Report on selection of services

D10.2

Authors:

Dominik Falkowski (EOP)

Rok Lacko (GEN-I)

Bálint Hartmann (BME)

Janoušek Václav (CEZ DISTRIBUCE)

Nermin Suljanović (EIMV)

Distribution Level	PU
Responsible Partner	Dominik Falkowski (EOP)
Checked by WP leader **[name surname]**	Date: 25.02.2022 Rušt Primož [ELES]
Verified by the appointed Reviewers	Date: 25.02.2022 Alexandre Lucas [INESC] 25.02.2022 Aleth Barlier [ENEDIS]
Approved by Project Coordinator	Date: 22.03.2022

Dissemination Level	PU	
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	
CI	Classified, as referred to in Commission Decision 2001/844/EC	

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

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

About OneNet

OneNet will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure.

The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".

While the electrical grid is moving from being a fully centralized to a highly decentralized system, grid operators have to adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. For this reason, the two major associations of grid operators in Europe, ENTSO-E and EDSO, have activated their members to put together a unique consortium.

OneNet will see the participation of a consortium of over 70 partners. Key partners in the consortium include: already mentioned ENTSO-E and EDSO, Elering, E-REDES (formerly 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 which aim at the coordination of all actors, from grid operators to customers;
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.

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

Table of Contents

1 Introduction 7

2 Services and products 8

2.1 Demo Need in Eastern Cluster 8

2.2 Services in the Easter Cluster 9

2.2.1 Congestion management services 10

2.2.2 Voltage control services 11

2.2.3 Frequency control services 12

2.3 Products in the Eastern Cluster 13

2.4 Key parameters for products in the Eastern Demos 19

2.4.1 Congestion management 20

2.4.2 Voltage regulation 22

2.5 Requirements for flexibility service providers 27

3 Business Use Cases 32

3.1 Methodology 32

3.2 Actors 32

3.3 Czech DEMO 39

3.4 Polish demo 43

3.5 Slovenian DEMO 48

3.6 Hungarian DEMO 53

4 Flexibility Platforms and Markets in Eastern Cluster 55

5 Innovation solution 63

6 Semantic data modelling to enable data interoperability 66

6.1 Overview of Common Information Model 66

6.2 Common semantics for the standardised flexibility products 68

6.3 TSO-DSO coordination 69

7 Conclusions 70

8 References 74

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

List of Figures

Figure 1 Services plane to use by the Demos in the Easter Cluster 9

Figure 2. Key parameters for defining products identified by the [7] 20

Figure 3. The main diagram of interaction between DSO, FSP and the market platform in Czech Demo 41

Figure 4. Diagram of the market platform's interaction with market participants in the Czech Demo 56

Figure 5. Administration module scheme in the Czech Demo 57

Figure 6. Demonstrative diagram of the operating principles of the market platform in the Czech Demo..... 58

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

List of Abbreviations and Acronyms

Acronym	Meaning
aFRR	Automatic Frequency Restoration Reserves
AGNO	Aggregated Network Offer
ASM	Active System Management
BSP	Balancing Service Provider
BUC	Business Use Case
CM	Congestion management
DSO	Distribution system operator
DSR	Demand Side Response
EBGL	Electricity Balancing Guideline
E.DSO	European Distribution System Operators
EHV	Extra High Voltage
FCR	Frequency Containment Reserves
FRR	Frequency Restoration Reserves
mFRR	manual Frequency Restoration Reserves
FSP	Flexibility Service Provider
HERM	Harmonised Electricity Role Model
LFC	Load Frequency Control
mFRR	Manual Frequency Restoration Reserves
MS	Member State
RES	Renewable Energy Sources
RR	Replacement Reserves
SO	System operator
TSO	Transmission System Operator
RES	Renewable Energy Sources
WP	Work Package

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

1 Introduction

This deliverable is focusing on the presentation of the selected services and products by the Demos involved in the demonstration of OneNet as a part of Eastern Cluster. The document presents the most important information on selected services, along with the background information as a context explaining the decisions and directions of action taken by each of the four Demos. The most important related items to the area of the flexibility services i.e. the way the flexibility services market operates were also included as a part of this deliverable. The aim is to show the unique character of the Eastern Cluster, highlight the elements influencing the definition of services by each of the countries and present common elements and differences in the Demo approach to market-based flexibility.

The document was prepared, based on the information and data from partners involved in the demonstration of OneNet Project as a part of the Easter Cluster. Information used in this deliverable was provided by the leaders of each Demos from the Eastern Cluster: Poland, Czech, Slovenia and Hungary. Some of the information prepared by the Demos for horizontal Work Packages (WP2,3,4) are also included in this document as an integral part of the demonstration i.e. Business Use Cases, the definition of products, market description. Etc. To be consistent in the terms of terminologies and definitions used in the project, results from horizontal Work Packages were used i.e. definitions for services and products in the OneNet project from WP2.

During the preparation of this document, information and results of the work of previous initiatives, activities implemented in the European Union related to the subject of flexibility markets and services, were used. The results and experiences from other projects co-financed by the European Commission in the area of building flexible energy solutions were also used.

EN 62559-2 Use case methodology was followed for the development of the Business and System Use Cases by each of the Demo in the Project. Dedicated templates for the definition of actors and requirements, as well as their relation to each other, was used to describe the business process and the sequence diagrams for each of the Demo.

In this document, the original assumptions and information presented in previous OneNet documents have been detailed and described according to the specific nature and case of each Demo.

The document was developed by the leader of task T10.2 ENERGA-OPERATOR SA and was verified by the leaders of individual demonstrators and partners from the Eastern Cluster.

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

2 Services and products

2.1 Demo Need in Eastern Cluster

Each of the demos involved in the eastern cluster implements the scope they define and tries to solve the main problems with network management. The scope of needs on the part of DSOs is practically the same, but due to different technical, market and regulatory conditions, the approach to solving a given issue is different.

The Czech demo focuses on solving voltage and congestion problems in the distribution network resulting from the development of the electricity market. Large-scale connected photovoltaics, electric vehicles and the general increase in demand impact electricity grid operation. The project will also address the problem related to undesirable flows of reactive power in the distribution network that can limit network capacity. In order to coordinate activities between DSO and TSO, it is planned to use the traffic light system for the flexibility services.

Both the DSO and the TSO are actively involved in the implementation of the Polish demo. The activities of DSOs focus on solving problems exceeding the permissible voltage range in MV and LV networks in connection with the rapid development of distributed renewable generation, connected mainly to the LV network. Due to the global increase in demand for electricity and the development of renewable energy sources, congestion occurs in various areas of the HV and MV grids during specific events i.e. extreme weather conditions related to wind or abnormal grid operating states. The above-described situations also affect the dynamics of network operation and the balancing of the power system in Poland. The main goal of TSO during the project is to use the resources located deep in the distribution network (at the MV and LV levels) to support the balancing process of the Polish power system. In addition, the Polish demo focuses on the issue of coordination of activities between DSOs and TSOs in the field of active energy management as part of the acquired services.

The Hungarian demo aims to solve problems in the distribution network that are mainly caused by renewable energy sources. The significant increase in renewable energy sources recently connected to the MV grid at various points in the grid causes voltage problems and problems of overloading the line elements of the distribution grid. In the selected area of the grid, it is planned to use PV power plants as service providers to eliminate voltage problems in the MV grid and to eliminate the congestion of HV / MV transformers, which are overloaded due to excessive power generation in the MV grid.

The main problems of the Slovenian demo concern the management of the low voltage network, which is characterized by a specific group of customers: prosumers equipped with PV installations and heat pumps used as the main source of heat. Such a combination of generation and load can cause in specific periods voltage

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

problems and can lead to congestion of MV / LV transformers in the supply station of given consumers. The Slovenian demo focuses on using the above-described resources of the prosumers to solve network problems, both congestion and voltage by using the market platform and flexibility services.

2.2 Services in the Easter 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 that will be implemented under each of the DEMOs, including the Demos from the eastern cluster. The main areas of interest of Demos from the eastern cluster are: congestion management and voltage control services, which will be tested in every demonstration in the cluster. Additionally, in the Polish demo, it is planned to test frequency control services by the TSO provided by the resources connected to the DSO's network. The acquisition and testing of the frequency control services in the Polish Demo, depends on the result of introducing the necessary legal changes to Polish regulations. None of the Demos in the Eastern Cluster is interested in the Black start or Adequacy services. Same scope of services is implemented in the Demos from other Clusters as a part of OneNet project. Below, in the matrix developed as part of task T2.2, the main areas of interest of each demo are marked:

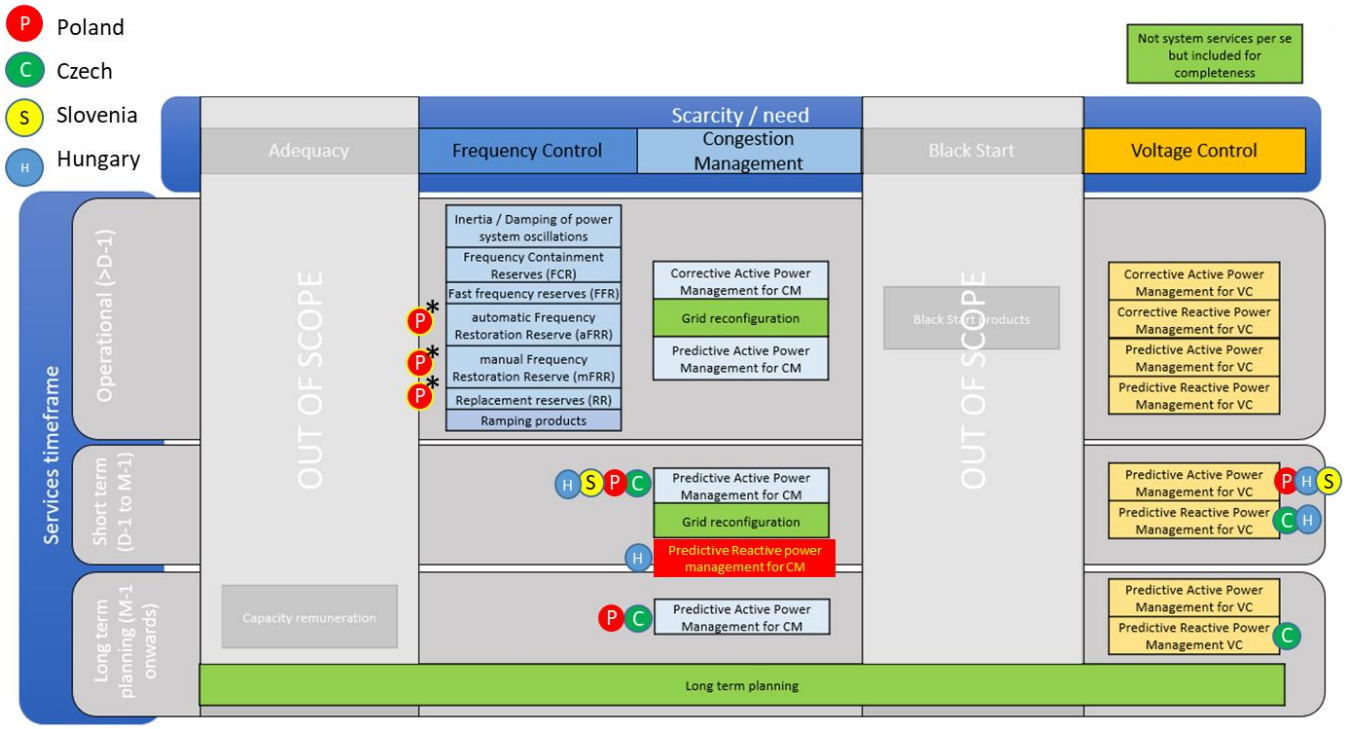

Figure 1 Services plane to use by the Demos in the Easter Cluster

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

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

Despite the provision of services from the same service catalogue, i.e. congestion management or voltage control, the scope and parameters of the services differ for each country in the Eastern Cluster. This is due to the different needs of each of the network operators involved in the implementation of a given national demonstration. 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. Czech and Polish Demo is focusing on solving problems on the HV, MV and LV network, Hungarian Demo aims to support HV and MV network and the goal of the Slovenian Demo is to protect LV network and some elements of MV network. The Polish demo is the only one that plans to test the operational timeframe balancing services. All other services that are of interest to the Eastern Cluster demonstration are in the short and long term service area.

2.2.1 Congestion management services

In the case of congestion management services, every Demo in the Eastern Cluster is expected to use services based on active power management. Only in the case of the Hungarian demo, it is also planned to use reactive power management for congestion management.

In all cases, it is assumed that the solution will be used with predictive activities in mind, mainly in the short term perspective. In the case of the Czech and Polish demos, it is also planned to be used in the long term. In the Slovenian Demo, procurement is performed in medium-term but activated in operational.

The biggest difference concerns the cases when the congestion management service is to be used. In the case of the Czech demo, the idea is to protect mainly the MV network. In the case of the Polish demo, it is planned to use resources connected to the MV and LV network for the protection of network elements: HV, MV and LV.

Slovenian and Hungarian Demos aim to use Congestion management services for the protection of transformers in the DSO network. In the case of the Slovenian demo, these are MV / LV transformers, and in the Hungarian demo, HV / MV transformers.

In the table below basic parameters for services used by DEMO in the eastern cluster is presented.

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

	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

Table 1 Congestion management service with basic parameters in each of the Demos of Eastern Cluster.

2.2.2 Voltage control services

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.

In all cases, it is 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, it is also planned to use the services in the long-term perspective. In all DEMOs, it is planned to contract both capacity and energy for services related to voltage regulation.

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.

In the table below basic parameters for services used by DEMO in the eastern cluster is presented.

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

	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

Table 2. Voltage control service with basic parameters in each of the Demos of Eastern Cluster.

2.2.3 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 regulations enabling this on the Polish balancing market (work is currently underway). Currently, the balancing services are provided mainly by large conventional centrally dispatched units. Although EHV and HV connected demand units have open access to the balancing market they are not as yet interested in participating. Poland has not yet implemented Directive 2019/944. Its implementation proposal in Polish Energy Law was consulted in 2021 but has not been adopted as yet. Further national implementation acts are still under development. The large increase of renewable generation on all voltage levels in combination with the foreseen shutdown of a large number of conventional units (due to CO2 emissions limits) leads to the need for balancing market reorganisation. First stage took place on January 1st, 2021 and opened it to wider participation of renewables, demand side response and energy storage units. The second stage is foreseen for 2022 and will include division into up and down products as defined in Electricity Balancing Guideline.

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

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).

2.3 Products in the Eastern Cluster

Based on the identified challenges by the DSO according to network management and identification services that can support System Operators in solving these challenges a list of products was prepared by the Demos in the Eastern Cluster. Basic mapping of the products by the Demos in the Onenet project was done as a part of task 2.2 from WP2. The results of the mapping are included in the [2]. As work continued, the demonstrations evolved and the originally identified products and the scope of the demonstration changed. Despite identifying similar needs by System Operators and the approach to solving problems, the products developed by individual demos differ. At a very high level of generality, the products described are very similar to each other, but when analyzing their underlying assumptions in a more detailed perspective, it will very quickly be concluded that they are more different than similar. The scope of activities within individual products is practically the same and concerns power management by service providers. This applies to both active and reactive power and - depending on the type of resource used to provide the service - can be performed both ways (reduction or increase in power), depending on the need. In the table below the products defined by each of the Demo from the Eastern Cluster have been assigned to individual services that are related to a specific need. According to the breakdown of products developed in task T2.2 of WP2 and the list of harmonized / standard products, the definition from WP2 can be also find below in the table on the next page.

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

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
		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

Table 3. Defined product by the Demos from the Eastern Cluster including definition for the standard/harmonized products according to [2].

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

In the further part of the subsection, the products for each of the Demonstrators from the eastern cluster are described in detail.

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

Demo PL

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 a possibility to provide in the day ahead market balancing services to TSO. 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.

Also, a brand new service, 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 auction 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.

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

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

Table 4. Products in the Polish Demo

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

Demo CZ

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 defined 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 (same as the product below but used for a little different purpose)
- 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)

Congestion management product is dedicated to short term, predictive and local problems. DSO 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

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

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.

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

Table 5 Products in the Czech Demo

Demo SL

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 fellfield DSOs 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.

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

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

Table 6. Products in the Slovenian Demo

Demo HUN

Hungarian Demo aims to solve congestion and voltage violation problems with the use of active and reactive power-based products. In the demo two similar products in terms of activation time, ramping, and so on were defined to fulfil DSOs needs. Both products are characterized as predictive and local products, because there are solving local needs of DSO i.e. overload of HV/MV transformer or violation of standard voltage bands on selected MV lines as a result of too high generation from RES connected to MV network. For both products, the auction will take place in two steps: capacity for ensuring availability of Flexibility Service Providers 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 System Operators 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.

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

Products proposed by Hungarian Demo	Description	Harmonised Products
HUN1: Change in active power (P) (CM & VC)	Active power (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 and energy products.	Predictive short-term local active
HUN2: Change in reactive power (Q) (CM & VC)	Reactive power (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 and energy products.	Predictive short-term local reactive

Table 7. Products in the Hungarian Demo

2.4 Key parameters for products in the Eastern Demos

When creating products, it is necessary to use clear and commonly understood concepts by all market participants, so that everyone knows exactly what the product is about. Therefore, it is necessary to define parameters that will allow for an unambiguous and understandable description of the products. As part of the previous work on the subject of flexibility, a report [7] was prepared, in which exemplary parameters for individual products were proposed. They were adopted in the next report [6] jointly prepared by DSOs as key partners to consider when developing products related to building network flexibility. The tables below show the main parameters grouped by category.

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

Timing in the product	Choices for bid design	Procurement process
Preparation period	Minimum/maximum bid size	Time granted to the market parties to offer bids
Start-up time	Divisibility allowed	Validity period of the bid
Ramping period	Direction of deviation (up/down)	Time required by the system operator to select the bids which will be activated
Full activation time	Granularity	Availability window (per day, per week, per year)
Mode of activation	Certificate of origin	Baseline methodology
Minimum/maximum duration of delivery period offer	Aggregation allowed	Measurement requirements
Deactivation period	Symmetric/asymmetric product	Penalty for non-delivery
Recovery period	Unit-based or portfolio-based within a certain geographical area allowed	Resolution (e.g.) 15min
Maximum number of activations (per day, week…)	Minimum/maximum duration of delivery period requirements	

Pricing of the product
Max./min Price
Availability price
Activation price

Characteristics of the traded good
Capacity/energy
Active/reactive energy
Location
Level of availability

Figure 2. Key parameters for defining products identified by the [7]

More detailed definitions for each of the parameters can be found in the document [7] and [2].

Not all parameters are critical and have little usefulness from the point of view of system operators. Some of them are not at all in the technical area of interest of TSOs and DSOs, e.g. Certificate of origin. To identify the parameters of key importance from system operators' perspective, an analysis of products was carried out for individual services defined by each DEMO. The tables below show the key parameters identified by each demo for each product. The local nature of the problems in operators' networks, i.e. congestion or voltage violation, makes solving the problem based mainly on local resources. Therefore, products related to congestion and voltage control management services must be local in nature. There is no such requirement for products for the balancing service.

2.4.1 Congestion management

The basic parameter that defines each product is the type of power used for a given service. In the case of Congestion management, most of the products in the Eastern cluster are based on active power. Only for product 2 in the Hungarian demo is it planned to use reactive power management for congestion management. Another basic parameter: direction of deviation (up / down) results directly from the identified problems experienced by system operators. System operators, when deciding to use a given product from the market, assume in advance what impact it will have on the network and for what purpose it will be used.

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

Depending on the voltage level of the given product, the requirements for power volumes will be different. This has a direct impact on the power granulation and power resolution that is allowed. In the case of low-voltage networks, it is at the level of 1 kW / kVAR. For medium voltage grids, it may already be higher, as is the case with product 1 in the Hungarian demo. The granulation was adopted at 50 KW and is the same for medium and high voltage.

In Polish Demo, granulation of 1 MW was adopted for the high-voltage grid. Depending on the voltage level, the minimum and maximum bid size are also different. In most cases, there is no need to define a maximum allowable bid size. The minimum bid size is also adopted at the lowest possible level, permitted by the specified power gradation. The above-described situation applies to almost all products identified by Demo. Only in the case of product 1 from the Hungarian demo, the minimum and maximum offer size for MV and HV network was indicated: 0.05-10MW. Thanks to the divisibility and aggregation of offers submitted for specific products, it is possible to increase the market liquidity. In the case of disallowing offers aggregation, there is a risk that the submitted offers will not meet the expectations and needs of the system operators. Additionally, the divisibility of the offer allows adjusting the offers to the strictly defined needs, which results in the reduction of costs for the system operator. It also has an impact on the comfort of work for some of the service providers e.g. DSR, which does not have to limit the whole production.

A common feature of almost all products for congestion management in the Eastern Cluster is an identical approach to the way of purchasing products, the time horizon of purchasing products and activating resources. All of the Demos from the Cluster assumes the use of products based on capacity and energy, purchased several weeks in advance. Most of the Demos are going to activate on the service a day before. In the case of the Slovenian Demo activation will be a part of the operational activity of the DSO.

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

Parameter	CZ	PL	HUN1	HUN2	SL
Power: active/reactive	Active	Active	Active	Reactive	Active
Direction of deviation (up/down)	down	up/down	up/down	up/down	down
Granularity and Voltage levels	LV: 1 kW	HV: 1MW MV: 1kW LV: 1 kW	HV: 0,05MW MV: 0,05MW	HV: 1MVAR MV:1kVAR	LV: 1 kW
Minimum/maximum bid size	LV: 1kW – n/a	HV: 1MW - n/a MV: 1kW - n/a LV: 1 kW - n/a	0,05MW - 10MW	n/a	LV: 1kW - n/a
Divisibility allowed	yes	yes	yes	yes	yes
Aggregation allowed	yes	yes	yes	yes	yes
Capacity/energy	Capacity and/or energy	Capacity and/or energy	Capacity and/or energy	Capacity and/or energy	Capacity and energy
Procurement	Week(s) Ahead	Week(s) Ahead	Week(s) Ahead	Week(s) Ahead	Week(s) Ahead
Activation	D-1	D-1	D-1	D-1	Operational

Table 8. List of selected parameters for the Congestion management products in the Eastern Cluster Demos.

2.4.2 Voltage regulation

A lot of parameters set by the demo for the Voltage regulation products are the same as for the Congestion management. Similar to Congestion Management, the basic parameter that defines each product is the type of power on which a given service is based. In the case of Voltage control, products in the Eastern cluster are based on both active and reactive power. Czech Demo will use only products based on the reactive power for voltage control. Hungarian demo plan to use both active and reactive power management for voltage control.

Same as in the case of Congestion management direction of deviation (up / down) results directly from the identified problems experienced by system operators. System operators, when deciding to use a given product from the market, assume in advance what impact it will have on the network and for what purpose it will be

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

used. Due to the nature of the phenomena related to voltage regulation, it is very important that the DSO has the appropriate level of knowledge about the possible effects of the actions performed. Depending on the voltage level of the given product, the requirements for power volumes will be different. This has a direct impact on the power granulation and power resolution that is allowed. In the case of low-voltage networks, it is at the level of 1 kW / kVAR. For medium voltage grids, it may already be higher, as is the case with product 1 in the Hungarian demo. The granulation was adopted at 50 KW and is the same for medium and high voltage. Depending on the voltage level, the minimum and maximum bid size is also different. In most cases, there is no need to define a maximum allowable bid size. Only in the case of the Czech Demo, the maximum bid size has been specified. The minimum bid size is also adopted at the lowest possible level, permitted by the specified power gradation. The above-described situation applies to almost all products identified by Demo. Only in the case of product 1 from the Hungarian demo, the minimum and maximum offer size for MV and LV network was indicated: 0.05-10MW. Thanks to the divisibility and aggregation of offers submitted for specific products, it is possible to increase the market liquidity. In the case of disallowing offers aggregation, there is a risk that the submitted offers will not meet the expectations and needs of the system operators. Additionally, the divisibility of the offer allows adjusting the offers to the strictly defined needs, which results in the reduction of costs for the system operator. It also has an impact on the comfort of work for some of the service providers e.g. DSR, which does not have to limit the whole production.

A common feature of almost all products for Voltage regulation in the Eastern Cluster is an identical approach to the way of purchasing products, the time horizon of purchasing products and activating resources. Only in the case of the Czech Demo, procurement of the service related to voltage regulation is different than other demos. Czech Demo assumes to contract the services in the long term (more than a week(s) ahead). Except for the Czech Demo, all Demos from Cluster assumes the use of products based on capacity and energy, purchased several weeks in advance. The Polish and Hungarian Demos are going to activate the service in the day ahead time frame. Slovenian and Czech demo activation procedure will be taken as a part of the operational activity of the DSO. Also, product for Voltage regulation in the Czech demo will be a capacity product.

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

Parameter	CZ	PL	HUN1	HUN2	SL
Power: active/reactive	Reactive	Active	Active	Reactive	Active
Direction of deviation(up/down)	up/down	up/down	up/down	up/down	down
Granularity and Voltage levels	HV:1 MVAR MV: 100 kVAR	MV: 1kW LV: 1 kW	HV: 0,05MW MV: 0,05MW	HV: 1MVAR MV:1kVAR	LV: 1 kW
Minimum/maximum bid size	HV: 1 MVAR - 10x MVAR, MV: 100 kVAR - 1x MVAR	MV: 1kW - n/a LV: 1 kW - n/a	0,05MW - 10MW	n/a	LV: 1kW - n/a
Divisibility allowed	yes	yes	yes	yes	yes
Aggregation allowed	yes	yes	yes	yes	yes
Capacity/energy	Capacity	Capacity and/or energy	Capacity and/or energy	Capacity and/or energy	Capacity and energy
Procurement	Long term	Week(s) Ahead	Week(s) Ahead	Week(s) Ahead	Week(s) Ahead
Activation	Operational	D-1	D-1	D-1	Operational

Table 9. List of selected parameters for the Voltage regulation products in the Eastern Cluster Demos.

As part of the work on services and products, a list of the most important elements and parameters from the Eastern Cluster DSOs point of view was defined. Based on the presented data and information, it is possible to develop a general description and basic assumptions for future harmonized services and products for the DSOs needs in the Eastern Cluster. It is very difficult to develop standard products for DSOs in the scope similar to those used by TSO for balancing (aFRR, mFRR, FCR, ...) because each demo has its own unique character and approaches the topic of product definition in an individual way. As can be seen from the above descriptions and tables, all of the demos within the Eastern cluster plan to test services for congestion management and voltage regulation. Based on the data presented in the Table 9 for these services, the main thoughts and an idea on possible directions of product harmonization from the point of view of the Demos from Eastern Cluster are presented.

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

An obligatory element in the case of congestion management and voltage control services is the FSP's localization in the network. Both issues are having a local nature of the problem, and need to be solved with the resources that are within a specific area of the network, near the source of the problem [6].

Products for congestion management are primarily based on active power regulation. In all demos from the Eastern Cluster, there is an active power product dedicated to congestion management. Hungarian Demo is the only one that also developed the Congestion management product based on reactive power management. It is a less popular approach, but in special cases, it can bring the expected results with less interference in the way a given FSP works.

Products for Voltage regulation in the Eastern Cluster are based both on reactive and active power. The common approach for voltage regulation in the network is to control reactive power flow. Reactive power flows in comparison with the active power are more complex, need more data and measurements from the network and need an advance tool for grid analysis. Control of reactive power flow is also more complex in the case of the mesh network. Before taking any action by the system operator, it is necessary to perform a thorough network analysis so as not to worsen the network operating conditions by accident.

An alternative way for controlling the voltage level in the network is active power control. Such approach is often used by DSOs if they don't have knowledge about the reactive power flow in the network. This solution gives very good results in the case of radial networks. The main drawback is influencing the balancing of the network and the necessity to limit the consumption of active energy, which is always related to the performance of some work. Such a situation does not occur, or it occurs to a minimum extent when reactive power is used to regulate the voltage. In some cases, the full range of reactive power regulation is only achievable with a change in active power. This change is significantly smaller than if only the active power was used in the voltage regulation process.

The use of active power for voltage regulation may bring the expected results, but this applies mainly to MV and LV networks with a radial structure. In the case of HV networks that are built as mesh networks, it is not reasonable to control the voltage level in this way. Achieving the expected effect requires too large volumes of power, which may adversely affect the balancing of the system.

In some cases, similar or even the same active power based product may be used for congestion management and voltage. Such a situation take place in Polish and Hungarian Demo. Thanks to this approach, it is possible to simplify the market and make it clearer and more transparent for the FSP.

In the case of products based on active power, a very important element that has already been mentioned is the influence on the system balancing. In cases where DSO decides to purchase and activate products based on active power, it is reasonable to provide information about the deviation of active power to TSO or other

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

entities responsible for system balancing. If the market for flexibility services is integrated with the balancing market, it is possible to develop mechanisms that optimize the use of active power products by DSOs and TSOs. As part of the Polish demo, such a mechanism is developed. It has been described in more detail in chapter 5. Market integration makes it possible to take into account the needs of both operators as part of the purchase of one service and the possibility of using - after meeting the appropriate conditions - resources that have not won the auction for active power CM or VC for balancing purposes.

An important element is the method of contracting services and activation of the resource. However, it is a key parameter that influences what type of service providers will be able to provide services. Too short activation time and procurement at the last minute may exclude potential service providers from the market. On the other hand, purchasing and activating services well in advance puts System Operators at the risk of purchasing a service that will ultimately not be required within a given period of time, causing unnecessary costs.

In the Eastern Cluster, no demo plans to use market solutions to manage congestion at the operational level. In the case of voltage regulation, the Slovenian and Czech Demos plan to take close-to-real-time measures in the field of voltage regulation. This is due to the use of resources that have the ability to quickly change power and are equipped with inverters that enable remote control.

The main time parameter defined by the DSO in the eastern cluster was the duration of the service and time for full activation. None of the Demos specified detailed requirements for ramping up/down time after sending the activation signal. In the case of DSO services, these are not as critical parameters as in the case of balancing services. As a result, both Manual and Automatic ways to control for flexibility resources are allowed in the Eastern cluster demos.

DSOs from the Eastern cluster allow for aggregation and division of offers during biding on the market platform, both in the case of congestion management and voltage regulation services. Such actions increase the possibilities of optimal selection of resources to solve the problem in the distribution network. The possibility of using not only the full potential of a given resource but also part of it allows for more efficient use of resources and reduction of costs on the part of System Operators. Nevertheless, it should be remembered that most decisions about the purchase of services by System Operators are made based on computer network analyses, based on forecasts, which may be inaccurate. In extreme cases, when there is a deviation from the forecast, it may happen that the optimal amount of power contracted in advance does not allow for the elimination of the threat in the network. In such situations, System Operators are forced to use corrective market tools, i.e. intraday products. In the absence of such tools, they should use other, non-market solutions to adapt the operation of the network to the prevailing conditions.

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

As described above, during the OneNet project, a set of key parameters was defined by system operator during the development of the products. Each parameter, specified in detail, is limiting the possibilities of submitting an offer, affects the market liquidity and introduces restrictions for service providers. This mainly concerns the power requirements and the timing of service delivery. System Operators should use common sense and understanding towards service providers to jointly build a market for flexibility services. Operators should strive to define as few unique, harmonized or even standardized products as possible, so as not to lead to too much fragmentation, which may result in a reduction in market transparency for flexibility service providers and adversely affect market development.

2.5 Requirements for flexibility service providers

The requirements for customers who are going to play the role of flexibility service providers for system operators result directly from the needs of DSOs and TSOs. These, on the other hand, are directly related to the nature of the physical phenomena that cause a given, undesirable situation in the network. The requirements set by system operators towards flexibility service providers are a very important factor that affects the shape of the market.

The basic elements required for a given entity to provide services to system operators is to have adequate energy resources that can be controlled. This applies to both generation units as well as devices consuming energy from the grid.

One of the key elements is the measurement system that allows monitoring the work of given resources of the entity that decides to become the FSP. The role of such system may be a properly configured smart meter with the possibility of remote data reading and with an appropriate gradation of the measurements. The meter should be capable of counting energy both consumed and fed into the network. Without this, it is not possible to verify the correctness of the service provision in accordance with the concluded contract between SO and FSP. Meter data is also required for the correct billing of the service. Depending on what type of service a given FSP plans to provide, an advanced real-time energy monitoring system on the FSP site is or is not required. Such systems have the advantage of allowing the FSP to keep track of its resources. In the event of deviations from the contracted value, the FSP can react quickly and compensate for the deviation from the contracted parameters. Many medium and big business customers have their own system for energy control, due to the nature of their work.

Depending on the type and the technology of the device that is used as the resource for flexibility service there can be a different possibility to control it. The way of control of the FSPs resource can be very important in some cases when a specific time of reaction or taking action is needed.

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

Services in the area of balancing and frequency control have much more stringent requirements compared to other services, such as congestion management or voltage regulation. The biggest difference is related to the required time parameters, i.e. activation time, time to obtain maximum power, time of service provision, etc. In many cases, it is necessary to use direct communication between the FSP object and the SO with the control automatics allowing for the control of the given resource directly by the SO. This is due to the nature of physical phenomena and the speed of changes taking place during the frequency regulation.

In case of the congestion management or voltage regulation services, requirements of the monitoring and control system depend on the time frame in which we want to counteract undesirable phenomena in the network. The approach to the control of resources is different in the case of planned works weeks in advance, where a deviation from the planned work schedule is acceptable and different in the case of quick reactions to network congestion caused by the failure in the network. The different requirements may be set for FSPs in the case of long/mid term products compare to short term products.

The ability to fully control and smoothly adjust the output/input power of a given resource by the FSP is a very important feature that allows a very flexible provision of services to system operators. The inability to fluently regulate the power of the resource may result from many factors, i.e. technological limitations of a given FSP. The ability to work only in one of the two states (max <-> min power) is not always a disadvantage, but it is not an optimal solution for technical and economic reasons.

The approach to providing services to SOs should be technology-independent. System Operators should make every effort to build the market and ensure that all entities that have the technical capacity participate in it. Badly imposed requirements for flexibility service providers can significantly limit the market and cut out a large number of entities that, in the case of less stringent requirements, could provide services for System Operators. The idea of a super product (described in [2]) that allows solving any problems in the DSO and TSO networks with only one product may also lead to the market of flexibility services being dominated by one type of service provider using a specific technology.

The flexibility requirements for the service provider in each demo are presented below as a short description. They were prepared based on the assumed scope of services that will be tested during the demonstration in each of the countries of the Eastern Cluster.

Czech Demo:

The parameters and criteria for non-frequency flexibility/services are set through grid code issued by the Commission for the operation of distribution grid (non state expert group consisted of main DSOs). These criteria concern five non-frequency services: black start, islanding operation, nodal area congestion

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

management, reactive power management and voltage control (however the project will test only three of them). This grid code details mainly technical requirements for units providing flexibility – limits for active/reactive power, remote control of resources (connection to DSO dispatching center) etc.
Requirements concerning service procurement and market operation are partly defined in the Energy law. There are provisions concerning communication between DSO and flexibility providers on planned outages/outages including time limits for the announcement of these events. After the traffic light scheme enabling centralized data exchange is in place all market participants/flexibility providers will have to take into consideration information on grid availability indication. New contracts with flexibility providers will also involve further requirements concerning data exchange on contracted/activated flexibility for grid operation planning purposes.

Polish Demo:

The Polish demo focuses on the use of resources connected to the distribution network, mainly from MV and LV levels, to improve the efficiency of the power system. The main objective is to support TSO in balancing the system and DSOs in managing congestion in the HV, MV and LV networks and voltage regulation in the MV and LV networks.

As network congestion and voltage problems are local problems, it is imperative that the flexibility service providers are in a well-defined area. In the OneNet project, these are the areas where the demonstration will be carried out. This is a basic requirement for the FSP by the distribution network operator.
Balancing services are not dependent on location in any way, as the system balancing process is a global issue.
As part of the tests in the Polish demo, it is planned to use the ability to control the power consumed by various types of customers and to control the generation power of various generation sources. The group of customers with control of the power consumption includes household consumers, small and medium businesses entities and utility facilities. The group of customers with control generating power includes prosumers equipped with photovoltaics, wind farms, and gas power plants. Additionally, the project plans to use energy storage located in the demonstration areas, which combine the ability to control the level of consumption and generation of electricity. Depending on their technological solutions, customers will use various tools to manage their power: controlling inverters at PV, controlling heat pumps, changing the technological process, switching to their own power supply, controlling the output power of generators. The requirement related to the monitoring system is solved by the use of smart meters implemented as part of the AMI system in EOP.

Lack of knowledge about the flexibility services market and limited experience in providing services for DSOs in Poland forced the adoption of very safe requirements for FSP by DSOs. During the demonstration, DSO had to focus on the long term and day ahead products for Congestion management and Voltage Regulation

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

services. It resulted directly from the limited number of entities on the market prepared to provide DSO services, with activation time shorter than 24 hours.

As shown inTable 8 and Table 9 the minimum power of the resource that can provide congestion management and voltage regulation services depends on the voltage level. Nevertheless, the power requirements for the FSPs' resources were set to the minimum level (single kW in LV and MV case and single MW for HV) in order not to restrict the emerging market.

In the Polish Demo, it was planned to involve entities naturally operating on the energy market in the tests. The DSO does not impose any requirements regarding the technology that can participate in the process of limitation management or voltage regulation. Additionally, in the Polish demo, the same product is to be used for congestion management and voltage regulation. Consequently, there are no individual requirements for either service. No requirements for the ability to automatically or locally control resources by the FSP have been imposed for congestion management and voltage control services.

Slovenian Demo:

The Slovenian demo is focusing on solving problems locally in the LV networks, which are caused by increasing consumption of energy by the customers and expansion of renewable energy sources. The main problems are the overload of the MV/LV transformers and power lines and voltage violation in the LV networks. The LV networks were selected based on feasibility analysis. The flexibility is procured from aggregated demand response. The Congestion Management and Voltage control services will be provided by the aggregator GEN-I.

The aggregator combines households with heat pumps in its portfolio to solve the congestion of grid elements. Switching off heat pumps can prevent the transformer from overheating and line congestion. The aggregator also combines PV household power plants with batteries to solve the voltage problems in the LV network. When voltage control is needed, active power curtailment would be activated via an inverter. The excess energy would be used to charge the battery systems and the stored energy could be used later in the day. In the process of acquiring customers, which would be participating in the project, motivational factors such as financial benefits and guarantee of minimal impact on comfort and the absence of risks were used.

The expected response time after the call from the DSO to solve problems in the LV network is 15 minutes (to reach 100 % of service provision). The minimum quantity or bid size for congestion management is set to 1 kW for DSO products.

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

Hungarian Demo:

The Hungarian demo is focusing mainly on the problems arising from the high penetration of generation sources (mainly PV) in the MV and LV network. The generator connection guideline of DSOs prescribes load flow calculation, whether the new PV will cause $\Delta 2\%$ voltage increase or not. A lot of overhead lines are already „saturated" due to the PV proliferation. Besides voltage increase the PVs also can cause HV/MV transformer overloading according to load flow calculation, this is the other reason of „saturation" of a HV/MV substation supply area. The above mentioned phenomenon prohibits the connection of new renewables. The Hungarian Network code allows DSOs to use classical flexibility services, non-market-based redispatch, and so called flexible connection. Flexible connection means that instead of the reinforcement of the grid, DSOs can allow new customers to connect the network provided that the customer agrees to be constrained off when the network is close to capacity limits. The non-market-based redispatch can be the last resort, i.e. DSO has a right to curtail the production of a generator (in case of renewables it cannot exceed the 5% of the yearly production).

The Hungarian Demo is focusing on the use PV plants as flexibility providers in the OneNet Project. These can be both market or non-market based it depends on the liquidity of the market and the intention of the PV plants. If there will be not enough market offers then DSO has to use the non-market based flexibility, nonetheless, this type of flexibility also has an official price which was laid in the Network code. The main difference between of non-market based flexibility resources from a selection point of view will be the so called sensitivity factor. Of course, this factor will have also a role in market based flexibility provision, but in that case, the price differences have an impact on the merit order list contrary to non-market based flexibility. The non-market based flexibility resources also will be involved in Merit Order List.

As the Hungarian demo is based only on PV installations, it was possible to define specific requirements with specific parameters and values in relation to service providers. Both P (Active) and Q (Reactive) products have the same set of parameters, nevertheless, the goods of the product differ. In the case of P product PV plants will provide active power which causes production outages (i.e. lower revenue for the owner). On the other hand, the case of Q product will not cause production outages.

The rational of using both products is that the inverter of PVs is not capable to provide enough Q without reducing the P, so P product also can contribute to voltage band violation mitigation. The other reason is that MV Overhead lines ratio of R/X is ~1, which means that both P and Q has the same efficiency from the voltage control point of view. PV installations are capable to provide a short activation time, furthermore the controlled variable (Voltage) can be rooted back to 10 min RMS measurement which is the basis of EN 50160 standard as well (which has to be considered when we examine the complaints of customers). The maximum required time for full activation was defined on the level of 12,5 minutes and maximum deactivation period to 10 minutes

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

(similar to mFRR product). The required duration of the service is set to the time period between 1 and 6 h. Hungarian demo plan to mitigate the negative effect of PV plants for supply quality, but the cause of the negative effect is the PV itself, with its special profile (gauss curve like), the possible violation of voltage band can be 6 hours maximum (at the latitude where Hungary is located).

3 Business Use Cases

3.1 Methodology

One of the crucial parts of developing the OneNet solution was to define clear business objects by each of the Demos. The idea of the OneNet project is to build an open and unified solution, that experience and results of the project can be easily used in future installation that is repeatable and scalable. Similar to the previous project related to flexibility solutions a standard approach to the development of the documents was used. Based on best practice from previous projects, OneNet also uses a standard IEC 62599 for a description of all use cases. This process is specified by a template in the standard IEC 62559-2. Thanks to this approach a clear description was possible. The full standard template has eight sections, each of which provides information about the use case from different viewpoints:

1. Description of the Use Case,
2. Diagrams of the Use Case,
3. Technical details,
4. Step by step analysis of the Use Case,
5. Information exchanged,
6. Requirements,
7. Common terms and definitions,
8. Custom information.

BUCs were used by the DEMO to further develop their solutions, especially preparing a description for System Use Cases (SUC). BUC was developed as a part of Work Package 2, under task 2.3. A full description of the methodology used by the Demos is described in the public document [5].

3.2 Actors

Identifying all entities that may be involved in the implementation of a given business process is necessary to correctly describe the process and allows for taking into account all aspects of a given activity. The scope of

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

activities of each of the actors may be differently defined and understood by different market participants. Additionally, in some cases, some of the entities operating in the energy market may play more than one role in relation to the way the market is shaped in a given country. As part of defining BUC, each of the Demos from the Eastern Cluster defined which entities operating on the energy market will be involved in individual business processes. For each developed BUC, the main actors were identified along with the definition of its role and a short description.

In the case of the Czech DEMO, for the three developed BUCs, a total of 3 actors of the business type and 2 actors of the IT systems type were determined:

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 resources (DER).
Unit/Flexibility provider	Business	Single units (part of the portfolio of the aggregator) proving flexibility to the distribution grid operator.
Platform	IT	IT environment allowing for market parties exchange of market-based flexibility products, providing necessary feedback both on Aggregators/Units involved in flexibility provision. Moreover, in gives all participant relevant information on the grid availability through traffic light scheme.
LMS	IT	IT system allowing planning of charging patterns according to expected grid conditions and RES production

Table 10. Key actors in the Czech Demo.

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

In the case of the Polish demo, a total of 10 business-type actors were defined for 4 BUC:

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
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
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.

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

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

Table 11. Key actors in the Polish Demo.

In the case of the Slovenian demo for 2 BUC, 4 actors were defined:

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

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

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.
		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.

Table 12. Key actors in the Slovenian Demo.

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

In the case of the Hungarian demo, for the 2 developed BUCs, a total of 5 actors were identified for which a more detailed actor type was indicated:

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

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

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 carry out market clearing process.
OneNet common platform (Hungarian platform for TSO-DSO coordination)	• 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.

Table 13. Key actors in the Hungarian Demo.

As the scope of individual demos differed from each other, therefore, in some cases, the scope of the definition of a given actor may be treated more broadly. In the case of FSP, in addition to individual service providers, aggregators and aggregated FSPs also fall within the scope of this actor. In some cases, DSO may also act as a collector and supplier of metering data for the needs of the flexibility services market.

Despite the different approaches to the way of defining individual actors and their roles, it is possible to choose the key actors who were identified by each of the demos (despite the differences in nomenclature). Generally, 4 main actors were identified as a part of each of the Demos in the Eastern Cluster BUC description:

- Distribution System Operator
- Transmission System Operator
- Market Operator
- Flexibility Services Provider

Since all 4 demos in the Eastern Cluster focus on Congestion Management and Voltage Control services, these 4 actors are necessary to carry out market activities resulting in system operators obtaining the necessary services from customers acting as flexibility service providers. Additionally, these four actors form a fully complete system operator - market platform - customers chain.

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

The Polish demo is the only one from the Eastern Cluster that additionally focuses on the use of flexibility services for balancing the Polish power system. This results in the necessity to establish a connection between the flexibility market and the currently functioning balancing market in Poland. Therefore, there are a greater number of unique actors compared to other demos from the eastern cluster.

ENSTO-E, as an organization associating all transmission operators from Europe, strives to develop standards that will be unambiguous throughout Europe. Together with other organizations, it carries out activities aimed at developing harmonized and standardized definitions for individual actors and their role in the energy market in Europe. The Harmonized Electricity Role Model (HERM) document is continuously developed and adapted to the changing energy market, regulation and legal environment. As part of task 2.5, the OneNet project works to verify how the definition of individual actors adopted by the Demo and their roles fit into the definitions from HERM. More information on this topic and the results of the analysis can be found in the public report of the OneNet Project: [9].

3.3 Czech DEMO

The main goal of the Czech demonstration is to test how flexibility services acquired on the market base rules can support DSOs in their day activates and enhance grid efficiency. The main part of the demonstration is the development of a new flexibility market platform for non-frequency services which will be used as a supporting tool by DSOs. Issues that the demonstration is going to deal with, are congestion management of various line elements of the network and problems related to the voltage mainly voltage violation in the network and the undesirable reactive power flows. The goal of the demonstration is to verify how active and reactive power products can solve those problems. The traffic light scheme developed as a part of the demonstration will be used for the coordination between the system operators. The expected results of the demonstration will impact analysis of active network management by utilization of grid services thanks to the development of a new environment for active customers, new business models and increase of grid hosting capacity for RES and decentralized generation. In Czech demo 3 Business Use Cases was developed under OneNet project activities to achieved identified business objective:

- Nodal area congestion management
- Reactive power overflow management
- Voltage control

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

First BUC (Nodal area congestion management) – the objective of this BUC is to identify a relevant way of service procurement to address local congestion management in the distribution networks. The performed test of this BUC is expected to deliver knowledge on how to specify bids/offers (data format for bid announcement, specific parameters of bid, transparent market environment, activation of flexibility). The BUC will inquire into market-based procurement of non-frequency service (congestion management) for System Operators, with the idea of solving local congestion through management of the active power provided through units connected to the LV network. The DSO procures the service at the dedicated market platform where it determines location, reserved capacity (MW) and duration of the service. Flexibility Service Provider can indicate his capacities simultaneously in the same environment (market platform). The platform ensures all parties will receive the notification about called auctions. Once a relevant offer is accepted by the DSO, the given flexibility service provider will receive confirmation through the market platform. After the service is accepted (by both parties), the relevant provider sends the list of units involved in the provision of the service. This amount of flexibility is reported to the dispatch control centre of the relevant DSO – to enable grid planning/scheduling. Relevant units are directed by DSO through the Aggregator (which possess direct control of the flexibility resources). The metering/billing is processed bilaterally between DSO and flexibility provider. All activities in this BUC are divided into a few scenarios:

- Grid evaluation - runs by DSO to validate the grid in terms of load capacity and future load profile/grid users connected.
- Market phase – this process is focussing on the communication on auction, collection and selection bids by the market platform
- Activation phase - flexibility bids selected by the market and accepted by the DSO are activated to solve the forecasted congestion management

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

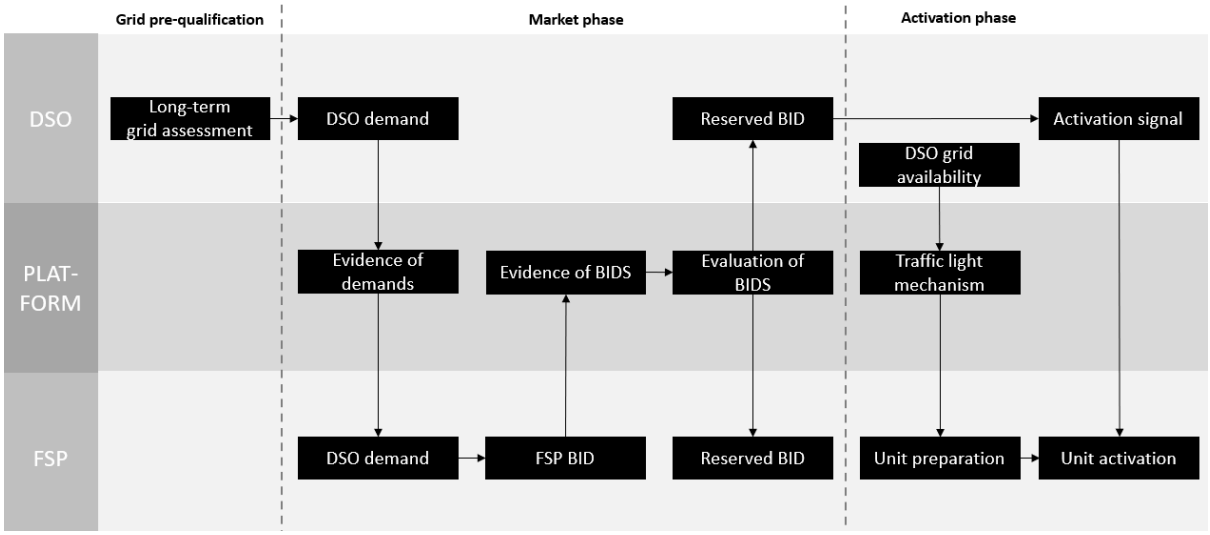

Figure 3. The main diagram of interaction between DSO, FSP and the market platform in Czech Demo

The main actors involved in this BUC are: Distribution System Operator (DSO), Aggregator, Platform, Unit/Flexibility provider, LMS.

Second BUC (Reactive power overflow management)- is describing a process of identifying relevant ways of service procurement to control the flow of reactive power between TSO and DSO in order to keep reactive power flows within given limits. The test is expected to deliver knowledge on how to specify bids/offers (data format for bid announcement, specific parameters of bid, transparent market environment). Nowadays reactive power overflows from DSO to TSO are controlled through management of the reactive power provided through units (generators/units) at the Medium Voltage/High Voltage level. The BUC will inquire into market-based procurement of non-frequency service (reactive power flow) for DSO to keep reactive power overflows within limits agreed between DSO and TSO. The BUC assumes that the DSO procures the service of reactive power management at the dedicated market platform by calling an auction that includes locality, reserved capacity (MVAr) and duration of the service. The Flexibility Service Provider can submit their capacities simultaneously at the same environment (market platform). The platform will ensure all parties will receive the notification about bids. Once relevant offer is accepted by the DSO, the given flexibility service provider will receive confirmation through the market platform. After the service is accepted (by both parties), the relevant provider sends the list of units involved in the provision of the service. This amount of flexibility is reported to the dispatch control centre of the relevant DSO – to enable grid planning/scheduling. Relevant units are directed by DSO through the Aggregator (which possess direct control of the flexibility resources). The metering/billing is processed bilaterally between DSO and flexibility provider. All activities in this BUC are divided into a few scenarios:

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

- Grid evaluation – the process of long term grid assessment concerning flows of reactive power between TSO and DSO
- Market phase - this process is focussing on the communication on auction, collection and selection bids by the market platform

Main actors involved in this BUC are: Distribution System Operator (DSO), Aggregator, Platform, Unit/Flexibility provider

Third BUC (Voltage control) - is describing a process of identification of relevant way of service procurement to address voltage issues in the distribution networks through reactive power. The test is expected to deliver knowledge on how to specify bids/offers (data format for bid announcement, specific parameters of bid, transparent market environment). The BUC will inquire into market-based procurement of non-frequency service (voltage control) for DSO. The voltage is controlled through the management of the reactive power provided through units (generators/units) at the Middle Voltage/High Voltage level. The product is meant to keep the voltage within given limits in terms of quality of supply. The BUC assumes that the DSO procures the service of voltage control at the dedicated market platform by calling an auction that includes locality, reserved capacity (MVAr) and duration of the service. The Flexibility Service Provider can submit their capacities simultaneously at the same environment (market platform). The platform will ensure all parties will receive the notification about bids. Once a relevant offer is accepted by the DSO, the given flexibility service provider will receive confirmation through the market platform. After the service is accepted (by both parties), the relevant provider sends the list of units involved in the provision of the service. This amount of flexibility is reported to the dispatch control centre of the relevant DSO – to enable grid planning/scheduling. Relevant units are directed by DSO through the Aggregator (which possess direct control of the flexibility resources). The metering/billing is processed bilaterally between DSO and flexibility provider. All activities in this BUC is divided into a few scenarios:

- Grid evaluation – process of long term grid assessment concerning the capacity of grid in terms of keeping voltage in given limits
- Market phase - this process is focussing on the communication on auction, collection and selection bids by the market platform

Main actors involved in this BUC are: Distribution System Operator (DSO), Aggregator, Platform, Unit/Flexibility provider.

More detailed information about Czech Demo BUC can be found in [5].

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

3.4 Polish demo

The main goal of the Polish demonstration is to test how market driven flexibility can increase national system stability and improve TSOs and DSOs network operation. The main area of TSO interest is the use of resources connected to the DSO distribution network (mainly at the MV and LV levels) to support the balancing processes of the national power system, which today is done with the use of large units connected to the HV grid. The DSO plans to use the flexibility and possibility of controlling the resources connected to the MV and LV grids to support the distribution network in certain situations in order to eliminate overloads and maintain the voltage within the permissible range. To achieve this goal a new market platform for flexibility services is developed with a design of all procedures and methods of cooperation between different market users. In Polish demo 4 Business Use Cases were developed under OneNet project activities to achieved identified business objective:

1. Prequalification of resources provided by Flexibility Service Providers to support flexibility services in the Polish Demo
2. Managing flexibility delivered by DER to provide balancing services to TSO
3. Event-driven Active Power Management for Congestion Management and voltage control by the DSO
4. Balancing Service Provider (BSP) on the Flexibility Platform

The above-mentioned BUCs fully describe the entire business process of purchasing services by DSO and TSO from flexible service providers with the use of the market platform. In each of the BUCs, the key market participants involved in a given process were identified, along with all activities that must be performed to achieve the assumed business goal of the Polish Demo.

First BUC (Prequalification of resources provided by Flexibility Service Providers to support flexibility services in the Polish Demo) is a dedicated whole process of registration, verification, certification flexibility service provider on the market platform called prequalification. The use case describes the prequalification process of Distribution Energy Resources (DER) introduced by Flexibility Service Provider that will be registered in Flexibility Register. This registration is the prerequisite to participate in flexibility market processes on Flexibility Platform. The DER can be based on generation resources, energy storage and consumption (households, Small and Medium Enterprises s and industrial enterprises). The Flexibility Service Provider can own one or more DERs or can be an aggregator which aggregates several DERs in its portfolio (called as Flexibility Service Provider Aggregator). All activities in this BUC are divided into a few scenarios:

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

- Market prequalification of FSP - the purpose of market prequalification is to confirm the legal and financial status of FSP and provide it with access to the flexibility platform. There is a separate scenario for FSP being an aggregator.

- Certification - the certification process aims to provide technical data of the resources constituting the DER proving the basic service capacity. The system operator who verifies the possibility of providing services also takes part in the certification process.

- Product prequalification - the purpose of product prequalification is to confirm the feasibility of delivering the products selected by FSP. It is an iterative process for each product separately. In the case of balancing products, additional conditions must be met.

- Static grid prequalification - the purpose of static grid prequalification is to reject or limit those resources that will always breach the grid security limit under normal circumstances.

- Market prequalification of FSPA - the purpose of market prequalification is to confirm the legal and financial status of FSPA and provide it with access to the flexibility platform. There is a separate scenario for FSP being an aggregator.

- Certification of portfolio and SDER (significant DER for the network or the system) - the certification process aims to provide technical data of the resources constituting the SDER proving the basic service capacity and basic information of portfolios allocated to the TSO-DSO coupling points. The system operator who verifies the possibility of providing services also takes part in the certification process.

- Product prequalification - the purpose of product prequalification is to confirm the feasibility of delivering the products selected by FSPA. It is an iterative process for each product separately. In the case of balancing products, additional conditions must be met.

Main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), System Operator (SO), Flexibility Service Provider (FSP), Flexibility Service Provider being Aggregator (FSPA), Market Operator (MO) or Flexibility Platform Operator (FPO), Balancing Service Provider, Metered Data Responsible, Metered Data Collector. In Poland at this moment DSO acts as the Metered Data Responsible, Metered Data Collector.

The second BUC (Managing flexibility delivered by DER to provide balancing services to TSO) scope is to bring the flexibility provided by resources connected to the distribution network at Low and Medium voltage level in the form of active power and/or active energy to the polish TSO balancing market. This BUC will ensure that the energy system is balanced and frequency is kept within the permitted range due to opening a balancing market

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

for resources connected to the distribution network (LV/MV). Very important part of using resources connected to DSO's network by other entities like the TSO is well developed rules for coordination between those entities and DSO when using flexibility services and ensure the safety of the DSOs network. The use case describes the process of purchasing flexible services in day-ahead horizon based on active power and/or active energy for TSO needs and then using these services for balancing purposes. Balancing services for TSO are procured on a continuous basis. The purchase of services takes place on the Balancing Market platform according to the rules described in Terms and Conditions Related to Balancing. Only Balancing Service Providers (BSPs) who have positively passed the prequalification process can offer balancing services. In case their resources are located in DSO's grid (LV/MV) submitting bids for balancing services is only possible through the Flexibility Platform. In the day-ahead mode, it is distinguished by the acquisition of capacity (Primary Balancing Capacity Market) and balancing energy (Day-Ahead Balancing Energy Market). Flexibility market platform is the main tool used for collecting offers from resources connected to MV and LV network owned by the DSO that want to provide balancing services for the TSO and verifying process in terms of technical possibilities of using those resources, taking into account the operating conditions of the DSO network. The process using offers from flexibility market platforms for balancing purposes by TSO is divided into a few scenarios:

- Collecting offers for balancing capacity products from BSPs whose sources are located in the DSO network
- Formal verification of offers for balancing capacity products and selection of offers on the Flexibility Platform
- Verification of technical feasibility of offers for balancing capacity products and selection of offers by DSO
- Transfer of offers for balancing capacity products to the Balancing Market within the Primary Balancing Capacity Market
- Selection of offers for balancing capacity products on the Balancing Market
- Information about offers for balancing capacity products selected on the Balancing Market
- Collecting offers for balancing energy from BSPs whose sources are located in the DSO network
- Verification of technical feasibility of offers for balancing energy and selection of offers on the Flexibility Platform or DSO (depending on the variant of the technical solution)
- Transfer of offers for balancing energy to the Balancing Market within the Balancing Energy Market
- Selection of offers for balancing energy on the Balancing Market
- Information about offers for balancing energy selected on the Balancing Market
- Delivery of balancing capacity products and/or balancing energy
- Settlements for balancing capacity products or balancing energy between TSO and BSPs
- Settlements for balancing capacity products or balancing energy between BSPs and FSPs and FSPAs

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

Main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), System Operator (SO), Flexibility Service Provider (FSP), Flexibility Service Provider being Aggregator (FSPA), Market Operator (MO) or Flexibility Platform Operator (FPO), Balancing Service Provider, Technical Market Operator (TMO). In Poland, at this moment DSO acts as the Metered Data Responsible, Metered Data Collector.

Third BUC (Event-driven Active Power Management for Congestion Management and voltage control by the DSO) - describes the general process of purchasing flexible services based on active power for congestion management in the distribution network and elimination voltage violations in the distribution MV and LV network by the DSO. BUC is described as a general process covering possibilities of acquiring services in the day ahead and medium term time frame. The purchase of services takes place using the market platform from Flexibility Service Providers who have positively passed the prequalification process. The active power flexibility services in the medium time frame can be used by DSO to solve network problems that could occur during network modernization and maintenance work, especially during planned works that required outages and are performed under abnormal grid configuration. Day ahead congestions and voltage violations can appear due to incorrect forecast of the DER generation, change of the load or change of grid topology of DSO or TSO. In both cases buying flexibility services by DSO will be event driven. The auction will be called by DSO only in specific situations when the need appears in the network. The main objective is the elimination of congestion and voltage violations in the distribution MV and LV network, using active power provided on the market platform by Flexibility Service Providers and coordination of TSO and DSO activities in the field of congestion management and voltage control. The process of using offers from flexibility market platform for congestion management and voltage control by DSO is divided into a few scenarios:

- Selection/Bidding for mid-term and day-ahead - the process of selecting offers from the market to solve the DSO problem related to network congestion or voltage violations with the use of active power management. The DSO opens an auction with detailed information about the location affected by the problem and provides all the required parameters to receive offers. Offers are submitted by FSPs who have successfully passed the prequalification process. Before selecting an offer, network analyses are performed, which eliminates offers that have a negative impact on the operation of the DSO network reporting the need or others DSOs.
- Delivery for DSO - Activation and delivery of the offer by a strictly defined FSPs resource under the previously contracted offer for the DSO. After contracting the offer under scenario 1 (Selection/Biding for mid-term and day ahead), the DSO performs the final assessment of the feasibility of planned work and the legitimacy of using the offer. After the final confirmation of the necessity to activate the offer for medium term auctions, the DSO sends information to the platform operator about the commencement of activation of the contracted offer. Based on the information received from the

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

platform operator, the FSP activates his resource and provides the service following the contracted offer. The DSO supervises the execution of the offer by the client in real-time.

- Settlement - scenario describes settlement for auctions of both described previously cases: day ahead and medium term auctions.

Main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), Flexibility Service Provider (FSP), Flexibility Service Provider being Aggregator (FSPA), Market Operator (MO) or Flexibility Platform Operator (FPO).

Forth BUC (Balancing Service Provider (BSP) on the Flexibility Platform) is focusing on the introduction of Balancing Service Provider, linking it with Flexibility Service Providers and Flexibility Service Providers Aggregator, creation of a scheduling unit and its prequalification for the Balancing Market. The main objective is to enable pre-qualified Flexibility Service Providers and Flexibility Service Providers Aggregator resources to provide balancing services in the balancing market via Balancing Service Provider. According to the new Balancing Market rules in Poland, only the Balancing Service Provider will be able to put their offers on the Balancing Market for balancing products. Flexibility Service Providers and Flexibility Service Providers Aggregator need to cooperate with the Balancing Service Provider to be able to be part of the Balancing Market. In the BUC Balancing Service Provider registration on the flexibility platform and verification of the technical capabilities of Flexibility Service Providers and Flexibility Service Providers Aggregator by Balancing Service Provide is described. The next step is the creation of a scheduling unit by the Balancing Service Provider based on selected Flexibility Service Providers and Flexibility Service Providers Aggregator resources. TSO is responsible for testing the scheduling unit and confirming that the Balancing Service Provider and this scheduling unit meet the conditions set out in the Terms and Condition Related to Balancing. Based on the results of verification and TSO confirms Balancing Service Provider ability to provide balancing services based on a scheduling unit made up of Flexibility Service Providers and Flexibility Service Providers Aggregator resources. Described in the BUC process is divided into a few scenarios:

- Registration of the BSP and its preliminary scheduling unit on Flexibility Platform – formal registration process. The registering process requires to confirm the fulfilment of several duties related to being a participant of the balancing market. In detail, BSP must fulfil on its own or by proxy technical (scheduling operator) and communication requirements.
- Assignment of prequalified FSP and FSPA resources to the BSP Scheduling Unit – the process of creation new or updating existing Scheduling Unit by Balancing Service Provider based on the prequalified units of Flexibility Service Providers and Flexibility Service Providers Aggregator

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

- Verification and test of Scheduling Unit - According to the requirements defined in the Terms and Condition Related to Balancing, BSP is obliged to prequalify each Scheduling Unit.
- Registration of Scheduling Unit by TSO – after positive verification of the Balancing Service Provider TSO confirms on the Flexibility Platform approval of the BSP.

Main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), Flexibility Service Provider (FSP), Flexibility Service Provider being Aggregator (FSPA), Market Operator (MO) or Flexibility Platform Operator (FPO), Balancing Service Provider (BSP).

More detailed information about Polish Demo BUC can be found in [5].

3.5 Slovenian DEMO

The main goal of the Slovenian demonstration is to test how local flexibility based on the demand side management can be used by the DSO to solve problems in the LV network. Change in the network dynamic due to the appearance of new active elements in the LV network influences the way of functioning of the network, which is different from what it was several years ago. Increase consumption of the energy by the customers connected to LV network and expansion of renewable energy sources connected at the LV level causes problems for DSOs in the management of grid operation and maintenance of power supply parameters. The main problems are the overload of the MV/LV transformers and power lines and voltage violation in the network, mainly on the LV level. The Demo is focusing on using resources connected to LV network (e.g. heat pumps, EVs etc.) to increase network efficiency and solve those problems. The key element of the Slovenian Demo are the locational flexibility market platform and several locations on low voltage level, where network issues will be solved using flexibility sources. In Slovenian Demo 2 Business Use Cases were developed under the OneNet project activities to achieved identified business objective:

1. Congestion management in distribution grids under market conditions
2. Voltage control in distribution grids under market conditions

First BUC (Congestion management in distribution grids under market conditions) is aiming to demonstrate the effectiveness and appropriateness of flexibility services for the congestion management of a distribution grid, under market conditions. Due to excessive and increasing energy consumption, existing MV/LV secondary substations occasionally becomes thermally overloaded and power lines congested. Demand response services can be utilised to decrease the duration or even prevent overloads of the distribution grid components. This BUC will validate a process in which managing flexibility in the distribution grid (e.g. switching

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

off heat pumps during peak hours) can prevent that distribution grid overreaches its physical limits (e.g. transformer overheating, line congestion). It will also verify information exchange between all stakeholders in this process enabling data as well as communication interoperability, under flexibility market conditions. The main business objectives are: deferral of grid reinforcement investments and improve the security of supply, validate demand response mechanism to prevent congestion in the distribution grid by testing flexibility products under market conditions. The flexibility tested with this BUC can also be utilised for mFRR at the balancing market. Depending on how the local flexibility market is organised, two variants are considered. The first corresponds to the counter (OTC) market in which flexibility service providers (FSP) make a long-term (e.g. 6 months) bilateral contract with DSO related. In the second variant, DSO procures flexibility on the organised local flexibility market. Activities in the first variant are divided into the following Scenarios:

- Prequalification – the process of evaluation by DSO of units that have entered the previously announced need of flexibility and confirmation of the capability of the FSP to deliver a service.
- Offering – the process includes identification by DSO a need for the flexibility, sending requests by DSO for offers, biding by FSP, collection and ranking of the offers, selection and contracting selected bid.
- Activation-OTC - when congestion in the grid is predicted or occurred, DSO sends a request to FSP for contracted flexibility at a given location in the distribution grid. FSP acknowledges the request and activates service.
- Settlement-OTC - using calculated base line, the volume of the delivered power is calculated, confirmed by both sides and invoice is sent.

Activities in the second variant are divided into the following Scenarios:

- Grid prequalification - at the start of this process, flexibility resources are registered at the flexibility register, which initiates prequalification of the registered resource run by DSO, to validate the existence of the resource and its impact on the distribution grid.
- Product prequalification - DSO defines the requirements that each local flexibility product should meet. Flexibility market operator coordinates the prequalification process. The flexibility service provider sends the prequalification request with accompanying information to the FMO, who forwards this request to DSO. DSO runs predefined tests and calculations, after sending the results and acknowledging FMO about the final decision. FMO stores this information to the flexibility register and acknowledges FSP.
- Bidding - DSO expresses the need for the flexibility service to FMO, which publishes requests for bids. FMO collects the bids from the flexibility service provides and selects the optimal bids.

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

- Activation - For the selected bid, activation is initiated by DSO sending an activation signal to the flexibility service provider. DSO informs TSO about activated flexibility resources in the distribution grid in order to avoid collision and double activation on the balancing market.
- Settlement - Flexibility register calculates the base line. After the activated product has been delivered, flexibility register calculates delivered volume and information to DSO and FSP.

The main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), Flexibility Service Provider (FSP), Market Operator (MO) or Flexibility Market Operator (FMO).

Second BUC (Voltage control in distribution grids under market conditions) focused on the increased number of household solar power plants that are causing voltage increase on MV/LV voltage substations. Due to the increase of variable renewable energy sources (RES), such as household PV power plants (PV PP), we are facing an increase of voltage in the MV/LV distribution systems, when demand does not meet production. Adjustments could be made on the transformers, so the delivered power is within the regulatory requirements, but this method is limited. Another way to reduce the voltage could be putting an export limit on solar systems, but in this case, the investors/owners of the PV plants would suffer losses when the net-metering calculation is made at the end of the year. To avoid these losses, batteries could be installed into their households, connected directly to the inverter. When voltage control is needed, active power curtailment would be activated via an inverter, and the excess energy, that would usually be directed into the LV system, would be used to charge the battery systems. The voltage in the MV/LV system would drop, and the stored energy could be used later in the day (for charging EVs, or for other demand response services). Demand response services can be utilised to decrease the duration or even prevent overloads of the distribution grid components. Integrated smart inverters have advanced power controlling functions and with adjusting the output of active power, they may be used as voltage reduction devices. Using the Volt-Watt method we would properly design the control parameters in the PV inverters. With this control method voltage violation would be mitigated and the power curtailment would be evenly distributed among the PV power plants. In this BUC, battery systems (charged by the excess energy from the PV PP production), connected to the distribution grid, are used as flexibility resources to lower the voltage level. Voltage reduction would be Using PV inverters as smart control devices, which are already installed in the system, DSO could postpone investments in the grid reinforcement. The flexibility tested with this BUC can also be utilised for mFRR at the balancing market. The main business objectives are: deferral of grid reinforcement investments and improve the security of supply, improve the security of supply, validate demand response mechanism to prevent voltage increase in the distribution grid, test flexibility products to prevent voltage increase in the distribution grid under market conditions. Depending on how the local flexibility market is organised, two variants are considered. The first one corresponds to over the counter (OTC) market in which flexibility service provider (FSP) make a long-term (e.g. 12 months) bilateral contract with DSO related. In the

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

second variant, DSO procures flexibility on the organised local flexibility market. Activities in the first variant are divided into the following Scenarios:

- Prequalification – the process of evaluation by DSO of units that have entered the previously announced need of flexibility and confirmation of the capability of the FSP to deliver a service.
- Offering – the process includes identification by DSO a need for the flexibility, sending requests by DSO for offers, biding by FSP, collection and ranking of the offers, selection and contracting selected bid.
- Activation-OTC - when a voltage increase in the grid is predicted or occurred, DSO sends a request to FSP for contracted flexibility at a given location in the distribution grid. FSP acknowledges the request and activates service.
- Settlement-OTC - using the calculated base line, the volume of the delivered power is calculated, confirmed by both sides and an invoice is sent.

Activities in the second variant are divided into the following Scenarios:

- Grid prequalification - at the start of this process, flexibility resources are registered at the flexibility register, which initiates prequalification of the registered resource run by DSO, to validate the existence of the resource and its impact on the distribution grid.
- Product prequalification - DSO defines the requirements that each local flexibility product should meet. Flexibility market operator coordinates the prequalification process. Flexibility service provider sends the prequalification request with accompanying information to the FMO, who forwards this request to DSO. DSO runs predefined tests and calculations, after sending the results and acknowledge FMO about the final decision. FMO stores this information in the flexibility register and acknowledges FSP.
- Bidding - DSO expresses the need for the flexibility service to FMO, which publishes requests for bids. FMO collects the bids from flexibility service provides and selects the optimal bids.
- Activation - For the selected bid, activation is initiated by DSO sending activation signal to the flexibility service provider. DSO informs TSO about activated flexibility resources in the distribution grid in order to avoid collision and double activation on the balancing market.
- Settlement - Flexibility register calculates the base line. After the activated product has been delivered, flexibility register calculates delivered volume and information to DSO and FSP.

The main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), Flexibility Service Provider (FSP), Market Operator (MO) or Flexibility Market Operator (FMO).

In the Slovenian pilot site, there will be used the method of dynamic thermal monitoring of distribution transformers to determine the load impact on the transformer. The method considers the influence of the ambient temperature and the temperature of the transformer along with the actual measured loading of the

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

transformer. This will allow the MV / LV transformer to be overloaded for some time without damaging its components. However, when dynamic thermal monitoring detects an unacceptable overload, the flexibility services offered by the aggregator or electricity supplier will be triggered to achieve a decrease in loading of the local network and therefore the transformer itself. In this way, we can postpone the investment at the local transformation station and make much more efficient use of the existing grid infrastructure.

In the area of Elektro Celje, the pilot will take place at the location of the local transformer station TP Železno (municipality of Žalec), where the ambient temperature and transformer phase currents will be measured for testing purposes on fifteen minutes time basis. The same will be used for measuring the distribution transformer housing temperature and ambient temperature. To measure the transformer housing, a special dedicated thermally insulated probe will largely eliminate the influence of the environment, such as insolation etc. Flexibility services in the pilot project will be provided by 7 household customers connected on TP Železno.

The second similar Slovenian demo pilot is TP Gradišče in distribution network Elektro Ljubljana. Based on the ambient temperature a thermal power is calculated. If measurements of the current power of the transformer exceed thermal power, then FSP (an aggregator) is activated to lower consumption. Before curtailment of flexible power from FSP, a definition of the product has to be done with an analysis of historical measurements. Defended parameters were a yearly season, the period between weekdays and weekends, the response time of activation, requested power. Also, maximum price that DSO is willing to pay to the FTP. On tender aggregator offered 20 kW of power with seventeen households which are heaving heating pumps.

The second BUC (Voltage control in distribution grids under market conditions) will be tested in the area of Elektro Gorenjska in transformer station TP Srakovlje. It is an example of a small LV rural cable network with 7 PV power plants installed. The increase of voltage at the end of LV feeders where PV power plants were installed will be reduced with different approaches (Q(V), P(V) characteristics, battery installation). Integrated smart inverters have advanced power controlling functions and with adjusting the output, they may be used as voltage reduction devices. One way to reduce the voltage is correct settings of limits on solar inverters (Q(V) and P(V) characteristics). In this case, owners of PV power plants will lose some produced energy. To avoid these losses in some locations batteries will be installed after the inverters. When voltage control is needed, active power curtailment would be activated via an inverter, and the excess energy, that would usually be directed into the LV network, would be used to charge the battery systems. The voltage in the LV network would drop, and the stored energy could be used later.

More detailed information about Slovenian Demo BUC can be found in [5].

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

3.6 Hungarian DEMO

The main goal of the Hungarian demonstration is to test how a new flexibility platform can support DSO in their day activates and enhance grid operability, taking into account communication and data exchange between DSO and TSO. The Demo is focusing on the increase network effectiveness and stability in the field of voltage control of MV network and ensuring safe operation as a key element of the distribution network, which are HV/MV transformers. In Hungarian Demo 2 Business Use Cases was developed under the OneNet project activities to achieved identified business objective:

1. MV feeder voltage control
2. HV/MV transformer overload

First BUC (MV feeder voltage control) is dealing with the voltage violation problems of the MV network due to increasing renewable penetration. Too many renewable resources connected to of power line (not only MV) can cause violation of standard voltage ranges in the line. The main scope of this BUC is to mitigate voltage variations of MV feeders by activating flexibility services and to keep actual voltage values of MV feeders within the standard bands.

Described in the BUC process of acquiring voltage control services to deal with voltage violation in the MV network is divided into a few scenarios:

- Prequalification – during this process Flexibility Service Providers that want to provide services to DSO send a request for prequalification, which is considered by the DSO. Based on the product and grid prequalification DSO agrees or not to include resources to be included in Flexi Register.
- Forecasting – in this scenario, DSO performs certain action that leads to the identification of flexibility needs based on the network analysis. Data and information exchange between TSO and DSO is also a part of this process.
- W-1 flexibility procurement W-1 – this scenario includes every action that leads to contracting the services from Flexibility Service Provider (capacity) to DSO in the week ahead term, based on the results of the previous scenario: forecasting. BUC include all of these actions: call an auction, bids submission, bids prequalification, and delivery, market clearing.
- D-1 flexibility procurement – actions included in this scenario allows DSO to acquire services from Flexibility Services Providers (energy) in the Day ahead term. Scenario describes in the step by step whole process from identification of the need base on the network analysis, call for an auction, biding by the Flexibility Service Providers, bid prequalification, delivery and market clearing.

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

The main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), Flexibility Service Provider (FSP), Market Operator (MO), OneNet common platform.

The second BUC (HV/MV transformer overload) is developed to deal with the increasing renewable penetration that causes overloading of HV/MV transformers in the DSO's network. The main scope of BUC is to mitigate the overloading of HV/MV transformers by activating flexibility services in all operational states of the power system. Due to the proliferation of PV plants, connected to DSO MV lines or directly to the MV side of HV/MV substations, overloading of HV/MV transformers is afore coming issue in Hungary. This technical issue can be mitigated by P and/or Q on the MV level. The BUC operates on two time horizons, each related to the specified grid service: capacity auction and energy activation (scheduled), respectively. Capacity auctions will be driven by the technical needs of the DSOs, which are determined on a weekly basis based on weekly maintenance plans. Described in the BUC process of acquiring services to solve HV/MV transformers overloads is divided into a few scenarios:

- Prequalification – during this process Flexibility Service Providers that want to provide services to DSO send a request for prequalification, which is considered by the DSO. Based on the product and grid prequalification DSO agrees or not to included resources to be included in Flexi Register.
- Forecasting – in this scenario, DSO performs certain action that leads to the identification of flexibility needs based on the network analysis. Data and information exchange between TSO and DSO is also a part of this process.
- W-1 flexibility procurement W-1 – this scenario includes every action that leads to contracting the services from Flexibility Service Provider (capacity) to DSO in the week ahead term, based on the results of the previous scenario: forecasting. BUC include all of these actions: call an auction, bids submission, bids prequalification, and delivery, market clearing.
- D-1 flexibility procurement – actions included in this scenario allows DSO to acquire services from Flexibility Services Providers (energy) in the Day ahead term. Scenario describes in the step by step whole process from identification of the need base on the network analysis, call for an auction, biding by the Flexibility Service Providers, bid prequalification, delivery and market clearing.

Main actors involved in this BUC are: Transmission System Operator (TSO), Distribution System Operator (DSO), Flexibility Service Provider (FSP), Market Operator (MO), OneNet common platform.

More detailed information about Hungarian Demo BUC can be found in [5].

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

4 Flexibility Platforms and Markets in Eastern Cluster

During the project, each of the Demo described the way how the flexibility market is or will work in the future. Depending on how the energy market is developed in a given country, the prepared descriptions concerned the currently functioning market for flexibility services, the future version of the market that will take place in the future, or the assumed market variant, if it is still being shaped.

Based on the description, similarities in the way how the market is working and approach to flexibility in each of the countries can be identified.

Czech Demo

The first Czech Demo SUC is a new market platform for procurement of non-frequency services. The main aim of this BUC is to create a transparent and non-discriminatory market environment for bids & offers to all market participant relevant for non-frequency service procurement: System operators is one side (especially DSOs, but TSO as well), and Flexibility providers (aggregators or single stand units) on the other side.

This new market platform enables mainly to DSOs procure services for active network management and engage the customer for the solving of the grid-related issues. For that purpose, the newly created IT environment shall cover activities related to the procurement of non-frequency services. The system shall:

- accommodate different types of non-frequency services
- enable DSOs to procure non-frequency services in a way that fits needs of the operation of the distribution grid
- allow access for a Flexibility service provider (FSP) to the platform in order to provide bids regarding non-frequency services
- enable via traffic light system available for activation of relevant resources

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

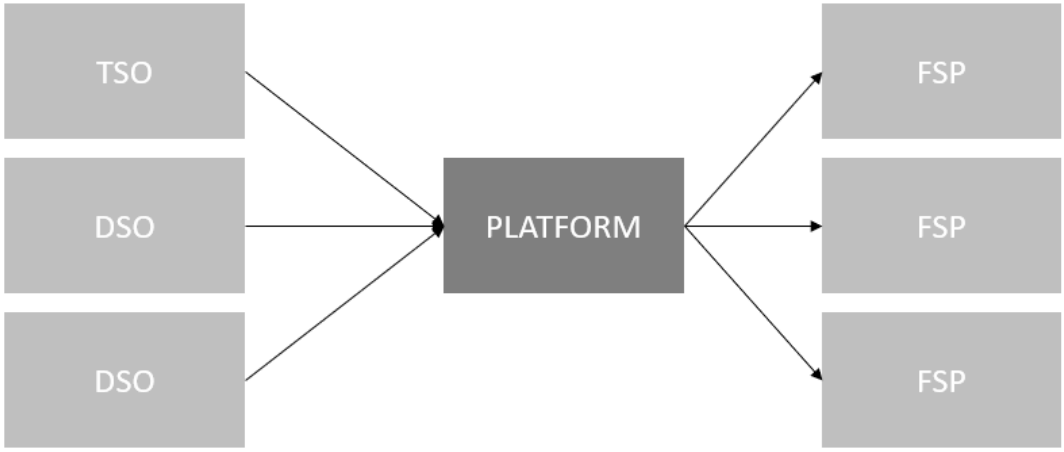

Figure 4. Diagram of the market platform's interaction with market participants in the Czech Demo

In order to deliver the previously mentioned activities, the IT platform is divided into 3 main functional elements:

- Administration module
- Market module
- Traffic light module (availability of the grid for unit's activation)

Administration module:

1. Flexibility service providers (FSP) and Units providing non-frequency services (UPNFS) are registered into the platform
2. The functional system in the platform uses a specific identification code (EAN) which is unique to any unit providing flexibility, and specific identification (EIC code) unique for each FSP
3. Each unit needs to specify information regarding its operation (e.g.: reserved capacity, location, to which FSP provider belongs (if relevant), etc.)
4. The system also involved system operators as well (DSOs, TSO)

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

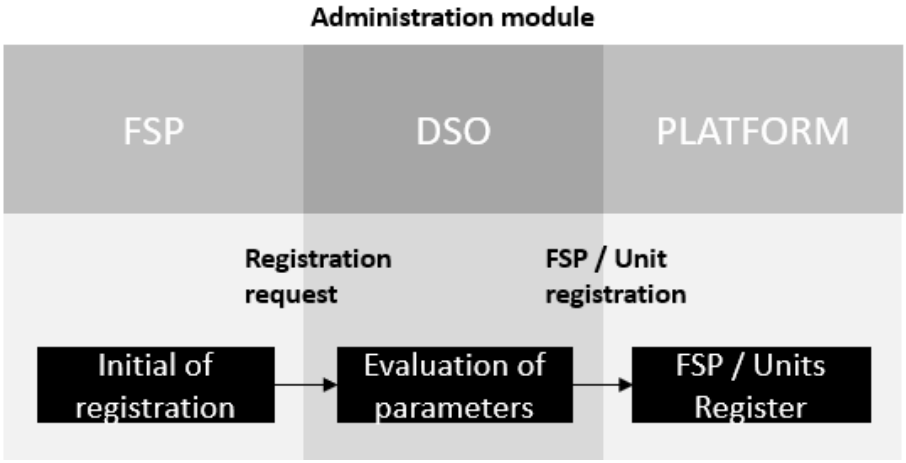

Figure 5. Administration module scheme in the Czech Demo

Registration to the administration module is managed by DSOs and distinguish to which distribution area is unit providing non-frequency service connected. Respective DSO also evaluates the parameters of the units or the whole portfolio of aggregators.

Market module:

1. Registration of needs (by DSOs or TSO) and bids (by FSP) via GUI or API
2. Overview of needs and flexibility bids (offered/accepted values)
3. Each unit needs to specify its location (nodal area), capacity, FSP provider (if relevant)
4. Semi-automatic evaluation (needs-offers matching) supervised by TSO / DSOs

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

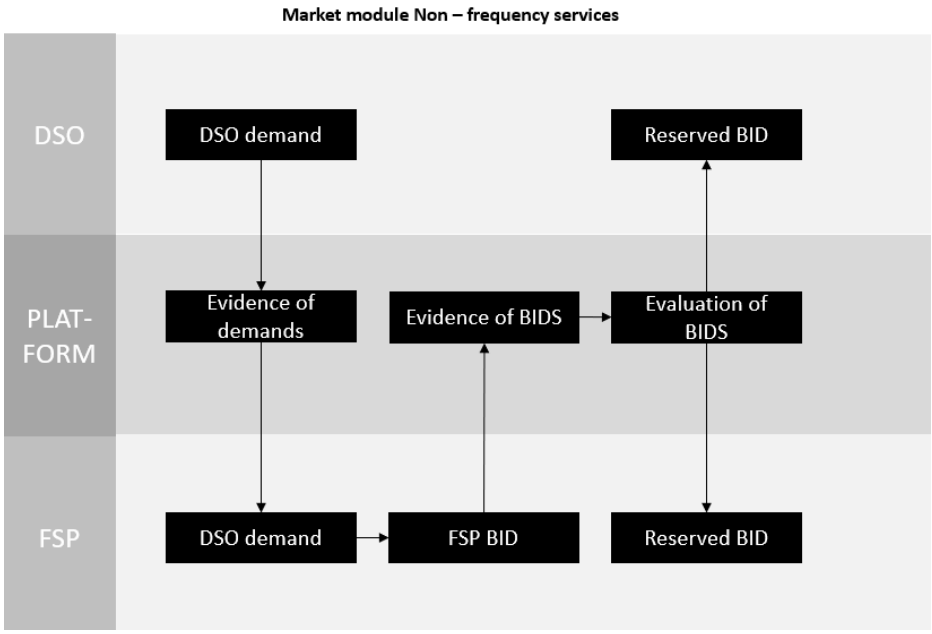

Figure 6. Demonstrative diagram of the operating principles of the market platform in the Czech Demo

Traffic light module (availability of the grid for unit's activation)

1. DSO reports every unavailability of the distribution grid through an announcement on the grid events
2. The way of reporting is different for planned outages/outages → planned events also include planned duration (from-to) which is impossible to indicate in case of sudden outages
3. As a dedicated communication tool, XML messages are used
4. This information of grid unavailability is automatically sent through ECP communication to the registered units and FSP
5. The system also displays grid unavailability as a traffic light via GUI to the registered units and FSP

Details of the flexibility procurement process are not defined yet. Preliminary discussion indicated that non-frequency grid services will require rather long term contracts as they are closely related to the grid planning/maintenance rather than to unexpected grid issues. Because these services need to be activated in an almost real-time manner, relevant units must be directly connected to the grid (activation through the platform will not enable appropriate reaction). Taking into account above mentioned new platform will serve as an environment collecting and matching bids/offers rather than an activation tool for flexibility services.

More complex description of the Czech market, with the market architecture, is presented in the [10]

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

Polish Demo

The Polish demonstrator has the objective to deliver system services provided by resources connected to the DSO network. These services will be used for balancing, congestion management and voltage regulation. In addition, the flexibility services will be procured and activated to deliver services both for TSOs (balancing) and DSOs (congestion management and voltage control). The whole market platform is based on the new market for the DSOs needs (congestion management and voltage control) and TSOs needs related to the balancing. Flexibility market will be connected with the existing in Poland balancing market, operated by the TSO. In the case of balancing services, the market platform will serve as a new tool for TSOs to acquire new resources for balancing purposes. The role of the platform will be collecting and offers from flexibility resources for balancing purposes and verifying them in terms of the possibility of a given resource's share in the balancing market. The platform will act as a kind of aggregator of offers, which will then be transferred to the balancing market. In order to perform this process, it is necessary to involve additional entities such as Balancing Service Provider (BSP) or Scheduling Agent (if relevant).

Every customer that will participate in the flexibility market can register on the platform. After positive verification by the market operator, the potential FSP can register his resource that is planned to be used for providing services. Each of the resources has to be verified and certified by the DSO. On the other hand, System Operators need to prepare and describe products for certain services are willing to procure. After certification of the resources by the DSO, the customer can define what services and products it wants to provide with the use of its certified resources. In some cases, services like i.e. balancing services will have additional requirements, that need to be checked before final certification of the specific resource. TSO and DSO can call an auction on the market platform that will meet their needs for specific services.

For balancing products auction will be called by the TSO every day for the day ahead needs (D-1). Timing for the gate opening and closed time will be correlated with the timing of the balancing market. After gate closing, all the offers for specific products will be collected and verified with the participation of DSOs, whether their activation is possible and whether they do not violate the integrity and safety of DSO networks. The list of verified bids will be converted into MOL and forwarded to the balancing market, where the rest of the process will be carried out with the selection of bids and selection of the auction winners. Activation of the FSP that will be selected for the process of system balancing will be performed with the use of the balancing market tools and procedures.

Auction for Congestion management and Voltage control products will be event-driven, which means DSO will call an auction when a specific situation occurs in the network. Two types of auctions are planned to use during the demonstration: for the day ahead timeframe and in the weeks timeframe. The first one is planned to use if situation when the inaccuracy in the long term forecast of the network appears. The second one is dedicated to the maintenance works that are planned with the weeks ahead in mind. This auction will be

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

announced weeks before the activation and will have a long opening gate time for the offers. Two variants for the gate closing time are considered. The first approach assumes that offers will be selected one week prior to activation. The second option assumes that the offers will be selected the day before activation. The ideal approach is to select the best offers as close to the activation time, even a few hours before activation. Unfortunately, this involves imposing requirements on service providers that can be difficult to meet, especially when they are not mature and fully developed. When calling the auction, the DSO will have to specify the exact area the auction concerns. Since congestion and voltage problems are local, only customers from the areas affected by the given undesirable phenomenon will have an influence on its solution.

After the announcement of the auction by the DSO, customers from a specific area will be able to submit their bids as part of a given auction. After closing the gate, the DSO performed a technical analysis assessing the impact of each offer on the resolution of a given undesirable event. The most profitable offers to solve the problem will then be selected. Selected customers will be informed about winning a given auction. In the case of an auction for the next day, winning the auction is tantamount to a signal confirming the need for activation. For auctions with a longer time window, a signal confirming the need to activate a given resource will be sent after another technical analysis on a preceding day. The activation of the resource will be on the part of the FSP, which, based on the command received from the DSO, will be responsible for the execution of the contracted activity. Information on the results of auctions conducted by DSOs will be transferred to TSO in order to coordinate activities in the scope of system balancing and avoid possible system overbalancing.

Settled services (full or partial, and in extreme cases not performed) will take place cyclically every specified period of time, e.g. once a month. Based on the measurement data provided by DSO from smart remote reading meters, calculations will be made to make payments for the service provided.

A more complex description of the Polish market, with the market architecture is presented in the [10]

Slovenian Demo

The Slovenian demonstrator develops and tests the interoperable DSO marketplace (platform) to be used to procure the DSO flexibility services developed in OneNet project. System services will be provided by resources connected to the DSO network and will be used for congestion management and voltage control. DSO platform is independent of the TSO marketplace platform for balancing services which is not considered of the OneNet project. Even though the TSO is not actively involved in the activity of the OneNet Slovenian demonstrator, the market platform will be designed so that TSOs and DSOs will be able to use same sources of flexibility while considering each other needs and limitations. The new flexibility marketplace platform will not replace the existing balancing IT infrastructure of TSO and DSOs, but it will be integrated into existing TSO and DSO

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

platforms. The integration of the existing with the novel platform for local flexibility would enable to manage all flexibility in “one place”.

Depending on how local flexibility market is organised, two variants are considered. The first corresponds to over the counter (OTC) market in which flexibility service provider (FSP) make a long-term (e.g., 6 months) bilateral contract with DSO related. In the second variant, DSO procures flexibility on the organised local flexibility market.

All FSPs who will participate in local flexibility market have to prove its capability to deliver services through the qualification procedure run by DSO. The process is based on simple prequalification with disclosing individual points of the parties connected to the grid, demand response technology type, rated flexible capacity per party, total available capacity of the pool. On the other hand, DSO needs to define the requirements that each local flexibility product should meet. In case of organised market, FSPs are previously registered at the flexibility register, which initiates prequalification of the registered resources run by DSO, to validate existence of the resource and its impact on the distribution network. After positive verification, this information is then stored in flexibility register.

If DSO recognize any congestion or voltage violation in the network, they determine product which could solve the problem. In the first scenario DSO sends requests for offers to FSPs. The bids are then collected and ranked by DSO. After the selection of the best bid, contract is signed. In the case of organised market DSO expresses the need for the flexibility service to Flexibility Market Operator (FMO), which calls an auction on the marketplace platform. Auction call is announced one month before delivery. The auction event lasts two hours, where FMO collects the bids from FSPs and selects the optimal bids. The selected customer will be informed 5 minutes after the gate closure time about winning a given auction. The information of the auction winner is also sent to DSO, TSO, and flexibility register. Since congestion and voltage control are local, only FSP with resources from the affected areas can place their bids.

When congestion (or voltage increase) in the grid is predicted or occurred, DSO sends an activation command to FSP for the execution contracted flexibility at a given location in the distribution grid. FSP acknowledges the request and activates the service. DSO informs TSO about activated flexibility to avoid collision and double activation on the balancing market. The measurements from DSO and FSP are collected during the activation process.

Validation and payments of the delivered service are based on the DSO’s measurements data and the baseline, which is provided by the FSP itself. Delivered volume is confirmed by both sides (DSO and FSP) and invoice is sent. When volume can’t be validated, alignment process is initiated.

A more complex description of the Slovenian market, with the market architecture is presented in the [10]

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

Hungarian Demo

The flexibility platform ensures the level of playing field for any kind of flexibility services including market based procurement, data sharing and coordination functions. Each national flexibility platform connects to an integrated platform which among others contains the result of prequalification in the flexibility register.

Any market player who is willing to offer its service has to prove its ability through the qualification procedure. The process is based on standardized methodology and clear requirements and the result (including location, P/Q min/max) are stored in the flexibility platform. Based on the location information the DSOs determine the impact factor for each node on which the concerned unit has an effect.

All market players can participate both in flexibility and balancing the market if they fulfil the requirements. In order to handle the simultaneous needs, the flexibility market has priority against balancing services which is ensured with the proper timing and coordination among system operators.

If the DSOs during system security analyzing recognize any congestion in the network they determine the product (the location and the required level of activation) which could solve the problem. This information is forwarded to the TSO who give back its acknowledgement. If a DSO request is not acceptable then the TSO give back this status and they start to negotiate about the situation.

The flexibility platform consists of the following functions regarding the flexibility services:

- user interface
- capacity auction
- energy activation (scheduled)

All units which have accreditation are registered in the platform by the market operator. Capacity auctions will be driven by the technical needs of the DSOs, which are determined on a weekly basis based on weekly maintenance plans. Gate opens at W-1 Monday 0:00 and closes at W-1 Friday 14:00, thus enabling bidders a fairly long time to place bids, but the market can be cleared during working hours on W-1. Results of the auction are to be published by W-1 Friday 15:00. Only those FSPs can place their BIDs who have valid accreditation in a certain location. They have to give the ID of the unit, the offered capacity, and the price (both capacity and energy) for each timestep.

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. The gate closure on D-1 allows SOs to procure services based on day-ahead predictions and network calculations. Results of the clearing are to be published by D-1 7:00, which is 60 minutes ahead of local daily balancing capacity market gate closure, and well before the active period of DAM market bidding. This allows market players to participate in flexibility and day-ahead

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

markets separately, and also supports that uncleared flexibility bids are submitted to shorter horizon markets (DAM, BAM).

Besides the cost, the location has also an important factor in the clearing process. Each unit has an impact factor on the concerned location which is taken into consideration. The result of clearing is available both for market players and the SOs as well and therefore the parallel or in the worst case conflicting activation is avoidable. The activation of the BIDs is executed with manual activation outside of the platform. A more complex description of the Hungarian market, with the market architecture is presented in the [10].

5 Innovation solution

At the Cluster level a solution for data exchange between Demos with the use of the OneNet system was developed by the Demos from Eastern Cluster. The solution is focusing on the process of sharing the key flexibility/balancing market data that characterizes each national demonstration. The data are aggregated using the same principles and presented to OneNet system in the unique way for all the demos as described in deliverable 5.2 “OneNet Reference Architecture”. This allows the national flexibility markets to be compared. The more information about this solution, BUC and SUC will be presented in the Deliverable 10.3 “Report on development of integral market platform”.

Czech Demo:

Part of the tested solution consists of the involvement of EV charging infrastructure in the flexibility provision. As it is expected to increase charging poles both in figures and capacity as well as its growing impact on the distribution grid, CZ DEMO will test ability of EV charging infrastructure to provide market-based flexibility. There will be installed charging poles of 1 MW of installed capacity and incorporated into the system managed by the local management system (LMS). This LMS (provided by Driivz) calculates the amount of flexibility available for the aggregator and then is subsequently offered at the flexibility market. This flexibility is operated and managed by the aggregator.

Polish Demo:

The unique element in the Polish demo compared to the other demos, not only ones from the Eastern Cluster is Aggregated Network Offer (AGNO) mechanism. Today in Poland, the DSO congestion management is an independent process that is not coordinated with the Integrated balancing market. In other words, the Integrated balancing market procurement results are not providing any input to the DSO congestion management process.

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

Instead, if the activation of the procurements of the Integrated balancing market is creating network problems, the DSO performs corrective actions. For instance, the DSO may curtail the wind farms power to solve voltage & congestions without any coordination with the TSO (which is responsible for balancing the system). In addition, 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. Those actions are not market-based and may not be coordinated with the TSO.

According to EU guidelines, TSO and DSOs should act to enable the participation of DER in the provision of flexibility services. Amongst others, they should be able to participate in the balancing market. Therefore, the future bigger FSP participation in the balancing market services may create bigger problems in both TSO and DSO networks, there arises a need for TSO-DSO coordination. In case one of the operators could redispatch the units to fix a problem (such as congestion), a new redispatch could create a problem for the other operator. For this reason, a coordination scheme is needed, to avoid opposite action, and to enable safe and effective coordination of procurement of services from the FSP.

In the Polish DEMO, it is proposed a TSO-DSO coordination solution for the participation of DER into the day ahead Integrated balancing market. It creates a Multi-level market model which is based on the bottom-up/hybrid coordination. Since the access of the DER to the Integrated balancing market helps to prevent the DSO congestion management problems while the balancing products are procured.

Nowadays, the TSO does not have observability of the DSO network, thus, the direct TSO procurement of the DSO offers could endanger the DSO network. However, the proposed solution is that the TSO may receive an offer that ensures that the DSO network is secure regardless the TSO procurement. This is the aim of AGNO which aggregates all the DER offers following a market-based approach while ensuring the DSO network security. In other words, the AGNO optimizes the DSO offers considering the security at the same time. That's why it can be categorised as a bottom-up/hybrid coordination scheme which is prioritizing the DSO needs. This optimization layer is a market-based automatic mechanism that allows the DER participation in the balancing market without the need for constant TSO-DSO coordination iterations.

Additional information about AGNO and the coordination between DSO and TSO in the Polish Demo are described in the [10].

Slovenian Demo:

Dynamic thermal rating (DTR) is approached in order to adjust the ampacity of energy infrastructure devices i.e. power line, transformer to the actual prevailing environmental conditions. In the Slovenian Demo, DTR solution will be used for the MV/LV transformers in the demonstration area. The maximum load of the

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

transformer depends on the outdoor temperature. Therefore, the weather parameters around the transformer have to be measured, on which based the actual permissible maximum load can be determined using the permissible overload factor. By using DTR in the Slovenian case it is possible to reduce the total number of events when a thermal overload occurs in the winter periods. Thanks to that solution the amount of action that need to be taken decreases. This has a direct impact on efficiency improvement and can lead to a reduction in the costs of purchasing flexibility services in borderline situations when the transformer load is close to the rated load.

Hungarian Demo:

The Hungarian demo will focus dominantly on MV networks, where flexibility providers are expected to be connected either directly to HV/MV substations or more likely to MV lines. It can be easily realized that the location (electrical distance) of the provider will affect the effectiveness of the activated product, both for overloading and voltage control issues. However, designing a market with such fragmentation seems illogical and inefficient. To tackle the issue, existing examples apply a derating factor, which characterises the "strength" of the location, where the service is provided. During the demonstration, we will formulate this derating factor, test its range and implement these on our platform.

Electricity networks are more and more operated in a non-traditional ways due to the integration of renewable and distributed energy sources, electricity markets etc. However, it is currently rarely taken into account how these changes affect the physical elements of the grid. Accordingly, network tariffs do not include the loss of life of physical equipment. The task includes the calculation of loss of life of high-to-medium voltage transformers, based on temperature sensors and thermal calculations. This loss of life is calculated for the actual electricity market products, thus can be a basis of a quantitative decision support system for the TSO or DSO approving the product. On the other hand, the available transmission capacity of the network elements can restrict the design of market products or the extended installation of RES. Traditionally, the transmission capacity of this equipment is determined by the static rating calculation method, which takes into account the worst-case environmental parameters. A novel approach called dynamic thermal rating (DTR) is developed in order to adjust the ampacity of such equipment to the actual prevailing environmental conditions. Therefore, the weather parameters around the given system element have to be measured, on which based the actual transmission capacity can be determined by using the element's thermal equation. Using dynamic thermal rating, the transmission capacity of these network components can be increased by 20-40% on average in more than 95% of the time.

Each demo in the OneNet project is unique in its own way due to various factors resulting from the regulations, legal environment, and historically used technological solutions. Although many of the designed

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

solutions and ideas are the same, e.g. the main market processes for the purchase of flexibility services (pre-qualification, offering, activation and settlement), each of the demos approaches this topic individually. Therefore, each demo has unique solutions that fit into the national environment of a given demonstrator. The chapter below describes the unique elements used by the demo from the eastern cluster, which constitute an innovative idea and approach to a given issue.

6 Semantic data modelling to enable data interoperability

The process of flexibility service harmonisation requires data interoperability between different stakeholders at the pan-European level. The term of data interoperability refers to the ability of two or more systems (or platforms) to exchange information and use that information for correct co-operation. The two most important aspects of data interoperability are semantic interoperability and syntactic interoperability. Semantic interoperability ensures the understanding of the information contained in the exchanged messages. Syntactic interoperability means understanding of data structure in exchanged messages [11]. IEC Common Information Model (CIM) is a key enabler for achieving data interoperability in modern power systems. It is widely-accepted and the most comprehensive semantic model of the electric power system. In each specific implementation, a comprehensive CIM (canonical) model is reduced to a profile, which includes all classes necessary for data exchange in a given use case.

This chapter briefly overviews CIM applicability for flexibility markets and the advantages that introduces. Deliverable 10.3 “Report on development of integral market platform” provides more details on the semantic data modelling that will enable data interoperability in the flexibility markets. More details about CIM profiles for modelling of information instances exchanged within system use cases (SUCs) that describe demonstrations in the OneNet project are given in the deliverable D5.6 “Report on Extended Data, Platform and Service Interoperability”.

6.1 Overview of Common Information Model

At the beginning, CIM was developed as a concept to facilitate interoperability between applications. During the time it evolved into a standard for interoperability between systems. CIM canonical model is described in UML (Unified Modeling Language) and includes three core standard suits:

- IEC 61970 “Energy Management System Application Program Interfaces (EMS-API)”, focused on static and dynamic network analysis and incorporates models of power system components;
- IEC 61968 “Application Integration at Electric Utilities - System Interfaces for Distribution Management” is used for the distribution network and operational systems, such as distribution management system (DMS) and geographical information system (GIS);

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

- IEC 62325 “Framework for energy market communications” describes data exchange for the business processes at the electricity markets.

Each of the listed standard suits includes more standards with specific purposes. For instance, group of IEC 61970 is the most mature group of CIM standards and are related to:

- Parts 301 & 302 – models,
- 400 series – profiles, and
- 500 series – serialization of profiles using RDF Schema.

Based on IEC 61970 standards, ENTSO-E developed a new profile related to the transmission grid modelling and analysis – CGMES (Common Grid Model Exchange Standard). CGMES is defined with the two IEC 61970 documents, in particular:

- Part 600-1: Common Grid Model Exchange Standard (CGMES) - Structure and rules;
- Part 600-2: Common Grid Model Exchange Standard (CGMES) – Exchange profiles specification.

CGMES is “European specification used for the exchange of power system models between TSOs for the purpose of performing bilateral, regional or pan-European studies or data exchanges in the frame of system operation, system development or TSOs’ projects as defined in the EU legislation” [12]. Currently, CGMES can be used for the modelling of HV and MV distribution grid, while it is not appropriate for the LV grid due to phase unbalances.

A set of IEC 61968 standards are focused on information exchange related to the DSO business processes and systems. Examples of the standards important for the information exchange within the deployment of flexibility services:

- IEC 61968-3: Interface for network operation;
- IEC 61968-4: Interfaces for records and asset management;
- IEC 61968-5: Distributed energy optimization (related to the operational planning);
- IEC 61968-5: Interfaces for customer operations;
- IEC 61968-9: Interfaces for meter reading and control;
- IEC 61968-13: Common distribution power system model profiles (for distribution grid modelling).

IEC 62325 standards facilitate the exchange information between market participants independently on the internal representation of information. The standard suit covers two styles of markets, the European-Style markets and North American-Style markets. IEC 623235-450 describes the modelling framework in which two steps are defined: profiling derivation and implementation derivation. The first step refers to the

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

reduction of the canonical models to specific profile business requirements, while the second step is focused on the message assembly and implementation. In order to enrich the European style market profile, ENTSO-E developed “new business processes within the IEC 62325-451-n series for international standardization purposes or a specific business process complying with the IEC 62325-450 methodology” [13]. In general, ESMP meets the requirements for the information exchanges in the scope of the TSO balancing market, while further adaptations are necessary to meet the needs of flexibility markets. Within ESMP, “market document” is a format of exchanged messages.

6.2 Common semantics for the standardised flexibility products

Chapter 2 of this report describes flexibility services and harmonised flexibility products assigned to these services. Each product is further evaluated using attribute-value pairs. Product attributes are included in the data models used in the information exchange within business processes on the flexibility market. European Style Market Profile (ESMP) can be used as a common semantics for the flexibility products, with some further adaptations. When service requires the exchange of information related to the grid models (operation, measurements) CGMES can be used. Task 5.6 comprehensively analyses using CIM for semantic modelling of business objects (information instances in SUCs) related to the flexibility services and reports it in the deliverable D5.6. All necessary CIM profiles necessary for the delivery of flexibility products (including OneNet demonstrations) are developed within task T5.6.

East Cluster demos include three main flexibility services and one or more products related to the service: congestion management, voltage control and frequency (balancing) service. The common business process describing procurement and usage of flexibility service on the flexibility market include: prequalification, bidding, market results, activation and settlement. The following analysis provides information on which standards and market documents should be used for the exchanged data. A particular product is within a market document denoted with a code. ENTSO-E provides a list of codes for TSO ancillary service. However, these codes should be harmonised also for the DSO ancillary services.

Prequalification

Currently, there is no available profile for market and product prequalification within ESMP. A new profile for prequalification, however, was developed within H2020 INTERRFACE project and will be further adapted within task T5.6. Prequalification documents should incorporate all data specific for each product.

Bidding

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

For the bidding process, IEC 62325-451-7 standard can be used. ReserveBid_MarketDocument is used for the bids relating to the capacity products as well as for the energy products.

Market results

IEC 62325-451-7 standard can be used. Information about the selected bid is written as Reserve_Allocation_Market_Document. Merit Order List (MOL) is represented with the MeritOrderList_MarketDocument.

Activation

System operator sends an activation signal to FSP to activate products. The activation signal is modelled with Activation_Market_Document within IEC 62325-451-7 standard.

Settlement

Standard IEC 62325-451-4 describes the settlement business process that can be used throughout a European style market. EnergyAccount_MarketDocument is used to represent settlement data.

6.3 TSO-DSO coordination

The document "TSO – DSO report: an integrated approach to active system management" [6] states that unlocking the flexibility market requires TSO and DSO to harmonize processes in regard to the data exchange and to avoid actions that would put power systems security at risk. It is recommended that DSO introduce a Traffic Light System (TLS) for signalling of the distribution grid state (e.g. congest, voltage profile violation). TLS signal is shared between DSO, TSO and all market parties. The normal grid state is represented with the green state, and there are no limitations for actions such as activation of DERs in distribution grid for the TSO ancillary services. In the yellow phase, a congestion or voltage limitation is expected. In such phase, no market party is allowed to take action that would have a negative impact on the distribution grid state. FSPs in this phase provides flexibility service in the affected area, which should bring the grid in the normal (green) state. If such action fails, TLS is going in the red phase and DSO follows different rules.

Currently, there is no CIM profile for modelling TLS data provided in the scope of ESMP and CGMES. A new profile was developed within task T5.6 of OneNet. It is available in the deliverable D5.6.

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

7 Conclusions

This deliverable 10.2 presents the most important work results, developed by the Demos from the Eastern Cluster, carried out under task 10.2: Selection of services and other design elements of the integral flexibility platforms of the OneNet project. The document describes the services and products selected by demonstrations within the Eastern Cluster, along with the context and related issues. focuses on the issue related to the selection of services and products in the demo of the incoming cluster, along with the context. This part of the document presents the conclusion of the in-depth analysis for the Eastern Cluster in terms of flexibility services that will be tested within the OneNet project.

The network needs of DSOs involved in the project within the Eastern Cluster are convergent and focus on congestion management and voltage control services. Problems with exceeding the permissible voltage range and the occurrence of overloads may occur in the network, regardless of the structure and type of the network and the method of network management. Congestion management services are needed at all voltage levels: HV, MV and LV which is reflected in the demonstrations done within the Eastern Cluster. Congestion may apply to various network elements: overhead and cable lines, MV/LV or HV/MV transformers. Although each of the Demo in the Eastern Cluster struggles with its own individual problems, the idea of using flexibility services to improve network efficiency is similar. Demos focus mainly on the predictive approach for congestion management and voltage control services. The main time horizon for problem-solving is day-ahead. Additionally, in the case of the Polish and Czech demos, it is planned to use the services more than a day in advance.

New products for congestion management and voltage control services developed as a part of the OneNet project have been prepared based on the DSO's knowledge of the problems in their networks and possible solutions for these problems. Each of the Demos approached the topic of product definition individually and focused on the problems occurring in their network. Nonetheless, the way the products are constructed is similar and there is some similarity between the individual Demos in the Eastern Cluster. Nevertheless, the legal and market environment, the technologies used by the System Operators and the approach to building IT solutions make it difficult to develop one, common and standard product, taking into account the unique nature of each demo.

The Polish demo, as the only one in the Eastern Cluster, plans to investigate the possibilities of using flexibility services to support the balancing of the national power system. As part of the demonstration, the technical possibility of purchasing balancing services from entities connected to the MV grid that do not operate directly on the balancing market will be verified. In the Polish demo, the flexibility services market will be connected with the balancing market, thanks to which it is possible to coordinate actions between DSOs and TSOs and to take into account the actions taken by entities operating within the flexibility services market in the balancing process.

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

In order to solve the problems defined by each of the Demos in the East Cluster, System Operators defined adequate products to solve their problems. New products developed by the DSO focused on the area of congestion management and voltage regulation. The Polish demo, which will additionally focus on the issue of balancing, will use standard balancing products like FRR or RR. DSOs in the Eastern Cluster focus on active power management for congestion management and voltage control services. The Hungarian demo plans to use a product based on reactive power to eliminate congestion and control voltage. In the case of the Czech demo, reactive power management will be used to limit reactive power flows in the grid and to regulate voltage. Demonstrators focus mainly on predictive service, which enables them to solve problems in the day-ahead horizon. The Polish and Czech demos also plan to use the services purchased in a time horizon longer than the next day. This requires system operators to have tools to simulate future grid operations based on generation and consumption forecasts over a longer time horizon.

DSO's problems related to voltage control and elimination of overloads in the network are local and relate to specific elements in the distribution network, ie. HV/MV or MV/LV stations, transformers or power lines. Therefore, each of the cases of these problems in the network should be approached individually, taking into account the specificity of a given area. The key is to use local resources to solve a given problem located in the area affected by the undesirable phenomenon. This is one of the main parameters that characterize DSO dedicated products.

As part of the demonstration, DSO from the Eastern Cluster focused on active power management, as it is an effective way to eliminate network overloads and can be used in the case of MV and LV networks for voltage regulation. Although reactive power management is a more natural approach to voltage regulation, it has a number of barriers. In order to be able to influence the reactive power flows, it is necessary to have controllable resources enabling the consumption or delivery to the network of reactive power. In order to analyze the impact of a given flexibility service provider on the operation of the network and to improve the power quality, it is necessary to have the appropriate network analytical tools. Since controllable reactive power resources are not as common as active power resources, there is a certain barrier that hinders the market approach to the use of reactive power resources.

All activities related to active power management influence the balancing of energy systems. Where the market for flexibility services does not operate in connection with the balancing market, any activities carried out by System Operators will require additional actions on the side of the entity responsible for balancing. Coordinating activities in both markets can bring significant benefits to entities operating in both markets. The mere provision of information about the planned change in the consumption or generation of active power may have a positive effect on the balancing process and eliminate the problem of excessive balancing of the system.

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

The ideal solution is to combine both of these issues within one action, i.e. solving the problem in the DSO network (congestion/voltage issues) and contributing positively to the system balancing.

The Demos from the Eastern Cluster, plan to use the same products for different purposes, eg. active power management for congestion management and voltage regulation. Since the output of some actions can be used to solve different problems, the products for congestion management and voltage control can be identical and have the same parameters. Not in every case considered by Demo from the Eastern Cluster, it is possible to use one product for several services. Nevertheless, during the demonstration, all Demos from the Eastern Cluster plan to use some products that can be used to solve more than one problem. This approach makes it possible to limit the number of products defined on the market and increases its transparency.

One of the factors determining the way products are defined by System Operators is the way the energy market operates, including the flexibility services market in a given country. The way of functioning of energy markets dictates the way of trading in services related to increasing the flexibility of grid operation. Market mechanisms have a great impact on the way services are contracted on market IT platforms. The way of functioning of the flexibility services market, described in more detail in document 3.1, in each of the countries where demonstrations are carried out, imposes the method of testing and product design.

In the OneNet project, each Demo tackled specific problems on the network in the demonstration areas. DSO had knowledge of the technical possibilities of solving a given problem. Due to the research nature of the project and the specific problems that each DSO planned to solve, the scope of the requirements for the flexibility service provider was precisely defined. The products have been designed for a specific type of customer who can provide services to a given operator, e.g. prosumers equipped with photovoltaics. DSOs have adopted very subdued requirements for flexibility service providers. There were no requirements that would be difficult to meet for the recipients, which would entail the need for a potential flexibility services provider to incur additional expenses or the use of additional technological solutions. The DSOs did not require the ability to remotely control the sources of flexibility, which would allow very fast activation times, but required direct communication with DSO domain systems. Both the possibility of manual and automatic source control has been approved by the DSO from the Eastern Cluster. Activation and response times and way of the control of the flexibility resources depending on the products to be provided for the needs of System Operators. In the case of the DSO's need related more to the congestion and voltage problem in the day ahead or longer time frame, there is no need for very restrictive requirements regarding the time parameters of services (unlike balancing services for which response times are very important). The main requirement for the customer is to have a monitoring system for energy flow from and to the grid. In most cases, the role of this system can be fulfilled by appropriately configured measuring systems equipped with the possibility of remote reading, i.e. smart meter. The range of power possible to be offered by the flexibility service provider was adjusted to the needs of the

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

given DSO and the grid voltage level in the demonstration areas. Requirements for the maximum power declared by a given provider of flexibility services were not provided by the DSOs, as they are not considered the most important parameters of the service. A more important element from the DSO's point of view is the possibility of dividing and aggregating the offer.

System Operators should use common sense and understanding towards service providers to jointly build a market for flexibility services. A large number of products defined by System Operators may reduce market transparency and adversely affect market development. Poorly selected parameters for services, including strict time parameters, at a time when the flexibility market is only taking shape, may also inhibit the development of the market.

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

8 References

[1] European Commission - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Energy Roadmap 2050 - COM(2011) 885/2 – *http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf (last accessed: DATE)*

[2] OneNet Deliverable D2.2: "A set of standardized products for system services in the TSO-DSO-consumer value chain" 2021

[3] European Commission, COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing, Off. J. Eur. Union. 2017 (2017) 312/6-312/53. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.312.01.0006.01.ENG&toc=OJ:L:2017:312:TOC#d1e2376-6-1.

[4] Interrface project, Interrface Deliverable 3.1: Definition of new/changing requirements for services, n.d.

[5] OneNet Deliverable D2.3: "Business Use Cases for the OneNet" – 2021

[6] TSO-DSO Report: "An integrated approach to active system management with the focus on TSO-DSO coordination in congestion management and balancing" – April 2019

[7] Report: "Flexibility in the Energy Transition - A toolbox for electricity DSOs' and from Guideline Electricity Balancing [GL EB]" – 2018

[8] THE HARMONISED ELECTRICITY MARKET ROLE MODEL - VERSION: 2020-01 by ENTSO-E and the associated organisations EFET and ebIX.

[9] OneNet Deliverable 2.5: "Recommendations for the Harmonised Electricity Role Model" – 2021

[10] OneNet Deliverable 3.1: "Framework for coordination models and market set-ups" -2021

[11] A. Souvent, T. Kodek and N. Suljanović. CIM-based integration in smart grids: Slovenian use cases. 18th International Symposium INFOTEH-JAHORINA (INFOTEH) 2019, Jahorina, Bosnia and Herzegovina, 20-22 March 2019.

[12] IEC 61970 Part 600-1: Common Grid Model Exchange Standard (CGMES) - Structure and rules. 2021.

[13] ENTO-E, European style market profile User guide, 2017. https://eepublicdownloads.entsoe.eu/clean-documents/EDI/Library/cim_based/20170110_ENTSO-E_CIM.pdf

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

This paper reflects only the author's view and the Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.

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