Report on customer engagement

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List of Abbreviations and Acronyms

BAU	Business As Usual
BESS	Battery Energy Storage Systems
CASS	Coordinated Security Analysis
CEPS	Česká Energetická Přenosová Soustava
DER	Distributed Energy Resources
DLC	Direct Load Control System
DSM	Demand Side Management
DSO	Distribution System Operator
ECCoSP	ENTSO-E Communication And Connectivity Service Platform
ECP	Energy Communication Platform
EDX	Energy Data Exchange
EOP	Energa Operator
ENTSO-E	European Association For The Cooperation Of Transmission System Operators
ERO	Energy Regulatory Office
ESPA	Electricity Supply Act
FSP	Flexibility Service Provider
FSPA	Flexibility Service Provider (Aggregated)
EG.D	Name Of Company (DSO) Former E.ON distribuce
EN 50106	European Standards For Electricity
EU	European Union
IRiESD	Distribution Grid Operation And Maintenance Manual (Poland)
IRiESP	Transmission Grid Operation And Maintenance Manual (Poland)
KPI	Key Performance Indicator
mFRR	Manual Frequency Restoration Reserve
MQ	Message Queues
MRA	Multilateral Remedial Action
LV	Low Voltage
MV	Medium Voltage
NC RfG	Network Code On Requirements For Grid Connection Of Generators ((EU) 2016/631)
NKKT	Negative Critical Peak Tariff
NRA	National Regulatory Authority
OSD	Operator Systemu Dystrybucyjnego
P	Active Power
PF	Power Flow
PKKT	Positive Critical Peak Tariff
PN-EN 50438	European Standards For Electricity
PSE	Polskie Sieci Elektroenergetyczne

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PST	Phase Shift Transformer
PV	Photovoltaic
Q	Reactive Power
RES	Renewable Energy Source
ROCOF	Rate Of Change Of Frequency
SE	State Estimation
SLP	Synthetic Load Profile
TSO	Transmission System Operator
ULN	Line Neutral
ULL	Line Line
VVC	Voltage Var Control
WLS	Weighted Least Square

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Executive Summary

This report provides insight into contribution of DEMOs involved in Eastern cluster to dedicated solutions enabling market for non-frequency flexibility services. Each DEMO prepares dedicated IT environment enabling market-based procurement of non-frequency flexibility services. This solution will enable participation of wide array of active customers and thus will unlock the potential of smaller units for the provision of flexibility. IT solution will allow creation of open and transparent way for participation in flexibility market providing information on bids/offers to wider amount of market participants – replacing existing way of flexibility procurement through bilateral contracts.

The report is a case study covering four countries – members of cluster East of One Net project: Hungary, Czech Republic, Poland and Slovenia. The description will involve compilation on existing ways of flexibility procurement before dedicated IT platform is in place. The report will also depict existing regulatory environment and its impact on flexibility market. Finally, there will be part discussing expected benefit for participation of customers/aggregators through One Net demonstration projects.

The report concludes that proper implementation of relevant solutions intended for DEMO projects involved in the Cluster East shall have positive impact on customer engagement. This is namely because of creation of dedicated tools enabling involvement of new energy market participants and introduction of new business models.

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1 Introduction

The deliverable is a description concerning contributions of DEMOs involved in the Cluster East of the One Net project towards customer engagement through innovative market-based solutions for non frequency flexibility services. The report is divided into three parts in order to demonstrate the improvement which the DEMO project will bring through implementation of dedicated solutions.

1. Current State - Non frequency flexibility services
    - First part covers current situation reflecting recent options for dealing with grid issues (especially in distribution networks). The aim is to analyse what tools are available with no market based/multilateral place for flexibility procurement by DSOs. All cluster members report on existing national schemes including tariffs-based tools for grid operation, bilateral contracts between DSOs and involved units or given technical parameters for units/generators allowing safe and reliable grid operation. This part also discusses how these services are divided according to voltage level.
2. Regulatory and Technical Barriers
    - Second part provides insight into regulatory and technical barriers preventing some part of providers/aggregators/units from flexibility provision in each country and define corrective measures that need to be changed.
3. DEMOs Contributions
    - The third section shall demonstrate how the pilot DEMO projects contributes in terms of unblocking flexibility potential for providers and how they are enabled to gain access to flexibility market and thus empower customer engagement.

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2 Methodology

This document was prepared based on the information and data from partners involved in the demonstration under Eastern cluster, especially from leaders of each DEMOs: Poland, Czech Republic, Slovenia and Hungary. Some of the information that was prepared by the DEMOs for OneNet horizontal work packages was included in this document as well. To be consistent in the terms of terminologies and definition, some inputs from horizontal work packages was used, i.e. definitions for services and products in OneNet project from WP2[1].

The deliverable aims to collect information on existing policies in relevant countries belonging to Eastern cluster concerning grid related issues. In addition, involved parties provided information on regulatory environment to complete description also in terms of regulatory point of view. Above mentioned information provide basis for further research on possible benefits of innovative solutions on both transparency and customer-oriented measures in the field of flexibility services.

Last part of the deliverable based on the findings in the previous sections indicates potential of DEMO (at the time of writing), however, the projects are still ongoing) through innovative solutions. This potential cannot yet be measured, however each DEMO reflects measurable benefits through KPIs delivered to the relevant work package. Involvement of customers in the tests can be direct of indirect based on the scenarios tested. Mostly the projects aim at rethinking and reconsidering of the whole process and chain of service procurement which doesn't need direct participation of the customer in the process. For example, ability of aggregators for the tests will result in the participation of the whole customer contingent, without need to conduct specific recruitment campaign; however customer are part of the process/testing.

[1] Task 2.2: Definition of standard products in the TSO-DSO-consumer value chain

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3 Current State - Non frequency flexibility services

This chapter includes current situation reflecting recent options for dealing with grid issues (especially in distribution networks). The aim is to analyse what tools are available with no market based/multilateral place for flexibility procurement by DSOs.

The following table shows a summary of the different options used in each country that are explained in the subchapters:

	Czech Republic	Hungary	Poland	Slovenia
Generators	DSO - Generators Low voltage level control		DSO – Generators low voltage	
	DSO -Generator medium voltage level control		DSO -Generator medium voltage level control	
	DSO -Generator high voltage level control		DSO -Generator high voltage level control	
Consumers	DSO -Consumption control for congestion management	Direct load control system (DLC)		Dynamic tariffs

Table 1: summary on non frequency flexibility services (current state)

3.1 Non – frequency flexibility services (Czech Republic)

Low voltage level – grid operator mainly addresses voltage issues. To control voltage in given limits and to increase the hosting capacity of the grid there is an obligation to implement smart PV inverter to control voltage that is set up according to NC RfG (Network Code on requirements for grid connection of generators; Commission Regulation (EU) 2016/631). Q(U) and P(U) functions work autonomously without the need of communication towards the DSO – the system controls reactive power in order to keep voltage in required limits. In fact, customers provide a "service" to the grid, but it is not purchased through market/contract – it is required through relevant legislation in place. The setup for Q(P), P(U) and Q(U) control functions is within limits set by relevant Czech grid code.

Medium voltage level – the relevant regulatory pattern is similar to previous section. Generators at these voltage levels have the obligation to support the grid in terms of production/consumption of reactive power. Again, it is not a service purchased on the market or through bilateral contract with DSO. Voltage control mechanism is a bit different from previous example – At ČEZ Distribuce (a DSO) distribution area it is still partially controlled by the dispatcher from dispatch control system of DSO. Generators/DERs receive a set point of requested voltage value which is set by the dispatcher (however the unit's regulation works autonomously). At

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EG.D (another DSO), MV SCADA system includes Automatic Voltage Regulator, which automatically calculates optimal P(Q) setup according to the current state of the grid, and remotely sets the appropriate power factor set point for MV-connected generators. The limits for this setup are likewise within the rights of the DSO described in the national grid code for distribution grid operation. The system can be manually deactivated or overruled by a dispatcher for any given generator and is used not only to keep local voltage within limits, but also to mitigate reactive power flows into high voltage grids and subsequently into transmission grid.

High voltage level – the grid operator addresses voltage issues and overflows of reactive power into the transmission grid. The aim of the former issue is to manage voltage fluctuations (keeping voltage in defined limits) through management of reactive power. The latter issue addressed is the management of reactive power. According to relevant contract between DSO and TSO there is certain amount of reactive power which is allowed to be transferred to the transmission grid. For that purpose was analysed some primary substations at EG.D distribution area. As a conclusion, some of them we have Q overflows to transmission grid about 99 % of time (see Figure 1.)

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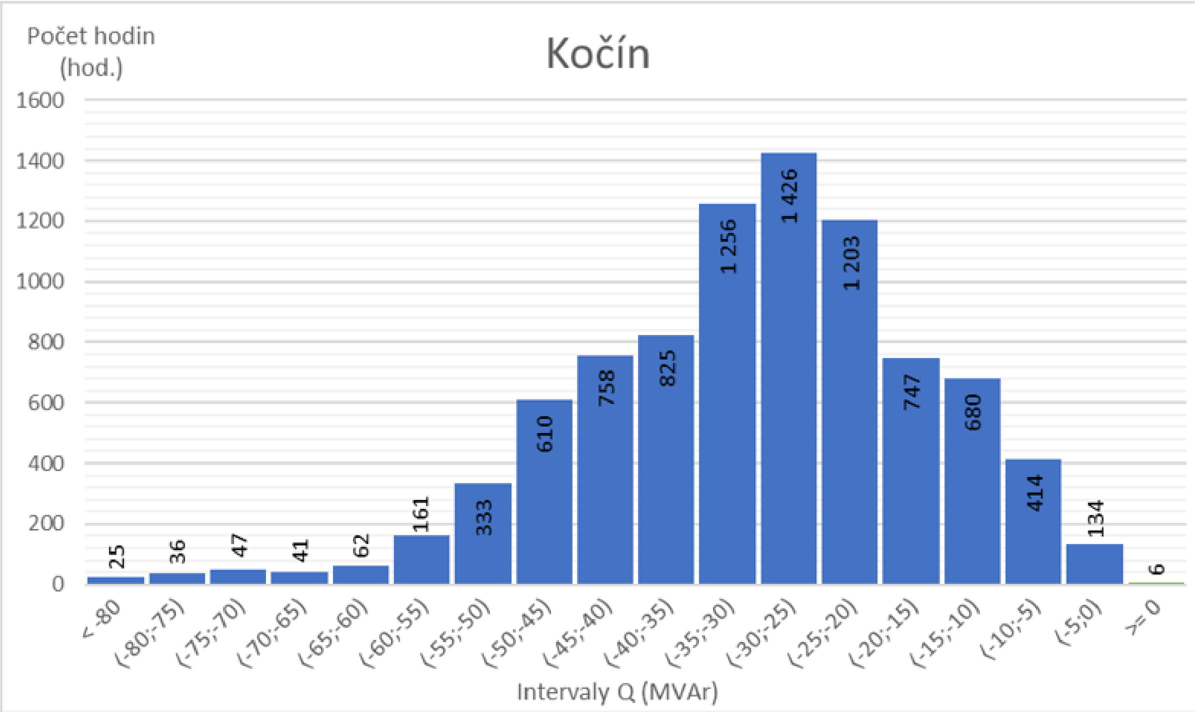

Figure 1 Q overflows to Transmission grid at Kočín Substation

In respect of that, relevant generators are directly connected into the dispatching centre of the DSO and they are managed through it within certain power factor limits defined in Czech grid code. It is a certified service procured based on capacity basis – a provider of the service is required according to the contract to provide a certain capacity in given time.

Congestion management at the distribution level (in this regards it refers specifically congestion of relevant grid elements) is done via ripple control system (called HDO: centralized control of loads - in Czech "Hromadné Dálkové Ovládání") - the DSO controls the consumption by the ripple control system, shave peaks of the load profile, reduces losses and, more importantly, controls generation in small, decentralized sources. This significantly contributes to the optimization of distribution network operation. Thanks to the HDO, the distribution system is developed in an optimized manner with minimum investment costs. This system is used for direct remote control of groups of appliances according to the time schedules set, reflecting the network load level. For example, electric boilers have their Time of Use scheduled for periods, where overall grid load is estimated to be low.

The HDO system also allows sending tariff signals to the customers (enable to differentiate between the high and the low electricity price level).

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On the transmission level, the TSO procures non frequency flexibility services from transmission-connected devices. The procured services include black start capability, island operation and voltage control. All the services are subject to prequalification (certification) with terms and conditions described in the TSO Grid Code and subject to NRA approval.

Specifically for voltage control, TSO procures the reactive power capability of synchronous units [2] to complement the TSO's reactors. Each providing synchronous units´ reactive power is controlled by a voltage controller in the substation it iis connected to. The setpoint of the voltage controller is set by TSO operators in real-time based on the system needs (keeping voltage within operational security limits and maximizing transmission capacity) or following a recommendation from optimizing algorithm (minimizing losses).

Congestion management on the transmission level is carried out in coordination with TSOs in the region. ČEPS participates in the coordinated security analysis (CSA) facilitated by the regional coordinator TSCNET. Based on the regional analysis, ČEPS activates remedial actions in line with Art. 22(1) of SOGL. On top of that, an optimizing algorithm in ČEPS' control system may recommend the activation of remedial actions in real-time based on the actual contingency analysis results.

The most common remedial actions are reconfiguration and PST tap change. ČEPS has also concluded contracts for redispatch with all transmission-connected units as well as the largest distribution-connected units. Additionally, ČEPS may activate cross-border redispatching in accordance with the Multilateral Remedial Action (MRA) agreement.

3.2 Non – frequency flexibility services (Hungary)

There is a legacy of direct load control system (DLC) in Hungary for residential customers, owned and operated by DSOs. This system can switch on/off the power supply of dedicated connection points. The supply must be operating for at least 8 hours per day, from which 4-6 hours are outside the peak time, the shortest switching time must be longer than 15 minutes. Customers can only connect fixed devices (boilers, heaters) to these electrical connection points. The DSO uses ripple control or radio ripple control technology to send out control signals. Every DSO formed groups of DLC customers with the aim of even spatial distribution (therefore locally the effects on e.g. voltage will be negligible), the main purpose of the system is to reduce the residential peaks and increase the consumption during night-time on a system level. However, the reduction of peak load also avoided network developments at the DSO level. The customers have a reduced tariff (called „B" tariff,

[2] No power park modules or demand is connected to the transmission system of the Czech Republic

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currently around 63% of the regular tariff) for this part of their consumption which is separately metered. The cumulative installed capacity of such loads is approx. 1.3 GW (the peak load of the country is 7.1 GW). The system started the operation around 1975 and most of the customers joined in the 90s.

Later the DSO's introduced a new tariff for heat pumps (called „H" tariff). This is a seasonal tariff also with direct load control available from mid-October to mid-April and the price is not higher than the "B" tariff. There is also so-called Geo tariff, which is only available for the customers of 2 DSOs, according to which the DSO can switch the supply off for 2×2 hours per day (so minimal 20 hours of operation), and offer a reduced tariff, slightly higher than the "B" tariff.

Currently DSOs do not use non frequency flexibility services as commercial, procured products from market players. Any action between customers (either generation, storage or consumption) is due to planned maintenances or disturbances. Due to the implementation of the EU directives, the regulation currently introduces the framework for flexibility (market based) and DSO redispatch (regulated). Since the DSOs currently cannot use redispatch, as a first step the regulation focuses on that part, until then DSOs and the regulator analyse the potential of the market and are introducing pilot flexibility platform projects. The distribution grid code and the Hungarian Energy Law contains information about the framework. However, it is still in implementation phase and DSOs do not use such options yet in practice.

In the current framework the DSO is the market operator, the only procurer and responsible for the product definition. The flexibility market is separated from the ancillary services market (operated by the TSO) and provided products do not count as energy trading.

Regarding redispatch, any generation, storage or demand side management facility can be included as the directives describe (2019/943/EU). The DSOs must use the least amount of redispatch and treat all the actors equally. The goal is to keep the curtailed energy under 5% of the total yearly production (in a 10-year average span). DSOs must give notice to the relevant customers 30 (MV) or 60 (HV) days before the redispatch.

DSOs must analyse the flexibility services and redispatch as an alternative of conventional network development methods to meet the least cost approach in their operation. If the DSO procures such services, it will be included in the acknowledged costs. The grid code describes the cornerstones for the accreditation procedure, the cost comparison principles, contractual and data sharing needs. A flexible connection agreement was also introduced in this step, where generation facilities can agree to curtailment in a bilateral contract to reduce the network development costs due to their connection.

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3.3 Non – frequency flexibility services (Poland)

In Poland, the requirements for generation sources connected to the DSO / TSO network are currently defined by the provisions of the NC RfG (Network Codes Requirements for Generators). The provisions from the network code concerning the requirements for sources connected to the DSO network are also transferred to the Distribution Grid Operation and Maintenance Manual (IRiESD) and to the Transmission Grid Operation and Maintenance Manual (IRiESP).

The NC RfG grid code divides all generation sources, due to the connection capacity and connection voltage, into 4 groups: A, B, C, D.

For sources connected to the LV grid, from the point of view of the generation source owner:

- In the case of new sources connected to the LV grid, they should be prepared for "on-off" control for a given source.

- For PV installations, there is a list of approved inverters that meet the technical requirements approved by the DSO. The inverter must have a certificate of equipment meeting the requirements of the NC RfG and General Use Requirements developed on the basis of the provisions of the NC RfG, issued by an authorized certifying entity or a compliance test report carried out in a simplified mode. The devices are preconfigured before installation, and the implemented protection or regulation settings comply with the „U" limit values specific for the LV networks.

- The Distribution Grid Operation and Maintenance Manual (IRiESD) specifies the requirements for automatic shutdown (without the active role of the customer) of PV in the event of exceeding the permissible voltages.

Security function		**Required setting a value exclusionary**		**Maximum disconnection time**	**Minimum time operation**
U_{LN}	Voltage reduction	0,85 Un	195,5 V	1,5s	1,2s
	Voltage rise stage 1*	1,1 Un	253,0 V	3,0 s	-
	Voltage rise stage 2	1,15 Un	264,5 V	0,2 s	0,1 s
U_{LL}	Voltage reduction	0,85 Un	340 V	1,5 s	1,2 s

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	Voltage rise stage 1*	1,1 Un	440,0 V	3,0 s	-
	Voltage rise stage 2	1,15 Un	460,0 V	0,2 s	0,1 s
Frequency reduction		47,5 Hz		0,5 s	0,3 s
Increasing the frequency		52 Hz		0,5 s	0,3 s
Protection against island operation	ROCOF	2,5 Hz		0,5 s	-
	active	-		5 s	-
* 10-minute average value according to EN 50160. Detailed measurement requirements the average value is included in the PN-EN 50438: 2014-02 standard.					

Table 2: Protection system settings

For sources connected to the MV grid, from the point of view of the generation source owner:

- In the case of new sources connected to the MV network, the DSO has the option of "on-off" control for a given source. Additionally, if there are technical possibilities - the generating source transfers the measurements online to the SCADA OSD system of basic parameters such as voltage, current, power, non frequency. flexibility services. The control for the source is extended by remote (from the SCADA level) making the Q, P, cos φ, U control.

- There is a possibility of local, autonomous control of the source based on predefined values of P, Q, cos φ, U parameters.

- DSO does not provide flexibility services with producers connected to the MV grid.

- From the DSO's point of view, voltage regulation in the MV network takes place using automatic voltage regulation, and in the future with the use of the VVC module - volt var control (regulation of generation sources connected deep in the MV grid).

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For sources connected to the HV grid from the point of view of the generation source owner:

- In the case of sources connected to the HV grid, the DSO has the option of "on-off" control for a given source. Additionally, if there are technical possibilities - the generating source transfers the measurements online to the SCADA OSD system of basic parameters such as voltage, current, power, non frequency flexibility services. The control for the source is extended by remote (from the SCADA level) making the Q, P, cos φ, U control.

- There is a possibility of local, autonomous control of the source based on the predefined values of P, Q, cos phi ,U parameters.

- DSO does not provide flexibility services with generators connected to the HV grid, however, if in the case of implementing regulations for the needs of the DSO, the limit values specified in the connection conditions will be exceeded, the generating source does not bear any financial consequences.

- Regulations of RES generation sources are performed only when there is a risk of exceeding the permissible voltage limits in the HV grid (which may damage the primary and secondary equipment) or minimizing the effects of transient states during operational connections and are performed only after using all other available grid and other possibilities.

- From the DSO's point of view, the voltage regulation in the HV grid is performed by PSE (the TSO) with the use of the LV grid.

3.4 Non frequency flexibility services (Slovenia)

Currently more demonstration projects are taking place where dynamic tariffing is used for providing grid flexibility, therefore enabling congestion management on the LV grid at the secondary substation level. First type of flexibility is done through special low price and special high price tariffs. These tariffs are currently used for small businesses and physical customers (households/SMA). One- or two-tariff billing system is supported. Two-tariffs system aim is shifting consumers' energy consumption into periods when the network load is smaller. Price of electricity and network fee are higher between 6:00 to 22:00 during workdays, otherwise the prices are lower. The electricity price during hours with the lower fee is roughly 55% of the higher price and the network fee for households is 76% of the higher price network fee. The fees are not truly changed dynamically in time, they can be fixed for several months.

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With a new regulation a possibility of dynamic tariffing has been introduced in Slovenia. The regulations´ first phase intention is to allow to offer a conscious buyer lower market price on account of their flexibility. The electricity prices could be changed even during a day. For example, the buyer could be signalled a day in advance that the price will be lower during evening hours from 21:00 to 24:00. The buyer could use the specified time frame to increase his consumption by charging his electric vehicle, wash or dry laundry, etc. For network fees the Energy Agency (the NRA) in the Slovenian energy market has prepared a regulation, a network act, that enables their dynamic charging. The dynamic tariffing pilot projects use some of the dynamic charging possibilities of the network act, namely PKKT – positive critical peak tariff, and NKKT – negative critical peak tariff. At the time of the PKKT the network fee is approximately 10 times higher and at the time of the NKKT 66% lower than ordinary network tariff. There are 3650 hours of NKKT and 30 to 100 hours of PKKT available in a year for a distribution grid using dynamic tariffs.

The Energy Agency is in this year working on a project on new tariff system which will be available in the next period by the end of 2024. The network fees will be different according to time of day. The day will be split into time blocks with a pre-defined fee according to network conditions in the time frame. The end users will have a possibility to announce their consumption during the blocks. They will pay reserved price for the announced consumption and higher price for the consumption beyond the announced one. Since the project is ongoing, more information on all possibilities will be available at the end of this project.

Flexibility services using dynamic tariffing at energy communities

Another pilot mechanism used in Slovenia is dynamic tariffing for citizen energy communities. The main goal is to perform local balancing between electric energy production and consumption, which leads to greater self-sufficiency, higher energy efficiency and consequently decreased carbon footprint. Practical implementations of some forms of such communities are already operational in some European countries and the first communities are under development in Slovenia as well. From the perspective of energy billing, citizen energy communities can currently be subject to pilot mechanisms introducing special dynamic tariffs, under the condition that such communities are qualified as pilot projects at Slovenian Energy Agency. The pilot mechanisms specifically for citizen energy communities are defined in more detail in article 137 of *Slovenian Legal Act on the methodology for determining the regulatory framework* and network charges for the electricity distribution system. A real pilot case is currently ongoing in Slovenia where citizen energy community is performing self-balancing in exchange for lower network fee in those times. When energy is locally available, the consumers are stimulated to consume that energy, since they are eligible to 20% reduction in network fee cost for the energy that is produced locally. These costs are divided according to the percentage of consumption. On the other hand, the

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consumers have to pay 100% of network fee costs for all the energy they are consuming from the MV grid. By this mechanism the consumers are motivated to balance the grid on hourly level when energy is available locally.

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4 Recent regulatory/technological barriers for flexibility provision

This chapter provides insight into regulatory and technical barriers preventing some part of providers/aggregators/units from flexibility provision in each country and define corrective measures that need to be changed.

The following table has a summary of the relevant points by country:

Resource	Czech Republic	Hungary	Poland	Slovenia
Technical barrier	there is no regular marketplace for non-frequency flexibility	there is no regular marketplace for non-frequency flexibility	there is no regular marketplace for non-frequency flexibility	there is no regular marketplace for non-frequency flexibility
Corrective measures	Ripple control system (HDO)	N/A	Bilateral	

Table 3: Summary on barriers on flexibility provision

4.1 Flexibility provision (Czech Republic)

For the time being there is no regular marketplace for non frequency flexibility services respecting transparent and non-discriminatory manner. Relevant services needed for safe and reliable grid operation are contracted directly on bilateral basis between DSO and units/generators based on conditions under negotiation or used as a mandatory support to the grid defined in Czech grid code.

To unify parameters and criteria of non frequency flexibility services Commission for operation of distribution grid (non-state expert group consisted of main DSOs) issued a supplement for „(Distribution) Grid Code“ detailing types of non frequency flexibility services approved by NRA (black start, islanding operation, nodal area [3] congestion management, reactive power management and voltage control) and technical parameters in terms of resources' ability to provide relevant response to given grid issues. This exercise is a first step allowing regular market procurement of non frequency flexibility services as it contains common criteria adopted by all major players which was so far one of main regulatory obstacles for regular use of non frequency

[3] Part of distribution grid covering voltage up to 110 kV with connection point to TSO

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flexibility services. Recent guidelines set the obligation for DSO to assess potential for use of non frequency flexibility services for given nodal area. Backed up by the assessment, the DSO is entitled to procure services in line with Czech Grid Code, which is approved also by NRA and as such, the service cost is seen as an eligible expense[4].

Based on the analysis of reactive power excess from distribution to transmission grid in EG.D distribution area, costs for reactive power management via shunt reactors installation and ancillary services acquisition has been compared. With respect to the durability of the compensators and constant values of reactive power overflow over their lifetime the fee for approaching the ancillary service (reactive power flow management) was determined on a level of 1 €/MVArh. Provided that the amount of overflow stays in the next years approximately similar and the assumed price of the service would be multiple of the one here identified, appear the acquisition of shunt reactors for the DSO as a preferred variant.

However, the national Grid Code describes only services, but not the way how services are procured. The Energy Act, the main regulatory framework for energy sector doesn't recognize any intermediary between customer and DSO – aggregator – so far. No rights/obligations for flexibility provider are defined, in particular, in terms of baseline settings and position of so-called independent aggregator etc. With respect to above mentioned the multilateral interaction amongst suppliers, DSOs and aggregators/ independent aggregators isn't possible, which blocks market development.

To enable multilateral interaction allowing flexibility offer/procurement at one centralized marketplace, the Czech Republic also lacks relevant environment. The robust platform encompassing all flexibility exchange including both grid and trade flexibility is now under discussion, and it also shall be included into new version of Energy Act. Part of this solution will be also the "Traffic Light" scheme developed under One Net (see section 5.1)

From technical point of view, flexibility potential at the lower voltage level is also blocked because of limits of monitoring capacities. The implementation of smart metering infrastructure allowing remote reading of data from household customer and (through additional interface) load control of these consumption is not in place yet. As it was declared from suppliers, building alternative control and monitoring infrastructure (independent from DSO operated capacities) would be expensive and it would not outweigh potential benefits.

In addition to this, large part of flexibility potential at the low voltage is operated directly by DSO through so called district ripple load control (in Czech so called HDO = "Hromadné Dálkové Ovládání"). It is a set of technical instruments (e.g. transmitters, receivers, central automatics, transmission paths, etc.) that enable sending of

[4] Pravidla pro provozování distribuční soustavy (příloha 7), 7/2021, www.eru.cz

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commands or signals in order to switch on or switch off appliances, and tariffs switching. HDO utilizes power lines for transmission. The system is a reliable (reliability is greater than 99%) and strong tool used for: optimal networks usage, direct consumption management and direct generation control. Basis for the HDO system exploitation is a customer agreement with remote blocking of heating appliances in pre-defined time band by the DSO. Subsequently billing of consumption in this time band is calculated for low tariff, which has advantageous price. HDO system applied at generators is used for a stepwise output regulation according to the agreed rules. Similar tariffs are introduced for points of connection with EV chargers. Customer concludes with the DSO an agreement that their consumption of heating appliances is blocked in the period of high load (high tariff), and in the case of emergency. Consumer receives a benefit of lower price during remaining daytime (low tariff). Nowadays, the DSO controls consumption by the system, shave peaks of the load profile, reduces losses, and more importantly controls generation in small, decentralized sources. This significantly contributes to the optimization of distribution network operation.

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4.2 Flexibility provision (Hungary)

Current situation in Hungarian legislation: While implementing the Clean Energy Package, the main goal of the Regulator was to focus on the minimum requirements, so the regulation as of today gives rather a framework than an exact solution. However, when we take a look at the other topics of the Clean Energy Package, like energy communities etc., flexibility is still the most detailed one in the Hungarian Energy Act.

The Act defines what DSO flexibility is, making a clear difference to the TSO's ancillary services. DSO flexibility may include redispatch, non frequency flexibility services ancillary services or any congestion management services. The main message of regulation is to focus on the market: DSOs should procure the needed flexibility on the market in a transparent way and for market-based prices. While doing this, the DSO should observe the requirement of equal treatment, the network development plan and the principle of lowest cost.

In order to ensure the application of the above-mentioned principles, DSOs should implement a detailed procurement process in the DSO Code based on rules set out in the Energy Act. Such procurement can be performed by a single DSO or in a cooperation with other DSOs as well. Specifications shall include the type of the necessary product or service, length of the contract and the technical criteria. The Energy Act only mentions the website as the tool of tender, but the DSO Code refers to "any other DSO tool" as well referring to the platform itself.

Legislation defines the potential flexibility providers as well. Any electricity producer, storage or demand-side response facility could provide flexibility services if they meet all the criteria laid down in the DSO Code. The minimum legal requirements include description of the necessary flexibility services and the standardized product, furthermore establishment of an accreditation procedure.

It is important to note that the cost paid by the DSO for the flexibility should be an eligible cost in the distribution tariffs, meaning that its reimbursement shall be assured by the regulator, however, the level of eligible cost accepted is not known yet.

It is also a critical purpose of legislation to make a clear order when the TSO and DSO want to use the same flexibility provider at the same time. The legislation plainly defines that, given the location-based solution a DSO may need, DSOs are given priority in such situations. To make this work in a smooth way and also not to risk the TSO's operation, suitable information and data exchange is needed between the system operators. This information and data exchange should cover the whole procedure from the reservation through activation and usage.

The legislation gives priority to market-based solutions, but for the time being, there is no flexibility market in Hungary and DSOs need a tool to ease the problems generally caused by intermittent renewable generation. For that reason, regulator can give an exemption and allow also a non-market-based procedure. To do so, DSOs

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should prepare a report each year in which they give an overview of the actual situation regarding the flexibility market. On the one hand, they should give a description of the available flexibility providers and services, tell their opinion if the market is liquid enough or not, whether their needs are met by the offer etc. On the other hand, they should present their expectations regarding the future. They could even make suggestions to the regulator if any regulatory intervention is needed on the market. Based on the report, the regulator might come to the finding that the criteria for a well-functioning market is not funded. In this case, a general exemption from the market-based procurement can be granted by the a regulatory authority, giving a greenlight to the use of non-market-based redispatch mechanisms.

If the DSO uses this tool, it shall pay a compensation. If the DSO is willing to pay, such request cannot be refused by the facility. The level of compensation is the price equal to the hourly price settled at the Hungarian Energy Exchange for the same hours as the hours affected by the restriction. This compensation is an eligible cost for the DSO as well.

Beside classical flexibility services and non-market-based redispatch, there is one more tool DSOs may use, namely flexible connection. It means that instead of the reinforcement of the grid DSOs can allow new customers to connect the network provided that the customer agrees to being constrained off when the network is close to capacity limits. This may reduce the cost of connecting to the network and also the time to connect as works are not required. The conditions of flexible connection should be laid down clearly by previously determining the technical criteria of the possible constraint. The customer having a flexible connection can decide anytime to switch to a normal connection if they are ready to pay the normal connection fee to the DSO. It is also important that having a flexible connection does not exclude the customer from participating at the flexibility service market or being used for non-market-based redispatch.

Beyond the regulatory framework provided for by the Energy Act, details are to be elaborated by DSOs in the DSO Code. This work is still ongoing. There are currently some important principles regarding the procurement, accreditation, and TSO-DSO cooperation. As the technical criteria of real-time data exchange is either regulated, nor existing yet, we determined that the DSOs should inform the affected producers 30 or 60 days prior to the redispatch, depending on which voltage-level the producer is connected to. We (projects participants) have also set a timeframe for accreditation, it should be renewed every 3 years by the producer or the facility. DSO's need has a priority over the TSO's (at national level included in the grid code) , but at the same time, DSO should primarily use those facilities which do not participate at the TSO market. However, flexibility service providers can be used at both markets at the same time if it is technically possible. Data exchange is prescribed not only between system operators but towards FSPs and balancing responsible parties as well.

DSO Code is still under elaboration, DSOs aim to discuss further the level and scope of standardization, the definition of products and services. One of the most important questions is pricing, which leads us to one of our dilemmas: how to incentivize producers to participate at market-based tenders if they are forced to accept the DSOs request for redispatch at a predefined price? Which is more important: operate on a market-based way and use flexibility services from the market or to pay as little as possible and use only non-market based redispatch? What does the principle of least cost mean in such situation? Only the price of service or non-executed investments should be taken into consideration as well? How to set the right order of flexible connection, market-based procurement and redispatch?

As mentioned above, DSOs have already launched projects which aim to create flexibility platforms. The projects themselves generated a lot of questions which are interrelated with regulation. The detailed regulations should appear in the DSO Code, but there are some remaining questions in regulation which make uncertainties in platform development.

The main hindering topics which should be answered are the following:

1. DSO Code stated that Flexibility use by DSO should follow a given order: 1st Flexible connection→ 2nd Market based procurement→ 3rd Non-market-based redispatchable power plants. However, the Hungarian Energy Act calls attention to the principle of least cost. In this context, the principle of least cost is not sufficiently clear, e.g. if DSOs would prefer using more expensive market-based flexibility than non-market based redispatch, they would violate legislation.
2. Technical details missing from regulation: e.g. Control mechanism of Flexibility providers and Redispatchable Renewables: The DSO Code has not dealt with it. It is not yet defined who should make it technically possible.
3. The cost of flexibility will be recognised by NRA, but its methodology is unknown yet.

4.2.1 Technological challenges which can lead to barriers

Earlier was mentioned that DSOs are developing so called Flexibility platforms. Below are listed the main topics which are related to the challenges and can sooner or later create barriers.

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4.2.1.1 Flexibility needs calculation (Network calculation)

The aim of the network calculation is to estimate the needed flexibility for the network. In traditional method the so-called worst-case method is used, which is not suitable for flexibility need calculation. For sake of flexibility estimation time series data should be used for network calculation.

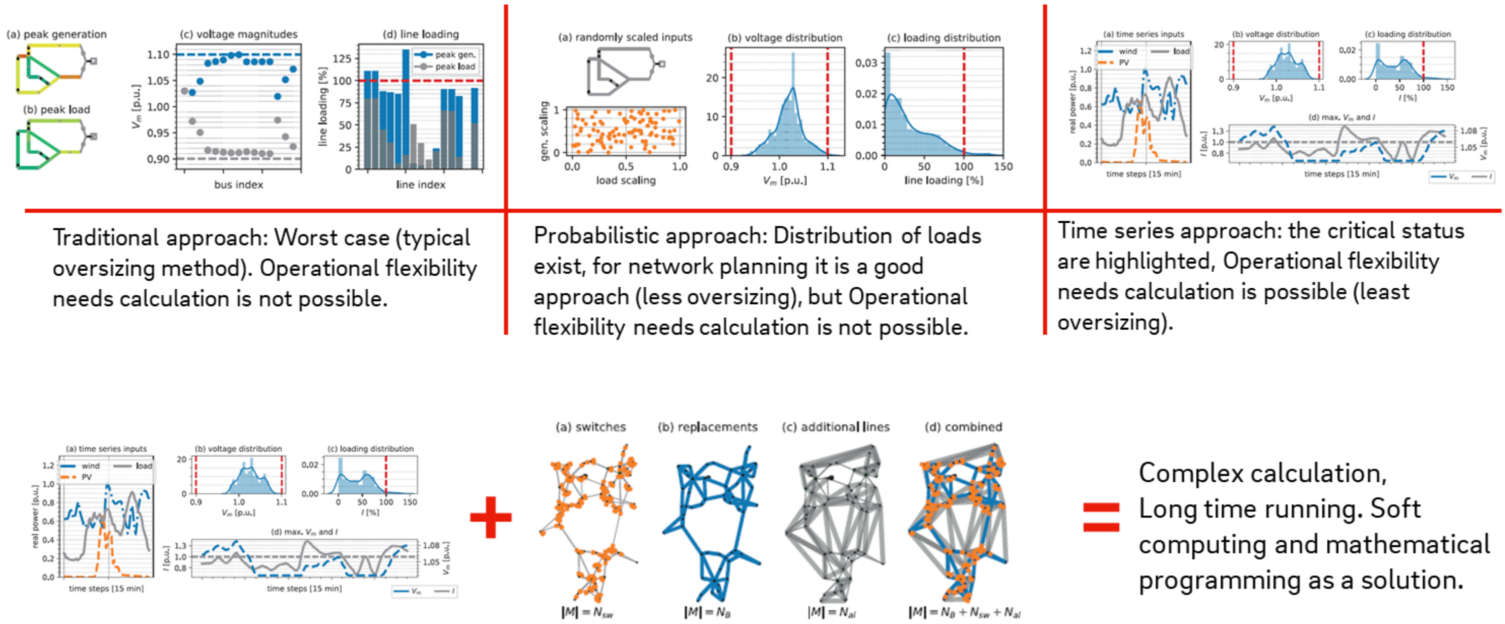

Figure 2: Basic flexibility estimation approaches ((Source: Florian Schäfer: Multi-Year Time-Series-Based Power System Planning with Hybrid Optimization and Supervised Learning Methods).

Figure 2 describes the basic approaches. Traditional (worst-case)/ Probabilistic/ Time series approach.

Figure 3 sums up what kind of network calculation are envisaged and what types of technological challenges can hinder the DSO in terms of accurate flexibility needs calculation.

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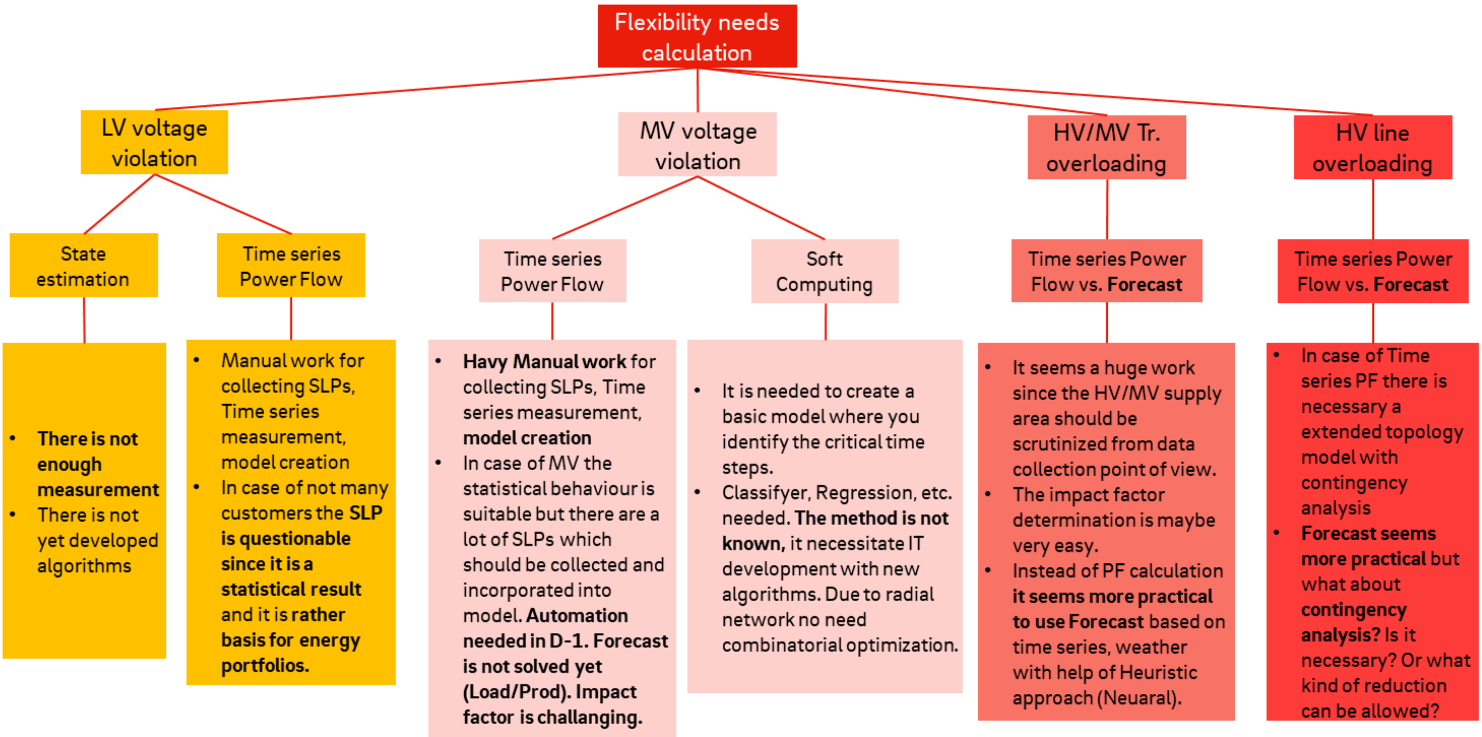

Figure 3: Flexibility needs calculation

1. LV network (mostly vvoltage deviation):

   There are two main directions (State estimation and traditional Load Flow calculation). In order to estimate the flexibility needed for the network (time, quantity), it is necessary to work with time series. Since the LV network does not measures Synthetic Load Profile (SLP) yet and remote measurement of customer can be used (mostly SLP). The SLP aggregation is a good tool for energy portfolio optimization, but if the number of customers is low then the SLP will give not sufficient pseudo measurement. To improve the accuracy of the calculation SE (state estimation) can be used (WLS method). In both methods there is no business as usual approach yet, DSOs have to develop these new methods. On top of this the data gathering method and data connection to topology means also a challenge for System operators. The other challenging task is the forecasting of production.

2. MV network (mostly voltage deviation):

   There is a similarity to LV methodologies. SLP gathering is necessary, however, there are feeder measurements in HV/MV stations, so the SE can be improved by them. The upper voltage level uncertainties also should be considered. Either SE or Time series Load Flow calculation uses the pseudo measurements, the data gathering is challenging. Furthermore, another challenge is the fine tuning of

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SE with real measurements. Other task is the determination of so-called sensitivity factor (or in other name Impact factor) of FSPs, since the location of the FSPs are crucial for voltage profile calculation.

3. HV/MV substation (mostly transformation overloading):

   If the methodology is based on SLP, the challenge is similar as in MV network (taking into account the larger the supply area the harder to collect SLP data and connect to topology). The other approach is also time series based but uses the substation measurements, based on measurement some soft computing method can be used instead of load flow calculation, but new algorithms are necessary which are not used yet in BAU.

4. HV network (mostly Line overloading):

   The main difference to the above-mentioned methods in case of HV calculation is the contingency analysis (N-1 principle). It is very challenging if it is used together with time-series based calculation. Some new network reduction approach is needed.

What is common in the above-mentioned flexibility calculations is the R&D characteristics because DSOs do not use these methods in their daily work.

4.2.1.2 Control of Flexibility Service Provider and Redispatchable Renewable plants

As we mentioned in regulatory barriers chapter the DSO Code[5] has not yet imposed a rule for redispatchable renewables in terms of control technology. Only RfG NC is in force which prescribes a power control protocol for inverters but does not yet address the legal requirements for making it mandatory for use of DSO. As the outcome the execution of a redispatch – which is the last resort - is not solid. For the sake of security of supply the flexibility calculation method should consider the non-market-based flexibility as basis for network planning. Until the technology background of the controllability is not prescribed by the legislation there is an operational uncertainty.

4.2.1.3 Baseline methodology for different assets of Flexibility Service Providers

In order to be able to pay for the flexibility used, it is necessary to implement as many baseline methodologies as FSPs are used (based on technology).. Up to now in DSO Code there is a baseline calculation only for PV plant, the other potential FSPs have not yet baseline calculation guideline.

[5] Section 6, National grid code for flexibility

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The task of projects is to develop these baseline calculation guidelines and give input for DSO code as well.

4.3 Flexibility provision (Poland)

Flexibility services - Current status in Poland.

The flexibility services market in Poland does not exist yet, it requires the preparation of legal regulations, verification, and building of business models, and an increase in investment outlays. Poland is currently facing major challenges related to the energy transformation. These challenges are related to the dynamic growth of energy from renewable sources (RES), ensuring the security of power supply during peak periods as well as the necessity of deep modernization of the power system.

Services related to the flexibility of the power system (transmission and distribution) can help to optimize investment costs in distribution networks.

Flexibility services are one of the areas of changes taking place on the Polish energy market, the legal basis for introducing flexibility services is a Directive of the European Parliament and of the Council (EU) 2019/944 of 5 June 2019 on common rules for the internal market in electricity. The Member States had to bring into force the laws, regulations, and administrative provisions necessary to comply with Art. 32 of the Directive until December 31, 2020. According to this directive, flexibility services provide consumers (industrial, commercial, and households) access to the electricity market and enable them to provide flexibility (e.g. limiting or increasing energy production or consumption). Distribution companies will be able to buy such flexibility services. Such services are to help counteract transmission congestion in the network, and additionally, such a solution is to be an alternative to possible costly modernization and expansion of the network.

A characteristic feature of the current Polish power system is the concentration of resources in the transmission system that ensures its flexibility. The current market model does not simulate the flexible operation of the grid, a new approach is required in the method of grid development planning to ensure the security and reliability of energy supply and the integration of variable energy sources [3].

The key to increasing the flexibility of the power system is to use the capabilities of all system participants, and the energy market is the tool for their activation [4].

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Figure 4 below shows a model of a flexible power system that can be introduced in Poland.

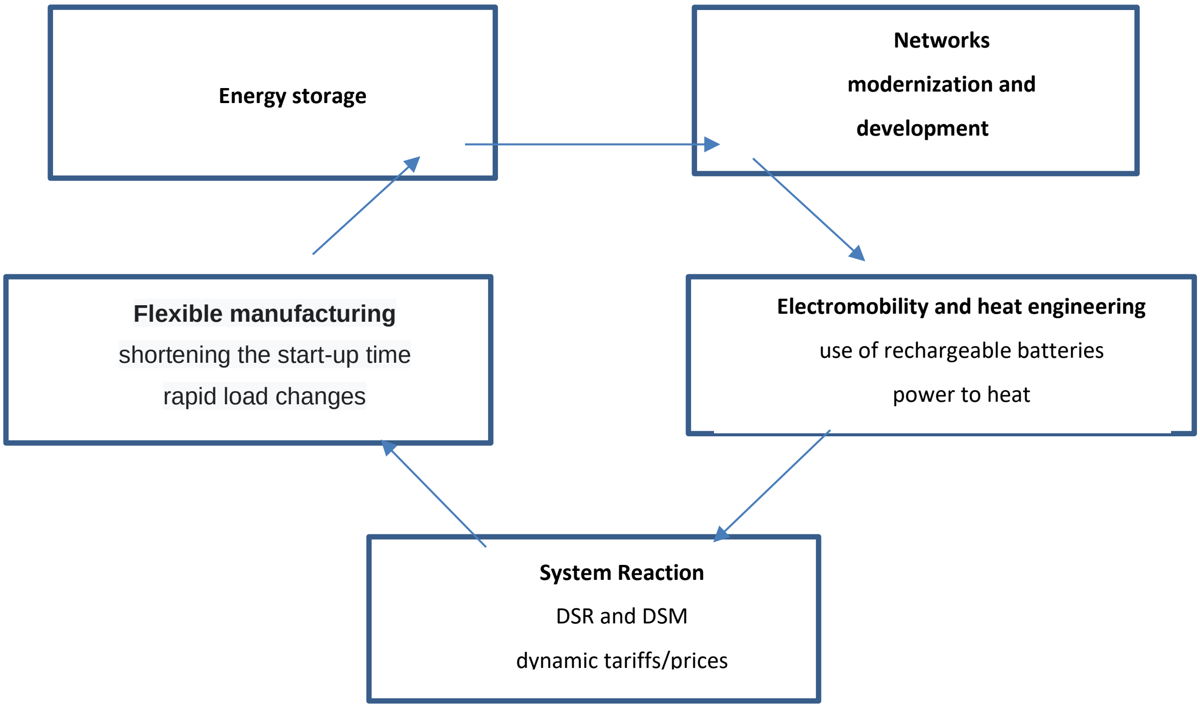

Figure 4: Model of a flexible power system in Poland

To improve the flexibility of the power system in Poland, we are currently at the stage of public consultations on amendments to the Energy Law and the Renewable Energy Sources Act. The draft act introduces a legal framework to introduce a flexible system that reacts to changes in the system, both on the technical level and in the behavior of users of this system while maintaining stable network operation and maintaining quality parameters and reliability of supplies.

The purpose of the recommended solution is to provide a legal basis for electricity system operators in terms of the possibility of using flexibility services provided by distribution system users. The evolution of the power system towards decentralization of generation and market activation of system users means that the DSO - acting as a moderator of the development of the retail energy market - should use this new energy potential. Cooperation in this area will take the form of a service provided by users to DSOs, referred to as the flexibility service.

The proposals presented in the PL DEMO include:

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1) introducing definitions of concepts appearing in European Union law and necessary to describe the possibility of using flexibility services;
2) specification of the scope, conditions, and manner of using the flexibility services by the electricity distribution system operator, including the authorization to define these elements in detail in implementing acts and instructions;
3) specification of the terms of cooperation between electricity system operators, including the authorization to define these elements in detail in implementing acts and instructions;
4) strengthening the terms of cooperation with the electricity transmission system operator in the development of rules for the use of flexibility services;
5) specification of technical requirements for entities providing flexibility services, including the empowerment for the detailed specification of these elements in lower-level acts;
6) adaptation of the rules for the preparation of development plans by DSOs and inclusion in these plans of investments necessary to connect electric vehicle charging points. Ensure transparency concerning DSOs' demand for flexibility services and consider the use of demand response, energy efficiency, energy storage, or other resources as alternatives to extending the distribution grid;
7) obligation to include in the network development plans the guidelines regarding the direction of network development and implementation of priority investments defined by the President of ERO, the aim of which is to ensure their coherent, systematic, and coordinated development in the desired directions at the national level and to receive remuneration for their implementation;
8) providing the necessary regulatory framework and incentives enabling electricity distribution system operators to award contracts for flexibility services, including for the management of system congestion in their areas, and empowering to specify these elements in lower-level acts

The draft also establishes the legal framework for the operation of system services necessary for the operation of the transmission or distribution system, including balancing and non frequency flexibility services ancillary services [5].

Summing up, even though in recent years Poland has made significant progress in the development of energy based on renewable energy, it is our electricity system that continues to be based on centrally managed coal-fired power plants. In addition, transmission and distribution grids are aging and investment is limited. Demand-side elasticity and small-scale energy storage are not yet developed. There are no regulations in Poland that would allow the introduction of a system of incentives for customers who could potentially provide flexibility services. There is also no market platform for the provision of flexibility services by clients to DSOs and TSOs, apart from the balancing market. We are currently at the stage of reviewing the options and arrangements that will prepare the provisions and regulatory framework that will enable the implementation of the Directive on common rules for the internal market for electricity. The above results in low overall flexibility of the power system, and the only chance to increase the efficiency of the national power system without incurring huge capital expenditures is to properly design an appropriate regulatory framework for flexibility services.

[1]

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4.4 Flexibility provision (Slovenia)

The flexibility services market for DSO in Slovenia does not exist yet.

In 2019, national regulator, the Energy Agency, amended the act governing the network charge to allow for the qualification of projects that had been launched in the previous regulatory period, which further contributed to an increase in applications for the qualification of projects under the R&I scheme in 2020. According to the Annual report on energy sector in Slovenia in 2020 [6], published by Agency, there were 12 qualified projects related to flexibility. Elektro Ljubljana as one of five DSOs has applied many pilots, including dynamic tariffs with cooperation of energy supplier for bigger savings on the side of end customers.

In 2020, the Agency, in cooperation with partners, continued the public consultation on establishing a market with active consumption flexibility in Slovenia by addressing a thematically narrowed consultation document, which addressed the issue of the introduction of the (independent) aggregator model into the organized market [7]. The Ministry of Infrastructure also participated in drafting the consultation document, thus establishing a link with the implementation of the Clean Energy for All Europeans package in national legislation and incorporating some of the findings into the draft of the Electricity Supply Act (hereinafter: ESPA).

In Slovenia, the TSO can procure/use services from all voltage levels. Before the TSO will procure a service (mFRR or aFRR) (independent of the voltage level) a service provider (aggregator aggregating flexibility of large consumers or DERs) must complete a prequalification procedure (unique and repetitive) and in this prequalification procedure the DSO is included. DSO in this procedure only agrees or disagrees and checks if activation of flexibility will compromise distribution grid taking whole year. In Slovenia, aggregation is somehow permitted, but its presence is still limited. There are several active aggregators in Slovenia. Aggregators are mainly aggregating flexibility from the industry with flexible loads or diesel generators and distributed energy resources, DERs (small hydro power plants and CHP). In Slovenian OneNet demo we are establishing a common system for all five distribution companies in Slovenia which will enable tenders for purchasing flexibility form end consumers or aggregators. This system will be used also for sending activation MQ messages to aggregators and for sending restrictions in the distribution grid to all actors (traffic light concept). With traffic light we will establish coordination between DSOs and TSO. Beside TSO, information with restriction will be send also to aggregators so they will not compromise distribution network with activating flexibility and thus worsen situation in distribution grid.

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5 DEMOs Contributions

This chapter shall demonstrate how the pilot DEMO schemes contributes in terms of unblocking flexibility potential for providers and how they are enabled to gain access to flexibility market and thus empower customer engagement.

The following table has a summary of the relevant contribution by each country:

Country	Service	Voltage Level	Mechanism	IT development
Czech Republic	active power, reactive power	HV, MV, LV	Market based	country-wide solution (IT platform) for non-frequency services
Hungary	active power	MV	Market based	DSO/TSO coordination mechanism, predictive models, baseline methodology assessment
Poland	active power	all voltage levels	Market based	IT platform
Slovenia	reactive power	LV	Market based	IT platform

Table 4: Expected DEMOs achievements

5.1 DEMO of the Czech Republic: Customer engagement through innovative solutions and new market models

5.1.1 General description

The demo aims at utilization of flexibility aggregated from distributed energy resources (DER), battery energy storage systems (BESS) and demand side - large consumers (DSR). Focus is on sources of 0.5 MW installed power or above, connected into the distribution grid and on large consumers connected to 110 kV.

The goal of the CZ DEMO is to develop market for non frequency flexibility services to be used by grid operators and other grid users. CZ DEMO will establish country-wide solution (IT platform) for flexibility of grid services; there will be tested participation of flexibility providers of various size in the whole area covered by two major DSOs in the Czech Republic.

The new platform will cooperate with existing platform for non frequency flexibility services namely through traffic light scheme allowing to share relevant data between DSOs and TSO. Apart from TSO and DSOs there are two aggregators involved in providing flexibility.

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5.1.2 Information exchange

Debate on the structure of the platform and data exchange model has been ongoing at present (that goes especially for information model and relevant channel deployed). Basically, there are several DSOs, TSO and two aggregators as main actors in the CZ DEMO and all of them have to interact and communicate between each other. For that purpose, was create ECP communication network based on general used standards defined and developed by ENTSO-E.

The data exchange platform therefore will be based on the state-of-the-art architecture and employ the latest technologies available to meet high expectations concerning reliability and robustness. The platform will be interconnecting various functionalities and geographical modules through common semantic model.

ENTSO-E has provided the ECCoSP[6] platform ensuring secure, confidential, comprehensive and reliable information exchange between mainly TSOs and their partners (Figure 5). It currently comprises two main functional blocks:

- Energy Communication Platform (ECP) acting in the communication layer and
- EDX (Energy Data eXchange), responsible for the service layer.

The ECP messaging platform facilitates bellow listed characteristics:

- **security** – access to the content of the messages is only accessible to the addressees as all messages are encrypted along the way, and each sender of each message can be authenticated at any time
- **reliability** – all messages are correctly and promptly delivered with validation when properly functioning
- **transparency** – traceability of sending and receiving is guaranteed for sent messages
- **connectivity to different external platforms** – a platform for open to connect, send and receive messages with different technologies

[6] **E**NTSO-E **C**ommunication and **Co**nnectivity **S**ervice **P**latform

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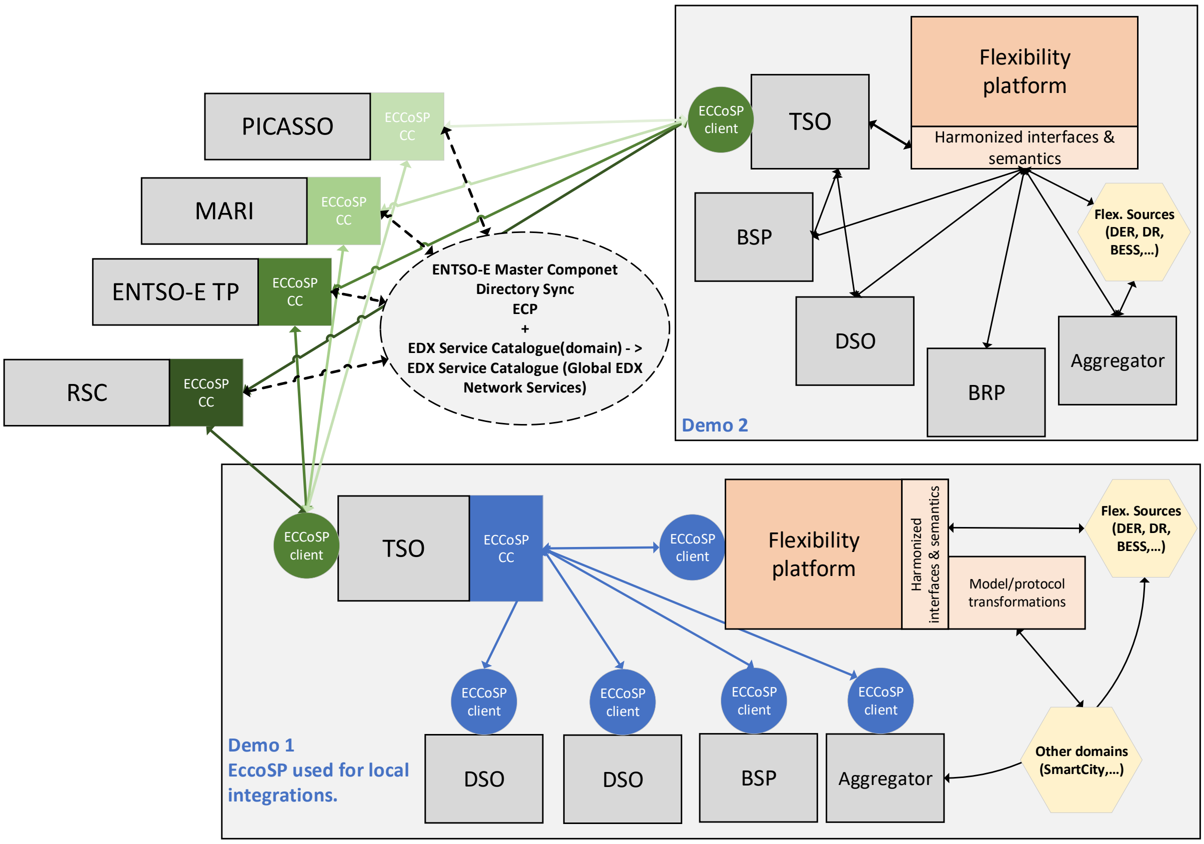

Figure 5: Overview of use of EccoSP

5.1.3 Grid prequalification – traffic light scheme

For the first part of implementation there is a traffic light concept to be used in which following data exchange is foreseen: expected outages/outages reported from DSOs to the platform providing for each generator or flexibility unit, registered in the platform, (un)availability of the system for the flexibility activation. This information is provided for planned outages 15 days ahead, for unforced interruptions is information provided in real-time. Data exchange through communication layer is reported also in web application. This can be seen in figure 6 below:

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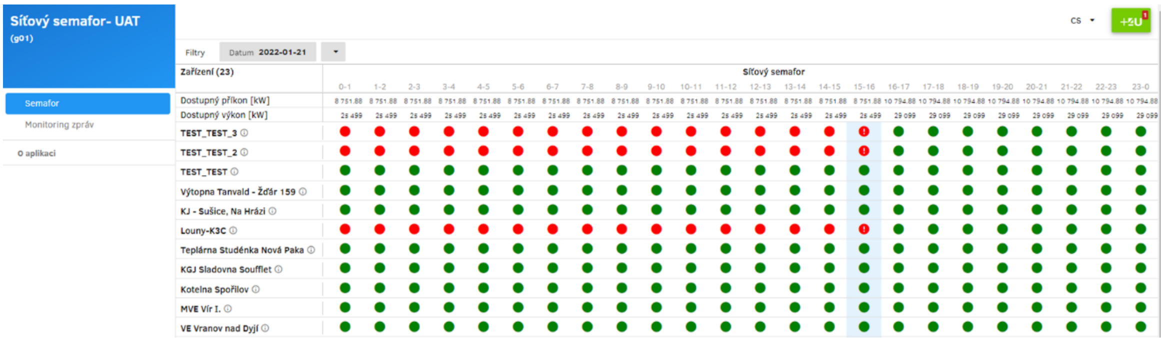

Figure 6: Web application of traffic light scheme

The TSO sends into platform (as referred in the Figure 7) the information concerning procured/contracted services (amount of services) for DSOs. Provider of services sends into the platform information about activated services detailing all participating resources (which is important for the DSOs in terms of quality of supply in nodal areas). The platform contains data on planned/activated flexibility for evaluation of services provided that are delivered to the TSO.

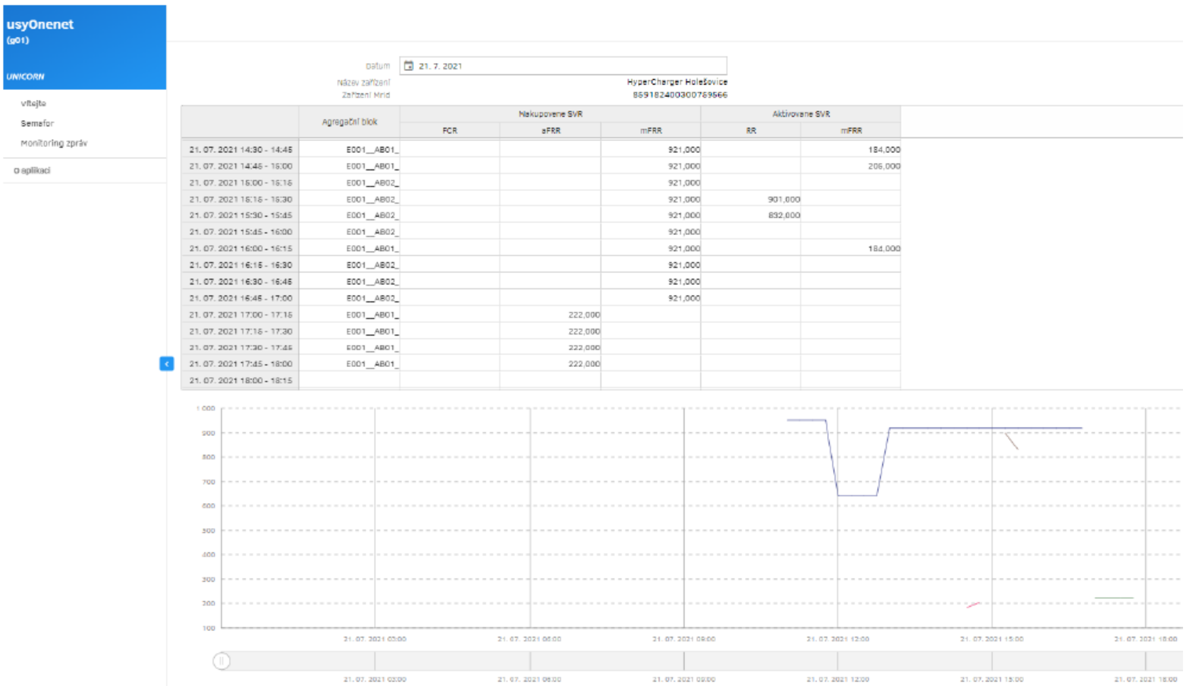

Figure 7: Report of planned and activated flexibility units

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5.1.4 Market platform of non frequency flexibility services services

The second phase of the CZ DEMO project will encompass provision of the non frequency flexibility services from aggregators/customers to the DSOs. The system will involve database of units/resources, which are able to provide non frequency flexibility services to DSOs (as referred in the Figure 8). The information in flexibility register involves e.g. installed capacity as well as location of the units/resources. To this end the project team established set of criteria under which resources will be identified in order to ensure each of units has its unique identification means. To distinguish amongst three different non frequency flexibility services through bidding process, there is a specific XML data format relevant for given service.

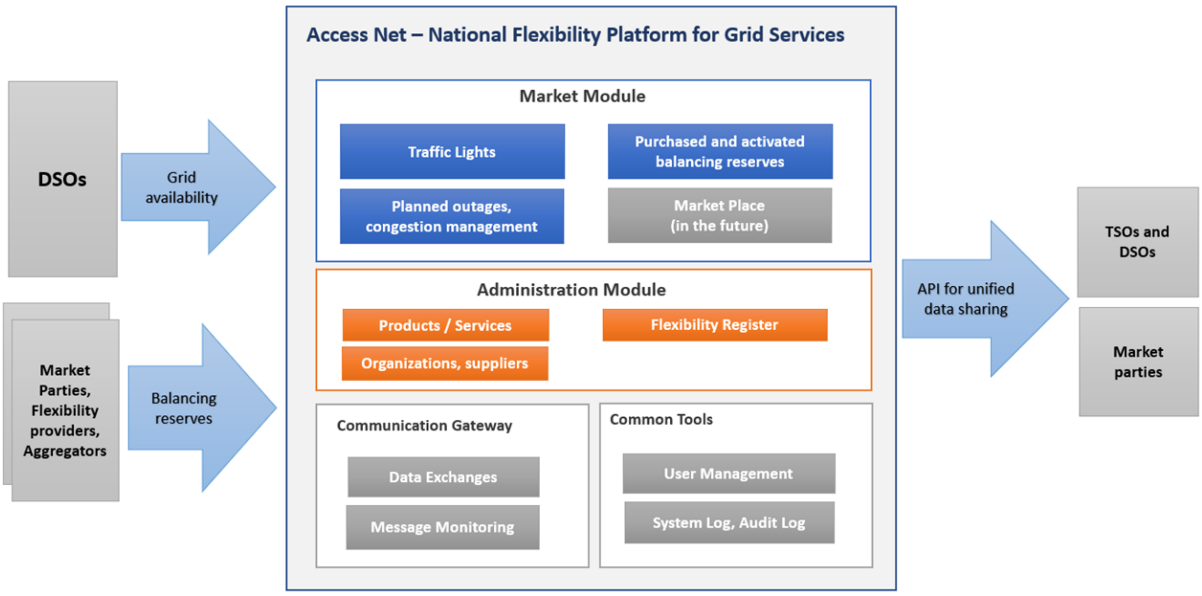

Figure 8: Flexibility market platform

5.1.5 Market mechanism

In principle, there must be included demanded capacity (in MWh for active and in MVAr for reactive power) and duration of the contract. As the DSOs cannot disclose the grid topology for security reasons, the bids are passed only to resources relevant for given nodal area. That is why location of resources must be stored in the common register and is a vital part of the system. (as referred in the Figure 9)

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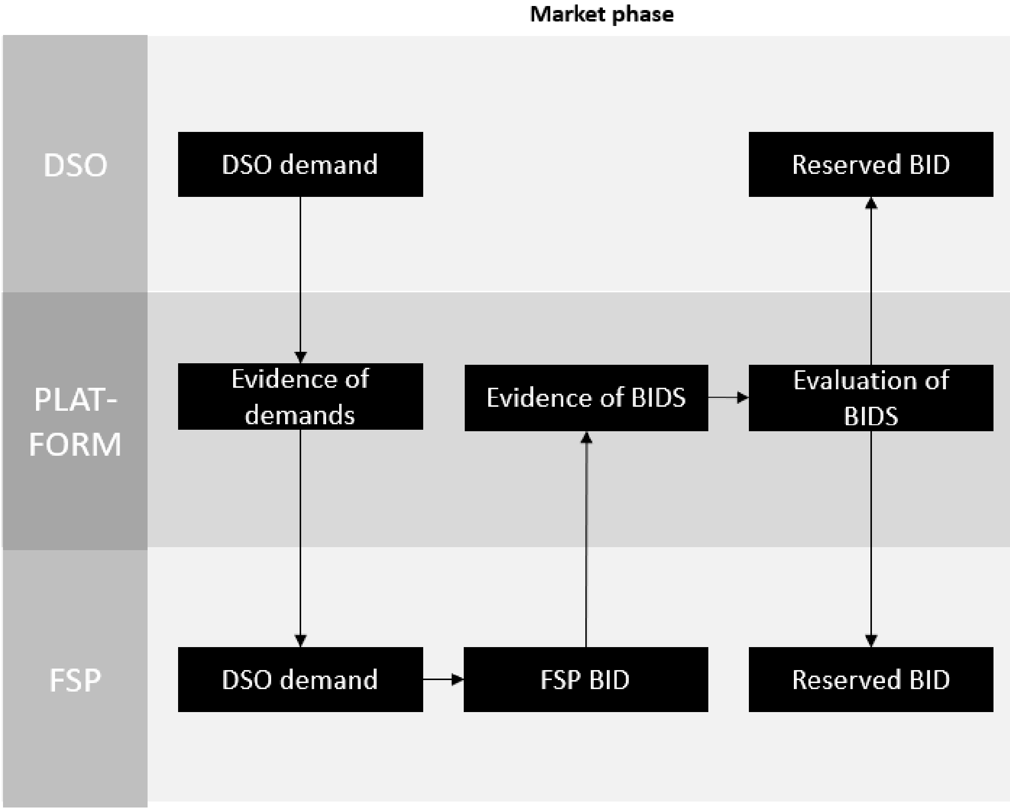

Figure 9: Market mechanism

5.1.6 Products and services

To address needs of distribution grid in a market-based way, the CZ DEMO aims to test non frequency flexibility services – e.g. voltage control through reactive power management, nodal area load management or management of overflow. These products are defined specifically to address main challenges for the distribution grid in terms of growing amount of RES and non-dispatchable resources. There are voltage issues and deviation of reactive power.

The marketplace will be designed by IT provider of CZ DEMO – Unicorn. As indicated at the chart (Figure 9), there is an administrative section with register of flexibility units and information about relevant nodal areas. The market module contains information on flexibility services contracted/provided while the other module serves for evaluation and settlement. What is referred to as a "congestion management" is actually part of the traffic light scheme – indication of the grid availability.

5.1.7 Conclusion to customers engagement

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With this IT platform in place, together with services to be exchanged, the project can fulfill its ambition to enable market based of non frequency flexibility services procurement. As these services will be exchanged at the one central dedicated place, this will bring also fundamental change to the system in terms of access of new entrants/market players.

As it was referred to in previous parts concerning description of state of play, contracts on flexibility are negotiated on bilateral basis with units possessing relevant capacity. This excludes in fact a lot of smaller units/aggregators, as they are not aware of capacities needed and DSO is not aware of their capabilities capablities. However, participation of smaller units in terms of provision of e.g. reactive power might be an interesting business opportunity for them as reactive and active power could be produced simultaneously. This potential could onot be used fully because of both regulatory and technical constraints.

CZ DEMO intends to reflect this growing potential for customer/smaller units in its project measurable indicators (KPIs). From this point of view it is important to highlight added value of the IT platform for enhancing capacity for aggregators. Because they will be regularly updated on outages/planned outages they can use the available flexibility in most efficient way.

5.2 DEMO of the Hungary: Customer engagement through innovative solutions and new market models

5.2.1 General description

The need for flexible sources in Hungary mainly comes from the growing number of photovoltaic (PV) generators. The grid infrastructure is quite old and lacks available hosting capacity, therefore the increasing connection requests would lead to costly developments with traditional investments. Flexibility can help to reduce those connection times, increase the hosting capacity with investment deferrals or as a permanent alternative of grid assets. The Hungarian demonstrations aims at the utilization of flexibility solutions at the medium voltage (MV) level. This project can help the distribution system operators (DSOs) to understand the processes connecting to flexibility: how to calculate the needs, compare the different alternatives and reach the customers who can provide such services. Flexibility could help on different levels, **in this demonstration the focus area on the MV is twofold:**

- **Avoid overload on the high voltage (HV) to MV substation transformers**
- **Voltage control at MV feeders**

Currently the framework defined in the Clean Energy Package is under implementation in Hungary. This means that the definition of flexibility is present in the legislation, but the practical operation is yet to come.

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The legislation also introduced the redispatch option at the distribution level and the rules for the non-market based redispatch of distributed generators offer a new possibility for DSOs. However, the processes are still under development to utilize redispatch as an alternative for further grid developments. **Meanwhile, DSOs working on pilot projects such as OneNet to demonstrate the advantages of market-based flexibility. This approach could help to reduce the costs of the DSOs while offering new market possibilities for customers. Due to the nature of the issue (overgeneration causing the operation constraint), the flexibility sources are expected to be PVs, but other options on the demand side (incl. storage) are currently under evaluation as well.**

5.2.2 Information exchange

The framework of the OneNet solution for the Hungarian demonstration sites are still under development. TSO and DSO coordination is an utmost important part of the process as the operation of flexibility service providers affects the local parameters and the whole system as well. The function of the market operator, such as the information sharing for this coordination and the flexibility register module will be provided through the interconnection to the OneNet system.

This includes several steps. The prequalification includes the request from the service provider, the information about the grid and the product and the approval. Forecasting steps determine the need for flexibility. The identification of the service need needs coordination between the TSO and the DSO, which is followed by the volume, and spatial-temporal location of the DSO flexibility need which can be covered by the market participants. The bids from the flexibility service providers will be sent to a platform. The market clearing is planned in W-1 and D-1 (week before/day before).

In this manner, the DSO act as the sole buyer, while the TSO is present to have all the information which is necessary to operate the ancillary service market. The coordination provides a process that enables DSO to access flexible resources while the TSO has the opportunity to intervene if the DSO flexibility procurement would cause problems.

5.2.3 Products and services

Participants of the Hungarian demonstration identified two goals for the OneNet project. The scope of the project will remain on the MV level. The demo site grid infrastructure mostly consists of overhead lines, and the length of the feeders' results in varying voltage conditions along the line. The usual operation constraints for these grid parts are the loading of the HV/MV transformer in the substation and the voltage fluctuations along the line. The demonstration partners agreed that the services will be predictive in all the business use cases.

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The loading of the HV/MV transformer is a limiting factor due to the security of supply operation constraints. DSOs will forecast the loading, identify the critical timespans and publish the flexibility needs on the market platform. Flexible service providers – mostly PV generators – then can bid to reduce the generation to avoid the overloading of the transformer, overloading of transformer by local generation. . Products will include active power changes in the direction of relieving the transformer loading.

The voltage profile on long MV feeders with considerable amount of PV generation is quite different compared to the ones without any distributed generation. The current infrastructure was planned to meet the requirements to serve the loads. The HV/MV transformers have the on-load tap changing possibility, however this solution is suitable to follow the consumption patterns. As PVs increase the voltage at their connection point and vicinity, the setting of the MV to low voltage (LV) transformers is also disrupted, and end customers may experience voltage problems. Therefore, keeping the MV voltage profile is important to keep the DSO service quality. Active and reactive power products are both possible based on the local grid impedance values.

This approach clearly aims to open new ideas for further research and development. Currently DSOs in the Hungarian demo lack the capability of the calculations to define flexibility needs, and there is no business as usual process to compare this with conventional developments. Also, the grid development guidelines in place now does not allow system states that have parameters (loading, voltage etc.) out of the limits – therefore the DSOs right now does not have an operational cost type alternative of flexibility (e.g., redispatch) in normal state. As the option for redispatch is now available, DSOs can create the processes and knowledge through the OneNet project with two dedicated business cases. **If this demonstration will be successful, the DSOs will be able to identify further use cases, include other voltage levels and more customers to participate in the markets. The definition of further business cases for the platform should be the topic next addressed**. The market-based approach might provide a more cost-effective alternative compared to the conventional developments (investment deferrals) or the operation alternatives. **The demonstration also aims to measure the number and cumulated power of FSPs and consider the customer engagement increase (promotion of the market-based provision of flexibility) as an important goal. The exact KPIs for the demonstrations are currently being discussed by the partners.**

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The BUC KPIs of the Hungarian demo, that are related to this issue are the following:

5.2.4 HU_BUC_KPI_01

KPI definition template (Demo KPIs)		
	KPI DEFINITION SECTION	
General Information	1. **KPI ID**	NEW [Not required – it will be filled by the T2.4 Core Team]
	2. KPI Demo ID	HU_BUC_KPI_01
	3. Name	Flexible capacity vs. flexible volume offered ratio (T24)
	4. **KPI domain**	[Not required – it will be filled by the T2.4 Core Team]
	5. **KPI category**	[Not required – it will be filled by the T2.4 Core Team]
	6. **Description**	The ratio between total registered flexibility capacity and the amount of flexibility that FSP offers via market platform
	7. OneNet Pillar	[Not required – it will be filled by the T2.4 Core Team]
	8. OneNet Objective	[Not required – it will be filled by the T2.4 Core Team]
	9. OneNet Cluster	East (WP10)
	10. OneNet Demonstrator	Hungary
	11. Related BUC(s)	EACL-HU-01; EACL-HU-02
	12. Link with other projects	EUniversal
	13. KPI responsible	BME
	14. General comments	N/A
Calculation information	15. **Formula**	$\frac{F_{FSPbid}}{F_{cap}}$
	16. Variables	F_cap: Total flexibility capacity registered. F_FSPbid: Amount of flexibility offered by FSP
	17. **Unit of measurement**	%
	18. KPI baseline explanation	0
	19. KPI baseline source	Market data at the project start
	20. Baseline responsible	BME
	21. KPI target value	10% (as of today)
	22. Calculation Methodology	$\frac{F_{FSPbid}}{F_{cap}}$
	23. Gaps and challenges for KPI definition and quantification	N/A

KPI DATA COLLECTION SECTION

BUC	Data ID	Data Description	Source/ Tools/ Instruments	Methodology for data collection	Location of data collection	Non frequency	Monitoring period	Data collection

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			for data collection			flexibility services of data collection		responsible
BUC ID	[Unique data identifier]	[Describe here the data type (e.g. Total capacity installed)	[Inventory list/ meters/ polls]	[Manually/ automatically/ simulation]	[Demo site]	[e.g. Monthly (at the end of the month)/ once (at the end of the project)]	[e.g. M1-M16]	[Type here the partner acronym]
EACL-HU-01; EACL-HU-02	HU_BUC_KPI_01_D01	F_cap	Simulation	Manually, simulation	HU demo areas	Monthly	M24-M30	BME
EACL-HU-01; EACL-HU-02	HU_BUC_KPI_01_D02	F_FSPbid	Simulation	Manually, simulation	HU demo areas	Monthly	M24-M30	BME

Table 5: HU KPI I

5.2.5 HU_BUC_KPI_03

KPI definition template (Demo KPIs)		
	KPI DEFINITION SECTION	
General Information	1. **KPI ID**	KPI_T50 [Not required – it will be filled by the T2.4 Core Team]
	2. KPI Demo ID	HU_BUC_KPI_03
	3. Name	Ratio of activated reserved flexibility (E11)
	4. **KPI domain**	[Not required – it will be filled by the T2.4 Core Team]
	5. **KPI category**	[Not required – it will be filled by the T2.4 Core Team]
	6. **Description**	Percentage of the total flexibility reserved that is activated used to manage operation for both active and reactive power. The Flexibility Activated Reserved Ratio (FARR) KPI, defined as the percentage of the total flexibility reserved from FSPs that is activated to manage the grid operation without technical constraints.
	7. OneNet Pillar	[Not required – it will be filled by the T2.4 Core Team]
	8. OneNet Objective	[Not required – it will be filled by the T2.4 Core Team]
	9. OneNet Cluster	East (WP10)
	10. OneNet Demonstrator	Hungary
	11. Related BUC(s)	EACL-HU-01; EACL-HU-02
	12. Link with other projects	EUniversal

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	13. KPI responsible	BME
	14. General comments	N/A
Calculation information	15. **Formula**	$$FARR_{P\%} = \frac{\sum_{t=0}^{T} P_{\text{flex,Activated}_t}}{\sum_{t=0}^{T} P_{\text{reserved}_t}} \times 100\%$$ $$FARR_{Q\%} = \frac{\sum_{t=0}^{T} Q_{\text{flex,Activated}_t}}{\sum_{t=0}^{T} Q_{\text{reserved}_t}} \times 100\%$$
	16. Variables	FARRp%: Percentage of the total flexibility (Active power) from FSP reserved in the network that was activated for grid management purposes, for the period T; Pflex,Activatedt: Total flexibility from FSPs reserved that is activated in the network at each time instant t used for grid management purposes (Active power); Preserved_t: Total flexibility from FSP reserved in the network at each time instant t (Active power). The same applied to reactive power Q.
	17. **Unit of measurement**	%
	18. KPI baseline explanation	0
	19. KPI baseline source	Market data at the project start
	20. Baseline responsible	BME
	21. KPI target value	50% (as of today)
	22. Calculation Methodology	$$FARR_{P\%} = \frac{\sum_{t=0}^{T} P_{\text{flex,Activated}_t}}{\sum_{t=0}^{T} P_{\text{reserved}_t}} \times 100\%$$ $$FARR_{Q\%} = \frac{\sum_{t=0}^{T} Q_{\text{flex,Activated}_t}}{\sum_{t=0}^{T} Q_{\text{reserved}_t}} \times 100\%$$
	23. Gaps and challenges for KPI definition and quantification	N/A

KPI DATA COLLECTION SECTION

BUC	**Data ID**	**Data Description**	**Source/ Tools/ Instruments for data collection**	**Methodology for data collection**	**Location of data collection**	**Non frequency flexibility services of data collection**	**Monitoring period**	**Data collection responsible**
BUC ID	[Unique data identifier]	[Describe here the data type (e.g. Total	[Inventory list/ meters/ polls]	[Manually/ automatically/ simulation]	[Demo site]	[e.g. Monthly (at the end of the	[e.g. M1-M16]	[Type here the partner acronym]

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		capacity installed)				month)/ once (at the end of the project)]		
EACL-HU-01; EACL-HU-02	HU_BUC_KPI_03_D01	Pflex,Activatedt	Simulation	Automatically, simulation	HU demo areas	Monthly	M24-M30	BME
EACL-HU-01; EACL-HU-02	HU_BUC_KPI_03_D02	Preserved_t	Simulation	Automatically, simulation	HU demo areas	Monthly	M24-M30	BME
EACL-HU-01; EACL-HU-02	HU_BUC_KPI_03_D03	Qflex,Activatedt	Simulation	Automatically, simulation	HU demo areas	Monthly	M24-M30	BME
EACL-HU-01; EACL-HU-02	HU_BUC_KPI_03_D04	Qreserved_t	Simulation	Automatically, simulation	HU demo areas	Monthly	M24-M30	BME

Table 6: HU KPI I

5.3 DEMO of the Poland: Customer engagement through innovative solutions and new market models

5.3.1 General description

The main objective of the Polish demonstration is to deliver flexibility services for TSO and DSOs by using a digital platform where flexibility services for balancing, congestion management and ancillary services will be procured and activated to deliver services for TSO and DSOs.

To ensure a large-scale demonstration of network services, the selected demonstration area has been selected to include TSO and DSO networks as well as energy consumers and producers at all voltage levels – HL, MV, LV. For the Polish DEMO, in which the goal was adopted for more efficient and effective network management, for the benefit of increased demand response and the ability to integrate increasing shares of renewables, the area of northern Poland was selected. This area is characterized by the most favorable conditions for the development of wind farms and the lack of conventional power plants. In addition, this region has many solar installations and two active energy storage facilities based on modern technological solutions. Moreover, thanks to the possibility of co-financing from EU funds, a rapid increase in microgeneration was noted last year, which also addresses problems related to network flexibility.

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In the Polish demo, four locations were selected for testing. Each of the clients will be trained in the operation of the flexibility platform and registered on the platform in order to provide flexibility services. In Puck and Kalisz, tests will be carried out on high and medium-voltage grids. Large and medium-sized enterprises with adequate RES resources will take part in the tests.

In the commune of Przywidz, tests will be carried out on communal facilities connected to the medium voltage grid (e.g. a school with a sports arena, a modern sewage treatment plant). Additionally, in the Przywidz commune, individual customers connected to the low voltage grid will be involved in the tests. These customers have PV installations, energy storage and heat pumps.

In Mława, the residents of a housing estate connected to the low voltage grid, with PV installations and heat pumps, will take part in the tests.

The project area is marked on the map (Figure 10):

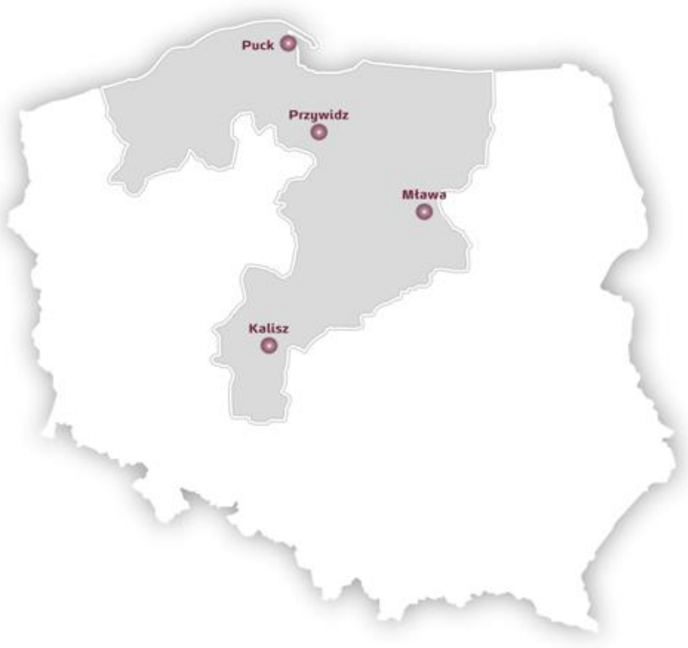

Figure 10: Demo area in Poland

Works in the demo will focus on:

- Close cooperation between DSO and TSO in building a large-scale demonstrator, using the potential of customers by using the experience and capabilities of the Enspirion company.
- Tests of use cases for the flexibility of both DSOs and TSOs developed under the project will be carried out.
- The protocols and standards for exchanging data between systems developed as part of the project will be implemented and tested in the Polish demo framework.

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- The efficiency of the computational algorithms for congestion management will be tested and verified in large-scale areas.
- The ability of integration of developed solutions with the national balancing market will be verified.
- Verification of developed business models for flexibility services in real network conditions
- The coordination schemes (procedures) between TSO and DSOs in the field of congestion management will be developed and tested.
- The coordination schemes between a flexibility platform for managing congestion and a flexibility platform for managing balancing services will be developed and tested.

5.3.2 Information exchange

The digital platform developed as part of the Polish demonstration area is intended to introduce the opportunity for entities operating on the energy market to participate in two markets: balancing services market and ancillary services market, which will include services related to solving congestion problems. The mechanisms used by this digital platform in these markets will be based on algorithms that optimize the use of available offers in a way, that ensures the effect of socio-economic optimization.

For the Platform, multi-module architecture is proposed. Separate modules for different parties of the process (TSO, DSOs, distributed flexibility service providers, Platform operator) will be developed. Designed architecture provides for high-level integration, multilingualism and ease of scalability for different markets.

The developed Flexibility Platform will have a number of functionalities that allow for the exchange of data between its participants.

Information on individual objects, in addition to the attributes that are stored on the platform, can be transferred by users using the functionality of uploading to the documentation platform.

The platform allows to upload files for the following objects:

- Products (services),
- Subportfolio – a collection of DER aggregators,
- Potentials for flexibility,
- Graphics units.

The flexibility platform will also have many other functionalities, such as:

- Transmission of data via chat. The chat enables the communication between entities and sending each other the necessary documentation/consents/contracts.
- Uploading the work plan of a given DER. Each FSP and FSPA is required to upload the work plan of a given DER to the platform, which is required to participate in auctions because it contains information at what hours a given DER can cover the demand specified on the platform for a given product.
- Uploading the current network diagram by DSOs. The network diagram will include the areas where the participants of the platform are located. This pattern will be taken into account when assessing the bids that will appear during the auction in order to determine their profitability and impact on the power system.

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- Export and import of offers. The platform has a window where all bids submitted for auctions are stored. All bids must be assessed manually or by an algorithm for suitability and network capabilities. Therefore, the platform allows these offers to be downloaded by DSO or an algorithm responsible for the evaluation of the offers. Once this assessment has been made, it is possible to import the new bid statuses to the platform, which informs participants about their results.

5.3.3 Products and services

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 DSOs. 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 DSOs need 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.

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.

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The Polish Demo was planned to involve entities naturally operating on the energy market in the tests. The DSOs do 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.

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, DSOs had to focus on the long-term and day-ahead products for Congestion management and Voltage Regulation services. It resulted directly from the limited number of entities on the market prepared to provide DSOs services, with activation time shorter than 24 hours.

5.4 DEMO of the Slovenia: Customer engagement through innovative solutions and new market models

5.4.1 General description

The Slovenian demo is focusing on solving problems, locally in the LV networks, that are caused by increasing consumption of energy by the customers and expansion of renewable energy sources. Main problems are overload of the MV/LV transformers and power lines and voltage violation in the LV networks. The three chosen parts of LV networks were selected as demo locations 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 SLO DEMO will contribute to unlocking the flexibility potential located in LV networks. By means of systematic implementation of flexibility services in all their scope, from activities on the side of end-users, to developments on the grid side as well as implementation of the supporting marketplace infrastructure, testing and result analysis SLO demo will provide insights to the Slovenian partners for further development of flexibility markets.

5.4.2 Information exchange

The flexibility services that will be demonstrated in SLO Demo will be acquired through the dedicated flexibility portal. It is based on existing distribution network data hub named Single-Entry Point that is upgraded with the functionality of publishing tenders and collecting flexibility offers. The described system has been

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implemented at Elektro Ljubljana (ELJ). Two systems were established Flexibility procurement system and flexibility management system with traffic light system (TLS), as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

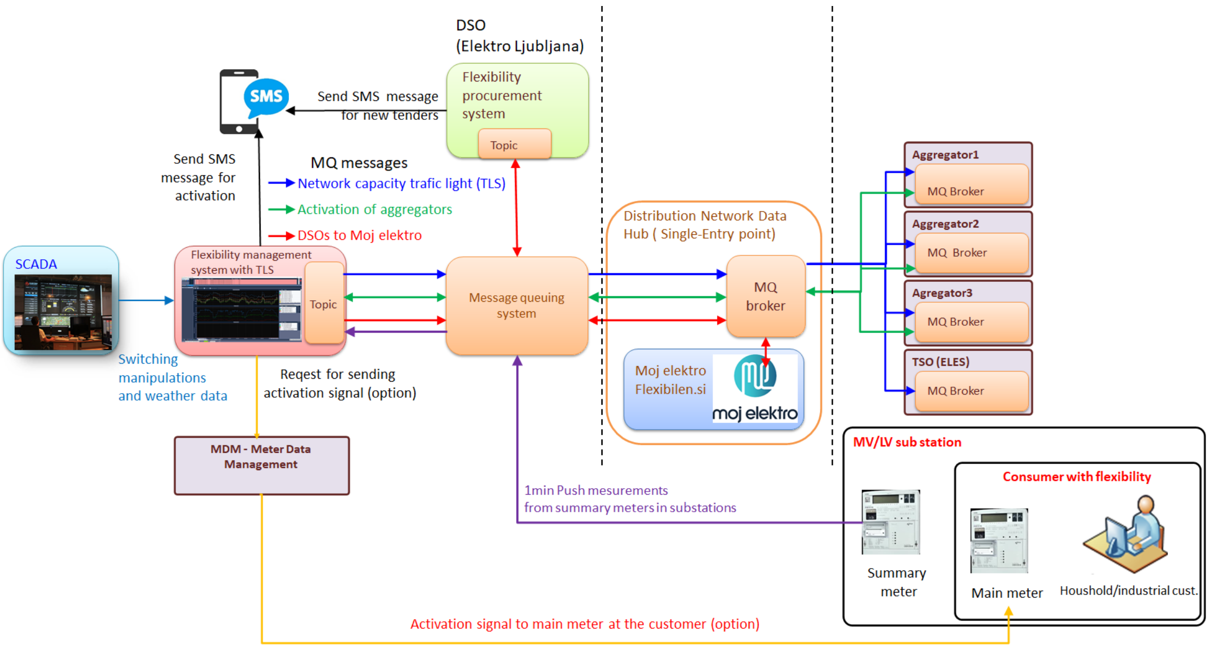

Figure 11: Systems for flexibility procurement and management in ELJ

Flexibility procurement system has two subitems. In the case of Elektro Ljubljana Flexibility management system is a standalone system, but it could be part of SCADA system. We could divide the two systems into three functionalities or subsystems which exchange MQ messages with single-entry point and external stakeholders (aggregators, TSO and individual consumers with flexible loads):

- System for publishing tenders and collecting flexibility offers (part of Flexibility procurement system)
- Flexibility management system and traffic light
- Settlement system (part of Flexibility procurement system).

The exchange of messages is based on message queues (MQ) shown in Figure 12.

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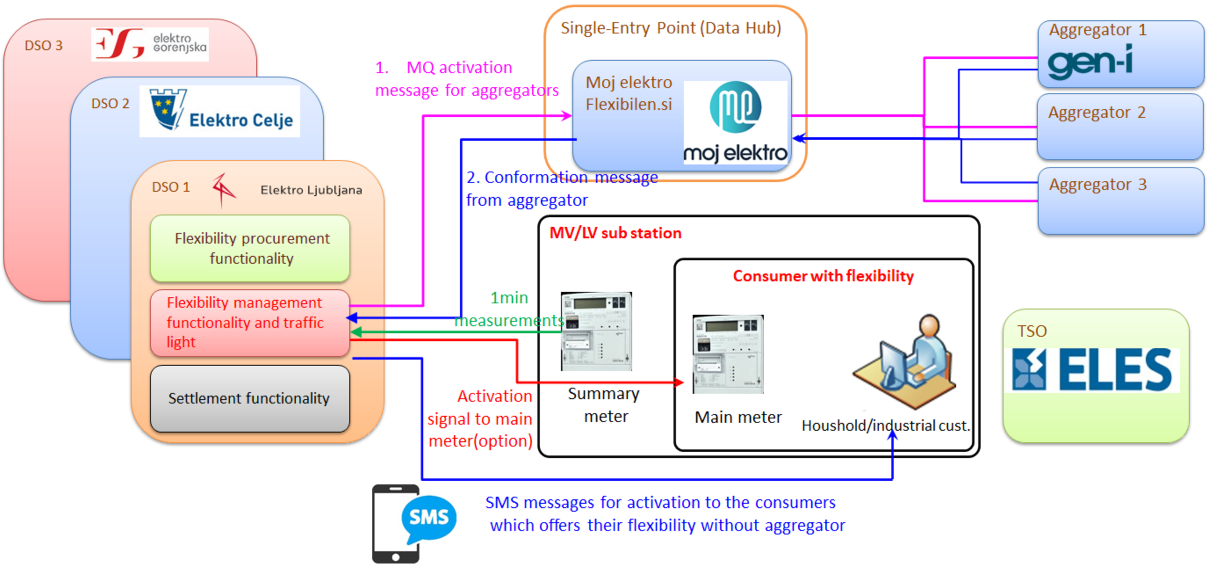

Figure 12: Functionality of DSO's subsystems for flexibility

As there is currently no system for publishing calls for flexibility, we used the System for Unified Access to Measurement Data (SEDMp) also known as Portal of the single entry point Moj elektro. Electricity distribution companies have set up a free web portal named Moj elektro. Users can access their metering data regardless of the electricity distribution area or supplier. The Moj elektro portal enables the user to log into the advanced metering system and, based on his entitlement to metering point data (owner / payer), review data such as:

- technical equipment of the metering point, which is the basis for electricity billing,
- monthly billing data of consumed electricity,
- electricity consumed in previous days in the selected time period, and
- electricity consumed at 15-minute intervals for previous days.

The user access management function also allows end-user data to be accessed by third parties (suppliers, aggregators, etc.) via the same B2C web access. The system provides multi-level authentication of users through SiPASS and REKONO authentication services.

In addition to the above, the platform also transmits RES metering data to the transmission system operator ELES via its dedicated oSPECCoSP platform according to the AMQP protocol. Thus, all actors are already exchanging information with SEDMp. The full set of SEDMp system functionalities is summarized in Figure 13:

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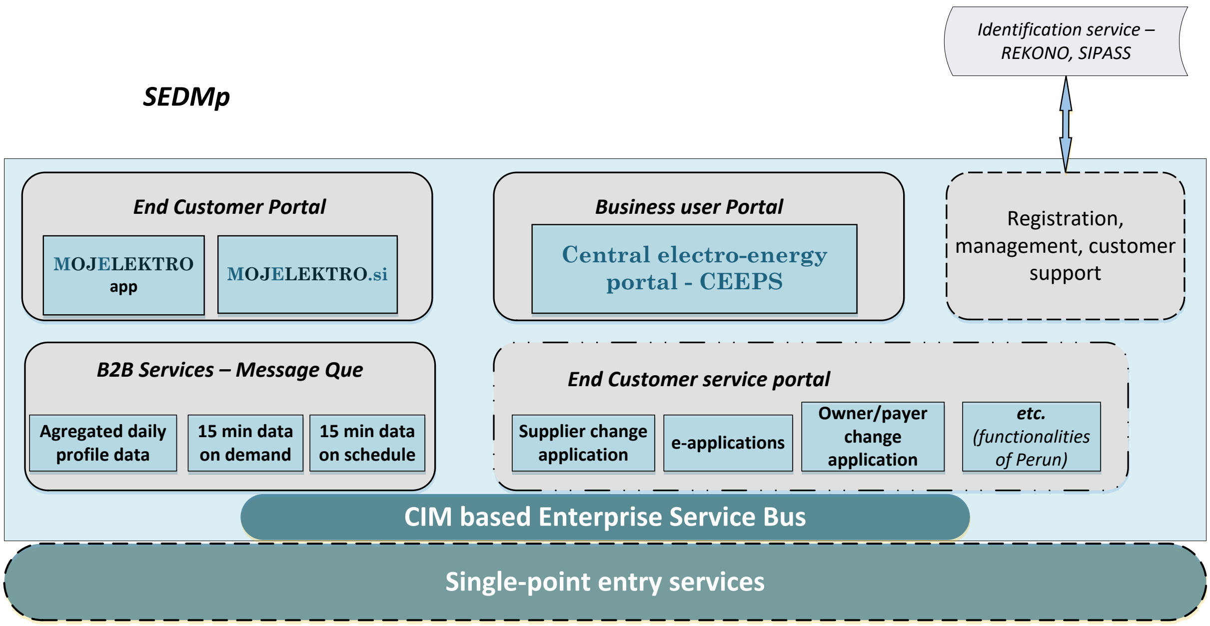

Figure 13: Functionalities od SEDMp system

5.4.3 Products and services

To address the needs of distribution grid in a market-based way the SLO DEMO aims to test non frequency flexibility services– e.g. voltage control and congestion management through active power management. The aggregator manages a portfolio of several households in the congested grid areas where heat pumps are already installed. Switching off heat pumps can prevent the transformer sub-station from overheating and line congestion. The aggregator also manages several household-sized PV power plants with batteries energy storage units to solve the voltage problems in the LV network. When voltage control is needed, active power curtailment will be activated via an inverter. The excess energy will be used to charge the battery systems and the stored energy could be used later in the day. In the process of acquiring participating customers motivational factors, the financial benefits and guarantee of minimal impact on comfort and the absence of risks were used.

The products have been designed to meet the needs of respective LV grid areas where specific time periods and seasonality have been selected. For the congestion management the product duration is limited from September to March of three consecutive winters. In addition, the activations of service are limited to day-time hours from 6.00-22.00.

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6 Conclusion

Energy transition and growing number of renewable and non-dispatchable resources poses a significant challenge for system/grid operators. The system is confronted with unstable flows of energy which needs to be addressed e.g. through innovative solutions – new business models for flexibility services. This solution is based on customer-centric approach, where system/grid operators can procure the flexibility services from customers and their assets connected to the grid. Furthermore, all above mentioned grid issues relate to certain locality, there is not efficient for system/grid operator to have their own assets in each locality but use the current customers assets.

The deliverable consisting of case studies of four DEMO project shows similar experience in terms of existing framework for grid operation and flexibility for distribution network operators. The framework for flexibility provision at the lower voltage levels is less developed in comparison to services/products available for TSOs. This draw from current situation in ancillary services market – only big power plants or high loaded consumption devices can provide the significant amount of flexibility for the system. Compared to the situation in transmission grid, the voltage issues or reactive power overflows are connected to the certain locality, which unlock the potential for smaller customers.

The recent development concerning growing amount of renewable resources and new load patters brings new challenges for system/grid operators in both filed: to ensure enough grid capacity available by grid reinforcement, as well as needs for better network management in order to voltage limits and reactive power flows. As the amount of new connected renewable resources is rapid than the grid reinforcement, the easier way is foreseen to integrate customer-centric approach to the network management and procure flexibility services from already connected customers.

According to received inputs, flexibility for DSOs is purchased rather indirectly than on market-based approach. Either, it is provided through tariffs scheme or it is incorporated through the technical requirement for connection. In same cases, flexibility so far can be provided based on the bilateral contract/agreement between DSO and units/generators. Development of the flexibility on market based is undermined by legal uncertainty (as relevant legal framework on flexibility is about to be developed) as well as by lack practical know how needed. This latter goes namely for relevant business models, definition for services, methodology for flexibility services evaluation, baseline definition etc. Last but not least precondition for transparent and efficient purchase of market flexibility procurement requires implementation of dedicated IT architecture enabling active interaction of market participants.

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However, all DEMO project are under development and the results are not available yet, there is foreseen in all DEMO project creation of environment enabling broader and more active cooperation of grid user namely active consumers. All action taken in the project should remove existing barrier and enable broader and more intensive participation of customer in the energy/flexibility market. Through creation of IT central market place as well as through defined flexibility market products there will be opportunity for group of customer to take a part in the flexibility market. It is also expected that innovate solutions/new business models will encourage namely suppliers/aggregators to enter this new flexibility market which used to be less interesting for them due to lack of legal certainty and unclear business opportunity. In order to maximally facilitate smooth and easy approach to the procurement process, it seems like unification of communication channels is the best way. Implementation of already developed communication standards and protocol really helps to set up appropriate data exchange channels, which is necessity for dynamic procurement of flexibility services regarding to unpredictable local issues.

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