After the calculation, the DSO confirm or negate the plan and the **system service activation** and **resource control** can happen. Finally, a settlement information is stored (**reports** function). Flexibility register collects the **measurement & monitoring** information.

A data exchange function enables participants to request aggregated data about the market operation. This includes cross-sector domain functions as management of data logs.

6.2.2.4 Overview of the functional elements of the Slovenian demo

In case of the Slovenian demonstration, FSPs can request the **authentication and authorization** tasks to register on the platform and initiate the **resource pre-qualification**. DSOs also can register on the platform, evaluate the prequalification requests, and send the results, from which the MO can create the prequalification report. This includes cross-sector functions such as consent management, data collection and authentication.

The registered FSPs can access congestion management services on the platform (**Flexibility market participation**). To offer such, a product prequalification is required. Through the bidding process (either as an over-the-counter market and bilateral contract or a market-based solution), the DSO run **simulations** (based on load **forecasts, measurement & monitoring data and grid model**) and publish the attributes of the congestion management needs. Then the FSPs can bid, and matching can be done by the platform.

During activation, **system service activations** and **resource control** happens for the selected bids and **measurements** are being shared. During settlement, the parties (SO and FSP) acknowledge the service so **reporting and invoicing** functions can be done. Flexibility register collects the **measurement & monitoring** information. This includes data handling as a cross-sector function.

6.2.3 System Use cases of OneNet general architecture

OneNet Deliverable D5.1 [8] describes demonstrators system use cases and functionalities. It defines general SUCs, that would directly describe the OneNet platform's functional use cases.

However, unlike the specifically defined general BUCs, general SUCs have the goal of being platform agnostic, so they can be only applicable as general categories, skeletons of the necessary functions of IMP:

- Cross-Platform Energy Data Exchange for market-based flexibility management: this standardized data connector enables several key cross-platform services in the Electricity Domain, such as: pre-qualification, market phase, service activation. It includes identification of participants, establishing data connectors and exchange of data.

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- AI, Big Data, IoT Data Orchestration for cross-platform service: It aims to allow the necessary scalability support for the near real time IoT sensing, gathering and big data management of consumer and/or network data at the grid. It includes job scheduling, tracking, monitoring and notification.
- Integration of devices and other data sources to OneNet using FIWARE: It aims to connect different data sources using standardized FIWARE components, providing a data-model agnostic connector, especially for IoT devices.

Cross-platform services are defined in D5.3 (Cross-platform interoperability services for the OneNet System) however they are defined as data connector services. The 56 identified connectors are categorized in 10 sets, as described in the next section.

6.2.4 Cluster system use cases and cross-platform services of OneNet general architecture

The purpose of this chapter is to identify the cross section of the Eastern Cluster demo SUCs, and the services provided by the OneNet platform. It reveals the group of specific applied services by Eastern Cluster demos and discuss the different implementation aspects of both national and regional system use cases in context of the platform. To meet SUC functional components and platform functionalities each service group is defined shortly in the first step.

- **Authentication and authorization** include authentication, verification and specification of data exchange and cross-platform operation. Besides, the services in this category define the data access policies for all the platform participants.
- **Measurements and monitoring** service category is dedicated to handle measured data transformation, supervision and sharing tasks.
- **Forecast** services handle all kind of forecast data related actions (upload, read, update etc.). There is a variety of multiple information categories: weather, load, generation, capacity limit, maintenance period and DLR simulation forecasts. Such data is responsible for the estimation of future market operation boundaries.
- **Reports and invoices** category has an information role to announce and communicate various market operation outcomes. It includes the settlement process and market results and invoicing data.
- **Market participation** includes all interactions of the market and participants. This means the communication of the bids (e.g.: acceptance or rejection), offers, market congestions or even the clearing results.
- **Grid models** services focus on the network topology related issues. This category consists of network reconfiguration and planned topology changing processes, but these are dominantly static attributes.

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- **Simulation results** services are responsible for grid simulation result (i.e.: load flow, state estimation) communication between the various actors.
- **Resource (pre)qualification** group covers the processes needed to implement the market participant/resource selection. This includes the attributes of market participants and service providers i.e.: technical parameters, local requirements.
- **System service activation** service group is responsible for the activation of a requested service and provides the related monitoring and performance metrics.
- **Resource control** services activate assets and defines the setpoints of operation. Besides, activation signals can be dedicated for a group of assets or dedicated to achieving specific objectives (e.g.: islanding operation, balancing etc.).

Each of the elements listed will be applied national level of Eastern Cluster demonstrations. However, some of the services implement quite similar actions while others perform substantially different tasks due to the different concepts.

6.2.5 Overview of the required functions in IMP

Summarizing the connection of demonstration functions and modules vis-á-vis the cross-platform services the necessary components in the functional layer of IMP can be derived. As the following Table 6-3 outlines, all cross-platform services are necessary in IMP, at least one demonstrator states each function (marked with X) part of their SUCs.

Table 6-3 Connection of OneNet cross-platform services and demonstrators' SUC functions and modules – asterisk marks an indirect relevance of the service – thus outside of IMP scope.

OneNet cross-platform services	**CZ demo**	**HU demo**	**PL**	**SI**	**INTERRFACE-IEGSA**
Authentication & Authorization	Administration module	Demonstration market tool	Pre-qualification	Market Platform	X, User management
Measurements & Monitoring	**Long-term grid assessment*	SO simulation tool + Flexi register	**Forecast +* Flexibility register	*DSO cong. demand*	-
Forecasts	**Market module*	SO simulation tool	**Market platform + *Forecast*	DSO cong. demand + Activation	-
Reports & invoices	Report, logs	SO Simulation tool (reports)	Settlement	Settlement	Settlement Unit, Logging & reporting
(Flexibility) Market participation	Market module	SO Simulation tool (bid generator)	Market platform	Market Platform	*Single Market Interface
Grid models	**Long-term grid assessment*	Demonstration market tool	**Forecast*	**DSO cong. demand*	**Flexi register*

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Simulation results	Long-term grid assessment + Market module	SO Simulation tool	Forecast	DSO cong. demand	TSO-DSO coordination platform
Resource (pre-) qualification	Administration module	SO Simulation tool + Flexi register	Pre-qualification	Market Platform	Flexi register TSO-DSO coordination platform
System service activation	Flexi register & traffic control	**Demonstration market tool* + Flexi register	Activation	Activation	Flexi register
Resource control	Flexi register & traffic control	**Demonstration market tool*	Activation	Activation	-
Other functions					
Cross-platform Data Exchange	Report, logs	Demonstration platform tool	Market platform	Flexibility register	TSO-DSO coordination platform

The identified modules, components in national demonstrators are in fact combining various sub-functions, corresponding to one of the cross-platform service categories. For example, the cross-platform data exchange function, that is the core function of the Eastern Cluster regional BUC is connected to different modules, functions in the demonstrators.

Other hindering factors create difficulties in the integral definition of functions, as cross-platform services span multiple business scenarios along the complete market chain. Reporting function can be used throughout the process, despite settlement and invoicing are not part of all demonstrators. Nevertheless, some general functional connection can be identified:

- authentication, user management is part of the market module and/or the pre-qualification module;
- reporting, data publication, flexibility register and market result communication shall be grouped together, practically in the flexibility register to allow communication between sub-markets, to/from OneNet users via the regional BUC;
- activation and resource control shall be grouped, and connected to flexibility register, using traffic control mechanisms;
- measurement & monitoring is not only trivially connected to settlement, but rather creates the input for forecasts, grid models and simulation result communication.

The latter one reflects on a key issue – the SO demand definition and the standardization of the process leading to defined and quantified services demand.

The progress of demonstration implementation and the increased efficacy of using the common OneNet vocabulary will facilitate the further standardization of functional modules in the demonstrators, potentially across clusters.

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6.3 Adaptation of market layer to each demonstration

The Eastern Cluster Demonstrator aims to develop an interoperable network of flexibility platforms to support the utilisation of various flexibility services, service integration and interaction, as well as the related data exchange. Demo coordinators will perform pilot testing of flexibility services. The alignment of each national demonstrators is two-fold.

First, the general OneNet nomenclature and planning methodology is used to describe the details. Moreover, the defined business and functional layer of the Integral Market Platform aggregates the requirements of each market and creates a common set of business process and functional modules. This facilitates the WP objective of establishing a combined and digitalized TSO-DSO flexibility process for balancing and grid services, commonly procured, and activated to deliver services for TSOs and DSOs.

IMP framework presented covers a wider scope of the functionalities, that are not necessarily in the full scope implemented in each demo. Every national demo applies this concept according to their needs and national regulatory framework in their local development. As Figure 6-11 illustrates in comparison with Figure 6-5, that the described IMP process (Section 6.1.4), namely its business use case scenarios cover all demonstrators' key process steps in their respective markets. However, the flexibility of each scenario is necessary, as the scope and details of each use cases widely varies, albeit multiple core features (Section 6.1.2) are aligned within the Cluster.

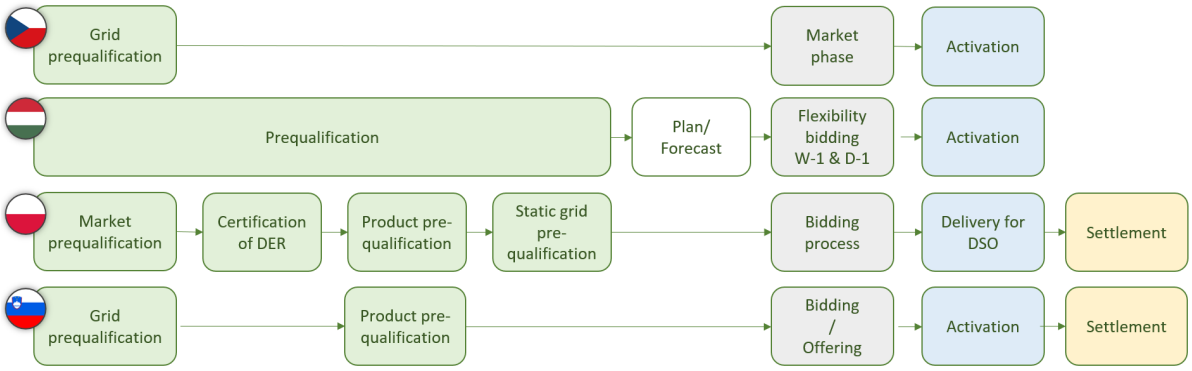

Figure 6-11 Business use case scenarios of the Eastern Cluster demonstrators.

On the functional layer, demonstrators have different setups in module definition. As Table 6-3 illustrates, all core market functions (as OneNet cross-platform services) are used in all Cluster markets, however with different naming, setups, grouping and combination, and in cases with mixed scoping of project demonstration vs. complete market process. For a complete overview, an established platform, IEGSA is cited and used in the comparison that has advanced the conceptual (and practical) design of key supplementary, yet electricity domain functions in the market layer: Flexibility Register, Market Interface, TSO-DSO Coordination and Settlement Unit.

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For the sake of harmonizing efforts, the Bridge Reference Architecture layer segmentation was used to differentiate the building elements to help identify interoperable parts of the Cluster IMP. The alignment of business layer is clear; however, the functional elements need further coordination as the demonstrators were early at the implementation at the time of writing this report.

The full interoperability, (e.g., to allow reuse functional components) requires the general OneNet use cases to be further developed. The general SUCs are overarching skeletons of the necessary SUCs for the marketplace realizations, but the related cross-platform services are fully applicable and needed to define connectors of the demo scenario building blocks. Further harmonization is necessary on the details of the general BUC that will directly connect to specific functions, system use cases that will help the alignment into a single OneNet platform. The presented market layer of IMP contributes to further develop the general OneNet use cases.

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7 Data governance layer

Before defining data governance, it is important to be aware of the differences between data management and data governance, as these are often confused. The best way to explain their relation is by looking at the Data Management Framework ("DAMA Wheel") shown in Figure 7-1 [15].

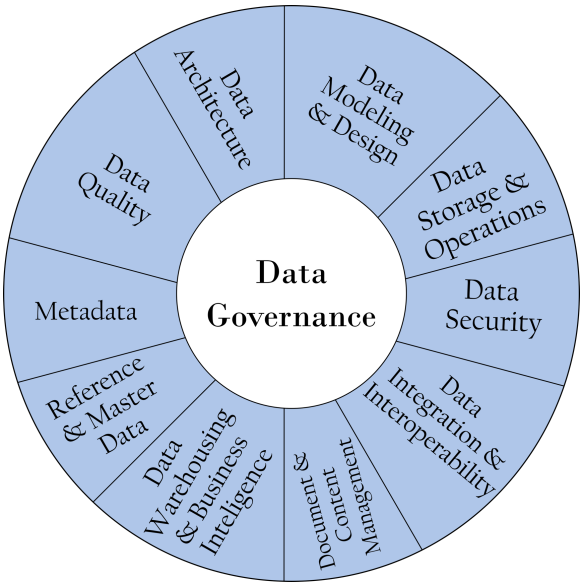

Figure 7-1 Data Management Framework ("DAMA Wheel") (adapted from [15]).

Data management presents a much broader picture, from data quality, security to integration and interoperability. Everything is connected and under the name of Data Management. In the center of the DAMA Wheel is Data Governance. Data Governance is a part of Data Management and is concerned with policies, processes, standards, roles, and responsibilities to ensure that data is managed as an asset [15].

7.1 Governance models for information management

In DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU [16], article 23 is discussing data management models for MS (Member States). According to this article, it is important to specify roles and assure transparent and authorized access to the final customers data. Which layers a data management model will consist of depends highly on the organization of each MS, but these are some fundamental components [16]:

- **Role models**: The stakeholders engaged in the data management model, as well as how they interact with one another, are described through role models. Examples are DSOs and suppliers, independent service providers and data exchange platform administrators.

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- **Communication standards**: A great technological challenge is the communication between stakeholders, originating both from the same and different MS. Therefore, communication standards, preferably international, have to be defined and used. Examples are EDIFACT or CIM, but communication standards can also be national-specific.
- **Policy choices**: Differences in data management models might be influenced by energy or economic policy choices made at the national or regional level.

The directive also states that, *independently of the data management model applied in each Member State, the parties responsible for data management shall provide access to the data of the final customer to any eligible party.*

The *REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on harmonised rules on fair access to and use of data (Data Act)* [17] is another important source of information regarding data governance. This act is complemented by many sub-acts. One of high relevance for this chapter is the Data Governance Act [18].

In this act, one role has a special importance – the data sharing service provider. It defines data sharing service providers neutrality as key element to bring trust and more control for data holder and data users in data sharing. It is of highest priority that the data sharing service providers act only as intermediaries in the transactions, and do not use the data exchanged for any other purpose. This will also require structural separation between the data sharing service and any other services provided, to avoid issues of conflict of interest.

7.2 Data access and privacy

Data privacy, accessibility, and shareability are extremely important today. From TSO to consumer, the awareness of data privacy and being able to control who can access it has risen.

When defining who, how, and when can access certain data, not only energy-relevant standards and rules should be consulted. General Data Protection Regulation (GDPR), regulation on electronic identification and trust services for electronic transactions (eIDAS) or Network and Information Security directive (NIS) are of high relevance on this matter [19].

The smartEN position paper [20] recommends defining clear rules and recommendations to ensure the protection of consumers privacy, while not holding back further development of business models and inovations. Improving access to data means that businesses and research institutes will drive representative scientific development and market innovation throughout the EU [18]. This is especially important in situations where coordinated EU action is needed, such as the COVID-19 crisis [18]. Some steps proposed by smartEN are [20]:

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- *Clear rules governing the possibility for aggregators to handle personal data should be set, accompanied by security and transparency measures specifying to consumers how their data is used and shared by aggregators.*
- *Clear rules on governing mixed data sets.*
- *Requirements on data pseudonymisation should be developed, while safeguarding data privacy as it allows to preserve statistical accuracy and data integrity needed for the development of demand-side flexibility services.*

To make sure data is accessed without discriminating certain parties, roles and procedures have to be determined. Apart from roles, data has to be stored properly and the technologies used to access it have to support a high level of security (validation, authentication, etc.).

Since 2018, the GDPR specifies criteria for the protection of natural persons in relation to the processing of personal data and the free movement of such data in all Member States [21]. It covers the following roles' tasks, rights, and obligations, as well as their interactions:

- Data subject,
- Controller,
- Processor,
- Recipient of data (whether a third party or not),
- Data protection officer,
- Supervisory authority.

The data subject has the right of access to his/her data and the ability to control the (third) parties with whom the data is shared under the GDPR's specific scope. Authentication and consent procedures should be used to specify access and control. The Controller decides the aims and methods of personal data processing. Collection, recording, organization, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination, or otherwise making available, alignment or combination, restriction, erasure, or destruction are all examples of how the processor processes personal data on behalf of the controller. A data protection officer advises both the controller and the processor and is in responsibility of monitoring compliance with the rule and cooperating with the supervisory authority.

The key requirements of GDPR are [19]:

- Lawful, fair and transparent processing of personal data;
- Consent mechanism to the processing of personal data;
- Transparent information and communication towards the data subject;
- Access of personal data by the data subject;

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- Data subject's right to object, rectification and erasure ('right to be forgotten');
- Data subject's right to portability of personal data from one controller to another;
- Data protection by design and by default;
- Processing of data outside the EU;
- Documentation of processing activities.

It is in the best interest of each of the roles to respect and fulfil the above listed requirements.

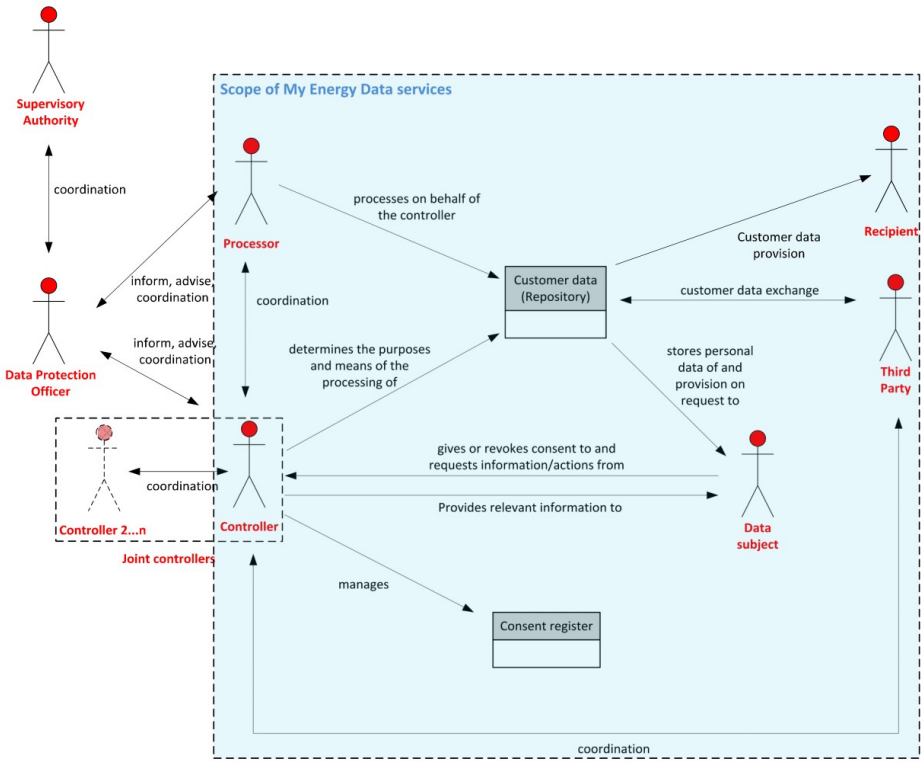

Figure 7-2 Interaction model of GDPR roles [19].

In accordance with the roles from GDPR (presented above), more flexibility market related roles can be defined. Taking the Harmonised Electricity Market Role Model [22] as a reference model and following GDPR concepts, the following roles can be defined [23]:

- Consumer - "A party connected to the grid".
- Metered Data Responsible - "A party responsible for the establishment and validation of metered data based on the collected data received from the Metered Data Collector. The party is responsible for the history of metered data for a Metering Point" (mostly DSO).
- Balance Supplier - "A party that markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the Party Connected to the Grid. In addition, the

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Balance Supplier markets any difference with the firm energy contract (of the Party Connected to the Grid) and the metered production."

- Energy Service Company (ESCO) - "A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The ESCO may provide insight services as well as energy management services."
- Data provider - "A party that has a mandate to provide information to other parties in the energy market."
- Meter Administrator - "A party responsible for keeping a database of meters."

The above listed roles are all based on the Harmonised Electricity Market Role Model. To cover all aspects of data access some additional roles are recommended. EG1 Working Group has proposed four more roles within their final report "Towards Interoperability within the EU for Electricity and Gas Data Access & Exchange" [23]:

- Consent Registry Responsible - "A party that collects, operates and deletes customer consents",
- Identity Service Provider – "A party which offers an authentication service to identify the customer",
- Access Rights Manager – "A party which offers an authorization service to grant a customer the rights to access data functionalities related to a given metering point",
- Metered Data Dispatcher – "A party which sends metered data to the authorized third party and to the consumer".

7.3 Ensuring data quality

Data quality represent the concept that describes data which is appropriate for use by data consumers. Quality data are intrinsically good, contextually appropriate for its use, clearly represented and accessible. Most frequently used data quality dimensions are:

- **Accuracy**: it refers to which level data corresponds to their real values. This is achieved through the validation process.
- **Timeless**: defines to what degree data are up to date. Three occurrences of data change are important: when data changes in the real world, when change is recorded in the information system and when data is used.
- **Completeness**: determines the level to which data are full in complete in the content. This dimension refers to the data missing and information for the users that data is not complete.
- **Consistency**: defines that data representation remains the same in all cases. In other words, all data are stored using the same data model and structure.
- **User friendliness**: refers to the complexity of the user access to data.

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In general, data quality is improved when data exchange platforms are used [24]. In decentralized systems, quality of data varies widely between different companies and entities. While some companies provide high quality data, others provide data with a poor quality. Usage of data exchange platforms (DEPs) significantly improves quality and availability of data. When strict standards are applied, companies are forced to provide structured data with predefined standardized formats and using standardized interfaces.

7.4 Data governance concepts used in national demos of the East cluster

7.4.1 Czech demo

Communication in the Czech demo is realized through the central IT platform. This platform contains several functionalities ensuring safety and reliable data exchange between all stakeholders. Overview of modules and functionalities is presented in Figure 7-3.

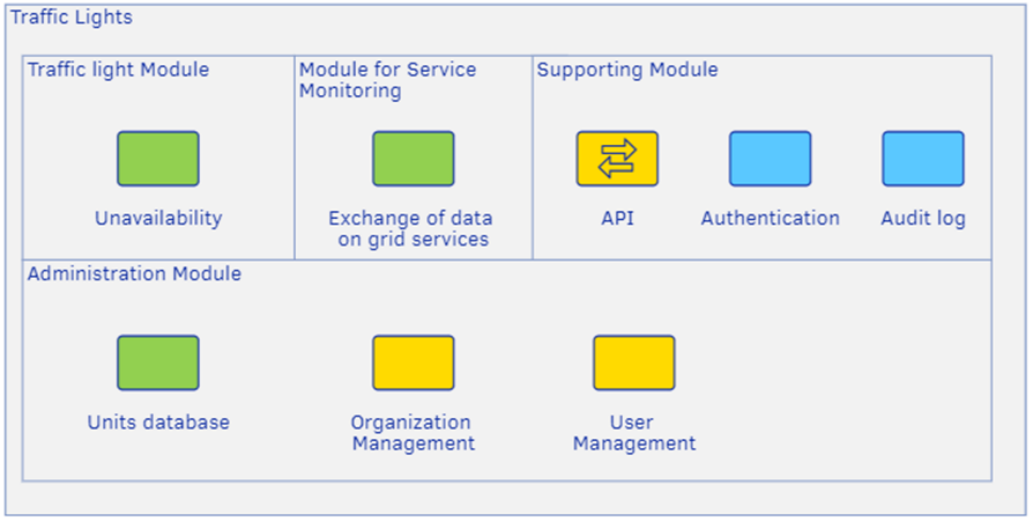

Figure 7-3 Functional block of IT platform in Czech demo.

Generally, there are two main categories of data providers in the CZ demo:

- DSOs providing data to the system concerning grid unavailability,
- Data from supplier/aggregators on contracted/activated flexibility which are reported both to the TSO (for billing purposes) and for DSOs enabling operation preparation for following days (Figure 7-4).

Data is exchanged through the IT system provided by Unicorn. Each project partner has implemented a dedicated interface allowing exchange of XML messages thorough ECP channel (using CIM standard) in the Czech Republic. Data access through the IT environment is restricted according to the role given to a subject on the

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platform. DSOs and TSO have no limits in terms of data accessibility, however suppliers/aggregators can access only data relevant to their assets/organizations.

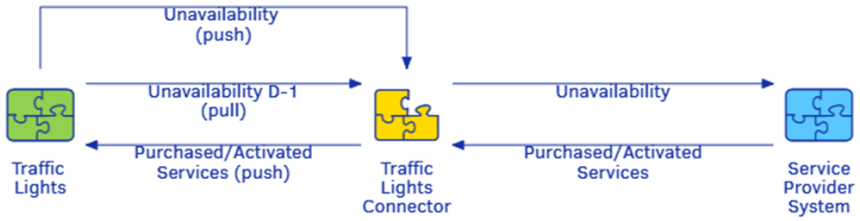

Figure 7-4 Data exchange in Czech demo.

7.4.1.1 Authentication/registration

The registration of a new supplier/aggregators to the platform is a two-step process. DSOs are involved in the first step of the process concerning verification – the new entity must have a relevant contract with the DSO for provision of flexibility. After the step was completed successfully, the platform administrator (Unicorn) will enable access to the IT platform for the new provider. The same procedure is followed concerning change of data, or deletion of any provider/units from the system.

+4U enviroment is used for end users accessing the web application. +4U environment is based on OIDC - the third generation of OpenID technology. It is an authentication layer on top of the OAuth 2.0 authorization framework. It allows computing clients to verify the identity of an end user based on the authentication performed by an authorization server, as well as to obtain the basic profile information about the end user in an interoperable and REST-like manner. In technical terms, OpenID Connect specifies a RESTful HTTP API, using JSON as the data format. OpenID Connect allows a range of parties, including web-based, mobile and JavaScript clients, to request and receive information about authenticated sessions and end users. The OpenID Connect specification is extensible, supporting optional features such as encryption of identity data, discovery of OpenID providers, and session management.

7.4.1.2 Data storage/hosting

The platform is organized as *Solution-as-a-Service* and is hosted in the Unicorn Plus4U uuCloud, which ensures secure, performant, flexible and reliable operation. Plus4U uuCloud is deployed in Microsoft Azure at Azure West Europe Region (Netherlands).

The uuCloud is a cloud management platform dedicated to deploying, running, monitoring applications, which adhere to modern microservice-based architecture, especially designed to act as runtime environment

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for applications. It is an add-on (*Platform-as-a-Service*) created for use above private or public clouds (*Infrastructure-as-a-Service*).

The uuCloud provides a set of essential services to applications:

- **Authentication**: OpenID-compatible OIDC service, providing highly secured authentication capabilities to any deployed application. Extended by Identity management (registration, account management, credentials maintenance, etc.) and default identity provider.
- **Persistence**: Majority of applications require persistent storage for their data. uuCloud provides storage for all main data types: structured data (MongoDB), binary data (MongoDB), relational data (MySQL/MariaDB) and fulltext-searchable data (ElasticSearch).
- **Messaging**: enabling the asynchronous communication between applications and application components (e.g., triggering asynchronous or scheduled jobs). Based on well-known RabbitMQ message broker.
- **Deployment**: automated deployment process that is easy to integrate into the application delivery pipeline. In fact, it is an integral part of the Unicorn production line. The uuCloud deployment process includes such advanced features as blue-green deployment, auto-healing, dynamic scalability, source-to-image building, application multi-tenancy etc. Technically based on Docker containerization.

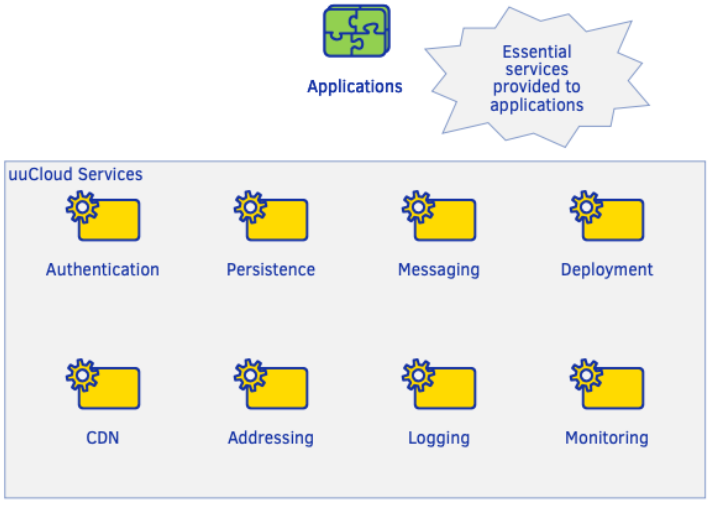

Figure 7-5 uuCloud Services.

7.4.2 Hungarian demo

The proposed architecture has three layers. The presentation layer consists of the UI, i.e. the front-end part of the system. Business logic layer contains the structure and operation of the algorithm that contributes to the

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support of business capabilities related to the system itself. Last but not least, data access layer contains all the databases and data storage solutions within the system (ETL and other data extraction processes all affect this layer).

The information flows presented on the landscape are the following:

- The type of service unit identifier is transferred from the FSP in an XML format for pre-qualification {1}.
- After pre-qualification, the status is forwarded back towards the FSP {2}.
- In case of a successful pre-qualification, the results are sent to the flexibility register {3}.
- The main part of the business logic layer is the order book that consumes data from both the flexibility register and the DSO demand estimation, from where flexibility service need data is transferred {4}.
- Via flexibility register, pre-qualifies FSPs bid to the market, the bids are qualified against registered data and checked and firm bids are forwarded to the order book {5}.
- The order book processes all the input data via an algorithm, then forwards the clearing results towards the user interfaces and the capacity register {6}.

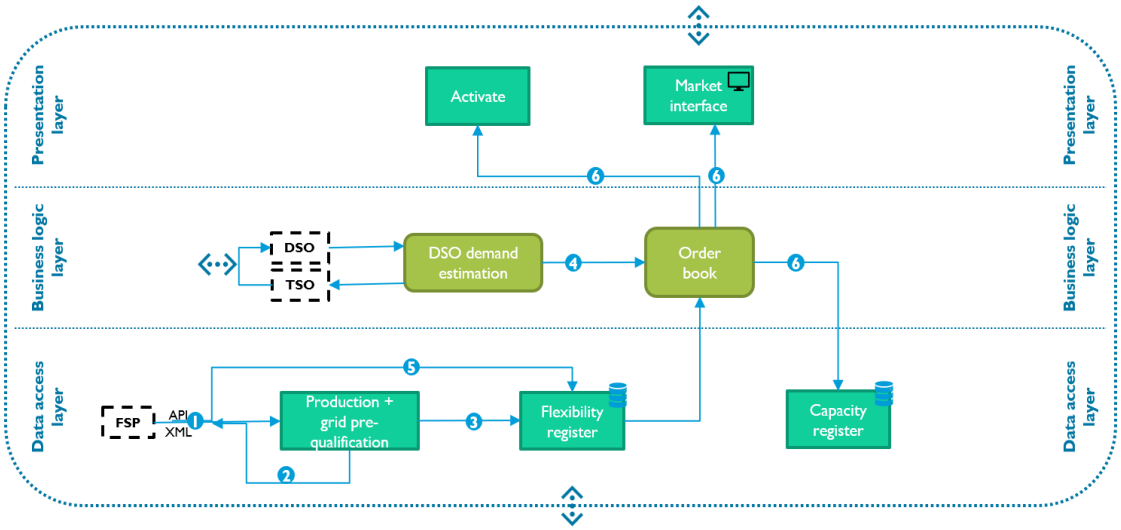

Figure 7-6 Figure Hungarian demo architecture.

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Table 7-1 Demo overview.

Demo Name	Comments
IT solution envisioned:	In high level 3 layers should be differentiated: the head-end master platform (platform of platforms), which gives the governance and master data model to all local and regional platforms. Next one is the local platform solution, in our demo this is a Hungarian flexibility platform, which covers the TSO, DSOs, aggregators, large consumers/producers, traders and other stakeholders, and nevertheless small energy 'communities', which can be a regional P2P market, balancing group, etc. The third layer is the end user from platform point of view. The data flow between 2 layers is bilateral, mainly via middleware solution, and there are input data sources, which planned only one direction communication (e.g. weather forecast, etc.)
Actors of the system:	TSO: responsible for system stability via flexibility use DSO: zonal responsibility for optimal power flow B2B consumers: giving bids and contracting trades Traders: giving bids and contracting trades Producers: giving bids and contracting trades End users: giving bids and contracting trades Aggregators: giving bids and contracting trades Regulator: supervisory role (passive connection to the platform) Other: other known and unknown entities Flexibility providers: giving bids and contracting trades
Information sharing details:	Three main info groups can be differentiated: - technical (load, voltage, time, etc.) - financial (prices, probability (uncovered options), etc.) - other (weather data, traffic information, etc.)

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Need to link to tools/ external systems and-or platforms/ data hubs:	- TSO, DSO asset data hubs - Exchange information - Trading platforms - Head-end master platform - Local market platforms - Input data hubs (weather) - Middleware technology
What protocols you consider relevant for interoperability:	- Web services - Internet protocols - File transfer - Industrial protocol stack

The whole operation is planned on local solution and hosting, but at least at two points it will cooperate with the central IT platform, as it can be seen on the architectural map. The local platform contains several functionalities ensuring safety and reliable data exchange between all stakeholders.

Data will arrive generally from two sources: one is DSO source (two different Hungarian DSOs) and public databases. All data will be hosted on a cloud based safe environment with ate least a 2-layer setup.

Data are exchanged through an IT system provided by MEI technology provider partner in Eastern Cluster. Each project partner has implemented dedicated interfaces allowing the exchange of XML messages thorough the sFTP channel (secure file transfer) or manually. Data access in the IT environment is restricted according to the role given to a relevant subject on the platform. DSOs and TSO have no limits in terms of data accessibility however suppliers/aggregators can access only data relevant to their assets/organizations. TSO role in this demo is more as an observer, rather than an actor.

7.4.2.1 Authentication/registration

There is a two steps process for the registration of new suppliers/aggregators to the platform. DSOs are involved in the first phase of the process concerning verification – the new entity must have a real geographical connection within the demo zone and relevant and realistic value for bidding flexibility. After this first phase of check is completed, they will be registered as an authenticated market participant in the flexibility register – we can call them FSP: flexibility service provider.

The market interface is based on a rest API JSON data format, making processes as simple as possible to avoid unnecessary developments. Important is to keep the functionality and provide safe operation of the demo.

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7.4.2.2 Data storage/hosting

The platform is provided as an Infrastructure-as-a-Service and is hosted in MS Azure cloud, same as in the Czech demo, which ensures secure, performant, flexible and reliable operation of the solution. The MS Azure uuCloud provides a set of essential services to applications, listed in subsection 7.4.1.2.

7.4.3 Polish demo

Data exchange between parties involved in the Polish demonstration is managed by a centralized IT market platform “atFlex”. The platform consists of several microservices as depicted in the graph below:

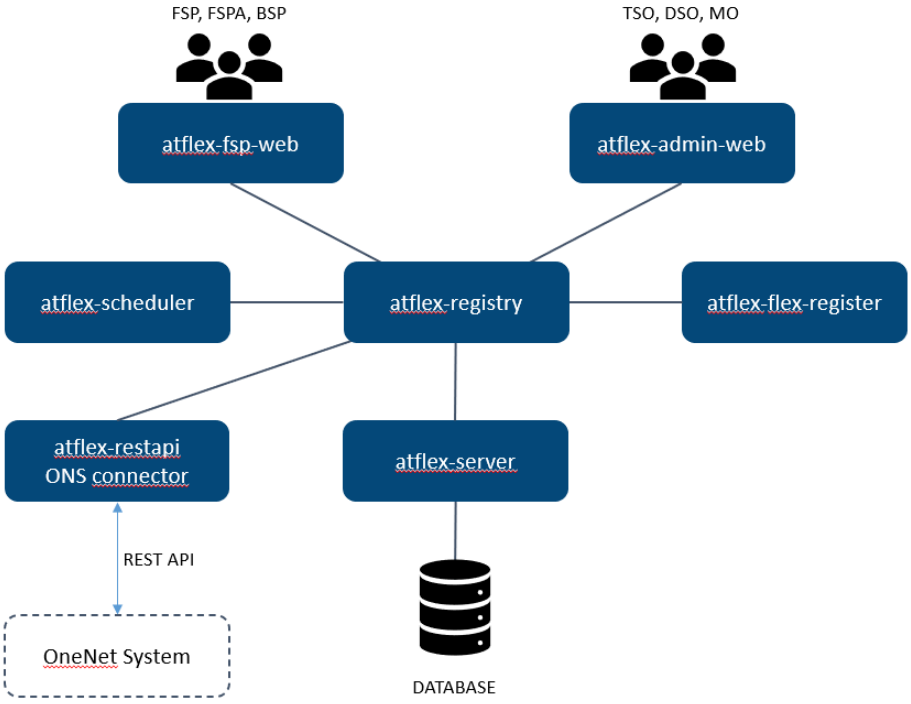

Figure 7-7 Market platform in polish demo.

Data is exchanged through following services:

- atflex-fsp-web and atflex-admin-web – between users and the platform,
- atflex-restapi – between the platform and the OneNet System,
- atflex-served – between the platform and the database.

Generally, data is governed within the project following rules of:

- Minimum access – users have access only to a minimum set of data and only to data which is needed within their roles.

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- Permission based – each user has a specific role which corresponds to set of permissions governing what actions user can perform and what scope of data user has access to.
- Secure and encrypted communication – for all external connections only SSL connections are used.
- Persistence – all data is stored in a database or in files on a server and is not deleted.
- Logging – all actions are logged (both successful and unsuccessful).

7.4.4 Slovenian demo

Within the Slovenian demo communication is realized through the single-point services (SEDMp) platform. More detailed description of SEDMp is given in Chapter 4.1.4. Until flexibility market is organised, each DSO will have an internal tendering system and settlement system for flexibility, alternatively this functionality will be on SEDMp. DSO will exchange MQ messages with kafka MQ server on SEDMp, while the end consumers will have web access to the portal *mojelektro.si*. Aggregators and DSOs will use MQ messages to exchange information with SEDMp as shown in Figure 7-8.

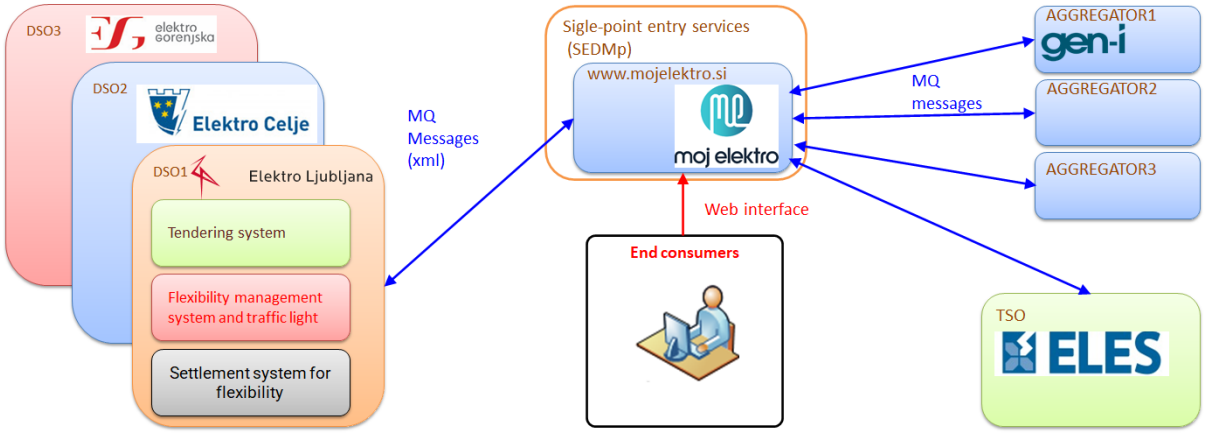

Figure 7-8 Information exchange between actors in SI demo.

At first end customers have to register on the *mojelektro.si* web portal and insert their amount of power on their metering points. Registration involves secure access (with certificate or SMS authentication), so every consumer can register the flexibility only on their own metering points. There are plausibility checks applied, such as relation to contracted power for example. Because contracted power is in the SEDMp, the consumer cannot insert flexibility power higher than its contracted power. Also, with the registration consumers have to agree with the terms and conditions for providing services. If FSP doesn't perform in accordance with the contract he will pay a penalty.

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Consumers could register their flexibility even if the DSO does not issue a tender for flexibility in the network where the consumer is powered. Based on the analysis of network congestion and voltage problems, the DSO is issuing tender for areas with network problems. The tender is published on the DSO's web page, alongside technical and commercial conditions. Based on analysis of historical measurements, DSOs have to define what kind of 'flexible product' is needed (season- winter or summer or monthly, daily schedule of possible activations, duration and maximum number of activations, response time of activation, total amount of flexible power, etc.). End consumers which registered flexibility and are powered in a problematic network receive messages about new tenders so they can add a bid for their flexibility, or they can authorize an aggregator to place a bid. In that case the aggregator places a bid for consumers which are all in the same problematic network and they have an agreement (contract) with the particular aggregator. By entering the bid (price for energy), the aggregator confirms that it has an agreement/contract with the customer to provide flexibility and thus the aggregators take responsibility for non-response in case of activation. The tendering system than selects most favourable bidders and sends contracts. When contracts are signed by FSP, they are inserted into the Flexibility management system. The flexibility management system is making dynamic congestion monitoring of distribution transformers based on near real-time ambient temperature measurements, voltage measurements and measurements of active and reactive power of LM/LV transformers. For instance, when current measurements of the power of the transformer exceeds the thermal limit, then the Flexibility management system activates FSP (end consumers or an aggregator) to lower consumption. Activation of end consumer is done via SMS, e-mail, or phone call. In case of an aggregator, a MQ message is sent to the aggregator. A response aggregator returns an acknowledgment MQ message. This message is pushed over SEDM-p regardless of DSO, since MQ messages define who is the sender and receiver of the message and other data for activation (start and end time of activation, requested power and direction of the product).

After the activation, the settlement system calculates the baseline and activated energy. The way settlement information is displayed depends on the type of FSP. If the FSP is an end consumer the settlement information is sent to SEDM-p, where data is being displayed, so the end-consumer can check its performance. If the FSP is an aggregator, the settlement system sends a MQ message with activation settlement information.

Also, messages for Traffic Light System (TLS) will be exchanged over SEDMp. Each DSO will have its own TLS, which will inform all aggregators and TSO about restrictions on the network. In case of overload, DSO's TLS will send a MQ message with all measurement places that are located in the overloaded network. Restrictions in case of overload will be increase = false and decrease = true, meaning, that the aggregator could still use flexibilities which can decrease their power.

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8 Data interoperability layer

The diversity of data and participants in communication on the flexibility market is a serious burden on data interoperability. Different entities use different approaches to data processing and storage, thus not being compatible. Market places should be interoperable to promote open competition. smartEn supports broad usage of CIM IEC 62325-based API enabling data operability among marketplaces across Europe [20].

This inability of two systems to communicate on their own is a large burden on budgets of companies as well. Building and maintaining a “translator” (usually middleware layer) between them takes time and success is not even guaranteed. Therefore, data interoperability is a key factor for a functionating system. The aim of this chapter is to define how a (semantic) data interoperability layer will enable operation and communication between different systems and users on the flexibility market.

This chapter describes data interoperability between market platforms and provides insight in to CIM profiles that could be used for semantic modelling at the integrated market platform.

8.1 Semantic data interoperability

Combining multiple heterogeneous data sources asks for interoperability at all levels, the ability to utilize and harmonize data from various sources will be a crucial factor for a successfully operating system [25]. Interoperability is not a simple matter and is therefore analyzed at different levels. IEEE defines interoperability as *"the ability of two or more systems or components to exchange information and to use the information that has been exchanged"*, at the system level, at the data level it is defined as *"the ability of two or more datasets to be linked, combined, and processed"* [25]. *The GWAC (GridWise Architecture Council) proposes an eight-layer interoperability structure, comparable to the ISO/OSI model* [26], presented in Figure 8-1.

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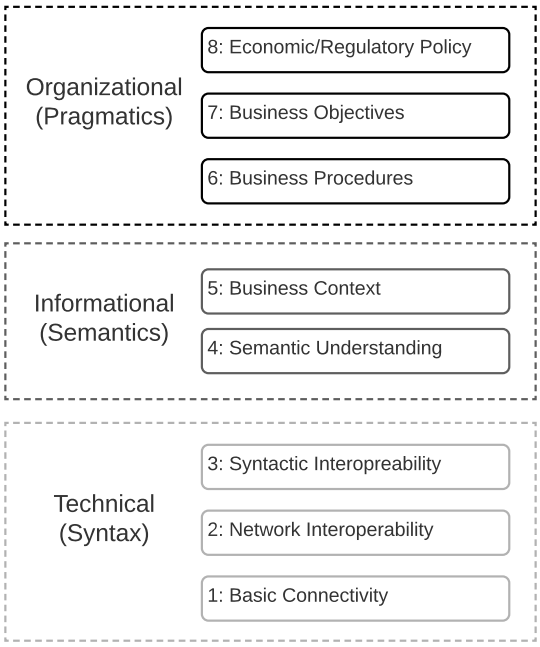

Figure 8-1 GWAC layers of interoperability also known as GWAC stack.

The capacity for systems to exchange information with shared meaning using universal standards is known as semantic interoperability [27].

The desired universal language to model data already exists and is called the Common Information Model (CIM). The Common Information Model (CIM) provides a powerful data model and diverse interface specifications and technology mappings [28], assuring the exchange of electrical network information between different software applications. IEC is developing CIM in the work scope of technical committee *TC57*. Three work groups are focused on CIM - WG 13, 14 and 16 [29]:

- **WG 13** develops and maintains CIM as an independent UML-data model, where energy system entities are modeled as classes with appropriate relationships between them, regardless of the data format. In this way, a generic model of the energy network is created, and the only necessary translator is from and to the CIM based data, which significantly increases the level of interoperability.
- **WG 14** develops and maintains extensions for the base CIM. Data extensions allow the CIM model to go beyond its initial framework and move into the world of distribution networks and modelling of data exchange between systems. This part of CIM is published within the IEC 61968-11 standard and is also used to create an interface that will further serve system integration.
- **WG 16** is focused on CME (CIM for Markets Extensions), it was created to expand the use of CIM in the area of deregulated energy markets. It is important to note that these models do not model the market,

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but the data exchanged by market participants. There are two subgroups of this working group, one creating models in a style characteristic of the European market and one for the US market.

CIM is one important step towards full interoperability, one of the means to achieve this goal is standardization. It helps reduce the cost and complexity of the network and allows for the joint development and advancement of smart grids. CIM is standardized within three different IEC standards - IEC 61970, IEC 61968, and IEC 62325:

- **IEC standard 61970** - one of the goals of this standard is to develop a platform-independent data model that uses technology-independent services and continuously improve them [29]. This standard is maintained and developed by IEC TC 57 WG 13. It contains an extensive data model defined in IEC 61970-301. IEC 61970-301 is a semantic model that describes the components of an electrical system at the electrical level and the connections between all components. In addition to this extensive model, it also contains CIS and GID.
- **IEC standard 61968** extends the IEC standard 61970 and its focus is not primarily on CIM objects, but on secondary objects such as billing and network extensions. The IEC 69170-301 data model has been extended with model 61968-11. This standard is maintained and developed by IEC TC 57 WG 14.
- **IEC standard 62325** extends the previous two and focuses on communication in the electricity market, that is the exchange of data between different participants in the electricity markets. There are two different styles of markets - European style and US style. This standard is maintained and developed by IEC TC 57 WG 16.

The European style market profile (ESMP) is developed in IEC 62325-351. Its objectives are specific core business processes within Europe's internal electricity market, for example, scheduling, settlement, capacity allocation and nomination, acknowledgment, etc. [30].

Standard IEC 61968-100 defines message format (CIM XML document) for the three patterns of message exchange: request/response mechanism, unsolicited event message and consequential event message [31]. For the purpose of demos in the Cluster East, we will consider only message envelope for sending a request for data from the system and response to the request with the payload which is CIM XML document.

8.2 European style market profile (ESMP)

The two basic standards of the IEC 62325 series are [32]:

- **IEC 62325-301** "CIM extensions for markets" standard - provides an abstract model that defines objects required for the operation of electricity markets.

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- **IEC 62325-450** "Profile and context modelling rules," - an International Standard defining necessary rules and guidelines for creating profiles.

The IEC 62325-351 "CIM European market model exchange profile" or shorter called ESMP is an internationally accepted standard maintained and further developed based on the two above listed standards. ESMP provides core components for use in the IEC 62325-451- 'X' standards. This group of standards cover certain business processes within IEM (Europe's internal electricity market), such as scheduling, settlement, capacity allocation and nomination, acknowledgement, etc. [33].

The ESMP package structure is shown in figure Figure 8-2. ESMP is based on different parts of the CIM IEC standard (IEC 61970, IEC 62325, and IEC 61968) and specifies business processes and the content of the messages exchanged [34]. While relying on CIM, ESMP defines new classes, datatypes, and enumerations as well. ESMP is an extension to the canonical CIM, providing all necessary elements for representing a variety of processes within the European market. Figure 8-2 shows as well the IEC 62325-451- 'X' group of standards being based on ESMP, as it was mentioned earlier.

The European style market is use case oriented and is based on business processes along with their document exchanges [34].

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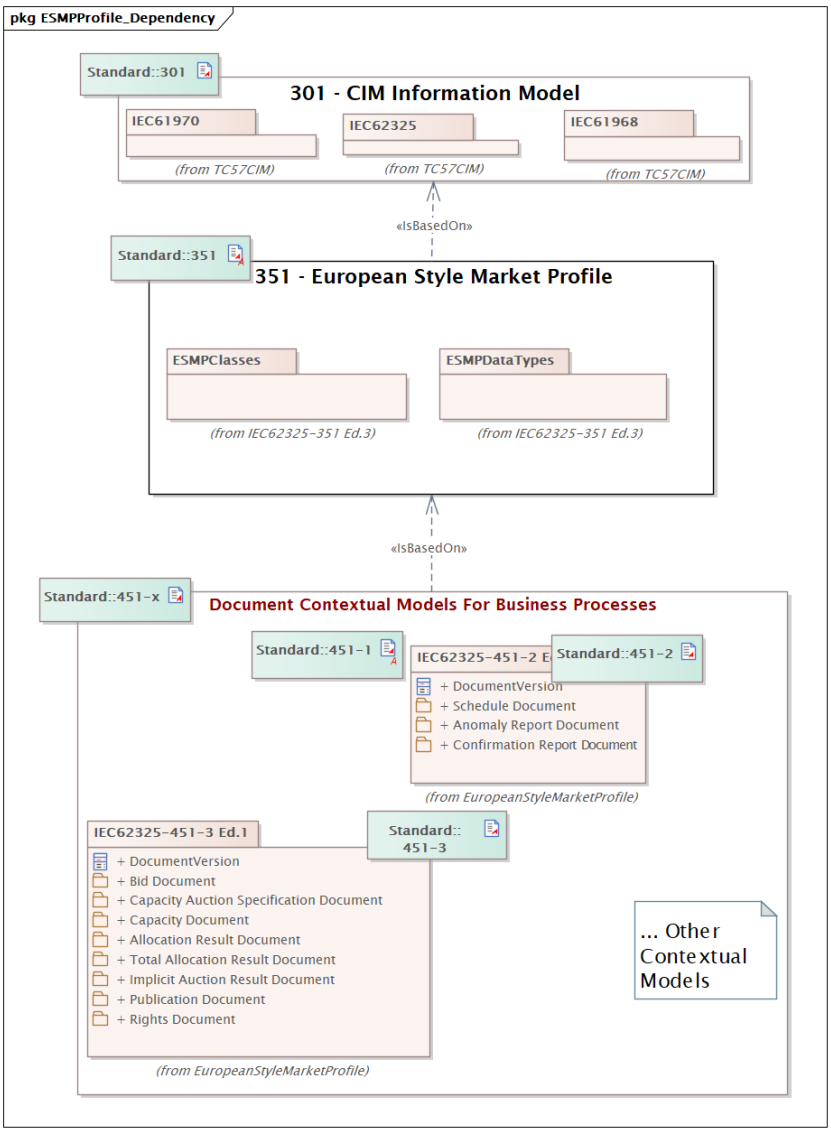

Figure 8-2 Overview of European style market profile dependency.

8.3 Examples of Business Objects used by East Cluster demonstrators: standard analysis

The following table contains BOs extracted from the SUC that will be demonstrated in the Cluster East pilots and the CIM standard analysis. With the descriptions of BOs, last column describes which CIM profile should be used for BO modeling.

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Table 8-1 Business Object List developed in the context of T10.3.

Business objects	Description of BO	Data format/Standard analysis
Completion of registration data	Units are requested to provide: capacity (MWh/MVAr), location and identification code	This is the registration of the unit (as a part of prequalification). Currently, the prequalification model is not available in ESMP.
Registration	Unit is successfully validated and registered	IEC 62325-451-1. Acknowledgment document.
Flexibility bid	The platform process bid from FSP – time availability, location, flexibility service availability (MWh/MVAr) and capacity	The bid on flexibility market auction. IEC 62325-451-3. Bid_MarketDocument or ReserveBid_MarketDocument.
Flexibility demand	The platform process demand from DSOs – time availability, location, flexibility service availability (MWh/MVAr) and capacity	When flexibility needs are known, it can be published with Publication_MarketDocument (IEC 62325-451-3).
Check of grid availability	Any FSP involved in flexibility provision receives information on grid availability concerning planned outages/outages including location (nodal area) and duration.	This is related to the "Traffic Light System". New CIM profile for TLS is proposed in OneNet deliverable D5.6. However, this profile should be extended with information about outages (IEC 61968-3).
Processing of data from CZ demo to OneNet environment	Data on flexibility services/grid unviability (as specified above) can be exchanged with external subjects through OneNet environment.	This BO is general. Data model can adjust to a specific use case.
Processing data on grid unavailability	The traffic light scheme indicates duration of grid unavailability (through outages/grid outages) in hours, as well as area (nodal area) in which the grid issues happen.	IEC 61968-3. CIM profile for operations and outage management system.
Processing of data on contracted services	DSOs are provided data on contracted flexibility services (in MWh) for dedicated nodal areas.	IEC 62325-451-3. AllocationResult_MarketDocument.
Energy auction data	Product, Auction type, Gate opening time – energy, Gate closure time – energy, Max desired energy, Min desired energy, Availability – energy, Grid Impact Assessment variant, First auction date, Last auction date	IEC 62325-451-3. CapacityAuctionSpecification_MarketDocument

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Capacity and energy auction data	Product, Auction type, Gate opening time – power, Gate closure time – power, Gate opening time – energy, Gate closure time – energy, Max desired power, Min desired power, Max desired energy, Min desired energy, Availability – power, Availability – energy, Grid Impact Assessment variant, First auction date, Last auction date	IEC 62325-451-3. CapacityAuctionSpecification_MarketDocument
Daily energy auction	ID, Auction status, Auction name, Product, Gate opening time, Gate closure time, Max desired energy, Min desired energy, Availability	IEC 62325-451-3. CapacityAuctionSpecification_MarketDocument
DA energy bid	Potential, DER, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-3. Bid_MarketDocument or ReserveBid_MarketDocument.
DA energy set of bids	Set of objects with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-3. Bid_MarketDocument or ReserveBid_MarketDocument.
Daily capacity auction (capacity phase)	ID, Auction status, Auction name, Product, Gate opening time, Gate closure time, Max desired capacity, Min desired capacity, Availability	IEC 62325-451-3. CapacityAuctionSpecification_MarketDocument
DA capacity bid (capacity phase)	Potential, DER, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-3. ReserveBid_MarketDocument.
DA capacity set of bids (capacity phase)	Set of objects with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-3. ReserveBid_MarketDocument.
Daily energy auction (energy phase)	ID, Auction status, Auction name, Product, Gate opening time, Gate closure time, Max desired energy, Min desired energy, Availability	IEC 62325-451-3. CapacityAuctionSpecification_MarketDocument
DA energy bid (energy phase)	Potential, DER, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-3. Bid_MarketDocument or ReserveBid_MarketDocument.

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DA set of bids	Set of objects with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-3. Bid_MarketDocument or ReserveBid_MarketDocument.
Set of post-AGNO bids	Bids that passed AGNO with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period, Accepted volume, Accepted delivery period	IEC 62325-451-3. Bid_MarketDocument or ReserveBid_MarketDocument.
Outcome of evaluating bids	Bids sent from BM verification with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period, Accepted volume, Accepted delivery period	IEC 62325-451-7: Reserve allocation results document.
Winning bids	Winning bids from BM verification with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period, Accepted volume, Accepted delivery period If from SO: Bid date, RP/RPA, Potential, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	
Loosing bids	Losing bids from BM verification with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period, Accepted volume, Accepted delivery period If from SO: Bid date, RP/RPA, Potential, Price, Volume, Status, Volume divisibility,	

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	Delivery period divisibility, Delivery period	
Activation plan	Plan which specifies working plan for specified DER	IEC 62325-451-7: Planed Resource Schedule document.
Outcome of activation plan	Results of fulfilling activation plan	IEC 62325-451-7: Historical Activation document.
Confirmed plan	Confirmation of fulfilment of activation plan	Acknowledge document can be used. Reason attribute do define the status of the confirmation.
Negated plan	Negation of fulfilment of activation plan	
Settlement information	Information about settlements between SP's and SO's	IEC 62325-451-4: Settlement document.
CM/VC auction form	Product, Localization, Delivery date, Delivery date time from, Delivery date time to, Gate opening time, Gate closure time, Max desired power, Min desired power	IEC 62325-451-3: Auction Specification document.
CM/VC bid	Potential, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	This is treated as a flexibility bid (only different products).
Flexibility market data	Disaggregated data about objects, participants and results of auctions, which is transferred between FP and DH.	IEC 62325-451-7: Reserve allocation results document.
Aggregated data	Aggregated data send from FP to DEP	Adaptation of IEC 62325-451-7: Reserve allocation results document.
Outcome of registration process	Information about outcome of RP's or SP's registration	Part of the prequalification process Bos and will be modeled within T5.6.
Registration accepted	Information about acceptance of RP's registration	
DER form	Name, Code, Source power/receiving power, Connection power, Direction of deviation, Type, PoC, Operational period, Active, Localization	
DER object	DER ID, Name, Code, Direction of deviation, Source power/Receiving power, Connection power, Type, Is SDER, Aggregated, RP, Creation date, Last modified, Valid from, Valid to, PoC,	

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	Coupling point ID, mRID, Active, Certified, Version	
Outcome of certification	Information about certification of DER or SU	
Certified DER object	DER ID, Name, Code, Direction of deviation, Source power/Receiving power, Connection power, Type, Is SDER, Aggregated, RP, Creation date, Last modified, Valid from, Valid to, PoC, Coupling point ID, mRID, Active, Certified, Version	
Flexibility potential form	Product, RP DER, Volume, Divisibility, Operational period, Full activation time, Minimum duration of delivery, Documentation if needed	Part of the prequalification process Bos and will be modeled within T5.6.
Flexibility potential object	DER ID, Name, Code, Direction of deviation, Source power/Receiving power, Connection power, Type, Is SDER, Aggregated, RP, Creation date, Last modified, Valid from, Valid to, PoC, Coupling point ID, mRID, Active, Certified, Version	
Outcome of prequalification	Information about prequalification of Flexibility potential	
Prequalification rejected	Information about rejection of Flexibility potential	
Prequalification accepted	Information about acceptance of Flexibility potential	
Flex register object	ID, Product, RP, RP DER, Volume, Volume unit, Divisible, Full activation time, Minimum duration of delivery, Creation date, Last modified, Added by, Modified by, Valid from, Valid to, Aggregated, Active, Product Prequalification, Static Grid Prequalification, Version, Scheduling Unit ID, Name, SP, Type, DERs	Information for the Flexibility register and probably part of the modeling of Bos in the prequalification process.
Subportfolio form	Name, DERs, Operational period, Active	Requires new CIM profile.
Subportfolio object	Subportfolio ID, Name, Number of DERs, Combined power of DERs, TSO-DSO Coupling point ID, mRID, RPA, Creation date, Last Modified, Valid from, Valid to, Active, Certified, Version	

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Certified subportfolio object	Subportfolio ID, Name, Number of DERs, Combined power of DERs, TSO-DSO Coupling point ID, mRID, RPA, Creation date, Last Modified, Valid from, Valid to, Active, Certified, Version	
Objects of auctions	Set of objects with following attributes: Product, Auction type, Gate opening time – power, Gate closure time – power, Gate opening time – energy, Gate closure time – energy, Max desired power, Min desired power, Max desired energy, Min desired energy, Availability – power, Availability – energy, Grid Impact Assessment variant, First auction date, Last auction date	IEC 62325-451-3: Auction Specification document.
Daily energy auction	ID, Auction status, Auction name, Product, Gate opening time, Gate closure time, Max desired energy, Min desired energy, Availability	IEC 62325-451-3: Auction Specification document.
DA energy bid	Potential, DER, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-7: Reserve Bid document
Daily capacity auction(capacity phase)	ID, Auction status, Auction name, Product, Gate opening time, Gate closure time, Max desired capacity, Min desired capacity, Availability	IEC 62325-451-3: Auction Specification document.
DA capacity bid (capacity phase)	Potential, DER, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	IEC 62325-451-7: Reserve Bid document
DA capacity set of bids(capacity phase)	Set of objects with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	
Daily energy auction(energy phase)	ID, Auction status, Auction name, Product, Gate opening time, Gate closure time, Max desired energy, Min desired energy, Availability	
DA energy bid(energy phase)	Potential, DER, Price, Volume, Volume divisibility, Delivery period divisibility, Delivery period	

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DA energy set of bids(energy phase)	Set of objects with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	
DA set of bids	Set of objects with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period	
Set of post-AGNO bids	Bids that passed AGNO with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period, Accepted volume, Accepted delivery period	
Outcome of evaluating bids	Bids sent from BM verification with following attributes: Bid date, SP, Potential, DER, Price, Volume, Status, Volume divisibility, Delivery period divisibility, Delivery period, Accepted volume, Accepted delivery period	IEC 62325-451-7: Reserve allocation results document.
Auctions results	Set of results of specific auctions	
Ready for tests scheduling unit	Scheduling Unit ID, Name, SP, Type, DERs, Number of DERs, Creation date, Last modified, Active, Ready for tests, Certified	Prequalification process Bos and will be modeled within T5.6.
Grid prequalification request	Request for grid prequalification sent by FSP or flexibility resource owner. The 98en tal contains all technical data such as: 1. Flexibility resource type 2. Connectivity (voltage level, transformer substation, DSO) 3. Location (GPS coordinates) 4. Active power Based on these data, flexibility resource will be registered in the flexibility register. Otherwise, grid	

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	prequalification test can be required from DSO	
Grid prequalification test results	This is information that DSO sends to market operator after running the grid prequalification tests. It concludes does or not flexibility resources can be registered, and used later without negative impact on the distribution grid.	
Grid prequalification report	This is information to FSP about the grid prequalification and it is in the form of a document.	
Product prequalification requirements	Detailed description of the flexibility service product and requirements. This is a document.	
Product prequalification request	Request for product prequalification with accompanying documents.	
Product prequalification test results	Results of tests run by DSO.	
Product prequalification report	Detailed report of the product prequalified. This is a document.	
Flexibility need	Based on load forecast and simulation, DSO predicts the state of the distribution grid. Time intervals and volume of flexibility are determined. DSO sends a request to market operator to open a call for bids. This request contains information about the needed flexibility service, location/area, volume, date and time interval.	No available CIM profile.
Call for bids	Request to prequalified FSP to place a bid for the flexibility service.	
Selected bids	Results document that includes: Location ContractID Accepted availability volume	IEC 62325-451-7: Reserve allocation results document. For the merit order list (MOL), Mol document is used.
Activation signal	This a request for activation of the contracted flexibility resource.	IEC 62325-451-7: Activation document.
Activation acknowledgement	To confirm that activation has been executed.	IEC 62325-451-1: Acknowledgement document.
Activation status	DSO informs TSO about successful activation of the	No available CIM profile. Similar profile has been developed in the TDX-ASSIST project.

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	flexibility service in the distribution grid.	
Real-time measurement	Measured active power delivered by the flexibility resource. This is time series, delivered in real-time.	IEC 61970-600-2: CGMES, Package EquipmentOperationProfile.
Flexibility service volume	Information about calculated delivered volume, from the baseline and measurements.	Usually a part of the IEC 62325-451-4: Settlement document.
Volume acknowledged	FSP agrees with the calculated volume related to the delivered flexibility service.	IEC 62325-451-1: Acknowledgement document.
Recalculation request	FSP determinates the deviation in the calculated volume and requests a check of the calculation.	IEC 61968: request/response mechanism.
Volume validation request	After delivered flexibility service, volume is determined based on measurements. This volume is a basis for reimbursement.	

8.4 Semantic interoperability with OneNet platform

One of the core components of the OneNet Reference Architecture is the OneNet connector, that will allow stakeholders and data sources to access the OneNet platform [1]. This connector uses a REST API named NGSI-LD for publishing, querying, and subscribing. The *LD* stands for Linked Data, since NGSI-LD has evolved from a property graph with semantics based on RDF and the Semantic Web framework.

Among all the data coming to the connector are also CIM modelled data. A CIM profile is not used for sharing, for this purpose one has to generate instance files. Figure 8-3 shows the implementation cycle, from canonical CIM to RDF/XML instance file.

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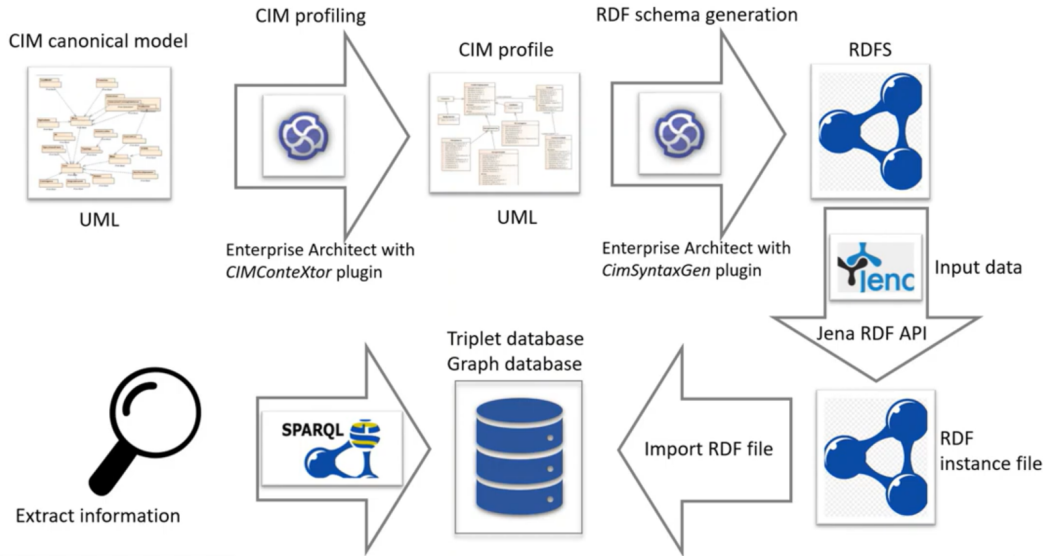

Figure 8-3 Implementation cycle.

There are two possible scenarios:

- CIM profile instantiated as RDF (generated RDFS),
- CIM profile instantiated as XML (generated XSD).

Since NGSI-LD is based on a property graph, it is closely associated to RDF. Therefore, NGSI-LD can be serialized as JSON-LD (linked data represented in JSON format). JSON-LD is one of the many serializations of RDF, hence being compatible with the connector requirements.

XML is one of the most popular formats for data interchange, but there are many differences compared to JSON-LD. The NGSI-LD API supports only JSON-LD, therefore XSD would have to be converted to JSON-LD to make them compatible.

8.5 Data modelling and exchange in Cluster East Regional SUC

The Regional BUC/SUC scope is aggregation of the market data upon a request received through common data exchange platform. The objectives are enabling retrieval of aggregated data through common information exchange platform and enabling data interoperability of market data at the pan European level.

8.5.1 Information exchange in Regional SUC

Market data aggregation can be used for benchmarking, statistics, new market entrants, investors etc. It is assumed that requests for market aggregation are received through the common data exchange platform (e.g., OneNet platform) and that they meet the required format. After the reception of the request, data aggregation application check the regularity of the request (format, time period, are all mandatory attributes are provided

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and similar) before starting the aggregation process. If the request is regular, the aggregation application retrieves market data from the data hub and runs the aggregation algorithm. Aggregated data are formatted as an XML message in accordance with the predefined CIM profile. In the last step, the aggregation application sends aggregated data through the common data exchange platform.

8.5.2 CIM profile

Figure 8-4 shows the *Aggregated data retrieval profile* (ADRP) in Enterprise Architect (EA). The profile is based on ESMP and was created using EA functionalities and EDFs MODSARUS plugin. The profile consists out of four classes shown in Table 8-2.

Table 8-2 Classes in Aggregated data retrieval profile.

Class name	Class description (from EA)
ReserveAllocationResult_MarketDocument	An electronic document containing the information necessary to satisfy the requirements of a given business process.
TimeSeries	A set of time-ordered quantities being exchanged in relation to a product. For each time series in the document, the identification shall be a unique number assigned by the auction office.
Point	The identification of the values being addressed within a specific interval of time.
Series_Period	The identification of the period of time corresponding to a given time interval and resolution.

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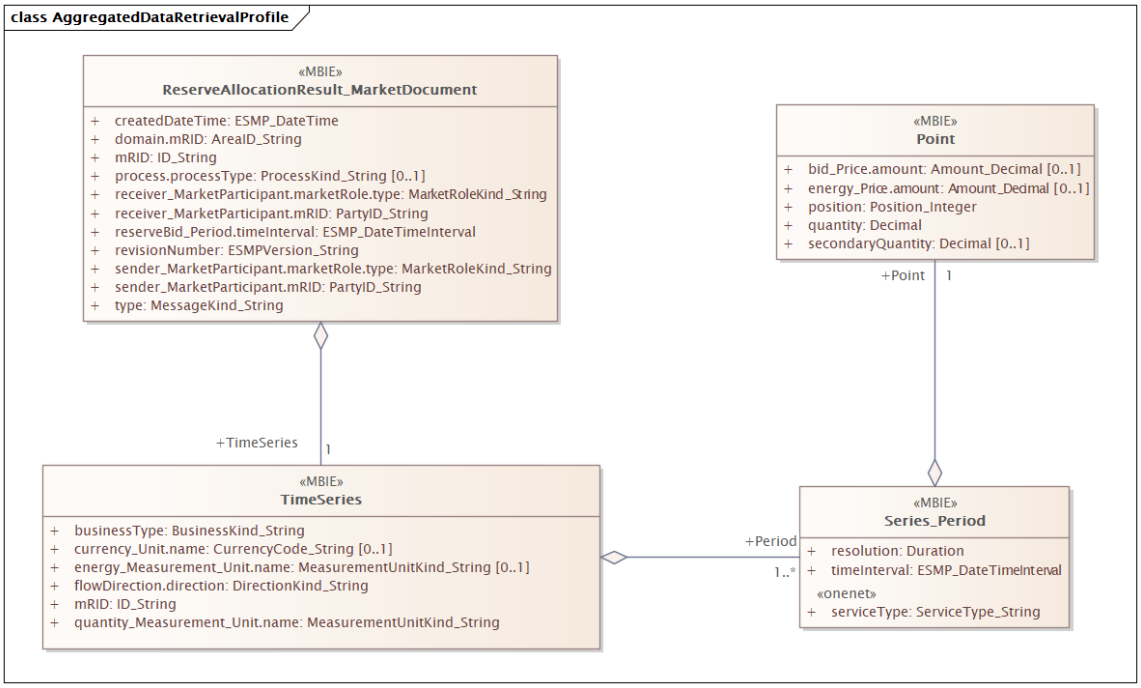

Figure 8-4 Aggregated Data Retrieval Profile in Enterprise Architect.

In Table 8-3, attributes from each class are explained thoroughly. Apart from the description, XML example values are given as well. This profile contains only one extension. Class *Series_Period* was extended with a new attribute called *serviceType.* For the need of defining what kind of service it is, a new attribute was added, following profiling rules, without altering the main class, yet achieving the desired functionality. To denote the extension, it is common practice to give it a stereotype, in this case *«onenet»*.

Table 8-3 Attributes of each class in ADRP.

Attribute	Type	Description	XML example values
ReserveAllocationResult_MarketDocument			
createdDateTime	ESMP_DateTime	The date and time of the creation of the document. In ESMP, the dateTime shall be expressed in UTC as YYYY-MM-DDThh:mm:ssZ	*2022-03-30T08:25:00Z*
domain.mRID	AreaID_String	The unique identification of the domain.	

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		The coded identification of a domain, i.e. balance area, grid area, etc. In the ESMP context, it is an authorized issuing office that provides an agreed identification coding scheme for domain identification.	
mRID	ID_String	The unique identification of the document being exchanged within a business process flow.	
Process.processType	ProcessKind_String	The identification of the nature of process that the document addresses.	*Day ahead*
receiver_MarketParticipant. marketRole.type	MarketRoleKind_String	The identification of the role played by a market player. --- Document recipient.	*Anyone registered on the platform*
receiver_MarketParticipant.mRID	PartyID_String	The identification of a party in the energy market. --- Document recipient.	*EIC code*
reserveBid_Period.timeInterval	ESMP_DateTimeInterval	The beginning and ending date and time of the period covered by the document.	*Start: 2022-03-30T08:25:00Z* *end: 2022-04-30T08:25:00Z*
revisionNumber	ESMPVersion_String	The identification of the version that distinguishes one evolution of a document from another.	
Sender_MarketParticipant.marketRole.type	MarketRoleKind_String	The identification of the role played by a market player. --- Document owner.	*System Operator*
sender_MarketParticipant.mRID	PartyID_String	The identification of a party in the energy market. --- Document owner.	*EIC code*[3]

[3] The EIC code of the sender can be found at EIC CODES (entsoe.eu)

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type	MessageKind_String	The coded type of a document. The document type describes the principal characteristic of the document.	*Aggregated energy data report*
TimeSeries			
businessType	BusinessKind_String	The identification of the nature of the time series.	*Aggregated energy data*
currency_Unit.name	CurrencyCode_String	The currency in which the monetary amount is expressed.	*EURO*
energy_Measurement_Unit.name	MeasurementUnitKind_String	The identification of the formal code for a measurement unit (UN/ECE Recommendation 20).	*kilowatt hour*
flowDirection.direction	DirectionKind_String	The coded identification of the direction of energy flow.	*UP/DOWN/UP and DOWN/ Stable*
mRID	ID_String	A unique identification of the time series.	
Quantity_Measurement_Unit.name	MeasurementUnitKind_String	The unit of measure that is applied to the quantities in which the time series is expressed, e.g. MAW.	*Kilowatt*
SeriesPeriod			
resolution	Duration	The definition of the number of units of time that compose an individual step within a period.	*PT1H*
timeInterval	ESMP_DateTimeInterval	The start and end time of the period.	*Start: 2022-03-30T08:25:00Z*
			end: 2022-03-30T09:25:00Z

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«onenet» serviceType	ServiceType_String	The data is categorized by type of service: Congestion management or Voltage control	*Voltage control*
Point			
position	Position_Integer	A sequential value representing the relative position within a given time interval.	*1*
bid_Price.amount	Amount_Decimal	A number of monetary units specified in a unit of currency. --- The price expressed for each unit of quantity allocated.	
Energy_Price.amount	Amount_Decimal	A number of monetary units specified in a unit of currency.	
Quantity	Decimal	The quantity that has b een allocated or resold in the auction. The principal quantity identified for a point.	*30.0*
secondaryQuantity	Decimal	The quantity that was in the original bid or resale document. The secondary quantity identified for a point.	*40.0*

Using the plugin MODSARUS, an XML Schema (XSD) was generated and is shown in Figure 8-5. The XSD tree structure shows all elements and their relations even better. The main class is *ReserveAllocationResult_MarketDocument*. The document contains one class *TimeSeries*. *TimeSeries* contains multiple classes *Period* and each period contains one *Point*.

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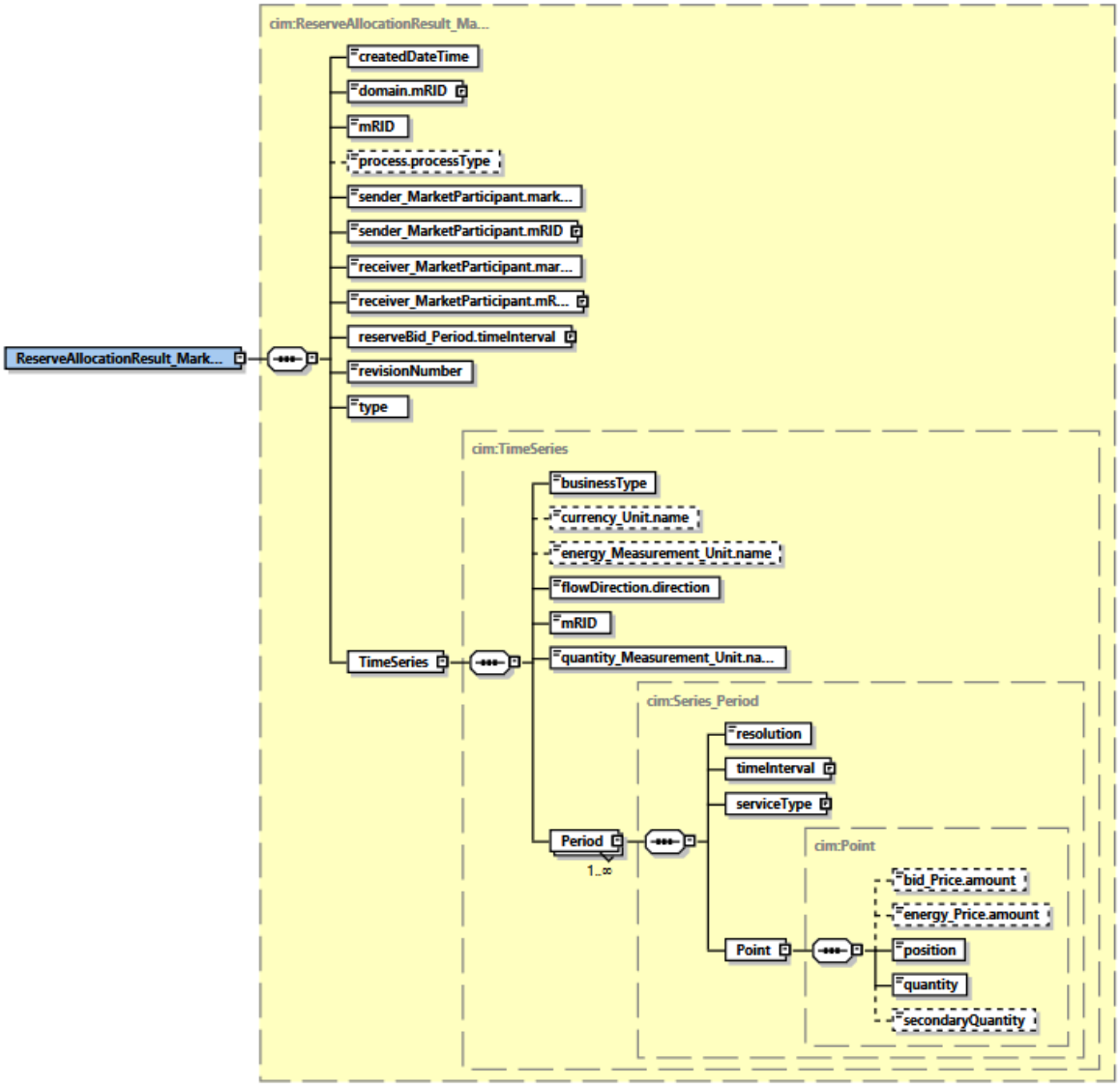

Figure 8-5 XSD for Regional SUC.

An XSD allows instance XML generation. The instance XML, based on the previously shown XSD and CIM profile, is shown below. Note that the documented XML contains only one *Period,* when it should be 24, for each hour of the day. This is due to limitations of this document, the concept is explained with one *Period* and *Point*, and the same follows for all other. The complete instance file is an attachment to this deliverable.

```
<?xml version=«1.0« encoding=«UTF-8«?>
<cim:ReserveAllocationResult_MarketDocument
xmlns:cim=«http://iec.ch/TC57/2021/CIM-schema-cim17#«
xmlns:xsi=«http://www.w3.org/2001/XMLSchema-instance«
xsi:schemaLocation=«http://iec.ch/TC57/2021/CIM-schema-cim17# adrp.xsd«>
      <createdDateTime>2022-03-30T09:30:47Z</createdDateTime>
      <domain.mRID codingScheme=«???«>???</domain.mRID>
      <mRID>String</mRID>
```


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```
	<process.processType>Day ahead</process.processType>
	<sender_MarketParticipant.marketRole.type>System
Operator</sender_MarketParticipant.marketRole.type>
<sender_MarketParticipant.mRID codingScheme=«A50«>28XELEKTROLJ058W
</sender_MarketParticipant.mRID>
	<receiver_MarketParticipant.marketRole.type> ???
</receiver_MarketParticipant.marketRole.type>
	<receiver_MarketParticipant.mRID
codingScheme=«EIC«>???</receiver_MarketParticipant.mRID>
	<reserveBid_Period.timeInterval> <!—one day interval→
		<start>2022-03-30T09:30:47Z</start>
		<end>2022-03-31T09:30:47Z</end>
	</reserveBid_Period.timeInterval>
	<revisionNumber>1</revisionNumber>
	<type>Aggregated energy data report</type>
	<TimeSeries>
		<businessType>Aggregated energy data</businessType>
		<currency_Unit.name>EURO</currency_Unit.name>
	<energy_Measurement_Unit.name>kilowatt</energy_Measurement_Unit.name>
		<flowDirection.direction>UP</flowDirection.direction—!--OPTIONAL-->
		<mRID>155452</mRID><!—Time series ID-->
	<quantity_Measurement_Unit.name>kilowatt
hour</quantity_Measurement_Unit.name>
		<Period>
			<resolution>PT1H</resolution> <!—hourly resolution-->
			<serviceType>
				<value>Voltage Control</value>
			</serviceType>
			<timeInterval>
				<start>2022-03-30T09:30:47Z </start>
				<end>2022-03-30T10:30:47Z </end>
			</timeInterval>
			<Point>
				<position>0</position>—!--it will go from 0 to 23-->
				<quantity>0</quantity>—!--power-->
				<secondaryQuantity>0</secondaryQuantity> <!—energy-->
				<bid_Price.amount>0</bid_Price.amount>
				<energy_Price.amount>0</energy_Price.amount>
			</Point>
		</Period>
	</TimeSeries>
</cim:ReserveAllocationResult_MarketDocument>
```

8.5.3 Request and response message structure

The CIM profile presented in 8.5.2 is the response to a request for aggregated data. This XML is n108en taloneone, but as payload of the response message.

Prior to sending any response, a request has to be made. The request and response message structures are from the standard IEC 61980-100, no new profiles have been made.

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The request message structure is shown in XSD format in Figure 8-6.

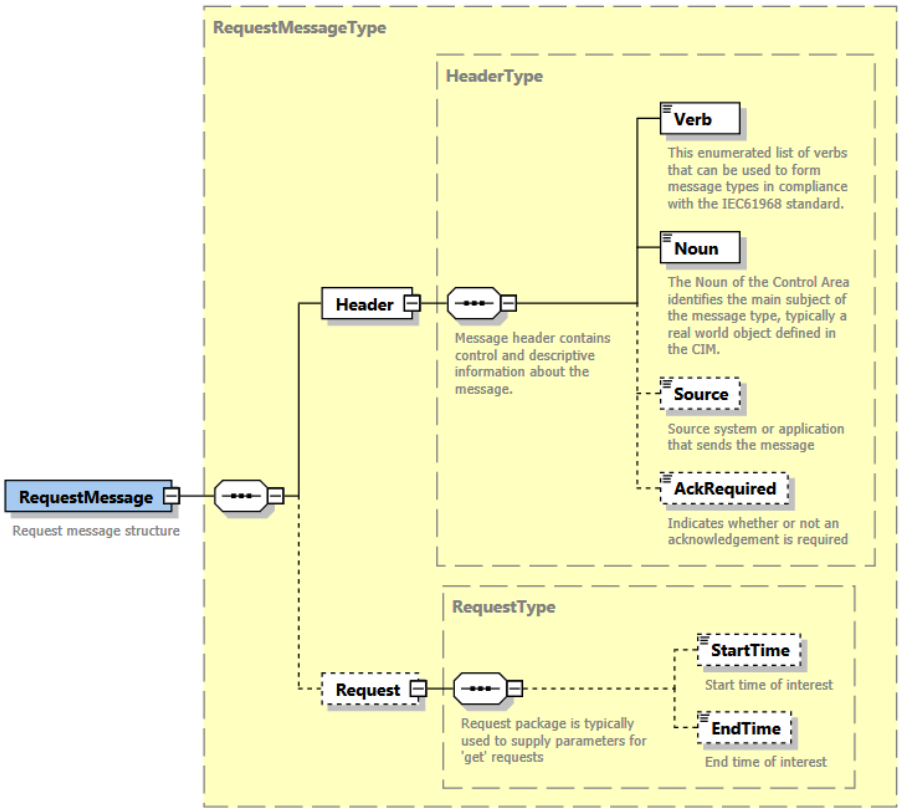

Figure 8-6 XSD for the request message.

The description of each element in the above shown XSD is given in Table 8-4.

Table 8-4 Elements of request message XSD.

Element name	Description	Required	XML example value
Header			
Verb	This enumerated list of verbs that can be used to form message types in compliance with the IEC61968 standard.	YES	get
Noun	The Noun of the Control Area	YES	System Operator

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	identifies the main subject of the message type, typically a real world object defined in the CIM.		
Source	Source system or application that sends the message	NO	
AckRequired	Indicates whether or not an acknowledgement is required	NO	true
Request			
StartTime	Start time of interest	NO	2022-03-30T09:30:47Z
EndTime	End time of interest	NO	2022-03-31T09:30:47Z

Based on this XSD, the following sample XML can be generated:

```
<?xml versi«n="«.0" encodi«g="UT«-8"?>
<n1:RequestMessage xmlns:«1="http://iec.ch/TC57/2011/schema/mess«ge"
xmlns:x«i="http://www.w3.org/2001/XMLSchema-insta«ce"
xsi:schemaLocati«n="http://iec.ch/TC57/2011/schema/message iec61968-100.«sd">
	<n1:Header>
		<n1:Verb>get</n1:Verb>
		<n1:Noun>System Operator</n1:Noun>
		<n1:Source>??</n1:Source>
		<n1:AckRequired>true</n1:AckRequired>
	</n1:Header>
	<n1:Request>
		<n1:StartTime>2022-03-30T09:30:47Z</n1:StartTime>
		<n1:EndTime>2022-03-31T09:30:47Z</n1:EndTime>
	</n1:Request>
</n1:RequestMessage>
```

The response message structure is shown in XSD format in Figure 8-7.

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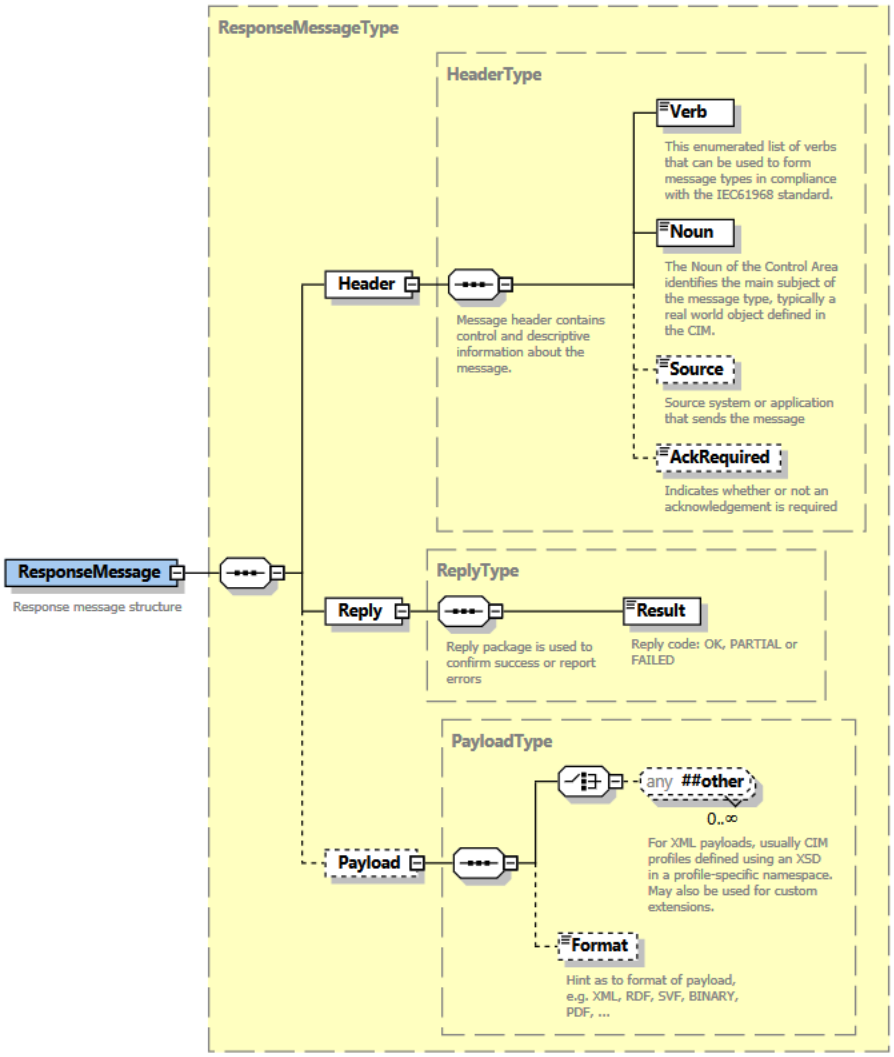

Figure 8-7 XSD for the response message.

The description of each element in the above shown XSD is given in Table 8-5.

Table 8-5 Elements of response message XSD.

Element name	Description	Required	XML example value
Header			
Verb	This enumerated list of verbs that can be used to form message types in compliance with	YES	reply

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	the IEC61968 standard.		
Noun	The Noun of the Control Area identifies the main subject of the message type, typically a real world object defined in the CIM.	YES	
Source	Source system or application that sends the message	NO	
AckRequired	Indicates whether or not an acknowledgement is required	NO	false
Reply			
Result	Reply code: OK, PARTIAL or FAILED	YES	OK
PayLoad			
##other	For XML payloads, usually CIM profiles defined using an XSD in a profile-specific namespace. May also be used for custom extensions.	NO[4]	*XML file*

[4] In CIM format this attribute is not required, but in the case of OneNet use cases **it is a required** attribute, as we are sending the data via response message.

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Format	Hint as to format of payload, e.g. XML, RDF, SVF, BINARY, PDF, ...	NO[5]	XML

Based on this XSD, the following sample XML can be generated:

```
<?xml versi«n="«.0" encodi«g="UT«-8"?>
<n1:ResponseMessage xmlns:«1="http://iec.ch/TC57/2011/schema/mess«ge"
xmlns:x«i="http://www.w3.org/2001/XMLSchema-insta«ce"
xmlns:«2="http://www.altova.com/samplexml/other-namesp«ce"
xsi:schemaLocati«n="http://iec.ch/TC57/2011/schema/message iec61968-100%20-
%20Copy.«sd">
	<n1:Header>
		<n1:Verb>reply</n1:Verb>
		<n1:Noun>OneNet platform</n1:Noun>
		<n1:Source>??</n1:Source>
		<n1:AckRequired>false</n1:AckRequired>
	</n1:Header>
	<n1:Reply>
		<n1:Result>OK</n1:Result>
	</n1:Reply>
	<n1:Payload>
		<n2:auto-generated_for_wildcard/><!—XML payload-->
		<n1:Format>XML</n1:Format>
	</n1:Payload>
</n1:ResponseMessage>
```

[5] In CIM format this attribute is not required, but in the case of OneNet use cases **it is a required** attribute, as we are sending the data via response message.

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9 Data sources layer

This chapter overviews the data sources in the context of the flexibility market. The focus is put on the actors that generate data and EU acts on the data ownership. The used methodology classifies data according to the data ownership not according to the business process. Detailed classification of smart grid data according to the business processes is available in Thema report "Data exchange in electric power systems" [24]. The analysis is limited to the main data sources at the flexibility market.

9.1 Identification of data sources

9.1.1 Consumer/Prosumer data

Information about consumer's behaviour is crucial in the development of business models that will incentivise consumers to participate in the provision of flexibility services. Besides proper consumer information, this data is an enabler for third parties (e.g., flexibility service providers) to develop and offer new services at the flexibility market. According to the Data act and Electricity Directive, usage of consumers data by a third party requires consumer's consent [17, 16]. It is important that market participants and service providers inform consumers how and for which purpose their data is used for, give them descriptions and interpretations of their baseline consumption, provide them an estimate of their flexibility potential, and explain how their flexibility can be monetised on the market [20]. Furthermore, consumers must be assured that they are requested only for the minimal data set necessary for the provision of their flexibility.

With a high penetration of RES, consumer data becomes more important for the utilisation of the demand response potential. The data that fits into this category are:

- *Smart metering data*. Data collected by a smart meter, at the consumer/prosumer premises. Data is collected by system operators and is available for market players under regulatory obligations and consumer's consent. These data include:
    - Consumption data (real-time data on the energy usage or historical data, with 15 minutes resolution, consumption profile).
    - Production data (real-time data on the energy production or historical data, generation-specific data).
    - Customer information.
    - ID and location.
    - Contract associated with the metering point.
    - The balance group to which the metering point belongs.

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- *Sub-metering data*. Metering data collected behind the smart meter and sensor data related to the flexibility sources connected at the consumer premises (e.g., heat pumps, electrical vehicles and EV chargers, smart appliances etc.). Sub-meters are important for the real flexibility measurements and better incentivisation through fair awards for activated flexibility [35].

9.1.2 System operator data

This category contains data owned by system operators (TSO and DSO), used at a flexibility market. It includes data related to the grid operation, configuration, and measurements. System operator should provide data on network constraints and capacity to the market participants. According to the time horizon, this data can be real-time, planned, or historic [32].

- *Real-time data*. This data is necessary to enable visibility on network constraints at distribution and transmission level and provide necessary information for the flexibility service activation or feeding traffic light system. It includes measurements such as voltage, active and reactive power flows, power quality, frequency, and grid configuration. This type of data also includes the status of the energy mix and greenhouse gas content.
- *Planning data*. Grid planning is crucial when flexibility services are used as alternative for grid reinforcement. Besides long-term planning, it includes short-term planning and operational planning. This data can include plan maintenance (e.g., changing grid configuration, start and end date, etc.), outage planning data (e.g., known outages that will affect planed consumption and generation) and planned grid configuration (e.g., day-ahead grid operation). Flexibility needs is information also published by a system operator.
- *Historic measurements*. Similar as real-time, but available for offline analysis in the longer time period (e.g., hours of operation at full power equivalent, peak utilisation hours (at x% capacity), average duration of peak utilisation [32]).
- *Market data*. This category is related to the data generated by a system operator within flexibility market process, such as prequalification, long-term flexibility needs, request for flexibility offers etc.

9.1.3 Flexibility service provider data

This category relates to the flexibility market fed by flexibility service providers. It includes:

- Flexibility offers.
- Settlement of flexibility.
- Location and type of flexibility assets.

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9.1.4 Market operator data

This category of data strongly depends on regulatory models and market design in a specific country. In general, these data include:

- Market results (e.g., merit order list).
- Aggregated market results.

9.1.5 Balancing responsible party data

It includes schedule of the balancing group.

9.1.6 Data from other sources

Data originating from other sources, such as weather forecast service (e.g., solar radiation forecast).

9.2 Common data formats

Flexibility services can be traded at different marketplaces, and it is important to establish semantic and syntactic information interoperability. Semantic interoperability and semantic data model based on CIM is presented in the Chapter 8 of this report. This section lists common data formats used in the data exchange.

We divide data formats into two categories, human-readable and machine-readable. Machine readable formats are appropriate for machine-to-machine communication and are essential for automation of flexibility market processes.

9.2.1 Human-readable formats

This format is friendly for the end user, which can view data and make simple analysis using common IT tools, such as MS Office. The most common data formats in this category are CSV, XLS and PDF.

9.2.2 Machine-readable formats

Machine-readable formats are usually serialised from an information data model on concrete data values, using standardised rules. When CIM is used, there are standardised serialisation rules for RDF, XML and JSON formats. For instance, XML is commonly used for ESMP (e.g., flexibility service offer, merit order list etc) and RDF for grid models. CIM can also be serialised in JSON format. In some cases, JSON is preferred against XML as better readable and more appropriate for faster data exchange over REST-API.

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Another alternative for serialisation is JSON-LD, which is a standard data model for NGSI-LD interface used by FIWARE. There are no standardised rules, however, for CIM serialisation into JSON-LD. This topic is treated in WP5 and WP6 of the OneNet project.

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10 National flexibility markets in the East cluster

This chapter overviews the current status of the national flexibility markets in the East cluster and the OneNet national demo objectives.

10.1 Czech Republic

10.1.1 General description

The Czech demo aims at utilization of flexibility, aggregated from decentralized energy resources (DER), battery energy storage systems (BESS), and demand side - large consumers (DSR). Focus is on sources of 0.5 MW installed power or above, connected to the distribution grid, and large consumers connected to 110 kV. The goal of this demo is to develop a market for non-frequency services to be used by both DSO/TSO. The Czech demo will establish a country-wide solution (IT platform) for flexibility for grid services. Participation of flexibility providers of various sizes in the whole area will be tested, covered by two major DSOs in the Czech Republic. The new platform will cooperate with the existing platform for frequency services namely through the traffic light scheme allowing sharing of relevant data between DSOs and TSO. Apart from TSO and DSOs, there are two aggregators involved providing flexibility. Market structure and implementation options are now debated, and it is not defined yet. There is no platform enabling market-based provision of non-frequency flexibility for DSOs. Through implementation of the new platform, we can test new services for the DSOs/appropriate cooperation and data exchange between DSO and TSO and last but not least broaden the flexibility market by involvement of new participants and services.

10.1.2 Products and services

The Czech demo aims to test non-frequency services – e.g., voltage control through reactive power management and nodal area load management. These products will be described in terms of standards and terms of references. So far, these services are not used at a broader scale/market based at present and mostly bilaterally (based on a contract with relevant users and grid operators).

10.1.3 Information exchange

Debate on the structure of the platform and data exchange models have been ongoing at present (that goes especially for the information model and relevant channel deployed). Basically, there are several DSOs, TSO and two aggregators as main actors in the demo. For the first part of implementation there is a traffic light concept to be used in which following data exchange is expected: expected outages/outages reported from DSOs to the platform providing for each generator registered in the platform availability of the system for the flexibility

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activation. This information is for planned outages provided 15 days ahead. The TSO sends to the platform information concerning procured/contracted services (amount of services) for DSOs. The provider of services sends to the platform information about activated services detailing all participating resources (which is important for the DSOs in terms of quality of supply in nodal areas). The platform contains data on planned/activated flexibility for evaluation of services provided to the TSO. The second phase of the CZ demo project will encompass provision of the non-frequency services from aggregators/customers to the DSOs. The data exchange will be based on the structure defined in the first phase, but details need to be discussed yet.

10.1.4 Market platform

The marketplace will be designed by IT provider – Unicorn. As indicated at the chart shown in Figure 10-1, there is an administrative section with register of flexibility units, information about relevant nodal areas. The market module contains information on flexibility services contracted/provided while the other module serves for evaluation and settlement. What is referred as "congestion management" is the traffic light scheme – indication of the grid availability. The entire scheme that represents the national Czech flexibility platform is given in Figure 10-1. Please note this scheme could be modified as the project is still evolving.

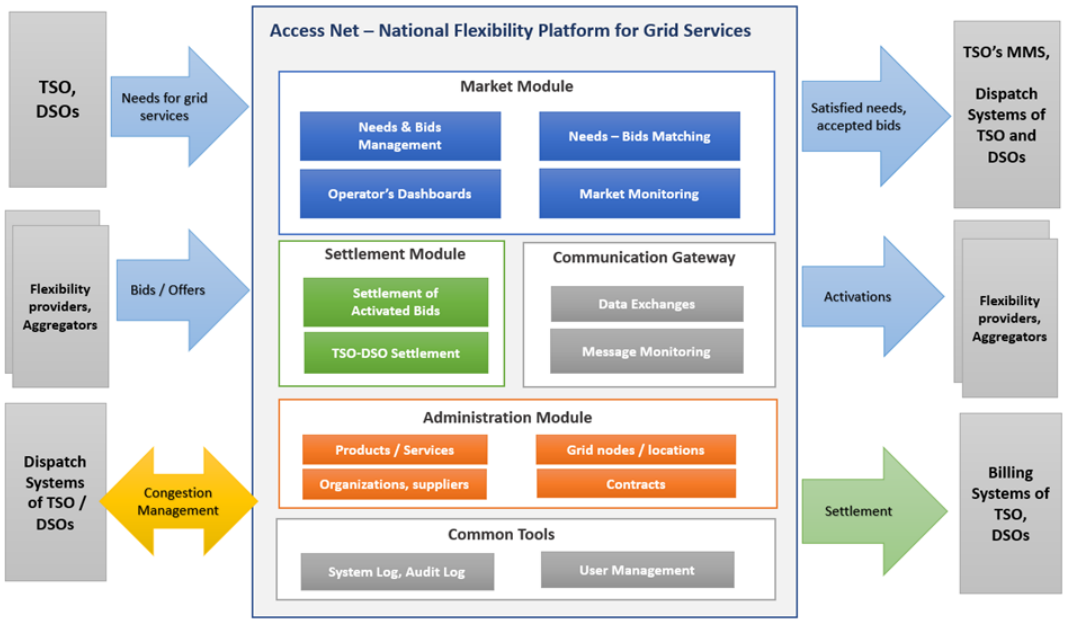

Figure 10-1 The concept of Czech national flexibility platform.

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10.2 Hungary

10.2.1 General description

Important disclaimer: The Hungarian Electricity Act has been modified by the Assembly in mid-December 2020, due to the required harmonization of the national regulation to the European Directive on Internal Energy Market (CEP-IEM) (944/2019). Amendments of the national flexibility market are still being formed to ensure full compatibility with the Hungarian, the EU regulations.

The high-level scope of the national market is centred around the following cornerstones:

- main issue on the Hungarian market and the focus of the national market demonstration is solving the greatly extensive and accelerated (up to 10% of total installed capacity add-ons per year from 2020-2030) PV generation add-ons that is planned by the National Energy and Climate Plan of Hungary;
- provide market-oriented grid services for the DSOs, and extend the TSO's similar potential;
- extend the grid management toolset with asset-light, flexible solutions;
- foster the involvement, participation of DSO-connected assets;
- keep the results of the current, technology neutral, DSO-connected asset including, individual and virtual power plant based diverse balancing service provider portfolio;
- sustain the already tight balancing service (FCR, aFRR, mFRR) supply also on the TSO's market;
- compatible with the regulation both on Hungarian and European level.

Type of the market: flexibility market with congestion management services.

Congestion is however defined not only as active power limitations on grid elements, but with a wider scope, as the main focus is on DSO assets where voltage limitations also regularly limit the transferred power flows.

Balancing services are clearly out of the scope. Certainly, the connections have to be investigated, but no objectives and market part is defined in the OneNet relevant national flexibility market that would steer the defined path of the TSO-led balancing markets (FCR, aFRR, mFRR with energy and capacity products). Also, regular energy-only marketplaces (DAM, IDM) are out of scope, as they have a defined, and closed development path to have a fully unified single coupling solution on TSO-TSO level.

Market goals (e.g., use flexibility to utilise network operation):

- use DSO-connected flexibility sources – preferably with the use of PV flexibility (both with generation shedding and inverter control);
- limit network congestions;
- serve the booming additional network capacity demand for PVs:

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- both with power plant sized PVs (up to 50 MW for 132 kV lines);
- and with household scale (up to 50 kVA, typically 3-10 kVA) rooftop solar add-ons;

- defer network assets investments;
- close the time gap necessary for completing larger network reinforcement projects.

Market structure:

- Domain: congestion management, sub-domain: intra-zonal CM, with TSO-DSO involvement
- Market defined on National level, with national network scope.

Implementation options (separated/integrated balancing and congestion management market, day-ahead market, intraday market....):

Focus: CM separated from other markets:

- TSO-DSO combined by subset/overlapping, but DSOs may keep their individual market platforms, so fully integration is not planned;
- Congestion Management service with DSO/TSO specific activation is in focus:
  - long term CM for its purpose, thus reservation
  - but with short, even intraday (up to H-90 minutes.) activation decision
  - aligned with the 2B market option in H2020 project INTERRFACE

Note: feasibility of this timeline is yet to be validated, especially with CRP – conditional reprofiling, and baseline determination – all aspects are driven by new updated on energy and standard balancing products.

Market parties (stakeholders)

Active roles:

- Resource Provider (provider of technical flexi capability)
- Resource Aggregator (provider of technical flexi capability)
- Flexibility bidder (marketing the technical flexi capability)
- Distribution System Operator
- Transmission System Operator
- Merit Order List Responsible (not a new actor)
- Balance Responsible Party
- Balance Supplier + Balancing Service Provider
  - supplier individually or through aggregation

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Market structure

For each connection, periodic prequalification reviews (generally yearly, bi-yearly)

1. Grid prequalification

- The whole prequalification process is initiated by the flexi provider. Also, grid connection contract may define obligations on providing flexibility capability.
- The DSO/TSO responsible for grid connection receives the request for grid pre-qualification.
- For evaluating the overlapping effect of grid service provision, DSOs and TSO coordinate the technical (initiator of this coordination is the grid connection responsible SO).

For each LT congestion management capacity procurement (e.g., quarterly, but depends on the balancing capacity auctions!)

2. Product prequalification (for each long-term congestion management session):

- a common flexi register is required to cross-check the market bid, from the flexibility providers.

3. Bidding for LT CM flexibility provision

- DSO/TSO handle the bids, as the network operators have contractual agreements with bid providers on the grid service settlements
- Note: the stability of the market, the resilience from market gaming, and the necessary price caps are yet to be investigated in the flexibility market concept.

4. Bid Matching – based on merit order generated from market bids, technical details on the bids (most importantly: location).

For each flexibility activation periods (daily, as part of the intraday process):

5. Calculation of the activation needs
6. Activation of CM flexibility
7. Measurement and verification

For each settlement period (monthly):

8. Settlement: between SO initiated the necessary CM service and the flexibility provider

Market access (who can access market and how):

- TSO and DSO as demand, and technical data provider
- all other, eligible, pre-qualified flexibility provider either individually or through aggregation
    - standard balancing capable flexibility providers
    - PV generators
    - household rooftop solar

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- storage
- *later*: energy communities, aggregators, and active prosumers as independent market entities.

TSO and DSO collaboration (e.g., avoid activation interlocks, grid congestion, voltage profile violations...):

- In pre-qualification steps, affected SOs coordinate on the validation of flexibility resources.
- DSOs has a preference in the congestion management service phase in the activation step.
- Basically, this is a traffic light model described in ENTSO-E's ASM document.

10.2.2 Products and services

The main focus of the national flexibility market is the congestion management services, with two distinct products:

- Active power flexibility – with a preferred, mFRR-like "activation" with direct balancing consequences;
- Reactive power flexibility – specifically for local voltage regulation.

Both products have specific locational dimension, with two typical use case:

- congestion management for radial MV network (20 kV, 10 kV), and
- congestion management for loosely meshed HV network (132 kV).

Further differentiation of the use cases will be detailed with the usage of reference grids (e.g., lines/areas with the most issues).

For the merit order creation, the exact location (as for the constraint to be relieved different activations have different impact, calculated by PTDFs) of the activated products is required.

For a complete list, connected balancing products are:

- FCR symmetrical,
- aFRR +/- (single products, in transition from 15-minutes. to 5-minutes. FAT),
- mFRR +/- (standard) + currently used 15/30-minutes mFRR +/- (non-standard).

Non-frequency products:

- proposed: network reserve capacity,
- TSO redispatch (both intra-zonal and cross-border).

10.2.3 Information exchange

It is going to be based on the standard CIM information model with two main components:

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- network state sharing platform – for both (quasi) real-time and planning operational data exchange,
- flexibility register – to have a continuously updated status database on the availability of the resources, diversely connected to DSOs/TSO grid.

10.2.4 Market platform

Currently TSO (MAVIR) uses a balancing market platform that handles all currently available products and services. focusing on balancing and TSO coordinated redispatch and its settlement. The six Hungarian DSOs have a non-market based, technical. **The goal of the local flexibility national market is to include a merit order prioritization over the current, connect the settlement.** The market per se might be based not only on supply-demand balance but rather on regulated or pre-set (in the network connection contract) rate, prices on the – also in connection with the CEP IEM directives on the adequate but not over-compensation of the lost electricity generation at the (mainly) RES-E generators. **The predominant market action will be the negative regulation/activation of the local flexibility from PV power plants due to congestion management issues, but the overall goal is to provide a technology neutral marketplace for DSO-oriented grid services.**

10.3 Poland

10.3.1General description

The Polish electricity market follows the general approaches taken in EU. There is a segment of wholesale market that deals with energy and a segment of Balancing Market operated by TSOs.

The balancing market is Combined Congestion Management and Balancing Market. The model for balancing market is Central Dispatching[6] (as defined in art. 2(18) EBGL). The specificity of Poland is that while 110kV grid is owned and operated by DSOs, the coordination of meshed part of 110kV is done by TSO. The balancing market is currently under an extensive review – however major principles will not be changed (Central Dispatching Model, combined congestion management and balancing). **The main goal of the balancing market reform is to facilitate access to this market for a wide range of resources with different technologies, including DSO-connected units and compliance with EB GL and Regulation 2019/943, and improvement of price formation.**

[6] 'central dispatching model' means a scheduling and dispatching model where the generation schedules and consumption schedules as well as dispatching of power generating facilities and demand facilities, in reference to dispatchable facilities, are determined by a TSO within the integrated scheduling process;

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The wholesale market is pretty standard. Allocation of cross-zonal capacities is in the day-ahead/intraday timeframe done via SDAC/SIDC (Single Day-Ahead Coupling[7]/Single IntraDay Coupling[8]) respectively. On three borders (with Germany, Czech Republic, and Slovakia) there is an explicit allocation in a day-ahead timeframe. We are working on implementing allocation via SDAC (i.e., Interim Coupling Project). Apart from Power the Exchange (SDAC/SIDC) market participants can trade energy bilaterally (bilateral contracts).

10.3.2 Demo description

The goal of the Polish demo is to facilitate the flexibility market and to investigate a more efficient approach to the provision of TSO services by DSO-connected resources. The investigated approach should be robust to ongoing evolution of the Balancing Market.

The demo involves a platform that facilitates:

- Performing the grid and product prequalification.
- Submission of the flexibility bids by distributed resources (for different services addressed to TSO and DSO).
- Provision of bids for flexibility towards DSO (for congestion management in distribution grid).
- Performing the dynamic grid assessment.
- Coordination with the Balancing Market.
- Performing other essential tasks associated with flexibility market (e.g., settlement).

To the possible extent, the same product should be used to address needs of both TSO and DSOs.

The platform will have functionalities associated with the flexibility register, however, it won't be a separate module.

10.3.3 DSO approach to Congestion management (today)

DSO's Congestion management (overloads and voltage violation)

Elimination of congestions in the distribution network can take place in several ways and depends mainly on the voltage level of the network, available resources, and actions for solving the problem and the situation for which the congestion occurred.

[7] 'single day-ahead coupling' means the auctioning process where collected orders are matched and cross-zonal capacity is allocated simultaneously for different bidding zones in the day-ahead market;

[8] 'single intraday coupling' means the continuous process where collected orders are matched and cross-zonal capacity is allocated simultaneously for different bidding zones in the intraday market [CACM];

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The basic tool used by the DSO to solve problems with congestion in the network is reconfiguration of the network. It is the most common and most frequently used solution in case of solving typical problems in the MV network.

Another solution is to use controllable generation sources (mainly wind farms) in the process of elimination of congestions in the HV and partially in the MV networks. The possibility of using the generating units depends on the technical possibilities of control of the unit. It is common to use wind farms and control generated reactive power to regulate the voltage in the HV and partially MV network. Partially because a lot of generation units connected to the MV network have a limited possibility of control, especially in the term of reactive power. In the case of MV grids, it is also possible to solve voltage problems by limiting the active power generation of the unit. Active power limitations of the units connected to the HV network are also a common practice when the overload occurs due to excessive production of wind farms.

Most of the congestions in the LV network are related to the excessive generation of PV sources connected to one feeder/secondary substation. In such cases, the congestions are eliminated automatically by disconnection of the PV inverter when the permissible voltage in the network is exceeded.

In exceptional situations, the DSO (on its own or at the request of the TSO) introduces limitations of energy consumption i.e., for large consumers.

An important element of congestion management is cooperation with the TSO, because the 110kV network owned by the DSO is treated as a coordinated network.

10.3.4 Products and services envisaged in demonstration

Balancing services:

- FCR (under investigation yet),
- FRR (under investigation yet),
- Active Energy for RR (under investigation yet).

Congestion management:

- (For TSO) Active Energy for RR (under investigation yet) – the same product as Balancing,
- (For TSO) congestion management for short/mid-term operational planning – defined on »as needed« basis (for scheduled outages),
- (For DSO) congestion management for short/mid-term operational planning – defined on »as needed« basis (for scheduled outages).

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If we compare it with the work done in other H2020 projects, INTERFACE defines cross-border redispatching as separate services. PSE won't define products for those services, but rather uses the same products as for internal congestion management, as long as they fit inter-TSO processes (basically timings).

10.3.5 Information exchange

For data exchange there are some major areas:

- Exchange of structural data,
- Exchange of planning data,
- Exchange of real-time data,
- Exchange of metering data for settlement,
- Exchange of market data.

The exchange of structural data is performed:

- Between TSO (PSE) and DSOs connected to the transmission grid (includes generation and load data)
- From generators type A, B, C, D connected to the distribution grid to DSO, from generators type D connected to the transmission grid towards TSO.

Planning data received by TSO:

- From TSO-connected DSOs:
  - Planned grid configurations of 110kV grids (including substations),
  - Forecasted dispatchable power of B and C units,
  - Planned exchanges between 110kV grids.
- From D units:
  - Planned outages.
- From TSO-connected demand:
  - Planned outages.

When it comes to real-time data:

- TSO expects real-time data about all substations of 110kV or higher voltage, about operation of all B, C and D generating units and about ratings of lines operating at 110kV or higher voltage.
- TSO-connected DSO receive real-time data about:
  - 110kV and higher voltage substations: its own substations, substations connected to a given DSO and substations connected to DSOs connected to a given DSO.

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- B, C, D units connected to its own grid and connected to the grid of DSOs, connected to its grid.

- Non-TSO-connected DSOs receive real-time data:
  - 110kV substations from its own grid and from grid of DSOs connected to grid of given DSO.
  - B, D and D units connected to its own grid.

Settlement data:

- DSOs provide metering data for settlement.
- FSPs schedule (only for ex-ante method).
- FSPs additional data.

Market Data – those data are exchanged between TSO and BSPs/BRPs:

- Balancing bids.
- Nominations of scheduled: internal commercial trade schedules and external commercial.
- Coordination plans.
- Invoicing data.

10.3.6 Market platform

In the current approach there is no need for a flexibility platform (please mind – the current approach is not scalable for the future). The DSOs were not using flexibility from their users in a systematic way (as far as PSE knows, DSOs were not using flexibility from grid users in contractual way at all). Distributed resources can provide the balancing services for TSO if they have approval from DSO (static grid assessment).

When it comes to market platforms operating in the wholesale market – the situation is pretty typical for EU:

- SIDC/SDAC – standard design, there is a NEMO operating those markets (currently TGE, soon to be three: TGE, EPEXSPOT and Nordpool).
- Bilateral contracts – concluded directly by interested market participants, in Poland there are no significant market platforms supporting this market.

Balancing market/ Ancillary Services Market – the Balancing Market is run by TSO (i.e., PSE). It is operated in Central Dispatch Model. Balancing and Congestion Management is done jointly.

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10.4 Slovenia

10.4.1 General description

The Slovenian demo contributes towards reaching the goal to develop methodology for advanced grid planning taking into account flexibility sources as a substitute to strengthen the grid. We aim to demonstrate selected services using the locational flexibility market platform and several locations on low voltage level, where network issues will be solved using flexibility sources. The aggregator, who is part of the consortium, will involve flexible sources available on respective locations. TSO and distribution companies will use the same flexibility sources optimizing individual needs while taking into account grid limitations. While the TSO has already established its products for flexibility services, the main goal of the Slovenian demo within OneNet will be to develop corresponding solutions on the distribution side as a proof of concept. Services (that currently do not exist in such market driven form) will be operated locally on the national level, while striving to meet harmonized and common EU (OneNet) standards. Involvement of three distribution companies using different operation and control systems ensures interoperability of the flexibility marketplace. The aggregator involved will ensure needed flexibility directly from consumers, however the marketplace will also be open for other aggregators and flexibility providers. Even though the focus is on demonstrating services for DSOs, the market will be designed so that both TSOs and DSOs will be able to use same sources of flexibility while considering each other's needs and limitations. Thus, we will focus on standardisation of prequalification processes and products to ensure easy scalability of services. Flexibility procurement will be based on specific locations and grid conditions (localized market). Lastly, we will identify the relevant system data that enable market participants to better assess and forecast the need for grid services and publish such data (as much as possible).

We have already designed the market for the first DSOs demo (of Elektro Ljubljana):

- Market design: combined TSO/balancing and DSO/congestion management markets.
- Market product description: Locational congestion management service of existing congested secondary MV/LV transformer (substation) with flexibility activation from aggregated demand response. Volume of demand capacity. Contract period is 19.10.2020 – 31.3.2021. Mandatory product availability is limited during the weekdays from 16:00 to 22:00 and on weekends and public holidays from 9:00 – 14:30 and 15:00-21:00. Activation duration is limited to maximum 75 minutes, while allowing a maximum of two activations per day.
- Timeframe of the market: Several weeks before delivery
- Available bidding options: Single priced capacity orders for 20 kW positive reserve power (i.e., load reduction)
- Market clearing: Pay-as-bid. Delivered activation energy only.
- Market integration: None so far. Planned integration with mFRR (for TSO).

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- Communication to market participants: DSO requests from the Flexibility service provider, acting also as demand aggregator, to adjust their consumption within 30 minutes from notification in quantity up to full prequalified capacity in steps of 5 kW (i.e., 5, 10, 15 or 20 kW). Currently activations are implemented manually via phone call, but automatic/electronic process is being designed.
- Market parties (stakeholders): DSO, flexibility provider (aggregator), party connected to the grid.
- Prequalification method: Simple prequalification with disclosing individual connection points of parties connected to the grid, demand response technology type used, rated flexible capacity per party, total available flexible capacity of the pool per corresponding MV/LV transformer.
- Market access: all prequalified aggregators.
- TSO-DSO collaboration: currently none implemented. Avoiding activation interlocks to be implemented.
- Flexibility register: individual parties connected to the grid disclosed to DSO within prequalification.
- Information exchanged: The Aggregator sends to the DSO day ahead pool level baseline, with intraday corrections every 5 minutes. Bidding and activation information exchange is planned to be implemented electronically and harmonised with mFRR product.
- Baseline calculation and service validation: The aggregator provides the baseline by calculating it and regularly sending it to the DSO. Validation of the delivered service is performed based on the difference between the baseline and actual consumption. Gaming is mitigated by considering the baseline correction factor that is calculated as an average baseline error in the hour before activation. Consumption data from DSO's official smart meters are used for validation.

Two more use case demonstrations are envisaged to be specified and deployed within the Slovenian demo.

10.4.2 Products and services

Locational congestion management service is our main use case to be demonstrated. Based on identification of existing congested secondary MV/LV transformers (substations), we will implement flexibility activation from aggregated demand response.

Based on transformer real-time congestion estimation, the DSO will activate (when needed) the aggregated demand reduction. Based on historical data analysis the product will be spatially and temporally limited to congested periods (e.g., winter weekend evenings). Service response time will be sufficiently short to enable fast reactions to escalating conditions (e.g., 30 minutes for manual response and 12,5 minutes for automatic activations).

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10.4.3 Information exchange

Relevant bidding and activation data is envisaged to be exchanged based on harmonised version of balancing mFRR information exchange standards.

10.4.4 Market platform

Currently no market platform exists. The goal of OneNet is to develop and implement one.

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11 Conclusions

This report presented a framework for the design of the Integral market platform (IMP), which enables TSO, DSO, and other grid flexibility users to procure flexibility products on the organised flexibility market. The concept of integral market platform enables the following:

- *Robust market design*: layered architecture facilitates decoupling of different functionalities of the market platform.
- *Flexibility product design*: catalogue of the harmonised flexibility services is established, and flexibility products are defined based on the clear needs and the fact the actual products can be delivered. This has been accomplished by the alignment of the flexibility services and products defined in OneNet with the demonstrations in the Cluster East.
- *Market layer and coordination*: market layer describes the general realization of market processes that essentially follows the necessary core business functions of the Eastern Cluster demonstrated flexibility markets. This is a complex task, which has been tackled by dividing this layer into two sublayers: business sublayer and functional sublayer. This report also provides required functionalities of IMP that would lead to the interoperable network of platforms in the Cluster East.
- *Market interoperability*: this is considered through the application of IEC 62325 standard (CIM – European Style Market Profile) that enables interoperability of marketplace platforms across Europe.
- *Use of data*: IMP provides clear data governance principles and requirements how data is handled, including data anonymisation and aggregation. This is aligned with the major EU documents, such as data act and GDPR.

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