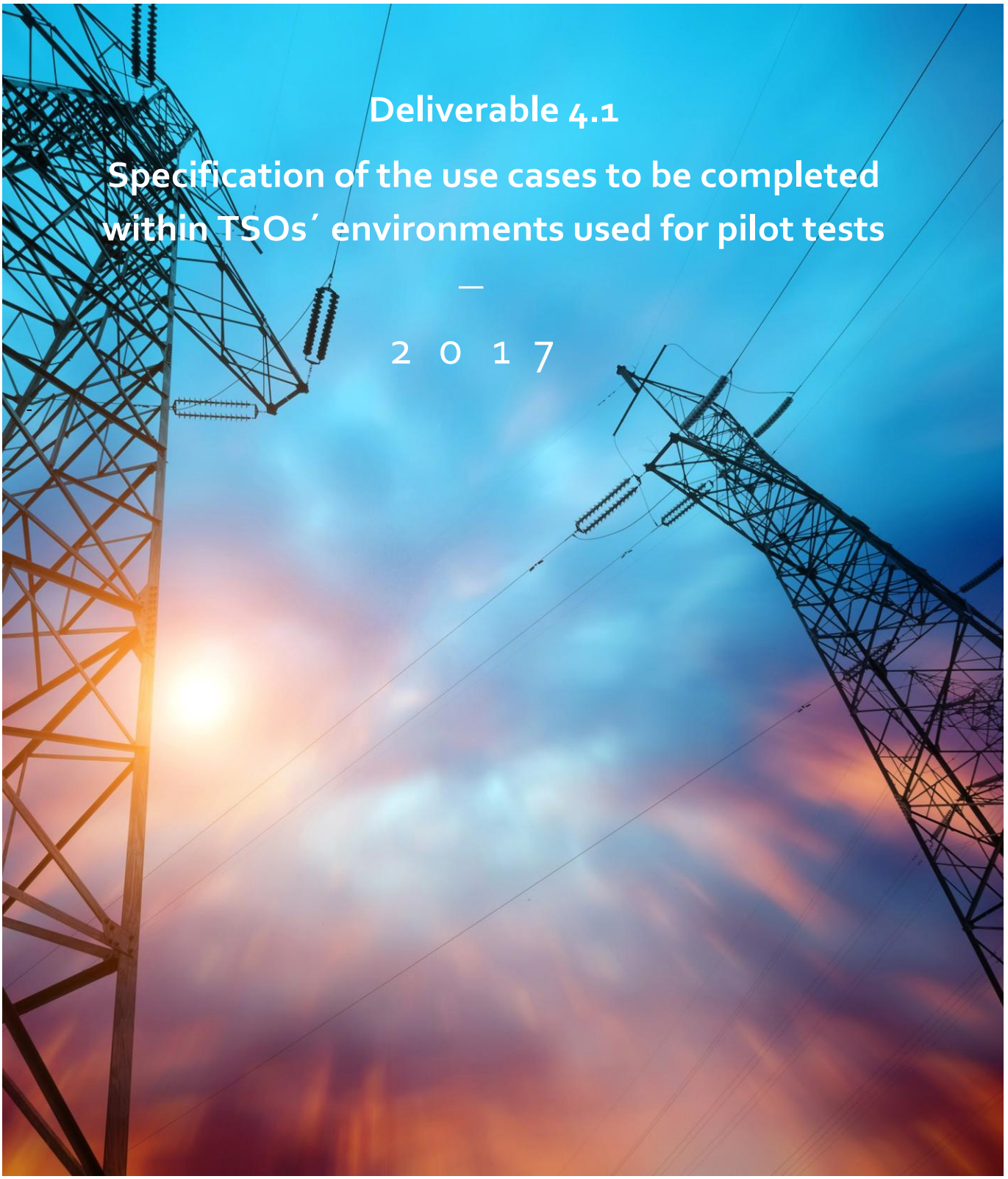
FutureFlow



Deliverable 4.1

Specification of the use cases to be completed within TSOs' environments used for pilot tests

2017

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 691777

FutureFlow

Document Information

Programme	Horizon 2020 – Cooperation / Energy
Project acronym	FutureFlow
GA number	691777
Deliverable	D4.1
WP/Task related	[WP4 / T4.1]
Type	Report
Confidential:	Public
Date of delivery	31.12.2017
Status and Version	Version 0.7
Number of pages	51 pages
Document Responsible	EIMV
Authors	Maja Kernjak-Jager, Radovan Sernec, Andrej Souvent; EIMV
	Renata Blatnik, Rok Lacko; GEN-I
	Uršula Krisper, Elektro Ljubljana
	Andraž Andolšek; cyberGrid
	Zoran Vujasinović; EKC
	David Gerbec, Matjaž Dolinar; ELES
Reviewers	MAVIR

Version	Date	Author(s)	Notes	Status
1.0	XX.12.2017	EIMV	Final for EC delivery	
0.7	11.12.2017	Gen-I, EIMV, CG, ELES	For internal review.	
0.5	5.12.2017	Gen-I, EIMV, CG	Tables of all tests.	
0.2	28.11.2017	Gen-I, EIMV, CG, ELES	Methodology.	
0.11	15.11.2017	Gen-I, EIMV, CG	Advanced tests.	
0.1	23.10.2017	Gen-I, EIMV, CG, ELES	Initial version.	

FutureFlow

Table of Contents

List of Figures

List of Tables

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

Glossary

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

The aim of the FutureFlow Project

Four European TSOs of Central-Eastern Europe (Austria, Hungary, Romania, Slovenia), associated with power system experts, electricity retailers, IT providers and renewable electricity providers, propose to design a unique regional cooperation scheme: it aims at opening Balancing and Redispatching markets to new sources of flexibility and supporting such sources to act on such markets competitively. By means of a prototype aggregation solution and renewable generation forecasting techniques, flexibility providers – distributed generators (DG) and commercial and industrial (C&I) consumers providing demand response (DR) – are enabled, to provide competitive offers for Frequency Restoration Reserve (including secondary control activated with a response time of 30 seconds and full activation time of 15 minutes). Retailers act as flexibility aggregators and pool the resource 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.

Project Partners

No	Name	Short name	Country
1	ELES DOO SISTEMSKI OPERATOR PRENOSNEGA ELEKTROENERGETSKEGA OMREZJA	ELES, d.o.o.	Slovenia
2	AUSTRIAN POWER GRID AG	APG	Austria
3	MAVIR MAGYAR 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

Use cases specifications for pilot testing on FutureFlow project are one of key objectives of the project itself. Use cases are structured by providing procedures with focus on later assessment of pilot execution results and main influencing parameters: DR/DG participation on the aFRR markets and cross border DR/DG activations and their influence on technical, economic KPI (defined in D4.2). There are four use cases specified from the TSO perspective, i.e. ACE behaviour in control zone:

- UC1: Testing of communications and IT systems and main building blocks.
- UC2: DR/DG participation in aFRR.
- UC3: Cross border DR/DG participation in aFRR.
- UC4: DR/DG connection with two BSPs.

A comprehensive use case execution methodology was developed that is a combination of simulation and real life pilot testing. The first step is recording reality. In this step, signal data gathered from control zones is simulated on a LFC, as well as market models for each control zone and coupled control zones. Key control parameters of these models can be adjusted accordingly. DR/DG units are added as activations to these simulated models and subsequently also piloted on the field.

Test methodology covers functionalities of major building blocks: DR/DG, aFRR aggregation platform, DEMO site, FF Cloud platform. Information exchange between those blocks is covered, too. Scalability, replicability and regulatory issues are outlined in separate chapters (sections) that can be also explored.

Detailed design of use cases, test scenarios their objectives and prerequisites are covered in Appendix in a set of tables.

1 Introduction

1.1 Outline

The main objective of task 4.1 is to shape a set of four use cases which will be implemented over one year (2018) by the partners on this task using real balancing service providers.

- Use case 1: Defines the system tests aimed at monitoring the system performance as a function of the number of users. Data collected shall be used for the assessment of the scalability and replicability properties of the developed prototype solutions as well as provide valuable data to evaluate the robustness of the proposed solutions assessed from the cyber security perspective.
- Use case 2: Defines test cases, which shall on one hand assess the costs and benefits of the IT platforms (aFRR aggregation platform, FutureFlow DEMO site, FF Cloud platform) when involvement of DR/DG under the management of the aggregators is addressed and on the other hand assess the capability of DR/DG customers to participate in the balancing and redispatching processes. Tests shall be performed independently for each control area by the IT platforms (exercised with zero Cross Zonal Capacity). It should be emphasised that assessment of technical capabilities of both DR/DG customers and developed aggregation platforms is the main priority of tests, economic parameters will be more evaluated using the simulations.
- Use case 3: Defines test cases, which pursue similar goals as tests defined in Use case 2, but with the involving customers both in each of the TSO control areas and across the control areas (exercised with non-zero Cross Zonal Capacity). The aim of this use case is to assess costs and benefits of cross-border activations of DR/DG.
- Use case 4: Aims at studying the introduction of the competition between the aggregators by allowing the switching of DR/DG between competing BSPs that act as aggregators, within control zone.

1.2 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 platform for pilot demonstration operations;
4. FF Cloud platform.

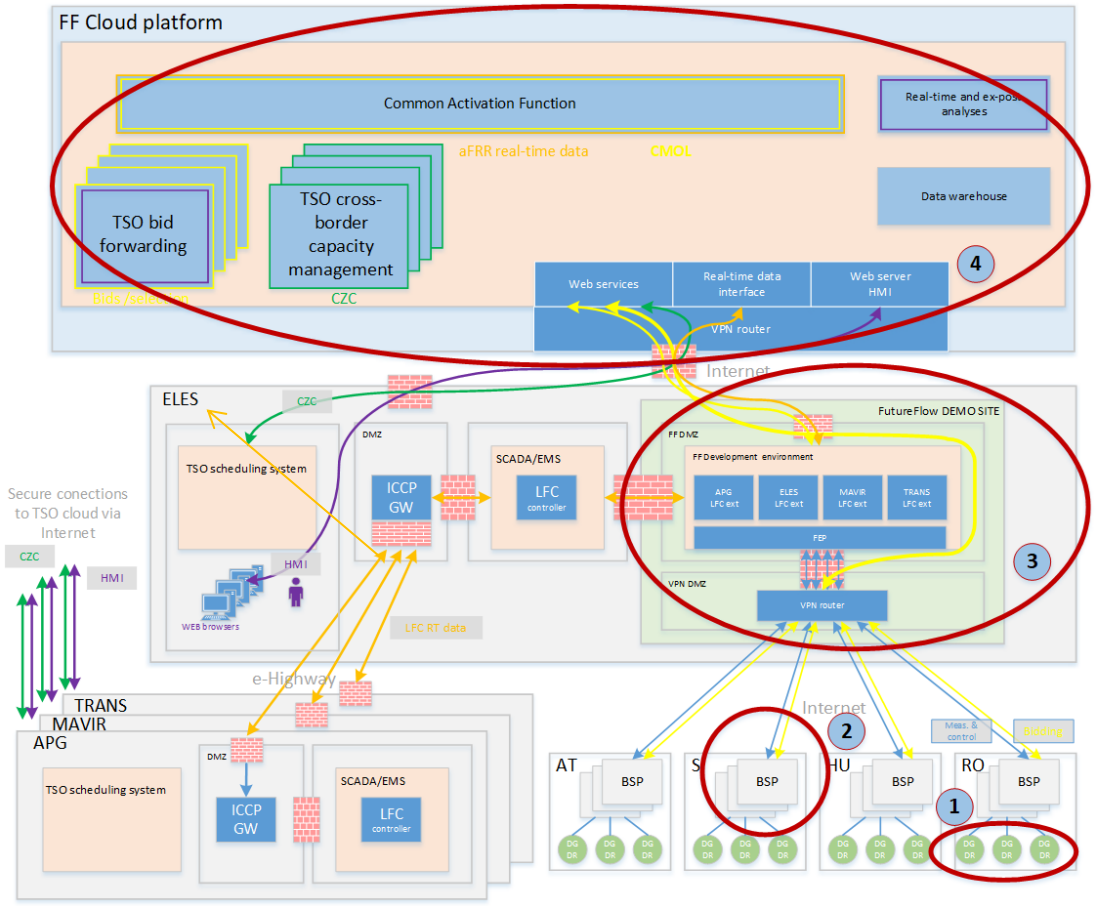


Figure 1: FutureFlow demonstration architecture: Building blocks under test.

Relevant connections between these blocks (shown in Figure 2, marked in red) are:

- **BSP – DR/DG.** BSP with aFRR aggregation platform interconnected with DR/DG sources.
- **FutureFlow DEMO site – BSP.** DEMO site interconnected to aFRR aggregation platform, used by BSP.
- **TSO – FutureFlow DEMO site.** TSO (ELES in our case) interconnected with FutureFlow DEMO site. ELES is the interconnecting building block for other TSO.
- **FF Cloud platform - DEMO site.** FF Cloud platform interconnected with FutureFlow DEMO site. FutureFlow DEMO site is intermediary between TSO and FF Cloud platform, interpreting SCADA protocols from ICCP to MQTT.

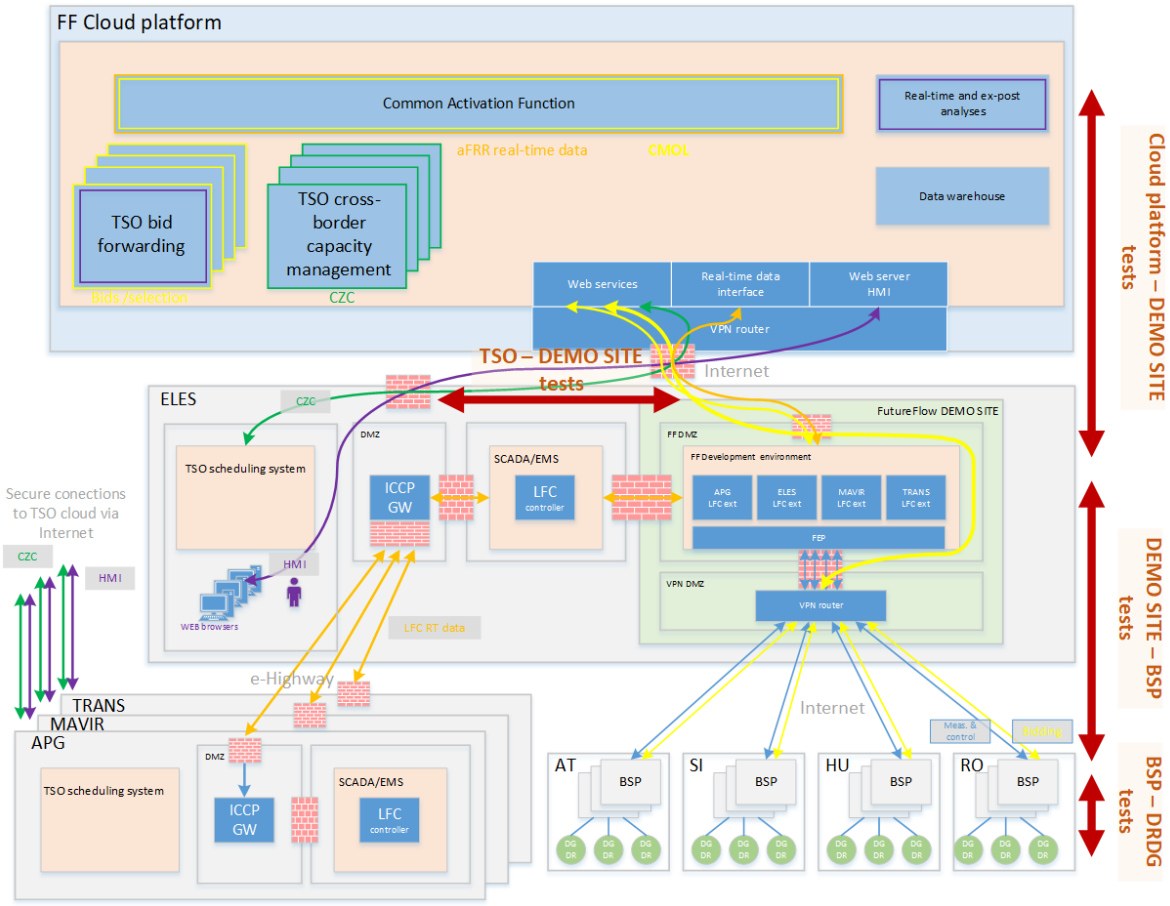


Figure 2: FutureFlow demonstration architecture: Tests between building blocks.

1.3 Types of tests and test scopes

Each building block is tested for building block to building block communications and related inter building block functionality. The scopes of major tests at these connections are:

- BSP – DR/DG
  - Test objective: Measurement and control signals from aFRR aggregation platform to DR/DG to enable activation of DR/DG sources according to aFRR aggregation platform requests and track the performance (e.g. delivered power, set point tracking) of each DR/DG.
- FutureFlow DEMO site - BSP
  - Test objective: Activation commands for power delivery from bids, measurement of activated bids.
- TSO – FutureFlow DEMO site
  - Test objective: Exchange of measurement and control signals from SCADA to enable real time FutureFlow DEMO site operation of LFC and CAF extension. Data from all TSOs are exchanged and four LFC models tested.

- FF Cloud platform - FutureFlow DEMO site
    - Test objective: Exchange of measurement and control signals to CAF extension implementation in FF Cloud platform. Bid activations and set point commands.

All functional tests performed on FutureFlow platforms (FutureFlow DEMO site, FF Cloud platform and the aFRR aggregation platform) are limited in scope to those functionalities that may significantly affect major KPI (defined in D4.2), most importantly ACE performance and social welfare.

1.4 Tests execution methodology

End-2-End tests are defined to accomplish major objectives of use cases 2, 3 and 4 from the TSO perspective. Building block and end-2-end tests are based on use case methodology, already outlined in deliverable D1.3. Tests are defined in several steps:

1. Reality recording.
2. Reality simulation.
3. Conversion to target model followed by simulation.
4. Simulation with added DR/DG units.
5. Pilot test with added DR/DG units.

Steps 3 and 4 are crucial for real data preparation, LFC adjustments and assessment of the level of aFRR requirements for pilot test within step 5. This last step is the only step executed on a pilot with real DR/DG units that are activated. Within this step the whole end-2-end process is closed: from bidding, acceptance of bids, CMOL formation, bids activations, measurements of DR/DG unit responses.

Step 4 simulation with added DR/DG units is performed with maximum flexible capacity potentials available in each control zone according to Table 1. The same units are also activated in step 5. To enable relevant conclusions to be drawn from experimental tests within UC2 and UC3 the minimum of 5 MW of balancing capacity per control zone has been considered feasible. Considering the regional presence of the retailers (GEN-I, Elektro energija) within each control area it is planned that the following zonal distribution of the portfolio will be pursued: 20 MW at ELES, 20 MW at APG, 5 MW at MAVIR, 5 MW at TRANSELECTRICA, but not more than 45 MW all together. The acquisition of resources that will participate in pilots will consider different categories of prosumers (industrial, business, renewable), have been enlisted to enable a balanced examination of balancing potential. Both positive and negative capacity will be available at the aFRR aggregation platform level.

Table 1: Maximal flexible capacity potential in pilot tests per control zone.

	SI (MW)	**AT (MW)**	**HU (MW)**	**RO (MW)**	**SUM4 (MW)**
Maximum flexible capacity potential participating in the pilot tests	20	20	5	5	45

1.5 Relation to other work packages

Deliverable 4.1 is related to WP1 where simulations of models are extensively studied and developed. D4.2 specifies KPIs that are used with Use cases developed in D4.1 to drive and exercise pilot tests done in WP5 (Figure 3).

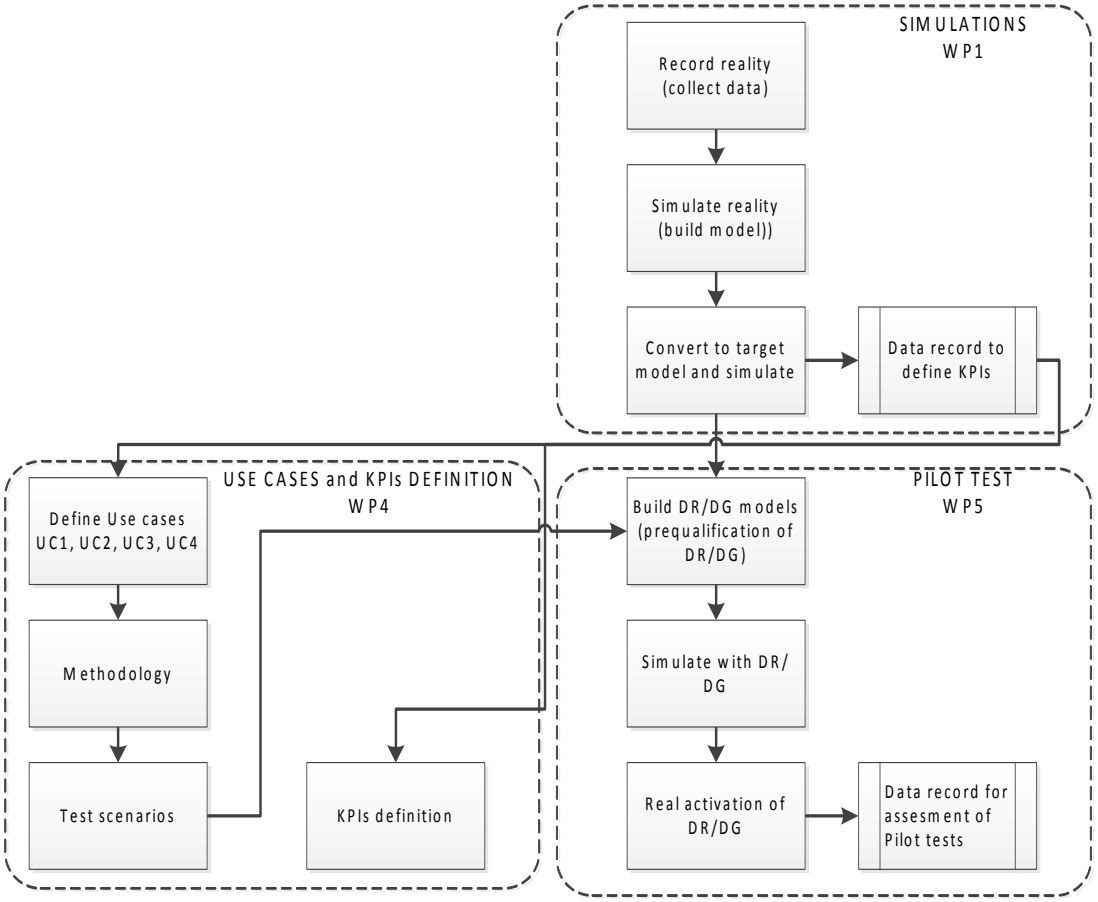


Figure 3: WP4, D4.1 relation to other work packages.

2 Use cases description

Three critical tuning parameters were considered in designing the four use cases:

- The level of technical complexity of the tests which will be progressively increased in order to sort out solutions to any type of malfunctioning observed in the field. The complexity will increase by level of blocks, interconnection of blocks and system-level testing.
- A growing number of real consumers and distributed generators (reaching in total between 30 and 45 MW of balancing power available to the four TSOs) agreeing to provide balancing energy upon request to serve the most demanding balancing needs (secondary reserve - aFRR) and re-dispatching. The later will be demonstrated in simulations (deliverable 1.5).

- The amount of accurate real-life data to be collected in order to perform meaningful ex-post impact analysis in coherence with the system economic simulations developed in WP1, D1.5.

The four use cases are specified in Chapters 2.1 - 2.4. The test scenarios for each use case are contained in Appendices. The planned timing schedule of Use cases execution is summarised in Table 2.

Table 2: Planned timing schedule of UC1-UC4 on project.

Activities - customer participation	**Q1 2018**	**Q2 2018**	**Q3 2018**	**Q4 2018**	**Q1 2019**	Availability of DG/DR per client [hours]	Maximal duration of pilot tests per aFRR aggregation platform [hours]	Maximal duration of pilot tests per client [hours]
Pilot testing						2016	108	60
Use case 1	IT testing (1 day per month - no activations)	IT testing (1 day per month - no activations)	IT testing (1 day per month - no activations)	IT testing (1 day per month - no activations)	A back-up quarter for unplanned difficulties	288	0	0
Use case 2		Real activations on customers machines (2 days per week - only 1-2 h activation per day)				576	36	20
Use case 3			Real activations on customers machines (2 days per week - only 1-2 h activation per day)			576	36	20
Use case 4				Real activations on customers machines (2 days per week - only 1-2 h activation per day)		576	36	20

2.1 Use case 1 - Testing of building blocks and the IT prototype solution

2.1.1 Introduction

Use case 1 aims at completing the IT system factory tests performed in WP2 and WP3 for the IT prototypes (hardware and software modules) by testing the whole IT system. The three IT providers implement a performance monitoring system which aims at delivering system performance assessment depending on the number of TSOs, BSPs, and number

of bids. The crucial performance factor is the execution time, that needs to respect the predefined 2 second system cycle, i.e. we must accomplish all optimization tasks and CMOL formation, with all inter systems communication data transfers within this time frame. The time needed to perform the optimization and CMOL formation is heavily dependent on the number of bids. This is a prerequisite for following three end use configurations (within a control zone, and in cross-border exchanges with access granted or not to the platform to single energy providers) can then be analysed properly.

2.1.2 Problem definition

The test scenarios of the IT system need to be created with focus on confirming:

- Scalability property of the prototype solutions as the number of connected users grows.
- Replicability property since the IT system is tested within different control zones, which allow understanding the performance of the IT platform under four different aFRR regulatory constraints (e.g. FAT), and therefore prepare the replication in other control zones of EU 28.
- Cyber security since the complete system consists of multiple IT interconnected platforms. The aims of these tests are to evaluate the overall IT security and robustness of the implemented solution.

2.1.3 UC1 test execution methodology

Scalability

FutureFlow project is demonstrating cross border aFRR balancing solutions on four control zones located in four countries. Scalability of proposed solutions ensures the applicability of proposed concepts and solutions to wider scales of the problems.

For balancing and redispatch services there are three dimensions of scalability that are tackled by our test methods (Figure 4).

Figure 4: Scaling dimensions influencing scalability of FutureFlow solutions.

Scale up of project solutions is investigated for two items and their key technologies:

- Communication solutions. Protocols, considering IEC 60870-5-104 and MQTT.

- CAF processing. Optimization algorithm, speed under large number of input variables.

Communications and computation time are two contributors that limit the scalability of our proposed solutions. We analyse them separately. The number of TSOs, BSPs and bids within the system influences both the communications and the computation time to derive optimization solutions and form CMOL.

The basic case and a reference starting point is the present performance under laboratory conditions of communication solutions and CAF processing optimization functionality.

The primary constraint is the system time that is determined by the TSO SCADA systems. In FutureFlow the working assumption for the target model is the system time of 2 seconds. The majority of TSO SCADA systems work at 2 - 5 second system times, i.e. acquisition of new data, processing and control of outputs.

The number of conventional units that are already present in the control zones and are driven by TSO's AGC control does not change.

The methodology of the scaleup performance investigation is a mixture of simulation tests on the FutureFlow DEMO platform and a meta-analysis of known performance capabilities of the key technologies that influence scalability. Meta-analysis is used for communication solutions scalability assessment, since our pilot demonstration runs are small scale. We will rely on performance data from other sources, since we are using standardized, mature solutions (> 5 years on the market), that were proven in labs and field on much larger scales.

Simulation performance under different constraints is parametrised by three sections and one general section for configuration only (Figure 5):

- General simulation parameters. Examples include: Option 1 (control demand) or Option 2 (control target) of control, activation type, cross zonal capacity calculation type.
- TSO list. Number of independent TSOs that participate in cross zonal aFRR energy exchange. Communication performance on TSO-BSP and TSO- FF Cloud platform is the scaling issue.
- TSO units specification. List of all units that are controllable by TSO in the segment of aFRR market, including conventional units and aggregated DR/DG from BSPs. BSP and its aFRR aggregated portfolio is seen by the TSO as a single unit in aFRR market. Optimization time performance is directly dependent on the number of BSPs and units, as well as number of TSOs in the complete system, since we are bound by the starting assumption of 2 second system time period.
- Bids per control zone list. Bids are associated with DR/DG units, connected via aFRR aggregation platform, within BSPs (including the units that are controllable by the TSO as aFRR) and their operating parameters (e.g. FAT,

gradient, delay). Optimization time performance is directly dependent on the number of bids within complete system.

Figure 5: Simulator scalability enabled configuration process.

For the scalability tests, the maximal number of TSOs, DR/DGs and corresponding bids was first assessed. Considering these assessments, tests will be executed at different meaningful sizes (number of TSOs and DR/DG), where the size of the tests shall increase. To determine the sizes of the meaningful tests , we consulted Table 3, containing the theoretical flexible capacity potential in the four control zones and the EU28 region. The numbers are taken from the article by Gils (Gils, 2014), which used a combination of techniques to assess this potential.

The present table is an enriched version of Table1, from deliverable D1.1. The first three data rows represent the theoretically assessed flexible capacity potential, by sector and country. Row #4 represents a total of Industrial, tertiary and residential DR theoretical flexible capacity, not considering the DG capacity. Note, that residential units are not subject of the FutureFlow project. Since the full estimation of the theoretical flexible potential from D1.1 relies on data for PV, Wind and Small hydro that were considered equal to their "entire" installed capacity is rather arbitrary we have accounted for the scalability testing in D4.1 only the identified C&I theoretical flexible potential, positive and negative (Row #5).

For the needs of the scalability performance assessment we have considered 1 MW as the smallest bid size and bid step (this is actually the case in two of the control zones, Slovenia and Hungary). The (purely) theoretical maximum number of bids per control zone (row #6) can therefore be estimated as being equal to the number of MW available in the control zone.

Table 3: Theoretical flexible capacity potential in the four control zones.

		SI (MW)	**AT (MW)**	**HU (MW)**	**RO (MW)**	**SUM4 (MW)**	**SUM EU28 (MW)**
1	DR Industry	+119/-16	+315/-103	+156/-37	+677/-87	+1.267/-243	+19.529/-4.392
2	DR Tertiary	+91/-79	+363/-321	+349/-295	+231/-198	+1.034/-893	+26.295/-29.222
3	DR Residential	+128/-789	+602/-3.546	+530/-2.938	+755/-4.896	+2.015/-12.169	+32.475/-182.006
1+2+3	Total	+338/-884	+1.208/-3.970	+1.035/-3.270	+1.663/-5.181	+4.316/-13.305	+78.299/-215.620
1+2	Theoretical flexible capacity potential C&I	305	1.102	837	1.193	3.437	79.438
		SI	AT	HU	RO	SUM4	SUM EU28
	Theoretical max # of bids	305	1.102	837	1.193	3.437	79.438

The theoretical highest maximum number of bids in any country of the four control zones is therefore 1.193, in all four control zones it is 3.437 and in the EU28 region it is around 80.000 bids. With these estimations we will proceed to test scalability in the following way:

Specific IT tests will be executed at various scales (# of TSOs / # of bids), measuring KPIs like: calculation cycle time, optimization time, FAT.

Performance tests will be executed via simulation (LFC model, CAF model and CMOL generation and optimisation) at a gradually increasing scale. For the purpose of scalability tests will be performed with simulations of communication between platforms and data processing by the respective platforms. The tests will begin by submitting the simulated artificial set of bids to the respective FF Cloud platform and FutureFlow DEMO site, Figure 2, followed by bids activation. In this process the following tasks shall be tested: CMOL creation, CAF optimisation as well as communication towards FutureFlow DEMO site.

A sample of possible scalability tests will include the following border scale combinations:

- (1,1)- one TSO, one bid,
- (1, approximately 1000)- number of TSO in a single control zone, largest theoretical maximum number of bids in any of the four control zones (Romania),
- (4, approximately 3500)- number of TSOs in all four control zones, theoretical maximum number of bids in all four control zones,
- (43, approximately 80.000) - number of all TSOs in the ENTSO-E, estimated theoretical maximum number of bids in the EU28 regions deducted from Gils if considered 1MW per bid (and not counting DG).

Note, that all the estimations only serve to set rough upper bounds for testing scalability. Moreover, on the pilot demonstration only a fraction (up to 45 MW) of this aFRR capacity will be activated.

Replicability

Replicability property is concerned with possibility of realization of proposed solutions across EU member states. A prior successful step of scalability is a required condition. Although on pilot tests we do not test replicability as such, we can summarize issues that will be analyzed for replicability during later stages of the FutureFlow project. These are:

- Different SCADA system times (e.g. 2 s or 4 s) in control zones influence to operability of cloud realized CAFx and CMOL generation (like with FF Cloud platform on FutureFlow).
- Different types of merit order vs pro rata bid ordering per control zone.

- Influence of different FAT of bids, and possibility of markets to support either only standardised (FAT = 5 min), only specific (FAT = 10 min) or a mix of both types of products.
- Differing aFRR regulatory constraints for FAT products between the control zones (e.g. 5 min vs 15 min FAT by country).
- Communication standards requirements in different control zones and difficulty of integration into cloud platform (e.g. IEC 60870-5-104).
- DR/DG power signal measurements on level of DR/DG unit vs DR/DG location, including the required reporting (e.g. 1/min) and sampling (e.g. 10/s) times.
- DR/DG prequalification procedures for DR/DG harmonization and requirements from TSO or BSP sides.

Cybersecurity testing

Cybersecurity testing consists in attempting system hacks, e.g. by pretended connected stakeholders, to enter the various IT software modules and generate system disruptions, which can go down through cascading to possible local system collapse. The aim of these tests is to evaluate the overall IT security and robustness of the implemented solution. In the present deliverable, we identify groups of tests that should be conducted for each part of the system, proposing relevant scenarios to verify that they meet the required security properties. Note, however that while the scenarios elaborated at this stage are pertinent to conduct penetration tests on commercial solutions, the FutureFlow project will assess feasibility of large scale deployments on the basis of specific modules targeting a known environment of limited size. Therefore, for purposes of efficiency in conducting this pilot project, the involved stakeholders may make reasonable assumptions and/or adapt the testing scenarios during the course of the project to assess the security requirements in the context of the demonstration environment. For further details please refer to deliverables in WP2 and WP3.

In Section 8.4 of the present deliverable, we identify groups of tests to be conducted on each part of the system, proposing pertinent scenarios to conduct penetration tests to guarantee the robustness in the context of commercial solutions. The aims of these tests are to evaluate the robustness of the firewalls and to ensure that the security requirements of the system are satisfied with respect to ensuring:

- authentication between stakeholders,
- integrity of the information,
- confidentiality of the exchanged information,
- authorization to access stored information and perform actions,
- availability of the provided services (resistance to Denial of Service attacks).

The testing scenarios are grouped by platform/module (building block) and communication level (DR/DG-BSP, BSP- FutureFlow DEMO site (TSO), TSO-FF Cloud

Platform), enabling to repeat similar testing patterns at the different levels of the complete system.

In the context of the FutureFlow project, the ultimate goal is to assess feasibility of large scale deployments based on specific modules targeting a known environment of limited size. Therefore, for purposes of efficiency in conducting this pilot project, the involved stakeholders will make reasonable assumptions to adapt the testing scenarios expressed in the present deliverable during the development and integration phases. This will result in assessing the security requirements in the context of the FutureFlow environment using customized subsets of the scenarios expressed in section 8.4. The FutureFlow deliverables under WP2 and WP3 will present such specificities.

Demo environment performance under various set-up conditions.

The objective is to monitor simulator behaviour under different setups of configuration parameters. It is possible to analyse different CAF setups, standard vs specific products, FATs and both target control model options (i.e. control demand and control target) where two different imbalance netting strategies can be applied (i.e. implicit and pre netting). The example of configuration parameters are those that influence the decision of optimizer under border conditions. For the BSP it may be important to show the impartial operation of the optimization process, regardless of country, control zone, when all other parameters are kept equal, e.g. the same MW for pre-netting in several regions (netting is implicit in Option 1, pre-netting is explicit in Option 2), the same cross-zonal transmission capacity prices, the same input signals / measurements. Several types of such simulator / optimizer tests will be prepared as specified in Appendix, BSP-DR/DG chapter. Note, however that only a single target control model is going to be tested on pilot in real life conditions.

Test scenarios

All test scenarios for Use case 1 are summarized in Appendix 1. They are separated into levels, corresponding to four communication layers, and two additional sections, as listed below:

- Level 1: BSP- DR/DG.
- Level 2: FutureFlow DEMO site – BSP.
- Level 3: FF Cloud Platform – FutureFlow DEMO site.
- Level 4: TSO- FutureFlow DEMO site.
- Level 5: Cybersecurity testing.
- Level 6: Scalability testing.

The testing scenarios in each level will be executed in sessions. The sessions (on all levels) for Use case 1 are as follows:

- Session 1: Communications connectivity.
- Session 2: Bidding.

- Session 3: Imbalance netting (Control Option 1 where it is done implicitly in control demand integration of LFC and CAF) and pre-netting (e.g. Control Option 2 where imbalance netting is done before the CAF optimization in control request integration of LFC and CAF).
- Session 4: Activation.
- Session 5: FAT Tests.
- Session 6: Cybersecurity testing.
- Session 7: Scalability testing.

Note that some sessions (e.g. Communications connectivity) are executed across several levels, while others (e.g. FAT tests, ATC) are only executed at one level.

Every table containing tests scenarios summarizes all tests to be executed at a certain level and session. Within the table, the individual test scenarios are grouped into groups of scenarios that perform a certain task, e.g. "communicate pool levels to TSO platform in real time". Some groups of scenarios may logically be connected and should be executed consecutively during testing across two or more communication levels, e.g. "Communication" and "Bid pricing".

Detailed specification of all scenarios is in Appendix 1.

2.2 Use case 2 - DR/DG integration within each of the four control zones independently

2.2.1 Introduction

Use case 2 aims at measuring costs and benefits of the IT platform when involving customers within each of the different control areas that will participate in the pilot tests under the management of aggregators, but therefore excluding cross-border exchanges. This use case is performed under known boundary conditions for one quarter of a year (12 weeks, two consecutive days per week). It is assumed that each of the pilot test participating control zones sees a significant number of customers registered to provide enough data needed to quantify costs and benefits of the demand response integration to serve secondary reserve and to address critical re-dispatching issues.

The IT platforms (FF Cloud, FutureFlow DEMO site, aFRR aggregation platform) are configured in such a way that costs and benefits of the services provided by real customers can be monitored and measured with a controlled accuracy: this study sets targets for customer recruitment and activity in order to ensure that accurate data is gathered from customer participation. This use case is critical since it allows pinpointing the influence of secondary control on the cost/benefit analysis using the same IT tool. The ex-post impact analysis performed with such data and the simulation tools allow identifying critical regulatory rules which either amplify or destroy the benefits expected from the contribution of demand-response and distributed generation.

The DR/DG pool needs to undergo a set of performance tests to assess its fitness for secondary regulation. Prior to that, all DR/DG units will individually be submitted to

performance tests. These tests will provide the much needed feedback on the response characteristics of each unit, which will aid the aFRR aggregation platform in assessing how to incorporate all these units into the pool and develop a smart internal algorithm that will transform the received signal into signals adjusted to single units. Each prequalification test will be executed several times for each DR/DG unit to prove that units are able to behave in a predictable manner and perform similarly at every activation. This way we will assess the repeatability of the experiments. It is also a valid justification why the subsequent tests will only be executed once, on DR/DG unit level and bid product level (aFRR aggregation platform).

Performance tests will then be repeated with combinations of similar units (e.g. diesel generators), and finally with the entire pool. Both the positive and negative flexibility will be tested.

The performance tests are detailed in Appendix.

2.2.2 Problem definition

The key question to be investigated is the suitability of DR/DG units for aFRR balancing services, taking into account major KPIs, such as ACE performance and maximization of social welfare. Testing conditions must consider the complete problem space for which we are defining the boundary conditions and general cases, under which those KPIs will be calculated.

Examples of different input conditions:

- ACE signal behaviour: typical (e.g. 1-2 via zero crossings per hour), extreme, (e.g. positive and negative deviation per each control zone), without netting potential.
- Regular day/extreme day expressed in the shape of ACE open loop.
- Different proportions of DR/DG vs. conventional units (e.g. 10-90 %). This test is performed only with the help of simulations, based on prior known responses of conventional units, DR/DG units, LFC, and grid model.
- Different position of DR/DG on MOL (beginning, middle, end of MOL).

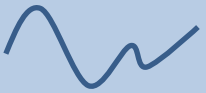
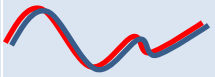
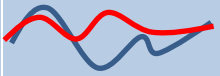
We will observe the influence of DR/DG participation on the KPIs (technical, economic). The KPIs which will be measured for input conditions are elaborated in parallel FutureFlow deliverable D4.2, like: ACE performance (better, worse, similar), market share of DR/DG in aFRR market (e.g. the share of balancing energy delivered by DR/DG compared to total delivered balancing energy), performance of aggregated DR/DG response (e.g. how well the aFRR aggregation platform follows the activation request while DR/DG units response perform comparably to conventional units in terms of response times, ramps and achieving FAT), aFRR energy costs and prices, social welfare. The table structure for these scenarios can be found in Appendix, section 9.2.

2.2.3 UC2 test execution methodology

The pilot test is executed in five stages. They are crucial to obtaining all the necessary

data for the ex-post impact analysis. Stages are described in Table 4.

Table 4: Gradual development of Pilot Test for use Case 2, in 5 stages.

	Name	Description	Goal	Ingredients	Correspondence with recorded signal
1	"Record reality"	Record ACE, Bids, Activations in each of 4 countries in selected time period(s) based on reality and original BSPs	To provide background data, control mechanisms and responses for the simulations and pilot tests.	ACE: real, as happened Bids (conventional): realistic, as happened Bids (DR/DG): none LFC setup: as applied	
2	"Simulate reality"	Within FutureFlow DEMO site, for each of the 4 countries: simulate the recorded reality (ACE, bids, activations), under the actually applied LFC and market setup	To verify the behaviour of simulator: use the same ACE, bids and control loop setups, to obtain same/similar activation responses.	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): none LFC setup: simulated (copied from 1st step)	 same or similar
3	"Convert to target model", then simulate	Within FutureFlow DEMO site, keep the basics from previous step, but adjust the setup of platform to the Target Model *Example: In SI, switch from Pro-rata to MO activation and re-run the simulation.*	Gradually move to Target Model (control Option 1 or control Option 2), keeping the basic (previously verified) setup of the DEMO site).	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): none LFC setup: adjusted to target model	 naturally deviates due to change of setup
4	"Simulate all with added simulated DR/DG"	Within FutureFlow DEMO site, keep the basics from previous step, and add DR/DG units in the simulation. *All (conventional) bids from previous step, then add simulated DR/DG, and re-run.*	Assess the needed potential of DR/DG of aFRR aggregation platform in each control area and inform GEN-I to prepare (contract) the roughly required level of DR/DG for the upcoming pilot test.	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): added, simulated LFC setup: adjusted to target model	
5	"PILOT TEST: simulate all with added real DR/DG"	Within FutureFlow DEMO site, keep the basics from previous step, and connect aFRR aggregation platform which includes real DR/DG units in the run. *All (conventional) bids from previous step, then add real DR/DG, and re-run.*	Real performance of DR/DG units within complete aFRR balancing energy market, where the rest (ACE, conventional original bids) stay simulated	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): added, connected real time LFC setup: adjusted to target model	

2.2.4 KPI evaluation methodology

Test scenarios defined in Appendix will be run partially or fully, according to the above test specification Table 4. The main inputs for evaluation are DR/DG presence in aFRR balancing energy bids and cross border energy flows between control zones due to bid activations from same control zones. D4.2 has defined KPI groups that will be evaluated,

particularly on UC2 and UC3 (Figure 6).

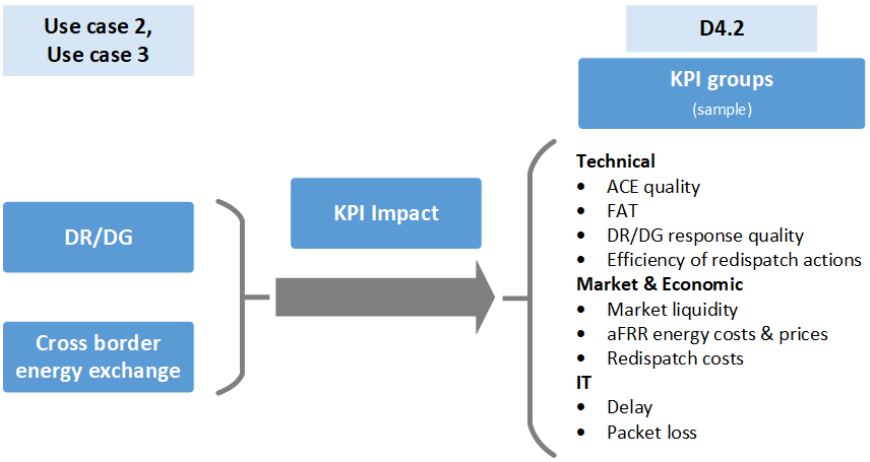


Figure 6: KPI impact flow evaluation: From cause to predefined KPIs.

2.3 Use case 3 - DR/DG integration within the four control zones coupled with Cross Zonal Capacity

2.3.1 Introduction

Use case 3 covers DR/DG integration via aggregators within the coupled control zones to serve FRR energy exchanges.

It aims at measuring costs and benefits of the operation of IT platform when involving customers both in each of the pilot test participating control zones and across control zones, under the management of aggregators only. This Use case is performed within a larger geographical boundary for one quarter of a year (12 weeks, two consecutive days per week). It is assumed that the number of customers has grown enough to keep the quality of the collected data similar to the level reached in Task 4.2. The IT solution is configured in such a way that costs and benefits of the services provided within or across control zones by real customers can be monitored and measured within a satisfactory and controlled accuracy. This study also sets targets for customer recruitment and activity in order to ensure that accurate data is gathered from customer participation, with a focus on cross-border exchanges. This use case is critical since it allows pinpointing the influence of existing national regulatory requirements on the cost/benefit analysis of cross-border exchanges, using a common IT tool. The ex-post impact analysis to be performed with such data and the parent simulation tools of WP1 allows identifying the attractiveness of the cross-border mode both for TSOs and the service providers, through aggregators.

2.3.2 Problem definition

The key question to be investigated is the viability of cross-border aFRR exchange, taking into account major KPIs, such as ACE performance and maximisation of social

welfare. Testing conditions must consider the complete problem space that is why we are defining its boundary conditions and general cases, under which those KPIs will be calculated.

Some examples of different input conditions are summarized:

- ACE signal behaviour: typical (e.g. 1-2 via zero crossings per hour), extreme, (e.g. positive and negative deviation per each control zone), without netting potential.
- Regular day/extreme day expressed in the shape of ACE open loop.
- Different proportions of DR/DG vs. conventional units (e.g. 10-90 %). This test is performed only with the help of simulations, based on prior known responses of conventional units, DR/DG units, LFC, and grid model.
- Different position of DR/DG on local MOL.
- Extreme day in one control zone, regular day in other control zones.
- High/low level of CZC.
- ATC, or Flow-based (PTDF&RAM) constraints; both exercised in parallel runs.
- Big disturbance in control zone.

The KPIs which will be measured for input conditions are elaborated in parallel FutureFlow deliverable D4.2, like: control quality (better, worse, similar), penetration level (market share) of DR/DG, quality of DR/DG response, aFRR energy costs and prices, social welfare.

On top of the KPIs relevant also for Use Case 2, also cross-border related KPIs can be observed within Use Case 3, like: CZC usage, occurrence of congestions, and behaviour of ATC vs. FB constraints.

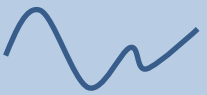
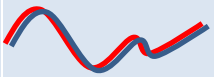
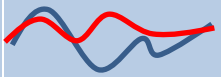
Also, performing Use case 3 enables not only the comparison of cases With/Without DR/DG inclusion, but also the comparison of With/Without cross-border exchanges, i.e. the comparison of the results of compatible tests within Use case 2 and Use case 3.

The table structure for these scenarios the same as for Use case 2, displayed in Appendix, section 9.2.

2.3.3 UC3 test execution methodology

The pilot test is executed in six stages. They are crucial to obtaining all the necessary data for the ex-post impact analysis. Stages are described in Table 5.

Table 5: Gradual development of Pilot Test for Use case 3, in 6 stages.

	Name	Description	Goal	Ingredients	Correspondence with recorded signal
1	"Record reality"	Record ACE, Bids, Activations in each of 4 countries in selected time period(s) based on reality and original BSPs	To provide background data, control mechanisms and responses for the simulations and pilot tests.	ACE: real, as happened Bids (conventional): real, as happened Bids (DR/DG): none LFC setup: as applied CZC: zero	
2	"Simulate reality"	Within FutureFlow DEMO site, for each of the 4 countries: simulate the recorded reality (ACE, bids, activations), under the actually applied LFC and market setup	To verify the behaviour of simulator: use the same ACE, bids and control loop setups, to obtain same/similar activation responses.	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): none LFC setup: simulated (copied from 1st step) CZC: zero	 same or similar
3a	"Convert to target model", then simulate	Within FutureFlow DEMO site, keep the basics from previous step, but adjust the setup of platform to the Target Model *Example: In SI, switch from Pro-rata to MO activation and re-run the simulation.*	Gradually move to Target Model (control Option 1 or control Option 2), keeping the basic (previously verified) setup of the DEMO site).	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): none LFC setup: adjusted to target model CZC: zero	 naturally deviates due to change of setup
3b	"Open cross-border exchange", then simulate	Define non-zero ATC-based or Flow-based cross-zonal capacities at the borders. (This step exists in UC3; could be done simultaneously within step 3a).	By defining cross-zonal capacities: to "open" the simulation for cross-border exchanges of aFRR energy.	OL ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): none LFC setup: adjusted to target model CZC: non-zero	
4	"Simulate all with added simulated DR/DG"	Within FutureFlow DEMO site, keep the basics from previous step, and add DR/DG units in the simulation. *All (conventional) bids from previous step, then add simulated DR/DG, and re-run.*	Assess the needed potential of DR/DG of aFRR aggregation platform in each control area and inform GEN-I to prepare (contract) the roughly required level of DR/DG for the upcoming pilot test.	ACE: simulated (taken from 1st step) Bids (conventional): simulated (taken from 1st step) Bids (DR/DG): added, simulated LFC setup: adjusted to target model CZC: non-zero	
5	"PILOT TEST: simulate all with added real DR/DG"	Within FutureFlow DEMO site, keep the basics from previous step, and connect aFRR aggregation platform which includes real DR/DG units in the run. *All (conventional) bids from previous step, then add real DR/DG, and re-run.*	Real performance of DR/DG units within complete simulated aFRR balancing energy market, where the rest (ACE, conventional bids) stay simulated	ACE: simulated (taken from 1st step) conventional BSPs: simulated (taken from 1st step) (DR/DG BSPs): added, connected real time LFC setup: adjusted to target model CZC: non-zero	

Note that compared to Use case 2 there is an additional step (3b) in Use case 3. This step can be done simultaneously within step 3.

All simulated and tested input conditions are the same as in UC2, in order to derive a meaningful comparison with UC3 that open zone borders and delivers cross-border aFRR exchanges.

2.3.4 KPI evaluation methodology

KPI evaluation methodology is the same as specified for UC2. Please, refer to relevant chapter for UC2.

2.4 Use case 4 - DR/DG integration, with possibility of switching among BSPs.

2.4.1 Introduction

Due to target model TSO-TSO we are only testing DR/DG to changing BSPs within single control zones. These tests will be executed in a controlled laboratory environment. In order to limit the impact of switching of DR/DG between aggregators (BSPs) on the performance, i.e. the ability to deliver what was requested by TSO, of both aggregators, our working assumption is that DR/DG could be prequalified at two BSPs at the same time. However, when BSP is activated, a clear and provable assignment of DR/DG units must be guaranteed, since only thus liabilities could be attributed to appropriate BSP. Prequalification phase is the process taken prior to any simulation and pilot testing and involves DR/DG owner (BSP customer) direct relationship negotiation. During UC2 test methodology, steps 3 and 4, we will use responses from both DR/DG units. Pilot test for UC4 will be executed only in controlled environment where all communication paths will be setup upfront and bids will be presented from BSP1 with DR/DG unit and later week from BSP2 from the same DR/DG unit.

2.4.2 Problem definition

Technological aspects

. Since the main drivers which shall regulate the switching process of DR/DG between the aggregators, where we do not expect that such process can happen to often and with ought connecting TSO being informed, are legal aspects, we shall here focus only on technical requirements of communications and data exchange between DR/DG and BSP. The aim is to assess under which conditions seen strictly form the communication point of view such switch of aggregators could be performed. Performance of key KPIs will be tested with a couple of extreme cases, e.g.:

1. All fast units of BSP1 migrate to BSP2; all slow units of BSP2 migrate to BSP1.
2. DR/DG control takeover by BSP2from BSP1 during activation.

Standardized communication solutions at each DR/DG location must be previously acceptance tested with both BSPs.

Legal aspects

There are many issues on the regulatory side when one considers changing DR/DG connection and contractual obligations from single BSP to two BSPs. It is the goal of UC4 also to investigate how to overcome some present legal issues, based on experiences we will gain from setting up the required business contracts and customer relationships between DR/DG and participating BSPs. Some are outlined below.

- Contractual part: How are DR/DGs who frequently attempt to change their BSP

dealt with.

- Regulatory part: which regulatory restrictions will be analysed closer, as they influence the performance?
- Document regulatory constraints per control zone.

3 Conclusions

We have presented four use cases that will be tested on FutureFlow. They tackle technical setup and performance testing of communication and IT infrastructures in the UC1. UC2 is exploring interesting scenarios of DR/DG participation for aFRR. UC3 extends these with cross border aFRR participation, as this is the main aspect of FutureFlow. UC4 will set up a laboratory controlled environment for testing special case of DR/DG changing BSPs on longer time scale (weeks).

Devised mix of simulation and real life pilot testing execution methodology allows for scenarios testing with wider scope. Although majority of scenarios are simulation based, they build upon real data gathered from TSOs, control zones aFRR past behaviour and accurate LFC models. Pilot testing is envisioned with real activations of DR/DG units that are connected to BSPs aFRR aggregation platform.

The prepared use cases will be tested in WP5.

4 References

Gils, H. C. (2014). Assessment of the theoretical demand response potential in Europe. *Energy, 67*, 1-18. doi:http://doi.org/10.1016/j.energy.2014.02-019

5 Appendix 1: Use case 1 Test scenarios

As stated in 2.1.3. tests will be executed on the following levels:

- Level 1: BSP- DR/DG.
- Level 2: DEMO site – BSP.
- Level 3: FF Cloud – DEMO site.
- Level: TSO – DEMO site.
- Level 5: Cybersecurity testing.
- Level 6: Scalability testing.

Levels are logically separated logically into the following sessions:

- Session 1: Communications connectivity.
- Session 2: Bidding.
- Session 3: Imbalance netting and pre-netting.
- Session 4: Activation.
- Session 5: FAT Tests.
- Session 6: Cybersecurity testing.
- Session 7: Scalability testing.

5.1 Level 1: BSP-DR/DG

5.1.1 Session 1: Communications connectivity

Test objective: Communications, data flow between BSP-DR/DG. BSP is hosting aFRR flexibility platform, from where tests are initiated. Establishment of basic cyber security mechanisms.

Table 6: Test scenarios, UC1, BSP-DR/DG: Communications connectivity.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
CC-01	Communication	ID-01	BSP-DR/DG connectivity, IEC 104	Data flow established	BSP-DR/DG, bidirectional	BSP, DR/DG or VPP provider
CC-02	Cybersecurity	ID-01	BSP-DR/DG connectivity with security mechanisms, IEC 104	Securing data flows (measurement, control)	BSP-DR/DG, bidirectional	BSP, DR/DG or VPP provider
CC-03	Semantics	ID-01	BSP-DR/DG semantic interoperability, IEC 104	Semantic model of data flows (measurement, control)	BSP-DR/DG, bidirectional	BSP, DR/DG or VPP provider
CC-04	Activation	ID-01	Send measurements	Data received	DR/DG-BSP	BSP
		ID-02	Send availability, positive	Data received	DR/DG-BSP	BSP
		ID-03	Send availability, negative	Data received	DR/DG-BSP	BSP

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
		ID-04	Send Lower limit of controllable range, absolute value	Data received	DR/DG-BSP	BSP
		ID-05	Send Upper limit of controllable range, absolute value	Data received	DR/DG-BSP	BSP

5.1.2 Session 4: Activation

Test objective: Activation commands from aFRR aggregation platform, between BSP-DR/DG. DR/DG reacts to activations with changing operational setpoint of delivered power.

Table 7: Test scenarios, UC1, BSP-DR/DG: Activation.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
AC-01	Activation, basic	ID-01	Send Activation Start/Stop	Received	BSP-DR/DG	DR/DG
AC-02	Activation, varying	ID-01	Send Setpoint, absolute value	Received	BSP-DR/DG	DR/DG
AC-03	Activation, monitoring	ID-01	Valid response from DR/DG	Received	BSP-DR/DG	DR/DG

5.2 Level 2: DEMO site-BSP

The sessions executed at Level 2 are: 1. Communications connectivity, 2. Bidding, 3. Imbalance netting and pre-netting, 4. Activation, as well as 5. FAT tests.

5.2.1 Session 1: Communications connectivity

Test objective: Communications, data flow between FutureFlow DEMO site-BSP. FutureFlow DEMO site is hosting demonstration TSO platform (LFC controllers, CAFx) from where tests are initiated. BSP is hosting aFRR aggregation platform. Establishment of basic cyber security mechanisms.

Table 8: Test scenarios, UC1, DEMO site-BSP: Communications connectivity.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
CC-01	Communication	ID-01	FutureFlow DEMO site-BSP connectivity, IEC 104	Data flow established	DEMO site-BSP, bidirectional	BSP, DR/DG
		ID-02	FutureFlow DEMO site-BSP connectivity, MQTT	Data flow established	DEMO site-BSP, bidirectional	BSP, DR/DG
CC-02	Cybersecurity	ID-01	FutureFlow DEMO site-BSP connectivity with security mechanisms, IEC 104	Securing data flows (measurement, control)	DEMO site-BSP, bidirectional	BSP, DR/DG
		ID-02	FutureFlow DEMO site-BSP connectivity with security mechanisms, MQTT	Securing data flows (measurement, control, bids)	DEMO site-BSP, bidirectional	BSP, DR/DG or VPP provider
CC-03	Semantics	ID-01	FutureFlow DEMO site-BSP semantic interoperability, IEC 104	Semantic model of data flows (measurement, control)	DEMO site-BSP, bidirectional	BSP, DR/DG

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
		ID-02	FutureFlow DEMO site-BSP semantic interoperability, MQTT	Semantic model of data flows (measurement, control, bids)	FutureFlow DEMO site-BSP, bidirectional	BSP, DR/DG

5.2.2 Session 2: Bidding

Test objective: Bidding functionality between DEMO site-BSP hosted aFRR flexibility platform. Bids and acknowledgements are exchanged.

Table 9: Test scenarios, UC1, DEMO site-BSP: Bidding.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
BD-01	Place bids on the trading platform	ID-01	aFRR aggregation platform operator sends the bids to the DEMO site bid forwarding function	FutureFlow DEMO site bid forwarding function receives the bids from aFRR aggregation platform	BSP→ FutureFlow DEMO site	BSP
		ID-02	Acknowledge of reception of bid message	Message received	BSP→ FutureFlow DEMO site	FutureFlow DEMO site
		ID-03	Confirmation of acquired bids	Trader is able to observe the acquired bids	FutureFlow DEMO site → BSP	BSP

5.2.3 Session 3: Imbalance netting and pre-netting

Test objective: Imbalance netting (Control Option1) and pre-netting (Control Option2) functionality between FutureFlow DEMO site-BSP hosted aFRR aggregation platform. BSP reacts to different setpoint signals due to netting with changing operational setpoints of selected bids.

Table 10: Test scenarios, UC1, DEMO site-BSP: Imbalance netting, pre-netting.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
IM-01	Imbalance netting, Control option 1	ID-01	ACE quality, imbalance netting followed by CAF optimization. Netting scenarios between control zones [none, 1-1, 1-2, 1-3, arbitrary].	Lower aFRR activation, depending on the netting capacities.	FutureFlow DEMO site - BSP	FutureFlow DEMO site
IM-02	Pre- netting, Control option 2	ID-02	ACE quality, pre-netting followed by CAF optimization. Pre-netting scenarios between control zones [none, 1-1, 1-2, 1-3, arbitrary].	Lower aFRR activation, depending on the pre-netting capacities.	FutureFlow DEMO site - BSP	FutureFlow DEMO site
IM-02	Pre- netting, Control option 2	ID-03	ACE quality, with proportional or algorithm decision pre-netting volume, pre-netting followed by CAF optimization. Border cases of equal zonal MW pre-netting options. Pre-netting scenarios between control zones [none, 1-1, 1-2, 1-3, arbitrary].	The same ACE quality, regardless of type of pre-netting selected.	FutureFlow DEMO site - BSP	FutureFlow DEMO site

5.2.4 Session 4: Activation

Test objective: Activation of functionality between DEMO site-BSP hosted aFRR flexibility platform. BSP reacts to different setpoint signals due to bid activations with changing operational setpoints of selected bids.

Table 11: Test scenarios, UC1, DEMO site-BSP: Activation.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
ACT-01	Receive setpoints and evaluate setpoints. BSP receives setpoint from FutureFlow DEMO site and checks if it is within defined limits.	ID-01	BSP receives and validates set-point from DEMO site	The user can view set-point send from DEMO site	FutureFlow DEMO site → BSP	BSP
		ID-02	Setpoint in BSP's control module is changing or refreshing every 2s	Setpoint in BSP's control module does change/refresh every 2s	FutureFlow DEMO site → BSP	BSP
ACT-02	Communicate pool values to DEMO site in real time. BSP transmits required data on the pool level to the DEMO site	ID-01	BSP sums individual measured values – pool	Summed pool values are available in BSP's control module or sent to FutureFlow DEMO site	BSP→ FutureFlow DEMO site	BSP
		ID-02	DEMO site receives summed pool values	FutureFow DEMO site receives summed pool values	BSP→ FutureFlow DEMO site	FutureFlow DEMO site

5.2.5 Session 5: FAT tests

Test objective: Bid products with different FAT (standard, specific, mixed products) and their activations between FutureFlow DEMO site-BSP hosted aFRR aggregation platform. BSP reacts to different bid activations that have different FAT with changing operational setpoints of those bids.

Table 12: Test scenarios, UC1 DEMO site-BSP: FAT.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
FAT-01	Bid products with different FAT	ID-01	Standard. Analyzing influence to ACE and social welfare performance.	realized FAT	FutureFlow DEMO site → BSP	BSP
		ID-02	Specific. Analyzing influence to ACE and social welfare performance.	realized FAT	FutureFlow DEMO site → BSP	BSP
		ID-03	Mixed products. Analyzing influence to ACE and social welfare performance.	realized FAT	FutureFlow DEMO site → BSP	BSP

5.3 Level 3: FF Cloud platform – FutureFlow DEMO site

The sessions executed at Level 3 are: 1. Communications connectivity, 2. Bidding, and two special sessions 6. Cybersecurity testing and 7. Scalability testing.

5.3.1 Session 1: Communications connectivity

Test objective: Communications, data flow between FF Cloud-FutureFlow DEMO site. FF Cloud is hosting CAFx. FutureFlow DEMO site is hosting demonstration TSO platform (LFC controllers, CAFx). Tests are initiated from either side. Establishment of basic cyber

security mechanisms.

Table 13: Test scenarios, UC1, FF Cloud platform-FutureFlow DEMO site: Communications connectivity.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
CC-01	Communication	ID-01	FF CLOUD platform-DEMO site connectivity, MQTT, measurements	Data flow established	FF CLOUD platform→ DEMO site, DEMO site → FF CLOUD platform	DEMO site, FF CLOUD platform
		ID-02	FF CLOUD platform-DEMO site connectivity, MQTT, control	Data flow established	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
		ID-03	FF CLOUD platform-FutureFlow DEMO site connectivity, MQTT, bids	Data flow established	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
		ID-04	FF CLOUD platform-FutureFlow DEMO site connectivity, HTTPS, HMI	Data flow established	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
CC-02	Cybersecurity	ID-01	FF CLOUD platform-FutureFlow DEMO site connectivity with security mechanisms, MQTT	Securing data flows (measurements, control, bids)	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
		ID-02	FF CLOUD platform-FutureFlow DEMO site connectivity with security mechanisms, HTTPS	Securing data flows, HMI	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
CC-03	Semantics	ID-01	FF CLOUD platform-FutureFlow DEMO site semantics, MQTT, measurements	Semantic model of data flows classified, stored in local DB on CLOUD, DEMO.	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
		ID-02	FF CLOUD platform-FutureFlow	Semantic model of	FF CLOUD	FutureFlow

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
			DEMO site semantics, MQTT, control	data flows classified, stored in local DB on CLOUD, DEMO.	platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	DEMO site, FF CLOUD platform
		ID-03	FF CLOUD platform-FutureFlow DEMO site semantics, MQTT, bids	Semantic model of data flows classified, stored in local DB on CLOUD, DEMO.	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform
		ID-04	FF CLOUD platform-FutureFlow DEMO site semantics, HTTPS, HMI	Semantic model of data flows classified, HMI commands proper response.	FF CLOUD platform→ FutureFlow DEMO site, FutureFlow DEMO site → FF CLOUD platform	FutureFlow DEMO site, FF CLOUD platform

5.3.2 Session 2: Bidding

Test objective: Bidding functionality between FF Cloud platform-FutureFlow DEMO site. FutureFlow DEMO site transparently sends bids received from BSP (aFRR aggregation platform) to FF Cloud. Bids and acknowledgements are exchanged.

Table 14: Test scenarios, UC1, FF Cloud platform-FutureFlow DEMO site: Bidding.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
BD-01	Bidding	ID-01	Bids in control zones [1, 2, 3, 4], positive, negative, single / multiple unit generate multiple bids, random bids price distribution	CMOL constructed with all bids.		FutureFlow DEMO site
BD-02	Bid pricing	ID-01	Bids with equal prices in control zones [1, 2, 3, 4].	CMOL bids construction, distribution.		FutureFlow DEMO site
		ID-02	Positive and negative prices per control zones [1, 2, 3, 4].	CMOL bids construction, distribution.		FutureFlow DEMO site
BD-03	Bid rejection	ID-01	Bids send with different FAT than the one valid for respective TSO:	CMOL constructed only from bids with proper FAT parameters.		FutureFlow DEMO site
		ID-02	Limited transfer capacity on control zone pairs [1-2, 2-3, 3-4], multiple combinations.	CMOL constructed only from bids from control zones with available transfer capacities.		FutureFlow DEMO site
		ID-03	No transfer capacity on control zone pairs [1-2, 2-3, 3-4], multiple combinations.	CMOL constructed only from bids from control zones with transfer capacities.		FutureFlow DEMO site

5.4 Level 4: TSO – FutureFlow DEMO site

5.4.1 Session 1: Communications connectivity

Test objective: Communications, data flow between TSO-FutureFlow DEMO site. Information exchange comprises SCADA measurements of ACE, tie lines power flows and setpoints of selected conventional units.

Table 15: Test scenarios, UC1, TSO-FutureFlow DEMO site: Communications connectivity.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
TD-01	Communication	ID-01	TSO-FutureFlow DEMO site connectivity, OPC UA	Data flow established	TSO-FutureFlow DEMO site, bidirectional	TSO, FutureFlow DEMO site
TD-02	Semantics	ID-01	TSO-FutureFlow DEMO site semantic interoperability, OPC UA	Semantic model of data flows (measurement, control)	TSO-FutureFlow DEMO site, bidirectional	TSO, FutureFlow DEMO site

5.5 Level 5: Cybersecurity testing

Test objective: Description and specification of production ready tests for replicated and scaled, production ready environments and platforms participating in cloud implemented, multi cross zonal aFRR balancing energy exchange. Note: These are only tests specifications and are not executed on demonstration platforms during pilot tests.

Table 16: Test scenarios, UC1, Cybersecurity.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
CY-01	Level 1 (DR/DG<>BSP)	ID-01	AUTHENTICATION: Attempt DR/DG Hacking for Spoofing / impersonation	Only authenticated DR/DG are allowed to connect to BSP	Ingoing to BSP	BSP
		ID-02	AUTHENTICATION: Attempt impersonation to control a DR/DG	Only allowed authenticated entities are allowed to control DR/DG	Ingoing to DR/DG	DR/DG
		ID-03	INTEGRITY: Attempt DR/DG hacking to compromise outgoing information	Detect compromised integrity	DR/DG>BSP	BSP
		ID-04	CONFIDENTIALITY: attempt to spy DR/DG-BSP communication	Information is protected from unauthorized access	DR/DG<>BSP	DR/DG-BSP links
		ID-05	CONFIDENTIALITY: attempt to access protected information stored at BSP level	Information is protected from unauthorized access	Ingoing to BSP	BSP
		ID-06	AVAILABILITY: Attempt DoS attacks against BSP	BSP platform can resist DoS attacks	Ingoing to BSP	BSP

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
CY-02	Level 2 (BSP<>TSO)	ID-01	AUTHENTICATION: Attempt to access TSO platform (e.g. via BSP impersonation)	Only authenticated BSPs are allowed to submit bids	Ingoing to TSO	TSO
		ID-02	AUTHENTICATION: Attempt TSO impersonation to activate a bid	Only allowed authenticated stakeholders can control the bids	TSO>BSP	BSP
		ID-03	INTEGRITY: Attempt BSP hacking to compromise outgoing information	Detect compromised integrity	BSP > TSO	TSO
		ID-04	CONFIDENTIALITY: attempt to spy TSO/BSP communication	Information is protected from unauthorized access	TSO<>BSP	TSO/BSP links
		ID-05	CONFIDENTIALITY: attempt to access protected information stored at TSO level	Information is protected from unauthorized access	Ingoing to TSO	TSO
		ID-06	AVAILABILITY: Attempt DoS attacks against TSO platform	TSO platform can resist DoS attacks	Ingoing to TSO	TSO
CY-03	Level 3 (TSO<> FF Cloud)	ID-01	AUTHENTICATION: Attempt to access FF Cloud platform	Only authorized entities can access FF Cloud platform	Ingoing to FF Cloud	FF Cloud
		ID-02	AUTHENTICATION: Attempt FF Cloud impersonation to interact with TSO	Only allowed authenticated TSO can control the bids	FF Cloud > TSO	TSO
		ID-03	INTEGRITY: Attempt TSO hacking to compromise outgoing information	Detect compromised integrity	TSO > FF Cloud	FF Cloud
		ID-04	INTEGRITY: Attempt FF Cloud hacking to compromise outgoing information	Detect compromised integrity	Ingoing to TSO	TSO
		ID-05	CONFIDENTIALITY: attempt to spy TSO / FF Cloud communication	Information is protected from unauthorized access	TSO <> FF Cloud	TSO/FF Cloud links
		ID-06	CONFIDENTIALITY: attempt to access protected information stored at FF Cloud level	Information is protected from unauthorized access	Ingoing to FF Cloud	FF Cloud
		ID-07	AVAILABILITY: Attempt DoS attacks against FF Cloud	FF Cloud platform can resist DoS attacks	Ingoing to FF Cloud	FF Cloud

5.6 Scalability testing

Scalability testing is done based on simulations only. Simulations are performed within FutureFlow DEMO site where CAFx and LFC models are run under various conditions and numbers of TSO, BSP, bids to derive time complexity vs number of variables

relationships.

Test objective: Scalability on simulation platforms (e.g. FutureFlow DEMO site, FF Cloud platform) of CAFx optimization functionality vs time complexity.

Table 17: Test scenarios, UC1, Scalability.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
SC-01	Optimization time, Base case	ID-01	Base case, 4x TSO, conventional units only, 1 bid/unit/CZ, Option1	Simulation time	NA	FutureFlow DEMO site
		ID-02	Base case, 4x TSO, conventional units only, 1 bid/unit/CZ, Option2	Simulation time, IN netting	NA	FutureFlow DEMO site
SC-02	Optimization time, Scale, conventional units bids	ID-01	Scale case, 4x TSO, conventional units, Nx bid/CZ (N = 10, … 1000), Option1	Simulation time	NA	FutureFlow DEMO site
		ID-02	Scale case, 4x TSO, conventional units only, Nx bid/CZ (N = 10, … 1000), Option2	Simulation time, IN netting	NA	FutureFlow DEMO site
SC-03	Optimization time, Scale, conventional units and DR/DG	ID-01	Scale case, 4x TSO, conventional units and Mx DR/DG, 1 bid/unit/CZ (Mx = 10, … 1000), Option1	Simulation time	NA	FutureFlow DEMO site
		ID-02	Scale case, 4x TSO, conventional units and M DR/DG, 1 bid/unit/CZ (M = 10, … 1000), Option2	Simulation time, IN netting	NA	FutureFlow DEMO site
SC-04	Optimization time, Scale units and bids	ID-01	Scale case, 4x TSO, conventional units and Mx DR/DG, Ox bid/CZ, O > M, Option1	Simulation time	NA	FutureFlow DEMO site
		ID-02	Base case, 4x TSO, conventional units and Mx DR/DG, Ox bid/CZ, O > M, Option2	Simulation time, IN netting	NA	FutureFlow DEMO site
SC-05	Optimization time, Scale units, bids, TSO	ID-01	Scale case, Px TSO (P = 5, … 50), conventional units and Mx DR/DG, Ox bid/CZ, O > M, Option1	Simulation time	NA	FutureFlow DEMO site
		ID-02	Base case, Px TSO (P = 5, … 50), conventional units and Mx DR/DG, Ox bid/CZ, O > M, Option2	Simulation time, IN netting	NA	FutureFlow DEMO site

6 Appendix 2: Use case 2 Test scenarios

Use case 2 allows only within the same cross zone bid activations from local MOL that is formed of bids from the same control zone. Tests are organised into two groups: performance tests of DR/DG units or products and test scenarios.

6.1 Performance tests

These tests cover performance tests (in a manner equivalent to prequalification tests in use by TSOs today) of individual DR/DG units that will be used in bids during UC2 – UC4 tests. Selected performance tests will be used also for bids, i.e. products that are composed of pools of DR/DG units from aFRR aggregation platform. The performance test set includes the testing DR/DG units or bids with a selection of example activation signals in Figures below.

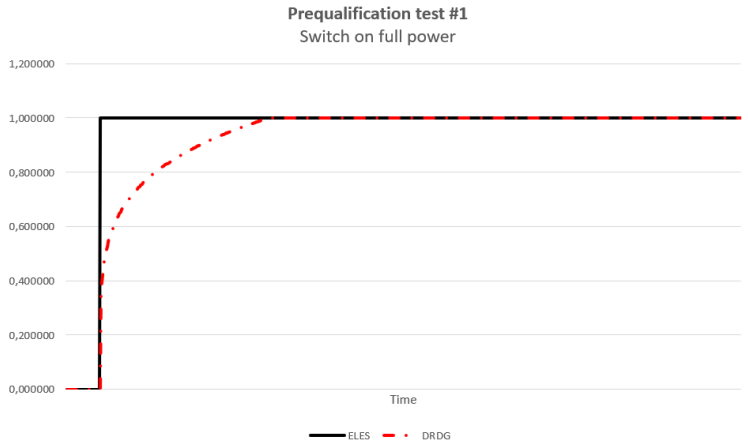


Figure 7: Test scenarios, UC2: Activation signal, positive step.

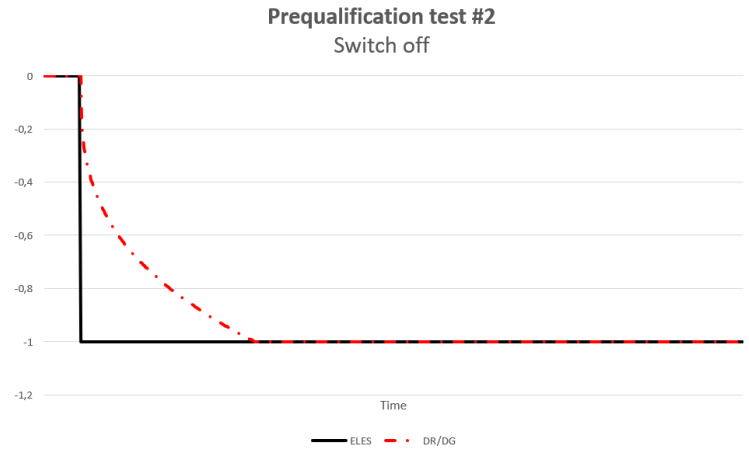


Figure 8: Test scenarios, UC2: Activation signal, negative step.

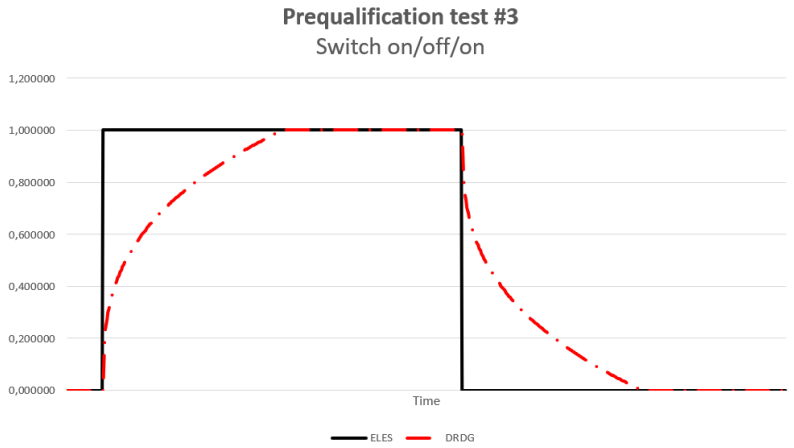


Figure 9: Test scenarios, UC2: Activation signal, positive on/off/on.

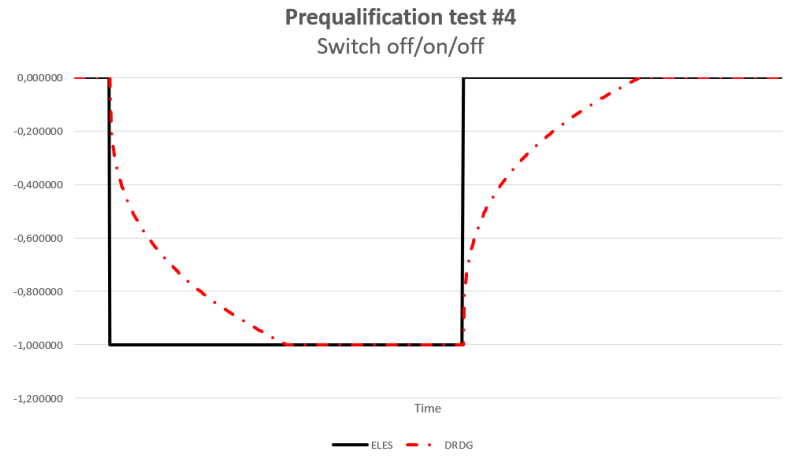


Figure 10: Test scenarios, UC2: Activation signal, negative on/off/on.

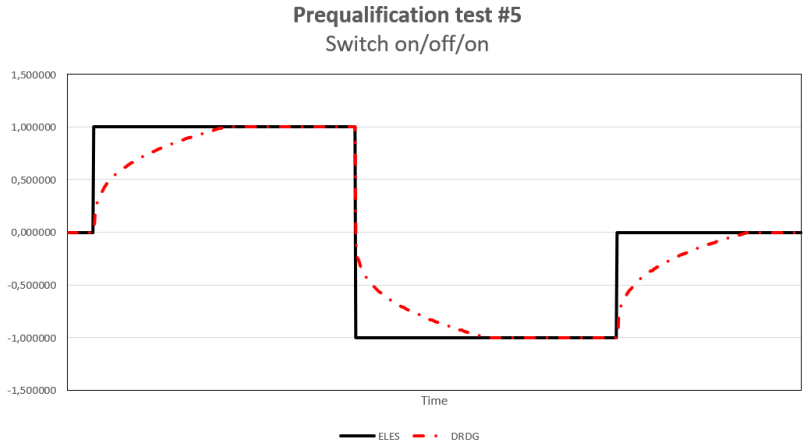


Figure 11: Test scenarios, UC2: Activation signal, positive/negative, on/off/on.

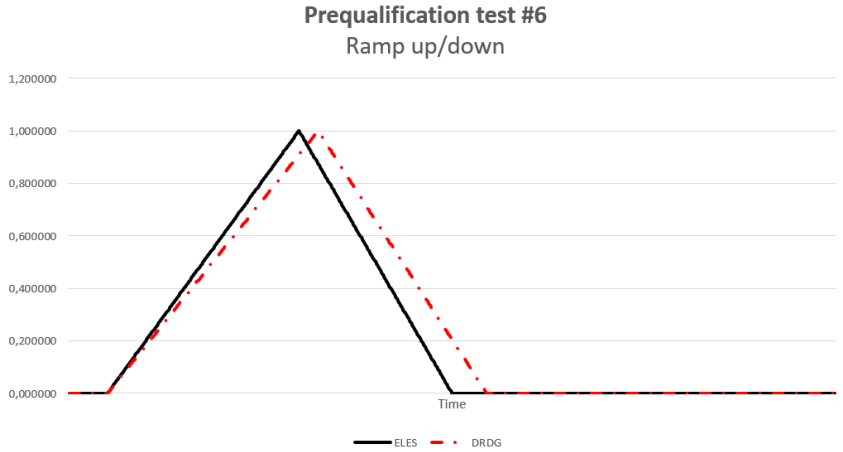


Figure 12: Test scenarios, UC2: Activation signal, positive ramp up/down.

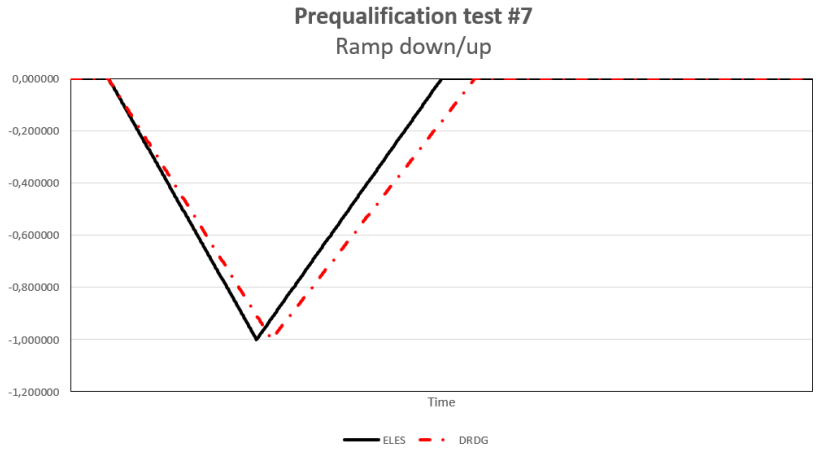


Figure 13: Test scenarios, UC2: Activation signal, negative ramp down/up.

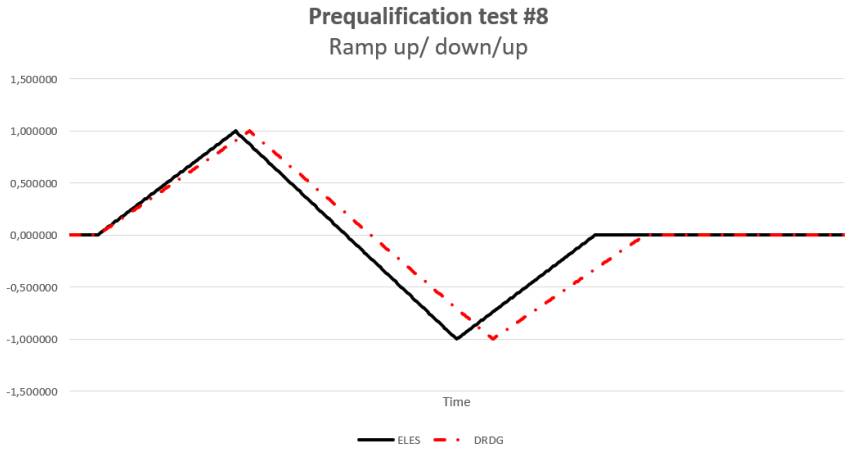


Figure 14: Test scenarios, UC2: Activation signal, positive/negative ramp up/down.

6.2 Use case 2 Test scenarios (simulations)

Test sessions will be identified and executed based on relevant identified circumstances defined by TSOs, considering TSO- available data suitable for simulations. The specific % of DR/DGs (first column), for which the test scenarios will be executed, will be determined later on.

6.2.1 ACE signal behaviour

Test objective: Under various ACE conditions in control zone: typical (e.g. 1-2 via zero crossings per hour), extreme, (e.g. positive and negative deviation), without netting potential.

Table 18: Test scenarios, UC2: ACE signal behaviour.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
AB-01	ACE behaviour	ID-01	Positive ACE, per control zone.	Bid activations follow CMOL, setpoints follow as required by real time ACE.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	Negative ACE, per control zone.	Bid activations follow CMOL, setpoints follow as required by real time ACE.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	ACE positive-negative, per control zone.	Bid activations follow CMOL, setpoints follow as required by real time ACE.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

6.2.2 Regular day, extreme day

Test objective: Day characteristics are expressed in the shape of ACE open loop.

Table 19: Test scenarios, UC2: Regular, extreme day.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
RE-01	Day characteristics of ACE open loop changes	ID-01	Open loop ACE on regular day.	Bid activations follow CMOL, ACE performance is satisfactory.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	Open loop ACE on extreme day, special event or similar.	Bid activations follow CMOL, ACE performance is satisfactory.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

6.2.3 DR/DG proportion of full activations

The whole spectrum of possible DR/DG proportion of activated aFRR capacity is only simulated, based on prior known behaviour of conventional units, LFC, grid model of each control zone and DR/DG unit responses. This scenario is performed as a simulation only. Proportion of DR/DG is achieved by pricing of bids and number of bids accepted in MOL.

Test objective: Different proportions of DR/DG vs. conventional units (e.g. 10-90 %) of the all aFRR capacity activations from all control zones for a given hourly bid interval.

Table 20: Test scenarios, UC2: DR/DG proportion of full activations.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
DA-01	DR/DG proportion of whole actions changing	ID-01	DR/DG proportion set to lower bound, approximately 10 %.	ACE performance is as with conventional units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
		ID-02	DR/DG proportion set to middle proportion, approximately 50 %.	ACE performance is as with conventional units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	DR/DG proportion set to upper bound, approximately 90 %.	ACE performance is as with conventional units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

6.2.4 DR/DG MOL positions

The assessment of relative merits of DR/DG bid depending of it positions within MOL are tested on simulation. Relative positioning of DR/DG bids within MOL is achieved by pricing of bids.

Test objective: Evaluate different positions of DR/DG bids on MOL (beginning, middle, end of MOL).

Table 21: Test scenarios, UC2: DR/DG MOL positions.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
DC-01	DR/DG bid positions	ID-01	DR/DG bids are placed at the beginning of CMOL, rest are populated by conventional units.	Bids are activated according to CMOL and setpoints of units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	DR/DG bids are placed in the middle of CMOL, rest are populated by conventional units.	Bids are activated according to CMOL and setpoints of units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	DR/DG bids are placed at the end of CMOL, rest are populated by conventional units.	Bids are activated according to CMOL and setpoints of units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

7 Appendix 3: Use case 3 Test scenarios

Use case 3 allows for cross zone bid activations from CMOL that is formed of bids from all control zones. This is a natural extension of Use case 2.

7.1 Use case 3 Test scenarios

Test scenarios in UC3 consider cross border flow and activations. Majority of test scenarios are the same as in UC2, but with added cross border flows and bids from all control zones, activated from CMOL. Different proportions of cross zonal ATC are specifically evaluated.

7.1.1 ACE signal behaviour

Test objective: Under various ACE conditions: typical (e.g. 1-2 via zero crossings per hour), extreme, (e.g. positive and negative deviation per each control zone), without netting potential.

Table 22: Test scenarios, UC3: ACE signal behaviour.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
AB-01	ACE behaviour	ID-01	Positive ACE, per control zone.	Bid activations follow CMOL, setpoints follow as required by real time ACE.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	Negative ACE, per control zone.	Bid activations follow CMOL, setpoints follow as required by real time ACE.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	ACE positive-negative, per control zone.	Bid activations follow CMOL, setpoints follow as required by real time ACE.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

7.1.2 Regular day, extreme day

Test objective: Day characteristics are expressed in the shape of ACE open loop.

Table 23: Test scenarios, UC3: Regular, extreme day.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
RE-01	Day characteristics of ACE open loop changes	ID-01	Open loop ACE on regular day.	Bid activations follow CMOL, ACE performance is satisfactory.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	Open loop ACE on extreme day, special event or similar.	Bid activations follow CMOL, ACE performance is satisfactory.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

7.1.3 DR/DG proportion of full activations

This scenario is performed as a simulation only. Proportion of DR/DG is achieved by pricing of bids and number of bids accepted in CMOL.

Test objective: Different proportions of DR/DG vs. conventional units (e.g. 10-90 %) of the all aFRR capacity activations from all control zones for a given hourly bid interval.

Table 24: Test scenarios, UC3: DR/DG proportion of full activations.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
DA-01	DR/DG proportion of whole actions changing	ID-01	DR/DG proportion set to lower bound, approximately 10 %.	ACE performance is as with conventional units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	DR/DG proportion set to middle proportion, approximately 50 %.	ACE performance is as with conventional units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	DR/DG proportion set to upper bound, approximately 90 %.	ACE performance is as with conventional units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

7.1.4 DR/DG CMOL positions

Relative positioning of DR/DG bids within CMOL is achieved by pricing of bids.

Test objective: Evaluate different positions of DR/DG bids on CMOL (beginning, middle, end of CMOL).

Table 25: Test scenarios, UC3: DR/DG CMOL positions.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
DC-01	DR/DG bid positions	ID-01	DR/DG bids are placed at the beginning of CMOL, rest are populated by conventional units.	Bids are activated according to CMOL and setpoints of units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	DR/DG bids are placed in the middle of CMOL, rest are populated by conventional units.	Bids are activated according to CMOL and setpoints of units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	DR/DG bids are placed at the end of CMOL, rest are populated by conventional units.	Bids are activated according to CMOL and setpoints of units.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

7.1.5 ATC dependence

ATC are only changed on 1 hour period so that restrictions on ATC are observed only on subsequent CMOL periods (also happening with 1 hour period).

Test objective: ATC on control zone borders changes (e.g. 0-100 %).

Table 26: Test scenarios, UC3: DR/DG CMOL positions.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
AT-01	ATC dependence	ID-01	ATC is fully available, more that required aFRR activation in any control zone	All bids are activated unrestricted as specified by CMOL	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-02	ATC is partially available on specific control zone borders, not full aFRR capacity is possible to be activated on cross border.	Bids are activated, but CMOL and setpoints are scheduled according to ATC restrictions.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-03	ATC is not available on specific control zone borders.	Bids are activated, but CMOL and setpoints are scheduled according to only on cross borders with available ATC.	FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform
		ID-04	ATC is not available on any control zone borders.		FutureFlow DEMO site-BSP-FF Cloud platform	FutureFlow DEMO site, BSP, FF Cloud platform

8 Appendix 4: Use case 4 Test scenarios

8.1 Use case 4 Test scenarios

Test scenarios in UC4 consider DR/DG changing participation with two BSPs within single control zone and both BSP are part of the same balance group. Change from BSP1 to BSP2 is allowed only longer time period, called delta time. Tests are performed under controlled laboratory conditions and limited scope. Goal is to make a complete cycle from bidding, bid acceptance, MOL placement and bid activation from BSP1 and after delta time BSP2.

8.1.1 DR/DG changing between BSPs

A prerequisite is that DR/DG has done performance tests with both BSPs.

Test objective: Changing DR/DG participation between two BSPs.

Table 27: Test scenarios, UC4: DR/DG changing BSP.

Group ID	Group of Scenarios	Scenario ID	Test scenario	Expected result	Comm. Direction	Location
DB-01	DR/DG changing BSP	ID-01	DR/DG complete process with BSP1, after delta time, complete process with BSP2.	Activation of bid from BSP1 and after delta time from BSP2 is done.	BSP1-DR/DG, BSP2-DR/DG	BSP1, BSP2, DR/DG