

## Deliverable 6.2

### Barriers to scaling up and replication of the most promising field test results

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## Table of acronyms

Acronym	Meaning
ACE	Area Control Error (Frequency Restoration Control Error)
aFRR	Automatic frequency restoration reserve
BRP	Balance Responsible Party
BSP	Balancing Service Provider
C&I	Commercial and industrial
CAF	Common Activation Function
CEE	Central-East Europe
CMO	Common Merit Order
CMOL	Common Merit Order List
CWE	Central-West Europe
CZC	Cross Zonal Capacity
D-1	Day-ahead
D-2	Two-days ahead
DG	Distributed generation
DR	Demand response
DSM	Demand side management
EBGL	Electricity Balancing Guideline
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
EP	Electricity Producer
EU	European Union
FCL	Final Consumption Levies
FAT	Full Activation Time
FB	Flow-based
GCT	Gate Closure Time

GL	Guideline
ID	Intra-day
IN	Imbalance Netting
IP	Imbalance Price
IS	Imbalance Settlement
ISP	Imbalance Settlement Period
IT	Information Technologies
mFRR	Manual Frequency Restoration Reserves
LFC	Load Frequency Controller
MOL	Merit Order List
MP	Marginal Price
MRC	Multi-Regional Coupling
MW	Megawatt
MWh	Megawatt-hour
NC	Network Code
NRA	National Regulatory Authority
RES	Renewable energy sources
NRA CRE	French regulator
SOGL	System Operation Guideline
SEE	South-East Europe
TSO	Transmission system operator

## Glossary

Refer to ENTSO-E glossary, <https://www.entsoe.eu/data/data-portal/glossary/Pages/home.aspx>.

## **The aim of the FutureFlow Project**

Four European TSOs of Central-Eastern Europe (Austria, Hungary, Romania, Slovenia), associated with power system experts, electricity retailers, IT providers and renewable electricity providers, propose to design a unique regional cooperation scheme: it aims at opening Balancing and Redispatching markets to new sources of flexibility and supporting such sources to act on such markets competitively. By means of a prototype aggregation solution and renewable generation forecasting techniques, flexibility providers – distributed generators (DG) and commercial and industrial (C&I) consumers providing demand response (DR) – are enabled, to provide competitive offers for Frequency Restoration Reserve (including secondary control activated with a response time of 30 seconds and full activation time of 15 minutes). Retailers act as flexibility aggregators and pool the resource to provide the products required by the TSO. A comprehensive techno-economic model for the cross-border integration of such services involves a common activation function (CAF) tailored to deal with congested borders and optimised to overcome critical intra-regional barriers. The resulting CAF is implemented as a cloud solution of a prototype Regional Balancing and Redispatching Platform, which makes research activities about cross-border integration flexible while linking with the aggregation solution. Use cases of growing complexity are pilot tested, going from the involvement of DR and DG into national balancing markets to cross border competition between flexibility providers. Based on past experience with tertiary reserve, participating C&I consumers and DG are expected to provide close to 40 MW of secondary reserve. Impact analyses of the pilot tests together with dissemination activities towards all the stakeholders of the electricity value chain will recommend business models and deployment roadmaps for the most promising use cases, which, in turn, contribute to the practical implementation of the European Balancing Target Model by 2020.

## Project Partners

No	Name	Short name	Country
1	ELES DOO SISTEMSKI OPERATOR PRENOSNEGA ELEKTROENERGETSKEGA OMREZJA	ELES, d.o.o.	Slovenia
2	AUSTRIAN POWER GRID AG	APG	Austria
3	MAVIR MAGYAR VILLAMOENERGIA-IPARI ATVITELI RENDSZERIRANYITO ZARTKORUEN MUKODO RESZVENYTARSASAG	MAVIR ZRT	Hungary
4	COMPANIA NATIONALA DE TRANSPORT ALENERGIEI ELECTRICE TRANSELECTRICA SA	TRANS	Romania
5	ELEKTROINSTITUT MILAN VIDMAR	EIMV	Slovenia
6	ELEKTROENERGETSKI KOORDINACIONI CENTAR DOO	EKC	Serbia
7	ELEKTRO LJUBLJANA, PODJETJE ZA DISTRIBUCIJO ELEKTRIČNE ENERGIJE IN DRUGIH ENERGENTOV, SVETOVANJE IN STORITVE, D.O.O.	EL	Slovenia
8	GEN-I, TRGOVANJE IN PRODAJA ELEKTRICNE ENERGIJE, D.O.O.	GEN-I, d.o.o.	Slovenia
9	SAP SE	SAP SE	Germany
10	CYBERGRID GMBH	CYBERGRID	Austria
11	GEMALTO SA	GTO	France
12	3E NV	3E	Belgium



## Executive summary

aFRR services are technically very demanding as they require real-time operations and high reliability of the delivered services. As the consequence, main aFRR providers of European TSO's are conventional generation units, mainly hydro and thermal power plants, who have a large reserve of primary resource reserves and are able to increase or decrease its generation as requested by TSO. In many areas, only a limited number of suitable conventional providers are available considering technical performances and price optimisation. This situation can create a dilution of market liquidity and lead to volatility of prices. In many countries that is the reason that generators connected to the grid are obliged to reserve a certain amount of capacity to meet the needs of the grid. Hybrid procurement scheme model is used to operate the network in such situations when it is not enough capacity on the market. But even so, some countries can face the shortage of aFRR resources as the growth of the RES, which can influence the demands for aFRR in the future. Integrated EU market, aggregators and DR&DG participation can contribute to the solution of that problem. In FutureFlow project, we showed that DR&DG could be a solution to get more capacity reserve and attenuate the volatility of aFRR market.

In this deliverable, we described the current barriers identified for DR & DG reserve to enter the aFRR market. We have tested them toward the current situation in the EU and summarised our findings from TSOs perspective and from DG&DR interests.

Project assumptions from the theoretical studies have been tested in practice with the real DR&DG customers. Conclusions from on field experiences and optimized project solution regarding a reliable and safe ICT connection from DR&DG to the aggregator and from the aggregator to TSO are presented under the Technical barriers chapter. Advanced aFRR service including loads – DR, and generation - DG requires a decentralized solution capable of connecting different systems into one efficient system. The use of information services expands to private communications infrastructures. Attention should be paid to authentication and authorization methods, and to the supervision and recording of users and customer activities. Interoperability has been taken into account to minimise the costs of service and enable usage of highest possible DR potential.

Several technology barriers have been identified within the customer acquisition and technical integration stages of the project – these range from process operational restrictions to design limitations. The majority of the identified limitations could be overcome fairly effective if addressed in the design or installation phase of the device, for example, installing heat sinks or storage units, or including additional control actuators or sensors. In some cases, the retrofit or adaptations are also feasible, while other regulatory changes would spur the technical measures mitigating these barriers.

In the subtask 6.2.2. Economic barriers as the barriers that prevent or diminish aFRR market development are analysed. They could be related either to the supply side,

demand side, or to the functioning of aFRR market.

On the way toward the targeted FF model, we have identified the barriers hindering the involvement of DR&DG units in providing aFRR services on an integrated EU electricity market. We analysed the current status regarding the identified barrier in the light of our findings from FF simulations and real-life pilot tests. Further analysis of existing models and practices of aFRR services in European countries has been done, and correlations to the FF project and recommendations from the FF project are presented.

In the subtask 6.2.3. Regulatory barriers, we have analysed the legislative frameworks in the EU countries to assess the current situation and future development. Through the assessment, we have tried to find the positive examples of regulative actions which lead to the opening of the market for the new technologies. From these positive examples, we have proposed general recommendations. These recommendations are universal and not market specific so that they can be adapted in the other EU countries. The second part of the study was dedicated to energy storage, its role in the modern energy systems and the question of ownership, development, and operation. We have provided recommendations and considerations which could be helpful when developing the regulatory framework, to enable better participation of energy storage in the markets.

The most benefits brought the integration of four countries Slovenia, Austria, Romania, and Hungary into one integrated regional cooperation scheme. In the final chapter, we have tested scalability and replicability of the most promising used case selected in previous work packages.

## 1. Introduction

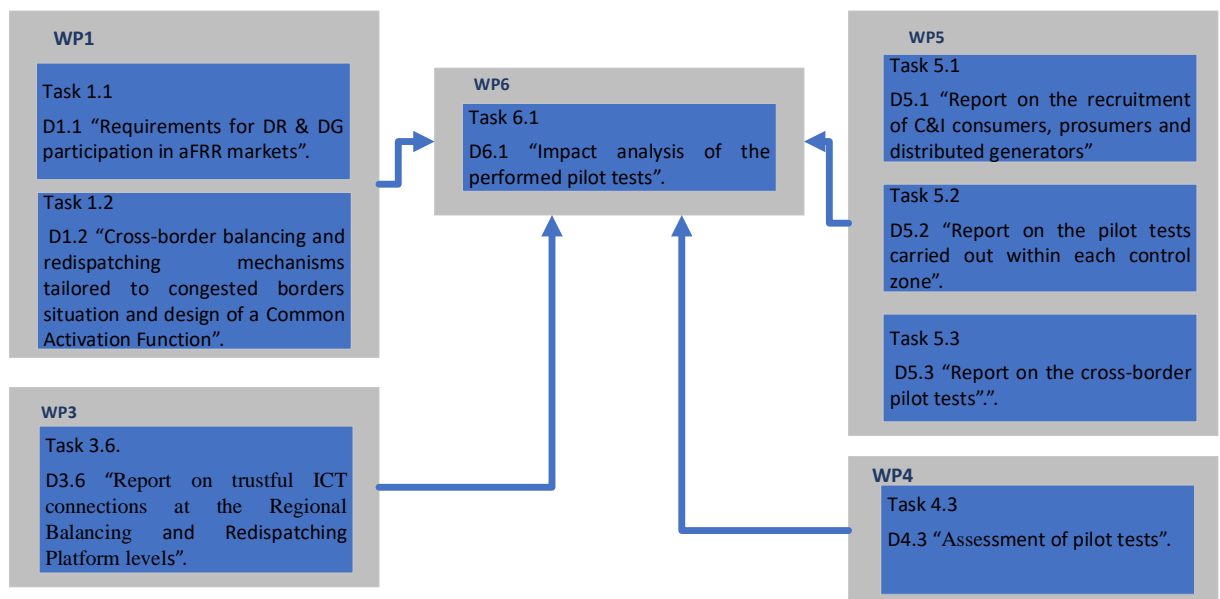
### 1.1 Outline

The main objective of task 6.2 is to summarise the barriers we identified during the FF project and may affect the scaling-up and replication of the most promising use cases. We studied them and proposed some measures for overcoming the identified barriers.

### 1.2 Relation to other work packages

Deliverable 6.2 (D6.2) is related to WP1, deliverables D1.1, D1.2, and D1.4 dealing with Requirements for DR&DG participation in aFRR markets, cross-border balancing, redispatching mechanisms tailored to congested borders situation, and techno-economic assessments.

D6.2 is also related to WP4 and WP5, deliverables D4.3, D5.2, D5.3, reports on pilot tests defined in D4.1.” Specification of the use cases to be completed within TSOs’ environments used for pilot tests.”



*Figure 1: Relations among other work packages*

### 1.3 Integrated European energy market

EU has set two ambitious targets in the energy supply area. The first target is the fully integrated European energy market, which is crucial for maintaining the security of the energy supply, increasing competitiveness, and ensuring that all consumers can purchase the energy at affordable prices. And secondly, due to the concerns about climate change, the electricity sector decarbonisation should be achieved. Europe set an ambitious goal for 2030: a binding renewable energy target of at least 32 % and an energy efficiency target of at least 32.5 % - with a possible upward revision in 2023.

The full implementation of these policies will lead to steeper emission reductions for the whole EU as anticipated – some 45 % by 2030 relative to 1990 compared to the existing target of a 40 % reduction<sup>1</sup>.

To reach those targets European Commission invested a lot of effort into enabling an integrated energy market and an increase of the electricity generation from renewables. An integrated electricity wholesale market was successfully established in the last two decades, and the renewables reached 29.9 % of gross electricity generation in 2015.

Following good results on both targets, the European Commission has begun with activities to promote cooperation related to ancillary services. The acceleration services became of huge importance due to the volatility of RES. The entire value chain of the electric power system from generation, consumption, and balancing will become more complex and challenging.

Therefore four TSOs of Central-South Europe (ELES, Slovenia; APG, Austria; MAVIR, Hungary; and TRANSELECTRICA, Romania) which face the same increasing challenges to ensure transmission system security in their electricity power system, joined resources in research and innovation activities and explored how to ensure balancing activities and congestion relief through redispatching in integrated market, where the growing share of renewable electricity units is constantly reducing the capabilities of conventional, fossil-fuel based means. Partners in this consortium have through a unique regional cooperation jointly explored a techno-economic model of cross-border cooperation in ancillary services including balancing tailored to address increased internal and cross-border congestions, high cross-border capacity prices and the integration of advanced consumers and distributed generators in cross-border exchanges of ancillary services, with an emphasis on secondary control (aFRR-Frequency Restoration Reserve with automatic activation). A comprehensive prototype IT platform for regional ancillary service and balancing automatization, including active demand response, has been developed and tested.

This document aims to provide an insight to stakeholders and interested parties into the barriers which have been identified during the project Future Flow as they may affect the scaling up and replication of the most promising use cases.

Practical experiences gained from integrated German and Austrian aFRR market, as also work done by PICASSO project is considered while analysing barriers, scaling and replication lows.

## **2 Barriers identified in the Future Flow project**

Articles 2(4) of Directive 2009/72/EC defines a 'Transmission System Operator' as a natural or legal person responsible for operating, ensuring the maintenance of and, if

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<sup>1</sup> <https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans>

necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. High reliability and security of system operation is, therefore, the main focus of TSOs. Balancing, and especially aFRR as an important part of it are technically very demanding: they require real-time operations and high reliability of the delivered services. Therefore, this market is highly regulated and has strict technical rules. That might be necessary, but it might be just a legacy of old systems. Nevertheless, to maintain the high availability of electrical network, the approach toward necessary changes shall be made with a lot of caution. Projects, like FutureFlow, are playing an enormous role in that process, while it allows us to test and simulate different scenarios, and give valuable experiences to both sides, TSOs, and service providers.

Aggregators and DR and DG participation in aFRR services have an opportunity to gain experiences in real life tests and discover impacts that the loads participating in the services have on day-to-day operations.

From the beginning of the FutureFlow project, various sets of barriers were identified and explored. Some of the identified barriers were addressed and are expected to be eliminated, as of 23 November 2017 COMMISSION REGULATION (EU) 2017/2195 an electricity balancing guideline (EBGL) had been established. As EBGL sets the necessary regulatory framework for the elimination of some of the identified barriers, there are still some that are very much present, like for example, the appropriate product definitions, the gate-closure times, the validity of the offer, etc. As many of the parameters remain open for TSOs to define terms and conditions and the methodology, we cannot say for sure how effective will the EBGL eliminate identified obstacles. We will mainly remain focused on the evaluation of the ongoing process of the development of the terms and conditions or the methodology of the TSOs according to our own experiences, we gain through FutureFlow project.

### **Barriers for DR&DG participation in aFRR Markets as defined in the Future Flow project<sup>2</sup>:**

**Technology barriers (T)** – are the barriers related to the technical side of aFRR balancing process and aFRR market developments. These could be, for example, communications or interoperability issues.

**Economic barriers (E)** – are the barriers that prevent or diminish aFRR market development. They could be related either to the supply side, demand side or to the functioning of the aFRR market.

**Regulatory barriers (R)**- these are the barriers directly related to the development or adaptation of regulations.

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<sup>2</sup> Table of barriers is in conclusions

## 2.1 **Technology barriers at DR&DG**

### **BARRIERS and measures to overcome them**

Several technology barriers have been identified within the customer acquisition and technical integration stages of the project. These range from process operational restrictions to technological design limitations. The majority of the identified limitations could be overcome fairly effectively if addressed in the design or installation phase of the devices or systems. In some cases, the retrofits or adaptations are also feasible, while in other regulatory changes would spur the technical measures mitigating these barriers. Below we list the barriers we identified:

#### 2.1.1 **The low state of automation in the energy processes**

Our general (and somewhat arbitrary) observation is that the automation level and digitization of the energy sector vary by country, where the economically developed areas demonstrate higher level of automation than the emerging areas or countries. Thus, the DR/DG potential in later case is technically less accessible even if the flexibility intrinsically exists (from the process point of view).

**MITIGATION RECOMMENDATIONS:** The omnipresent digitalization and automation trends will eventually and by itself address this barrier and contribute to easier access to the DR/DG potential. It is necessary to conduct dedicated studies at the level of each customer, highlighting the load characteristics and variable consumption. A feasibility study on typical processes suitable for automated remote control can help the customers become a DSR provider in the electricity markets.

#### 2.1.2 **Power metering and baseline creation**

Although smart metering is in the centre of attention in the energy sector, and conventional metering devices are actually being gradually replaced with so called “smart meters”, these still don’t provide the data frequency (in the range of 2-10 seconds), which is required for the provision of aFRR by the TSOs. Secondly, even if the existing meter enables the extraction of suitably frequent data readings from the impulse output port the measurement accuracy of the existing (official DSO) meter does not meet the 0.5 % accuracy requirement of the TSO (for smaller sized DR/DGs, for example, less than 1 MW). The third barrier relates to the location of the measurement, which in many cases is limited to the grid connection point. This setting hampers the (precision of) evaluation (through baseline creation) of the aFRR regulation energy provided by the DR/DG due to the fact that extensive measurement noise may exist that is related to the (other) non-controllable loads behind the meter.

**MITIGATION RECOMMENDATIONS:** We advise that both requirements, for the measurement location and its accuracy, are such that existing official (DSO) measurements (with their measurement accuracy), as well as usage of internal (meter-behind-meter) measurements, are allowed.

### 2.1.3 Low/no energy or fuel storage

Energy storage has important implications for harnessing aFRR potential in order to assure a necessary availability of aFRR as block delivery time. That implies at level of DR&DG to change from concept of using storage for internal purposes to have a minimum reserve capable of being offered for delivery time required to providing aFRR. Here are some examples:

- a) Some DG types, for example, small hydro power plants, have demonstrated technical readiness for aFRR provision. Yet, these units can only deliver aFRR in the negative direction (decrease power generation) due to the fact that they are of run-of-river types, which hold no water storage.
- b) Similarly, we have found some biogas plants to operate without fuel reservoir, which limits their usage for the aFRR for economic reasons – during negative aFRR delivery, the biogas is wasted on the gas torch.
- c) Although the backup diesel generators have showcased excellent aFRR power delivery during pilot testing one extensive limitation to their usage in aFRR market is the limited fuel tank size that is insufficient for frequent aFRR activation.
- d) In some cases, the user of the heat that is produced by a CHP is directly connected via pipes to the engine, without any thermal storage in between them. Therefore any changes in the operating power of the CHP reflect proportionally the delivery of the heat to the thermal loads, which might not be acceptable for the user of the heat.

MITIGATION RECOMMENDATIONS: The above stated barriers could be mitigated in the following manner:

- a) Should there be reservoirs (water dams, gas reservoirs) built, these units could provide a positive and negative (aFRR) reserve. To some extent the small size of the dams is conditioned by the topography of the local area, which makes this barrier difficult to overcome. Nevertheless, small sized dislocated water pools could be located in the near vicinity of the hydro power plant that could serve as energy storage (dedicated for aFRR provision). In other cases where topography enables larger dams to be set up the barriers are mainly regulatory specifically the requirement for maintaining the constant water level height at the water dam should be overcome. A study regarding the minimum reservoirs dimensioning will be based on the approved requirements regarding aFRR providing from sources with limited reservoirs and the possibility to aggregate same type in an aggregation capable of fulfilling together the requirements regarding time aFRR delivery.
- b) Similarly, for the case of non-existent biogas reservoirs, the reason is regulatory, concretely the prohibition for such units to participate in the aFRR market.
- c) One possible solution to overcome the limited diesel fuel tank size and enable the backup diesel generators to meet the requirements for the provision of aFRR would be their upgrade that allows natural gas to be used as fuel. Such fuel conversion kits are already commercially available.

d) Thermal storage should be built should the analysis prove its economic efficiency.

#### 2.1.4 **Temporary restriction of DG availability for aFRR**

We have identified in some cases that DR units are not permitted to operate during nights, weekends and national holidays since the units while in operation emit the level of noise that exceeds the limits specified in the legal permits for these areas.

MITIGATION RECOMMENDATIONS: Noise reduction measures effectively reduce emitted levels. These should be sufficiently applied in such cases.

#### 2.1.5 **Seasonal DR/DG operation**

In some cases, especially combined heat and power units, we have found that the units are capable of delivering the aFRR service only while in operation at high load, which happens to be limited to the winter season. While during the warmer part of the year these units do not meet the requirements for aFRR provision, namely the full activation time.

MITIGATION RECOMMENDATIONS: One possible solution would be to connect the CHP units to the district heat network where their operation would be possible all year round. Another alternative, although less efficient, are to install heat storage or waste the excess heat into the environment through the installation of heat dissipation devices.

#### 2.1.6 **High technical minimum - overcome by algorithms**

In most cases, the DGs are subjected to restrictions in the range of power across which they are let to operate safely and efficiently. Such common restriction is the minimum power at which the unit is allowed to be operated, called technical minimum. Particularly CHPs and biogas units have set their technical minimums rather high at 50 % of nominal power. The reason lies mostly in the fact that the thermal efficiency of energy conversion drops at low power: hence the CHP manufacturers warrant the high performance of their products only if operated in that narrow range.

MITIGATION RECOMMENDATIONS: The CHPs are capable of delivering flexible operation even at less than 50 % of the nominal power if somewhat lower thermal efficiency and higher maintenance costs are economically acceptable, thus the warranty agreements between the manufacturers and CHP owners should be changed to allow operation at lower loads by making acceptable the reduction of performance of the CHP units at lower loads and make maintenance schedules be dynamically planned, depending on the extent of dynamic operation and state of the system. Another possible measure to overcome this barrier is deploying algorithms by the aggregator on the level of his pool that accepts the technical minimum limitations and finds an optimum combination of resources to deliver precise control of aFRR delivery across the entire pool (sum of individual units).

#### 2.1.7 **The unreliable communication link to DR/DG**

As DR/DGs are dispersed by their definition, some of these are significantly

geographically isolated. Such examples are small hydropower plants located in tight mountain valleys or even biogas plants in the midst of rural planes where the GSM signal strength may vary depending on the weather conditions. The loss of communication connection hinders the reliability of the aFRR delivery to the TSO.

MITIGATION RECOMMENDATIONS: Communication reliability may be improved by the installation of more powerful antennas or redundant internet communication. Both measures incur costs.

### 2.1.8 **Timeout between activations**

Some processes require sufficient time to reset after the activation (of aFRR) before they are available to respond to the next activation. This timeout period may be 3 to 15 minutes long for the cases of diesel backup generators and heat pumps, depending at what stage of their internal process's activation has ended. Such limitation reduces the availability (rate) of the aFRR reserve.

MITIGATION RECOMMENDATIONS: A possible measure to overcome this barrier is deploying algorithms by the aggregator on the level of his pool that accepts the timeout limitations and finds an optimum combination of resources to deliver precise control of aFRR delivery across the entire pool (sum of individual units).

## 2.2 **Technology barriers - Communication**

We can recognize the three levels of the communication infrastructure, which architecturally follow the newly created business needs. These three levels are suitable for separate treatment of communication protection and data exchange. In the first level, we can define the exchange of data between the information environments within the system operators themselves. The second level can define data exchanges between the information environments that are located with the system operators of individual companies. And in the last third level, we can define data exchanges between the information environments of system operators and service providers in power systems, where the communication paths are not precisely defined and usually form only through public communications networks. A detailed study of these three levels can also lead us to create three frameworks for providing basic information security concepts, such as confidentiality, integrity, and availability.

### 2.2.1 **Internal TSO, internal DSO communications - private networks, finally a small number of stakeholders and connections, the size of stakeholders with great potential for development, the existing e-platform.**

At this level of data exchange and the use of information services, in most cases, precisely defined and, most often, private communication channels are established. The information infrastructures of one system operator are formed on their communication lines. In addition to the power lines, the power companies also build their communication lines, which provide communication connectivity between locations and devices that are part of smart energy networks. Many system operators use these

communication lines for private communication channels among individual stakeholders - system operators. In these relations between the system operators, we can also use secure connections that run through the power lines of the energy network. For all these types of communication paths, we can consider certain advantages in terms of reduced security risks. Consequently, the data exchange mechanisms are also adapted to this parameter of the communication infrastructure.

The next important fact of this level of data exchange is that there is a limited number of stakeholders in the communication infrastructure. It is also important that these stakeholders are very static and practically do not change for a very long period. However, we must take into account that all these stakeholders in the data exchange are relatively large and with great potential for development, since the number of stakeholders and the number of communication channels are practically unchangeable, and the paths remain the same for relatively long periods.

**MITIGATION RECOMMENDATIONS:** When exchanging data at the level of an individual system operator, the most attention should be paid to authentication and authorization methods, and of course to the supervision and recording of users and customer's activities. Less attention can be paid to methods to protect integrity and confidentiality, as the risks to the compromise of information security in private networks are much smaller and different from that for data exchange via communication paths that run through public Internet networks. Also, all stakeholders in the use of the communication infrastructure within organizations trust each other, since they are practically all part of the same domain, perhaps separated only according to the nature of IT infrastructure and the purpose of supporting different separate key business processes.

Nonetheless, it is important to take care of the fact that it is becoming increasingly important to protect communications between individual information systems within a particular company. It is necessary to ensure the integrity and confidentiality of security also on the communication paths between the IS, as there is an increased risk of compromising information security with possible indirect interventions in the neighbouring ISs. In this way, we can recommend the introduction of secure encrypted communication cameras among individual information systems within a single company.

This is very important because many, e-platforms and communication services, which are already developed and established at system operators, offer many communication options for data exchange.

### 2.2.2 **TSO-TSO, TSO-BSP - communication links through private and public networks, many smaller stakeholders with disabilities.**

The exchange of information and the use of information services can also be carried out in the area of one district or one of the energy networks of one TSO and its tree structure of DSOs to a greater extent through its own private communications infrastructure. In any case, this cannot be a rule or a condition for the implementation of a communication

infrastructure between system operators, since the need for data exchange between system operators is expanding and exceeding the framework of private communications infrastructures through the construction of smart energy networks. Thus, communication channels are increasingly spreading out of private networks, including through public Internet networks. This creates an additional need for the corresponding architecture of communication infrastructures and applications to consider the risks and cyber threats of public networks.

At this point, however, we are not talking about a limited number of stakeholders, but it must be considered that their number is final but significantly higher than the number within a single operator. Since the amount of these communication channels is considerably higher, the dynamics of these stakeholders higher than that dynamic within one society.

In this large number of stakeholders, we should consider the fact that these stakeholders are not equally large as TSOs and thus do not have equal opportunities for development. The larger stakeholders are in advantage, and the smaller ones cannot follow their development. Rapidly, and consequently, the entire development of information exchange processes and the use of communication services are limited with the weakest link.

**MITIGATION RECOMMENDATIONS:** It is very important that design and solutions architecture, based on uniformed protocols for data exchange. In the pilot project, we made a generalization, for example, MQTT, which helps to establish internal and external communications. It is Important to use unified protocols for data exchange.

Another major key for unification could be end-to-end encryption using TLS, which ensure the integrity and confidentiality of data exchange, regardless of the communication path, internally or externally established.

For example, new upcoming e-platforms (as ECCO-SP) issued by the ENTSO-E, provide appropriate communication possibilities for data exchange and the use of secure communication services.

Another new upcoming communication platform (as ATOM Network) also issued by the ENTRO-E, provide appropriate possibilities for more EE services. The first option for designing is high availability and reliable Private/Public FF Cloud for TSO. This newly designed Network can provide redundant access to FF Cloud services for all TSOs and replace point-to-point communications for data exchange between TSOs with fully redundant designed communication architecture. More details about the usage of new upcoming communication platform will be described in deliverable 6.4 – “Recommendations for a deployment roadmap of the most promising use cases studied in the pilot tests.”

### 2.2.3 **DSO-DSO, BSP-DR/DG - communication links through public networks, many smaller stakeholders, and a larger number of small and micro stakeholders without suitable development opportunities.**

The lower level of data exchange and the use of communication services is a framework at the level of the distribution network, production facilities, final customers and all other stakeholders on the very edge of the electricity system. In addition to the fact that most of the data exchange is carried out on public networks, an important factor in the construction of communication architectures is the fact that in many places the restriction is the provision of the network itself.

At this level, there are many more stakeholders involved in the exchange of data and the use of communication services. Consequently, the architecture itself is more complex, and the risks of cyber-attacks, data misuse, and other security risks are also significantly higher.

It is also necessary to consider at this level, that many stakeholders, due to their small size and simplicity, are not able to take care of the development of information security. Thus, in cases where system operators, as superior communication partners, do not provide information security, these smallest stakeholders have a particularly high-security risk to the entire information level.

MITIGATION RECOMMENDATIONS: Planning architectures and solutions at the end of the service chain (at BSP-DR / DG communication points) should be based on uniform communications, as protocols and cybersecurity for data exchange are. A lightweight MQTT protocol could be used to exchange data at thin endpoints such as DR and DG. Development should consider authentication and authorization part of data exchange. Another pilot example was the use of TLS, which could ensure the integrity and confidentiality of data exchange in communication channels, together with authentication of the endpoint. The use of existing secure protocols like TLS (Transport Layer Security) can support many services in BSP-DR/DG level, but many other aspects must be tackled to define all possible facets of a secure architecture. These include activities using certificates for all devices, standardizing how to behave with rare long-standing TLS sessions, creating completely new encryption sub-protocols for specific use cases.

To obtain effective end-to-end security, secure protocols must establish secure connections based on some trusted private key of the actors and have a repository of actors allowed to act inside the system. This is mainly standardized in IEC 62351-9: Key Management, while onwards is standardized in IEC 62351-8: Role-based Access Control (RBAC), and further reviewed and explained in IEC/TR 62351-90-1: RBAC Guidelines.

## 2.3 **Technology barriers - Interoperability**

Analyzing the deliverables of the group, especially the “SGCG/M490/G\_Smart Grid Set of Standards” and “SG-CG/M490/L\_ Flexibility Management”, it was found, that there are no use cases related to cross-border balancing and redispatching. Consequently, the

semantics for the data exchange is not defined for all the data which needed to be exchanged. (Only market-related data is well covered with appropriate standards: on the European Style Market Profile (IEC 62325 set of standards) and standards in the scope of the ENSTO-E Electronic Data Interchange (EDI) Library.) The descriptions of use cases are essential for the development of standards which allow seamless integration. Descriptions of use cases for cross-border balancing and redispatching made in the Deliverable 1.3 are the contribution of the FutureFlow project to the standardisation.

In the scope of the FutureFlow project, the MQTT protocol was used and successfully tested, as well for the real-time data (measurements & control), as also for the market-related data (bidding, cross-zonal capacities, acknowledgement business process, etc.). The MQTT protocol is an IoT protocol, lightweight, open and easy to implement. It can also be well secured (by TLS), as was also proven in the FutureFlow project. It is standardized (ISO/IEC 20922:2016), but hasn't been considered for usage for such kind of applications. Thus, we recommend, that the MQTT (with CIM based semantics) is considered as an option for applications in the electric power system domain and that it is added to the list of available protocols in the scope of Smart Grid Reference Architecture.

## 2.4 **Economic barriers**

We have defined economic barriers as the barriers that prevent or diminish aFRR market development. They could be related either to the supply side, demand side, or to the functioning of aFRR market.

On the way toward the targeted FF model of an integrated market, we identified the potential barriers hindering the involvement of DR&DG units in providing aFRR services on an integrated EU electricity market. Further analysis of existing models of aFRR services in European countries has shown additional differences that are resulting in additional barriers. Altogether the following barriers were identified:

- cross-zonal capacity for balancing rules;
- DR&DG participation in the market should be authorised;
- aggregation should be allowed;
- aFRR market rules shall be transparent and non-discriminatory;
- Full Activation Time (call time) should be as long as possible;
- product resolution (in MW) as low as possible;
- symmetrical products should not be obligatory;
- price transparency and price incentives;
- regulated balancing pricing or not;

- the settlement should be defined;
- product resolution (in time) as low as possible;
- procurement cycle as short to real-time as possible.

**Differences in aFRR operation:**

- central- dispatch versus self- dispatch model;
- TSO balancing proactive or reactive;
- activation pro rata or merit order.

**2.4.1 Cross-zonal capacity for balancing rules**

The usage of Cross Zonal Capacity within the aFRR cross-border exchange and optimisation is based on the two theoretical principles:

- transaction-based (ATC-based) and
- Flow-based (PTDF/ RAM).

The two different approaches for these two definitions of CZC are applied, having in mind the TSO practice and the time and efforts needed for TSOs to manage and prepare the CZC to be suitable and ready for the real-time balancing process:

ATC-based capacities are analysed as capacity remaining after the Intra-day commercial trade. Flow-based capacities are analysed as recalculated on the basis of Intra-day network models for each following timestamp.

ATC values (as remaining after Intra-day) naturally provide more conservative constraints to the balancing exchanges, since original NTC values are currently calculated at two-days ahead time horizon in the best case, and therefore capture more conservative forecasting assumptions.

On the other hand, being calculated as late as possible, FB values can be more relaxed in the sense of forecasting the network situations roughly half an hour before its application.

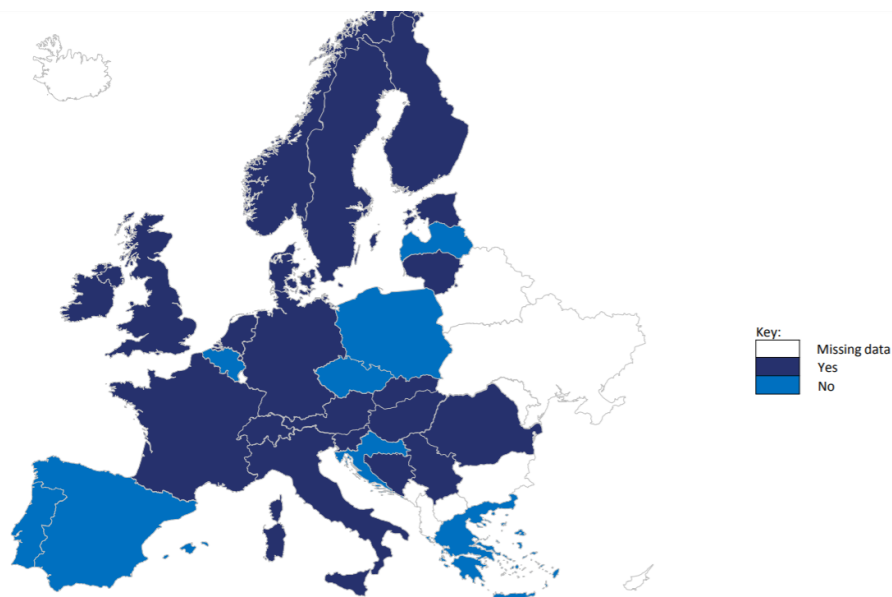
Reservation of portion of CZC for the needs of cross-border balancing, is applicable according to the EBGL, as long as it is either obtained through market-based mechanisms or proven as beneficial through the detailed techno-economic analysis. However, it is not desirable since it decreases the CZC for commercial exchanges. This is especially true when the results of aFRR optimisation with applied Flow-Based CZC calculated close to real time are seen, which also leads to an uncongested situation.

Therefore, obvious conclusion is that TSOs should rather invest their efforts in applying such Flow-based calculation approach and its direct usage in balancing process, then in the complex and sub-optimal process of reserving the portion of (a bit outdated) ATC; which recalculation close to real time is not easy nor straightforward as for FB values.

## 2.4.2 DR&DG participation in the market should be authorised (and encouraged)

### Current situation

Although the regulatory framework for DR&DG participating is set (see Chapter on regulatory barriers) in reality, the access to the ancillary service market for DR&DG is still very limited. In several markets, demand-side resources are only allowed to participate in a small number of programs and certain markets are currently still closed to Demand Response (such as the balancing markets in Italy and Spain or the re-dispatching markets in Germany). Mostly because of the national regulatory environment and lack of practical experiences in the majority of Member States.

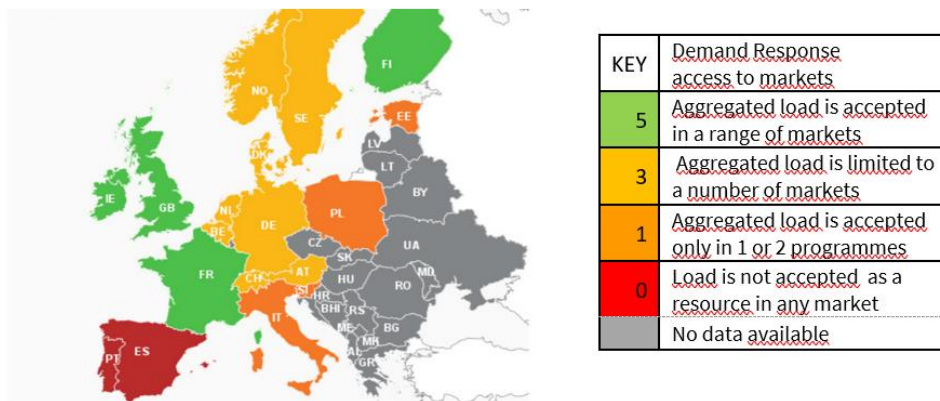


*Figure 2: Load providers use the same market mechanisms and activation procedure as generation*

Even if ENTSO-E<sup>3</sup> data shows that 18 countries from 28 EU countries include loads to provide these services for both capacity and energy, as the study goes more into detail, there are very few data available. According to SEDC<sup>4</sup>, load participation is in many countries at a very early stage.

<sup>3</sup> ENTSO-E\_AS\_Study\_2017

<sup>4</sup> SEDC - Mapping Demand Response in Europe Today 2017



*Figure 3: Demand response access to markets in Europe<sup>5</sup>*

Through the FF project, we identified that the participation of DR&DG in ancillary services is challenging for both sides, the TSOs as for DR&DG itself. TSOs are facing an increased load of work, as they must deal with the increased number of participating partners. All those partners have to be verified, prequalified, measured and controlled. New initiatives for the new procurement models should be verified and finally implemented. This will bring additional load on people, processes, technology, and security. On another side, DR&DG faces the lack of experiences how to deal with strict demands of aFRR, how to combine day to day business with offering aFRR services and how to build a successful business case to encourage investments. Incentive structures should be adapted to ensure this, and appropriate procurement mechanisms should be introduced in alignment with the services and energy markets at the wholesale level. In conjunction, network tariffs should support, rather than hamper as today, the use of demand-side flexibility at all network levels.

<sup>5</sup> SEDC - Mapping Demand Response in Europe Today 2017

Figure 3-1 Proliferation of fixed, variable and spot based tariffs by Member State<sup>39</sup>

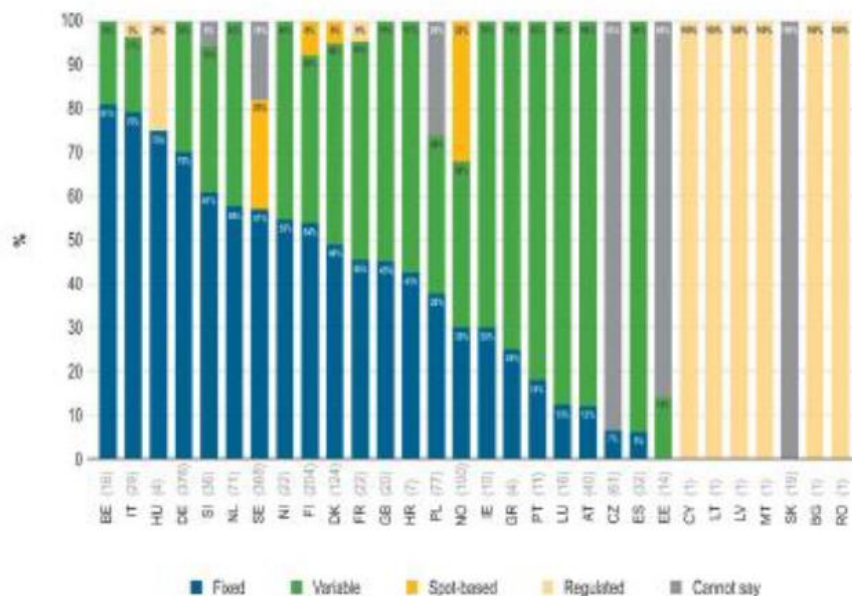


Figure 4: Proliferation of fixed, variable and spot based tariffs by Member State<sup>6</sup>

## Recommendations

Many different concepts are discussed to encourage the development of demand response and its inclusion in ancillary services. We can exclude some early ideas for long term contracts (Finon & Pignon, 2008), which could support prosumers (or aggregators) to invest in getting ready for ancillary services production, since the long-term contracts have the main drawback, they actually exclude the merit order and are in all characteristic's complete opposite of Future Flow target procurement concept.

More interesting are the capacity mechanisms. On 7th February 2018 EU approved under EU State aid rules for electricity capacity mechanisms in Belgium, France, Germany, Greece, Italy, and Poland. Capacity mechanisms have the important objective of ensuring the security of electricity supply. But they cannot replace electricity market reforms at national and European levels. Important legislative work is ongoing to address market and regulatory failures, which undermine the incentive for energy operators to invest in electricity capacity and maintain the security of supply. On 18. December 2018, the political agreement on the Commission's Clean Energy for All Europeans Package was reached. The formal approval by the European Parliament and the Council followed 26. March 2019. The Regulation enters into force immediately, and the Directive will have to be transposed into national law within 18 months. This package includes a new Market Design to create the right investment incentives and to enable further development of renewables in the electricity sector. When adopted Member States will have to adapt all existing State aid measures to the future legislation.

The six capacity mechanisms approved on 7th February 2018 under EU State aid cover a range of different types of mechanism that address the specific need in each Member

<sup>6</sup> ACER/CEER annual report on the results of monitoring the internal electricity and natural gas markets in 2014.

State, namely strategic reserves, market-wide mechanisms and measures specifically promoting demand response.

### **Demand response schemes**

In the cases of France and Greece and Germany in 2016, the Commission has authorised capacity mechanisms specifically promoting demand response. Demand response schemes are not focused only on aFRR, but they do pay customers to reduce their electricity consumption in hours when electricity is scarce and therefore promote all forms of ancillary services. The advantage of such schemes is that demand response operators may be able to react more quickly than electricity generators, they are generally more environmentally friendly, they can contribute to congestion problems and can render the investments in infrastructure (additional power plants, lines).

The new rules under the Clean energy for all Europeans are designed to empower energy consumers to play an active role in driving the energy transition and to fully benefit from a less centralised, and more digitalised and sustainable energy system. Capacity subsidies to power plants emitting more than 550gr CO<sub>2</sub>/kWh will be phased out under the new rules (by 2025). Despite that, many are afraid capacity mechanisms will be used to subsidize incumbent generators and do not provide enough incentives for the alternative, market-based solutions, such as “demand response” schemes.

Therefore FF's recommendation is to follow up the effects of the approved DR schemes and development under the New electricity market design considering the right investment incentives for the development of DR&DG. Currently there is little information available about the effects of the approved mechanisms. During the project, we found out that state aid rules for electricity capacity mechanisms in Belgium is not even implemented but is more an improved instrument that can be used in case of the need.

FF members will promote the establishment of equality between actors on the production and demand management side in the selection and participation process.

#### **2.4.3 Aggregation should be allowed**

The ambitious goal of Europe to reach 40 % of electricity generation from RES by 2030 will certainly contribute to establishing big sun or wind generation units, but also smaller decentralised RES generation units, the ones that FF project is focusing on, are very important. Both wind and solar generation are subject to seasonal variations and facing substantial daily cycles due to daily irradiation and temperature changes the predictability of RES generation is extremely challenging. In D1.1. we have analysed sun and wind P50 day-ahead (DAFC) and intraday (IDFC) forecast and actual measured load profile of an aggregated portfolio and the corresponding forecasting errors. However, a higher P10 or even P50 RES forecast could be used as a basis for aFRR bids in case aggregation is allowed with different generation units that enable to cover the

forecasting errors to reach a P1.5 with the help of other units (Results )<sup>7</sup>. Considering maximum availability of flexible capacity, moving from a portfolio solely containing RES to a portfolio combined with 10 % or 20 % of other DR or DG is unambiguous and recommended in systems.

The difference between theoretically identified DR/DG potential and its actual participation in the aFRR market shows that additional effort will be needed to engage more market participants. Even in Austria, one of the most developed EU countries in including DR&DG in aFRR, the percentage of aggregators offering aFRR is around 10 %.

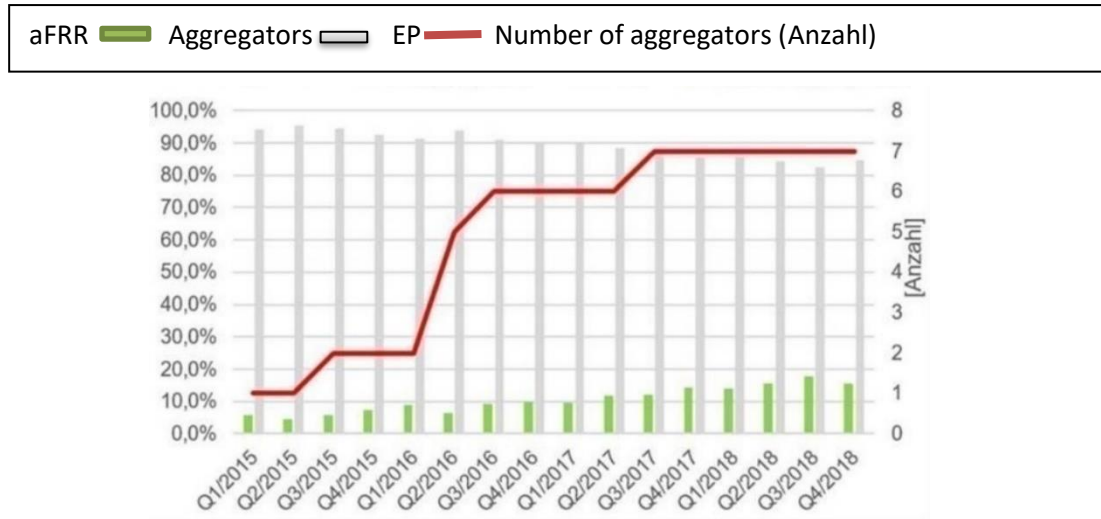


Figure 5: Aggregators offering aFRR in AT

The introduction of the role of aggregator into a market creates critical momentum around the growth of DR&DG, attracts private investment and spurs competition between service providers.

During the FF project, we have identified the following role of an aggregator in the encouragement of the DR&DG market:

- To bring the knowledge and means to the customers by providing a clearly defined offer, which is both simple to use and contains clear benefits.
- To uptake the role of the innovator of cost-effective and innovative solutions for the optimal use of these diverse resources.
- To build a reliable portfolio of combination DR&DG including RES

#### 2.4.4 aFRR market rules shall be transparent and non-discriminatory

aFRR market shall be based on open competition, transparent and non-discriminatory. Market rules shall consider all service providers equally and should not discriminate between different technologies.

<sup>7</sup> Future Flow D1.1.: Requirements for DR&DG participant

One of the challenges for independent aggregators to enter the ancillary market is the lack of clear rules on:

- Distinguishing between so-called implicit<sup>8</sup> and explicit<sup>9</sup> flexibility
- Measuring and validating the activation of the flexible consumption/generation
- Exchanging information with existing players, for example, when the aggregator enters into an agreement with a customer with different BRP

Although there are many possibilities for DR&DG participation in balancing (direct DR&DG participation, aggregation through BRP, independent aggregation) the focus of Future Flow was on introducing cross border aFRR and including DR&DG. We are fully aware that in the future new business models and new players on the balancing market will play a major role in DR&DG development. Future Flow addresses the issue of DR&DG units switching between two BSP providing ancillary service in use case 4 DR/DG integration, with the possibility of switching among BSPs.<sup>10</sup> The technical and legal aspect of such a change is analysed and is described in deliverable D5.2. Report on the pilot tests carried out within each participating control zone. Use case 4 is only one of the possible scenarios that will occur in the free market of aggregation of DR&DG.

To enable the participation of aggregation service providers safely, as much as possible standardisation of the processes for information exchange, the transfer of electricity and technical requirements should be defined for as many scenarios as possible. The role and responsibility of the aggregator should be clear, as the relationship between the BRP and the aggregator differs from the market model to market model.<sup>11</sup>

A financial settlement between these parties has not been the topic of FF research but was identified as a critical requirement to encourage aggregators to participate in aFRR.

#### 2.4.5 **Full Activation Time (call time) should be as long as possible**

Effect of FAT length on the quality of ACE has been analysed in Future Flow deliverable D1.4 Results from simulations of XB balancing and redispatching mechanisms with Common Activation Function and D4.3 Assessment of the pilot tests. All analysed FF Integration cases show significant improvement of overall ACE control quality compared to the status quo situation without regional cooperation. The FF Integration Case based on Control Demand activation with Standard Product shows better ACE control quality indices than the other two FF Integration Cases. Therefore, the target FAT for FF was chosen to be 5 min.

The pilot tests performed in WP4 have shown, that FAT of 5 minutes is achievable by

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<sup>8</sup> Implicit flexibility is when the customer reacts to the hourly price and is rewarded with an overall lower electricity bill.

<sup>9</sup> Explicit flexibility is when the customer is rewarded by adapting its consumption to the products in the electricity market

<sup>10</sup> Future Flow D 4.1 Specification of the use cases to be completed within TSOs

<sup>11</sup> Market models for aggregators, Confederation of Danish Industry, June 2017

most of VPPs. Of course, VPPs are constructed of DR&DGs where all of them don't have the capability to achieve the desired FAT of 5 minutes. The performance of DR&DGs depends on many factors which are described in detail in D4.3. However, with properly constructed portfolio of VPP pool target FAT is achievable with no issues. The fail-safe for underperforming VPPs in the real market is prequalification tests, which must be done to allow BSP to trade their energy with quality of service that is required by TSOs. Prequalification tests must be constructed with target FAT in mind as also were on FF pilot tests. This means that responses for common setpoint signal shapes (square, ramp, etc.) must be qualified according to desired FAT. It's BSPs responsibility how VPP portfolio is constructed, but it should pass all VPP's prequalification tests in order to allow for VPP to go online.

The pilot tests have proved that VPP with a proper portfolio of RES and DR&DG can achieve a five minute FAT. Even if we considered the hybrid of Standard & Specific product at the beginning of the FF, we have decided to go only with standard bids in our pilot project.

Article 21(3)(b) of EBGL foresees that in by one year after entry into force of this Regulation, all TSOs shall develop a proposal for the implementation framework for a European platform for the exchange of balancing energy from frequency restoration reserves with automatic activation. In parallel with FutureFlow, the implementation project PICASSO facilitates the fulfilment of the deadlines by foreseeing early regional operation of aFRR Platform for countries fulfilling parts of aFRR Implementation Framework before the deadlines defined by Article 21(6). Picasso has also addressed the FAT harmonisation as a key factor toward an integrated aFRR market. From current ENTSO-E discussions, also two kinds of products are foreseen, the standard product with FAT limited to 5 min and for the first period of Picasso implementation, probably the first 2 years, 7.5 min.

The FutureFlow has considered specific products with FAT 10 min at the beginning, but as the EU TSOs have agreed on standard product 5min, we have also concentrated in our pilot tests on 5 min FAT. Nevertheless FAT 10 min or 12,5 min can be used, for a limited period of time as specific product, only in internal TSO market. It can be a solution for starting projects of DR&GD in the local electricity market and encourage investors to act in a market and get experience.

#### 2.4.6 **Product resolution in MW and in time**

The lower the bids, the more participants on the balancing market. Two measures had been recognised and proposed by FutureFlow to achieve better product resolution. The first one is that the aggregation should be allowed, which we have analysed already, and the second is to lower the bid demands in the size of time and MW. FF target model was 1MW bid. A list of standard products is one of the tasks for TSOs requested by EBGL in Art.25 (2) "By two years after entry into force of this Regulation, all TSOs shall develop a proposal for a list of standard products for balancing capacity for frequency restoration reserves and replacement reserves."

In the Picasso<sup>12</sup> project, the time resolution proposed is a multiple of 15min but not more than 1hour (4 consecutive time interval), which is in line with the recommendations from FutureFlow.

#### 2.4.7 **Symmetrical products should not be obligatory**

Symmetrical product requirement is an entry barrier for resources that cannot provide an equal amount of positive and negative balancing energy. An interesting barrier we have discovered during the workshops with the stakeholders is coming from small hydropower plants. Although they performed well during the pilot tests, they cannot comply the demand to offer symmetrical products, because they can offer only negative regulation and not the positive regulation (due to regulation barriers connecting to the hydropower regimes). They have to follow strict environmental rules and conditions, like a run of the river, (letting the water flow without a dam. Most often, it also includes the payment of royalties or specific taxes). These conditions are based on the objective of national and local authorities.

Hydropower regimes in European countries vary considerably in terms of hydropower usage rights, in both their joint obligations and the degree of openness of the competition processes through which these rights are granted.<sup>13</sup> The strong differences among hydropower regimes in Europe and as in our case between hydropower regime for big and small hydropower units are resulting in different economic conditions for the Hydro units and bring competition distortion to the common European electricity market.

#### 2.4.8 **Price transparency and price incentives**

TSOs are buying aFRR services in two separate markets: capacity and energy market. Prices for aFRR capacity and energy should be transparent and be defined in the same way for all market players.

In most EU countries today, the balancing capacity costs are socialised through network tariffs, or the costs are allocated to BRPs. This means that the market does not get the right signals. Consequently, BRPs are not sufficiently incentivised to be balanced, and BSPs are not incentivised enough.

Especially is that the case in countries that do not have enough aFRR providers. Like Slovenia for example. For security reasons the National legislation: Energy Act (the Official Gazette of the Republic of Slovenia, No 17/2014) in Article 74 (imposing an obligation to conclude a contract to provide system services), which empower TSO to request aFRR services from the market providers that are able to provide such services for a regulated price, set up by the NRA. The price is set up for each category of aFRR service providers according to the costs (for hydro, for thermal, for gas). How to calculate

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<sup>12</sup> The PICASSO project has been selected to be the reference project for the establishment of an aFRR platform by ENTSO-E.

<sup>13</sup> FSR research report: “Regimes for granting right to use hydropower in Europe” (2015).

the aggregation is described in Article 9 in Act of establishing a methodology for determining the prices of ancillary services (Akt o določitvi metodologije za določanje cen sistemskih storitev 2017). It is foreseen only to include the technologies that are defined in the act. No price calculations for RES or DR&DG is included. So basically, whenever the prices on the market exceed the cost-based calculations from NRA, the TSO must conclude that the offers he has are not compatible and is more rational to enforce the low and request aFRR at a price defined by NRA. This situation is not encouraging for investors. The act defines the discount rate of 3.1 %, which is not the most attractive for private investors. The act also does not define any VPP costs<sup>14</sup>. Since the act is connected to the day ahead prices, it does not take into account the possible excess prices due to the special market conditions. If the cost for a resource to provide reserves exceeds the penalty factor, it will not be committed for reserves. The penalties must be set high enough, so that shortage being signalled is due to running out of reserves rather than going short for economic reasons. But higher penalties additionally raise the entry risk of new aFRR providers.

On the other hand, we would like the market to play the main role and take care of the right investments, which means that also a missing money problem should be addressed.[2] A solution, called Operating Reserve Demand Curves (ORDC), used in the USA, might be considered[3]. The idea behind the ORDC is to introduce an incentive for the market when the balancing reserves are depleted, and there is a probability of the loss of load. The price of Value of the Lost Load (VOLL) and the Loss of Load Probability (LOLP) mapped on the volume of the available reserves need to be estimated. By applying ORDC imbalance price rise higher, so the BRPs are motivated to be balanced. Therefore Intraday market energy prices rise, and balancing energy prices rise, so BSPs are incentivised to be available at the moments of system stress. This approach could solve the missing money problem and give an additional incentive for DR&DG investments.

#### 2.4.9 Settlement

From the ENTSO-E survey we can see that especially in this area, the EU market is very heterogeneous. Therefore, it is no surprise that the settlement rule in the balancing energy market is another serious point of discussion. Project Explore has favoured local marginal pricing for TSO-TSO settlement.<sup>15</sup> But PICASSO proposal is to use XBMP<sup>16</sup> of the group of uncongested areas, which is in line with the direction selected at the FF target model. Additionally, to this, the proposal of PICASSO foresees to apply different prices for balancing and system constraint activation purposes, which has not been implemented in FF.

FF target model foresees the 15-minute settlement period. In terms of balancing energy

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<sup>14</sup> More about VPP cost is described in D6.1. Impact analysis of the performed pilot tests

<sup>15</sup> Local means one imbalance settlement price per each area.

<sup>16</sup> Cross Zonal Marginal Pricing represents the price of the last bid of a standard product which has been activated to cover the energy need for balancing in uncongested group of areas

pricing and costs calculation, two potential principles for harmonised price determination within FF cooperation were analysed: pay-as-bid method and the local marginal pricing.

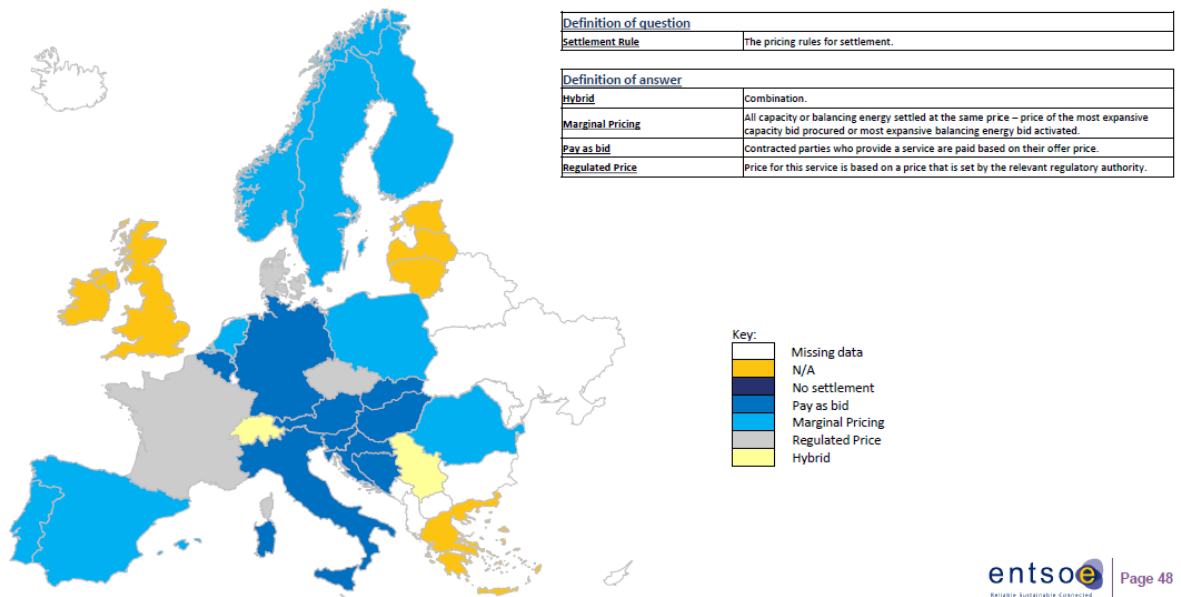


Figure 6: Settlement method<sup>17</sup>

The local marginal pricing principle, where all BSPs within a control area receive settlement price set by the most expensive activated bid within that control area was selected as a final target model for FF.

#### 2.4.10 Regulated balancing pricing or not

Even if currently few countries still have regulated prices for aFRR (like France and Poland on capacity and France and the Czech Republic on energy), the regulated prices for FRR and RR are not permitted anymore according to the EBGL (EBGL, Art. 32(2)). Though the problem, described in paragraph 2.2.6 Price transparency and price incentives shows, that in countries with a lack of aFRR resources, the situation can lead toward regulated prices.

In EBGL, the marginal cost pricing is foreseen as the final solution for the EU integrated market. Marginal cost pricing has the obvious advantage that it reflects the market situation. When capacity is tight, and the cost of balancing the system rises sharply with the extent of imbalance, a marginal price would be significantly higher. This would presumably give a BSP a greater incentive to participate on balancing market and will help market liquidity. It will motivate market participants as DR&DG and aggregators to install, maintain and offer the balancing services. ACER claim that pay as-bid pricing hinders effective price formation and affects smaller providers. Smaller BSP lack the knowledge and the tools to predict market behavior so effectively, so it could happen that they will bid closer to marginal costs and therefore become less stimulated to

<sup>17</sup> SEDC - Mapping Demand Response in Europe Today 2017

participate regularly on balancing markets, but rather place their offers only in situations when high balancing prices are expected. This leads toward a low utilization of DR&DG and hinders the development of the market competition. Poplavskaya and de Vries[4] concluded from their comparison of three neighbouring EU countries, Austria, Germany and the Netherlands as case of well-developed markets with quickly evolving organized markets for all balancing products compared to the rest of EU: “Marginal pricing may reduce information asymmetries between more and less experienced BSPs and stimulate DER investments over a longer term.” But if the market concentration is high, it can have an opposite effect. That is why not even the AGP had introduced marginal pricing yet. FF foresees the pay as you bid as an intermediate option toward the marginal pricing.

#### 2.4.11 Procurement cycle

In the delivery D1.1 and delivery D 2.2, we have already shown that the nearly procurement cycle allows DR&DG which have issues with forecasts for longer time period better participation in the ancillary market.

The timeline in

Figure 7

Figure 7: Gate Closure Time shows the interactions between:

- (a) The intraday cross-zonal gate closure time (IDCZGCT);
- (b) The balancing capacity gate closure time (BCGCT);
- (c) The balancing energy gate opening time (BEGOT);
- (d) The balancing energy gate closure time (BEGCT).

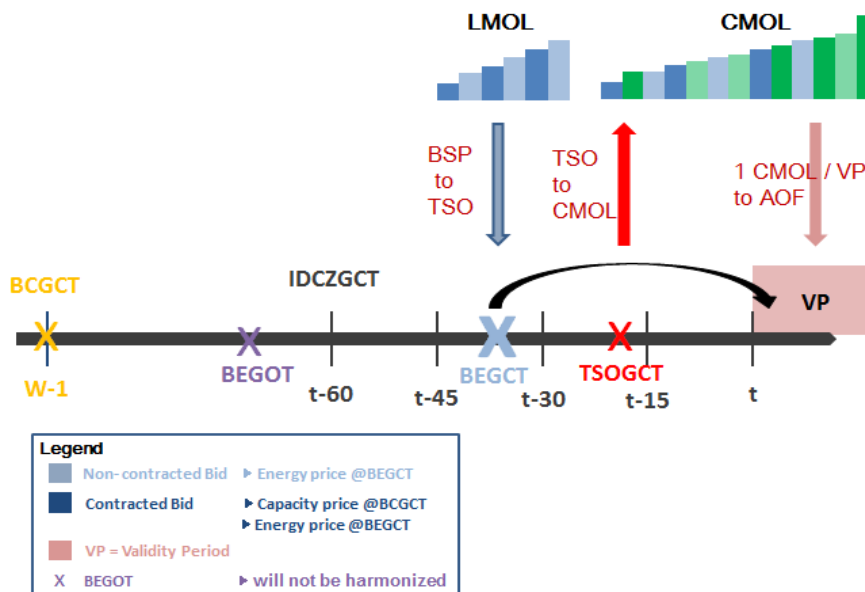


Figure 7: Gate Closure Time<sup>18</sup>

EBGL defines in Art.24 (2) “Balancing energy gate closure times shall:

- a) be as close as possible to real time;
- b) not be before the intraday cross-zonal gate closure time;
- c) ensure sufficient time for the necessary balancing processes.”

Currently, the capacity market and energy market are separated. TSOs procure capacity in different procurement cycles from yearly to daily procurement. At the time of procurement of balancing capacity, the related balancing energy price is usually unknown. The BSPs who’s bids for balancing capacity were selected are obliged to offer also energy bids after the BEGOT. The closer the BCGCT and BEGCT are, better prognostic can be used by BSPs to commit and participate in both capacity and energy market.

EBGL also foresees free bids, that should be treated equally as precontracted bids. In article 16: “Any balancing service provider shall have the right to submit to its connecting TSO the balancing energy bids from standard products or specific products or integrated scheduling process bids for which it has passed the prequalification process pursuant to Article 159 and Article 162 of Regulation (EU) 2017/1485.”

FF project was focused on energy bids and sees free bids as a good solution to decrease the prices in times of energy surplus and also bring additional resources of flexibility in scarcity situations.

#### **Differences in aFRR operation:**

For further scalability and replicability, we have identified three more differences present in the EU area, that can hinder the process of the integrated aFRR EU market.

#### **2.4.12 Central- dispatch versus self- dispatch model**

Both models are defined in EBGL under Article 2:

(17)‘self-dispatching model’ means a scheduling and dispatching model where the generation schedules and consumption schedules as well as dispatching of power generating facilities and demand facilities are determined by the scheduling agents of those facilities;

(18)‘central dispatching model’ means a scheduling and dispatching model where the generation schedules and consumption schedules as well as dispatching of power generating facilities and demand facilities, in reference to dispatchable facilities, are determined by a TSO within the integrated scheduling process.

The main distinguishing feature of central dispatch systems is that balancing, congestion management, and reserve procurement are performed simultaneously in an

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<sup>18</sup>Consultation on the design of the platform for automatic Frequency Restoration Reserve (aFRR) of PICASSO region (2017)

integrated process.

The FutureFlow project is based on the self-dispatching model, where the market is more important, while in the central dispatch model, the role of TSO has a greater role. Although the self-dispatch model is most common in the EU, few countries are using the central dispatch model. Those countries are Greece, Italy, and Poland.

#### 2.4.13 **TSO balancing proactive or reactive**

The self-dispatching model can be further divided by their activation of balancing energy to proactive and reactive. The difference between the two approaches is that with reactive balancing the TSO activates balancing energy to counteract imbalances in real-time, while with proactive balancing the TSO activates balancing energy before real-time based on forecasts of imbalances. This means that in a reactive approach, the BRPs have more time to manage their imbalances. FF goes for a reactive approach, intending to minimise the overall balancing cost by reducing the volume of balancing energy.

#### 2.4.14 **Activation Pro rata or merit order**

Even if two of the participating countries (Slovenia and Romania) are using pro-rata activation, the FF target model is merit order activation. Merit order activation allows the optimization of the offered reserves to achieve the common objective for suppliers and TSO.

In pro rata activation TSOs instruct aFRR providers in parallel and the requested aFRR is distributed pro-rata to aFRR providers connected to the LF Controller. In Merit order activation, TSO selects the cheapest bids one-by-one up to the required aFRR. From a technical perspective, the pro-rata scheme gains faster aFRR delivery. The disadvantage is that the average price is fixed as always; all bids are activated. Under merit order activation, the average price paid for aFRR energy depends on the activated volume. Therefore, merit order brings more social benefit.<sup>19</sup>

### 2.5 **Impact on day to day operation of the load participants in aFRR**

After the establishment of the services and during its running phase, customers who are the services providers, are facing with real operational costs. In other words, it is about the costs which arise in parallel with the provision of aFRR services on a daily activation and their impact on day-to-day operations of the loads participating to the services. After the end of this project, the aim of the project is, to recognize, identify the measures, which would minimize the financial and technical (negative oriented) caused impacts and consequently maximize the DR&DG wiliness for the participation.

For this analyse, we can take under the observation of three representatives, core cases of the involved customers:

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<sup>19</sup>IAEW(2016) Impact of merit order activation of automatic Frequency Restoration Reserves and harmonised Full Activation times

1. Types of the costs arising at the customer side when establishing the connection between his production process, which is controlled by the local SCADA system and the external FF system, the aggregation platform.
2. The integration of the flexibility provided by the diesel generator: the device is directly connected with the external system of the VPP via the RTU (information interface) of this project. The question is how to enable the input data for the VPP. It is mainly solved through the official distribution grid meter. If the unit is capable to run in parallel with the grid, then only an upgrade or even just a connection between the controller of the unit and the FF VPP interface has to be made. If the unit is not capable of synchronous grid operation, it has to be upgraded. The costs for the upgrade of the unit for the parallel operation with the grid are eligible and are covered by the project. These investment costs are an obstacle and are technical nature. Here is to consider the question of where to set the border of the input data collection for the aggregation platform. The result of the flexibility activation can be measured directly at the level of connected device in case of larger units or at the level of the installed official meter.
3. The integration of the RES or CHPs is again about the energy generation units with the identified flexibility. Usually, these are smaller units, lower than 1 MW, the connection between the VPP platform and the unit is via the local controller or its control system.

#### 2.5.1 **Customers in the phase before joining the project:**

The first, directly determined barrier is the working hours.

At the initial stage of the customer's engagement pilot campaign, several, initial meetings were organized, between the customers and the aggregator's agents, the promoters of this project. Involved customers did spend some working hours on one or even more of such introduction meetings. In this stage of deciding, of joining the project, all working hours spent by the side of the customers were not directly recorded or reported in any of the financial reports of this project. We can only assume that the customers had to spend many working hours on discussions and on deciding whether to join the project or not. Even more, in many cases, customers needed to consult their contractors, responsible for the maintenance of their management systems or devices. It can be concluded that besides holding the meetings, at least two meetings per customer were done, some additional efforts at the customer's backend were spent. The direct evaluation of these costs is almost impossible but can be noticed as a kind of barrier or non-refundable effort.

The work of the personal at the customer can be only identified as spending hours on the meetings, phone calls, and consultations with their internal and external experts, the technology providers. These costs can be defined as starting indirect costs.

Proposed measure: to have a complete instruction in written form. This would be king of the guidelines for the flexibility providing candidates.

### 2.5.2 **The collaboration is confirmed at both parties, by the aggregator, and by the customer**

To achieve a successful integration of the identified flexible units into the VPP platform, each interested flexibility provider has to put some of his efforts in the process of connecting to the aggregation platform. The basic fulfilled requirement to accept the collaboration on the FF project was the capability to provide the flexibility second was, to fulfil the technical requirements. Not each proposed flexibility unit was capable to fulfil the aFRR response time requirements.

If this basic question was solved, both parties could proceed to the contract negotiation phase. The time spent on bringing the contact to be signed took again some efforts at the customer's side. We can estimate that one person for at least three working days. After having the signed contract for the participation in the FF, the process of the technical integration could start.

Proposed measures: to have a list of the possible types of flexibility providing units, additionally to the type of the unit, the minimal requirement for each type has to be defined. This could be kind of a first step qualification test, prepared in the form of a table.

### 2.5.3 **To prepare the identified flexibility units for the integration**

Even by the fact, that the activation of each flexible unit was totally automatically, in some, especially the first trials, the customer's supervision, and involvement were necessary. The time spent (working hours) at the side of the participants is again harder to identify directly. We can talk about so-called working hours spend on the preparedness for the tests. It has to be mentioned that the customers could not directly charge this project for their staff engagement, because the award, which is defined by the contract, shall cover them. Even at the very beginning of the FF project, it was foreseen, that contract addressed incomes, shall cover the internal customer's staff involvement costs. Signing the contract, enables the customers to be faced with an as much similar situation like the one on the real markets, and this is the added value for them. The customers get real experiences on how it is to enter the market of flexibilities.

On the other hand, there is also the requirement to fulfil the technical integration conditions. To fulfil the technical requirements, in most cases it was the customer's obligation to define and even to organize the process of redesigning or upgrading their units for the FF VPP integration. Customers got the necessary description of the interfaces, the RTUs and it was only to ensure the adaptation to establish the information connecting to these devices. For example, it considers the unit's supervisory systems or even only the local controllers, which have to be re-programmed for the integration. This issue was usually solved by purchasing the services by the external experts, the customer's contractors. It has to be explained, that usually, the owners of the facilities are not experts for their devices and systems, so they have to outsource this kind of services. The external experts, usually these are the companies who already do the maintenance and all other more or less regular works on the automation part of the

systems, and they were called to offer their services. All these external costs were covered by FF during the project, but it could also be a burden on the customer (depend on the agreement between aggregator and customer).

The benefits for the participant: integration with the aggregation platform is done only once, active participation on the market of the services is an investment for the future, the energy efficiency aspect could also be recognized, and the incomes can be recorded as an extra profit.

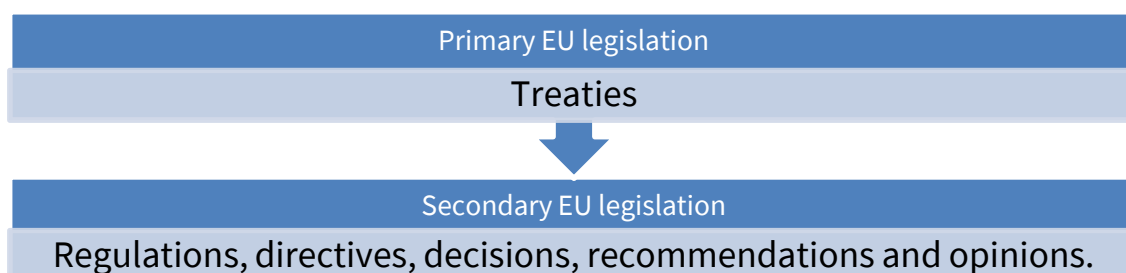
#### 2.5.4 Pilots are running

In this stage, we got no special feedback information, that longer customer's involvement or support was necessary. We can conclude that the operation phase if all previous phases were done properly, request almost no customer's engagement. The estimation of how many working hours were spent at this final stage of the demonstration by the end customers is minor and can be neglected.

## 2.6 Regulatory barriers

### 2.6.1 Overview of legislation framework in the EU countries

EU legislative framework is composed of two levels. The primary level constitutes treaties that are legally binding agreements between the EU and the member countries. Secondary legislation is based on the principles and objectives of the treaties.



*Figure 8: Legislation hierarchy, Source: EU Commission.*

The EU Member States have each their legal system and legislation. They are also bound by **EU and international law**. The precedence principle, which is enforced in the EU means that European law is superior to the national laws of the Member States. The same is also valid for the national constitution, which is also subject to the precedence principle. The member states shall not include any provision which contradicts European law into their constitution.

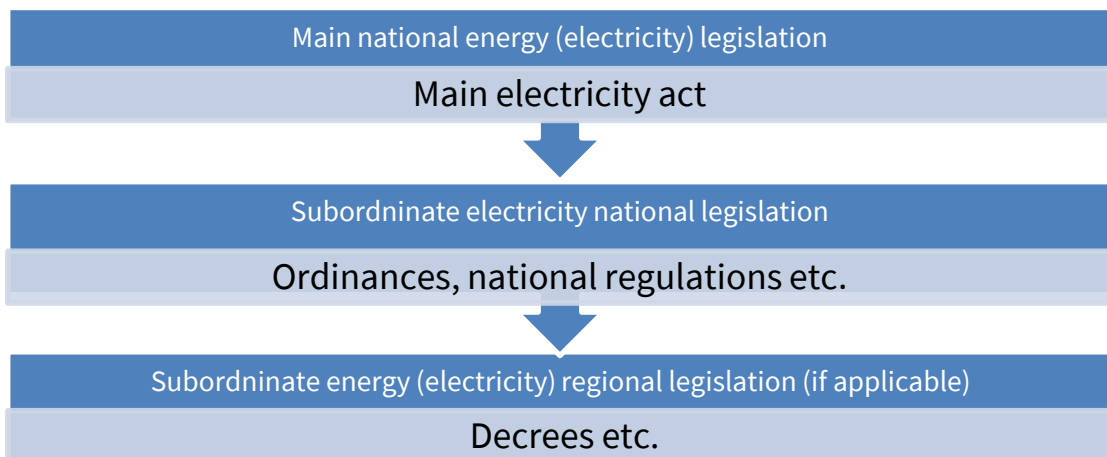
Secondary EU law is constituted from different legal acts. EU regulations and decisions enter into force directly and override the national laws. EU directives, on the other hand, are not automatically applied and must be incorporated into the national law, by the date stated in the directive. Regulations, directives, and decisions are legally binding, while recommendations and opinions are not. All subsequent national legislation which enters into force later than respectively EU legislation must also be compatible with the existing EU legislation.

In the **national legislation** hierarchy, we can distinguish between legislation passed by the parliament and subordinate legislation which could be issued by the government or by a designated authority. Legislation passed by the parliament set out general provisions and is usually updated less regularly. The national electricity legislation follows the same concept and also forms a hierarchical framework. Usually, the main electricity act regulates the whole electricity sector and has national significance. In some countries, for example, in Germany, the main act covers both electricity and gas markets.

The subordinate legislation deals with specific areas like market rules, national network codes, or network charges. It set out specific and detailed rules and prescriptions. Additionally, in some countries, subordinate regional legislation might exist. For example, in Belgium, the networks under 70kV are regulated by the separate regional legislation in Flanders, Wallonia, and Brussels-Capital. Regional legislation in Belgium also regulates renewable energy and rational use of energy<sup>20</sup>.

The main electricity act sets the principles and objectives for the subordinate law. Rather than stating specific rules, it sets out the general principles and does not require such regular updating as the secondary legislation. The act is passed by the parliament, and the process of adopting is usually long and complex.

Subordinate legislation could be issued by the government, ministry, or by a government-designated authority. In general, the law-making process of subordinate law is not that complicated and time-consuming. Therefore, the subordinate legislation might be changed faster and is more flexible. When we speak about regulatory barriers, this difference makes a significant impact. Usually, if the regulatory barrier is a part of subordinate legislation, it could be amended easier and in the shorter time frame than if would be a part of main legislation.



*Figure 9: Example of national legislation hierarchy*

<sup>20</sup> <http://www.elia.be/en/about-elia/legal-framework>

## 2.6.2 Electricity balancing in the current EU legislation

Provisions on electricity balancing can be found in the numerous EU secondary laws. The table in Annex1: Electricity balancing in the current EU legislation provides the list of the most relevant legislation and the provisions with regards to **balancing, especially the ones related to aFRR, cross-border balancing energy exchange, and participation of DG&DR.**

## 2.6.3 Recent developments of the EU electricity balancing legislation - background

The legislative framework in the EU countries is in the process of continuous development due to the EU's internal market integration, increased share of renewable energy, market development, and technological innovations. In the past years, the EU regulations accelerated the unbundling process of the vertically integrated systems, helped to increase market efficiency, fostered EU markets integration and evolution of the energy systems from the centralized distribution to the distributed generation. The main focus of these regulatory developments was mainly on the day ahead and intra-day markets where the large volumes of electricity are traded.

Developments of the regulations in the balancing markets (which include aFRR markets) have evolved more recently. As stated by ACER,<sup>21</sup> “Integrated electricity balancing market is the final building block in the creation of the European electricity market.” However, it is not just a market policy objective which has influenced the regulatory developments. The physical circumstances of balancing have changed significantly in the past few years. The share of energy from wind and solar energy sources have soared. This generation is hard to predict, and its output cannot be easily regulated due to the legally binding dispatch priority. All these are increasing system balancing requirements<sup>22</sup>. To answer these challenges set of rules Network Codes were established in the period from 2015 to 2017. The Network Codes include the guideline on electricity balancing.

### The electricity balancing guideline

The Electricity Balancing Guideline (EBGL), Commission Regulation (EU) 2017/2195 entered into force on in December 2017. Regulation (EU) 2017/2195 sets European wide market, technical, and operational rules for balancing, including aFRR. The Guideline objectives are to foster open, competitive, transparent balancing market, to integrate balancing markets and to remove barriers that prevent the participation of the new entrants.

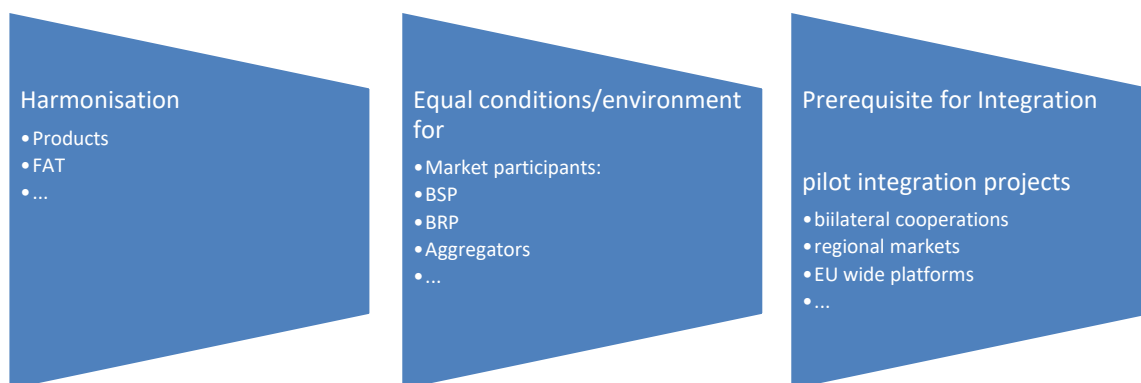
To be able to integrate EU balancing markets and not cause the market distortions, EBGL, and associated documents foresee the harmonisation of the national rules. Balancing rules in the national legislation shall be harmonised to a certain level to enable level playing field. The figure below shows the process of creating equal conditions for

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<sup>21</sup> [https://www.acer.europa.eu/en/Electricity/FG\\_and\\_network\\_codes/Pages/Balancing.aspx](https://www.acer.europa.eu/en/Electricity/FG_and_network_codes/Pages/Balancing.aspx)

<sup>22</sup> [https://www.entsoe.eu/fileadmin/user\\_upload/library/position\\_papers/111104\\_RESBalancing\\_final.pdf](https://www.entsoe.eu/fileadmin/user_upload/library/position_papers/111104_RESBalancing_final.pdf)

market participants and enable market integration through harmonisation.



*Figure 10: From Harmonisation to integration*

While the integration of the EU balancing market is the major focus of EBGL, it also fosters the participation of the new entrants in the balancing market, which is one of the main goals of the FutureFlow project. EBGL particularly addresses this topic in Articles 18 and 25:

In Article 25 (“Requirements for standard products”), it stipulates that the standard products for balancing energy and balancing capacity shall: “facilitate the participation of demand facility owners, third parties and owners of power generating facilities from renewable energy sources as well as owners of energy storage units as balancing service providers”.

In Article 18 (“Terms and conditions related to balancing”) stipulates that the terms and conditions for balancing service providers shall:

“(c) allow demand facility owners, third parties and owners of power generating facilities from conventional and renewable energy sources as well as owners of energy storage units to become balancing service providers.”

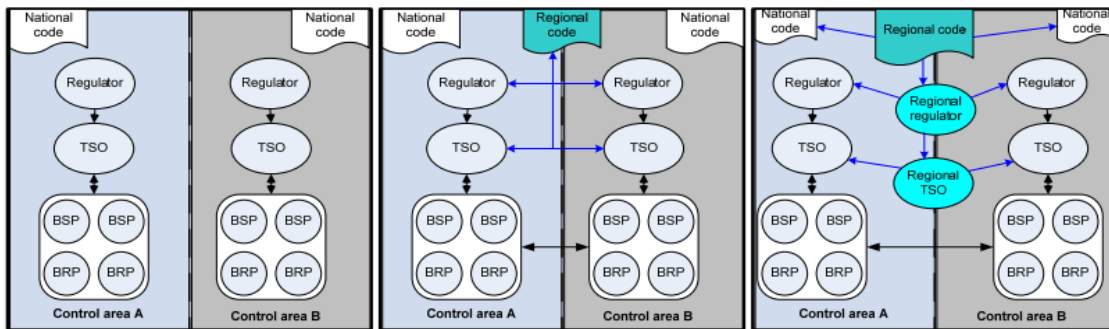
### **Co-existence of EU and national legislation**

It is important to understand that EBGL refers to the cross-border trade. The Regulation (EU) 714/2009 which sets the basis for the establishment of the network codes including EBGL, in the article 8, paragraph 7 states that: “the network codes shall be developed for cross-border network issues and market integration issues and shall be without prejudice to the Member States’ right to establish national network codes which do not affect cross-border trade”.

The co-existence of EU and national legislation has been explored in the CIGRÉ paper “Harmonization and integration of national balancing markets in Europe – Regulatory challenges”<sup>23</sup>. A relationship between regulatory authorities and the codes might develop as depicted in the figure below. In co-existence of national and regional (EU)

<sup>23</sup> [https://www.sintef.no/globalassets/project/balance-management/paper/harmonization\\_and\\_integration\\_of\\_bms\\_-\\_regulatory\\_challenges\\_van-der-veen\\_2010.pdf](https://www.sintef.no/globalassets/project/balance-management/paper/harmonization_and_integration_of_bms_-_regulatory_challenges_van-der-veen_2010.pdf)

Regulatory authorities and codes are important that roles and responsibilities are clearly defined. With the enhancement of the integration process, this becomes increasingly important.



*Figure 11: Regulatory regimes for an increasing degree of balancing market integration<sup>24</sup>*

## PICASSO

In parallel with the FF project, there were also other projects involving the integrated EU balancing market. As in November 2017 one of them – the Picasso initiative has been selected to be the reference project for the establishment of an aFRR platform by ENTSO-E, we have been actively involved in activities of this initiative and have actively participated in workshops and consultations done by Picasso. The project was presented from the first steps in Entso-e working groups. The audience was larger from Market to System Operation Committee, including working groups as ancillary services, system frequency group.

### 2.6.4 Electricity balancing in the national legislation

Similar to other areas, balancing is usually regulated by the hierarchical legislative framework. Main electricity/energy acts can include general provisions on balancing, for example, high-level provisions on balancing mechanism and responsibility of the market participants. It can also set out provisions for the development of the secondary legislation on balancing. Due to complexity, balancing is typically regulated by several rules which deal with technical provisions, market rules, settlement mechanism, and responsibility of market participants.

#### Recent developments of the national balancing legislation framework

According to article 18, TSOs shall develop “Terms and conditions related to balancing”. Terms and conditions define national market rules and roles for the market participants. Some requirements are very important in the context of FF project: terms and conditions shall allow participation of demand response, aggregation, and the requirement for the balancing bids to be assigned to the balancing responsible parties, which ensures balancing responsibility. The document is subject to the approval by the national

<sup>24</sup> [https://www.sintef.no/globalassets/project/balance-management/paper/harmonization\\_and\\_integration\\_of\\_bms\\_-\\_regulatory\\_challenges\\_van-der-veen\\_2010.pdf](https://www.sintef.no/globalassets/project/balance-management/paper/harmonization_and_integration_of_bms_-_regulatory_challenges_van-der-veen_2010.pdf)

regulatory authorities.

Terms and conditions shall comply with the frameworks for the establishment of European platforms for the exchange of balancing energy. With this rule in place, it is ensured that national legislation does not prevail over the EU legislation.

Different countries took different approaches to develop terms and conditions. Some (e.g., UK, Netherlands) updated the existing national regulations, while the others (e.g. Slovenia) developed entirely new terms and conditions.

In the following chapter, the national legislation in the EU countries is described and analysed. We have tried to include the status of the “Terms and conditions related to balancing”. For some countries, the information on the current status is available and is included, some documents might still be in the approval processing phase.

With the inclusion of the demand response and the aggregators, Terms and conditions related to balancing shall ensure the competition and equal treatment of all balancing services providers. It is very important that these requirements are established on the national level, which ensures a level playing field across the EU balancing markets.

### **Balancing in the national legislation of EU countries**

Below is an overview of the balancing legislation framework in four countries participating in the FutureFlow project and few EU countries with the most developed and progressive electricity and balancing market.

#### **France**

Law No. 2010-1488 of 7 December 2010 establishing a new organisation of the electricity market.

In France, the balancing market is regulated by two sets of rules. First “MA-RE” deals with balancing mechanism and balancing responsibility. The second set of rules is the “The Frequency System Services Rules,” which deals with system frequency regulation services.

Both rules are developed in accordance with the provisions of the Energy Code (Code de l'énergie - the main national energy legislation, originally adopted in 2011), proposed by the TSO RTE and approved by the national regulator CRE. The whole legislative process is contained in the rules themselves and is composed of three main steps:

- Consultation by the RTE with stakeholders relevant to balancing;
- Public consultation;
- CRE review and decision.

Following the EBGL enforcement and development of the TERRE project, the MARE has been amended, and its current version was adopted in August 2018. The new version includes provisions for compliancy with EBGL and the provisions which enable participation in the TERRE project. The latest revision “The Frequency System Services

Rules” is from October 2018.

In 2017 CRE delivered a deliberation on guidelines for the French electricity system. The document was developed to open discussion on the French balancing model and required adaptations due to the changes in the European legislation, European integration, and requirements for additional flexibility caused by the increasing share of renewable generation.

Enforced in 2015 the Energy transition law Act No 2015-992 sets the targets to cut the emissions reduces the energy consumption, increase a share of renewables and reduce the share of fossil fuels in energy production and cap the power from the nuclear power plants. The Act promotes demand response and its participation in the markets and sets out new provisions regarding demand response<sup>25</sup>.

In France, demand response and independent aggregation are allowed in all balancing markets. However, in the aFRR market demand response can participate only in the secondary market. In practical terms, this means that participation in the aFRR market is allowed in the first place only to generators, which can then subcontract their aFRR obligation to the demand response service providers. All generators with more than 120 MW are obliged to participate in the aFRR market.

France is also among a few EU countries with the clearly defined roles and relationships of independent aggregator, supplier, and BRP. The aggregators and consumers can participate in the balancing market without contractual obligation with the supplier. The aggregator and the consumer enter the agreement for the delivery of the demand response services. Based on this contract, the aggregator can offer consumers flexibility in the balancing market, without any special agreement with the supplier. The role of the aggregator is, therefore unbundled from the supplier. However, in order to compensate the absence of agreement between aggregator and supplier legislation defines a standardised process of compensation. The so-called “contribution” is a financial transfer from the aggregator to the supplier. “Contribution” aims to compensate the transfer of energy curtailed by the consumer from the supplier to the aggregator. The price is set administratively, and the process involves TSO as an intermediary. The opinion of the CRE is that this mechanism supports the optimal operation of the system. In the absence of payment, CRE claims, the aggregator would activate the demand response in times when this is not efficient for the electricity system as a whole. The justification of the “contribution” mechanism has been confirmed on many authority levels - the constitutional council, the competition authority, and the state council.

### **Key facts**

- The major set of rules governing balancing market MA-RE and “The Frequency System Services Rules”.

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<sup>25</sup> <https://www.cre.fr/en/content/download/16118/202704>

- These rules are updated on a regular basis through the consultation process.
- NRA and TSO play a very active role in the process of adopting regulations.
- Checks and balances: both balancing rules are proposed by the TSO (RTE). NRA(CRE) needs to approve both documents.
- Promotion of demand response through Energy transition law.
- Demand response is legally allowed in the aFRR market; however, participation is limited only to the secondary market.
- Clearly defined roles and relationships of independent aggregator, supplier, and BRP.
- The aggregators and consumers can participate in the balancing market without contractual obligation with the supplier.
- Main barriers seem to be pro-rata activation with remuneration based on the regulated prices which in theory attracts less new entrants than merit order activation and paid-as-cleared remuneration, and the other important barrier is that only secondary market is available for demand response.

#### **Correlation with FF project and recommendations**

In France, roles, and relationships between independent aggregators, suppliers and BRPs are clearly defined. The conclusion of FF is the same. Roles and relations between all actors shall be defined.

Demand response is legally allowed in the aFRR market; however, participation is limited only to the secondary market – in this area the FF project is ahead as it aims to establish aFRR market where demand response is fully allowed and promoted.

The aggregators and consumers can participate in the balancing market without contractual obligation with the supplier.

#### **Belgium**

The main federal electricity market legislation in Belgium is an Electricity Act of 1999, amended in 2012 (Loi relative à l'organisation du marché de l'électricité - Law on the organization of the electricity market).

The amendment from 2012 provides the high-level provision with regards to flexibility in article 71:

“(10) Flexibility services are provided in the most cost-effective manner and provide users with appropriate incentives to balance their injection and consumption. The rates associated with these services are equitable, non-discriminatory, and based on objective criteria.”

Original law from 1999 defines demand flexibility as "means the ability of an end customer to voluntarily change upward or downward its net off-take in response to an

external signal.” It also defines Flexibility Service Provider or FSP as an entity that uses for his activity flexibility of one or more end customers.

Additional provisions on flexibility and demand response are set out in article 8:

“Ancillary services include demand-driven services, including the activation of demand flexibility.”

“For the activation of the means of production and flexibility of demand necessary to ensure the balance of the control area, the network operator favours the use of a transparent market platform.”

Other important provisions are set out in the article 19bis, where the end customer is given the right to offer his flexibility to the supplier or flexibility service operator.

The article 19bis also provides the legal basis to develop "Energy Transfer Rules," a document that provides the framework for demand side and storage participation in the energy markets. The Energy Transfer Rules regulates mainly the following principles:

- Determination of the activated flexibility volume,
- Imbalance correction of Access Responsible Party (ARP) caused by demand response (ARP could be supplier, generator, or trader which signs the contract with TSO regarding balancing and other obligations. ARP is responsible for maintaining the quarter-hourly balance between total injections and total consumption),
- The exchange of information and implementation of Transfer of Energy.

Energy Transfer Rules stipulate that the FSP is responsible for the balance of the demand response, which he activates and for the compensation to the supplier and to the balance responsible party of the end customer.

The final customer has a right to choose his own FSP, without any barriers from the supplier or the BSP. The final customer also owns his own measurement information.

As requested in the Electricity Act, the Energy Transfer Rules were proposed by the Belgium TSO Elia and approved by Belgium NRA CREG. They entered into force in December 2018.

In Belgium, the DR&DG can participate in FCR and mFRR markets. Aggregation is also allowed. However, the aFRR market is open only for the generators with a power larger than 25MW.

In 2016 Belgium TSO Elia commenced a pilot project to confirm the capability of “non-CIPU” units to participate in the aFRR market (CIPU - Coordination of the Injection of the Production Units. CIPU units are in principle large central production units. CIPU contracts, signed between generators and Elia ensure sufficient generating capacities). The project was focused mainly on technical issues. However, some key market design questions like merit order activation and change from a weekly to a daily tender for the aFRR capacity were also investigated. The results of the pilot project have shown that participation of non-CIPU units would have a positive impact on the development of the

aFRR market.

The experiences from this project were used as an input for the study on the future market design of aFRR, which was presented at the public consultation organized in September 2018. The aim was to discuss the new design of the aFRR market and implementation of Transfer of Energy.

The study proposed changes which shall enable access to aFRR market for all technologies from high and medium voltage levels (low voltage users connected on DSO network are excluded), and implementation of a merit order activation. The provider of the aFRR services can be either BRP or BSP. The study suggests a change from weekly to daily procurement for the capacity and energy gate closure time close to real-time for the energy bids.

Following this, Elia launched a new public consultation on the implementation plan for the new aFRR design in November/December 2018. The implementation plan foresees the start of the new aFRR design in July 2020.

### **Key facts**

- The electricity act with its amendments is the main national legislation. It includes provisions to develop additional, secondary legislation.
- Development of the aFRR market follows a graduate, step by step approach, including pilot projects and public consultations.
- National TSO and NRA play an active role in the process of amending regulations and consequently open the aFRR market.
- High-level provisions with regards to flexibility – DR participation and some definitions are included in main electricity law from 1999.
- A special set of rules “Energy transfer rules” provides the framework for demand side and storage participation in the energy markets.
- While FCR and mFRR are opened to all technologies aFRR is not.
- New aFRR design is planned, with important changes: opening aFRR market for all technologies, all voltage levels, daily auctions, and merit order activation. Plan to commence with the new aFRR market design is in July 2020.

### **Correlation with FF project and recommendations**

The new aFRR design is likely to implement the following changes:

- Allowing all technologies and DR to participate in the aFRR market
- introduce the daily capacity auctions
- The gate closure time for reserved aFRR energy bids is D-1 at 15h00 and Balancing energy gate closure time for all bids 25 minutes before delivery

- Merit order activation of the energy bids. Currently, energy bids are activated based on the pro-rata principle. The remuneration method is paid-as-bid

The proposed changes are in line with the FF findings.

Currently, the aFRR service is provided by the large units (so-called CIPU units). They have a communication device (RTU – Remote Terminal Unit) installed by Elia at their premises. RTU is connected to Elia control system. This allows Elia and CIPU to communicate in real time in both ways.

New rules include the proposal to allow the use of so-called “private”<sup>26</sup> measurement devices and gateways that enable connection to the real-time communication platform. The compliance will be assessed in the prequalification process. The use of private devices and gateways is possible for CIPU and non-CIPU units. Elia’s objective to allow the use of private measurement devices and gateways is to minimize the entry barriers for the new market participants.

FF project recommendation is to assess the use of private devices and gateways (with specified minimum requirements) for communication with the TSO. The objective of this recommendation is to reduce entry barriers to the aFRR market.

### **Germany**

In Germany, the main provisions concerning aFRR are set out in the Energy Industry Act (EnWG) and the Electricity Network Access Ordinance (StromNZV) both of 7th July 2005.

EnWG and StromNZV contain high-level provisions with regards to the aFRR market. StromNZV stipulates that:

- TSO shall procure the balancing energy in the common tendering process;
- The tendering process shall be organized via the Internet Platform;
- Products traded in the balancing market are asymmetrical;
- The bids are selected based on the merit-order list. Remuneration method is pay-as-bid;
- TSOs have to publish anonymous tender results on their web pages and make them available to the regulatory authority;
- Based on these provisions, all German TSOs use the common tendering process starting from December 2007. The tendering process operates on the internet platform [www.regelleistung.net](http://www.regelleistung.net). The platform is used to announce the tenders, provides tender’s details and results, and informs market participants about acceptance of bids. The interested BSP can also use the prequalification portal to

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<sup>26</sup> Term “private” means that market participants will be allowed to use their own devices which will have to comply with the minimum requirements such as measurement accuracy, communication requirements, which are prescribed by Elia.

apply for the prequalification procedure.

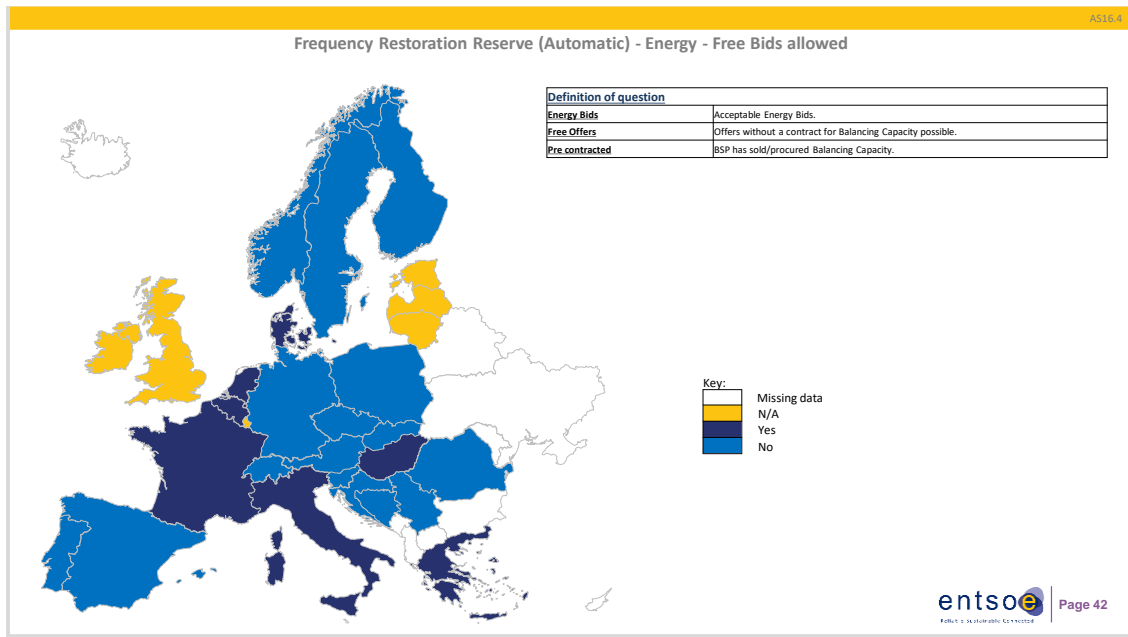
The two decisions from the German NRA Bundesnetzagentur (BNetzA) make further provisions with regards to the aFRR market:

- Decision BK6-15-158,
- And decision BK6-18-019.

Until recently, the aFRR market bids were selected based on the merit order of capacity prices. Providers of aFRR services submitted the power, price for capacity, and price for energy at the same time. The energy prices of bids were relevant only when the capacity prices were the same.

BK6-18-019 brought changes to the process of tendering. The aim of the decision was to foster competition and to reduce the costs of balancing energy. The price of balancing electricity has recently increased on many occasions. To limit price peaks, BK6-18-019 introduced changes in the bid selection mechanism. Instead of a bid selection based on the price for balancing capacity only, the decision introduced the component of balancing energy price, multiplied with a weighting factor. This component is then added to the capacity price, and the sum is used for bids evaluation.

Even with the improved methodology for bid selection, the German aFRR energy market is still available just for the BSPs which participate in the capacity bidding process. There are no free bids on the energy aFRR market. This could limit the competition in aFRR market and increase the price level of the selected bids. According to ENTSO-E 2019 ancillary services survey, only a couple of EU countries allow the free bids in the aFRR energy markets.



*Figure 12: free bids allowed in the energy aFRR market in EU (source: ENTSO-E<sup>27</sup>)*

Further provisions related to aFRR market are set in a document BK6-15-158. This document is regulating tendering conditions and publication requirements for aFRR. The BK6-15-158 is the successor of the BK6-10-098 of 12.04.2011, amended to adapt to the new environment of the electricity production in Germany. The share of RES in German Gross electricity generation is around 35 % and is expected to rise. The natural characteristic of RES is its volatility. The aim of BK6-15-158 is to adapt tendering conditions to include the participation of RES and demand response in the aFRR market. The two important changes brought by BK6-15-158 were to switch previously weekly tender period to daily auctions and to reduce product times to four hours. These two changes have a positive impact on the participation of DR and DG in the aFRR market.

The similar changes in the tendering rules have already been done in the past. The list of the past rules and changes are depicted in the Annex2: Changes of the tendering rules in Germany.

These changes: decrease of the minimum quantity, shorter auction timing, and shorter product duration, gradually established regulatory framework, which in principle enables open and competitive aFRR market.

As per decision BK6-15-158 current rules for aFRR tendering are as follows:

- The gate closure time is 8:00, D-1;
- The tender participants are informed on results by 9:00, D-1;
- If the demand has not been met the second tender is called in the afternoon D-1;
- A bid consists of three components: capacity [MW], capacity price [€/MW], energy

<sup>27</sup> <https://www.entsoe.eu/publications/market-reports/#survey-on-ancillary-services-procurement-and-electricity-balancing-market-design>

price [€/MWh];

- Bid selection is combined from the capacity and energy prices; details are described above;
- Activation is based on merit-order of energy bids.

The German balancing market has been characterized by an interesting evolution in the last couple of years. From 2008 to 2016 the capacity of wind and solar power generation has increased by 300 %. The balancing power reserves, however, decreased by 20 %. In theory, the larger share of RES contributes to the system imbalance. The explanation for the declining rate of imbalance could be an effect of the adapted market design and the grid control cooperation.

The aggregation is regulated by the recently adopted BnetzA decision BK6-17-046. The decision set out the relationships between the end customers who offer their flexibility on the market and their supplier. The customers have a right to offer their flexibility in the aFRR and mFRR market through an aggregator. However, they have to notify their supplier about offering flexibility at least six weeks in advance. The supplier cannot reject the request unless there is a specific provision in the supply contract between the supplier and the end customer. When providing flexibility, the end customer can provide services through the BRP of the aggregator.

With regards to compensation mechanism, the decision stipulates that suppliers cannot charge end customers for the higher risk (end customers participating in balancing activity through the aggregator might present a higher risk for the supplier/BRP since their participation cannot be predicted). However, they can charge end customers for the changes of schedule. This might present the market barrier for the aggregators as the costs imposed on customers eventually become also a cost for an aggregator<sup>28</sup>.

Since July 2016 Germany and Austria cooperate in exchanging of aFRR balancing energy. The cooperation is the first of this type in continental Europe and follows the provisions of EBGL. The exchange of aFRR is based on the common merit order for balancing energy. This cooperation is described in more details in Annex3: aFRR cross - border cooperation.

The German aFRR legislation has been significantly refined in the last couple of years. Some rules have been enforced very recently, and it is still too early to predict their influence on the market. The room for improvement in the delivery of aFRR services by DR and DG clearly exists. According to Smarten<sup>29</sup> demand response in Germany currently provides only a very small part of balancing energy.

### **Key facts**

- NRA BnetzA plays a very active role. With four TSOs, Germany is in this respect different from the majority of EU countries. Hence the first step to introduce more

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<sup>28</sup> <https://repository.tudelft.nl/islandora/object/uuid%3A1753f5b9-c1a1-4a80-a927-4f10b96216b0>

<sup>29</sup> <https://www.smart.eu/thesmartenmap/>

competition was to implement the common tendering process.

- The rules for the aFRR auctions are developed by BnetzA. These rules are frequently refined.
- The process of adoption includes public consultation with market participants.
- The increasing share of RES has been a strong push for the legislative changes.
- The rules for the aFRR market have been amended several times over the past decade to become more and more open to DR&DG.
- The customers have a right to offer their flexibility on the aFRR and mFRR market. However, they have to notify their supplier about offering flexibility in advance.
- Recently there has been increased development of a regulative framework on DR&DG participation. It is too early to predict their influence on the market.
- aFRR is now procured on daily tenders common for capacity and energy; product duration is 4 hours with minimum capacity bids of 5MW.
- Germany and Austria cooperate in exchanging aFRR balancing energy. The cooperation is the first of this type in continental Europe and follows the provisions of EBGL.
- Free bids are not allowed in the aFRR energy market.

#### **Correlation with FF project and recommendations**

aFRR market design in Germany in the most characteristics comply with the FF requirements set out in the deliverable 1.1. The participation of demand response and aggregator is allowed. Different technologies seem to be treated in a non-discriminatory manner. The product characteristics – minimum bid size and product duration is in line with the FF recommendations. It seems that the fees for changing the schedule of the supplier might present a barrier.

Free bids are not possible in the aFRR market, which could limit competition and have a negative impact on the prices. Contracted bids are the energy bids that are based on the previously contracted capacity. Free bids, on the other hand, are the energy bids that could not be previously contracted and are the result of unknown remaining flexibility of the BSP. As already stressed in this document, FF also recommends equals treatment of contracted and free energy bids. Energy bids might increase competition and decrease the price; therefore, they shall be enabled in the aFRR market.

#### **Austria**

Federal Law Regulating the Organization in the Electricity Industry (Electricity Act 2010 - ELWOG 2010) is the main legislation of the electricity sector in Austria. Paragraph 69 regulates the procurement of aFRR.

Procurement of aFRR shall be organized on the competitively organized tenders, carried

out by APG. The procurement conditions shall be approved by the NRA. The law also set out obligations for APG to establish the prequalification procedure. The procedure shall be transparent, and it should aim to include in the tender the largest possible number of the participants.

While the EIWOG in the definition of the primary reserve (Frequency containment reserve - FCR) specifically allows demand response, it does not mention demand response in the definition of aFRR.

The market rules set out requirements for the electricity market participants. They are developed by the Austria NRA E-Control and consulted with the market participants in the public consultation process. The legal basis and E-Control's responsibility for the development of the market rules are set in paragraph 22 of EIWOG.

Market rules include:

- General terms and conditions (GTC);
- Electricity market code (EMC);
- Technical and organizational rules for system operators and users (TOR).

The Electricity market code describes processes, relationships between market participants, and information exchange. The document is regularly updated to be in line with EIWOG and ENTSO-E requirements. It includes the definition of the aggregator and the description of the aggregator's participation in the balancing services.

Technical and organizational rules for grid operators (TOR) are a common set of national rules and standards for distribution and transmission systems. TOR is developed in cooperation between DSOs, TSOs, and E-Control. TOR is comprised of more parts; some general and others regulating specific areas. They are updated separately, so current TOR consists of the documents which have been updated in the period from 2004 to 2017. TOR set out technical rules for aFRR in part B which deals with the networks with nominal voltage equal or higher 110kV. Provisions on aFRR are high level technical and operational requirements such as responsibility for balancing of the system, responsibility of the BSPs, fundamental requirements for sizing of the aFRR reserve and prequalification.

More detailed provisions concerning procurement of aFRR are set out in the following documents, developed by Austrian TSO APG:

- Procedure for aFRR suppliers in Austria "Modalitäten für Regelreserveanbieter in Österreich";
- Pre-qualifications for the provision of aFRR in the APG control zone ("Präqualifikationsunterlagen für die Bereitstellung von Sekundärregelreserve in der Regelzone APG");
- Framework contract for aFRR provision ("Rahmenvertrag de Sekundärregelung").

"Modalitäten für Regelreserveanbieter in Österreich" sets out the framework conditions

for the aFRR market and have already been updated to be in line with EBGL. Approved by the NRA E-Control, they are published on the TSO webpage.

Pre-qualifications deals with requirements for an aFRR provider. It set out technical, business, IT, and organizational rules which aFRR has to fulfil. The prequalification is valid for three years. The rules were updated in 2014 to allow participation of the aggregation and demand response. The rules define the structure of the BSP aggregator's portfolio – so-called “Reservepools,” comprised of the technical units – a single non-separable generation or consumption unit which is used for the balancing services. More technical units from a single point of delivery comprise Reserve Unit. Reserve units are joined in the Reserve groups. All reserve groups from one BSP aggregator form so called Reservepools. An Aggregator can define only one Reservepool even if he participates in many different balancing markets. With regards to the relationship with the other market participants, the aggregator needs to get consent from the supplier if they don't belong to the same BRP. This leads to a situation where the easiest way for the aggregators is to create their own BRP or if the role of the aggregator takes over the existing supplier<sup>30</sup>.

The tendering details are published on the TSO's webpage and regularly updated (“Ausschreibungsdetails Sekundärregelung”<sup>31</sup> - Tendering details for aFRR). From 12.07.2018, the products duration is four hours (six four hours blocks per day). The tenders are organized daily. The minimum bid is 5 MW. Bids are selected based on the merit order principle and paid-as-bid. As already described above, demand response is allowed to participate in the aFRR market. Free bids are not allowed.

The daily tender schedule is listed below:

- The gate closure time is 8:00, D-1;
- The tender participants are informed on results by 9:00, D-1.

Another step forward has been achieved with the adaptation of the rules for network charges. Energy used for downward balancing (negative control energy) is separated from the energy used for regular consumption. The network charges (network tariffs) for downward balancing energy are set lower than the charges for normal consumption. The network charges for the peak demand are also set lower for the part increased by the balancing. This rule was established by the E-Control Regulation Commission Ordinance Setting the Electricity System Charges (Electricity System Charges Ordinance). The aim of this ordinance is to improve the liquidity of the balancing market and increase the security of supply. This measure also complies with the provision of the Energy Efficiency Directive (EU) 2018/2002 amending Directive 2012/27/EU; annexe XI, which states that Network regulation and tariffs shall not prevent demand response and energy storage service.

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<sup>30</sup> <https://repository.tudelft.nl/islandora/object/uuid%3A1753f5b9-c1a1-4a80-a927-4f10b96216b0>

<sup>31</sup> <https://www.apg.at/de/markt/netzregelung/sekundaerregelung/ausschreibungen>

Users from all network levels can participate in the balancing market and are entitled to the special network tariff described above. The inclusion of low voltage users has been possible due to the implementation of the smart metering and 15 minutes metering, which also corresponds to the imbalance settlement period.

### **Key facts**

- Robust legislation framework built from the primary legislation Electricity Act, market rules which set out requirements for the electricity market participants developed by the NRA and detailed rules developed by the TSO.
- Although some provisions are not specifically defined in the primary legislation (e.g., demand response authorized in the aFRR market) they are set out in the secondary legislation.
- The secondary national legislation is frequently changing. It is adapting to the developments of the markets and the EU legislation.
- Market rules include Electricity market code and Technical and organizational rules for grid operators (TOR) - two key secondary legislation acts. They are developed by the Austrian NRA and consulted with market participants.
- The Electricity market code includes a definition of the aggregator and its potential role in the balancing services.
- Most of the detailed, operational rules are developed by the TSO and approved by the NRA.
- NRA established reduced network charges for balancing services.
- progressive and dynamic development of the aFRR rules recently aiming to open market for all participants.
- Aggregation is allowed in the aFRR market already since 2014.
- aFRR market characteristics are similar to the one in Germany, which allow them cross border cooperation.
- The network charges (network tariffs) for downward balancing energy are set lower than the charges for normal consumption.
- users connected to low voltage with smart meters can participate in the balancing market.

### **Correlation with FF project and recommendations**

The Austrian aFRR market is in many ways similar to the German market. Most of the observations from the German aFRR market are valid also for the Austrian Market.

The aFRR market design has been progressively improved in recent years and is now open for the new entrants and allows aggregation. In terms of DR and DG participation, it is the most advanced market among all FF participating countries.

Austria is also one of the leading countries in the aFRR cross – border cooperation. The Austrian – German cooperation is the leading example in the EU and is further explained in Annex3: aFRR cross - border cooperation.

## **Hungary**

In Hungary, the Electricity Law A. No. LXXXVI of 2007 with later amendments constitute the primary legislation document in the electricity sector. The Electricity Law sets out the high-level provisions concerning balancing and the balancing mechanism. The law defines demand side response and the role of demand response in different processes, e.g. the network planning. The TSO shall coordinate the demand side measures as defined in the secondary legislation and regulations. The coordination of demand-side regulatory measures is defined in the electricity supply rules.

The Hungarian TSO MAVIR is responsible for developing balancing rules, and the national NRA HEO is responsible for their approval.

Market rules are governed by four codes - MAVIR's Code of Commerce (also known as "Commercial rules"), MAVIR's Code of Business (also known as "Business Rules"), MAVIR's Code of Operation and MAVIR's International Network Code

MAVIR's Codes of Commerce defines the aFFR market, as a market organized by TSO, where TSO buys the reserves for the purpose of balancing.

All of the Codes are mainly developed by MAVIR and approved by the NRA. Market participants could take part in processes of Codes creature. These Codes set out the general rules for aFRR, contain aFRR product definitions, the aFRR market rules, the aFRR bids and offers and settlement process.

MAVIR's Code of Business set out the draft contract between MAVIR and aFRR providers.

Other important rules in terms of aFRR are operational rules from Code of Operation. They set out technical and operational rules regarding aFRR. The rules include a provision on Virtual Power Plants (VPP). VPP shall have the regulation power of at least 1 MW, and they can consist of the generators with different technologies, consumers, and electricity storage facilities. They have an obligation to report to the TSO. The VPP, as the other aFRR providers have to pass the prequalification procedure. The accuracy of measurement shall be 0.5 % and is obligatory for all individual resources not just for the VPP as a whole.

The majority of the participants of the Virtual Power Pant are the combined heat and power (CHP) plants. These units have been built in the early 2000s, following the introduction of the feed-in tariff system support scheme for renewable and CHP electricity generation. In June 2011, the feed-in tariff system ended, and the CHP plants

found their opportunity to sell energy through VPP. The VPPs in Hungary have a typical size of around 50 MW and are able to provide almost the volume of their installed capacity of flexibility in each direction. In 2017 eight virtual power plants operated in the country.

The benefits of VPP operations have been reported in the 2017 “Data of the Hungarian electricity system”, a common report of HEA and MAVIR: “It has again been demonstrated that the operation of virtual power plants aggregating small power plants and involvement of large industrial consumers in the control of the electricity system is necessary and useful for MAVIR.

The Electricity Law A. No. LXXXVI of 2007 stipulates that the licensed production units shall offer their capacity for the system services.

Any market participant can bid on the balancing capacity auctions, having a pre-qualification is a prerequisite when the service has to be available. Balancing capacity auctions can be organized on a quarterlyweekly and even on daily basis separately for downward and upward regulation considering every product, except for FCR. The qualified BSPs bid on the day-ahead (D-1) balancing energy market, with a minimum bid of 1 MW, product length of 1 hour. The providers who have been awarded in the capacity auction have to submit the energy bids. Free balancing energy bids (not having procured balancing capacity bid) are also allowed. Bids are activated based on the merit order principle and settled pay-as bid.

### **Key facts**

- Hungary Electricity Law provides high-level provisions regarding balancing. Regulations developed by the TSO and approved by the NRA set out specific technical and commercial rules.
- Demand response is defined in the main Energy law, and the TSO is obliged to coordinate the demand side measures as defined in the secondary legislation and regulations.
- VPP is defined in national regulations. VPP's can include generators with different technologies, consumers and electricity storage facilities.
- VPP is currently aggregating primarily the distributed resources, mostly CHP plants. Although VPP can include demand side and energy storage systems.
- The VPP's impact on the aFRR market is positive. Their participation is increasing competition and decreasing prices.
- aFRR auctions characteristics, long FAT, minimum bid product length and the minimum bid seem to be very favourable for the participation of demand response.

### **Correlation with FF project and recommendations**

The legislative framework is favourable for DR&DG participation.

FAT is 15 minutes, which was an option with special bids in FF deliverable 1.1: “The more time consumers have to prepare for an event, the higher the participation level and the lower the cost. Through the FF project, we focused more on the FAT of 5 minutes, which is therefore recommended”.

The minimum bid quantity is 1MW, which, again is the quantity recommended in FF deliverable 1.1.

VPP is currently aggregating primarily the distributed generating resources; this includes mostly CHP plants and also other distributed generation resources: wind farms, and biomass heating plants. The VPPs seem to be successful in the integration of distributed generation; however, the participation of demand response in the VPP is limited.

### **Romania**

“The Law of electricity and natural gas” from 2012 is the main electricity and gas act in Romania and constitute the primary legislation document in the electricity sector. The participation of demand response as a dispatchable consumer, in the ancillary services market is authorized. The law defines ancillary services as “services provided by dispatchable producers or final customers, at the request of the transmission system operator.” High-level provisions with regards to ancillary services are set out in the different parts of the law, listed below are the most relevant provisions:

- TSO might purchase ancillary services in the competitive energy market (aFRR, mFRR, RR) according procedures elaborated by TSO and approved by ANRE – Romanian NRA. But there is also a provision which allows NRA to approve the prices and the quantities of ancillary services on the regulated market, to ensure the safety of the national power system.
- the obligation of the producers is to bid ancillary services without discrimination.
- the rights of the producers are to trade electricity and ancillary services in the regulated and competitive markets, in a transparent and non-discriminatory manner.
- the producers can bid ancillary services on the European ancillary services markets following NRA regulations. This shall not endanger the safety of the power system and shall be approved by the TSO.
- TSO can buy ancillary services from/to the TSOs in the regional markets.
- TSO qualifies producers and customers according to prequalification procedures elaborated by TSO and approved by ANRE – Romanian NRA.
- The aFRR ancillary services market is based 100 % on market rules and the marginal price, the price for each interval balancing market interval, being marginal price.

“The Law of electricity and natural gas” also defines demand side management. Apart from definition, demand side management is mentioned only in part dealing with procedures for new energy generation units.

Another important legislation concerning demand response is the Energy efficiency law 121/2014. The law set out provisions with regards to the tariffs, which shall not restrain the development of demand response and aggregation.

The secondary energy legislation related to the reserves market, which we could identify has entered into force in 2004. Two sets of codes regulate transmission network in the technical and market/commercial terms: The Commercial Code of the Wholesale Electricity Market and Technical transmission grid code.

These regulations have been updated, especially connections rules – during 2018 and 2019, except requirements regarding ancillary services.

Since 2017 the Romanian regulator ANRE issued several orders to implement Commission Regulation (EU) 2016/631, establishing a network code on requirements for grid connection of generators. The orders are listed below, and they contain the provisions related to the aggregator:

- Order no. 72 of 2.08.2017 and its modification order no. 214/2018 - technical requirements for synchronous generating groups for connection to the public electricity networks;
- Order no. 208/2018 - technical requirements for generating modules, centralized generating, and central generating modules formed by offshore generating modules (located Offshore) for connection to the public electricity networks
- Order no. 228/2018 - technical requirements for prosumers for connection to the public electricity networks
- Order no. 214/2018 – update for technical requirements for synchronous generating groups for connection to the public electricity networks.

Additionally, there are rules which, depends on the approval process might get approved in 2019:

- Two new regulations that contain direct references to DR are published this year;
  - one implementing EU regulation 2016/1388 -Order no. 67/2019 - technical requirements for distribution systems and consumers for connection to the public electricity networks,
  - other establishing the procedure of notification and conformity for consumers Order no. 176/2019 – Notification and conformity for distribution systems and consumers for connection to the public electricity networks.
- A new procedure of access to the ancillary services, with provisions on aggregation, was submitted to NRA.

- In preparation is a new procedure of aggregation, which was submitted from the TSO to the NRA, and could be approved by November 2019.

The Commercial Code of the Wholesale Electricity Market distinguishes between the ancillary service market, where the reserving capacities are traded and the balancing market where the balancing electricity is traded. The Romanian Regulator ANRE issued several orders since 2004 in order to change or supplement The Commercial Code of the Wholesale Electricity Market, the most recent being Order no. 31 of 31.01.2018.

The balancing market is mandatory. This means that dispatchable units and loads shall offer their non-contracted volumes on the balancing market. Dispatchable units are generating facilities that can be scheduled on the wholesale market and have some minimum capacity depending on their type (hydro, thermal), while the dispatchable loads are defined as consumers which can reduce their load according to the contract with the TSO.

The centralized Ancillary Services Market ensures sufficient quantities of reserves, traded in a transparent and non-discriminatory way. For aFRR, the bids need to be symmetrical (band), maximum 10 pairs quantity – price and the minimum bid size is 10MW. The reserves can be contracted maximum a year in advance, but usually the auctions are organized monthly, weekly and daily. The reserve contract obliges service providers to offer the contracted energy on the balancing market.

The mFRR and RI reserves are contracted only in upward direction, the quantities being purchased by Transelectrica via organized auctions, excepted 57 % from RI which is purchased until June 30, 2020 through regulated contracted by NRA.

A small part of the aFRR reserves is contracted through regulated contracts. In 2017 share of the regulated contracts in terms of volume was around 3 %. The regulated contract is signed between TSO and the balancing service providers, based on the prices set by the NRA.

Bids on the balancing market must be submitted at the latest on the day before delivery. Participation in the market is also allowed for consumers. The participants offer their bids for every separate hourly interval. The aggregation is allowed per type of primary source and for all type of renewables; however, there is legislation in the preparatory phase, which will bring some changes in this field. The bids need to be symmetrical. The minimum bid size is 10MW(band), but Balancing Market is mandatory, and uncontracted energy bids can be activated in this market. The type of activation is pro-rata (free bids are not allowed).

In the annual report for 2018, Romanian NRA ANRE highlights the issues with the competitiveness of the balancing market. The report states that the concentration index indicates excessive concentration in the balancing market and the existence of dominant participants in aFRR and mFRR markets.

The legislation framework, especially primary law, set out provisions that form solid

bases for the development of demand response. However, demand response does not have a significant role in the reserve market in Romania. This could be improved by the development of the secondary legislation, which is foreseen in the near future.

### **Key facts**

- Demand response is covered in the main national legislation, including:
  - definition of demand side response,
  - definition of ancillary services as services provided by dispatchable generators or final customers.
- The main law also includes provisions with regards to the cross-border trading of ancillary services. The producers can bid ancillary services on the European ancillary services markets, but they have to follow NRA regulations. The TSO can buy and sell ancillary services from/to the TSOs in the regional markets.
- The balancing market is obligatory market for the dispatchable production units.
- A small part, approximately 3 % of the aFRR reserves is contracted through regulated contracts, the rest being contracted on the competitive ancillary services market.
- The type of aFRR activation is pro rata. Free bids are not allowed.
- The aggregation is allowed per type of source/technology/renewable.
- The aFRR market is concentrated, the values of the HHI index in 2017 exceeded value of 4500.

### **Correlation with FF project and recommendations**

The FF recognizes that low minimum bid size decreases the entry barrier for the new market players. The FF recommendation for the minimum bid size is 1MW. Currently, in Romania, the minimum bid size for aFRR on Ancillary Services Market is 10 MW.

As in the majority of the EU countries, large generators still prevail in offering aFRR services the symmetrical bids are common. The FF recommends the introduction of the asymmetrical products bids which suit better the DR and DG balancing services providers. The ENTSO-E 2019 survey in ancillary service shows that in EU majority of the countries allow asymmetrical bids and some are planning to allow asymmetrical bids in the near future. Interestingly Belgium, which is on its way to introduce asymmetrical bids, is considering not just implementation of the asymmetrical bids, but also the ways to incentivize asymmetrical bids<sup>32</sup>.

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<sup>32</sup> [http://www.elia.be/~media/files/Elia/publications-2/Public-Consultation/2018/20180903\\_aFRR-product-design\\_EN.pdf](http://www.elia.be/~media/files/Elia/publications-2/Public-Consultation/2018/20180903_aFRR-product-design_EN.pdf)

Establishing a regulatory framework for aggregation, decreasing minimum bid size, allowing free bids and asymmetrical bids, could open market for the new participants, and increase competition.

The new legislative package which is on its way might help to achieve this.

## **Netherlands**

The Netherlands regulatory authority ACM sets out the codes which regulate the Dutch electricity market. The codes can be broadly divided into three major groups:

- Tariff codes, which contain rates and rules for the network charges;
- Technical codes, regulates technical processes, such as network connection, capacity management, measurement of electricity and transport of electricity;
- Information codes, which regulate information exchange between electricity market participants.

Dutch TSO, TenneT, publishes the basic information on aFRR, in the document "Summary note." The document is primarily intended to the prospect suppliers of aFRR. The document also lists all aFRR relevant legislation and associated documents:

- System code "Systeemcode elektriciteit",
- Implementation Guide,
- The Imbalance Pricing System,
- Manual for bidding of FRR (formerly named RRP).

The new legislation currently in the preparatory phase aims to improve the integration of the markets and includes the network codes into the national legislation. In May 2018 the Netherlands trade association of electricity and gas network operators submitted a proposal of changes to Dutch NRA Authority for Consumers & Markets (ACM). The changes were also proposed by the Dutch Energy Data Exchange Association (NEDU). The proposed changes have been published by the ACM. They include merging of the two national codes "Systeemcode elektriciteit" and the "Netcode elektriciteit" and integration of European network codes.

The aFRR providers might have a contract with the TSO and are committed to bid at least contracted volume of energy. Non-Contracted suppliers might also compete in the aFRR market. The contracted suppliers have no preference over non-contracted; the bids are selected based on the merit order and remunerated based on the marginal pricing. The settlement period in the aFRR market is 15 minutes. The minimum bid size in the aFRR energy market is 1 MW. Bids are activated depending on the rate of the imbalance. If the imbalance rate is significant, the pro-rata activation is implemented, and if the imbalance rate is lower, the merit order activation is implemented. The use of the pro-rata method for larger imbalances is based on the nature of the pro-rata activation method.

The requested minimum ramp rate of the aFRR bid is 7 % of the nominated bid/minute, which is required for full activation of the bid and elimination of unbalance within 15 minutes.

The demand response is authorized in the Netherlands aFRR market. Aggregation is also allowed. The aggregators have to make an agreement with the end customer's BRP in order to settle imbalances caused by the end customer's flexibility services.

The imbalance, which is traded in the aFRR market in the Netherlands is low comparing to the other European countries. The reason for this is understood to be in so-called "passive balancing." Passive balancing is based on the incentives to the BRP to balance their own position and balancing data which are publicly available with a very short time delay from the real time<sup>33</sup>.

The critical precondition for passive balancing is publishing real-time information on system balancing. In the Netherlands, the minute-to-minute activated balancing energy and the bid price of the last activated bid in both directions are published on the TenneT website in real-time, whereas in Germany no real-time information on the system balance state is spread to the market.

This has very important implications: In the Netherlands it is possible to internally balance the BRP portfolio based on the real-time information, speculating on the regulating state and the resulting imbalance prices, whereas in Germany BRPs have no idea of the sign of the BE volume, which has such an important impact on imbalance prices and actual BRP costs."

Netherlands is one of the first countries which explore the usage of EV batteries to participate in balancing. At the beginning of 2019, Netherlands TSO TenneT together with aggregator and VPP operator launched the pilot project which explores the use of electric vehicles batteries to provide aFRR balancing services. The project will run two years and will demonstrate the ability of the electric vehicles to provide aFRR services. The minimum quantity for the aggregated bids is the same as for the other bids 1MW, and there is no upper limit.

### **Key facts**

- Small aFRR market volume due to the passive balancing which takes place before aFRR market.
- aFRR balancing capacity is procured on monthly and weekly tenders.
- Minimum 1 MW size and aFRR open for demand response and aggregators.
- Aggregators are not independent; they need to have an agreement with the BRP.
- Activation depending on the level of the imbalance rate; merit order in case of

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<sup>33</sup>[https://www.tennet.org/bedrijfsvoering/Systeemgegevens\\_uitvoering/Systeembalans\\_informatie/BalansDeltaplusPrijzen.aspx](https://www.tennet.org/bedrijfsvoering/Systeemgegevens_uitvoering/Systeembalans_informatie/BalansDeltaplusPrijzen.aspx)

smaller deviations and or pro-rata in case of significant deviations.

- In the aFRR balancing energy market voluntary bids are allowed.
- The new legislation is in preparation. It shall incorporate network codes requirements.
- The pilot project with an aggregated electric vehicle as aFRR service providers.

#### **Correlation with FF project and recommendations**

In main principles, the Dutch aFRR market is open to demand response, new market participants, and aggregators. Minimum bid size is low, and free bids are allowed. The activation principle of energy bids is specific and tries to merge the best of both commonly used methods. Merit order is used for most cases, while for the larger imbalances pro-rata method is used which enables fast ramping.

Another specific in the aFRR market is passive balancing. The transparency and availability of close to real-time data seem to have a very positive impact on participants of the balancing market. Information is particularly valuable to the BRPs, helping them to evaluate the market and make decisions.

A similar service is now established also on the EU level. ENTSO-E collects and publishes market information for member countries on its transparency platform. aFRR market information is available for a specific time interval (mostly 15 minutes but can be different depending on country/market). We don't have enough information if the data published on the transparency platform might be useful for the same purpose as in the Netherlands. Nevertheless, the transparent publication of close to real data on ENTSO-E or specific platform is our recommendation for the FF project.

#### **Slovenia**

High-level provisions on ancillary services and balancing are set in the Energy Act 2014, the primary electricity and gas legislation in Slovenia. The Electricity act in the article 144 obliges Slovenian TSO ELES to develop "System Operating Instructions," which shall contain definitions and provisions on ancillary services.

"System Operating Instructions" contain technical and operational requirements for the aFRR market participants. TSO details metering and communication requirements for the BSP. Further detailed requirements are defined in the aFRR auction documents prepared by the TSO. The auctions are held once a year, for the whole period for the following year. Bids include offers for capacity and energy. The auctioning procedure consists of two parts:

- technical prequalification of the BSPs
- negotiation with the each of the BSP who passed the prequalification procedure

Upward and downward regulations are separate products. The required FAT is 5

minutes, and minimum bid size is 5MW. Aggregation is allowed. The contract contains prices for upward and downward balancing for capacity and energy. Since the bids are awarded based on the bilateral negotiations, it is not exactly clear how the bids are selected.

The awarded BSP has to provide TSO the information on the availability of the regulating units one day before delivery. The energy is activated pro-rata and remunerated pay as bid.

These rules are amending in 2019, with the new rules and implementation of the new platform for the balancing market. From May to June 2018, Slovenian ELES held the public consultation on the draft of the Rules and conditions for the balancing service providers. The draft has been developed based on the requirements from Article 18 of EBGL. In the first phase, the rules will provide a framework for developing the national balancing platform, which will be in the later stages integrated with the EU platform. The NRA has approved the draft at the beginning of February 2019.

The main points of the new Rules are outlined below:

- Definition of Aggregator;
- Detailed prequalification procedures;
- Equal treatment of generators, DR and DG and energy storage;
- Minimum bid size - 1 MWh;
- The minimum capacity of BSP – 1 MW;
- Daily product for the aFRR capacity, with 4 hours blocks;
- The requirement for the accuracy of the energy measurement devices depends on the connection capacity of the BSP. For example, for BSP providers with less than 43kW only class 2 (IEC) / class A (MID) accuracy is required;
- FAT is equal to 5 minutes, so it stayed unchanged from the previous rules;
- Voluntary energy bids are allowed;
- The rules for aFRR platform distinguish between two gate closure times: the GCT for the obligatory energy bids is 15:00 D-1, and the GCT for the voluntary energy bids H-1 D;
- Capacity bids are remunerated according to the pay-as-bid principle;
- The energy bids are selected based on the merit order and remunerated based on the pay-as-bid principle;
- The BSP might provide a balancing service using the flexibility of the end customer, which belongs to different BRP than BSP. In this case, BSP has to inform the BRP about participation and provide activation data.

The pay-as-bid remuneration method is used for both energy and capacity payments. In

the EBGL and associated documents, marginal pricing remuneration method is preferred. According to the explanatory document<sup>34</sup> “marginal pricing makes the participation of new entrants easier and reduces the operating costs”.

Based on the published timeframe for the implementation of the new rules and new balancing market platform, the platform shall be in full operation, including the merit order algorithm by the end of 2020.

New balancing rules are in terms of regulations related to SONPO (System operational rules for the transmission system). SONPO will need to be amended to incorporate changes due to the new balancing rules. This will have to be implemented before new balancing rules become fully operational. But SONPO has to be approved by the NRA and the government. The time frame for government approval can be long and might influence the time schedule.

Important provisions related to the balancing market are set in the NRA's tariff act<sup>35</sup>. Balancing can be provided by DR and DG and energy storage devices. Smaller balancing service providers can be aggregated. The role of the aggregator is defined in the broader terms without specifics concerning relationships between aggregator and other market participants.

The electricity market in Slovenia is small and with a limited number of balancing service providers. The Energy Act includes specific provisions if the TSO cannot acquire sufficient reserves or if there is a deficit of competitive offer on the market. In this scenario, the NRA can oblige certain generators or loads to provide necessary reserves (without modifications of existing contracts). The act on establishing a methodology for determining the prices of ancillary services<sup>36</sup>, includes the methodology to determine regulated prices for aFRR, mFRR, black start, and voltage regulation.

NRA introduced the special conditions for the providers of the downward balancing regulation. It concerns the peak demand tariff. If the peak demand of the end user has resulted from the participation in the balancing market, then the demand caused for the balancing is subtracted from the overall peak demand.

A similar provision is in place for the storage facilities which participate in the balancing market.

Balancing is possible also through the special balancing market, which is an energy only market and operates from 15:00 D-1 until delivery. The balancing market is a single buyer market, where the TSO buy and sell different products to balance the system. The balancing market is operated by the Slovenian power market operator Borzen.

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<sup>34</sup> [https://consultations.entsoe.eu/markets/ebgl-art30-pp/supporting\\_documents/180912\\_Explanatory%20document%20all%20TSOs%20Balancing%20Energy%20Pricing%20Proposal.pdf](https://consultations.entsoe.eu/markets/ebgl-art30-pp/supporting_documents/180912_Explanatory%20document%20all%20TSOs%20Balancing%20Energy%20Pricing%20Proposal.pdf)

<sup>35</sup> [http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT\\_1050](http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT_1050)

<sup>36</sup> [http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT\\_1029](http://www.pisrs.si/Pis.web/pregledPredpisa?id=AKT_1029)

**Key facts**

- aFRR market is based on yearly auctions. They consist of the prequalification procedure and bilateral negotiations between TSO and the BSP.
- Demand response, energy storage, and aggregation are allowed on the aFRR market.
- Minimum bid size is 5 MW, products can be asymmetrical, FAT is 5 minutes.
- aFRR market has a low competition level. There is a procedure in place to establish a mandatory market with regulated prices if TSO cannot procure enough reserves or cannot procure reserves under competitive conditions.
- The important legislative change is on the way. New balancing act implementing EBGL and establishing new balancing platform.
- Slovenian NRA introduced the special method of setting the peak demand tariff for the providers of the downward balancing regulation.

**Correlation with FF project and recommendations**

The Slovenian balancing market is ahead of the substantial changes, so we will mainly focus on the new market model. The new rules follow provisions of article 18 of EBGL. Detailed prequalification process and requirements are part of the new rules. This improves the transparency of the market and helps potential participants to enter the market. The low minimum bid, allowing free bids and opening the market for aggregation is all in favour of DR and DG participation.

The NRA has included some important provisions to open the balancing market in the tariff act. The special conditions for downward aFRR were included in the tariff act in 2018. The Slovenian aFRR market has long time issues with competitiveness and market liquidity. We hope that FF experiences will help to improve this.

**General recommendations**

National balancing markets in Europe are governed by multiple national regulations. In general, high-level provisions on balancing and ancillary services are set out in the primary legislation and detailed rules in the secondary legislation. Further, even more detailed rules can be found in operational documents like tendering rules.

The secondary legislation is important. We have seen that the primary legislation might include all necessary provisions to enable open aFRR market, like the definition of demand response and aggregators and authorisation for DR&DG to participate in balancing markets. However, if these provisions are not supported by the robust secondary legislation, then the results are usually not delivered.

The vice-versa situation, however, can exist. We have seen in some of the cases that primary legislation doesn't contain definitions and provisions concerning DR&DG participation, aggregation, and cross-border exchange. The important thing, however, is that the primary legislation does not specifically prohibit any of these features. In this case, secondary legislation can provide a legal framework that enables the participation of DR&DG and cross-border exchange.

The ideal legislative framework would include provisions to enable open aFRR market in the overall hierarchical legislation system. Definitions of aggregator, independent aggregator, etc. and high-level provisions such as participation of DR&DG in the balancing market in primary legislation would create robust fundamentals. The secondary legislation would then include further detailed provisions.

Non existing legislation can hamper market development. Legislation which does not exist might, in some cases, hamper market development in the same way as the explicit legal prohibition of some function or activity. A good example is a regulatory framework for independent aggregation. If the independent aggregation is allowed, but additional rules are not in place, then each case of independent aggregation becomes a special, unique case, where the required agreements between parties take a long time and require vast energy. This can hamper the market development.

The prequalification process has to be transparent and non-discriminatory for all technologies. The prequalification process can present a significant barrier for entering the market. It can happen that although legislation supports the participation of the new market players, they cannot pass the prequalification process. That's why it is important that qualification conditions are known and well documented and that the prequalification process is simple, timely and effective. This issue has also been addressed by the EBGL requested that the terms and conditions for balancing service providers shall contain the rules for the qualification process to become a BSP. Another provision is set out in the Guideline on electricity transmission system operation (Regulation (EU) 2017/1485) in article 159, which obliges TSO to develop FRR prequalification process. These provisions will help to achieve transparency and create a level playing field in terms of the member states.

Improve the availability of information and transparency of the market design. The aFRR market includes complexity in terms of rules, processes, and relationships between market participants. The smartEn Map 2018<sup>37</sup> states that "Transparency is a key element for a new energy company to consider providing services in a country." We have seen that simple measures can be taken to improve the situation. Some of the TSOs provide a short overview of the national balancing market, regularly updated and published on their web pages. This can have a profound benefit for the new market player. It can assist them in understanding the market principles and processes and can decide accordingly.

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<sup>37</sup> <https://www.smart-en.eu/th-smarten-map/>

Transparency of the market data is required. The positive impact is evident in the Netherlands, where data transparency significantly contributes to passive balancing. While the ENTSO-E transparency is a big step forward and shall provide up to date information, it looks like there is still some inconsistency concerning data publication<sup>38</sup>.

The legislation is adopting in different time frames. The majority of primary laws on electricity or energy were adopted some time ago (more than five years). The primary laws are adopted and later amended through the more or less complex legislation process. Secondary legislation can be developed at a much faster rate. The development of secondary balancing legislation will in most cases include draft proposal developed by NRA or TSO, public consultation, the decision-making process and final adaptation of the legislation. We have seen in many cases that this process can be very predictable in terms of timeframe, short and efficient. On the other hand, changing primary legislation requires more time and political agreement. This might restrain the development of the regulatory framework which should fit a fast-changing environment.

Pro-active stakeholders are the key players in the process of adoption of aFRR balancing rules from development, approval, and implementation. The pro-active actions can be done, for example, to assess the market and market needs through public consultations, to issue decisions that reflect the current market needs, to constantly amend the regulation to make markets more open and transparent.

The pro-activity can be demonstrated also in the other areas of the aFRR market development, not directly linked to the regulatory framework, e.g., pilot projects and cross-border initiatives.

Implementation of the EU Directives. The first major requirements with regards to DR participation in the energy market have been introduced already with the Directive 2012/27 on Energy Efficiency. The directive stated that:

- “MS shall remove incentives in transmission and distribution tariffs that might hamper the participation of demand response in balancing markets and ancillary services.”
- “TSOs and DSOs shall treat demand response providers un-discriminatory.”
- “Member States shall promote access to and participation of demand response in balancing, reserve, and other system services markets.”

Seven years from the introduction of these provisions, the regulatory framework in some countries still does not reflect these requirements.

#### 2.6.5 **Ownership of specific loads (storage systems)**

On 26 March 2019, the European Parliament adopted the regulation and directive on the

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<sup>38</sup> <https://www.smartem.eu/thSMARTemap/>

common rules for the internal market in electricity. This concluded the adoption of the broad legislation package known as Clean Energy for All Europeans, which consists of legislation on Energy Performance in Buildings, Renewable Energy, Energy Efficiency, Governance of the Energy Union, Risk Preparedness and ACER.

Directive and regulation on common rules for the internal market in electricity recognise the value of energy storage (ES) in the electricity system. The services provided with energy storage should be traded in the competitive markets, where new flexibility products could provide a market value. Concerning the balancing markets, the role of energy storage is explicitly addressed in the new regulation. Participation in the balancing market shall be technologically neutral, including demand response and storage.

With regards to ownership, management or operation of storage; all these shall be restricted to the TSOs and DSOs (additional restriction just for the DSOs is that they shall not be engaged in the development of the storage). The directive sets this requirement in article 36 and 54 for DSOs and TSOs, respectively. The exception (derogation) is allowed if there is no market interest for the energy storage, and the storage is necessary for the TSO and DSO to fulfil their obligations. Derogation could be enforced only after the NRA approval. For the TSOs additional notification on the exception to ACER and the European Commission is required. Although regulating companies shall not own, manage or operate energy storage, their task is to integrate storage in the networks using non-discriminatory and transparent procedures, approved by the NRA.

The provisions in directive have several important messages:

- First, they clearly state that energy storage facilities belong to the market and shall be separated from regulated activities. This is in broad principle a similar requirement as the separation of the generation and supply in the previous directive for the internal market in electricity (Directive 2009/72/EC).
- If the TSOs and DSOs could own, develop, manage, or operate energy storage, they could prefer using their storage facilities over the ones offered by the market players who would distort a market. Another issue is the information asymmetry between the TSO and the market participants as the TSOs have more information about the network and its operation. All this creates an unlevel playing field for the market participants.
- To assess the market interest to own, develop, manage, or operate energy storage, the directive requires an open and transparent tendering procedure.
- The approval of NRA is the final check – the safety net, which ensures that energy storage facilities are needed for the obligations of the DSOs/TSOs and there is no market interest to own, develop, manage or operate them.

Tenders with energy storage participation, already exist in practice. In the UK for example, the National Grid Transmission Operator organises tenders for Enhanced

Frequency Response (EFR) – a fast frequency response service, developed recently to help with system balancing in times of low inertia. In the tender held in 2016, which offers four years contract, the interest of market participants was very strong. The majority of participants were energy storages who could meet high-level technical requirements for this service.

This example shows how the properly designed market creates a new opportunity for energy storage. But it is very unlikely that market interest will always be so strong. Various possible reasons might exist, which diminish the market interest. Below we have outlined a few possible examples:

- Local services by nature - no cross border participation is possible due to local service characteristics. This can limit or even eliminate market interest.
- Emerging services – market interest does not yet exist.
- Market design – a particular market design can present a barrier for energy storage to participate. For example, if the contract duration is too short, market participants won't have the confidence to invest in facilities and offer the services in the market.
- The size of the market – the market is too small to attract competitors.
- Limited profitability – service is not interesting for market participants due to the small profitability.
- Double fees – energy storage pays fees for injection and withdrawing energy from the grid. This issue is further explored below.

It is important to stress that with the development of DG and a higher share of RES the new services might emerge in the future to help to control increasingly complex network operation. Market interest in these new services might not exist at the beginning. This is another possible scenario where the TSO ownership of the energy storage would need to be considered.

The ownership of the energy storage by TSO or DSO leads to another important question. The assets which TSO and DSO require in order to deliver their regulated services are integrated into the regulated asset base (RAB). RAB includes all past investments in the TSO's and DSO's infrastructure and is adjusted for the depreciation. The RAB is used by the NRA to determine the return on capital and depreciation, which represents the income for the TSO and DSO, and is remunerated from the tariffs. If the energy storage becomes part of RAB, its utilization shall be closely monitored. Under-utilisation of the asset would cause economic loss; its financial burden would be transferred to the network tariff payers.

In some countries, energy storage pays the network fees in the generating and consuming operating mode (so-called double fees). To create a level playing field with the other technologies, the specific characteristics of energy storage shall be considered. The most obvious is its ability to act as a consumer and as the generator in the same

instance. The energy storage enables energy management in time and consequently plays a significant role in the operation of the modern electrical systems, especially in the ones with large RES integration. Copying the existing model of load/generation tariff structure without consideration of the energy storage specifics does not allow the market to realize its full potential. It hampers the implementation and technological development of the storage.

In some cases, the issue of paying double fees is linked to the lack of definition of energy storage. In the absence of the definition, energy storage could be considered as a combined unit of generator and load, with obligation for both to pay the network charges.

The new directive does include the definition of the energy storage: "energy storage" means, in the electricity system, deferring an amount of the electricity that was generated to the moment of use, either as final energy or converted into another energy carrier". The definition recognizes specifics of the energy storage in the energy system. The directive, however, does not address explicitly the topic of double fees.

Two case studies below show the activities of countries related to energy storage implementation and development of the legal framework. Within the pilot project, Italy has allowed the TSO to own and operate energy storage facilities which are used to improve flexibility and stability of the network. In the UK the NRA adopted a definition of storage, remove double fees for units classified as storage for regulatory purposes and forbid generation activities to the DSO (and indirect, through definition also for TSO).

### **Use case: ownership of the energy storage by the TSO**

#### **Country: Italy**

With the decree Law 93/11, the Ministry of Economic Development allowed the ownership of energy storage for the TSOs and DSOs under certain conditions. Italy has since then implemented two major pilot projects with the battery storage systems owned by Italian TSO Terna. Pilot projects were supported by the set of regulations, issued by the government and the NRA in the period from 2011 to 2013.

The so-called "Energy Intensive" project included battery storage systems with a total capacity of 34.8MW, installed in southern Italy. The aim of the project is to test if energy storage can help to improve the flexibility of the transmission system and enable better integration of the wind generation electricity. The term "Energy Intensive" is used to characterise the function of the energy storage in the system which is to reduce congestions in the grid. To achieve this, the energy storage must be able to provide a sufficient amount of the stored energy (energy intensive) to the network.

The project was included in the 2011 network development plan and approved by Italian NRA AEEG in 2012. The legal reasoning for this decision can be found in the requirements of Directive 2009/28/EC (and in the national implementation of Directive 2009/28/EC - legislative decree 3-3-2011 n. 28).

According to 2009/28/EC: “Member States shall ensure that appropriate grid and market-related operational measures are taken to minimise the curtailment of electricity produced from renewable energy sources”. Wind production in southern Italy was previously often curtailed due to the network constraints. The pilot project objective was to show how energy storage could assist in such cases.

The entire project has been supported by the legal framework, which was developed over several years. The project started to operate in the testing regime in 2015.

The second project, the so-called “Power Intensive” project, aims to increase the security of Italia power system on the islands Sicily and Sardinia. The technology, in this case, does not have to provide a large amount of stored energy, but the rather fast response and large power output in the short duration. The project was approved by the Ministry of Economic Development. It includes installation of 40 MW energy storage facilities. Currently, 16 MW of battery storage is installed, approximately 8 MW on each of the island. The next phase with 16 MW supercapacitor system is under consideration. The first stage of the project was completed in 2018.

**Key facts:**

- The pilot project allows the TSO to own and operate energy storage.
- The main driver for the first project was better integration of RES as required by Directive 2009/28/EC. The main driver for the second project was to improve the system stability in the island's networks. This could not be achieved using conventional technology.
- Two projects have different goals, and they used different technologies and adapted regulatory framework to achieve these.

**Recommendations:**

- When investing in energy storage owned and control by the TSO, the aim shall be clearly defined. The case by case approach is required, considering the objective, the functionality of the energy storage and the required technology to reach the objective.
- The cooperation between TSO, NRA, and other stakeholders is necessary. In the Italian case, these include the Ministry of Economic Development, NRA and TSO. Which parties need to be involved, depends on the objective of the project. For example, the involvement of the Ministry of Economic Development was required because the energy storage was used to increase the security of the system

**Use case: Regulatory changes considering energy storage – unbundling and the new tariff structure****Country: UK**

In 2017 UK’s NRA Ofgem released a consultation document with the aim to clarify the regulatory framework for the electricity storage and possible changes of the licences.

The consultation document proposed a definition of energy storage as a subset of generation. According to Ofgem “generation and storage share similar characteristics and perform similar functions in terms of generating and exporting electricity onto the grid.”

The definition which classifies the energy storage as the subset of generation will also be incorporated in the UK’s Electricity Act 1989 when the parliamentary time allows. According to the latest information we could find, the definition has not yet been included in the Electricity Act. Some responses from the market participants indicated that this definition does not recognize all specifics of the energy storage, like numerous services it can provide, better flexibility than a conventional generation and energy management in time.

The other topic which was also released for the consulting was the issue of the final consumption levies (network charges paid by the final consumer). The Ofgem and consultation participants recognize that the costs of the final consumption levies (FCL) present a significant barrier for energy storage activity. These fees put additional burden on the operational costs, reduce the competitiveness of the energy storage and make investments in this technology less attractive.

To avoid this, the regulator proposed the new licence condition. The “Condition E1”, is designed specifically for the storage facility which exports electricity back to the network. If the energy storage is classified as E1, it is not required to pay FCL. The energy storage which primary function is not to export electricity back to the network cannot be classified under E1. An example of such a facility would be the energy storage used with the final consumer, where the primary function of the storage facility is not to export electricity back to the network but to store it and release it in the periods of high demand to reduce its peak demand and related fees. Such energy storage facilities won’t be entitled to the E1 classification, and they will still have to pay FCL.

In 2018, Ofgem organized public consultation related to the DSO’s ownership of energy storage. The statutory consultation proposed modifications to the DSO licence that prohibit DSO from generating electricity, which includes the operation of electricity storage assets. Although this consultation applies to the DNO’s, it also provides Ofgem’s view on the TSOs owning and operating the energy storage. In appendix 2, it clarifies that: “As a form of generation, existing unbundling requirements already apply to storage. Therefore, any network operator seeking to own or operate storage must comply with existing unbundling requirements. The requirements are currently different for distribution companies and transmission companies. The unbundling regime for transmission companies (TSOs) severely restricts them from owning or operating any generation facilities.” This implies that from the moment when energy storage is defined as a form of generation, the existing unbundling legislative framework applies. The definition of energy storage as a subset of generation has, therefore, two effects:

- Ownership and operation of the energy storage by the TSO are forbidden as the unbundling rules apply.

- Legislation on unbundling is already in place, so there is no need for the new legislation or to amend the existing one.

Later in 2018, Ofgem issued a decision on changes to the electricity distribution licence. New standard licences prohibit independent distribution network operators and distribution network operators to participate in the generating activity, including energy storage.

**Key facts:**

- Ofgem defines energy storage as a subset of generation.
- With this definition, unbundling regulation applies for the TSOs, who cannot own or operate the energy storage.
- Ofgem distinguishes two primary purposes of energy storage: one where the energy is exported back to the network and the one which primary function is self-consumption and storing the energy for the time of the peak periods.
- Only the energy storage serving the first purpose is classified as storage for regulatory purposes and does not have to pay final consumption levies.

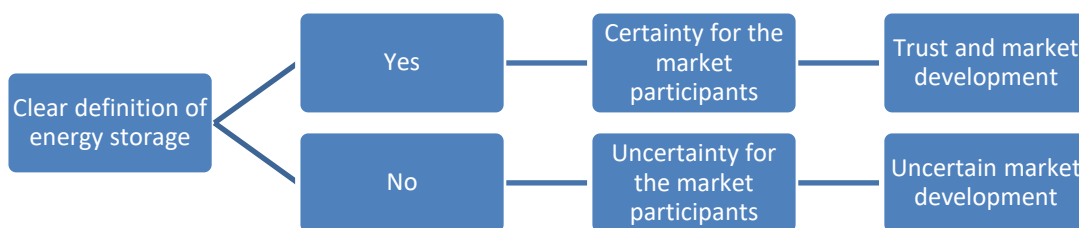
**Recommendations:**

- Ofgem has adopted a specific rule to distinguish between different types of storages. Only the storage which is beneficial for the network operations is awarded by the elimination of the double fees. The recommendation here is to consider the different types of energy storages and their role in the system.
- Ofgem's view is that TSO shall act as a neutral market facilitator. It should signal the flexibility needs of the market. Indeed, the energy storages will only be possible to offer their full benefits to the market and to the electricity system if there will be markets which allow them to participate. The TSO has a central role and knowledge to continuously assess the system requirements and provides an input to design and create new market mechanisms.

**General Recommendations:**

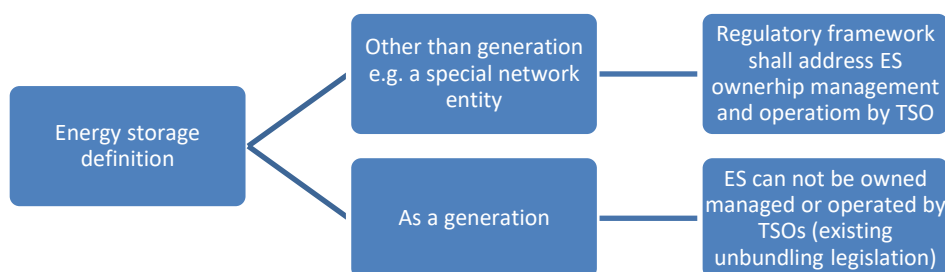
In the following section, we present high-level recommendations that could be used to consider the energy storage market design. Although the new EU legislation has addressed some of these topics, we include them to provide an overview of the whole concept.

1. Energy storage shall be defined to provide market participants with certainty and enables the development of the energy storage market.



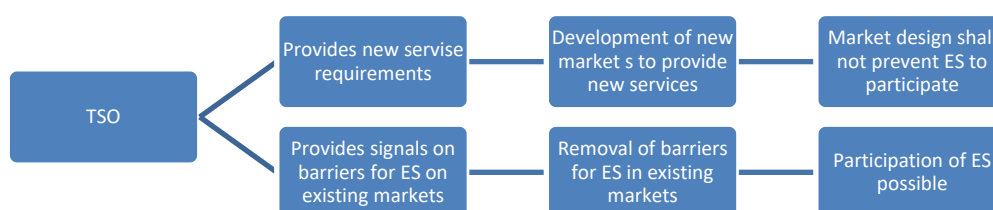
*Figure 13: Clear definition of energy storage.*

2. If energy storage is defined as a generator, the ownership, management and operation of the energy storage by TSO is regulated by the existing unbundling legislation. If energy storage is not defined as a generator, the regulatory framework shall address which parties can own, operate or manage the energy storage, to provide a clear signal to the market participants.



*Figure 14: Energy storage defined as a generator or a special network entity.*

3. To make use of the energy storage benefits, the market shall be developed, where the energy storage can participate. TSOs shall have a central role in the market development process as they have the best knowledge and competencies on the system needs.



*Figure 15: Role of the TSO in the development of energy storage.*

4. If the energy storage, following the derogation process gets owned by the TSO and becomes a part of RAB, its utilization shall be closely monitored. Under-utilisation of the asset would cause economic loss, and the financial burden would be transferred to the network tariff payers.
5. Utilisation is the key factor for the profitability and the market development of energy storage. The utilisation can be increased if there are multiple services available for energy storage. For example, the Irish and Northern Irish TSOs are

planning to procure up to 140 MW network services, with the high technical requirements which can be met mostly by the energy storage. The network service which is auctioned is actually a bundled service comprising of the fast frequency response and primary, secondary and tertiary operating reserve. This enables the participants to deliver multiple network services and achieve better utilisation. Allowing energy storage access to multiple services and markets enables better utilisation, provides investors with a certain guarantee and reduces the risk of being dependent on a single service or market.

6. In the end, in the absence of market interest, it could be beneficial to review the ENTSO's proposal, that TSO can own the energy storage and auction its capacity in the organized market. The energy storage facilities would be, in this case, integrated into RAB. Such a market would, for example, enable BRPs to bid for energy storage capacity to be able to balance their position. Such approach could have several benefits:
  - It makes use of the energy storage technology and benefits it can provide to the users and the system.
  - The role of the TSO as a neutral market facilitator is preserved. The TSO auctions its asset, but he does not interfere in the market.
  - The TSO has a knowledge and understanding of the system as a whole and can propose new services to be auctioned on the market and could benefit the market participants.

## 2. Scaling and replication laws of promising use case

Use cases have been defined within the framework of “WP4 Definition of use cases and KPIs and assessment of pilot tests”. The Deliverable D4.3 presents an “Assessment of pilot tests”.

Real time executions of Use cases started in April 2018. First, the prequalification tests were performed testing the technical performances of each individual VPP unit and its respective IT communications to FutureFlow cloud Common Activation Function CAF and to the four TSOs involved.

Physical VPP units could place as many as 94 Up or Down aFRR bids. In Table 1, all the bids are listed, of which were 56 are for Down and 38 for Up regulation. Some physical units, for example AT\_18 could place bids in both directions: for Up as well as for Down, whereas some other units, for example all the Diesel units placed bids only for Up. For obvious reasons of not disclosing the sensitive market information, the names of the bids have been anonymised.

*Table 1: Anonymised list of bids used when conducting the real-time tests.*

#	aFRR type	VPP type	TSO	Name	Size MW	#	aFRR type	VPP type	TSO	Name	Size MW
1	Down	Industry	APG	AT_284	-15.000	57	Up	Industry	ELES	SI_304	1.000
2				AT_18	-2.000	58				SI_159	4.000
3			MAVIR	HU_299	-0.200	59			APG	AT_18	1.000
4		Electrolysis	ELES	SI_282	-1.000	60		AT_284	15.000		
5				SI_163	-0.500	61		MAVIR	HU_299	0.200	
6		Cogeneration	APG	AT_30	-1.000	62		Electrolysis	ELES	SI_282	3.000
7				AT_285	-0.500	63				Cogeneration	APG
8				AT_35	-0.450	64		AT_36	0.600		
9				AT_37	-0.430	65		AT_32	0.600		
10				AT_36	-0.300	66		AT_37	0.900		
11				AT_32	-0.300	67		AT_30	1.000		
12		Biogas	ELES	SI_164	-0.500	68		AT_285	1.500		
13				SI_250	-0.500	69		SI_353	0.200		
14				SI_248	-0.417	70		SI_339	0.320		
15				SI_246	-0.417	71		SI_338	0.320		
16				SI_245	-0.312	72		SI_352	0.350		
17				MAVIR	HU_278	HU_278		-0.800	73	SI_361	0.360
18		HU_301	HU_301			-0.700		74	SI_362	0.400	
19			HU_300			-0.625		75	SI_337	0.400	
20		Hydro	ELES	SI_374	-1.350	76		SI_351	0.500		
21				SI_373	-1.350	77		SI_354	0.500		
22				SI_324	-1.150	78		SI_360	0.600		
23				SI_317	-0.999	79		SI_343	0.640		
24				SI_254	-0.730	80		SI_342	0.640		
25				SI_359	-0.590	81		SI_375	0.700		
26				SI_228	-0.500	82		SI_326	0.750		
27				SI_227	-0.500	83		SI_368	0.750		
28				SI_331	-0.480	84		SI_295	0.800		
29				SI_253	-0.380	85		SI_336	0.800		
30		SI_380	-0.170	86	SI_356	0.800					
31		Small Hydro	ELES	SI_261	-0.400	87		SI_152	0.850		
32				SI_314	-0.390	88		SI_155	1.000		
33				SI_312	-0.360	89		SI_156	1.000		

#	aFRR type	VPP type	TSO	Name	Size MW
34				SI_306	-0.290
35				SI_313	-0.290
36				SI_303	-0.280
37				SI_341	-0.200
38				SI_236	-0.183
39				SI_270	-0.150
40				SI_333	-0.150
41				SI_311	-0.130
42				SI_271	-0.120
43				SI_308	-0.110
44				SI_307	-0.100
45				SI_345	-0.090
46				SI_315	-0.090
47				SI_323	-0.060
48				SI_334	-0.050
49			TEL	RO_291	-0.200
50			ELES	SI_294	-2.300
51		Wind	TEL	RO_309	-1.000
52				RO_310	-1.000
53		Small Wind	ELES	SI_293	-0.860
54			ELES	SI_325	-0.190
55		Photovoltaics	TEL	RO_316	-1.000
56				RO_348	-0.244

#	aFRR type	VPP type	TSO	Name	Size MW
90				SI_277	1.000
91				SI_355	1.000
92		Biogas	MAVIR	HU_300	0.250
93				HU_301	0.250
94		Small Hydro	TEL	RO_292	0.100

As seen in Table 1, the Down aFRR bids were of 9 VPP generation/consumption types: Industry, Electrolysis, Cogeneration, Biogas, Hydro, Small Hydro, Wind, Small Wind and Photovoltaics, whereas the Up aFRR bids were of only 6 VPP types: Industry, Electrolysis, Cogeneration, Diesel, Biogas and Small Hydro.

The main part of prequalification tests took some half year until fall 2018, and, in some cases even until December. In fall 2018, as on the work schedule in Table 2, the real tests for UC2 and UC3 test scenarios started, ending in March 2019.

To save space, some rather similar categories (presented in Table 1) have been merged into one category: the “Indus.” column presents the Industry and Electrolysis together, the Hydro column also presents the Small Hydro category, and the Wind column presents the Small Wind category also. The Scenario names have been abbreviated, for example from UC2\_AB-01\_ID-03<sup>39</sup> has been abbreviated to “UC2 AB 03”. The Mark column abbreviations are VH for Very High, H for High, A for Average, L for Low and VL for Very Low test success.

*Table 2: Exhaustive list of all Used cases tests performed in real time*

#	Date	Hour	TSO	Test Scenario	Mark	Σ down	Σ up	Indus. down	Cogen down	Biogas down	Hydro down	Solar down	Indus. up	Diesel up	Biogas up	Hydro up
1	11-07-2018	13h	ELES	UC2 AB 01	VH	-5.656	4.000	-1.000	0.000	-2.146	-2.510	0.000	3.000	1.000	0.000	0.000
2	12-07-2018	13h	ELES	UC2 AB 02	H	-5.656	4.850	-1.000	0.000	-2.146	-2.510	0.000	3.000	1.850	0.000	0.000
3	18-07-2018	13h	ELES	UC2 AB 03	L	-5.656	4.850	-1.000	0.000	-2.146	-2.510	0.000	3.000	1.850	0.000	0.000
4	18-07-2018	13h	APG	UC2 AB 01	VH	-2.000	1.000	-2.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
5	19-07-2018	13h	ELES	UC2 RE 01	L	-5.656	4.850	-1.000	0.000	-2.146	-2.510	0.000	3.000	1.850	0.000	0.000
6	19-07-2018	13h	APG	UC2 AB 02	VL	-2.000	1.000	-2.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
7	22-08-2018	13h	APG	UC2 AB 03	L	-2.120	1.000	-2.000	-0.120	0.000	0.000	0.000	1.000	0.000	0.000	0.000
8	23-08-2018	13h	ELES	UC2 RE 02	H	-4.359	4.850	-1.000	0.000	-1.729	-1.630	0.000	3.000	1.850	0.000	0.000
9	23-08-2018	13h	APG	UC2 RE 02	VH	-2.120	1.000	-2.000	-0.120	0.000	0.000	0.000	1.000	0.000	0.000	0.000
10	29-08-2018	13h	APG	UC2 RE 01	VH	-2.150	1.000	-2.000	-0.150	0.000	0.000	0.000	1.000	0.000	0.000	0.000

<sup>39</sup> As defined in FF D4.1

#	Date	Hour	TSO	Test Scenario	Mark	Σ down	Σ up	Indus. down	Cogen down	Biogas down	Hydro down	Solar down	Indus. up	Diesel up	Biogas up	Hydro up
11	30-08-2018	13h	ELES	UC2 DC 01	VH	-4.776	5.650	-1.000	0.000	-2.146	-1.630	0.000	3.000	2.650	0.000	0.000
12	30-08-2018	13h	APG	UC2 DC 01	VH	-2.150	1.000	-2.000	-0.150	0.000	0.000	0.000	1.000	0.000	0.000	0.000
13	05-09-2018	13h	ELES	UC2 DC 02	VH	-4.776	5.650	-1.000	0.000	-2.146	-1.630	0.000	3.000	2.650	0.000	0.000
14	05-09-2018	13h	APG	UC2 DC 02	L	-2.150	1.000	-2.000	-0.150	0.000	0.000	0.000	1.000	0.000	0.000	0.000
15	06-09-2018	13h	ELES	UC2 DC 03	VH	-4.776	5.650	-1.000	0.000	-2.146	-1.630	0.000	3.000	2.650	0.000	0.000
16	17-10-2018	13h	APG	UC2 AB 02	A	-2.850	1.000	-2.000	-0.850	0.000	0.000	0.000	1.000	0.000	0.000	0.000
17	18-10-2018	13h	APG	UC2 AB 03	C	-3.030	1.000	-2.000	-1.030	0.000	0.000	0.000	1.000	0.000	0.000	0.000
18	24-10-2018	13h	ELES	UC2 AB 03	A	-5.192	5.650	-1.000	-0.500	-1.652	-2.040	0.000	2.000	3.650	0.000	0.000
19	25-10-2018	13h	ELES	UC2 RE 01	VH	-5.192	5.650	-1.000	-0.500	-1.652	-2.040	0.000	2.000	3.650	0.000	0.000
20	25-10-2018	13h	APG	UC2 AB 03	VH	-3.030	1.000	-2.000	-1.030	0.000	0.000	0.000	1.000	0.000	0.000	0.000
21	28-11-2018	13h	TEL	UC2 AB 01	C	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
22	29-11-2018	13h	TEL	UC2 AB 02	C	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
23	05-12-2018	13h	TEL	UC2 AB 01	C	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
24	06-12-2018	13h	TEL	UC2 AB 02	C	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
25	09-01-2019	10h	MAVIR	UC2 AB 01	VL	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
26	09-01-2019	10h	TEL	UC2 AB 01	L	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
27	09-01-2019	13h	MAVIR	UC2 AB 02	VL	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
28	09-01-2019	13h	TEL	UC2 AB 02	L	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
29	10-01-2019	10h	MAVIR	UC2 AB 03	VH	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
30	10-01-2019	10h	TEL	UC2 AB 03	C	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
31	10-01-2019	13h	MAVIR	UC2 RE 01	L	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
32	10-01-2019	13h	TEL	UC2 RE 01	L	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
33	16-01-2019	10h	MAVIR	UC2 RE 02	H	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
34	16-01-2019	10h	TEL	UC2 RE 02	C	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
35	16-01-2019	13h	MAVIR	UC2 DC 01	VL	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
36	16-01-2019	13h	TEL	UC2 DC 01	VL	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
37	17-01-2019	10h	MAVIR	UC2 DC 02	L	-0.500	0.170	0.000	0.000	-0.500	0.000	0.000	0.000	0.000	0.170	0.000
38	17-01-2019	10h	TEL	UC2 DC 02	VL	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
39	17-01-2019	13h	TEL	UC2 RE 02	C	-0.500	0.100	0.000	0.000	0.000	0.000	-0.500	0.000	0.000	0.000	0.100
40	23-01-2019	13h	ELES	UC3 AB 01	VL	-5.425	4.690	0.000	-0.500	-1.646	-3.279	0.000	0.000	4.690	0.000	0.000
41	23-01-2019	13h	APG	UC3 AB 01	VL	-3.030	1.000	-2.000	-1.030	0.000	0.000	0.000	1.000	0.000	0.000	0.000
42	23-01-2019	13h	MAVIR	UC3 AB 01	VL	-0.800	0.400	0.000	0.000	-0.800	0.000	0.000	0.000	0.000	0.400	0.000
43	23-01-2019	13h	TEL	UC3 AB 01	VL	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
44	06-02-2019	10h	ELES	UC3 AB 01	VH	-5.425	4.690	0.000	-0.500	-1.646	-3.279	0.000	0.000	4.690	0.000	0.000
45	06-02-2019	10h	APG	UC3 AB 01	VH	-3.030	1.000	-2.000	-1.030	0.000	0.000	0.000	1.000	0.000	0.000	0.000
46	06-02-2019	10h	MAVIR	UC3 AB 01	H	-0.800	0.400	0.000	0.000	-0.800	0.000	0.000	0.000	0.000	0.400	0.000
47	06-02-2019	10h	TEL	UC3 AB 01	VL	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
48	07-02-2019	10h	ELES	UC3 AB 02	A	-5.425	4.690	0.000	-0.500	-1.646	-3.279	0.000	0.000	4.690	0.000	0.000
49	07-02-2019	10h	APG	UC3 AB 02	H	-3.030	1.000	-2.000	-1.030	0.000	0.000	0.000	1.000	0.000	0.000	0.000
50	07-02-2019	10h	MAVIR	UC3 AB 02	H	-0.800	0.400	0.000	0.000	-0.800	0.000	0.000	0.000	0.000	0.400	0.000
51	07-02-2019	10h	TEL	UC3 AB 02	VL	-1.000	0.100	0.000	0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.100
52	13-02-2019	10h	ELES	UC3 AB 01	H	-5.360	2.966	0.000	-0.467	-2.218	-2.675	0.000	0.000	2.966	0.000	0.000
53	13-02-2019	10h	APG	UC3 AB 01	VL	-3.345	1.056	-2.221	-1.124	0.000	0.000	0.000	1.056	0.000	0.000	0.000
54	13-02-2019	10h	TEL	UC3 AB 01	VL	0.000	0.178	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.178
55	14-02-2019	10h	ELES	UC3 AB 02	VH (*)	-4.409	2.819	0.000	-0.467	-1.889	-2.053	0.000	0.000	2.819	0.000	0.000
56	14-02-2019	10h	APG	UC3 AB 02	VH (*)	-3.219	1.015	-2.256	-0.963	0.000	0.000	0.000	1.015	0.000	0.000	0.000
57	14-02-2019	10h	MAVIR	UC3 AB 02	VH (*)	-0.349	0.286	0.000	0.000	-0.349	0.000	0.000	0.000	0.000	0.286	0.000
58	14-02-2019	10h	TEL	UC3 AB 02	VH (*)	0.000	0.092	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.092
59	15-02-2019	10h	ELES	UC3 AB 03	VH (*)	-3.803	1.781	0.000	-0.466	-1.886	-1.451	0.000	0.000	1.781	0.000	0.000
60	15-02-2019	10h	APG	UC3 AB 03	VH (*)	-3.184	0.995	-2.231	-0.953	0.000	0.000	0.000	0.995	0.000	0.000	0.000
61	15-02-2019	10h	MAVIR	UC3 AB 03	VH (*)	-0.778	0.000	0.000	0.000	-0.778	0.000	0.000	0.000	0.000	0.000	0.000
62	20-02-2019	10h	ELES	UC3 RE 01	VH	-4.066	0.893	0.000	-0.467	-2.205	-1.394	0.000	0.000	0.893	0.000	0.000
63	20-02-2019	10h	APG	UC3 RE 01	VH	-0.815	0.000	0.000	-0.815	0.000	0.000	0.000	0.000	0.000	0.000	0.000
64	20-02-2019	10h	MAVIR	UC3 RE 01	VH	-0.640	0.269	0.000	0.000	-0.640	0.000	0.000	0.000	0.000	0.269	0.000
65	20-02-2019	10h	TEL	UC3 RE 01	A	-0.480	0.093	0.000	0.000	0.000	0.000	-0.480	0.000	0.000	0.000	0.093
66	21-02-2019	10h	ELES	UC3 RE 02	VH	-4.601	4.588	0.000	-0.445	-2.201	-1.955	0.000	0.000	4.588	0.000	0.000
67	21-02-2019	10h	APG	UC3 RE 02	VH	-3.052	1.029	-2.239	-0.813	0.000	0.000	0.000	1.029	0.000	0.000	0.000
68	21-02-2019	10h	MAVIR	UC3 RE 02	VH	-0.492	0.238	0.000	0.000	-0.492	0.000	0.000	0.000	0.000	0.238	0.000
69	21-02-2019	10h	TEL	UC3 RE 02	L	-1.124	0.094	0.000	0.000	0.000	-0.169	-0.955	0.000	0.000	0.000	0.094
70	22-02-2019	10h	ELES	UC3 DC 01	VH	-5.160	0.000	0.000	-0.463	-2.211	-2.486	0.000	0.000	0.000	0.000	0.000
71	22-02-2019	10h	APG	UC3 DC 01	VH	-3.008	0.000	-2.187	-0.821	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72	22-02-2019	10h	MAVIR	UC3 DC 01	L	-0.631	0.269	0.000	0.000	-0.631	0.000	0.000	0.000	0.000	0.269	0.000
73	22-02-2019	10h	TEL	UC3 DC 01	VL	-0.055	0.092	0.000	0.000	0.000	0.000	-0.055	0.000	0.000	0.000	0.092
74	27-02-2019	10h	ELES	UC3 DC 02	VH	-2.901	0.000	0.000	-0.464	-1.312	-1.125	0.000	0.000	0.000	0.000	0.000
75	27-02-2019	10h	APG	UC3 DC 02	H	-1.979	0.000	-1.979	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	27-02-2019	10h	TEL	UC3 DC 02	VL	-0.059	0.043	0.000	0.000	0.000	-0.059	0.000	0.000	0.000	0.000	0.043
77	28-02-2019	10h	APG	UC3 DC 03	H	-2.034	0.000	-2.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78	01-03-2019	10h	ELES	UC3 AT 01	VH	-4.056	3.887	0.000	0.000	-2.217	-1.839	0.000	0.000	3.887	0.000	0.000
79	01-03-2019	10h	APG	UC3 AT 01	VH	-2.015	0.918	-2.015	0.000	0.000	0.000	0.000	0.918	0.000	0.000	0.000
80	01-03-2019	10h	MAVIR	UC3 AT 01	VH	-0.701	0.268	0.000	0.000	-0.701	0.000	0.000	0.000	0.000	0.268	0.000
81	01-03-2019	10h	TEL	UC3 AT 01	VL	-2.065	0.042	0.000	0.000	0.000	0.000	-2.065	0.000	0.000	0.000	0.042
82	06-03-2019	10h	ELES	UC3 AT 02	H	-4.214	8.782	0.000	0.000	-1.252	-2.962	0.000	0.000	8.782	0.000	0.000
83	0															

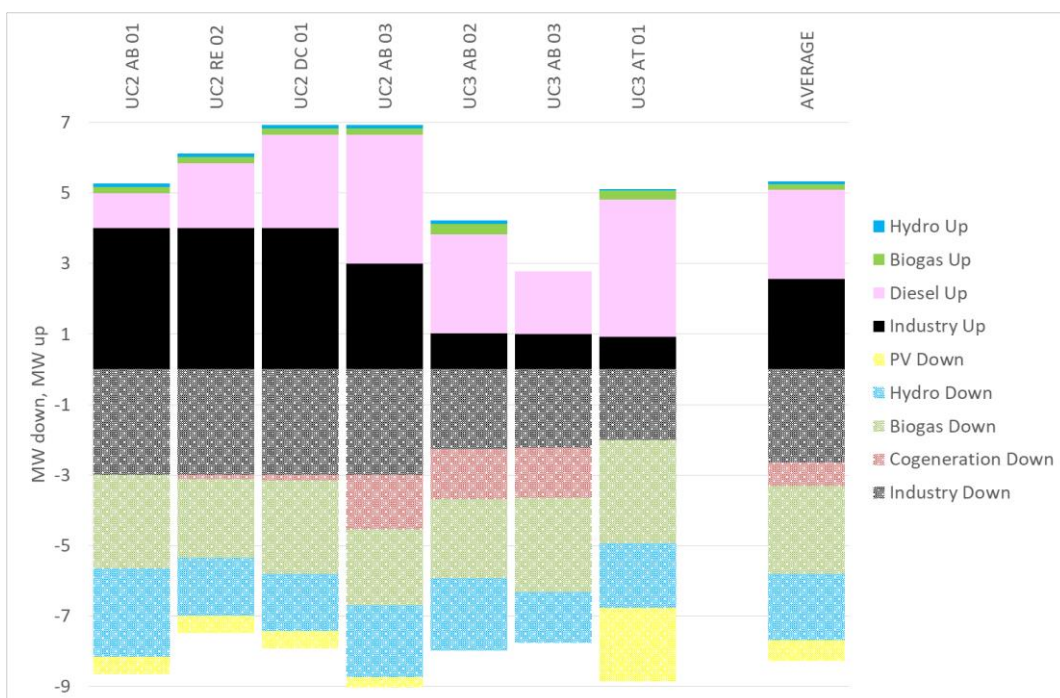
selection criterion was with respect to the quality of the VPP response, as presented in the Mark column of Table 2. The response for the selected cases was always either VH (very high) or H (high).

*Table 3: The selected seven best use cases (BUCs)*

No.	Used case	Group ID	Scenario ID	Date
1	UC2	AB-01	ID-01	2018-07-11 13:00:00
2	UC2	RE-01	ID-02	2018-08-23 13:00:00
3	UC2	DC-01	ID-01	2018-08-30 13:00:00
4	UC2	AB-01	ID-03	2019-01-10 10:00:00
5	UC3	AB-01	ID-02	2019-02-14 10:00:00
6	UC3	AB-01	ID-03	2019-02-15 10:00:00
7	UC3	AT-01	ID-01	2019-03-01 10:00:00

There are four use cases from UC2 where the cross-border netting and balancing among the TSO is not possible (cases 1, 2, 3, and 4) and three use cases where the cross-border netting and balancing is possible (cases 5, 6 and 7). The UC3 tests had to be performed for all four TSO zones at the same time, whereas the UC2 tests could have been performed separately for each TSO zone at different times (Table 3 gives only the starting date).

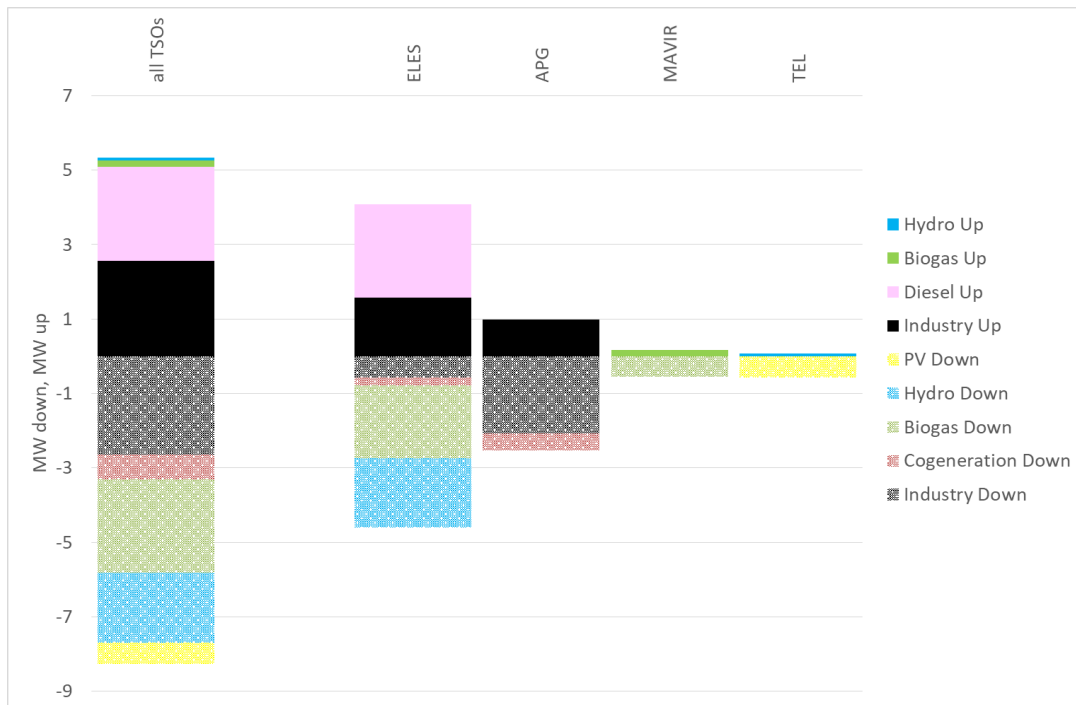
Figure 16 presents the inner structure of the seven BUCs and, in addition, the average structure over all seven cases on the right side. The aFRR balancing service has been provided mostly by the Industry units both for Up and for Down. Note that the Industry units can be viewed both as producers and as consumers of electricity. The term Industry included the Electrolysis, too.



*Figure 16: Internal DRDG units structure of the seven best use cases (BUCs)*

The total aFRR range offered was from some -8 MW of Down aFRR up to some +7 MW of Up aFRR. It turns out that the Up aFRR was served mostly by Industry units and by the Diesel generators, whereas the share of Biogas and Hydro units was considerably smaller. For Down aFRR, the distribution was more evenly distributed between Industry, Cogeneration, Biogas, Hydro, and Photovoltaics PV.

The Diesel units were located at ELES, as well as the most of Hydro units. The Biogas units were located at ELES and MAVIR. The PV units were located at TRANSELECTRICA. The Industry and the Cogeneration units were located at ELES and APG, Figure 17.



*Figure 17: The pilot tests locational distribution of DR/DG units among the TSOs (averages over BUCs)*

Scaling these results is hard since different countries have different geographic and social realities. The greatest part of DR/DG units of FutureFlow was located at ELES, but ELES is the smallest of the four TSOs. Figure 18 presents a reasonable guess, based on country population sizes, of obtainable DR/DG aFRR capacity in the FutureFlow regions assuming converging economies of those four EU countries. Of course, different assumptions would give different DR/DG structure at each FutureFlow TSO and consequently different aFRR range, but it seems that the overall amount should be more than some -50 MW of Down aFRR and more of some +50 MW of Up aFRR, which is approximately some 10 % of the total aFRR capacity market of those four countries.

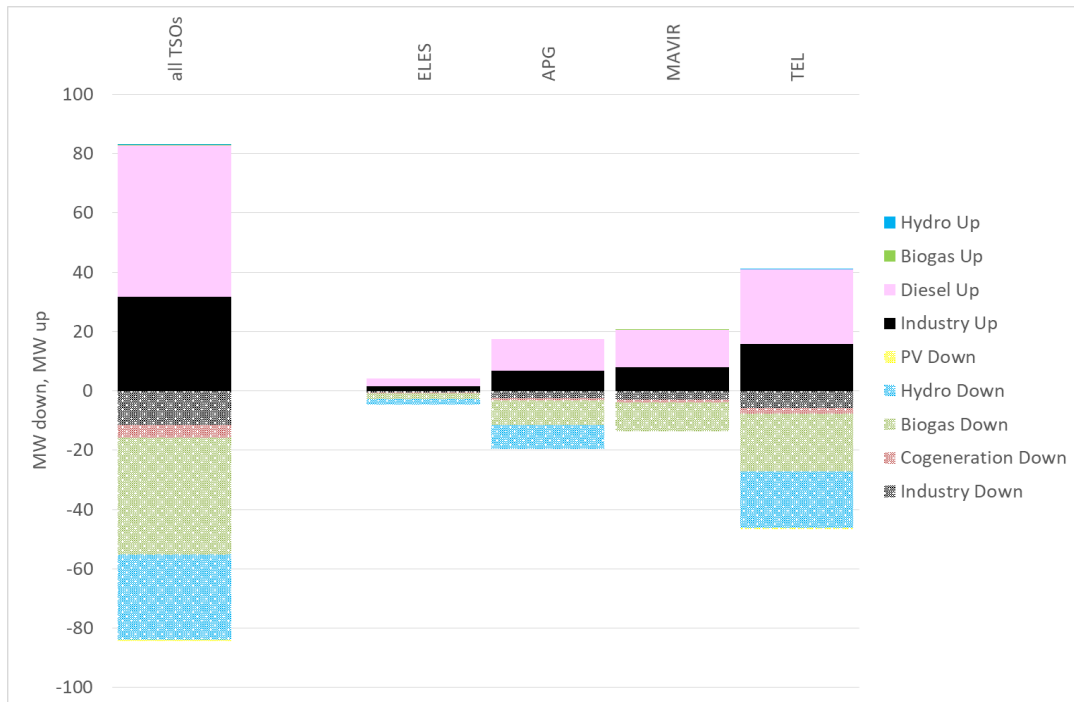


Figure 18: A vision of possible DR/DG contributions to aFRR by the TSOs.

## 2.7 Scaling laws of the retained promising use cases

According to chapter 5.6 in Deliverable 4.1[1], the scalability was studied on simulations. Simulations were performed within the FutureFlow DEMO site through the lx and LFC models. By varying the number of conventional bids, the number of DR/DG bids and the number of TSOs, the time complexity has been derived, thus implying the overall FutureFlow scalability.

The work was organised into five separate groups SC1, ..., SC5, as foreseen in the work schedule in D4.1<sup>40</sup> Table 17 **Napaka! Vira sklicevanja ni bilo mogoče najti..** Within each group, two main subgroups have been studied: the CD (control demand) subgroup and the CT (control target) subgroup. As the control demand subgroup has been selected as a target solution, only that part will be presented here.

In the FutureFlow DEMO site, it is foreseen that the set of bids changes hourly. There are 1800 real-time simulations within an hour. The simulation time of a single calculation must thus be under 2 seconds.

### 2.7.1 SC1 group

The purpose of the SC1 group was to establish the base case for other groups. This group contained no DR/DGs. There were ten conventional bids (approximately half of them for balancing 'down' and the other half for balancing 'up') in ELES, 73 in APG, 24 in MAVIR and 22 in TEL. This data has been used in all FutureFlow simulations and is taken from

<sup>40</sup> Futureflow deliverable 4.1: Specification of the use cases to be completed within TSO's environments used for pilot tests

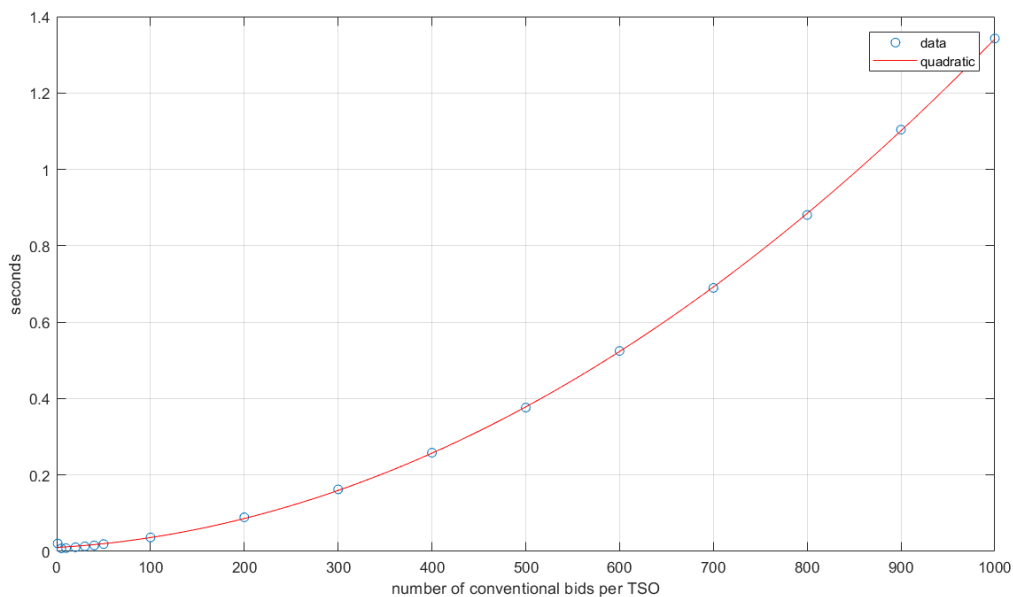
March 2017.

The elapsed time of a single CD control demand simulation amounted to 17.4 ms (milliseconds) on average.

### 2.7.2 SC2 group

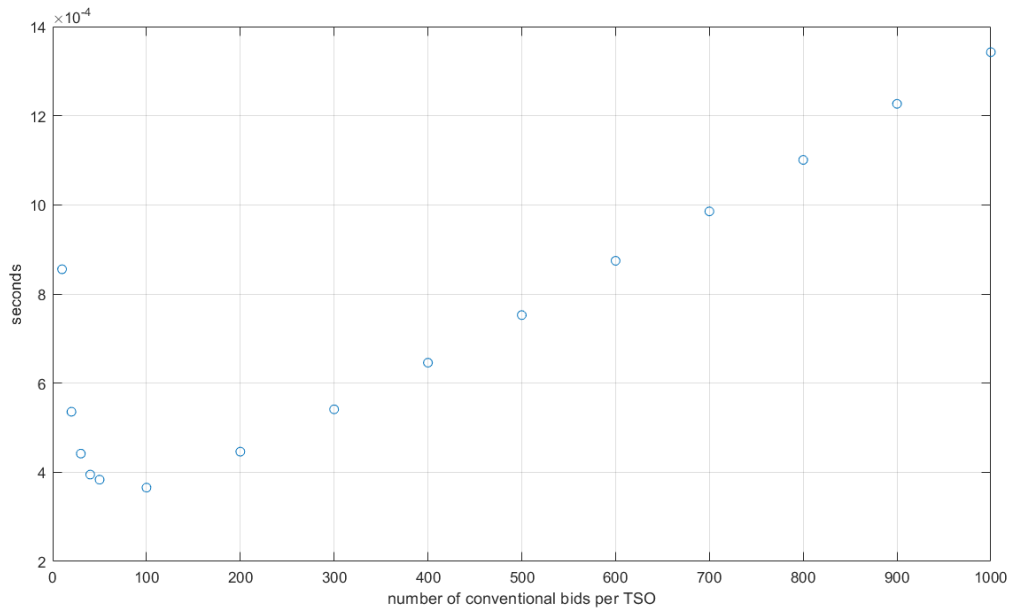
The SC2 group intends to assess how the number of conventional bids influences the simulation time. As in SC1 group, there is no DR/DGs. According to the work schedule of Table 17, the number of conventional bids  $N$  per each TSO should be varied from 10 to 1000.

Separate FutureFlow DEMO site simulations have been performed for the following 15 values of  $N$ : 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000. The simulation results are presented as circles, Figure 19. The figure also includes a red quadratic curve data fit. The overall time dependency is quadratic. The simulation time at  $N = 1000$  is 1.4 s, which is still less but already comparable to the time 2 s between simulations in real time.



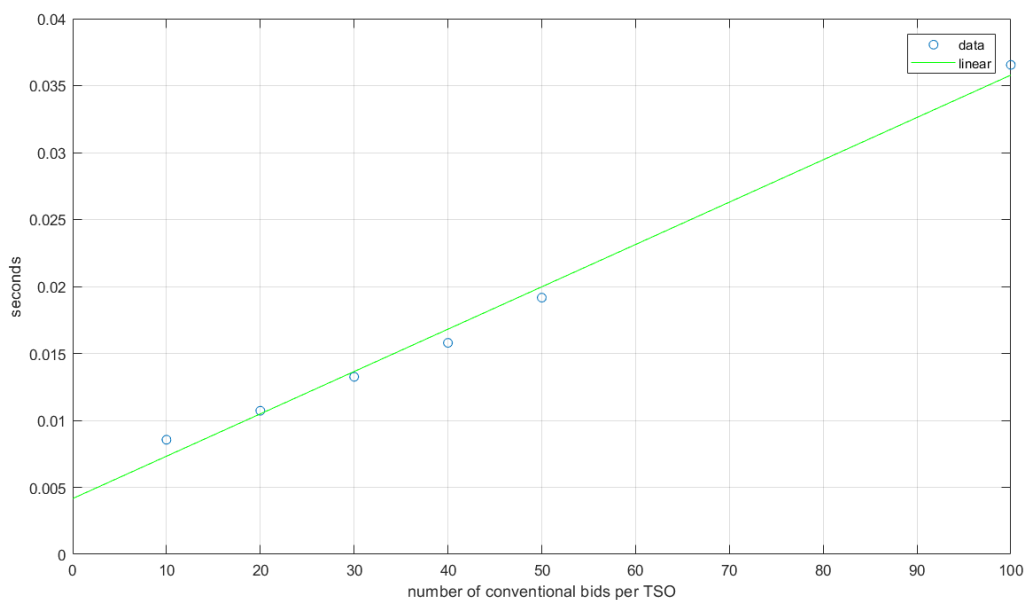
*Figure 19: The time dependency, SC2 group, CD control demand.*

Dividing the simulation time by the number of conventional bids  $N$  yields the average simulation time for a single conventional bid, Figure 20. The shortest time of some 40  $\mu$ s is achieved in the range of from some  $N = 30$  to some  $N = 200$  conventional bids. As the number of conventional bids gets even larger, the dependency remains linear.



*Figure 20: The time dependency per conventional bid, SC2 group, CD control demand.*

Admittedly, it is difficult to imagine  $N = 1000$  conventional bids from any single European TSO. So it makes sense to present the situation for a more realistic smaller number of conventional bids up to say  $N = 100$  bids, Figure 21. The time dependency may be represented quite well using a simple linear function.



*Figure 21: The time dependency for smaller values of N, SC2 group, CD control demand.*

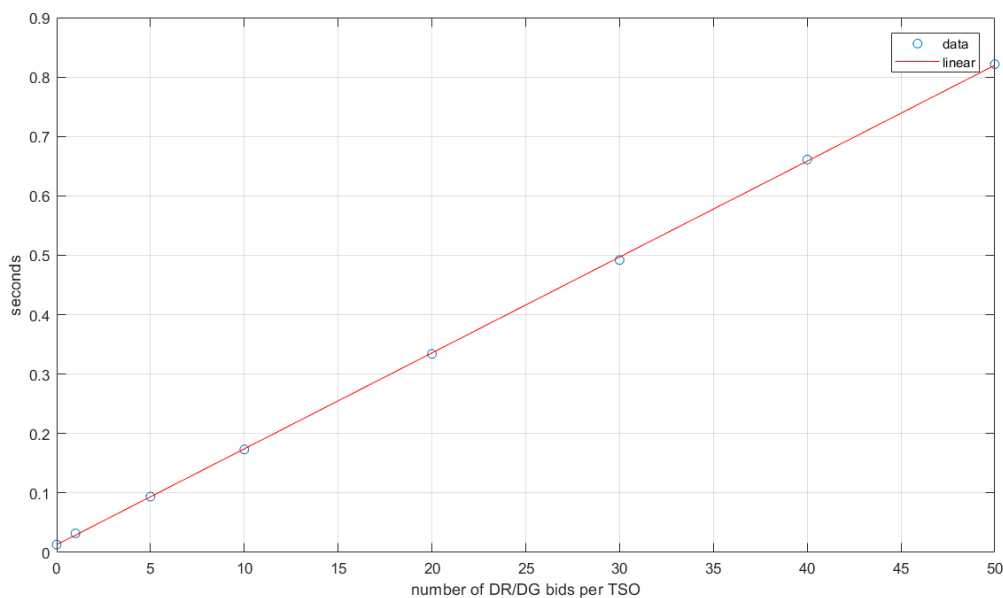
### 2.7.3 SC3 group

Here the DR/DG bids are introduced into the simulations for the first time. It is assumed to have  $M$  non-conventional DR/DG bids per each TSO in each simulation. The DR/DG

bids from within each TSO are summed into one DR/DG unit of each TSO. The system response of this single DR/DG unit is modelled as two blocks: a time delay and a first-order transfer function. The number  $N$  of conventional bids per TSO is a constant parameter in SC3 group.

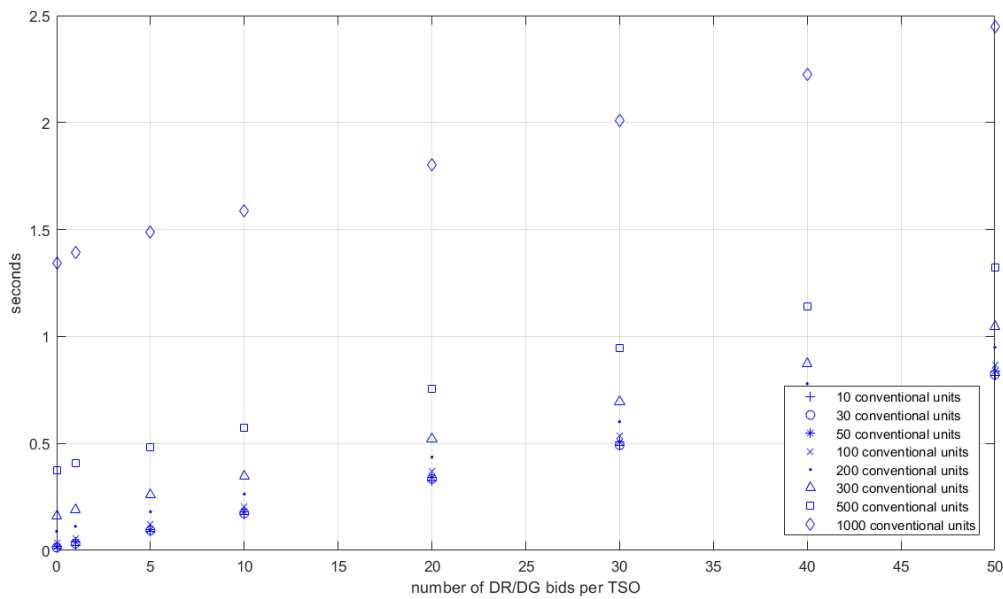
Separate FutureFlow DEMO site simulations have been performed for the following seven values of  $M$ : 1, 5, 10, 20, 30, 40, and 50. At present, it does not make sense to perform those simulations for hundreds of DR/DGs as in the case of conventional units of SC2 group.

The resulting time dependency turns out to be a simple linear dependency, Figure 22. This means that twice the number of DR/DGs will take twice as much time to calculate.



*Figure 22: The time dependency, SC3 group, parameter constant  $N = 30$  conventional bids per TSO.*

Changing the parameter number of conventional bids  $N$  per TSO the resulting dependency remains linear but gets shifted up or down, Figure 23. For small parameter values of  $N$ , this shift is relatively small.

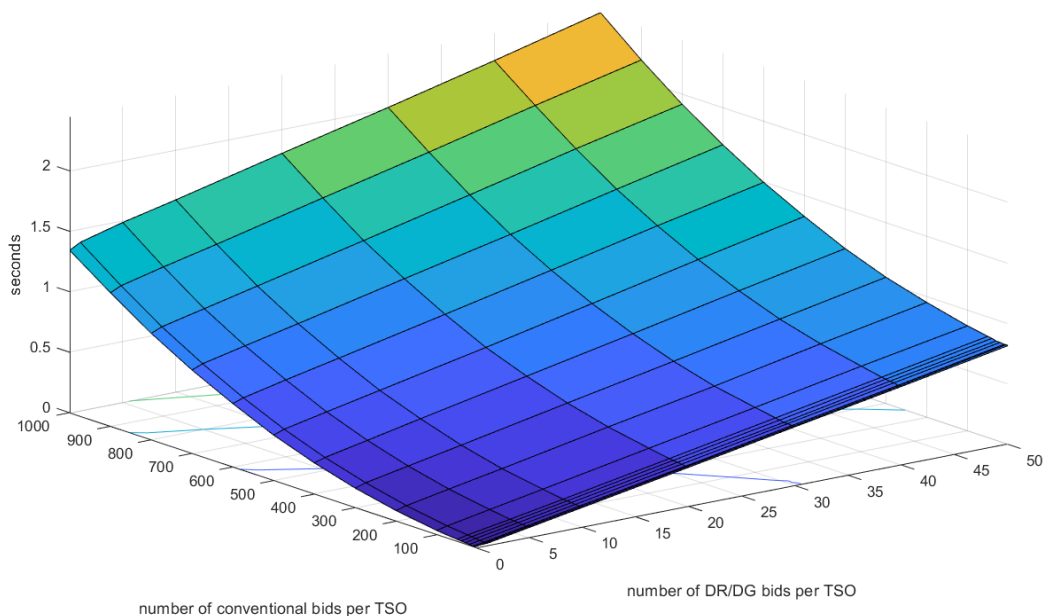


*Figure 23: The time dependency with respect to the number of conventional bids per TSO.*

Note that at extremely high values of conventional bids  $N$  per TSO the DEMO platform elapsed time might exceed 2 seconds, but this is infeasible since the interval between the two consecutive real-time simulations amounts to 2 seconds.

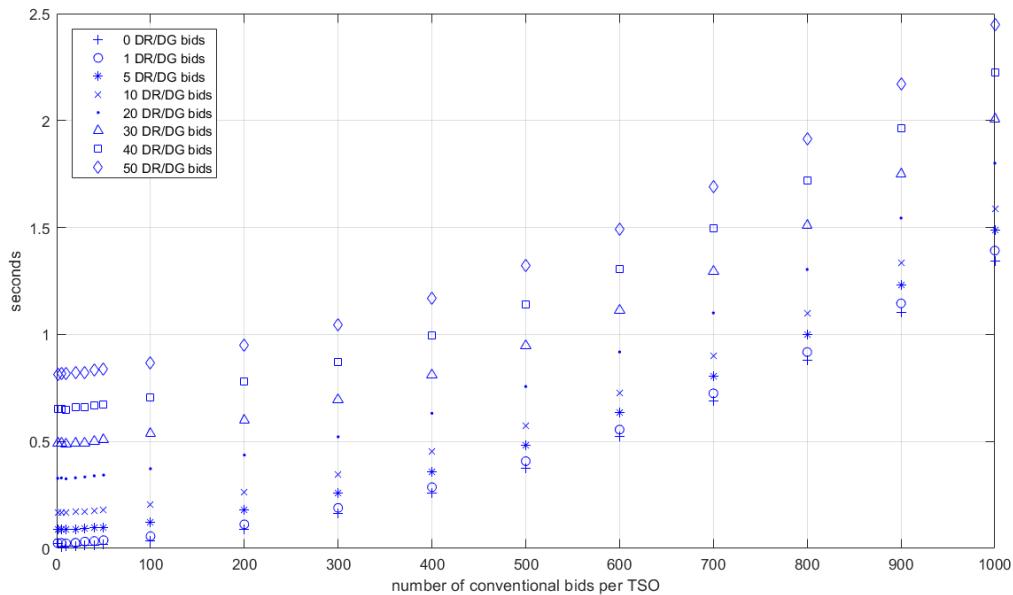
#### 2.7.4 SC4 group

In the SC4 group, the task is to vary both the number of DR/DGs  $M$  and the number of conventional bids  $N$  per TSO. The results can be presented on a three-dimensional  $M \times N$  plane, Figure 24.



*Figure 24: The time dependency with respect to the numbers of conventional and DR/DG bids.*

Assuming that the number of conventional bids to be a parameter, one obtains a somehow simpler one-dimensional graph of linear functions, Figure 23. Alternatively, assuming the number of DR/DG bids to be a parameter, yields a family of quadratic functions, Figure 24.

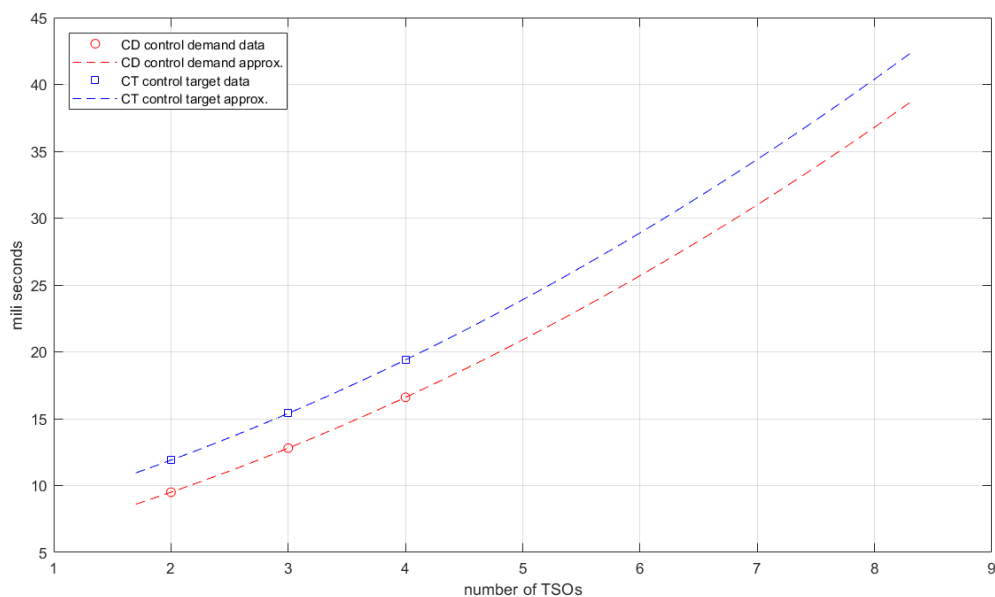


*Figure 25: The time dependency with respect to the number of conventional bids per TSO.*

Summary: the time dependency with respect to the number of DR/DG bids is linear, whereas with respect to the number of conventional bids it is quadratic.

### 2.7.5 SC5 group

The SC5 group aims to assess the time dependency with respect to the number of TSOs. All FutureFlow DEMO site simulations have been performed with four TSOs: ELES, APG, MAVIR, and TEL. It has been an enormous task to obtain all the data files and matrices just for those four TSOs. The CAF function (linear program) has been written with the assumption of a certain network topology among the four TSOs. Thus, a pragmatic approach has been used for the SC5, which can give us the basic picture, how will the inclusion of one additional TSO effect the calculation time of the demo platform. We used the CD control demand case and the CT control target case from the SC1 group. There were ten conventional bids in ELES, 73 in APG, 24 in MAVIR and 22 in TEL. This was the case of 4 TSOs. The case of 3 TSOs was obtained by abandoning TEL, and the case of 2 TSOs was obtained by abandoning MAVIR and TEL, Figure 26.



*Figure 26: Sensitivity with respect to the number of TSOs.*

The three measured data points of each line can be approximated very well using a simple linear approximation. Interestingly, the quadratic approximation fits even better!

The CD control demand calculation of 4 TSOs takes some 17 ms, as stated in chapter 2.7.1 and as is presented in Figure 26. Considering the inclusion of one, two, or three additional TSO the total number of TSOs in FutureFlow rises to 5, 6 or 7 and the total time rises to some 35 ms using the quadratic approximation. Thus, the inclusion of those additional TSOs has - in the worst case - a potential to double the calculation time.

### 3. Conclusions

The FutureFlow project is a good first step towards balancing market integration of four participating countries. Furthermore, it gives a good overview of current obstacles and measures possible to develop advanced procurement models to increase effective and efficient competition on the balancing market. However, the balancing market in Europe is far from being homogeneous. The NC, especially EBGL and SOGL brought the necessary framework, to address the barriers identified in FF, but since there is still a lot of differences between market approaches in different countries, the way toward the integrated market will request different steps. FF enlightened some barriers but also possible solutions, that will enable the integration of more countries and enable DR&DG participation in aFRR, which will bring further benefits for the EU as a whole.

*Table 4: List of barriers*

Identified barrier	Type of barrier	Details	Action plan
<b>Communication/ Cybersecurity</b>	T	Internal TSO, internal DSO communications level and data exchange in precisely defined. Private communication channels are established.	Attention should be paid to authentication and authorization methods, and the supervision and recording of users and customers' activities.
		The use of information services expands to the private communications infrastructures, communication channels.	Design and solutions architecture must base on uniformed protocols for data exchange.
		DSO-DSO, BSP-DR/DG - communication links use public networks; many smaller stakeholders are involved.	Ensuring integrity and confidentiality of data exchange together with the authentication of the endpoint.

Identified barrier	Type of barrier	Details	Action plan
<b>Interoperability</b>	T	Analyzing the deliverables of the CEN-CENELEC-ETSI Smart Grid Coordination Group in the context of the EU M/490 standardization mandate group, especially the “SGCG/M490/G_Smart Grid Set of Standards” and “SG-CG/M490/L_Flexibility Management”, it was found, that there are no use cases related to cross-border balancing and redispatching. <b>Consequently, the semantics for the data exchange is not defined for all the data which needed to be exchanged.</b> Also the MQTT protocol which was successfully implemented and tested <b>hasn’t been considered to be used for such kind of applications.</b>	The descriptions of use cases for cross-border balancing and redispatching made in the Deliverable 1.3 should be added to the IEC use case repository.  The MQTT protocol should be considered as an option for applications in the electric power system domain and should be added to the list of available protocols in the scope of Smart Grid Reference Architecture.
<b>Requirements for equipment shall be adapted to the size and type of resource</b>	T	Requirements for equipment, which is needed to provide aFRR services. IT equipment shall be adapted to the size and type of resources. They should not present a barrier for entering aFRR market.	TSOs shall incorporate the principle of proportional (with technical unit size) requirements in their respective prequalification rules.
<b>The cross-border organised market shall be established</b>	R/E	The participation of resources form different control zones shall increase competition and decrease the price.	Covered by EBGL Integration of the balancing energy market through the European platform for the exchange of balancing energy. The gradual approach towards regional solutions.
<b>Cross-zonal capacity for balancing rules</b>	T/E/R	To transfer balancing energy across borders available cross-zonal capacity is required. Rules for usage and eventual reservation of cross zonal capacities shall be transparent and non-discriminatory.	FutureFlow concept (D1.4) strives in late recalculation of CZC for balancing in Flow-based manner, to provide maximal free capacity, to avoid CZC reservations. If reservations would still be needed, there is a complex process to be followed, according to EBGL.

Identified barrier	Type of barrier	Details	Action plan
<b>Authorized participation in the market</b>	E/R	Participation of demand-side resources and their aggregation in balancing markets should be authorised	TSOs shall facilitate the participation of demand response, including aggregation facilities in the balancing services. MS shall encourage the participation of DR&DG in the balancing services.
<b>Aggregation shall be allowed</b>	E/R	Different types of aggregators shall be allowed (including independent aggregators <sup>41</sup> )	TSOs shall allow aggregators to offer aFRR services
<b>Rules and framework for aggregation shall be in place</b>	R	Rules for processes between BRP and aggregation shall be established. These processes include baseline, balancing responsibility, BRP – aggregator settlement, information exchange between parties. Rules shall also include a clear definition of the roles in the aggregation process.	Terms and conditions for balancing developed by the TSOs shall include the rules and conditions for aggregators as a balancing service provider. They should be transparent and non-discriminatory.
<b>Existing rules might include barriers for the DG&amp;DR participation</b>	R	Existing rules which have not been updated might prevent DG&DR resources from participation in aFRR market, although there is no technical, economic, or another barrier present.	With regards to the past rules, case by case assessment is required.
<b>Rules for aggregation between the end customer and aggregator shall be established</b>	R	Clear rules between market participants are the key for a successful demand response based on the aggregation model.	These rules are not covered by the current legislation. However, the proposal of a directive on common rules for the internal market in electricity states that member states shall enable contracts between the aggregator and the end customer and set out further provisions relating to these contracts.

<sup>41</sup> 2 In the Clean Energy legislative package proposal for a revised electricity Directive: ““independent aggregator” means an aggregator that is not affiliated to a supplier or any other market participant” (Source: CEER, ACER - Facilitating flexibility white paper)

Identified barrier	Type of barrier	Details	Action plan
<b>aFRR market rules shall be transparent and non-discriminatory</b>	E/T	aFRR market shall be based on open competition, transparent and non-discriminatory. Market rules shall consider all service providers equally and should not discriminate between different technologies.	Open standards and no special requirements for specific communication equipment or measuring devices.  Responsibilities between BRP and aggregator shall be clearly defined.
<b>PRODUCT DESIGN</b>			
<b>Full Activation Time (call time) should be as long as possible</b>	E	Longer FAT enables more participants to enter the aFRR market. This means that the market is more liquid and can deliver requested quantities of the balancing energy.	All TSOs' proposal for the implementation framework for the exchange of balancing energy from aFRR stipulates that FAT shall be 5 minutes.
<b>Product resolution in MW and time</b>	E	Low minimum bid quantity and more granular the products (in time duration) enables better participation of DG&DR resources.	The minimum quantity of 1 MW is proposed by FF. Four-hour products are foreseen as a short time target in FF
<b>Symmetrical products should not be obligatory</b>	E	A symmetrical product requirement is an entry barrier for resources that cannot provide an equal amount of positive and negative balancing energy.	FF proposes that aFRR platform shall consist of two CMOLs, one for the positive and one for the negative balancing energy bids. Bidders can bid only one or both types of energy bids.
<b>Price transparency</b>	E	Prices for aFRR capacity and energy should be transparent and be defined in the same way for all market players.	TSOs shall publish information on current system balance, on all balancing energy bids and other information.
<b>Settlement</b>	E	The very heterogeneous situation in EU is a barrier for integration	FF target model foresees the calculation of prices and costs based on 2-second Cross Zonal Marginal Pricing.
<b>Procurement cycle as short to real-time as possible</b>	E	Daily procurement cycle as near to the GCT as possible allows better participation of DR&DG which have issues with forecasts for the longer time period.	Harmonisation of the GCT close to real time.
<b>Differences in aFRR operation</b>		Central-dispatch vs self-dispatch Proactive vs reactive Pro rata vs merit order	FF will promote self-dispatch, reactive and merit order activation for aFRR

Identified barrier	Type of barrier	Details	Action plan
<b>Baseline methodologies</b>	T	There is no one baseline calculation method that would meet all the requirements. There are already different baseline methodologies present in national aFRR markets. TSO shall allow different baseline methodologies, as long as they are in line with the fundamental requirements. Different baseline methodologies fit better to particular resources. Allowing them to contribute to market liquidity.	APG and ELES (among others) already enable the use of different baseline methodologies. Nevertheless, not all European TSOs allow for it. FF will promote an open baseline methodology.

## 4. References

- [1] 'Results', *FutureFlow*. [Online]. Available: [http://www.futureflow.eu/?page\\_id=15](http://www.futureflow.eu/?page_id=15). [Accessed: 18-Jun-2019].
- [2] M. Hogan, 'Follow the missing money: Ensuring reliability at least cost to consumers in the transition to a low-carbon power system', *Electr. J.*, vol. 30, no. 1, pp. 55–61, Jan. 2017.
- [3] W. W. Hogan, 'Electricity Scarcity Pricing Through Operating Reserves', *Econ. Energy Environ. Policy*, vol. 2, no. 2, Apr. 2013.
- [4] K. Poplavskaya and L. de Vries, 'Distributed energy resources and the organized balancing market: A symbiosis yet? Case of three European balancing markets', *Energy Policy*, vol. 126, pp. 264–276, Mar. 2019.

## 5. Annex1: Electricity balancing in the current EU legislation

*Table 5: Electricity balancing in the current EU legislation.*

EU Legislation	Objectives of the legislation	Provisions concerning auxiliary services and balancing
<b>Directive 2009/72/EC concerning common rules for the internal market in electricity</b>	<ul style="list-style-type: none"> <li>Unbundling</li> <li>Establishment of ACER</li> <li>Establishment of ENTSO-E</li> <li>Better consumer protection and increased transparency of the retail markets</li> </ul>	<ul style="list-style-type: none"> <li>Network users shall be responsible for their balance</li> <li>TSO shall facilitate the participation of the final customers and aggregators in reserve and balancing markets</li> </ul>
<b>Regulation 71 /2009 on conditions for access to the network for cross-border exchanges in electricity</b>	<ul style="list-style-type: none"> <li>Internal electricity market</li> <li>Non-discriminatory network access</li> <li>Cooperation between TSOs</li> <li>Establishment of Network of Transmission System Operators for Electricity (the ENTSO for Electricity)</li> </ul>	<ul style="list-style-type: none"> <li>ENTSO for Electricity shall prepare network rules including rules on electricity balancing</li> </ul>
<b>Directive 2012/27 on Energy Efficiency</b>	<ul style="list-style-type: none"> <li>Common EU framework of measures for the promotion of energy efficiency</li> <li>Rules to remove barriers in the energy market and overcome market failures</li> </ul>	<ul style="list-style-type: none"> <li>Member states shall remove incentives in transmission and distribution tariffs that might hamper the participation of demand response in balancing markets and ancillary services</li> <li>TSOs and DSOs shall treat demand response providers un-discriminatory</li> <li>Member states shall promote access to and participation of demand response in balancing, reserve and other system services markets</li> </ul>
<b>Regulation 2017/2195 establishing a guideline on electricity balancing (EBGL)</b>	<ul style="list-style-type: none"> <li>Fostering competition, non-discriminatory access to the markets and transparency of balancing markets</li> <li>Integration of balancing markets across the EU</li> <li>Improving the efficiency of balancing markets</li> <li>Efficient operation of balancing market and efficient integration of renewables</li> </ul>	<ul style="list-style-type: none"> <li>Market rules for balancing markets</li> <li>Integration of balancing markets</li> <li>Participation of DG&amp;DR and aggregation in balancing markets.</li> <li>Cross-zonal capacity calculation and pricing provisions</li> </ul>
<b>Regulation 2017/1485 establishing a guideline on electricity transmission system operation</b>	<ul style="list-style-type: none"> <li>Transmission system operational security requirements</li> <li>Common load-frequency control processes</li> <li>Fostering coordination of system operation, planning and information exchange</li> </ul>	<ul style="list-style-type: none"> <li>Operational provisions concerning load-frequency control frequency quality</li> <li>Cross border FRR process</li> <li>FRR dimensioning, technical requirements and prequalification</li> </ul>

## 6. Annex2: Changes of the tendering rules in Germany

*Table 6: Changes of the tendering rules in Germany.*

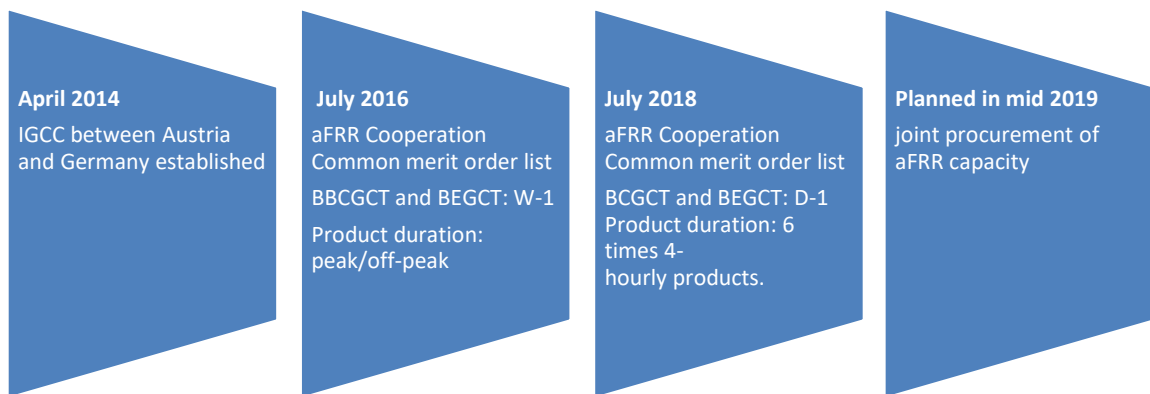
Year	Decision	Auction timing	Product duration	Minimum Capacity
<b>2007</b>	BK6-06-066	Monthly	peak: Mon-Fri 8am-8pm; off-peak: all times except peak and public holidays	10 MW
<b>2011</b>	BK6-10-098	Weekly	peak: Mon-Fri 8am-8pm; off-peak: all times except peak and public holidays	5 MW
<b>2017</b>	BK6-15-158	Daily	6 x 4 hours block/per day	5MW for the Germany and Luxemburg LFC block and 1MW for the LFC area

## 7. Annex3: aFRR cross - border cooperation

Apart from the Picasso and FF project, several other local initiatives on aFRR cooperation have been introduced in Europe. Austria – Germany aFRR cooperation is considered first of this kind in continental Europe, and it is shown to be very successful. The use case below provides more information on operational details and regulatory framework of this co-operation.

### Use case: Austria – Germany aFRR cooperation

The cooperation was launched in 2016. Previously Germany and Austria already participated in the International Grid Control Cooperation (IGCC), and aFRR implementation was considered as a next step.



*Figure 27: Evolution of the Austria-Germany balancing cooperation – IGCC and aFRR*

Today Austrian-Germany aFRR cooperation is based on the activation of the energy bids. The capacity is still procured locally. German TSOs procure capacity in their control areas and Austrian TSO in his control area.

The exchange of the aFRR capacity is the next step of integration. The planned implementation is in the middle of 2019. To achieve this, several things will have to be resolved such as transmission capacity and distribution of congestion management costs.

The cooperation is based on the TSO-TSO model and is compliant with the request of EBGL. The bids from both countries are joined in the common merit order list - CMOL. The methodology to determine prices for balancing energy is based on marginal pricing. The cross-zonal capacity is determined weekly, using the cost-benefit analysis. In this analysis, the market value of the day-ahead market and the aFRR market is compared and cross-zonal capacity allocated accordingly.

To create the regulatory framework which could support cooperation, several steps were required:

- Harmonisation of the pre-qualification procedure;

- Harmonisation of the market processes;
- Harmonisation of the aFRR products.

Harmonisation details are depicted in the table below.

1. Harmonisation of the pre-qualification procedure
2. Harmonisation of the market processes
3. Harmonisation of tendering process
4. Gate opening and gate closure times
5. BSP - settlement
6. TSO-TSO settlement rules
7. Imbalance pricing methods
8. Fallback procedure
9. Harmonisation of products characteristics:
9.1. Minimum bid size: 5 MW
9.2. FAT: 5 minutes
9.3. Product: 6 times 4 hourly blocks

*Figure 28: Harmonisation details of Austria-Germany aFRR cooperation*

If the aFRR cooperation process fails, the national aFRR procurement takes place. Both countries activate only their national/local aFRR bids. This can happen, for example in the case of the network congestion.

aFRR cooperation between Austria and Germany is a successful project. According to ACER's Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 - Electricity Wholesale Markets Volume<sup>42</sup>, "the overall cross-zonal exchange of balancing energy (including imbalance netting) has almost doubled since 2015". The results are published on the internet tender platforms in both countries.

<sup>42</sup> [https://www.acer.europa.eu/Official\\_documents/Acts\\_of\\_the\\_Agency/Publication/MMR%202017%20-%20ELECTRICITY.pdf](https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR%202017%20-%20ELECTRICITY.pdf)