



Deliverable 2.3
Validation report of prototyped
aFRR software suite
—
May 2018

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Table of acronyms

Acronym	Meaning
ACE	Area Control Error
aFRR	Automatic Frequency Restoration Reserve
AGC	Automatic Gain Control
ATC	Available Transfer Capacity
BSP	Balancing Service Provider
CAF	Common Activation Function
CMOL	Common Merit Order List
CZC	Cross Zonal Capacity
DG	Distributed Generation
DR	Demand Response
EU	European Union
FAT	Full Activation Time
FB	Flow-based
FF	FutureFlow
I&C	Industrial and Commercial
IEC	International Electrotechnical Commission
IN	Imbalance Netting
KPI	Key Performance Indicators
LFC	Load frequency controller
MOL	Merit Order List
MQTT	Message Queueing Telemetry Transport
OL ACE	Open-loop area control error
PTDF	Power Transfer Distribution Factors
RAM	Remaining Available Margin
SCADA	Supervisory Control and Data Acquisition
TSO	Transmission System Operator
UC	Use Case
VPP	Virtual Power Plant
WP	Work Package

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Glossary

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

Note, that despite the consortium reached the decision to use the term “aFRR aggregation platform” throughout the FutureFlow project, for historical reasons the following terms will occasionally be used interchangeably: “aFRR software suite”, “VPP flexibility platform”, “aFRR platform”.

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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 in order 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 optimized 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.

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Project Partners

No	Name	Short name	Country
1	ELES DOO SISTEMSKI OPERATER PRENOSNEGA ELEKTROENERGETSKEGA OMREZJA	ELES, d.o.o.	Slovenia
2	AUSTRIAN POWER GRID AG	APG	Austria
3	MAVIR MAGYAR VILLAMOSENERGIA-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 ENERGIJA, PODJETJE ZA PRODAJO ELEKTRIKE IN DRUGIH ENERGENTOV, SVETOVANJE IN STORITVE, D.O.O.	EE	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

Task 2.3 is attempting to answer the *two main questions*:

1. Is the aFRR aggregation platform, implemented according to specifications in Deliverable 2.1?
2. Is the aFRR aggregation platform able to operate under different balancing characteristics that exist in the four participating control zones (of ELES, APG, MAVIR and TRANSELECTRICA) as well as existing and possible future market rules?

To enable drawing the relevant conclusions within the aims of the Deliverable 2.3 we have used a combination of several methods, namely functional testing, computer simulations and thought experiment. These were selectively applied on the relevant areas of validation with varying the intensity needed to enable a clear result of validation.

To prove that certain functionality (for example "user login") is correctly implemented we have divided each functionality test into individual tests that the functionality test is composed of (for example "establish connection"). Each test was then executed by conducting the appropriate number of the simplest elementary steps (for example "change password"). Test scenarios, the supporting test procedures and the individual steps of validation as defined in this document (in Chapter 2 and Appendices) are therefore the most important ones for the successful operation of aFRR services in the FutureFlow DEMO environment.

The validation was performed by analysing 6 modules of the aFRR aggregation platform. The functioning of the modules have been tested with respect to the total of 16 functionalities that enable the modules to run. To prove that functionalities are operating as specified (or as expected) 37 individual elementary tests, composed of 117 steps have been performed by the testers.

The 107 of the tests (individual elementary steps) resulted in "OK", 4 of them as "not-yet-implemented", 4 were identified as "not-OK", 1 was marked "partially-OK" and 1 resulted in "to-be-implemented-later". The analysis produced 5 bugs that were subsequently fixed.

From the test results we can conclude that initially 92% of the functionalities have been in line with specifications, while 8% have not been suitably implemented. At the ending stage, once the identified bugs have been resolved we estimate that at least 96% of the functionality of the aFRR aggregation platform is implemented as specified.

It can be concluded that despite minor unfinished functions the aFRR aggregation platform meets the requirements of the FutureFlow project and is ready to be used for the pilot testing phase involving actual DR/DG resources.

Furthermore, due to its versatility it is ready to adopt different regulatory settings that can be found in the four control zones of this project. Since its application in different control zones is non-problematic it can be argued that regulatory intervention or attempts to (formally) standardize the aFRR aggregation platform designs in general are

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not required.

It would however be recommended in general to unify the communication interfaces of TSOs from the aspect of a Balancing Service Provider (BSP), since that would enable a faster and more economically efficient deployment of such unified tools in the developing aFRR markets, especially with the outlook on the integration of balancing market and creation of equal level playing field for any BSP.

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1 Introduction

1.1 Outline

Deliverable 2.3 (Validation report of prototyped aFRR software suite) is the document that results from the activities of the Task 2.3 (Software validation based on offline testing of the DR & DG flexibility aggregation platform for FRR) of the Work Package 2 (Prototype DR & DG flexibility aggregation platforms for aFRR) of the FutureFlow project.

Task 2.3 is attempting to answer the **two main questions**:

3. Is the aFRR aggregation platform, implemented according to specifications in Deliverable 2.1?
4. Is the aFRR aggregation platform able to operate under different balancing characteristics that exist in the four participating control zones (of ELES, APG, MAVIR and TRANSELECTRICA) as well as existing and possible future market rules?

The above stated questions result in the **four main targets** that we have pursued in the D2.3 – the targets two and three are formed as the use cases that will answer the above two questions:

- Creating a dynamic *computer simulation* of real historical data provided by the TSOs and distributed resources. The input signals are a valid reproduction of recorded signals, used by the TSOs, while the units' response is simulated in the form of a *transfer function* considering the actual unit's characteristics.
- USE CASE 1: defining an adequate *set of test cases* for validating the aFRR aggregation platform (a total of 37). These were constructed by considering different hypotheses regarding future scenarios and related objectives in WP1. As WP1 proposed a specific model as the reference future market model (the FutureFlow target model) all tests were performed using its characteristics, hence *testing the aFRR aggregation platform under the FutureFlow target model*.
- USE CASE 2: devoting particular attention to specific issues related to different control zones regarding balancing characteristics and market rules (national and cross-border). Several specific tests were performed to ensure that the aFRR platform is able to perform under different market settings, hence *testing the aFRR aggregation platform under different control zone- specific settings*.
- Including an *evaluation of* benefits & limitations of the prototyped aFRR aggregation platform software modules.

1.2 Structure of the deliverable

This *first* (introductory) *chapter* sets the basics for Task 2.3. *Section 1.3* describes the testing environment of T2.3, within the FutureFlow project architecture. It identifies it as the aFRR aggregation platform, connected to the FutureFlow DEMO site on one side, and

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the attached DR/DG units on the other side. *Section 1.4* gives the relation of D2.3 to other work packages. In *Section 1.5*, the methodology of work is explained, consisting of three intertwined parts: functional testing, computer simulation and thought experiment. The task's first target, computer simulation of real historical data, is covered extensively here; as well as the complete testing architecture.

Chapter 2 is central to this deliverable and dissects the structure of two use cases which were used to provide a ground for test reports available in Annexes 1 and 2. The structure and functionality of the computer simulation tool that was used to test the aFRR aggregation platform is also explained here. *Chapter 2* concludes with the discussion on the performance of the aFRR aggregation platform under different settings.

Chapter 3 presents the results of the validation tests.

Chapter 4 contains a discussion on the benefits and limitations of the present FutureFlow aFRR platform, summarizes the overall final conclusions and gives recommendations for the future European secondary reserve market.

The testing results represent the core of this deliverable while *Appendices A and B* enable the reader to be informed in detail with the individual steps of the testing procedure that enabled the authors to draw relevant conclusions outlined in *Chapter 4*.

1.3 FutureFlow architecture to be tested

The FutureFlow demonstration architecture contains the following crucial building blocks (Figure 1, where the building blocks are marked with red circles):

1. DR/DG sources;
2. aFRR aggregation platform (also called VPP flexibility platform). Operated by BSP;
3. FutureFlow DEMO site; that also plays the role of TSO balancing platform for pilot demonstration operations;
4. FF Cloud platform.

The focal point of Task 2.3 is testing if the aFRR aggregation platform (2) has been implemented in line with the requirements of D2.1. These tests comprehensively include the platform's outward connections to the FutureFlow DEMO site (3), as well as the attached DR/DG units (1).

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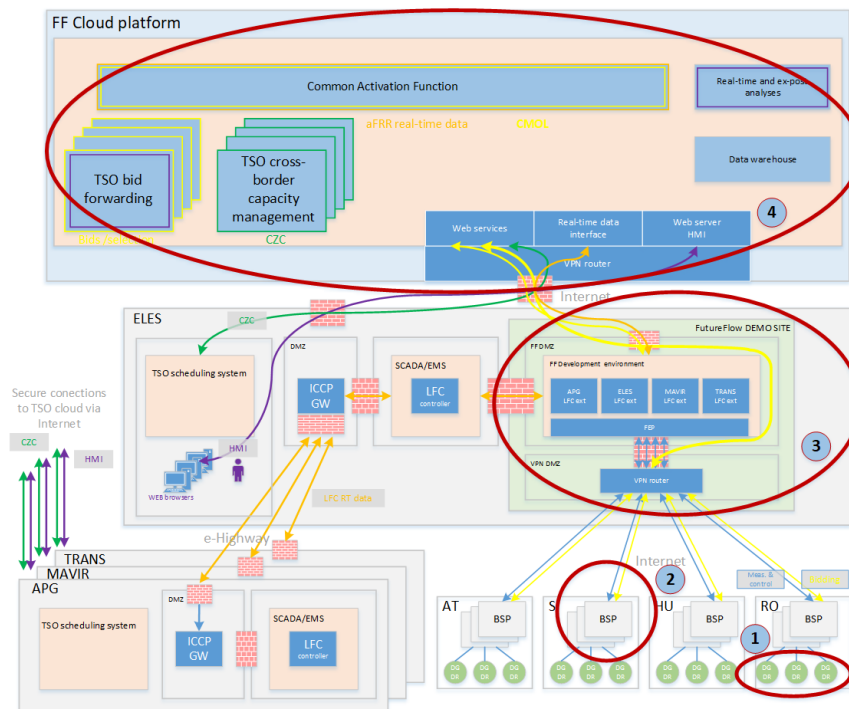


Figure 1: FutureFlow demonstration architecture: Building blocks under test.

1.4 Relation to other work packages

Deliverable 2.3 "Validation report of the prototyped aFRR software suite" builds upon the results of two previous deliverables: *Deliverable 2.1*. "Specification of the aFRR functionalities of DR/DG flexibility platforms", a basic document that specified the functionality and security for the aFRR aggregation platform, and the subsequent *Deliverable 2.2* "Novel aFRR software suite including experience feedback from pilot tests" that described the implementation of the aFRR aggregation platform. The validation, described herein, is directly following the specifications from Deliverable 2.1.

After D2.3 establishes that the aFRR aggregation platform is fully functional and that the software was produced according to the specifications, the platform will be used for execution of the pilot tests within the scope of WP 5. The report on the findings will be published in *Deliverable 5.2* "Pilot testing within each control zone (use cases 1 and 2)". There the aFRR platform will not be tested from within, rather it will be considered a "black box" element in testing the end-to-end communication line of the entire FutureFlow demonstration architecture as presented in the Figure 1.

The connection of T2.3 to other work packages is graphically represented in the Figure 2.

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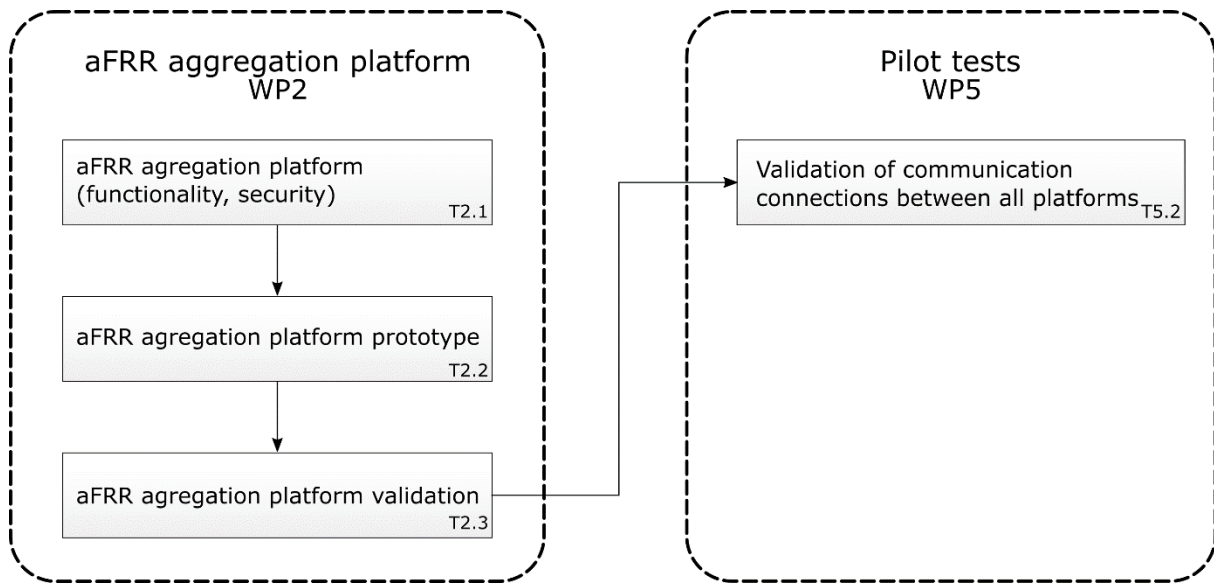


Figure 2: WP2, D2.3 relation to other work packages.

1.5 Methodology of work

Meeting the objectives of Task 2.3 - to comprehensively validate the aFRR aggregation platform - was achieved by using the following approaches:

1.5.1 Functional testing of the aFRR platform by experienced operators

The testers accessed the aFRR platform, by reaching its graphical user interface (GUI) through a secure Virtual Private Network (VPN) connection. They executed all available functionalities (for example logging in, setting up new users and their access permissions, adding and configuring new DR/DG units, importing bids, etc.). The operators have marked the behavior of the aFRR aggregation platform that is summarized in the testing reports available in Appendices A and B. Further details about testing single modules can be found in the description of Use case 1, in the Section 2.1.

1.5.2 Computer simulations

Functional testing of the aFRR aggregation platform by operators alone is not sufficient for execution of certain functionalities. The validation of these requires the use of computer simulations. Combined with functional testing the computer simulations enable not only testing the functionalities provided by the aFRR aggregation platform, but also to expose it as closely as possible to the environment that will be encountered later on in the pilot tests of WP 5.

This approach also enables validating the aFRR platform without the need to affect the real life systems by performing costly and cumbersome actual activations of physical resources that are not justified at this point of the project. The simulation approach is described in greater detail in the Section 2.3

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1.5.3 Thought experiment

In part, the potential application of the developed aFRR prototyped solution under the country specific market models is discussed by using a thought experiment. This approach was chosen to validate that aFRR aggregation platform is able to perform sufficiently under milder restrictions, once we were able to prove in UC1 that it performs well under the more challenging FutureFlow target model requirements.

2 Validation of the prototyped aFRR aggregation platform

As outlined in the introductory section the Task 2.3 aims at validating the aFRR aggregation platform through an adequate *set of test cases* constructed by considering different hypotheses regarding future scenarios as well as considering specific issues related to different countries regarding balancing characteristics and market rules.

Searching for the answers to the two research questions (defined above) by following the outlined targets we have constructed the main two groups of scenarios. We have exposed the aFRR aggregation platform to the tests' run by considering the characteristics of the FutureFlow target model, hence *testing the aFRR aggregation platform under the FutureFlow target model*. *FF target model has been proposed as the likely future setting in the Deliverable 1.2 of WP1. We name this scenario the USE CASE 1.*

However, to prove that the aFRR platform is operational also in other market and technical conditions we have additionally exposed it to certain specifics related to different countries regarding balancing characteristics and market rules (national and cross-border). Several specific tests were performed, hence *testing aFRR under different control zone-specific market models* that constitute the USE CASE 2.

Considering that such different scenarios for the validation of the aFRR aggregation platform in real environment is complex and cumbersome the introduction of dynamic *computer simulation* of real historical data was selected as the more suitable method to be used in addition to functional testing of the aFRR aggregation platform by the operators (i.e. human users of this tool).

The use cases and its populating scenarios can be characterized by the requirements of the regulatory regimes in the four participating control zones which are influenced mostly by the following characteristics:

- *set-point types* (stepwise vs. continuous),
- *activation rules* (Merit order vs. Pro rata),
- *full activation time - FAT* (5min, 15min) and
- *cycle time of AGC* (2s, 4s),

as is summarized in the right part (UC2) of Table 1 **Napaka! Neveljavno samosklícivanje zaznamka.** below¹.

Table 1: Comparison of technical requirements for aFRR activation; participating control zones vs. FutureFlow target model

	UC 1	UC 2			
Regime	FutureFlow	APG	ELES	MAVIR	Transelectrica
Set-point type	Stepwise	Stepwise	Continuous	Continuous	Continuous
FAT	5min/10min	5min	15min	15min	15min

¹ Source; Table 7, "Comparison of technical requirements for aFRR activation, current state", of the Deliverable 1.2.

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Cycle time of AGC	2s	2s	2s	2s	4s
Activation rule	Merit Order	Merit Order	Pro rata	Merit Order	Pro rata

UC1: All aFRR aggregation platform components (functional modules) are therefore tested under these settings, which represent on the one hand a common denominator of the four different regimes and on the other hand the most restrictive one. The functioning of the aFRR aggregation platform was tested by performing the simulations that were based on the recorded real historic aFRR set-point signal.

UC2: To verify that the aFRR aggregation platform also performs correctly under the current regulatory regimes in different control zones the same or similar tests were repeated with single control zone settings, focusing on testing modules which are primarily affected by the change of settings (e.g. forecasting, unit commitment, user interface).

The two cases are further specified in Sections 2.1. and 2.2. The test results are contained in the Appendices.

2.1 Use case 1 - Validation of the prototyped aFRR aggregation platform under the FutureFlow target model settings

The FutureFlow target model is selected based on the analyses performed by computer simulations run in WP 1. The target model is based on the favorable physical (such as ACE quality) and economic (i.e. social welfare) indicators, as well as political directives (for example in line with the Guideline on Electricity Balancing - EB GL). These are elaborated in detail in the Deliverable 1.2 The selected parameters tested within Use case 1 are the more challenging and future-prone settings, while their combination formulates the set of most rigorous settings observed in the participating TSOs.

The agreed upon FutureFlow target model is envisioned as a possible regulatory regime for the future unified European aFRR balancing market, if applicable.

In USE CASE 1 all aFRR components (modules) are therefore tested under these settings, which represent on the one hand a common denominator of all four different regimes and on the other the most restrictive one. The aFRR functionality was tested using simulations of recorded real cases of the aFRR activation signal as well as actual DR/DG units' response.

Validation of the prototyped aFRR aggregation platform under the FutureFlow target model, USE CASE 1, focuses on testing the aFRR platform's functionality, including testing all communication interfaces (IEC 60870-5-104) from the BSP towards the TSO and DR/DG simulators, respectively. All simulations within delivery D2.3 have been performed by operating the aFRR aggregation platform in an offline mode, without any (physical) connections whatsoever to the TSO systems or DR/DG units. For the purpose of D2.3 these have been emulated (mimicking behaviour has been implemented based on real historical data) to enable testing the input and output functionality of the aFRR platform.

35 tests, comprehensively divided into six aFRR modules were executed by using the aFRR aggregation platform. Detailed test scenarios are covered in Appendices A and B.

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Use case 1 is concerned with the internal validation of the prototyped aFRR software suite. The following integral parts of the aFRR aggregation platform were tested:

1. **User interface module**
2. **Data exchange module**
3. **Forecasting module**
4. **Bidding module**
5. **Unit commitment module**
6. **Control module**

The testing was executed offline, meaning that real resources were not activated, but instead simulated signals, created from historical real-time data, were used.

USE CASE 1 testing scenarios

The below scheme in Figure 3 **Napaka! Vira sklicevanja ni bilo mogoče najti.** lists all USE CASE 1 testing scenarios and the corresponding aFRR aggregation platform modules. Note, that the first two listed modules needed to be successfully tested before all the remaining ones, as their flawless functioning is a precondition for the operation and testability of the other ones. The later ones can be tested in (almost) any order.

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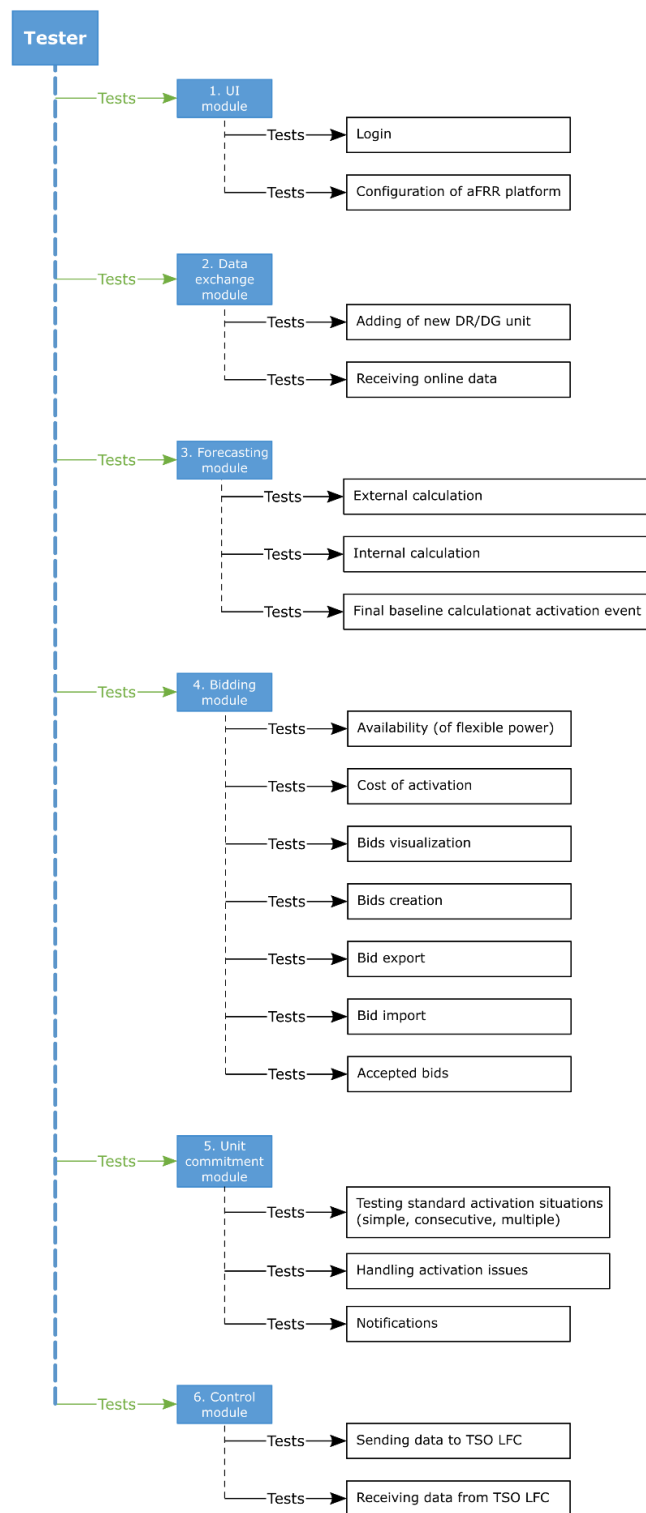


Figure 3: USE CASE 1 testing scenarios.

The test results for Use case 1 are presented in detail in Appendix A. They are divided into processes, corresponding to groups of individual tests that aim at validating a specific functionality.

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2.2 Use case 2 - Validation of the prototyped aFRR aggregation platform under market settings in 4 participating control zones

Use case 2, “*Validation of the prototyped aFRR aggregation platform under market settings in 4 participating control zones*”, aims to verify that the platform is enabled for usage under settings from different participating control zones.

One possible way to prove this ability is to perform a sensitivity analysis by exposing the aFRR aggregation platform to all possible combinations of setups from the Table 1. This would mean that each individual test from the UC1 would be repeated for each individual setup. Since most of the functionalities of the aFRR aggregation platform are independent of the market rules we argue that only relevant tests should be repeated, which would provide enough insight to form a relevant conclusion for validation.

The following hypothesis can be put into questioning:

- The aFRR aggregation platform is able to perform under milder restrictions (found in UC 2), once we were able to prove in that it performs well under the stricter FutureFlow target model requirements (considered in UC 1).

To prove the above hypothesis we will discuss how the change of any single parameter might influence the (non)operability of the aFRR aggregation platform.

FAT setting has no influence on the design of the aFRR aggregation platform, nor its functioning. It only influences the following:

- The billing and settlement for aFRR reserve activation differs

In this way the (requesting) TSO of one control zone would be able to (indirectly through connecting TSO) activate DR/DG resources of a TSO from another control zone with a different FAT requirement. The second (connecting) TSO would activate its resources according to the received set-point. In case the connecting TSO operates under shorter FAT than the requesting TSO, there will be no negative effects due to the DR/DG performance. In case the connecting TSO's FAT requirement is *longer* than the requesting TSO's the DR/DG units will potentially react slower and will be less responsive in following the set-point. Even if in such case the slow response of the DR/DG units would not meet the requirements of the requesting TSO, this is not inherently related to the design of the aFRR aggregation platform since FAT is merely a prequalification requirement, and a crucial parameter in the settlement calculation.

Set-point type (stepwise vs. continuous): the aFRR platform receives a new value of the set-point signal from the TSO, every 2 or 4 seconds. Each such received signal value needs to be processed. For the same resources and under the same conditions, the response of the resources should (theoretically) be the same. (Before contracting a certain pool of resources, the TSO is notified of the ramp inclination the BSP (or a pool of DG/DGs) is capable of following and considers this in the preparation of the set-point signal (called continuous activation set-point signal type). Even when the set-point type is changed from continuous to stepwise, the BSP's performance will not improve. What will differ

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though, is the settlement and billing of the activated reserve capacity.)

Despite the above theoretical argumentation, a practical test with both set-point type settings and equal set-point signal was performed (see Appendix B.2), to establish that the aFRR aggregation platform can handle both types of set-point signal, as well as that the response of DR/DG is (almost) the same in both cases.

Activation rule (merit order vs. pro-rata): The pro-rata option was not implemented in the aFRR platform within the FutureFlow project, as it is not part of the FutureFlow target model. Since the merit-order option is prevalent within the analysed four control zones, it was decided that the activation rule for the FF target model should be merit-order.

However, the activation rule that the TSO uses has no influence on the operation of the aFRR aggregation platform. The TSO, performing aFRR regulation, keeps a record of its own internal CMOL, which includes different individual BSPs, as well as pools of DG/DGs. In case it activates the pool's bid only partly, the aFRR platform would have no way of knowing whether this is a result of being the last used bid on a merit order list, or the bid was activated in a pro-rata activation rule. In both cases alike the aFRR platform starts receiving the set-point signal and activates the units in the pool according to its own internal merit-order, and the business rule it acts upon (it can be merit order, pro-rata or any other approach). The specific internal activation rule of the aFRR aggregation platform is subject to BSP's own internal decision.

Despite firm argumentation that the activation rule type has no effect on the operation of the aFRR aggregation platform, test 1.2. in Appendix A.5.1. verified that the aFRR aggregation platform is able to correctly activate units in order of increasing price, if it decided to choose this approach.

Cycle time: if the TSO sends its set-point signal more frequently (2s, as opposed to 4s), then the units are able to adjust better to it. The quality of aFRR reserve, obtained this way is higher so it is in the TSO's interest to use shorter cycle times.

For the rest, cycle time is just a setting in the platform that does not influence its design.

To test that aFRR aggregation platform can accept different set-point cycle times a physical test was executed. We have taken the same incoming set-point signal, and 2 different cycle times, 2 seconds and 4 seconds. Results in Appendix B.2 prove that the platform can support both options.

Results of all performed test for UC2 can be found in Appendix B.

2.3 Dynamic computer simulation

The following aFRR modules were tested by using the simulation tool that was specially developed for this purpose:

1. **User interface module:** signal-independent

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2. **Data exchange module:** needs DR/DG signals
3. **Forecasting module:** needs DR/DG signals
4. **Bidding module:** signal-independent (needs bids)
5. **Unit commitment module:** needs (simulated) TSO and DR/DG signals
6. **Control module:** needs (simulated) TSO and DR/DG signals

For the purpose of testing the communication interfaces (IEC 60870-5-104) which will be in place in the pilot tests, we prepared a simulation tool for all incoming and outgoing signals between the BSP (with connected DR/DG units) and the TSO.

With the simulation tool, a combination of logical aFRR flexibility aggregation algorithms, actual hardware controls located in Slovenia and Austria and simulated inputs from TSO and DR/DG can be extensively tested.

In Figure 4 the simulation tool is explained showing different parts of the environment. The *simulation environment* is placed between different physical locations (Slovenia and Austria) where communication channels (mobile and fixed) and the distance can be monitored as well.

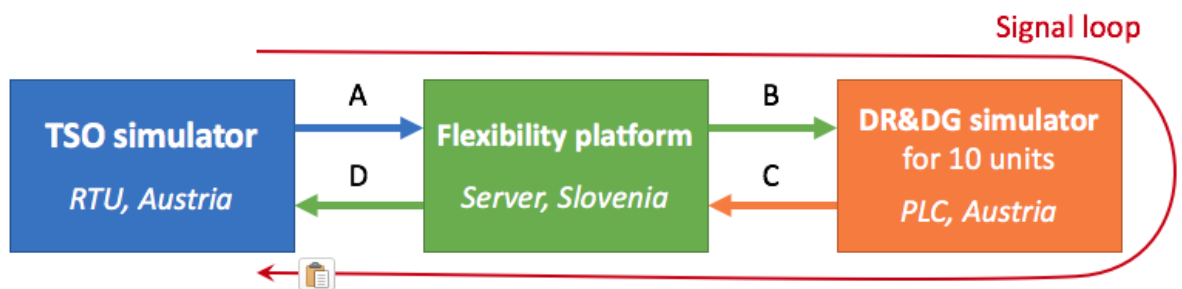


Figure 4: Simulation environment.

TSO simulator block in Figure 4 has all the necessary functionality, emulating the TSO in one of the FutureFlow control zone. The TSO simulator enables to communicate with flexibility platform via communication interfaces (IEC 60870-5-104) and is receiving, sending and visualizing the pool data from the BSP (flexibility platform).

User (TSO operator) can observe the following *incoming data* (letter D in Figure 4 **Napaka! Vira sklicevanja ni bilo mogoče najti.**):

- Current Power
- Lower Limit of controllable power
- Upper Limit of controllable power

[Type here]

- Baseline
- Baseline forecast (in $t + \text{FAT}$)
- Actual curtailed power
- Set-point loop back
- Indication if BSP has an active bid

The TSO simulator is emulating the local TSO AGC functionalities and is generating and sending set-points in configurable intervals to the flexibility platform. The *TSO simulator* is able to send the following types of set-points to the flexibility platform (letter A in the Figure 4 **Napaka! Vira sklicevanja ni bilo mogoče najti.**):

- Static set-point (manual)
- Automatic set-point generator: simulating set-points in the trapeze shape where user can set upper limit, lower limit, ramp rate and the duration of the set-point function
- Additional to the previous functionality user can select random mode where function is even more randomized
- Last option is to import predefined time-series data presenting the set-point

An example of a predefined time-series is displayed in Figure 5:

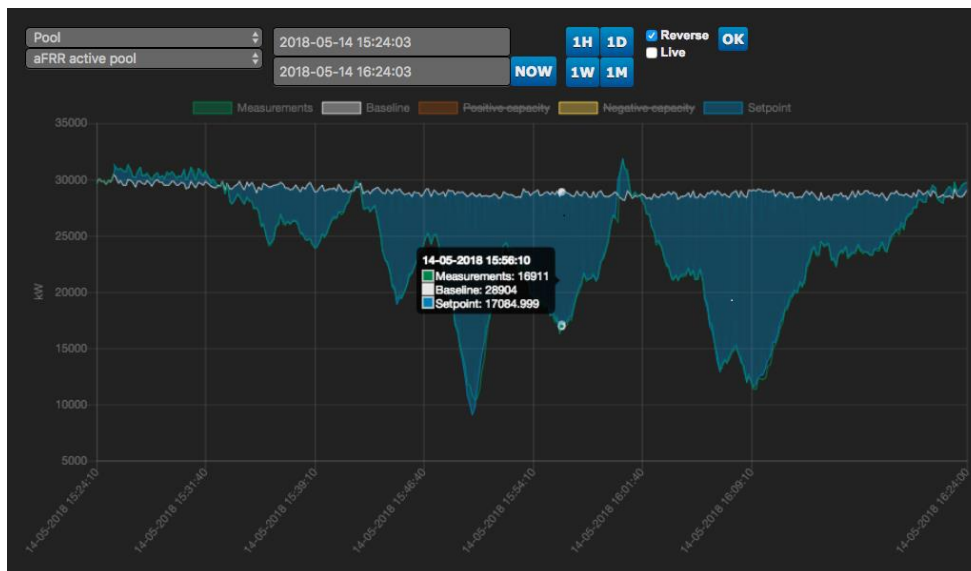


Figure 5: Real archive data from TSO

The TSO simulator interface is displayed in Figure 6 **Napaka! Vira sklicevanja ni bilo mogoče najti..**

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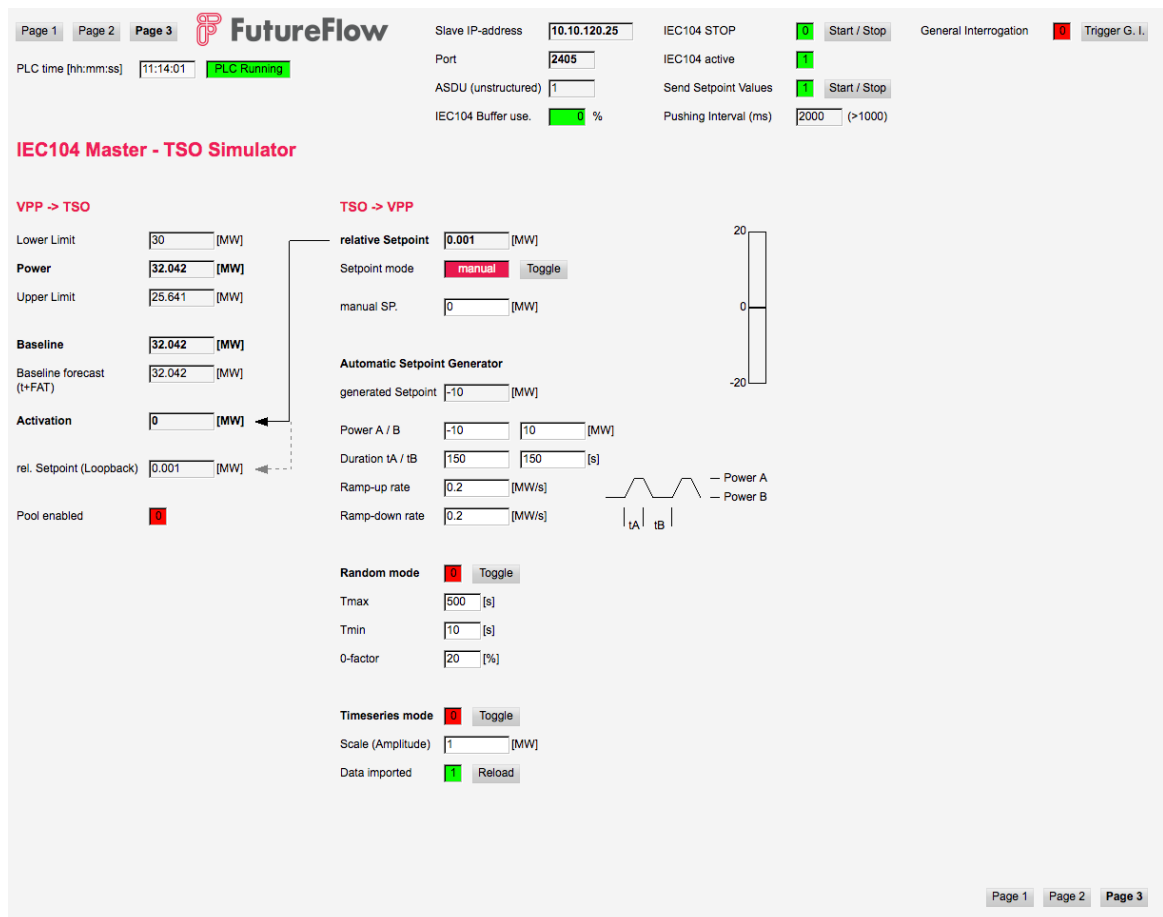


Figure 6: TSO simulator user interface.

On the right-hand side of Figure 4 a DR (distributed resources) & DG (distributed generation) simulator is placed simulating the behavior of the DR/DG technical units.

The technical units are able to generate load or generation profiles curves and send power data via communication interfaces (IEC 60870-5-104) to the flexibility platform and receive the set-point signals from the flexibility platform.

Data that are send to the flexibility platform (letter C in the Figure 4 **Napaka! Vira sklicevanja ni bilo mogoče najti.**):

- Power
- Positive and negative availability
- Positive and negative limit of controllable power
- Activation acknowledgement
- The DR/DG simulator can receive the following data (letter B in the Figure 4 **Napaka! Vira sklicevanja ni bilo mogoče najti.**):
- Set-point signal
- Start and Stop signal for activation start or end

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The load and generation profiles used inside the DR/DG simulator are sinus functions with several parameters to make them even more dynamic. The user is able to set the average, fluctuation, how many periods are in the sinus function per day, ramp rate of the unit when activation is received and noise parameters to simulate different real behaviors from the units.

The DR/DG simulator interface can be observed in Figure 7. Napaka! Vira sklicevanja ni bilo mogoče najti..

	Generator 11	Generator 12	Generator 13	Generator 14	Generator 15	Generator 16	Generator 17	Generator 18	Prosumer 19	Prosumer 20
Power [MW]	4.937	9.209	5.134	6.416	4.944	4.495	4.919	6.202	-7.207	-7.903
Availability	1 Toggle	0 Toggle	1 Toggle	0 Toggle	0 Toggle	1 Toggle	1 Toggle	1 Toggle	1 Toggle	1 Toggle
neg. Availability	1 Toggle	1 Toggle	1 Toggle	1 Toggle	0 Toggle	1 Toggle	1 Toggle	1 Toggle	1 Toggle	1 Toggle
Pneg, rel. [MW]	1.5	3	4	8.5	3	4.5	4	0.5	4	4
Ppos, rel. [MW]	0.5	1	3	2.5	2	5	3	0.5	2	4
rel. Setpoint [MW]	0	0	0	0	0	0	0	0	0	0
Activation ON	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse
Activation OFF	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse	0 Pulse
Activated	0	0	0	0	0	0	0	0	0	0
Act. Acknowledgmt.	0	0	0	0	0	0	0	0	0	0
Ack. Delay [s]	15	25	10	3	1	5	3	3	3	3
Baseline [MW]	4.937	9.209	5.134	6.416	4.944	4.495	4.919	6.202	-7.207	-7.903
Activation [MW]	0	0	0	0	0	0	0	0	0	0
Power Simulation Parameters										
Average [MW]	5	9	5	5	5	4	5	6	-7	-8
Fluctuation [MW]	0.5	0.9	1	2	0.5	0.5	0.5	0.5	0.5	0.5
Periods/day	2	3	1	7	2	0.5	2	3	2	3
Ramping	ON	ON	ON	ON	ON	ON	OFF	OFF	ON	ON
Slope [MW/s]	0.5	0.05	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.1
Noise Offset [MW]	0	0	0	0	0	0	0	0	0	0
Noise Amplid. [MW]	0.1	0.3	0.05	0.05	0.1	0.05	0.1	0.1	0.1	0.1
Noise Intervall [s]	30	10	2	50	1	120	1	1	1	1

Figure 7: DR/DG simulator user interface.

The set-up described above will be used throughout the testing procedures described in this document.

3 Results

In general different approaches to the validation of the software tools, such as aFRR aggregation platform, are possible. These range from the superficial overview of the functions available via the graphical user interface on the one hand to exhausting every possible check of the software code, even its supporting or most remote parts on the other hand. To enable drawing the relevant conclusions within the aims of Deliverable 2.3 we have used a combination of several methods, namely functional testing, computer simulations and thought experiment. These were selectively applied on the relevant areas of validation with varying the intensity needed to enable a clear result of validation.

To prove that certain functionality (for example "user login") is correctly implemented we have divided each functionality test into individual tests that the functionality test is composed of (for example "establish connection"). Each test was then executed by conducting the appropriate number of the simplest elementary steps (for example "change password"). Test scenarios, the supporting test procedures and the individual steps of validation as defined in this document (in Chapter 2 and Appendices) are therefore the most important ones for the successful operation of aFRR services in the FutureFlow DEMO environment. The aFRR aggregation platform was validated based on these tests with the possible results that the behaviour is implemented as specified (marked "OK"), behaviour is partially implemented as specified (marked "POK", behaviour is not in line with the specifications (marked "NOK"), to be implemented at a later stage in FF project (marked "TBIL") or not yet implemented (marked "NYI"). The results other than "OK" were commented with the observation of the tester and/or added to the Bug report table in Section A.7 and the test contains a note of the bug number.

The validation was performed by analysing 6 modules of the aFRR aggregation platform. The functioning of the modules have been tested with respect to the total of 16 functionalities that enable the modules to run. To prove that functionalities are operating as specified (or as expected) 37 individual tests, composed of 117 elementary steps have been performed by the testers.

The 107 of the tests (individual elementary steps) resulted in OK, 4 of them as NYI, 3 were identified as NOK, 1 was marked POK and 1 resulted in TBIL. The analysis produced 5 bugs that were subsequently fixed.

From the test results we can conclude that initially 92% of the functionalities have been in line with specifications, while 8% have not been suitably implemented. At the ending stage, once the identified bugs have been resolved we estimate that at least 96% of the functionality of the aFRR aggregation platform is implemented as specified.

It can be concluded that despite minor unfinished functions the aFRR aggregation platform meets the requirements of the FutureFlow project and is ready to be used for the pilot testing phase involving actual DR/DG resources.

4 Evaluation of benefits and limitations of the aFRR platform

Based on the test results of the aFRR flexibility platform we have identified several *benefits and limitations*.

These are the positive aspects:

- The biggest benefit is that aFRR flexibility platform *can adapt to the real-time deviations* when for example the DR/DG units are not performing as expected (providing requested aFRR service with deviation from the set-point).
- The next benefit is that the aFRR flexibility platform *can be used in different markets*, where each TSO specifies different market rules: for example, the communication interval and set-point reception rate is flexible (1s to 4s or higher), continuously changing set-points (ramps) as well as step-wise changing set-points are supported, etc...
- The platform is also *easy to use* (e.g. adding DR/DG units, monitoring the activation) and supports *heavy computation loads* (number of connected DR/DG units).

On the other hand, the testers noticed that the developed aFRR aggregation platform has some minor down sides:

- Firstly, it is a *complex tool* that enables the operators to choose from a large variety of options, monitoring tools and integration tools that takes some time to setup all the required parameters and options at the very first time when entering the aFRR market. The high number of parameters allows to cover several different options but can also be considered as a barrier considering ease-of-use from operator's perspective.
- The testers also found improvement potential in the activation process. The aFRR flexibility platform doesn't send a *final set-point value* at the level of the baseline (i.e. no curtailment need) to the DR/DG units at the end of an activation. It is not guaranteed, that the DR/DG units go back to the baseline if they just receive the "activation off" command.
- A possible further development would be to send a set-point indicating the level of the baseline for a duration of FAT in order to force the DR/DG units to go back to the initial level after the end of the activation, in order to guarantee a smooth ramp-down procedure at the end of an activation.
- Another limitation is the still improvable handling of DR/DG units, which only can perform discrete steps of activations, like on/off operations or require a minimum duration of activation. Such units cannot be offered to the aFRR market directly but might be integrated into a larger pool, where more flexible units could balance the discrete steps.

All in all, the aFRR aggregation platform that was designed and developed for the needs

[Type here]

of the FutureFlow project is a powerful tool and is certainly capable of managing the pool of distributed DR/DG units upon the request of the TSOs, as well as providing such service beyond the scope of this project – as a commercially available aFRR aggregation tool.

Furthermore, due to its versatility it is ready to adopt different regulatory settings that can be found in the four control zones of this project. Since its application in different control zones is non-problematic it can be argued that regulatory intervention or attempts to (formally) standardize the aFRR aggregation platform designs in general are not required.

It would however be recommended in general to unify the communication interfaces of TSOs from the aspect of a Balancing Service Provider (BSP), since that would enable a faster and more economically efficient deployment of such unified tools in the developing aFRR markets, especially with the outlook on the integration of balancing market and creation of equal level playing field for every BSP.

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Appendix A Test results for Use case 1: Validation of the prototyped aFRR aggregation platform under the FutureFlow target model settings

Under the FutureFlow target model settings the following aFRR modules were tested: 1. User Interface module, 2. Data Exchange module, 3. Forecasting module, 4. Bidding module, 5. Unit Commitment module and 6. Control module.


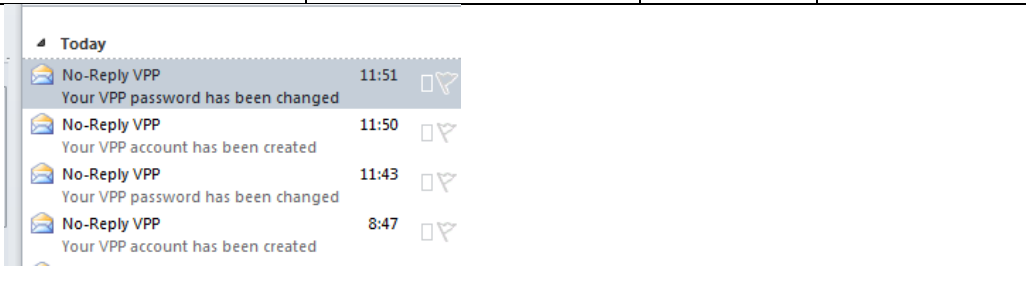
A.1 User interface module

In User Interface the basic functionality, necessary for starting to use the aFRR platform, is tested: 1. Login into the platform as admin and 2. Configuring the aFRR platform (adding users, granting and revoking permissions, removing users).

A.1.1 Login

Functionality name	No. 1 – Login			
Test ID	Test name	Test description		
1.1	Establish connection	System defined Admin has permissions to connect to aFRR platform		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Access login page	Login page is accessible	Admin	OK
Screenshots				
2	Enter admin username & password	Admin was able to enter username & password. Login successful. Admin able to see <i>Configuration page</i> .	Admin	OK

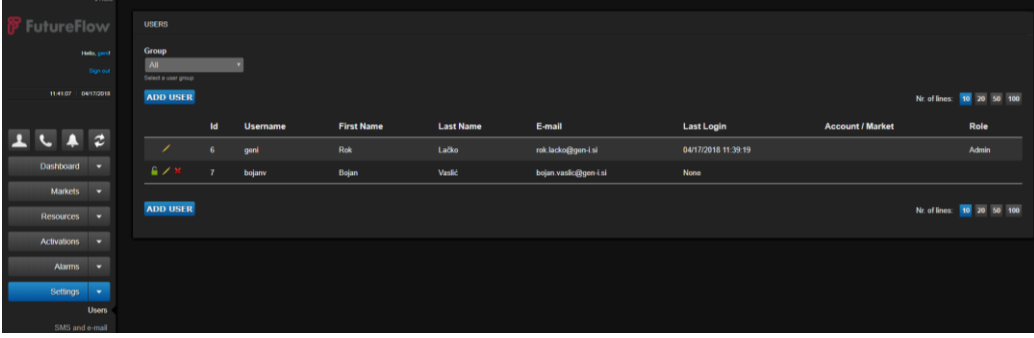
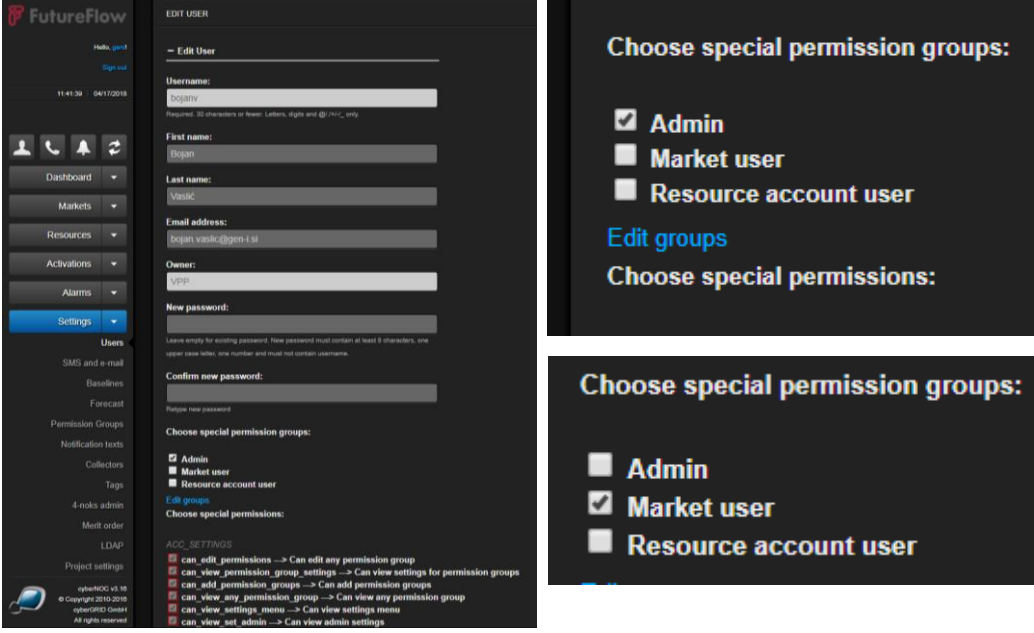
[Type here]

<p>Screenshots</p> 				
3	Change password	Password successfully changed	Admin	OK
<p>Screenshots</p> 				

A.1.2 Configuration of aFRR platform

Functionality name	No. 2 – Configuration of aFRR platform			
Test ID	Test name	Test description		
2.1	Configure platform	Admin has options to configure aFRR platform, such as: <ul style="list-style-type: none"> • Create new users • Set up user permissions • Enable/disable aFRR modules • Initial configuration of modules • Set up other system settings (Email server, ...) • Establish connection(s) to TSO 		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Admin creates new user. User tests logging into platform.	User is able to log into aFRR platform.	Admin, User	OK

[Type here]

<p>Screenshots</p>				
<p>2</p>	<p>Grant user permissions (one by one). User tests added permission.</p>	<p>User has every added permission.</p>	<p>Admin, User</p>	<p>OK</p>
<p>Screenshots</p>				
<p>3</p>	<p>Revoke permission (one by one). User tests revoked permission.</p>	<p>User does not have revoked permission.</p>	<p>Admin, User</p>	<p>OK</p>
<p>4</p>	<p>Remove user. User tests accessing aFRR platform.</p>	<p>User is removed. User can't access the platform.</p>	<p>Admin, User</p>	<p>POK (Bug ID#:1)</p>
<p>Test ID</p>	<p>Test name</p>	<p>Test description</p>		
<p>2.2</p>	<p>View configuration</p>	<p>System Admin can view configured settings</p>		
<p>Test procedure</p>				
<p>Step number</p>	<p>Step description</p>	<p>Expected result and evaluation criteria</p>	<p>Tester Role</p>	<p>Result</p>
<p>1</p>	<p>Admin checks if he sees new user in configuration page.</p>	<p>Admin sees new user.</p>	<p>Admin</p>	<p>OK</p>
<p>2</p>	<p>Admin checks if new user has all granted permissions (one by one).</p>	<p>Admin sees that user has all granted permissions. (one by one).</p>	<p>Admin</p>	<p>OK</p>
<p>3</p>	<p>Admin checks if permission X1 is revoked.</p>	<p>Admin sees that user has permission X1 revoked.</p>	<p>Admin</p>	<p>OK</p>

[Type here]

	Admin checks if permission X2 is revoked.	Admin sees that user has permission X2 revoked.		
4	Admin checks if user is removed.	Admin sees that user is removed.	Admin	OK

A.2 Data Exchange module

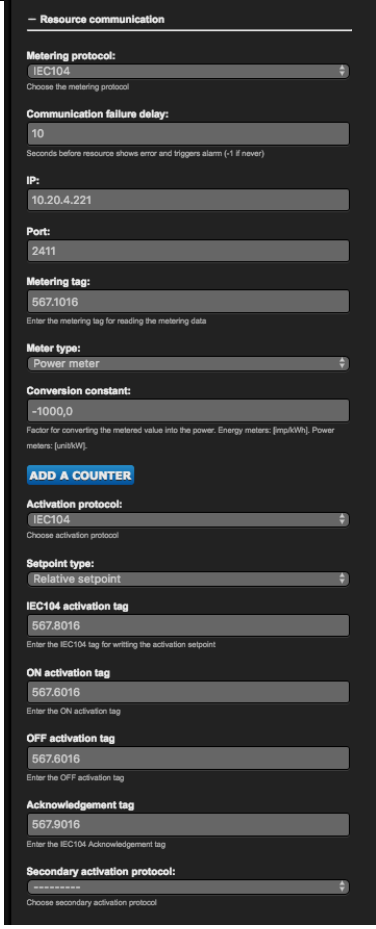
The Data Exchange module is the second one, necessary for the operation of all the other modules.

The following functionality was tested: 1. User adds a new DR/DG unit and its relevant information (such as address, contact info, forecasting flexibility and availability settings, resource communication settings, etc.), 2. User starts to receive online data from the DR/DG unit (such as active power, lower and upper limits, positive and negative availability, activation confirmation and mirror set-point).

A.2.1 Adding new DR/DG unit

Functionality name	No. 1 – Adding new DR/DG unit			
Test ID	Test name	Test description		
1.1	User enters new DR/DG unit to the aFRR platform	aFRR user enter the new unit and its relevant information (list) via the UI module.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	User accesses “new unit creation” page.	“New unit creation” page is accessible	User	OK
2	User enters relevant information about the new unit.	The relevant information (e.g. address, contact info, forecasting flexibility and availability settings, resource communication settings, resource facility data, peak, product data, fee settings) was successfully entered	User	OK
Screenshot	A: Example: Communication parameters when entering new DR/DG unit			

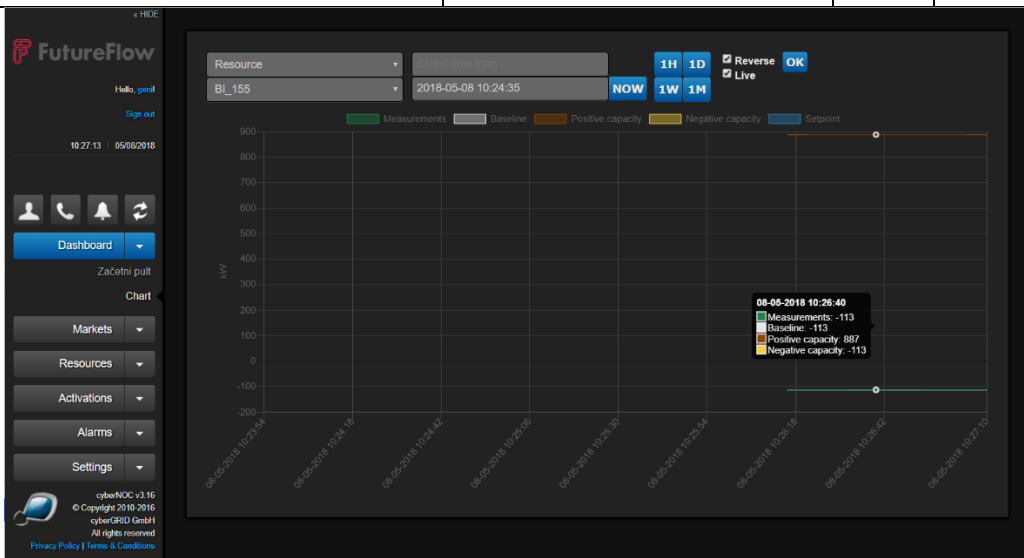
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Test ID	Test name	Test description		
1.2	User saves new unit's data via the "Add resource facility" page.	User saves the newly entered data about the new unit, via the "Add resource facility" page.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	User saves the new unit's data. He verifies that the data was saved successfully.	The new unit, together with all its corresponding data is visible and editable through the "View resource facilities" page.	User	OK

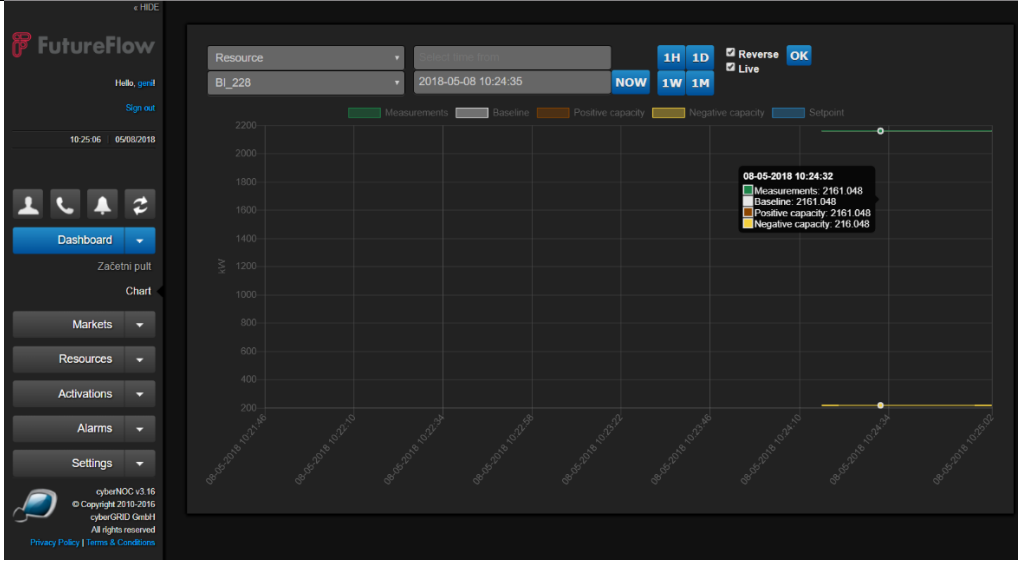
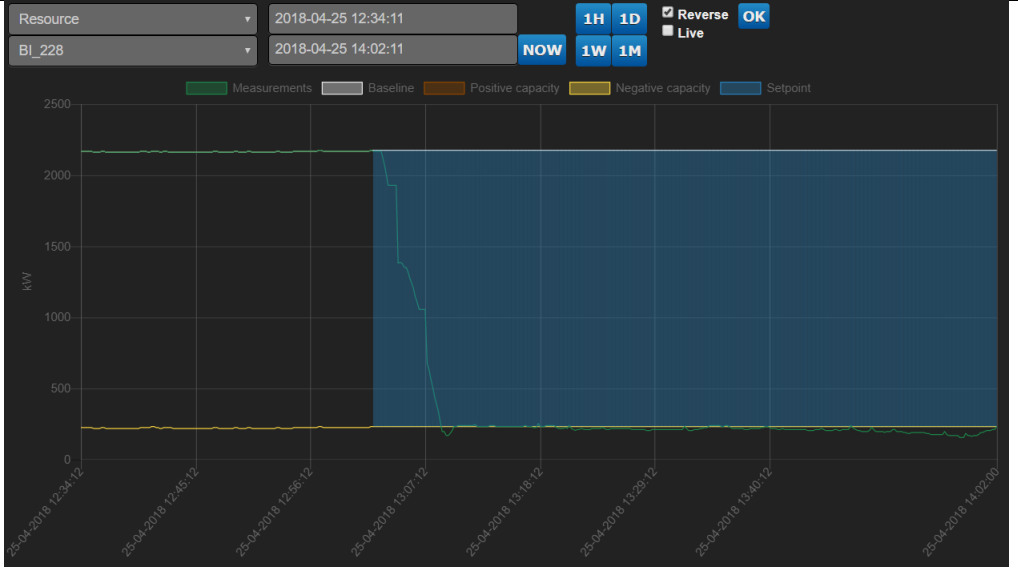
A.2.2 Receiving online data from units

Functionality name	No. 2 – Receiving online data from units			
Test ID	Test name	Test description		
2.1	Acknowledge that online data from units is being received	Data exchange module is receiving online data: <ul style="list-style-type: none"> • active power • lower limit • upper limit • positive availability • negative availability • activation confirmation (during activation) • mirror set-point (during activation) 		

[Type here]

Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Verify that online data was received and is visible (chart)	Online data (active power, lower limit, upper limit, positive availability, negative availability, <i>possibly</i> activation confirmation, <i>possibly</i> mirror set-point) is visible in UI	User	OK
2	Active power measurement [kW] value matching check	Active power observed at UI matches the active power observed at unit	User	OK
3	Lower limit of controllable range [kW] matching check	Lower limit observed at UI matches the Current Available Power Negative value observed at unit without the negative sign.	User	OK
4	Upper limit of controllable range [kW] matching check	Upper limit observed at UI matches the Current Available Power Positive value observed at the unit.	User	OK
5	Positive availability [0/1] matching check	Is observed to be 0 at the UI if upper limit is 0 at the unit and is 1 otherwise	User	OK
Screenshots	 <p>The unit has is currently consuming 113 kW energy. It has positive availability up to a production of 887 kW, hence altogether 1000 kW.</p>			
	6	Negative availability [0/1] matching check	Is observed as 0 at the UI if lower limit is 0 at the unit and is 1 otherwise	User

[Type here]

<p>Screenshots</p>				
	<p>The observed resource is currently producing 2126 kW, and is available for negative reserve up to the production of 216 kW, hence altogether 1900 kW.</p>			
<p>7</p>	<p>Activation confirmation (ACK) [0/1] observation</p>	<p>Is observed as 0 at the UI (Note: The value 1 <i>cannot</i> be tested without activation)</p>	<p>User</p>	<p>OK</p>
<p>8</p>	<p>Mirror Set-point [kW] observation</p>	<p>Is observed as 0 at the UI (Note: The value 1 <i>cannot</i> be tested without activation)</p>	<p>User</p>	<p>OK</p>
<p>Screenshot</p>				
	<p>The graph displays the real activation of a hydropower plant, which reduced its production to generate 2MW of negative power.</p>			
<p>9</p>	<p>The lower and upper controllable range changes according to similar changes performed at the unit.</p>	<p>If capacities are changed at the unit, these changes are visible <i>instantly</i> at the UI.</p>	<p>User</p>	<p>OK</p>
<p>10</p>	<p>Check if availability changes according to changes at the unit.</p>	<p>If availability is changed at the unit (e.g. switching off the unit, unit failure), these changes are visible <i>instantly</i> at the UI.</p>	<p>User</p>	<p>OK</p>

[Type here]

A.3 Forecasting module

All three different ways of executing forecasting calculations in the Forecasting module were tested.

Each forecasting procedure calculates the *baseline*, *upper* and *lower limits* of available flexible capacity. The forecasting algorithm is set per unit. Three different types of calculations were implemented:

- **External calculation:** produced by a 3rd party forecasting service provider. These forecasts are recalculated every 1h.
- **Internal calculation:** produced internally by the aFRR platform, once daily for a week ahead. When necessary, *real-time forecasts* can also be executed and added on top of the external/internal forecasting calculation.
- **Final baseline calculation at activation event:** - to correct the baseline of the dispatched units, if necessary.

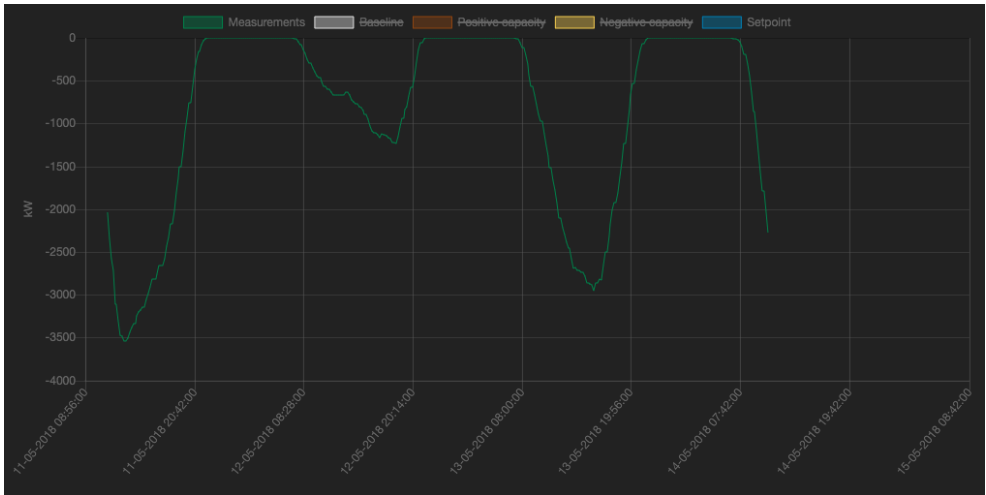
A more extensive description of the calculations can be found in Attachment 9.2. of Deliverable 2.1 (see: 2. Diagram of use case and 4.1. Overview of scenarios).

A.3.1 External calculation

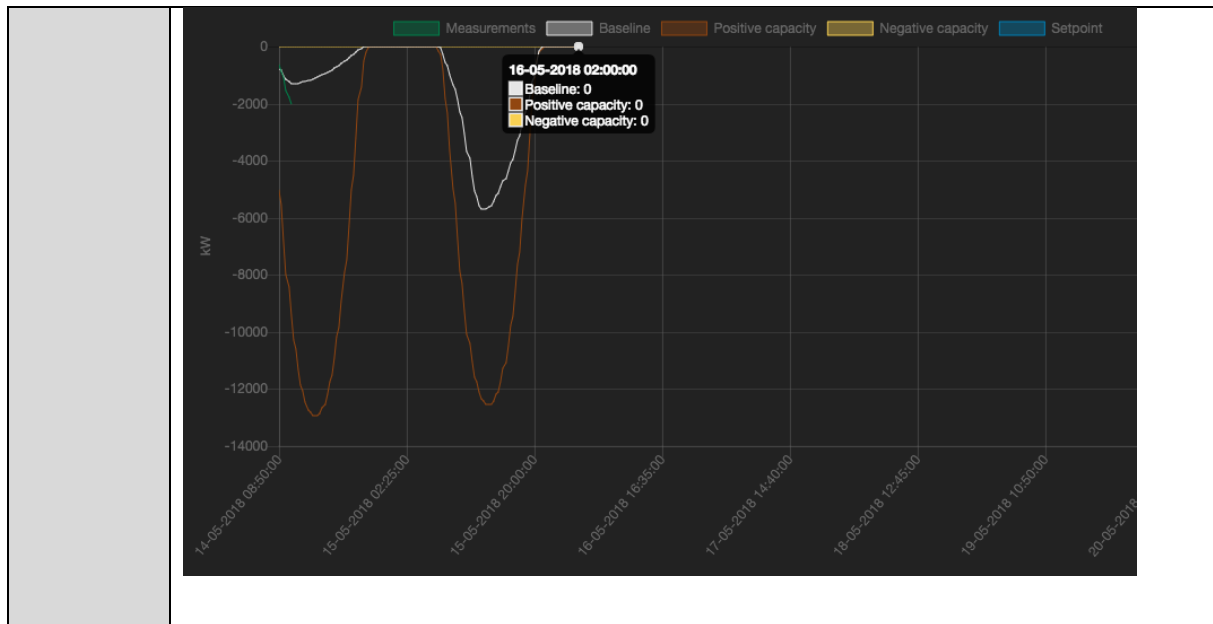
External forecasts are updated every hour.

Functionality name	No. 1 - External calculation			
Test ID	Test name	Test description		
1.1a	3 rd party (external forecast provider) is receiving data needed for the forecasting calculation in real time.	When the 3 rd party intends to produce the needed forecasts for a specific unit, based on its specifications they request certain data from the aFRR platform. They connect to the platform and start receiving data needed for forecasting calculation.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator adjusts the unit's settings, in a way that will permit the 3rd party to start receiving data needed for external calculation. The correct settings are: <ul style="list-style-type: none">• <i>Baseline type:</i> External• <i>Forecasting algorithm:</i> External nominal capacity	3 rd party receives the unit specific parameters needed for perform the forecasting calculation.	User	OK
2	3 rd party establishes a secure channel with the aFRR platform	3 rd party is securely connected to the aFRR platform.	3 rd party	OK

[Type here]

3	3 rd party requests the necessary real-time data	3 rd party is receiving the requested data (active power data) in real time.	3 rd party	OK
4	3 rd party is not able to access data that they are not authorized to view.	3 rd party cannot access unauthorized data (e.g. active power data)	3 rd party	OK
Test ID	Test name	Test description		
1.1b	Validate forecasting data	Data received from the 3 rd party appear to be valid, and within an expected range.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	The received forecast data can be observed on a chart. (Dashboard → chart)	The user is able to see the forecast curves (baseline, upper and lower limit of controllable power) on a chart	User	OK
2	User checks validity of the displayed forecasting data	The forecasting data, observable on the chart, appears to be within an expected range.	User	OK
3	User observed the duration of the forecasting data refresh cycle.	The forecasting data is refreshing at a rate corresponding to the one specified in settings. Changes are visible on the chart.	User	OK
Screenshots	A: Real-time measurement of DG emulating PV			
				
	B: PV day-ahead forecasting from 3 rd			

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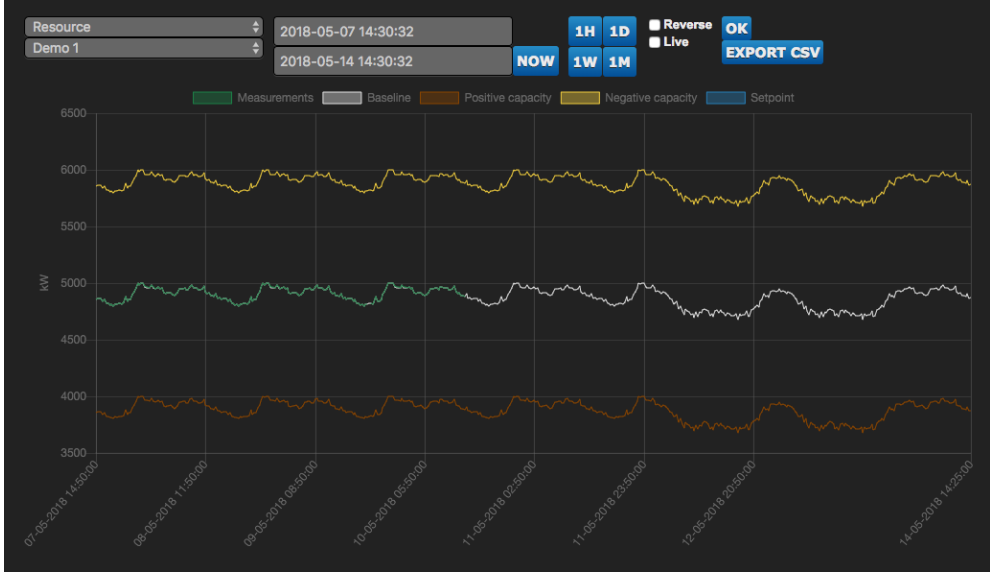


A.3.2 Internal calculation

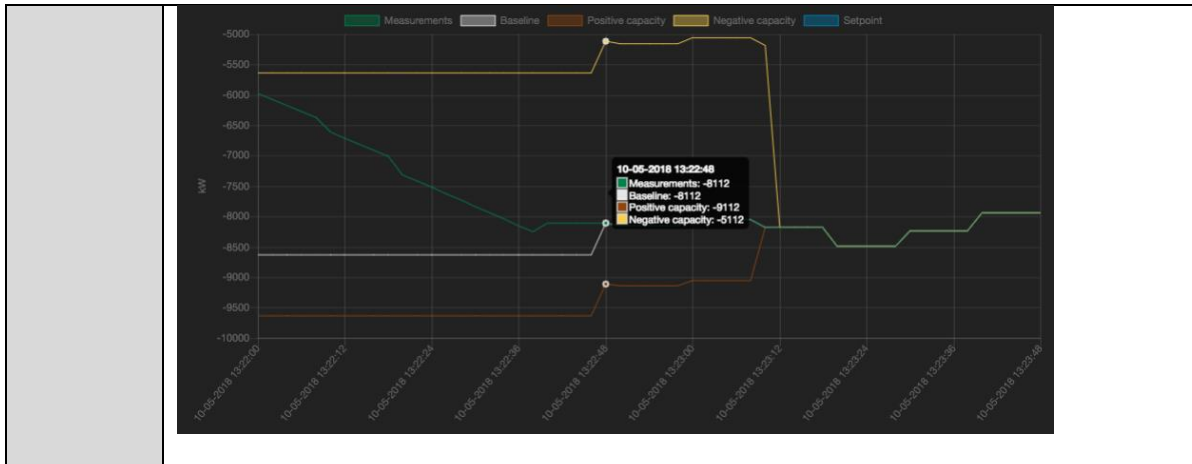
Internal forecasts are produced automatically once per day, for a week ahead (2.1a); when needed these forecasts are corrected intraday, by adding a correction on top of them (2.1b). The implementation of the internal calculation is explained in deliverables D2.1 and D2.2a.

Functionality name	No. 2 - Internal calculation			
Test ID	Test name	Test description		
2.1a	aFRR aggregation platform calculates forecasting data based on the historic data.	Forecasting data is within the range of expected behavior (based on historic data)		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator adjusts the unit's settings to internal forecasting calculation. The correct settings are : <ul style="list-style-type: none"> • <i>Baseline type:</i> Type1 • <i>Forecasting algorithm:</i> Clipped Nominal capacity 	Operator can observe specified forecasting parameters in the aFRR aggregation platform.	User	OK
2	Received forecasting data can be observed on the chart. (Dashboard → chart)	Operator can see forecasting curves on the chart (baseline, upper and lower limit of controllable power.)	User	OK
3	Forecasting data on the chart are valid.	Forecasting data on the chart are within range of expected data.	User	OK
4	Forecasting data refresh cycle can be set by the operator based on the	The forecasting data is refreshing at a rate corresponding to the one specified in	User	OK

[Type here]

	use-case needs, e.g. 15min.	settings. Changes are visible on the chart.		
Screenshots	A: Forecasting data calculated with the history data of DR/DG			
				
Test ID	Test name	Test description		
2.1b	Forecasting data correction	On top of the internal forecasting calculation additional <i>forecasting correction</i> is added to enhance forecast accuracy even further. Data is forecasted based on the real-time data (active unit power) from the units.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	<i>Correction</i> of forecasting data can be observed on the chart.	Operator can see <i>real-time</i> forecasting curves on the chart (baseline, upper and lower limit of controllable power.)	User	OK
2	<i>Correction</i> of forecasting data on the chart are valid.	<i>Real-time</i> forecasting data on the chart are within range of expected data.	User	OK
3	<i>Correction</i> of forecasting data refreshes based on <i>real-time</i> data.	Forecasting data is refreshing based on the incoming <i>real-time</i> data (active power) from the units. Changes must be visible on the chart.	User	OK
Screenshot	A: Baseline correction			

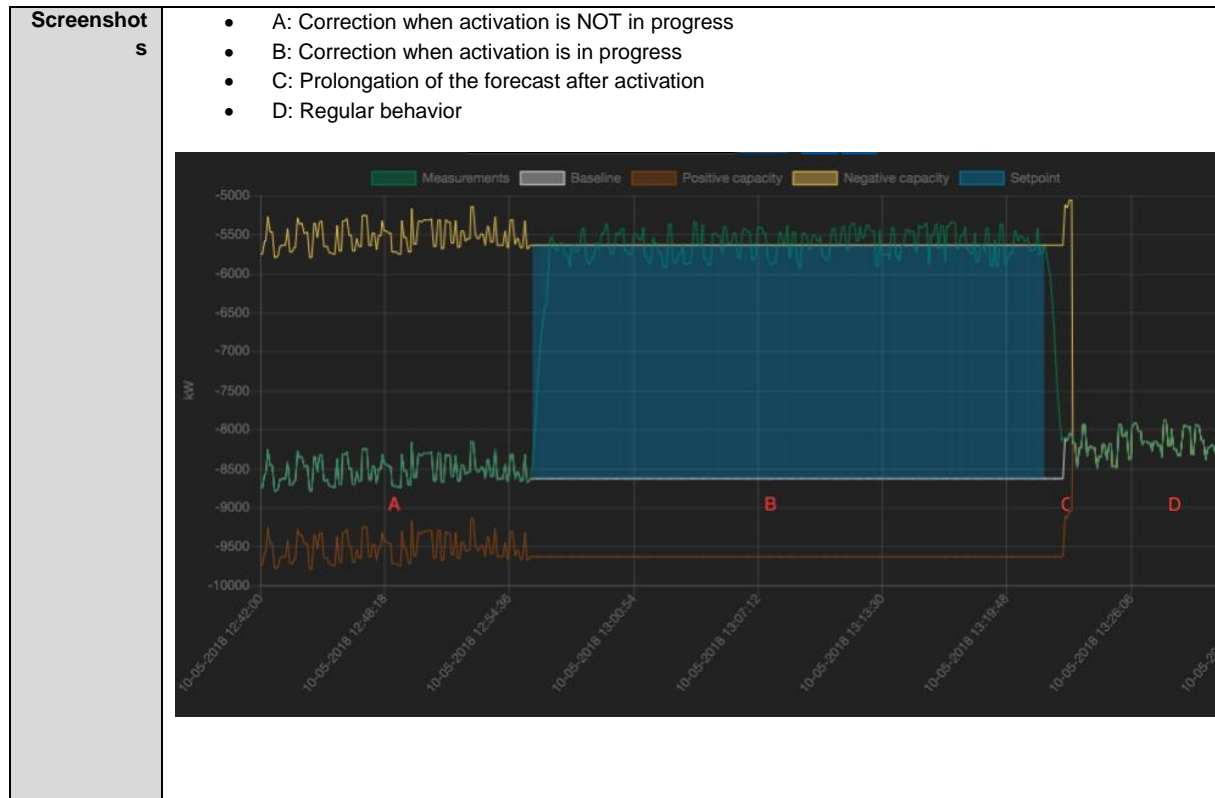
[Type here]



A.3.3 Final baseline calculation at activation event

Functionality name	No. 3 – Final baseline calculation at activation event			
Test ID	Test name	Test description		
3.1	When <i>activation</i> takes place forecasting data must not be updated.	When activation is in progress, forecasting data must not be changed.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Activation is not in progress	The standard behavior of forecasting calculation and forecast correction must be in place.	User	OK
2	Activation in progress	When activation is in progress forecasting data <i>must not</i> be updated and should be frozen at the time the activation signal was received from the TSO.	User	OK
3	Forecasting prolongation after the signal for end of activation is received from the TSO.	Forecasting data should remain frozen for a specified time interval (e.g. FAT time which in FutureFlow is set to 5 min) whenever the signal for the end of activation is send to the unit. In this way, forecasts and baseline will be considered correctly.	User	OK

[Type here]



A.4 Bidding module

Use case 4 first tests all basic bidding functionality (provision of power availability schedules (*availability calendars*), provision of unit parameters relevant for bidding (e.g. capacity, price of activation, price of energy), bids visualization, automatic and manual bids creation, manual export of bids, manual import of bids, provision of information on accepted bids), then proceeds to test some more marginal cases, where different rules need to be followed correctly at the same instant.

A.4.1 Availability (of flexible power)


Functionality name	No. 1 - Availability (of flexible power)			
Test ID	Test name	Test description		
1.1	Provision of <i>forecasted power</i> availability schedules (calendars).	Forecasting module provides power availability schedules for each DR/DG unit to the bidding module.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Each unit sends their availability/unavailability status	All the resources have the correct availability. This helps bidding module to predict the unavailability of the units for the particular time period for which the system is	User	OK

[Type here]

calculating the bids.

Screenshot

A: Unit sends the unavailability (Generator 12: Availability (positive) Toggled to "0")

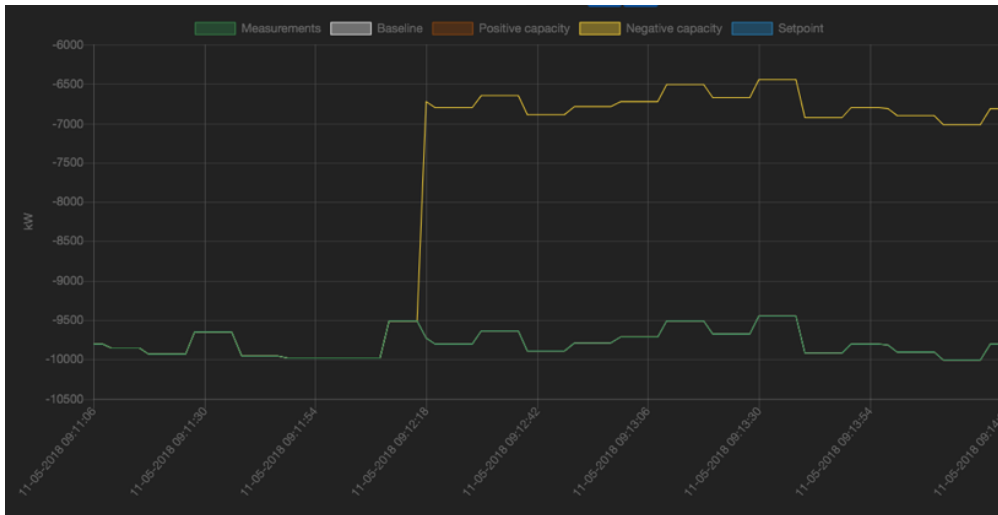
Page 1 Page 2 Page 3  FutureFlow

PLC time [hh:mm:ss] 09:14:53 PLC Running

Resource simulation (R)

	Generator 11	Generator 12	Generator 13	Generator 14
Power [MW]	<input type="text" value="4.577"/>	<input type="text" value="9.931"/>	<input type="text" value="5.622"/>	<input type="text" value="3.000"/>
Availability	1 Toggle	0 Toggle	1 Toggle	0 Toggle
neg. Availability	1 Toggle	1 Toggle	1 Toggle	1 Toggle
Pneg, rel. [MW]	<input type="text" value="1.5"/>	<input type="text" value="3"/>	<input type="text" value="4"/>	<input type="text" value="8.5"/>
Ppos, rel. [MW]	<input type="text" value="0.5"/>	<input type="text" value="1"/>	<input type="text" value="3"/>	<input type="text" value="2.5"/>
rel. Setpoint [MW]	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

B: Unavailability of the unit (Generator 12) on the chart (Yellow curve)



C: Units unavailability's

[Type here]

Resource facility name	Resource account	Resource pools	Region	Power	Positive capacity	Negative capacity	Type	Activation count D: W: M: Y:	Process status	FR
151	Test	aFRR active pool	Idrija	10.0 MW	1.0 MW	0.0 MW	Generator	1 1 525 744	🔒	0.0%
152	Test	aFRR active pool	Idrija	0.85 MW	0.85 MW	0.0 MW	Consumer	0 0 424 557	🔒	0.0%
155	Test	aFRR active pool	Idrija	1.0 MW	1.0 MW	0.0 MW	Generator	0 0 600 340	🔒	0.0%
156	Test	aFRR active pool	Idrija	1.0 MW	1.0 MW	0.0 MW	Generator	0 0 450 850	🔒	0.0%
164	Test	aFRR active pool	Idrija	1.1 MW	0.0 MW	1.0 MW	Generator	0 0 0 237	🔒	0.0%
236	Test	aFRR active pool	Idrija	0.21 MW	0.0 MW	0.183 MW	Generator	0 0 0 175	🔒	0.0%
253	Test	aFRR active pool	Idrija	0.45 MW	0.0 MW	0.30 MW	Generator	0 0 580 824	🔒	0.0%
254	Test	aFRR active pool	Idrija	0.0 MW	0.0 MW	0.0 MW	Generator	0 0 100 313	🔒	0.0%
282	Test	aFRR active pool	Idrija	130.0 MW	0.0 MW	0.0 MW	Consumer	0 0 516 696	🔒	0.0%
Generator T1	Test	aFRR active pool	Test	10.0 MW	1.0 MW	1.0 MW	Generator	0 0 0 819	🔒	0.0%

The bulbs on the figure above show the availability status: Yellow – available, Grey- unavailable, Red-offline, Blue- in activations

Test ID	Test name	Test description
1.2	Manual schedules	User manually enters to the platform availability schedules of flexibility for each DR/DG unit in the case, planned changes are foreseen in the near future. The schedules need to be visible in the UI (available flexibility decreases for the specified time interval)

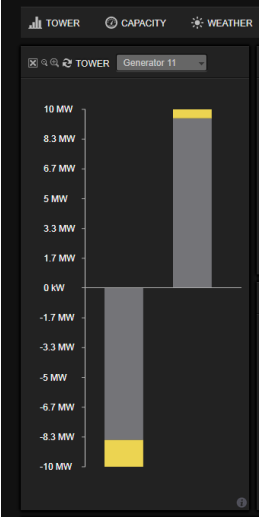
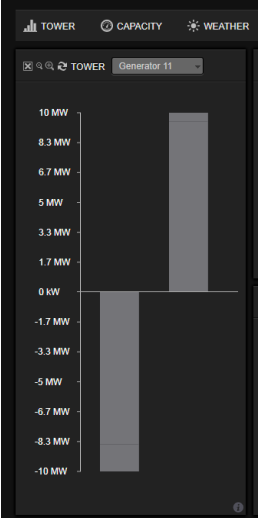
Screenshots	Start time	End time	Avail. [%]
	04/18/2018 00:00:00	04/19/2018 00:00:00	100 +/-
	04/19/2018 00:00:00	04/20/2018 00:00:00	50 +/-
	04/20/2018 00:00:00	04/21/2018 00:00:00	100 +
	04/21/2018 00:00:00	04/22/2018 00:00:00	1 -

Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator sets the availability of all resources	All the resources have the correct availability.	User	OK
2	Operator changes the availability of one or more resources during the day	All the changes are seen live as they happen.	User	OK

Test ID	Test name	Test description
1.3	Automatic schedules	External system (units or 3 rd party providing forecasting data) can send availability signals in real-time indicating there is a problem with the unit (e.g. unit has broken). The schedules needs to be visible in the UI (available flexibility decreases for the specified time interval)

Test procedure				
Step	Step description	Expected result and	Tester Role	Result

[Type here]

number		evaluation criteria		
1	External system sets the availability of all resources	All the resources have the correct availability.	User	NYI
2	External system changes the availability of one or more resources during the day	All the changes are seen live as they happen.	User	NYI
Screenshots	 <p>Generator #11 is 100% available</p>			
Screenshots	 <p>Generator #11 is 0% available</p>			

A.4.2 Cost of activation

Functionality name	No. 2 – Cost of activation	
Test ID	Test name	Test description
2.1	Provision of <i>unit parameters</i> relevant for bidding, such as available capacity, activation price and energy price.	aFRR user provides information to the bidding module about the costs of activation for all resources
Test procedure		

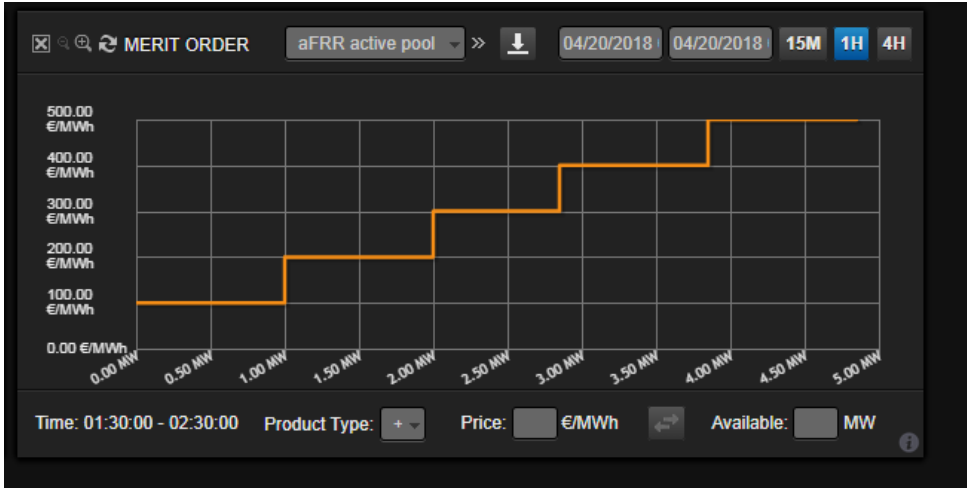
[Type here]

Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator sets the price (activation price, energy price and capacity price) of all resources	Operator sets the price of activation of every resource. The price for the same resource can vary by time frames, by positive/negative activation, and by power of activation.	User	OK
2	Operator modifies the price (activation price, energy price and capacity price) of all or some resources	Operator modifies the price set in step 1 of activation of every resource. The price can vary by time frame, by positive/negative activation, and by power of activation.	User	OK

Screenshot A: DR/DG parameters defining fees



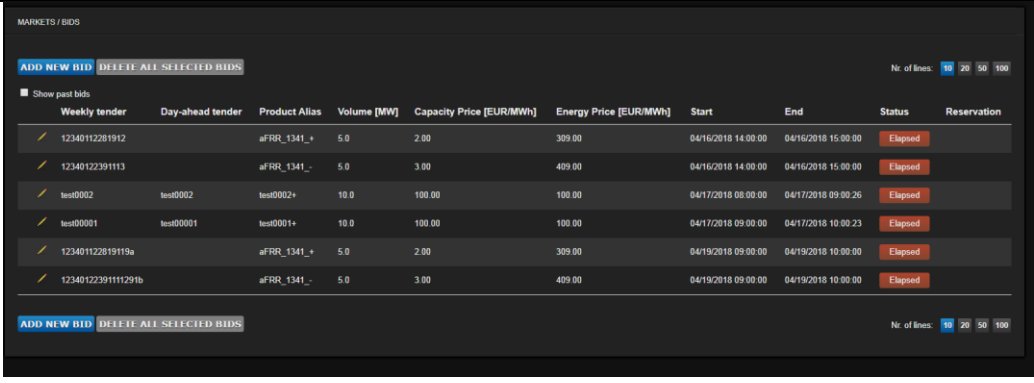
B: Merit-order of the active pool based on the DR/DG prices



A.4.3 Bids visualization

Functionality name	No. 3 – Bids visualization	
Test ID	Test name	Test description

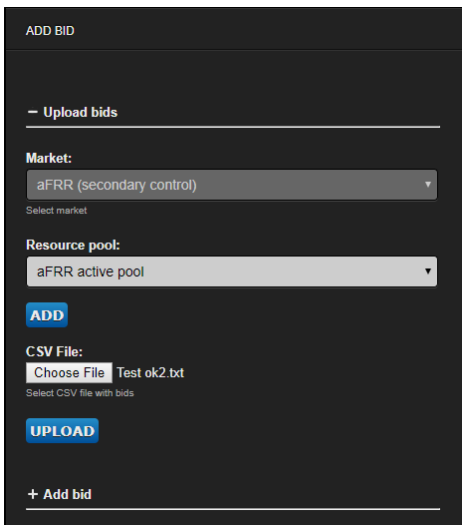
[Type here]

3.1	Display of bids in the system.	All the bids for (each) pool are displayed in the UI module.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator is able to see the information related to the bids in the system.	For every bid the operator can see: its quantity, price, bid number, period, energy direction (positive/negative) and status (pending, in progress, elapsed).	User	OK
Screenshot				
Test ID	Test name	Test description		
3.2	Display of cost of activation	The cost of activation is displayed in the UI module.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Testing Role	Result
1	Operator can see the cost of every bid (bid number, energy amount, energy direction, time frame, price)	For every bid the operator can see the quantity, time period, direction, price (energy and capacity) and the status of the bid.	User	OK

A.4.4 Bids creation

Functionality name	No. 4 – Bids creation			
Test ID	Test name	Test description		
4.1	Automated bid creation Full functionality will be developed in D2.2b.	aFRR platform is calculating bids periodically with respect to the available power of particular DR/DG unit and the products, based on the bid creation algorithms.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator initiates the automated bid creation process	Purposed bids are created in an automated manner, based on all relevant bid-creation parameters	User	NYI
2	The aFRR platform suggests bids to be offered at the auction	The proposed bids are displayed for the operator to review/confirm	User	NYI
3	The operator either confirms the	The confirmed bids are set in the platform	User	NYI

[Type here]

	proposed set of bids or modifies them			
Test ID	Test name	Test description		
4.2	Manual bid creation	User is able to import a set of bids he created manually, outside the aFRR platform. He can create bids with one unit or bids composed with several units. He should also be able to create more than one bid for one unit (<i>split bids</i>).		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator uploads the bids he created outside of the platform	Bids, that the operator created are inspected (correct format, correct positive/negative numbers,...) and uploaded. The uploaded bids overwrite the bid, created by the platform. Operator can upload minimal data (bid volume, price, direction, and control zone), maximal data (minimal data, plus resource, resource price, resource availability, priority,...)	User	OK
2	The system validates bids.	The system checks if bids import has an error and informs user about the error.	User	OK
3	Edit manual created bids.	User is able to manually edit the imported bids within the aFRR aggregation platform.	User	OK
Screenshot	<p>A: Input form for user to import the bids</p>  <p>B: List of imported bids</p>			

[Type here]

MARKETS / BIDS

ADD NEW BID DELETE ALL SELECTED BIDS

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Show past bids

Weekly tender	Day-ahead tender	Product Alias	Volume [MW]	Capacity Price [EUR/MWh]	Energy Price [EUR/MWh]	Start	End	Status	Reservation
REF.NR_Test_positiv_1_+	ANG.NR_Test_positiv_1_+	Test_positiv_1_+	5.0	1.00	200.00	04/20/2018 02:00:00	04/20/2018 03:00:00	In waiting	
REF.NR_Test_negativ_1_+	ANG.NR_Test_negativ_1_+	Test_negativ_1_+	5.0	1.00	200.00	04/20/2018 02:00:00	04/20/2018 03:00:00	In waiting	
REF.NR_Test_positiv_2_+	ANG.NR_Test_positiv_2_+	Test_positiv_2_+	5.0	1.00	200.00	04/20/2018 03:00:00	04/20/2018 04:00:00	In waiting	
REF.NR_Test_negativ_2_+	ANG.NR_Test_negativ_2_+	Test_negativ_2_+	5.0	1.00	200.00	04/20/2018 03:00:00	04/20/2018 04:00:00	In waiting	
REF.NR_Test_positiv_3_+	ANG.NR_Test_positiv_3_+	Test_positiv_3_+	5.0	1.00	200.00	04/20/2018 04:00:00	04/20/2018 05:00:00	In waiting	
REF.NR_Test_negativ_3_+	ANG.NR_Test_negativ_3_+	Test_negativ_3_+	5.0	1.00	200.00	04/20/2018 04:00:00	04/20/2018 05:00:00	In waiting	
REF.NR_Test_positiv_4_+	ANG.NR_Test_positiv_4_+	Test_positiv_4_+	5.0	1.00	200.00	04/20/2018 05:00:00	04/20/2018 06:00:00	In waiting	
REF.NR_Test_negativ_4_+	ANG.NR_Test_negativ_4_+	Test_negativ_4_+	5.0	1.00	200.00	04/20/2018 05:00:00	04/20/2018 06:00:00	In waiting	
REF.NR_Test_positiv_5_+	ANG.NR_Test_positiv_5_+	Test_positiv_5_+	5.0	1.00	200.00	04/20/2018 06:00:00	04/20/2018 07:00:00	In waiting	
REF.NR_Test_negativ_5_+	ANG.NR_Test_negativ_5_+	Test_negativ_5_+	5.0	1.00	200.00	04/20/2018 06:00:00	04/20/2018 07:00:00	In waiting	
REF.NR_Test_positiv_6_+	ANG.NR_Test_positiv_6_+	Test_positiv_6_+	5.0	1.00	200.00	04/20/2018 07:00:00	04/20/2018 08:00:00	In waiting	
REF.NR_Test_negativ_6_+	ANG.NR_Test_negativ_6_+	Test_negativ_6_+	5.0	1.00	200.00	04/20/2018 07:00:00	04/20/2018 08:00:00	In waiting	

C: Validation of the imported bids

ADD BID

Failed importing data. Could not determine delimiter

Upload bids

Market: aFRR (secondary control)

Resource pool: aFRR active pool

ADD

CSV File: No file chosen

UPLOAD

+ Add bid

D: User can edit bids

[Type here]

EDIT BID

– Edit bid

Start date and time:
05/07/2018 11:00:00
Insert start time of your bid

End date and time:
05/07/2018 12:00:00
Insert end time of your bid

Bid number:
Insert bid number

Parent bid number:
12340122391111916128
Insert parent bid number

Product alias:
aFRR_3341_-
Insert product alias

Capacity:
5,0
Insert capacity in MW

Capacity price:
3,00
Capacity price in EUR/MWh

Energy price:
409,00
Energy price in EUR/MWh

Market:
aFRR (secondary control)
Select market

Resource pool:
aFRR active pool
Select resource pool

Resource:
Select resource

Bid status:
Accepted
Select the status of the bid

SAVE

A.5 Unit commitment module

The Unit Commitment module deals with the correct activation of DR/DG units.

The following scenarios were tested: 1. Standard activation situations (e.g. simple activation, activating several units in a bid in the order of internal Merit Order, two activations within one bid, activating two consecutive bids with the same units), 2. Controlling unexpected activation behavior with closed loop (activating alternative units in case of too late activation, under-activation and over-activation of single units, unit failure), 3. Notifications.

A.5.1 Testing standard activation situations (simple, MO, consecutive activations, multiple bids)

Functionality name	No. 1 – Testing standard activation situations	
Test ID	Test name	Test description
1.1	Simple activation test	A simple test of activating one bid (one or more resources, positive or negative activation)

[Type here]

Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; one resource II. negative energy; one resource III. positive energy; more resources IV. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO Operator	OK
2	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
3	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
4	Operators see the activation is stopped and how the resources respond	Operator sees the request and sees the response from resources	User	OK
Test ID	Test name	Test description		
1.2	Test the correct sequence of activating units (<i>internal pool MO</i>)	A simple test of activating a bid (8 resources, positive/negative activation). The units forming the bid are activated correctly if they are activated in increasing order of their prices (<i>internal MO</i> on aFRR level)		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Create a bid with 8 units and prices ranging from 1 to 8. (in Bidding module). Set the bid price in order to ensure the bid will be activated.	Bid is created and selected for activation.	User	OK
2	A simple activation in both scenarios: I. positive energy II. negative energy is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK
3	Operator sees the activation has started and the order in which the resources are activated	Operator sees the request, and observes the <i>units being activated in increasing order of their prices</i> (also observes their response)	User	OK
4	The activation is stopped by the TSO	The requested STOP activation comes in the platform from the TSO and is seen in the platform	TSO User	OK
5	Operator sees the activation has ended and how the resources respond	Operator sees the request, and observes the <i>units being deactivated</i> (also observes their response)	User	OK
Test ID	Test name	Test description		
1.3	Two subsequent activations within the	Testing the response of the platform if a secondary activation		

[Type here]

	same bid	request comes immediately after the first one has ended		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; one resource II. negative energy; one resource III. positive energy; more resources IV. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK
2	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
3	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
4	Operators see the activation is stopped and how the resources respond	Operator sees the request and sees the response from resources	User	OK
5	After the <i>minimum determined recovery time</i> the second activation from the TSO is started	The requested activation comes in the platform from TSO and is seen in the platform	TSO User	OK
6	Operators see the activation is started and how the resources respond. Here a special focus will be on <i>baseline</i> (if the new baseline will be at the last measurement on the "normal" level)	Operator sees the request and sees the response from resources, the baseline behaves correctly	User	OK
7	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
8	Operators see the activation is stopped and how the resources respond	Operator sees the request and sees the response from resources	User	OK
Test ID	Test name	Test description		
1.4	Two consecutive bids that include the same resources are activated with one activation (the transition from the time frame of the first bid to the next one is tested)	If activation continues from one bid to the next one, the STOP activation signal must not be sent to the DR&DG units. Two consecutive bids will be activated.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; one resource II. negative energy; one resource III. positive energy; more resources IV. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK

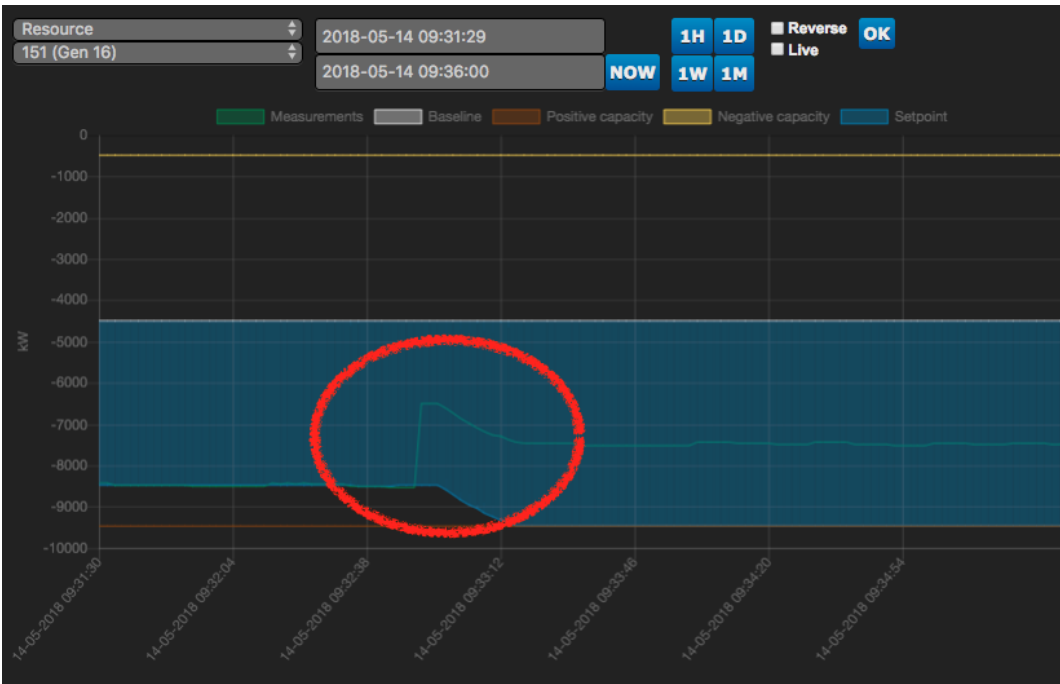
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2	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
3	The activation extends beyond the validity of the first bid. (there is no STOP activation from the TSO at this point)	No STOP activation signal has come in	User	OK
4	Operators observes how the resources respond	Operator sees the request and sees the response from resources. Also he monitors the baseline and what signals went out to the resource.	User	OK
5	The activation is stopped by the TSO, in the middle of the 2 nd bid.	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
6	Operators see the activation has stopped and how the resources respond	Operator sees the request and sees the response from resources	User	OK

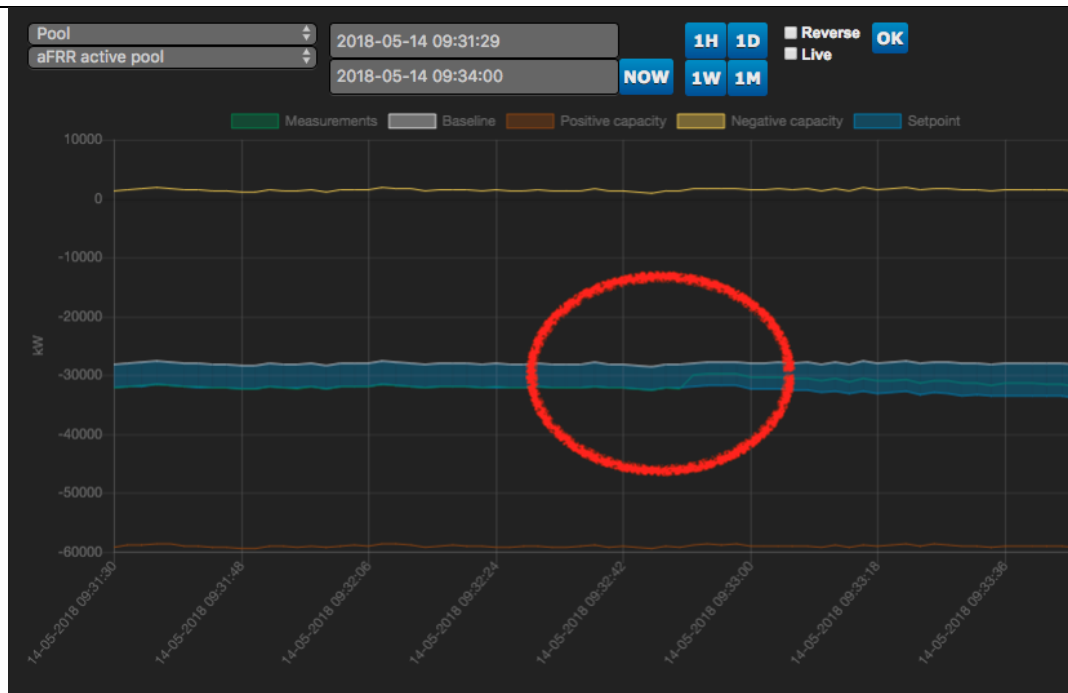
A.5.2 Closed loop - Controlling unexpected activation behaviour

Functionality name	No. 2 – Closed loop			
Test ID	Test name	Test description		
2.1	One of the customer <i>activates too late</i>	Testing if the platform will automatically activate another customers if one of the activated customers doesn't deliver on time		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; more resources II. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK
2	Operator sees that the activation has started and how the resources respond	Operator sees the activation request and sees the response from resources	User	OK
3	Operator sees that one of the customer's doesn't deliver in time	The platform automatically finds and activates the next resource	User	NOK (Bug #:2)
4	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
5	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
Test ID	Test name	Test description		
2.2	One or more of the customers always <i>under-activates</i>	Testing if the platform will automatically activate another customers if one of the activated customers always under-		

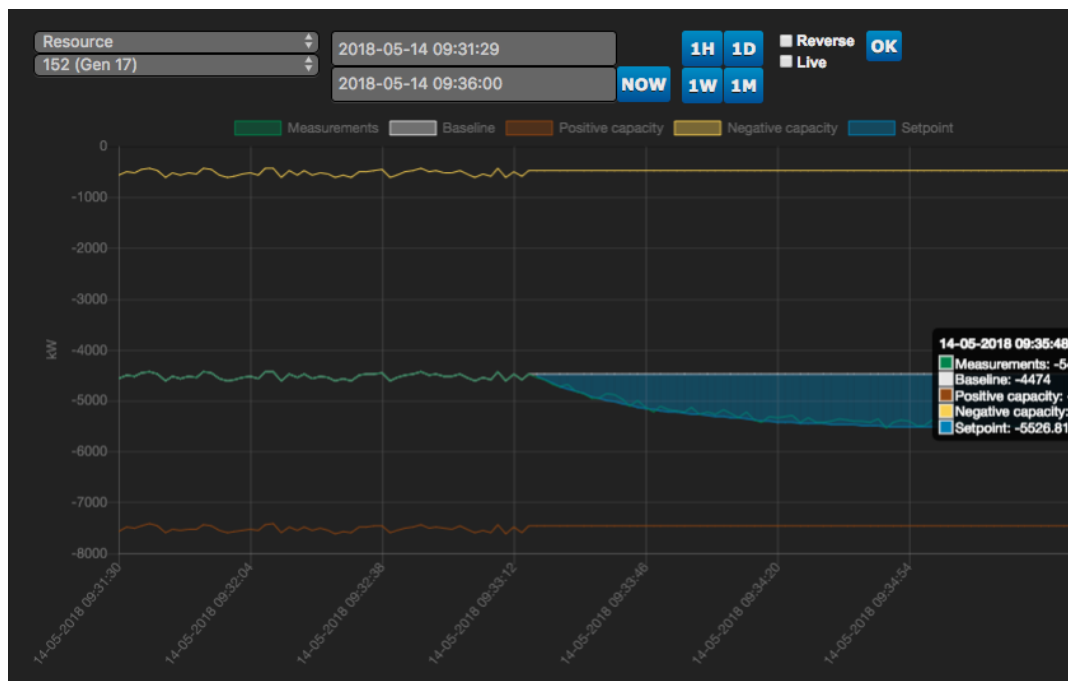
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		activates		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; more resources II. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK
2	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
3	Operators sees the one of the customer's doesn't deliver constantly	The platform automatically finds and activates the next resource	User	NOK (Bug #:3)
4	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
5	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
Screenshots	<p>TSO is requesting an activation of 4MW.</p> <p>A: Unit (Gen 16) underperforms (doesn't provide what was requested) for 2MW</p>  <p>B: Pool (aFRR pool) underperforms overall due to the Gen 16</p>			

[Type here]

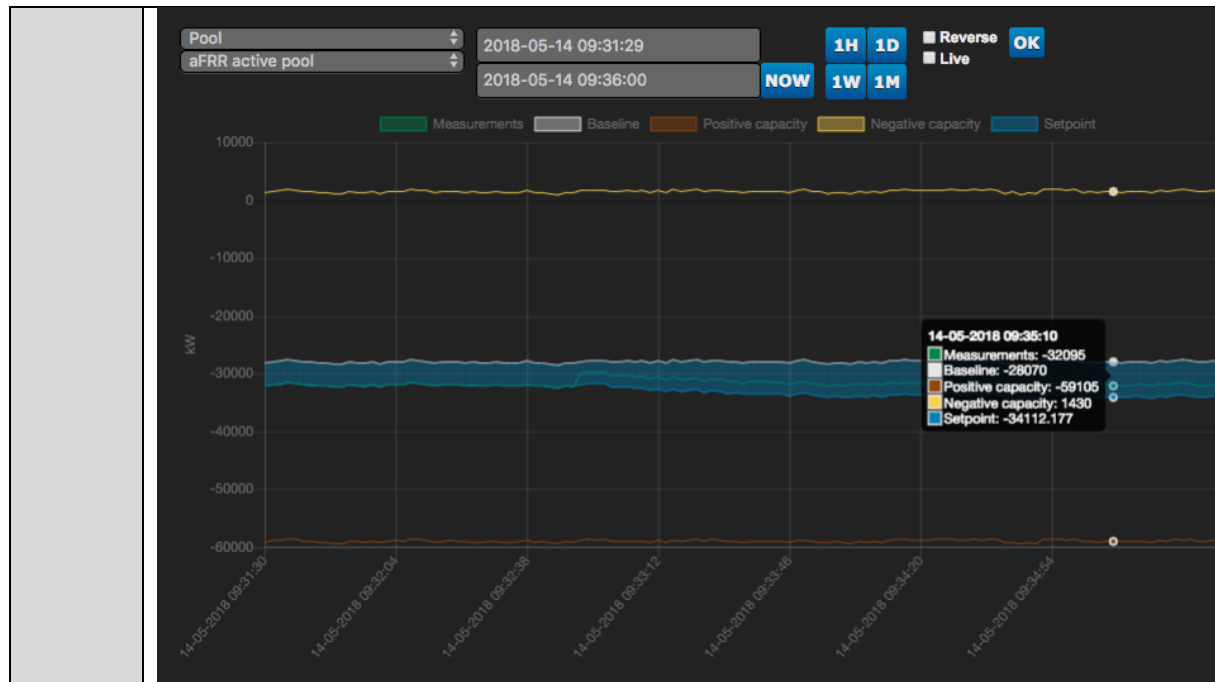


C: Unit (Gen 17) is added to correct the error for additional 2MW



D: After adding Gen 17 pool (aFRR pool) is again fulfilling the requested activation of 4MW (Measurement – Baseline; $3.2\text{ MW} - 2.8\text{ MW} = 4\text{ MW}$). Note: The set-point on the picture is showing set-point signal which is sent to the units and not received from the TSO!

[Type here]



Test ID	Test name	Test description
2.3	One or more of the customers always over-activates.	Testing if the platform will be able to automatically regulate the behavior of one of the activated customers always over-activates, by using the closed loop functionality

Test procedure

Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; more resources II. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK
2	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
3	Operators sees the one of the customer's always over delivers	The platform automatically finds and deactivates the next resource or lets the customer over activated	User	NOK (Bug #:4)
4	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
5	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK

Test ID	Test name	Test description
2.4	One or more resources fail during activation	Testing if the platform will automatically activate another customers if one of the activated customers suddenly fails due to break-down

Test procedure

[Type here]

Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	A simple activation in all scenarios: I. positive energy; more resources II. negative energy; more resources is started from TSO	The requested START activation comes in the platform from TSO and is seen in the platform	TSO User	OK
2	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK
3	Operators sees the one of the customers stopped delivering (<i>failure</i>)	The platform automatically finds and activates the next resource to cover the loss	User	OK
4	The activation is stopped from TSO	The requested STOP activation comes in the platform from TSO and is seen in the platform	TSO User	OK
5	Operators see the activation is started and how the resources respond	Operator sees the request and sees the response from resources	User	OK

A.5.3 Notifications

Reporting (3.1) and alarming (3.2) functionality will be delivered in D2.3b.

Functionality name	No. 3 - Notifications			
Test ID	Test name	Test description		
3.1	Reporting	After the end of activation the report of activation is available.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Operator will check that the export of raw data of the activation is available, at the end of the activation.	User is able to download the file with raw data to the activation to be used as a reporting.	User	OK
Test ID	Test name	Test description		
3.2	Alarming Alarming will be available in D2.2b.	The Operator can easier monitor the pool if the system is not performing as planned.		

A.6 Control module

The Control module is responsible for: 1. aggregating data to pool level and communicating it to the TSO LFC, 2. Receiving and validating TSO LFC's set-point data. Both communication channels were tested.

[Type here]

A.6.1 Sending data to TSO LFC

Functionality name	No. 1 – Send data			
Test ID	Test name	Test description		
1.1	Data aggregation into pool	Control module receives data from both the forecasting and the data exchange modules, considers minimum of both values for every resource, and aggregates these accordingly into pool		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Check if data was aggregated into pool	Data was aggregated into pool and should be visible on the UI.	User	OK
Test ID	Test name	Test description		
1.2	Sending data to the TSO	Control module starts continuously sending aFRR data to the TSO LFC.		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Send active power of the pool	Data transmission successful on the TSO side.	TSO	OK
2	Send upper limit of controllable pool power	Data transmission successful on the TSO side.	TSO	OK
3	Send lower limit of controllable pool power	Data transmission successful on the TSO side.	TSO	OK
4	Send baseline of the pool	Data transmission successful on the TSO side.	TSO	OK
5	At activation event send activated power of the pool.-	In time of activation TSO should receive how much flexibility is activated at the current time.	TSO	OK

A.6.2 Receiving data from TSO LFC

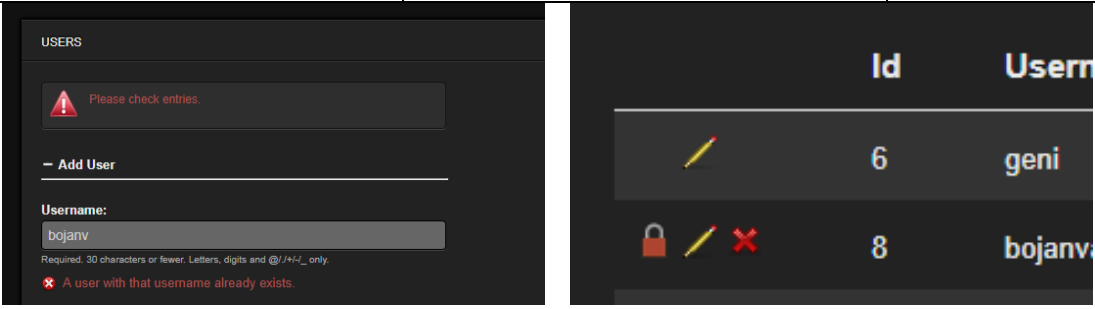
Functionality name	No. 2 – Receive set-point			
Test ID	Test name	Test description		
2.1	TSO sends set-point	TSO LFC continuously sends set-point		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Start sending set-point as TSO	TSO set-point sending started	TSO	OK

[Type here]

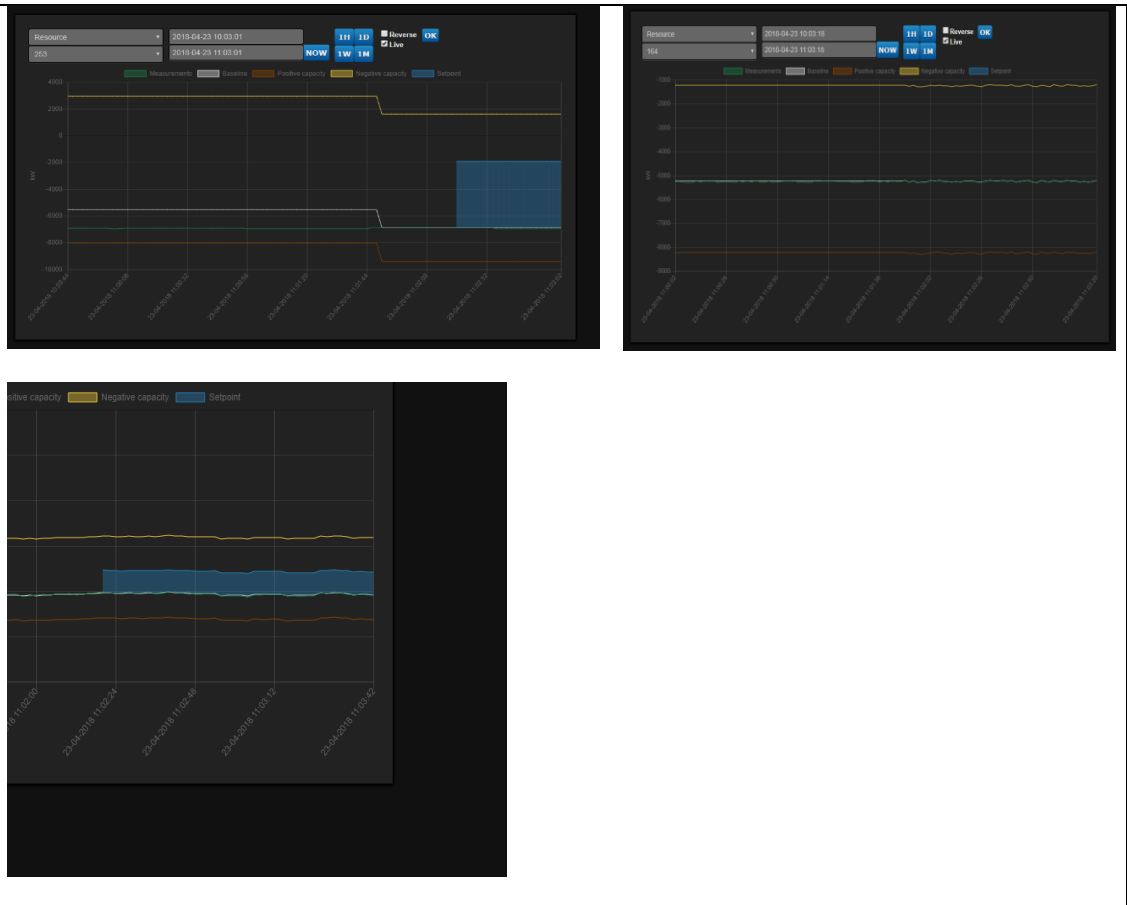
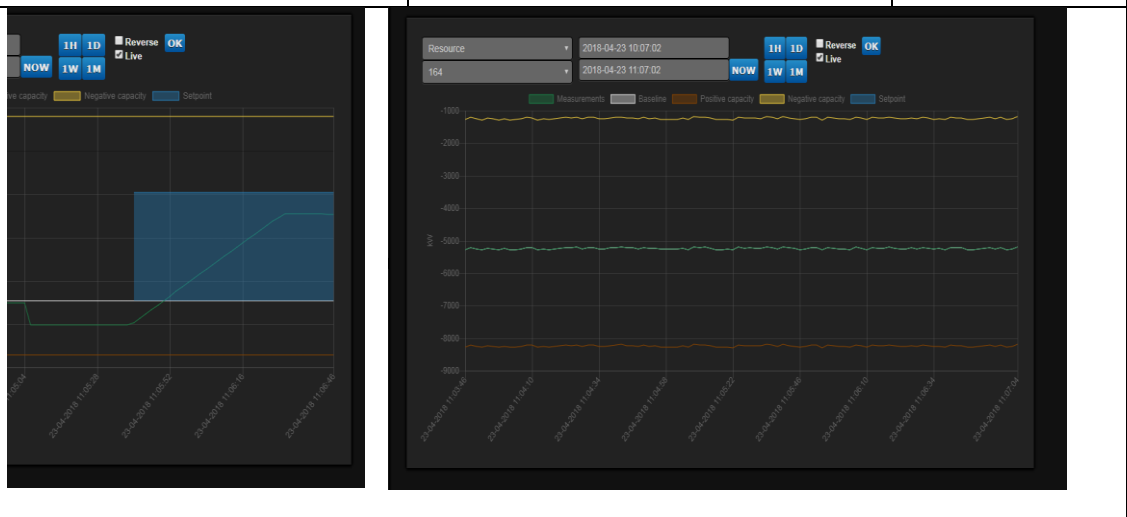
2	Verify receiving set-point	Set-point received from TSO LFC	User	OK
Test ID	Test name	Test description		
2.2	Acknowledge set-point	Control module validates received set-point and acknowledges it by sending it back. Note: Validation of received messages must be done before ACK is sent!		
Test procedure				
Step number	Step description	Expected result and evaluation criteria	Tester Role	Result
1	Acknowledge that aFRR is sending back the same set-point which it is receiving from the TSO	TSO should receive back the same identical set-point that he sent.	TSO	OK

A.7 Bug report

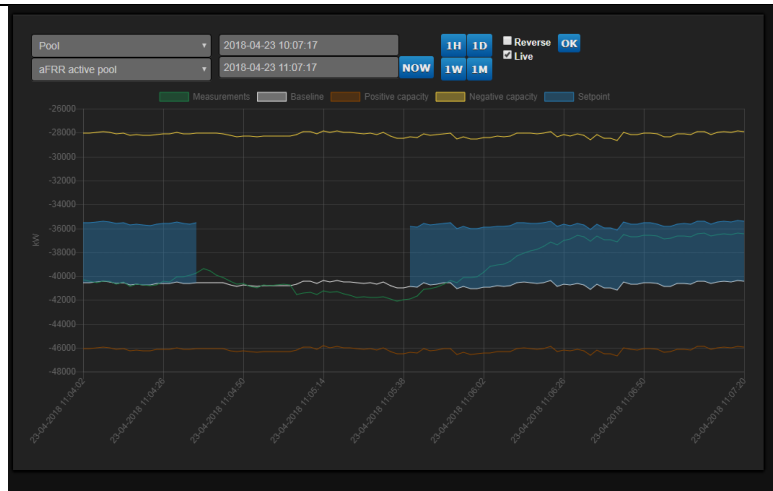
The below table contains descriptions of bugs discovered during tests in Sections A.1-0. Note, that not all of them are bugs in the sense of errors in software implementation. Some are features that are planned to be implemented later.

Bug #	Module name	Scenario #	Test ID	Step #
1	User interface	A.1.2. Configuration of aFRR platform	2.1	4
Bug Description		Status	Fixed	
Users can be removed but stay in the Database and aren't displayed in the UI		partially OK (Users shouldn't be removed but only deactivated)	YES	
Screenshots				
Bug #	Module name	Scenario #	Test ID	Step #
2	Unit commitment module	Napaka! Vira sklicevanja ni bilo mogoče najti.. Closed loop - Controlling unexpected activation behavior	2.1	3
Bug Description		Status	Fixed	
The platform didn't automatically find and activate the next resource		OK (fixed with closed loop)	YES. Switching on the parameter for closed loop corrected the errors.	

[Type here]

<p>Screenshots</p> 					
<p>Bug #</p>	<p>Module name</p>	<p>Scenario #</p>	<p>Test ID</p>	<p>Step #</p>	
<p>3</p>	<p>Unit commitment module</p>	<p>Napaka! Vira sklicevanja ni bilo mogoče najti.. Closed loop - Controlling unexpected activation behavior</p>	<p>2.2</p>	<p>3</p>	
<p>Bug Description</p>		<p>Status</p>	<p>Fixed</p>		
<p>The platform didn't automatically find and activate the next resource</p>		<p>OK (fixed with close loop)</p>	<p>YES. Switching on the parameter for closed loop corrected the errors.</p>		
<p>Screenshots</p>					

[Type here]



Bug #	Module name	Scenario #	Test ID	Step #
4	Unit commitment module	Napaka! Vira sklicevanja ni bilo mogoče najti.. Closed loop - Controlling unexpected activation behavior	2.3	3
Bug Description		Status	Fixed	
The platform didn't automatically deactivate the over-performing resource and activate the next one instead		OK (fixed with close loop)	YES. Switching on the parameter for closed loop corrected the errors.	
Bug #	Module name	Scenario #	Test ID	Step #
5	Unit commitment module	0. Notifications	3.1	1
Bug Description		Status	Fixed	
The platform doesn't have alarms yet		NOT OK (not yet implemented functionality)	NO. To be implemented later.	

[Type here]

Appendix B Test results for Use case 2: Validation of the aFRR aggregation platform under market settings in 4 participating control zones

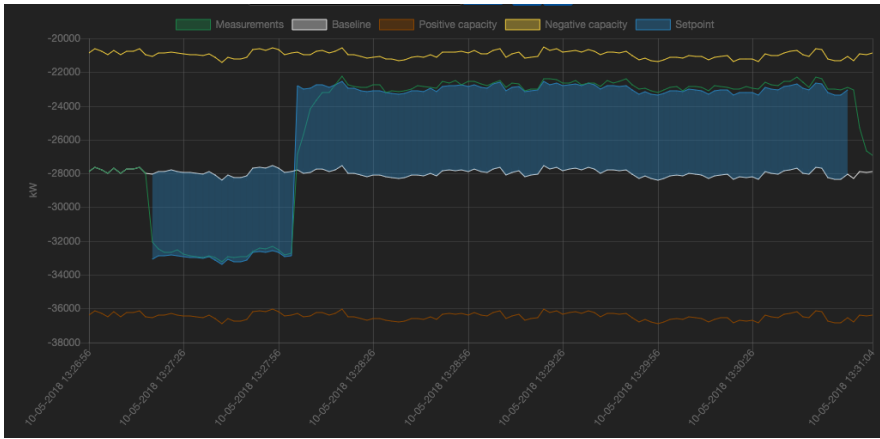
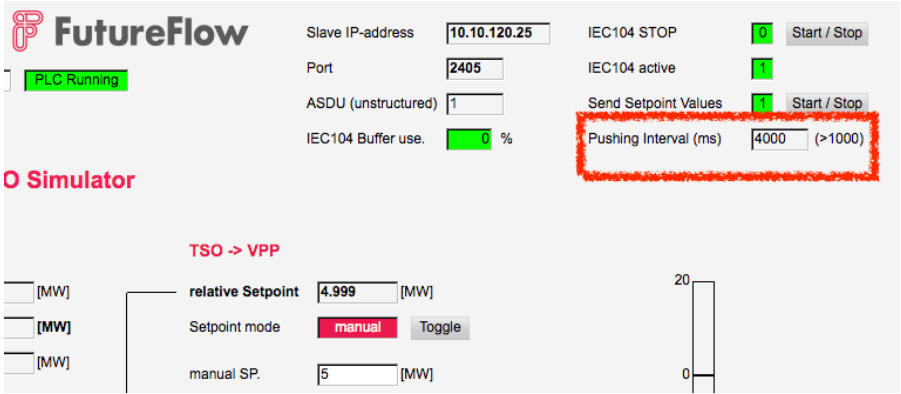
To verify that the aFRR aggregation platform is capable of operating under different market rules/characteristics, present in single participating control zones (Table 1) two tests were performed; one with two different cycle times of AGC (2 and 4 seconds), the other with two different types of activation rules, one stepwise (APG style), the other one continuous (other countries). All other parameters were set as in the FutureFlow target model.

The focus was on observing pool behaviour during the activation.

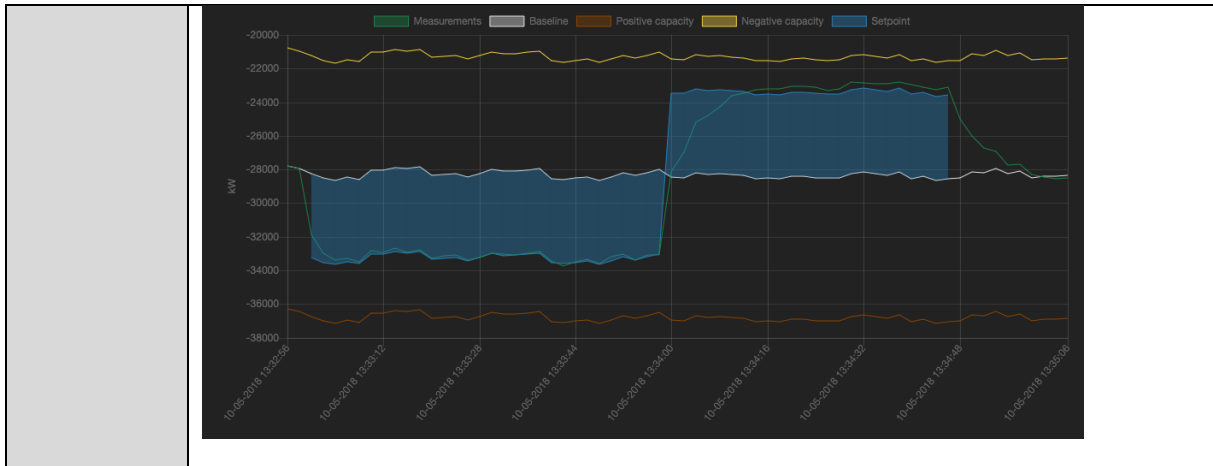
B.1 Cycle time of AGC

Functionality name	No. 1 – Cycle time of AGC		
Test ID	Test name	Test description	
1.1	Activation under 2s cycle time of AGC	aFRR activation with simulated units under FF target model settings (set-point type stepwise, FAT 5min, cycle time of AGC 2s, Activation rule MO)	
Test procedure			
Step number	Step description	Expected result and evaluation criteria	Result
1	Start sending set-point as TSO in 2s interval.	TSO set-point sending started and set-point is visible on the chart.	
2	Observe the behavior of the pool.	The activation is successfully created. The DR/DG units selected in the activation should start follow the set-point.	
Screenshots	A: sending interval 2s (Pushing interval in picture below)		

[Type here]

	<p>B: Activation based on 2s incoming set-point</p> 		
Test ID	Test name	Test description	
1.2	Activation under 4s cycle time of AGC	aFRR activation with simulated units under FF target model settings, with the modification of 4s cycle time of AGC	
Test procedure			
Step number	Step description	Expected result and evaluation criteria	Result
1	Start sending set-point as TSO in 4s interval.	TSO set-point sending started and set-point is visible on the chart.	
2	Observe the behavior of the pool.	The activation is successfully created. The DR/DG units selected in the activation should start follow the set-point.	
Screenshots	<p>A: sending interval 4s (Pushing interval in picture bellow)</p>  <p>B: Activation based on 4s incoming set-point</p>		

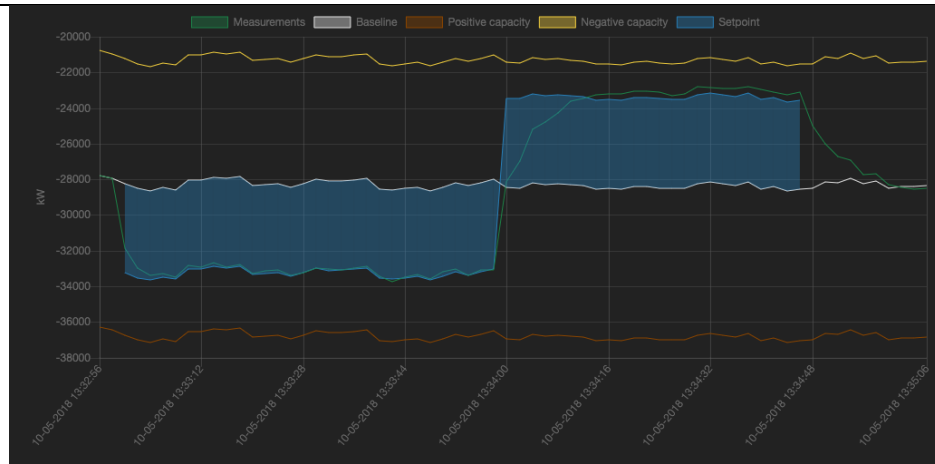
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B.2 Set-point type

Functionality name	No. 2 – Set-point type		
Test ID	Test name	Test description	
2.1	Activation under <i>stepwise</i> set-point type (APG style)	aFRR activation with simulated units under FF target model settings (set-point type stepwise, FAT 5min, cycle time of AGC 2s, Activation rule MO)	
Test procedure			
Step number	Step description	Expected result and evaluation criteria	Result
1	Start sending set-point as TSO	TSO set-point sending started and set-point is visible on the chart.	
2	Observe the behavior of the pool.	The activation is successfully created. The DR/DG units selected in the activation should start follow the set-point.	
Screenshots	<p>A: Step-wiser activation request</p> <p style="text-align: right;">Requested set-point</p> <p>B: Provided response from step-wise set-point</p>		

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Test ID	Test name	Test description	
2.2	Activation under <i>continuous</i> set-point type (other countries)	aFRR activation with simulated units under FF target model settings, with the modification of continuous set-point type	
Test procedure			
Step number	Step description	Expected result and evaluation criteria	Result
1	Start sending set-point as TSO.	TSO set-point sending started and set-point is visible on the chart.	
2	Observe the behavior of the pool.	The activation is successfully created. The DR/DG units selected in the activation should start follow the set-point.	
Screenshots	<p>A: Continues generated set-point (according to the BSP ramp-rate)</p> <p>In the configuration bellow, TSO simulator is generating ramp with ramp rate 0.1 MW/s, with 5min FAT</p> <p>B: Activation based on the continues set-point</p>		

[Type here]

