R2 NON-CIPU

DESCRIPTION AND CONCLUSIONS OF THE PILOT PROJECT

ASSESSMENT OF IMPLICATIONS OF TRANSFER OF ENERGY

Market Development

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Contents

In this pilot project, Actility Benelux, EDF Luminus, Next Kraftwerke and Elia have worked closely together to test the technical capability of alternative technologies to provide aFRR Control Power services. This study also describes the implications on applying transfer of energy to activated aFRR energy. Furthermore, the impacted DSOs (Ores, Eandis and Infrax) worked closely together with all the project partners to make this pilot project possible. The know-how and efforts introduced by all of the parties led to a successful completion of the pilot project. The conclusions of the pilot project were written by Elia in close collaboration with the project partners.

The conclusions regarding the implications of transfer of energy for aFRR are the result of an individual assessment made by Elia.

1 Executive summary

The report is divided in two large parts. The first part, i.e. chapter 3 to chapter 10, is describing the organisation and conclusions of the R2 non-CIPU pilot project, written by Elia with a significant contribution of the project partners, i.e. Actility, EDF Luminus and Next Kraftwerke. The second part of the report (chapter 12), describes the implications of transfer of energy in the aFRR market. These conclusions are the result of Elia's own assessment.

Elia, as a transmission system operator, is responsible for maintaining the balance in its control area in order to keep the system frequency between predefined ranges. In Belgium, the Balancing Responsible Parties are, on an individual basis, responsible for controlling the balance of the injections and offtakes of their own perimeter on a fifteen minute basis. For the residual imbalances, it is the responsibility of Elia to resolve them by activating contracted and non-contracted power reserves. Currently, the balancing market is already open for non-CIPU units for FCR and mFRR. aFRR is the only reserve product which is for the moment only accessible for CIPU-units.

The aFRR power reserve is and will be in the future the most important balancing product for Elia. The aFRR product has a high activation frequency with a large amount of activated energy and requires that flexibility is following up a continuous automatic signal via a SCADA-to-SCADA connection. This makes the aFRR product the most complex power reserve of the balancing products of Elia.

There are different challenges for the aFRR power reserves. Firstly, there will be an increasing need for aFRR reserve volumes towards the future. Secondly, a large share of this aFRR reserve capacity is mainly provided by conventional power plants and more specific gas-fired power plants which have signed a CIPU contract. However, the future of these historical providers becomes more and more uncertain and they experience high must-run costs. As a consequence, it is needed to investigate the attractiveness of new flexibility for the aFRR balancing market.

Elia has set-up a pilot project to investigate the technical capability of non-CIPU units to deliver aFRR services to the balancing market, with a focus on the technical aspects. The delivery of aFRR control power by non-CIPU units is investigated by the organization of a participation phase of 3 months where the effective delivery of aFRR power reserves by non-CIPU units on the aFRR balancing market is organised and tested.

The project was launched in August 2016, for delivering the services in July 2017. At the end of 2016, only 3 project partners successfully finalized the contracting phase, i.e. Actility, EDF Luminus and Next Kraftwerke. The limited number of candidates indicates that it was not easy to fulfil all the necessary and demanding requirements of the R2 non-CIPU pilot project on a short notice. The table below gives more information on the characteristics of the participating units of the portfolio of each partner.

Partner	Contracted upwards R2 non-CIPU control power	Contracted downwards R2 non-CIPU control power	Technology: production/load
Next Kraftwerke		2 MW	Cogeneration Units (biogas and natural gas)
EDF Luminus		2 MW	Cogeneration
Actility	1 MW (07h-19h) 0,5 MW(19h-07h)		Cogeneration units Water pumps

For participating at the aFRR balancing market, it is required to have a real-time connection between the SCADA of the BSP and the SCADA of Elia. The set-up of such a real-time connection in the framework of the pilot project was a time consuming process. For the project partners, both software and hardware investments were required. Afterwards, the real-time connection could be configured and the communication tests had to be performed in cooperation with Elia in order to be sure that the signals were exchanged in a correct way. During the same period the contractualization between the grid user and the BSP and the BSP and Elia had to be finalized.

Before the participation phase, the three project partners were obliged to pass successfully a prequalification test. During such a test, it is required to meet all the organizational and technical requirements. All project partners needed more than one prequalification test but successfully completed the test afterwards. The reasons for failure were not linked to availability issues of flexibility, but rather caused by communication and configuration problems.

Two activation methodologies were tested during the participation phase. In part A, the R2 non-CIPU power reserves were together proportionally activated as soon as the amount of aFRR reserves (144MW), delivered by CIPU contract holders, were fully used. In part B, the R2 non-CIPU power reserves were pro-rata activated together with the CIPU power reserves of Elia, i.e. a pure pro-rata activation.

The results of the participation phase are confirming that the delivery of aFRR is a complex operational process. Having experience in participating at an aFRR balancing market has an impact on the quality of the service at the start of the delivery.

The baselining (reference power) is a crucial aspect for delivering aFRR services. Based on the baseline, the delivered aFRR energy is calculated. This delivered energy is required for the settlement, activation check, transfer of energy, ... The quality of the baseline obtained during the participation phase has been analysed and Elia has obtained more insight in the baseline methodology. It is noticed that the set-up of the baseline methodology is a time consuming process, especially when the aFRR provider does not have experience with respect to this topic. Therefore, a learning curve is observed during the participation phase and in the end all three project partners have achieved a baselining methodology with an acceptable level of quality within the scope of the pilot project. It is also confirmed during the participation phase that a fixed baseline on a 15 minute basis, as it is applied for mFRR, is not applicable for aFRR. The aFRR product requires a variable baseline on 4 seconds basis in order to evaluate accurate the delivered energy. Since the importance of the baseline is confirmed, Elia will need to set-up in the future strict rules for the baseline quality. A prequalification of the baseline will be required. Furthermore, the baseline will also need to be evaluated during the participation at the aFRR balancing market in order to ensure the quality of delivery.

The quality of the reaction on the set-point, which was sent by Elia, has also been investigated during the participation phase of the pilot project. The set-point was sent by Elia each 4 seconds to the aFRR provider and the measured power was sent each 4 seconds by the provider to Elia. The difference between the baseline (reference power) and the measured power is equal to the activated power which is then compared with the requested power. For each provider a percentage of the size of the contracted volume is determining the margin for the error, i.e. the acceptable difference between the activated and the requested power. Consequently, for small volumes, it is observed that it is more difficult to reach an acceptable level of quality and therefore we conclude that a critical mass is required to participate at the aFRR market.

Also with respect to the quality of delivery, a learning curve is observed during the participation phase. In the end, all three project partners have succeeded in delivering aFRR with an acceptable level of quality. We conclude that R2 non-CIPU flexibility can deliver aFRR reserves with the same level of quality as CIPU units. In order to do so, a good quality of the baseline is crucial. Next to a good reaction on the set-point sent by Elia, it is equally important to have a stable real-time connection since an interruption of this connection will also lead to non-compliant reactions and thus penalties. We also expect, based on the obtained experience during the pilot project, that given the participation of aggregated smaller assets, Elia as well as the providers in the future should be capable in dealing with the exchange of a very important amount of data (potentially 10 of millions of data points per day).

The loss of a unit during an activation might also lead to non-compliant reactions because the baseline must be sent one minute in advance. Consequently, the loss of a unit will only be taken into account in the baseline one minute later. Potential solutions regarding this issue need to be further analysed in the future.

The focus of the pilot project was on technical aspects. However, some high-level market analyses were performed. The ranking of the non-CIPU bids in a merit order with respect to the CIPU bids were analysed. For the flexibility offered in the pilot project it appears that the downwards R2 non-CIPU bids would be at the end of the merit order and the upwards R2 non-CIPU bids would be at the beginning of the merit order. Hence it can be concluded that the activation price of the R2 non-CIPU bids could have a significant impact on the imbalance prices.

Going from a weekly to a daily tender for the aFRR capacity and putting the balancing energy gate closure time close to delivery should have a positive impact on the flexibility sourced from non-CIPU assets. But since 100% availability was required during the 3 months of the participation phase and providers did not offer additional volumes when possible, it was not possible to make additional conclusions based on the information received during the pilot project.

Throughout this document the basic principles from the Transfer of Energy rules, which lay the groundwork for all market situations with transfer of energy, are applied on R2 non-CIPU. Elia demonstrates the feasibility from a theoretical point of view. However, the technical and economic feasibility to implement a transfer of energy for the aFRR market needs further analysis and will be discussed in a concept note and feasibility study that will be delivered by end of 2018.

- All three project partners have demonstrated that non-CIPU units are technical capable in participating in the aFRR balancing market and thus in delivering aFRR in a qualitative way.

- However, it is confirmed that that the delivery of aFRR is a complex operational process and that for new entrants in the beginning it will be challenging to ensure a qualitative delivery as there will be a learning curve.

- Based on the results of the pilot project Elia believes that it is desirable that the aFRR market is opened to Non-CIPU flexibility. Therefore Elia will develop a new market design for aFRR including a technical evaluation of the implementation of Transfer of Energy. The results of this study shall be presented and consulted to stakeholders in the course of 2018.

2 Glossary & abbreviations

aFRR	Automatic Frequency Restoration Reserves
AS	Ancillary Services
BRP	Balancing Responsible Provider
BSP	Balancing Service Provider
CCGT	Combined Cycle Gas Turbines
CHP	Combined Heat and Power
CIPU	Coordination of the Injection of Production Units
DSO	Distribution Grid Operator
FCR	Frequency Containment Reserves
mFRR	Manual Frequency Restoration Reserves
NFS	Network Flexibility Study
Rx	One of the Power Reserves
SCADA	Supervisory Control and Data Acquisition
TSO	Transmission System Operator

PART 1: Description and conclusions of the pilot project.

3 Introduction

The report is divided in two large parts. The first part, i.e. chapter 3 to chapter 11, is describing the organisation and conclusions of the R2 non-CIPU pilot project, written by Elia with a significant contribution of the project partners, i.e. Actility, EDF Luminus and Next Kraftwerke. The second part of the report (chapter 12), describes the implications of transfer of energy in the aFRR market. These conclusions are the result of Elia's own assessment.

3.1. Context

Elia, as a transmission system operator, is responsible for maintaining the balance in its control area in order to keep the system frequency between predefined ranges.

In Belgium, the Balancing Responsible Parties (BRPs) are, on an individual basis, responsible for controlling the balance of the injections and offtakes of their own perimeter on a fifteen minute basis. BRPs are encouraged to support in real-time the balance of the Belgian control area by adjusting the generation and/or consumption in their balancing perimeter. For the residual imbalances (which are not solved by the BRPs), it is the responsibility of Elia to resolve them by activating contracted and non-contracted power reserves offered by balancing service providers (BSPs). Table 1 describes the different balancing processes and the associated products Elia is using to fulfil this responsibility.

Balancing processes	Current terminology	Description	Procurement	Market access	Current existing Balancing Products
Imbalance netting process	IGCC	Technical netting of opposed imbalances between TSOs of different balancing areas	N/A	N/A	IGCC
Frequency Containment Process (FCR)	Primary reserves (R1)	Very fast reserves to stabilize the European frequency in case of deviations after an incident.	Contracted reserves	CIPU/Non-CIPU	R1 200MHz, R1 100MHz Up, R1 100MHz Down, R1 100 MHz
Automatic Frequency Restoration Process (aFRR)	Secondary reserves (R2)	Fast reserves activated automatically and on a continuous basis to handle sudden disruptions in the area managed by Elia	Contracted & non-contracted reserves	Only CIPU	R2 reserves & bids (Up & down)
Manual Frequency Restoration Process (mFRR)	Tertiary reserves (R3)	Activated manually at request of Elia to address a major imbalance in the Belgian Control Area	Contracted & non-contracted reserves	CIPU/Non-CIPU	R3 Standard, R3 flex, ICH, CIPU Bids, Bids Bidladder

Table 1: Schematic overview of the different balancing processes

The power reserves mainly consist of three types of reserves: Frequency Containment Reserves (FCR, former primary reserves), Automatic Frequency Restoration Reserves (aFRR, former secondary reserves) and Manuel Frequency Restoration Reserves (mFRR, former tertiary reserves).

Currently, the balancing market is already open for non-CIPU units for FCR and mFRR. As a consequence the FCR and mFRR providers are BSPs. aFRR is the only reserve product which is for the moment for CIPU-units only accessible. Therefore, the aFRR reserves can only be delivered by large power plants and all providers (BSPs) are also BRPs. Present study is investigating how we can improve the market access for the delivery of aFRR-reserves (red frame in Table 1).

The aFRR product is the most complex power reserve of the balancing products of Elia. The aFRR product is automatically and continually activated in the upwards or downwards direction. It kicks in quickly and remains active as long as needed. For the activation, a signal transmitted by Elia's dispatching center to the providers' dispatching center automatically requests an increase or decrease of the power injected.

The table below indicates the frequency of activation and the amount of energy activated per product type. It shows that aFRR is also regarding flexibility requirements a complex product. For FCR, the product is frequently activated, but the activated energy is low. This is in contrast with mFRR where the amount of activated energy is large, but the frequency of activation is low. aFRR combines a high activation frequency with a large amount of activated energy.

product	FCR	aFRR	mFRR
Activation frequency	+++	+++	+
Activation energy	+	+++	+++

Table 2: The frequency of activation and the amount of energy activated per product type.

The aFRR power reserve is, and will be in the future, the most important balancing product for Elia. In 2016, 75% of all the activated energy for balancing purposes is delivered by the aFRR product (without IGCC), as represented in Figure 1. This product is setting the imbalance price for at least 80% of the time and together with FCR, it is accounting currently for 60-70% of the AS budget.

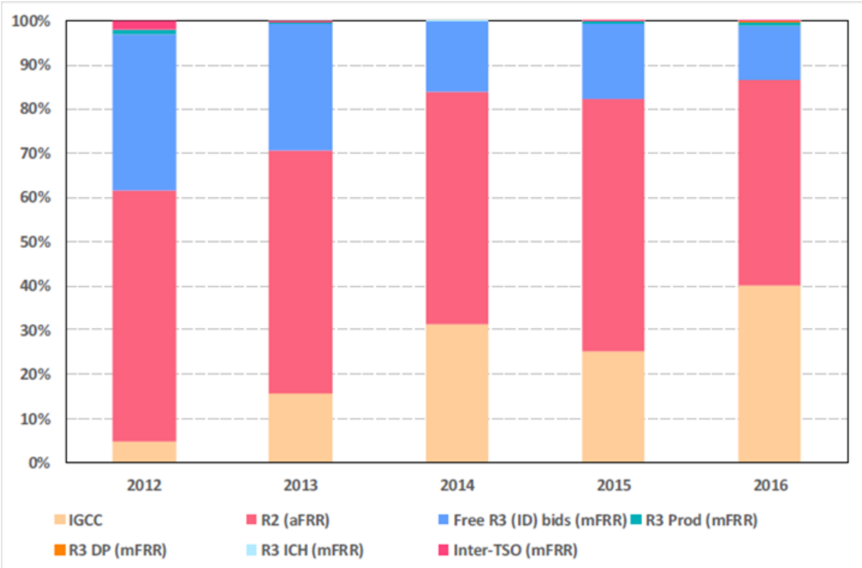


Figure 1: Shares of balancing energy activated per product type (Sources: Elia and CREG).

3.2. Added value of the pilot project

It is important to investigate the possibility to open this aFRR product to other technologies, and more specific non-CIPU units for following reasons:

- The expected increase of the aFRR capacity needs towards the future.
- Most of the aFRR capacity is delivered by gas-fired power plants (CIPU) which are suffering from declining market conditions resulting in high must run cost and thus higher costs to provide aFRR power reserves to Elia.
- Global Rx roadmap which indicates a standard contract for all flexibility.

The CREG and Elia therefore agreed upon a pilot project to investigate the possibility of non-CIPU units to deliver aFRR power reserves to Elia.

The main goal of this pilot project was to investigate the technical capability of non-CIPU units to deliver aFRR services to the balancing market, with a focus on the technical aspects such as the real-time communication, the follow-up of a set-point, baselining, ... The report provides answers on fundamental questions such as:

- Are non-CIPU resources technically capable to provide aFRR services to the TSO?
- What are the relevant differences between non-CIPU resources and conventional units for delivering aFRR services?
- Is the quality of the delivered aFRR service by non-CIPU resources the same as for conventional units?
- Does the Belgian aFRR market design enable participation of non-CIPU units?
- What is the quality of the baseline?
- How reliable is the service of R2 non-CIPU on provider and technology level?
- Is a merit order activation required for the delivery of aFRR services by non-CIPU resources?
- ...

In this pilot project the providers of the R2 non-CIPU control service participated for a period of about 3 months in the actual Belgian aFRR balancing market to answer the above mentioned questions. The results and conclusions are shared within this report. All design aspects must to be defined in close cooperation with all stakeholders in the future.

Since the results of the pilot project are positive as further explained in this report, Elia will redesign in 2018 the aFRR product. The objective of this design is to give access to the aFRR balancing market to all types of flexibility from all voltage levels (excluding low voltage levels on DSO grid) by all types of providers.

3.3. Report structure

Part 1: Description and conclusions of the pilot project:

In chapter 4, an overview is given of the current Belgian aFRR market framework.

In the next chapter 5, the organization of the pilot project is described.

Chapter 6 is drafted by the project partners explaining the technologies used in their portfolio and how the pool is managed to react on the set-point sent by Elia. More information is also given with respect to the determination of the offered volume for the energy bids.

The baseline methodology and the results of the baseline quality are represented in chapter 7.

The prequalification tests are described in chapter 8.

In chapter 9, the observed results of the participation at the Belgian aFRR balancing market are provided together with the analyses of the results.

High-level market analyses are performed in chapter 10.

In chapter 11, the main conclusions of the R2 non-CIPU pilot project are summarized.

Part 2: assessment of implications of transfer of energy:

Chapter 12 describes all the details with respect to the transfer of Energy.

4 Current Belgian aFRR market framework

The current aFRR market framework is set up for CIPU units and mainly for CCGT power plants who deliver the majority of the aFRR power reserves. The business processes of the aFRR market are summarized in the graph below.

Figure 2: aFRR business processes.

Before entering the aFRR market, units have to perform a prequalification test. Once, this test is successfully finalized, the units are allowed to participate at the aFRR balancing market. Elia procures all the required aFRR capacity on a weekly basis in combination with FCR. The bids selected during the tendering phase are the contracted bids. These bids are obliged to represent at least the contracted volume as aFRR energy bids at day-ahead. Also free energy bids, i.e. non-contracted aFRR power reserves, can be offered in day-ahead. After the gate closure time, the bids are selected per quarter-hour based on an economic merit order. During the day, the selected bids are activated on a pro-rata basis. Ex-post, the settlement is performed and activation and availability checks are done.

4.1. Prequalification

Before units can participate at the aFRR balancing market, they have to pass successfully the prequalification test. During the prequalification test, two aspects are verified, i.e. the organizational requirements and the technical requirements.

For the organizational requirements, it is verified whether the real-time and off-line communication requirements are fulfilled. Both ex-ante and ex-post, off-line data is communicated with Elia. For the real-time communication, a secure and redundant communication channel must be set up between ELIA and the provider. The provider must be able to receive and interpret the signals sent by the SCADA of ELIA and must be able to send the required data to the SCADA of Elia.

For the technical requirements, the provider must simulate the activation signal as shown in Figure 3. With this signal ELIA will test whether the provider can activate aFRR and if he is able to follow a variable signal with a deviation smaller than 7.5% of the maximum value. This signal has to stay within the upper and lower limit (band of 15%) as indicated in the figure below. It is checked whether the provider reaches the maximum value. This test will take 100 minutes.

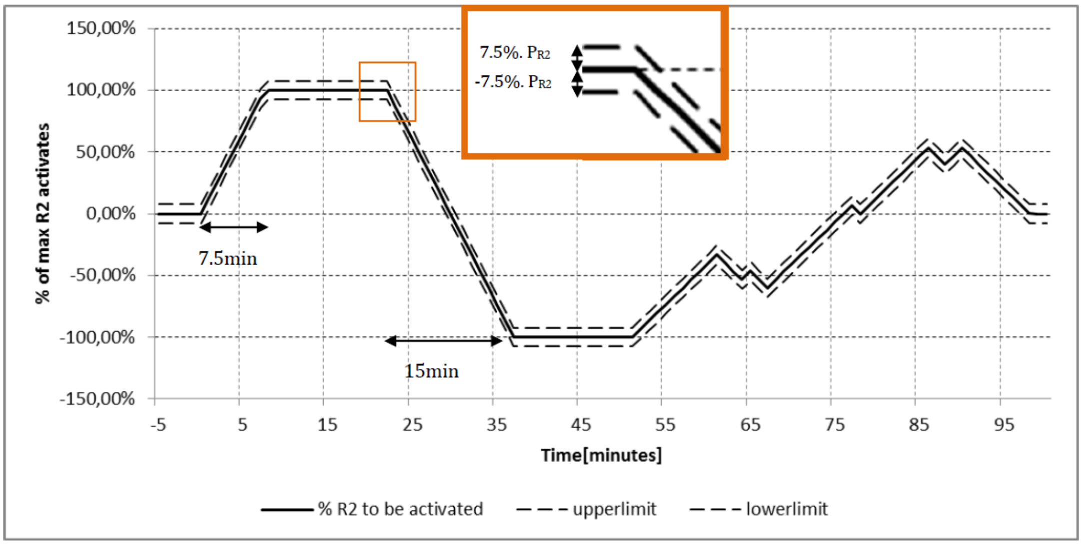


Figure 3: Prequalification simulation signal.

4.2. Tendering

A weekly tender is organized combined for FCR and aFRR in order to procure the minimum volume of balancing capacity (i.e. 144MW in 2017). The combined procurement is organized to achieve the lowest reservation costs for both FCR and aFRR together. An aFRR provider who has selected aFRR capacity is obliged to offer at least the contracted volume as aFRR balancing bids. The remuneration is a capacity fee [€/MW/h]. The contracted volume must be available for 100% of the time. A secondary market is organized where aFRR obligations can be exchanged on a bilateral basis between the aFRR providers. An intraday secondary market is organized from the first of January 2017 on to exchange aFRR obligations in case of a forced outage. From the 31st of December 2017 on, the secondary market for reserves will be extended in intraday no matter the circumstances and for all reserves R1, R2 and R3 contracted from CIPU units. It will also be extended in both day-ahead and intraday no matter the circumstances and for all reserves R1, R2 and R3 contracted from Non CIPU units. The most important characteristics of the aFRR capacity market are depicted in the table below.

aFRR capacity product	Value
Procurement cycle	Weekly
Product characteristics	• Weekly product • Peak – long off-peak product • Upwards and downwards product
Full activation time	7.5 minutes
Linking of bids	Possible: • between upwards and downwards aFRR; • between peak and long-off-peak; aFRR capacity bids (as well as between FCR and aFRR capacity bids)
Availability requirement	100% availability required
Minimum bid size	1 MW
Provision by Elia	Portfolio based (list of prequalified aFRR units) Co-optimization of FCR and aFRR procurement (minimization for the FCR and aFRR combination)
Remuneration	Pay-as-bid
Secondary market	• Day-ahead bilateral secondary market. • Intraday bilateral secondary market in case of forced outages. • Intraday bilateral secondary market with no circumstantial limitations (from the 31st of December 2017).
Penalty for non-availability	Uniform penalty for all market parties; Designed to incentivize use of secondary market

Table 3: aFRR capacity characteristics

4.3. Bidding and capping

Providers with contracted aFRR capacity (contracted bids) and providers without contracted aFRR capacity (free bids or non-contracted bids, without capacity remuneration) can send in day-ahead aFRR balancing energy bids on power plants. These energy bids will become binding in case the concerned power plants are selected for the delivery of aFRR.

The gate closure time for the aFRR energy bids is D-1 at 15h00. A valid aFRR energy bid in MWh per quarter hour indicates the unit that will provide the aFRR energy. The minimum quantity is 1 MWh. The providers are remunerated based on the activated aFRR energy [€/MWh]. There is a cap and floor for the aFRR activation prices:

- Price downwards activation: floor of 0€/MWh
- Price upwards activation: cap of fuel cost of a 50% efficient gas unit + 40€/MWh ≈ 100€/MWh

After the gate closure time, some consistency checks are performed on the submitted energy bids. Amongst other things, it is checked whether the sum of the aFRR volume and the power of the energy bid is not larger than the available minimum and/or maximum power of the concerned power units. The same check is also performed for the combination of the energy bids for all the ancillary services products (FCR, aFRR and mFRR). After these checks, the validated (and hence proposed) aFRR volumes of the energy bids will be considered in the selection. All the specificities of the aFRR energy bids are summarized in the table below.

aFRR balancing energy	Value
Procurement mechanism	• Obligation for contracted aFRR capacity (via primary or secondary market) to bid in at least the contracted capacity as aFRR balancing energy bids; • Non-contracted providers can also introduce bids
Bidding process	Bidding process is unit based
Activation process	Portfolio based activation
Product resolution	15 minutes
Gate closure time for energy bids	Day before delivery (D-1) at 15h00
Remuneration	Pay-as-bid
Pricing restrictions	Floor: 0 €/MWh Cap: +/- 100 €/MWh[1]
Minimum bid size	1 MW

Table 4: aFRR balancing energy characteristics

4.4. Selection

Two separated merit order lists per quarter hour are constructed at day-ahead. The merit order lists are a combination of contracted and non-contracted energy bids. For the upwards energy bids, the merit order is ranked from the lowest to the highest price and for the downwards bids, the merit order is ranked from the most expensive to the cheapest energy bids. The first aFRR energy bids for the volume of balancing energy, i.e. 144MW, are selected per merit order list. The non-selected aFRR energy bids become automatically non-contracted manual CIPU bids. The selected energy bids are summed per provider and the average weighted price and the participation factor is calculated per provider per direction as indicated in Figure 4. Also the average weighted price per direction for all providers is known D-1. These two merit order lists are sent to Elia's SCADA for pro-rata activation.

[1] Fuel cost of a 50% efficient gas unit [€/MWh_el] + 40 €/MWh

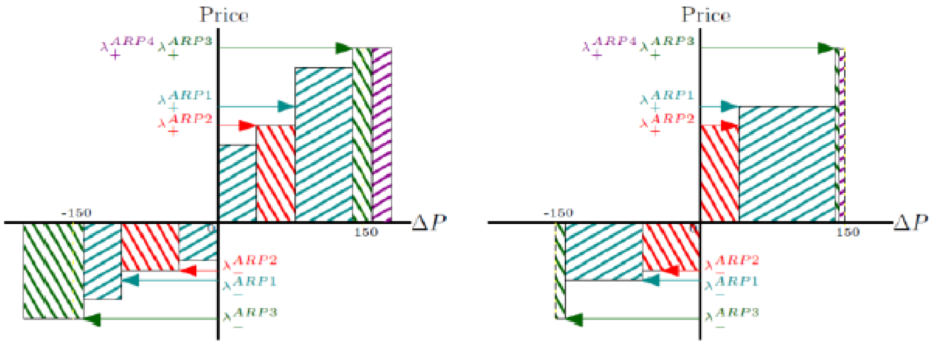


Figure 4: selected bids for the pro-rata activation: left per bid, right aggregated per BSP.

4.5. Activation

The PI controller is implemented in the SCADA of Elia. The imbalance (ACE) is the input of the PI controller. The activation is on a pro-rata basis and thus the PI controller determines the proportion of each bid that must be activated. Due to this pro-rata activation, all bids will be activated continuously. The control target does not take into account the ramping restrictions of the bids. This is done in the control request which is sent to the aFRR BSPs. Only one set-point is sent to one single BSP.

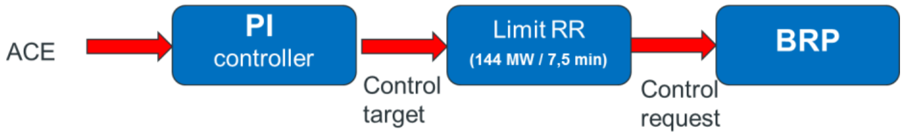


Figure 5: Activation process.

The advantage of such a pro-rata activation, as depicted in Figure 6, is that all bids are continuously activated, also for small imbalances, leading to very high ramping rates. A cap and floor are put in place by Elia in order to avoid excessive aFRR activation prices.

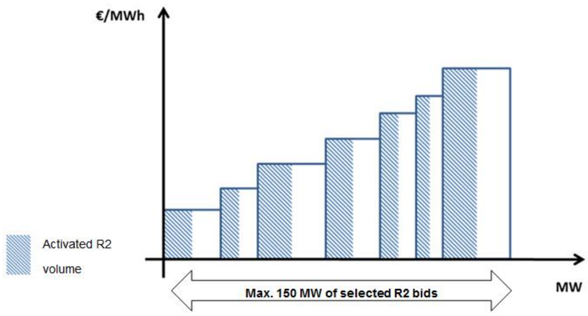


Figure 6: Illustration of aFRR pro-rata activation

A summary of the characteristics can be found in the table below.

aFRR balancing activation	Value
Activation mechanism	Pro-rata activation
Activation cycle	New set-point sent out every 4s
Required reaction	• The Elia activation signal respects the contractual ramp rate (determined by 7,5 minutes full activation time) • The aFRR provider must therefore follow in real-time the signal sent out by Elia (on 4s basis) • Verification on 10s basis
Activation signal	One aggregated signal is sent out to the aFRR provider • Aggregated for upwards and downwards activation • Aggregated for all aFRR balancing energy bids The provider determines which resources to activate.

Table 5: aFRR balancing activation characteristics

4.6. Settlement

The remuneration for the balancing capacity ('reserve') is the product of the unit price [€/MW/h] for the contracted aFRR capacity times the number of contracted aFRR capacity and the number of corresponding hours of the concerned delivery period.
The remuneration for the activated energy is the product of the activated energy upward (downward) with the concerned provider multiplied by the volume weighted average price of the day-ahead selected aFRR offers for upward (downward) of the provider during the concerned quarter hour. This remuneration is currently pay-as-bid.

4.7. Checks

For the availability control, the validated aFRR volumes of the energy bids (selected and non-selected) are compared per quarter hour with the awarded aFRR capacity during the tendering procedure. Elia will apply a penalty when the aFRR obligation of the contracted aFRR capacity is not fulfilled. This penalty is based on the clean spark spread and applies to any missing volume and for any quarter hour of the considered week in which Elia establishes that the quantity of the aFRR obligation has not been reached.

Besides the availability control, the activation control takes place. The upwards and/or downwards activated aFRR power supplied by the aFRR provider must be equal to the aFRR set-point sent by Elia. Elia will apply a penalty when this obligation is not fulfilled. The penalty is 45€/MWh for discrepancy. An exemption for non-compliancy is foreseen in very specific circumstances.

5 Organization of the pilot project

This section describes the different phases of the pilot project. An overview is given in the figure below.

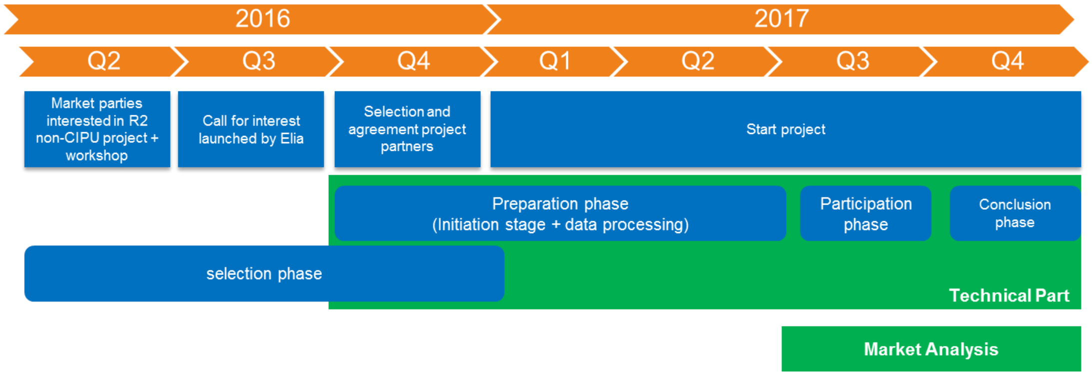


Figure 7: Timeline for the R2 non-CIPU pilot project

The pilot project consisted of 4 phases:

- Selection phase:
  Elia undertook several steps (e.g. organization of a workshop, launch of a tender, ...) in order to make a selection for the pilot project.
- Preparation phase:
  In this phase, all the necessary preparations for the participation phase were performed.
- Participation phase:
  During 3 months, the project partners participated at the aFRR balancing market.
- Conclusion phase:
  In this last phase, profound analyses were performed and a report with the conclusion of the pilot project has been drafted.

5.1. Selection phase

This paragraph gives more information concerning the selection phase of the pilot project, as also represented in Figure 8. Elia initiated this pilot project by giving a workshop in June 2016 by explaining the objectives and the organisation of the pilot project to possible interested stakeholders.

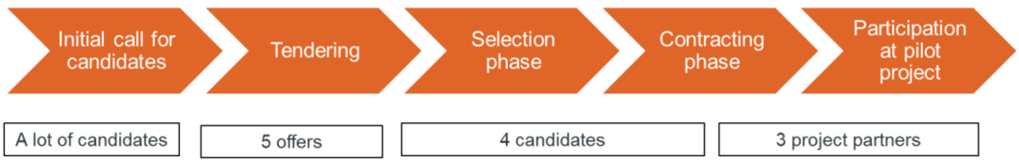


Figure 8: Timeline for the R2 non-CIPU of the selection phase

After this workshop, Elia launched a call for interest in order to identify the potential project partners for the R2 non-CIPU pilot project. 9 stakeholders indicated their strong interest in this project.

In august 2016, Elia launched a tender, where which besides a price and volume, potential candidates needed to explain also in detail, based on a list of questions submitted by Elia, their offer. Elia received finally 5 offers. The limited number of offers can be explained by sourcing, development and organizational issues. The aggregated offered volumes are represented in the table below.

	Upwards aFRR	Downwards aFRR
Offered volume	6,5 MW	25 MW

Table 6: Offered volumes during the tender.

Out of the 5 offers, 4 candidates were selected to proceed with contracting, based on the answers on the question list and in close cooperation with the CREG.

During the contractual phase 1 candidate was not able to deliver the offered technology as initially proposed. Therefore it was decided to proceed with the 3 remaining candidates for a specific volume: i.e. Actility, EDF Luminus and Next Kraftwerke.

The table below gives more information on the characteristics of the participating units of the portfolio of each partner. Elia selected diverse technologies in order to be able to assess their capability of delivering aFRR. EDF Luminus proposed one cogeneration unit, i.e. a production unit. Next kraftwerke had only production units in their portfolio. Their portfolio existed of around 14 cogeneration units (biogas and natural gas). Both project partners offered aFRR down. Actility is the only partner who provided upwards aFRR. Their portfolio is a combination of water pumps (load) and cogeneration units (production) and existed of 6 CHPs and 6 water pumping stations. The activation of the production units occurs on a continuous basis, the activation of the water pumps occurs on a discrete basis, i.e. with steps. More information on the used technologies and the pool management can be found in chapter 6. Behind one delivery point, several non-CIPU assets are located which are controlled on an individually basis.

Partner	**Contracted upwards R2 non-CIPU control power**	**Contracted downwards R2 non-CIPU control power**	**Technology: production**	**Technology: load**
Next Kraftwerke		2 MW	Cogeneration Units (biogas and natural gas)	
EDF Luminus		2 MW	Cogeneration	
Actility	1 MW (07h-19h) 0,5 MW(19h-07h)		Cogeneration units	Water pumps

Table 7: Overview offered volumes and technologies for project partners.

The limited number of candidates can be explained by the fact that the development of a portfolio of flexibility for the delivery of aFRR and meeting the technical requirements and organizational requirements (such as having an agreement with the grid users) are a time consuming process. Although the tender was yet launched in August 2016 for effective delivery from July 2017 onwards, this was considered by several potential candidates as a timeline which is too challenging.

5.2. Preparation phase

Before contracts were effectively signed, the preparation for the pilot project at the side of Elia and project partners had already started. The first months of 2017 were used to align and to implement the necessary accommodation for the participation phase with the project partners. The following steps were required before a prequalification test could be initiated:

- Set-up of the real-time connection:
  For the delivery of aFRR services, it is required to have a real-time connection between the SCADA of the BSP and the SCADA of Elia. The set-up of such a real-time connection is a time consuming process. For the project partners, both software and hardware investments are required. For example, routers and copper pairs needed to be installed by Elia and one partner needed to invest in a new fibre cable at their office.
- Configuration of the real-time connection and testing
  After the set-up, the real-time connection can be configured and the communication tests must be performed in cooperation with Elia in order to be sure that the signals are exchanged in a correct way. It was also necessary for Elia to perform a set-up of both hardware and software in order to make the real-time connection available with the project partners. These processes have to be completed for each delivery point. However, for some project partners, the set-up of the real-time connection was already done in the past for other products. The process of setting up and configuring a real-time connection and the testing of the signals took several months.
- Update of the SCADA of Elia:
  The set-up of participation phase was also a time-consuming process at the side of Elia. For the participation phase, the SCADA of Elia had to be updated in order to perform the two activation methodologies of the participation phase (section 5.3.2). An update of a SCADA is a cautious process, since this is a crucial real-time tool which is also used for the activation of the aFRR CIPU.

The set-up of the real-time connection was not evident and several unexpected problems, such as an interruption of the circuits, occurred. However, after the finalization of the steps mentioned above, the preparation for the prequalification tests and the prequalification tests itself were performed. Each project partner needed more than one prequalification test. More information regarding the lessons learned can be found in chapter 8. Also the monitoring of the participation phase is prepared in this stage. At the project partners side, it was also necessary to do the required implementations with respect to the pool reaction on the set-point, pool management, data management, ...

The access to the aFRR market is a time consuming process:

- Set-up of the real-time communication which requires potential investments for both hardware and software.
- Configurations need to be managed by Elia for each delivery point
- Contractualization between BSP and grid users and between BSP and Elia.

5.3. Participation Phase

The participation phase started at the beginning of Q3 2017. A detailed monitoring was set-up by Elia to analyse the results during this participation phase and to anticipate very quickly on unexpected behaviours.

5.3.1. Set-up of the participation phase

The project partners participated at the aFRR balancing market during the participation phase, which took place from the beginning of July until the end of September. A successful prequalification test was required before the project partners could start the participation phase. The participation phase enabled to gain experience during all different stages of the aFRR framework in delivering aFRR balancing energy (e.g. bidding quality, data exchange, reaction of the R2 non-CIPU provider on the aFRR set-point, quality of the baseline,...) by using different sources of technology.

The delivery of aFRR services of the R2 non-CIPU flexibility during the participation phase did not have an impact on the balancing prices and the net regulation volumes. The R2 non-CIPU prices were not taken into account for the calculation of the imbalance prices and the R2 non-CIPU volumes were not considered in the net regulation volume. A BRP notification was sent by Elia to the concerned BRPs before each Tuesday (17h00) of week (W+1) for week W concerning the aggregated impact of activated energy of R2 non-CIPU resources per quarter hour in their balancing perimeter.

5.3.2. The two parts of the participation phase

This actual testing of aFRR delivery by the activation of R2 non-CIPU Control Power was split in two parts: part A and part B.

In a first part (part A), the aim was to approach a merit order activation. In Figure 9, the difference between a pro-rata and a merit order activation is represented. In a pro-rata activation (left graph), all bids are activated in parallel and proportional way with respect to their bid size. In a merit order activations (right graph), only the cheapest bids are activated.

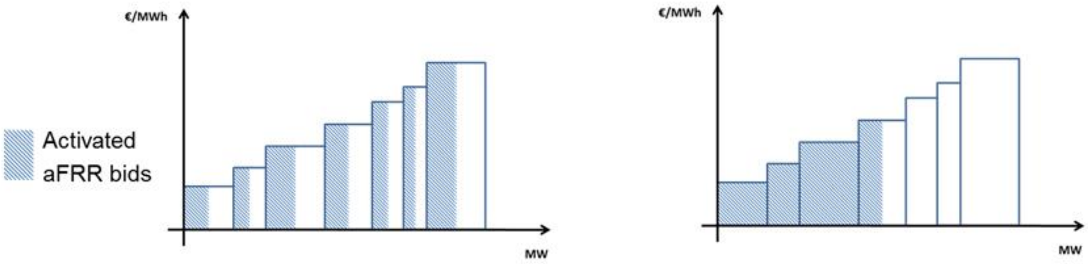


Figure 9: Pro-rata activation (left) versus merit order activation (right).

The application of a pure merit order activation was not possible because the current version of Elia's SCADA can only perform pro-rata activations. In order to simulate a merit order activation, Elia developed a work-around solution: from the moment the 144MW of selected aFRR power, delivered by CIPU units, were fully used, the R2 non-CIPU power reserves were activated also on a pro-rata basis. This is shown in Figure 10. In fact, this can be seen as a kind of a merit order between CIPU units and non-CIPU units, where the non-CIPU units are placed at the end of the merit order list. Indeed, it is expected that most of the non-CIPU units will be ranked in the merit order list after the CIPU units and therefore, this approach is assumed to be close to the merit order activation and within the limitations of the current version of the SCADA.

Part A was tested for a period of 10 weeks, starting from the beginning of July until mid-September.

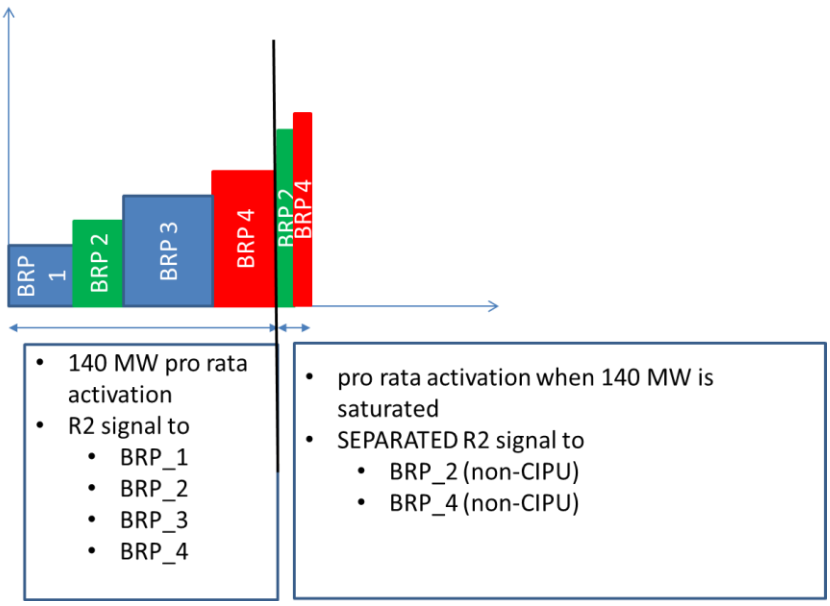


Figure 10: Activation methodology applied in part A of the participation phase.

In a second part (part B), the R2 non-CIPU power reserves were pro-rata activated together with the CIPU power reserves of Elia, as shown in Figure 11. Part B was tested for 3 days in the second half of September. The objective of this phase was to test whether R2 non-CIPU flexibility is capable in delivering aFRR on a more constant basis. In the future, even when a merit order will be implemented and even when R2 non-CIPU flexibility would be at the end of the merit order, they still must to be capable in dealing with frequent activations in case of structural imbalances.

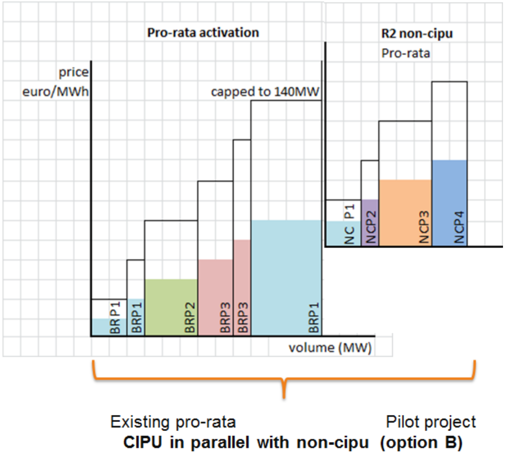


Figure 11: Activation methodology applied in part B of the participation phase.

5.3.3. Practical information of the project partners

EDF Luminus has started two weeks earlier due to the maintenance of the cogeneration unit, which took place at the end of July. In that way, the same duration time for the participation phase was obtained for all project partners. The maintenance occurred from mid-July until the end of July. Before the maintenance, the cleaning of the boiler occurred a few times per day. During this cleaning of the boiler, the cogeneration unit and thus the flexibility was not available. Afterwards, the boiler of the cogeneration unit had to be cleaned less frequently.

At the start of the participation phase, i.e. the beginning of July, there was dryness in Belgium and as a consequence there was a water shortage. Due to this event, it was for Actility not possible to activate the water pumps. These water pumps would be activated during the night (off-peak). The water pumps are put in service for the aFRR activation from the beginning of August on (i.e the 5th of August). As a result, Actility was not compliant during the night until that moment.

5.3.4. Information exchange during participation phase

During the participation phase, real-time communication as well as off-line communication (day-ahead and ex-post) was performed.

<u>Day-ahead information (off-line communication):</u>

The project partners were obliged to send day-ahead the following energy bids (unit based):

- Volume per unit (MW)
- Price per unit (€/MWh)
- Baseline per unit (MW)

Since the contracted volume must be available for 100% of the time during the participation phase, these energy bids are only used to check the capability of offering energy bids and to investigate the market impact of the activation prices.

Real-time information

In real-time, the project partners and Elia exchanged the following information per delivery point and/or per pool on a 4 second basis between the SCADA of Elia and the SCADA of the BSP.

- ELIA communicated the following information in real-time towards the BSPs:
  - The aFRR set-point (ΔPsec_tot)

- The project partners communicated the following information in real-time:
  - A return signal of the set-point (mirror of the received signal).
  - For each R2 non-CIPU Delivery Point or on pool level:
    - "Avail_sec": Logical signal (0 or 1) that indicates whether the R2 non-CIPU Delivery Point is actually participating in the Service.
    - "Psec": The number of MW of ΔPsec_tot. that are attributed to a non-CIPU Delivery Point
    - "Pref(t)": The power (in MW) that each R2 non-CIPU control delivery point of the provider participating in the R2 non-CIPU Control shall inject in t + Δts for its own needs. Also referred to as the Baseline.
    - The measurement of the net (gross if the net value cannot be measured) power produced per non-CIPU Delivery Point.
    - "Pmin_sec": The minimum power of the R2 non-CIPU Delivery Point, expressed in MW.
    - "Pmax_sec": The maximum power of the R2 non-CIPU Delivery Point, expressed in MW.

Ex-post information (off-line communication):

Ex-post, the next day, the real-time information was also sent per email to Elia, as is also currently the case in the current aFRR framework for CIPU units.

It must be emphasized that during the R2 non-CIPU pilot project a large data exchange happened between the project partners and Elia. In real-time, per delivery point 6 parameters were exchanged on a 4 second basis, i.e. almost 130.000 values per day per delivery point. It must be emphasized that 27 delivery points participated in the pilot project.

It is expected that in the future, pools of decentralised small flexibility will deliver aFRR. As a consequence for more and more delivery points, real-time data need to be exchanged. For example, 4MW down is delivered with 15 delivery points of EDF Luminus and Next Kraftwerke. An extrapolation gives 540 delivery points for 144MW and hence approximately

70 million values per day. If we only consider the pool of 2MW of Next Kraftwerke, this would give more than 1000 delivery points for 144MW and hence 130 million values per day. Hence we expect large data exchanges between the aFRR providers and Elia in the future. The operational implications will need to be taken into account in the future design of aFRR.

5.4. Conclusion phase

In the last phase of the pilot project, the data and information gathered during the participation phase was investigated in detail. Profound analyses were performed which are described in chapter 7, 8, 9 and 10 of this report. During the whole duration of the pilot project, on a regular basis, feedback was given to the Work Group Balancing. Elia consulted the CREG on crucial milestones in the project to give feedback on the progress.

5.5. Organisation with the DSO's

The three participating parties offered R2 non-CIPU control power from delivery points that were connected to the distribution grid. Therefore a close collaboration together with the impacted DSOs (Ores, Infrax and Eandis) was necessary to provide a successful pilot project. Organizationally the collaboration took place as follows:

1) The impacted DSOs were informed about the participating parties, the general project as a whole and possible participating delivery points.
2) Elia provided a definitive EAN-list of participating delivery points. Eandis, Infrax and ORES provided a Network Flexibility Study (NFS) to preventively check against possible congestions on the distribution grid due to the activation of flexibility on the distribution grid.
3) The DSOs, the project partners and Elia mutually agreed that the final EAN list could be used to deliver R2 non-CIPU control power for this pilot project.
4) The DSOs were on a regular basis informed on the progress of the R2 non-CIPU pilot project.

6 Delivery of aFRR services by different technologies

This chapter investigates the challenges for different technologies to provide aFRR services and is a direct contribution of the project partners to the report. Differences between the utilised technologies and conventional units for the delivery of aFRR services are highlighted. Structurally this chapter is divided according to the different solutions proposed by the providers for delivery of aFRR:

1) A water distribution system and greenhouse CHPs for aFRR by Actility
2) A mix of biogas and natural gas cogeneration units for aFRR by Next Kraftwerke
3) One cogeneration unit by EDF Luminus

In general, EDF Luminus showed the potential of delivering aFRR on the distribution grid with one unit, Next Kraftwerke performed the aFRR delivery by pooling several generation units and Actility delivered the aFRR service with a combination of generation and load delivery points. These differences are summarized in the table below:

Project partner	Difference with current R2 CIPU
EDF Luminus	Smaller unit size connected to the distribution grid
Next Krafwerke	Smaller unit size connected to the distribution grid Pool of generation delivery points
Actility	Smaller unit size connected to the distribution grid Pool of generation delivery points Pool of load delivery points

6.1. Water distribution system and greenhouse CHPs for aFRR

Actility participated in the aFRR pilot with 2 different technologies during different time periods. A water distribution system, consisting of dozens of pumps and several large water reservoirs delivered aFRR during the off-peak hours whereas greenhouse natural gas CHPs delivered the service during peak hours.

Greenhouse CHPs are run during daylight hours to provide the required heat and CO_2 for the crops, resulting in profitable running hours during the day. In general, operating the CHPs during the night results in negative results based on the day-ahead market, making the CHPs unavailable during the off-peak hours for the delivery of aFRR as the technology can only provide the reserve while running.

The water distribution system is run by a governmental municipality and ensures potable water is produced, stored and distributed at the right pressure to both residential and industrial customers. This system consists of several water production sites where pumps are used to extract water from aquifers and pump it to a central large reservoir. From this reservoir, the water is distributed to the connected industry and homes.

6.1.1. The technology

Water distribution system

The water distribution system can act as an energy storage system where the energy is stored in the form of filling the reservoir to comply with future water offtake. Within the context of aFRR, a water distribution system is an energy limited resource as the water, and thus the energy, in the reservoir is limited. Therefore, a sophisticated control algorithm is required to ensure the required water offtake is always met while delivering the aFRR service. Furthermore, to provide the water municipality with sufficient comfort, minimum and maximum limits are set on the volume of the reservoirs connected to the controlled pumps. Before the R2 non-CIPU pilot project, Actility used the water distribution system to trade energy volumes on the day-ahead and imbalance markets.

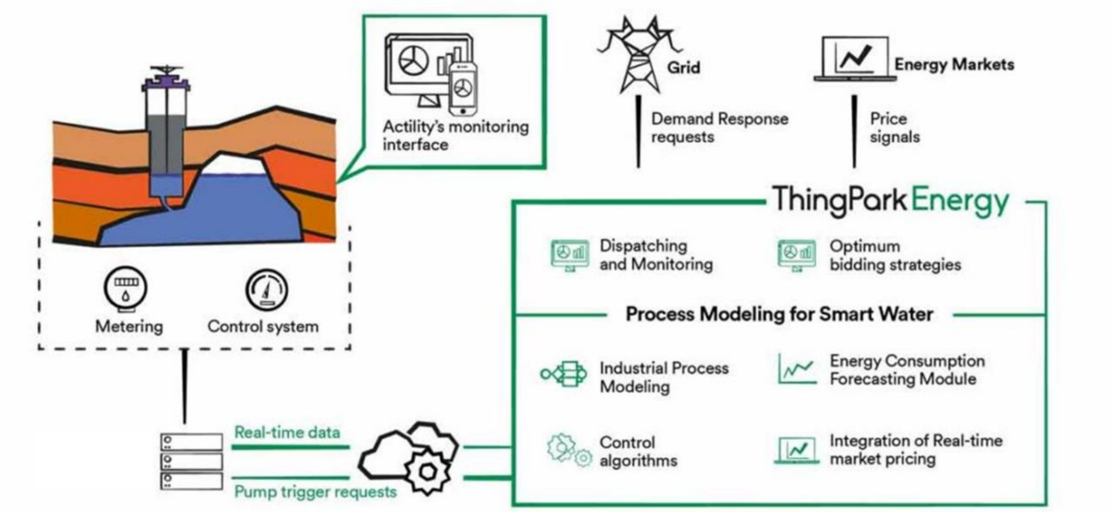


Figure 12: Schematic overview of the Actility software architecture for the control of a water distribution system.

To cope with the changing water offtake from the reservoir and the operational limits, a physical model is build which encompasses the water pump electricity consumption and its corresponding water flow, the network topology and the water reservoirs. Based on a prediction of the water offtake, the physical model can predict the aggregated future electricity consumption of the water pumps, while respecting the reservoir limits. The model is used to implement an advanced aFRR control method which relies on the dynamics of the system. The main advantage of this approach is the fact that it allows the current timeslot to be optimized while anticipating future events to take control actions accordingly.

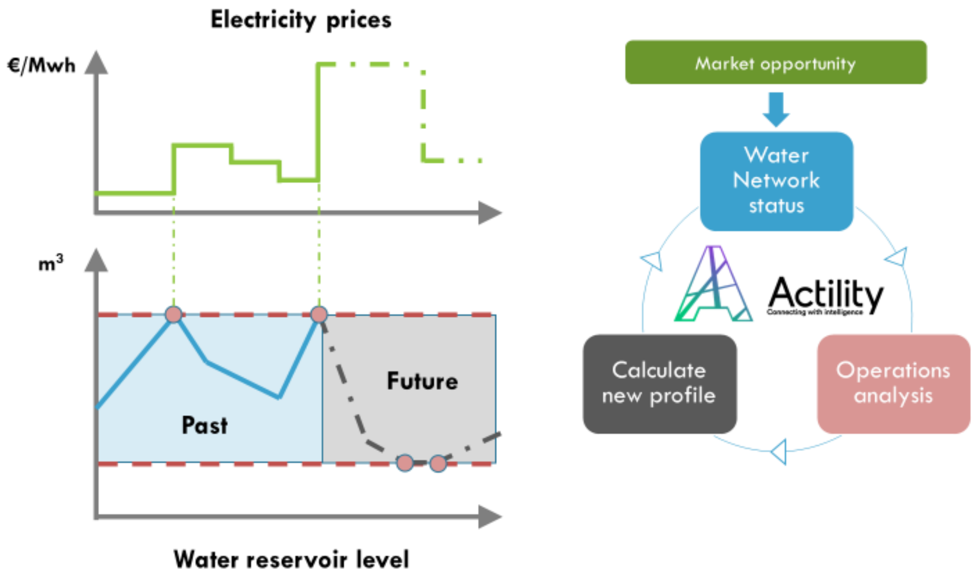


Figure 13: Schematic overview of the predictive control of a water distribution system based on electricity prices.

The required aFRR signal is sent by the TSO to the control system, which calculates the optimal control signal distribution towards the pumping stations, considering the current and future reservoir volumes.

Greenhouse gas CHPs

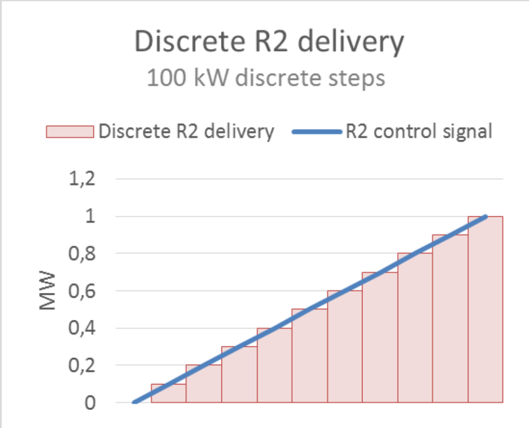
Most greenhouses use gas engines as they can generate power, heat and CO_2 simultaneously, resulting in an excellent and efficient solution. Gas engines have been used to generate power for years and are, in general, able to modulate their power with relative accuracy to provide the exact requirements for the greenhouse. The challenge lies in connecting the power modulation and control signal to a central platform after which the CHPs can modulate its power based on this signal. The gas engines showed medium to fast ramp rates which are more than sufficient to comply with the 7.5 minutes aFRR requirement.

6.1.2. Activation of the pool

Water distribution system

The controlled water pumping stations contain pumps which can be switched ON or OFF but are unable to modulate. Due to this characteristic, these water distribution systems can almost instantaneously deliver the maximum aFRR power by starting or stopping all pumps together. There is no inherent ramp rate present. On the other hand, as the aFRR control from the TSO is bound to a ramp rate characteristic, the discrete control of the water pumps must be adjusted to comply with this requirement.

To follow the control signal as close as possible, pumps are scheduled to start and stop based on the amount of power requested by the TSO, simulating an aggregated ramp rate. The accuracy of this simulated ramp rate heavily depends on the discrete step size of a pump relative to the total amount of aFRR power required. The figure below shows the inevitable error when following a continuous signal with discrete steps and the evolution of this error based on the number of discrete steps the aFRR delivery is based on.



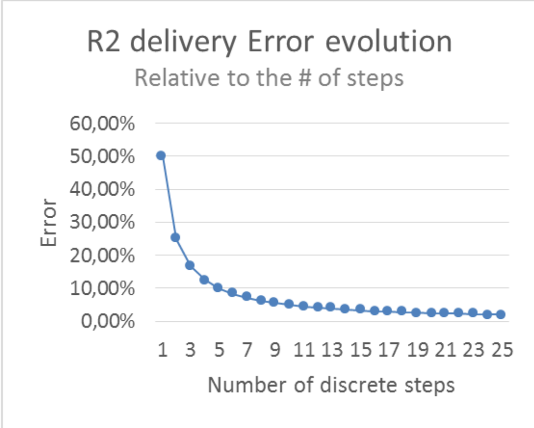


Figure 14: Discrete activations by the water pumps.

During the pilot, the physical model constructed a merit order of the different pumps with respect to the water reservoir volumes, the pumps availability and the future water offtake. For each change, a set of ON/OFF commands for the connected pumps was constructed to minimize the aFRR delivery error while complying with the water distribution operational constraints. Actility uses the same technology and system to trade on the imbalance markets and added the ramp rate requirement to the technology to be able to participate in the aFRR pilot.

The discrete activation of units can result in extreme ramp rates (close to instantaneous) but imposes an error on the aFRR delivery.

The delivery of aFRR with CHPs is closer to the conventional centralized generation model as it uses the same technology (generation) and only change the location (from centralized to distributed). Distributed discrete assets can provide extreme high ramp rates if required.

Greenhouse CHPs

After connection to the Actility platform, the activation of the greenhouse CHPs is relatively simple and consists of the simultaneous delivery of the aFRR signal by a fleet of distributed generators. Using multiple distributed generators instead of a single large generator for the aFRR has several large advantages

1. **Increased reliability** – A fleet of distributed generators is much more reliable as a single asset delivering the aFRR service. A fleet of 11 1MW generators, delivering 10 MW of aFRR with one backup generator and a failure probability of 90% for each generator, has a reliability of 99% for the delivery of 10 MW and a reliability of 99.9% for 9 MW. This heavily outperforms the delivery of the service with a single generator with 99% reliability for the entire volume.
2. **Increased ramp rate** – The ramp rate of the fleet will increase for each unit joining the aggregated pool of generators delivering the service as all units are able to start at the same time.

3. **Increased measurement accuracy** – By combining several measurements of distributed generators which are equally distributed, the measurement accuracy of the aggregated delivery of the pool increases for each unit added to the pool. This accuracy largely outperforms the accuracy of single measurements on a large generator.

6.1.3. Determination of the offered volume for energy bids

The energy bid for the water pumps is based on the physical model and is extremely close to the expected energy usage without aFRR control. The CHP energy bid currently is a fixed bid but can be updated to use the provided nomination of the greenhouse CHPs to their supplier. These grid users already all used nominations.

6.2. A cogeneration unit to provide aFRR

6.2.1. The technology

Recybois is a young and innovative company which has demonstrated through its business activities that it is possible to combine sustainable and economic development. From 1 of their 3 combined installations, Recybois ensures the recycling of wood waste within a cogeneration plant. The cogeneration uses Wood waste and the recovery of used pallets taken from customers supplied by François Paletterie and other manufacturers in the region.

They are unloaded onto a storage slab and then crushed into blocks that are less than 100 mm in size. Metal particles are recovered using magnetisation (ferrous metals) as well as an eddy current separator (nonferrous metals). The blocks are filtered to eliminate as many of the fines as possible. This dust will be reclaimed at a cement works.

These wooden blocks, calibrated and cleaned, are providing a regular feed to a boiler that produces steam. This steam drives a turbine that produces electricity, as well as heat recovered in the form of hot water and used for heating buildings and industrial units, for drying the sawdust that is used as a raw material to produce pellets and for the regulatory phytosanitary treatment of pallets.

Regarding the delivering of the R2 service, EDF Luminus based the solution on the systems used for the CIPU Power Plants. EDF Luminus didn’t encounter any problem for the translation and the treatment of the signal from ELIA towards our delivery point.

6.2.2. Activation of the pool

Not Applicable for EDF Luminus, since only one single unit.

6.2.3. Determination of the offered volume for energy bids

After daily alignment with the customer on the day-ahead program, the default status is available.

6.3. A mix of biogas and natural gas cogeneration units to provide aFRR

6.3.1. The technology

Cogeneration (Combined Heat and Power or CHP) is the simultaneous production of electricity and heat. In the pilot project various types CHP units were aggregated. One part of the aggregated units is fuelled with biogas that is created in a methanisation process; another part consisted of units fuelled with natural gas from the public gas network. The gas is consumed by a gas motor. Some motors are best or only suited for one type of gas. Other so-called dual fuel engines can process both natural gas and biogas.

The electricity is generated in a standard generator. The heat is extracted in parallel and can be transported to heat consuming secondary processes.

Technically all such engines can in general run very flexible above a certain base load minimum. Set-points can be sent in continuous steps and most engines can follow it with very high accuracy. The activation time of aFRR does not put a limit to the power that can be reached. The major constraints are set from the secondary use of electricity, heat and CO_2 (The latter is injected into green houses for optimal plant growth).

6.3.2. Activation of the pool

Next Kraftwerke's virtual power plant permanently evaluates the connection status, the current set-point and the operational point of all units in real-time. Based on this information the activated amount is split across all available units, keeping various units always above a safety margin (redundancy). In case there is a unit which does not follow its set-point accurately enough and within the expected speed, there is an outage or a connection loss of a unit, then within seconds the part of aFRR that was not accurately delivered is redistributed to either other active units or to another available unit that is in redundancy. Thus, any inaccurate aFRR activation due to e.g. losses of units or connections is corrected by other units of the pool almost instantly.

Within its pool, Next Kraftwerke can prioritize the activation of certain units if this increases the performance of the pool or in case the technical restrictions or economic constraints of the client make these necessary.

Biogas runs very steady and the owner of the biogas plant has typically an interest to run as many hours during the year as possible. Outside the usual maintenance which takes place during the daytime the biogas plants are always available, both day and night. CHP availability can be more restricted as it depends on the heat and CO_2 demand. Therefore they are typically run mostly during high price hours and will normally have more capacity available (for downward aFRR) during peak / daytime hours.

6.3.3. Determination of the offered volume for energy bids

In the pilot the availability of individual natural gas CHP installations is mostly based on historical availability. For some installations this could be improved by consulting their day-ahead market nominations. Since not all CHPs sell their power through the day-ahead market, this would not be possible for all. Clearly, variably operated installations such as natural gas CHPs can offer aFRR-down (and aFRR up) when they are pooled with other technologies that are available when the CHPs do not run. Such combination can unlock inexpensive reserve power provision. Their variability makes it typically difficult to predict their availability individually, but not in a pool. That makes pooling CHPs so interesting.

Energy bids for natural gas CHPs were in the pilot phase based on a weighted average of availability during preceding days. An increasing pool size will yield better pool availability predictions. In any case, the availability of the offered volume is always guaranteed through stable technologies.

Next Kraftwerke did not prioritize the implementation of a good forecast for energy bids as Next Kraftwerke makes sure that at all times more than sufficient reserve power is available during a typical provision period of currently one week. To calculate the minimum available capacity during one week it is rather important to make a statistical approach. In case provision periods are changed to shorter time periods like one day, a more precise forecast can be beneficial.

7 The baselining methodology

The baselining (reference power) is a crucial aspect for delivering the aFRR services. Based on the baseline, the delivered aFRR energy is calculated. This delivered energy is required for the settlement, activation check, transfer of energy, ...

7.1. Application of the baselining

The graph below explains the baseline methodology used in the pilot project. The expected baseline within 60 seconds is sent each 4 seconds meaning that the baseline is sent one minute in advance. Based on the baseline and the measured power, the delivered aFRR energy is determined, as graphically represented in the graph below.

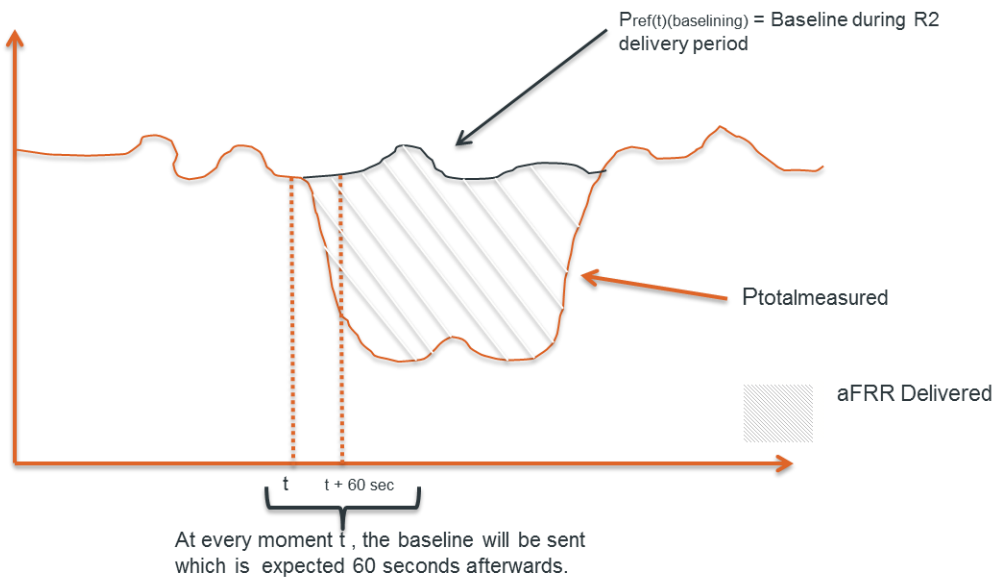


Figure 15: aFRR baseline

7.2. Baseline methodology applied by each project partner

In general, one can state that the methodology to determine the baseline by the project partners is independent on the technologies that are used. In the following sections, the baseline methodology for each project partner is described.

7.2.1. Baselining methodology for the water pumps and cogeneration units delivering aFRR

Currently, a 30 seconds average of the last measured values is used for both the CHPs and the water distribution system. The baseline is fixed during activation, also in case an activation takes longer than 60 seconds. This methodology has to and will be improved to account for the on and off scheduling of CHPs and pumps as they currently show a non-realistic aFRR baseline during these periods, which will have an impact on the aFRR delivery.

The same baseline is used for both technologies. The closer the baseline is to real-time, the better the quality of the baseline.

7.2.2. Baselining methodology for the cogeneration delivering aFRR

During the maintenance at the end of July, EDF Luminus has taken this opportunity to work on an improved baseline. The first weeks of the participation phase, i.e. before the maintenance, EDF Luminus has used a fixed baseline equal to maximum power. After the maintenance, a new baseline methodology is applied. The new baseline for T + 1min is calculated based on the average production delivery measured between [T ; T-30 seconds]. In case of ELIA aFRR activation, the system freezes the value of the production delivery at the value before activation in order to deliver a correct baseline, also in case the activation takes longer than 60 seconds.

7.2.3. Baselining methodology for the biogas and natural gas cogeneration units delivering aFRR

For the baseline per unit, Next Kraftwerke either knows the planned operation as it is retrieved directly from the unit owner or the base line is estimated by averaging the power production of the last few minutes of the unit. The baseline is fixed during an activation, also when the activations takes longer than 60 seconds.

For the pool, Next Kraftwerke used two baseline methods as promising:

- The baseline consists only of the units which are available for aFRR (Baseline A). In this case, the baseline is updated after one minute (in case of activation or without activation). Next Kraftwerke put this baseline forward as the most promising.
- The baseline consists of all units contracted for aFRR (Baseline B). In case of an activation, the baseline is updated after the activation. In case that there is no activation, the baseline is updated after one minute. The pilot project served as a good test environment to test and assess the impact of such an alternative baseline.

The Results of the pilot have shown that Baseline A is much more appropriate than Baseline B. Baseline B does not work well for the determination of the aFRR provision since units which go into manual mode or lose connection during an aFRR activation are not corrected in their individual baseline.

The remaining disadvantage of Baseline A is a wrong calculation of the aFRR-provision for 60 seconds directly after an addition or after a removal of a technical unit.

According to Next Kraftwerke, this disadvantage however could be improved by a “real-time” baseline which allows the real-time addition and removal of units without resulting in a wrong aFRR provision (difference between pool baseline and pool power)

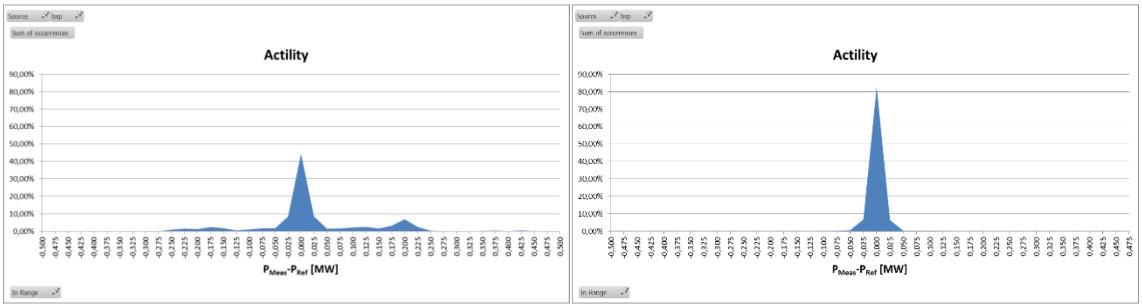
7.3. Quality of the baseline

The quality of the baseline during the participation phase is demonstrated with the help of a histogram of the difference between the baseline and the measured power in case of no aFRR activations. The histograms for part A are depicted below for the three project partners. In an ideal case, there is a narrow high peak around zero. This peak can be found on all the histograms. In general, one can say the narrower the peak, the better the results.

The possible outliers at the left and right side of the peak indicate where the measured power has a significant deviation from the baseline sent one minute in advance. These outliers should be avoided in the future and therefore, possible improvements are necessary.

7.3.1. Quality of Baselining for the water pumps and cogeneration units delivering aFRR

In the graph below, the histogram for the baseline is represented for Actility. The situation at the start of the participation phase is depicted in the left graph; the situation at the end of the participation phase is depicted in the right graph. It can be seen that the baseline quality has significantly improved during the participation phase. The peak around zero has become narrower and higher and the outliers at the left and right side of the peak have disappeared to a large extent. It can be noticed that a positive learning curve is achieved during the participation phase in order to achieve a good baselining quality at the end of the period. The development of a good baseline is a time-consuming process.



Start of the participation phase. End of the participation phase.

Figure 16: aFRR baseline quality for Actility

An example of a specific day of the baseline of Actility is depicted here below. This example illustrates a good quality of the baseline during that day since the measured power is equal to the baseline in case there are no activations.

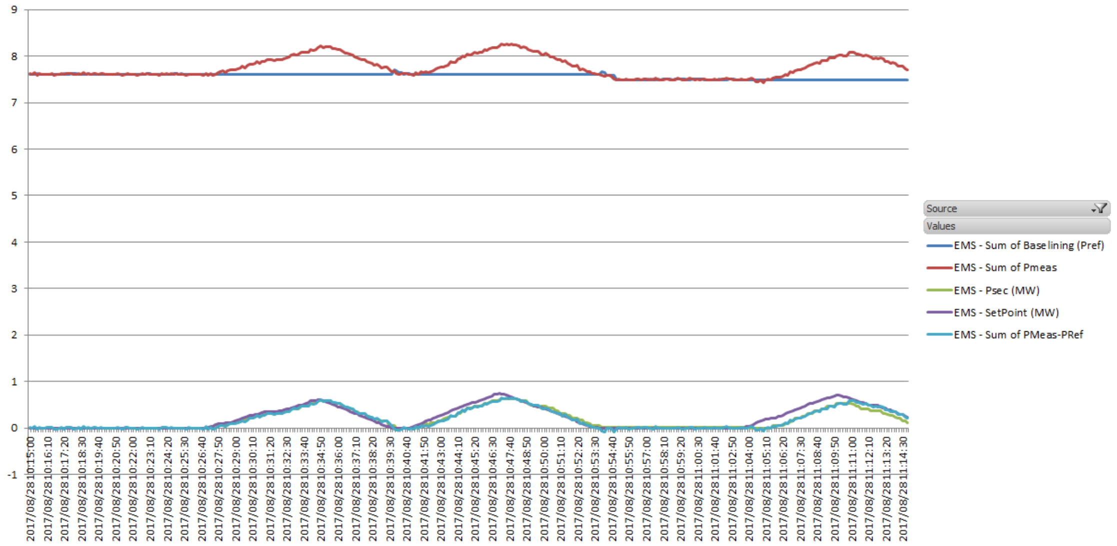


Figure 17: Baseline of Actility of a specific day during part A.

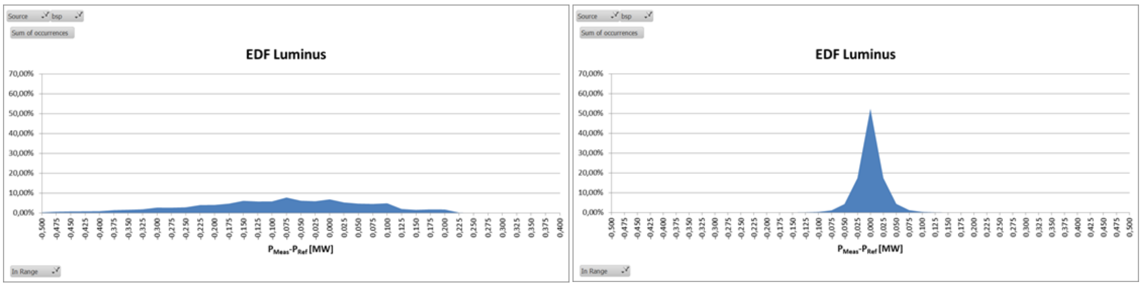
From peak to off-peak hours, Actility switch from the CHPs to the water pumps. During this switch, there is an error in the baseline if an activation is being followed due to the change of technology, as can be seen in Figure 18. The measured power (blue line) is going down around 19h00, but the baseline (green line) is staying high for a longer time. However, this issue can be solved by taking into the value of the availability flag where Actility has indicated the availability of the unit. Elia needs further investigations of the use of this parameter for these purposes.

Figure 18: Baseline of Actility of a specific day during part A with switch from peak to off-peak hours.

7.3.2. Baselining methodology for one cogeneration units delivering aFRR

As explained in 7.2.2, during the maintenance at the end of July, EDF Luminus has taken this opportunity to work on an improved baseline. The first weeks of the participation phase, i.e.

before the maintenance, EDF Luminus has used a fixed baseline equal to maximum power. The results for this baseline methodology are depicted in the left graph of Figure 19. The updated baseline is calculated based on the average of the last 30 seconds and frozen in case of an activation. As can be seen in the right graph below, this improvement of the baseline methodology has a significant impact on the quality of the baseline. It is clear that the histogram has become narrower and higher after the maintenance indicating that the baseline quality has significantly improved. Here is also a positive learning curve observed towards the end of part A of the participation phase with respect to the baseline quality.



Before maintenance After maintenance

Figure 19: aFRR baseline quality for EDF Luminus

A randomly chosen day before the maintenance is represented in the graph below. The baseline is the green line. The measured power is the blue area in the graph. There is a large deviation between the two values indicating that the quality of the baseline is not sufficient enough.

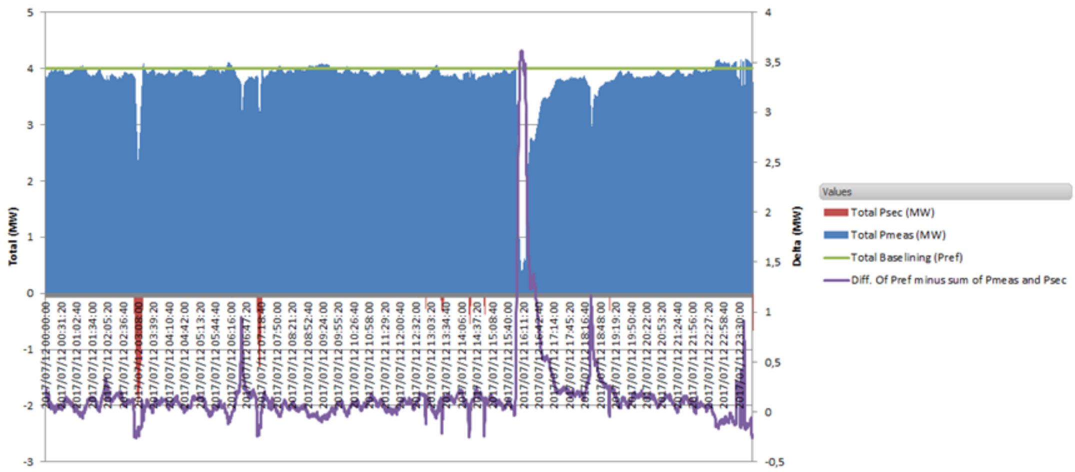


Figure 20: Reference power for EDF Luminus before maintenance.

The improved baseline is shown in the graph below. The baseline (green line) follows the measured power (blue area) more accurately in the case of no activations.

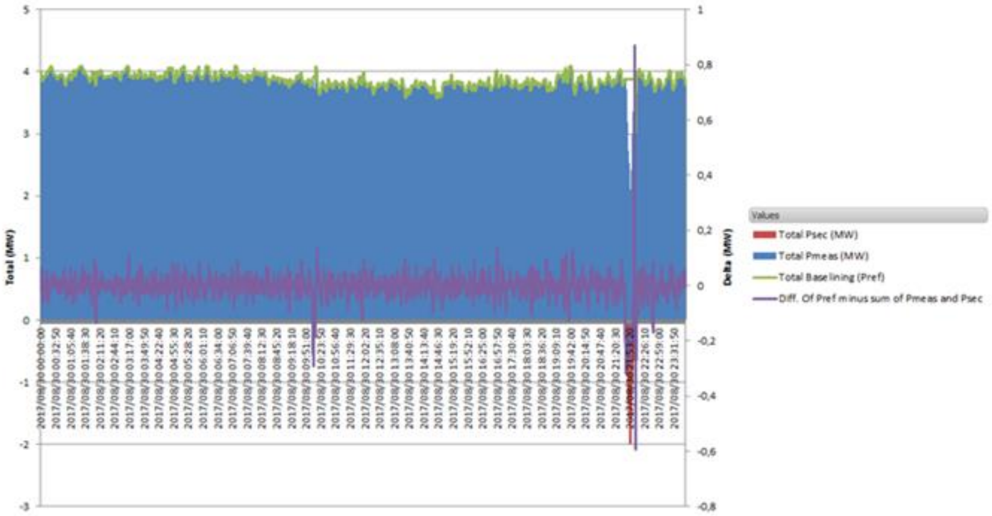
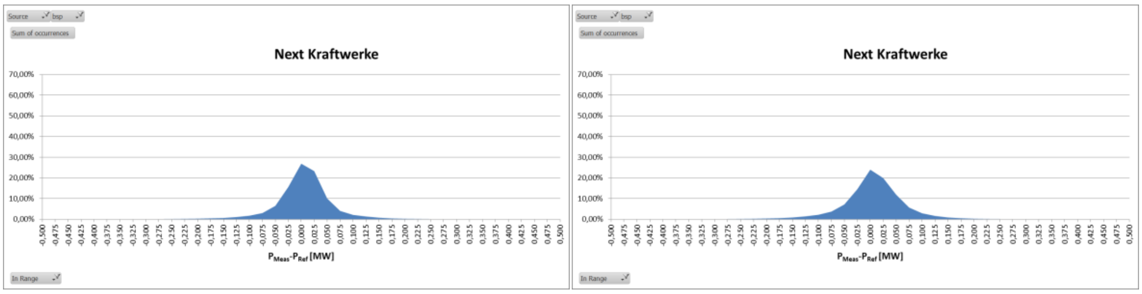


Figure 21: Reference power for EDF Luminus after maintenance.

This example confirms that the baseline methodology on a 15 minute basis as currently applied for mFRR is not accurate enough for aFRR. For aFRR, a baseline updated on a 4 seconds basis is required to have an accurate calculation of the delivered energy.

7.3.3. Baselining methodology for and cogeneration/biogas units delivering aFRR

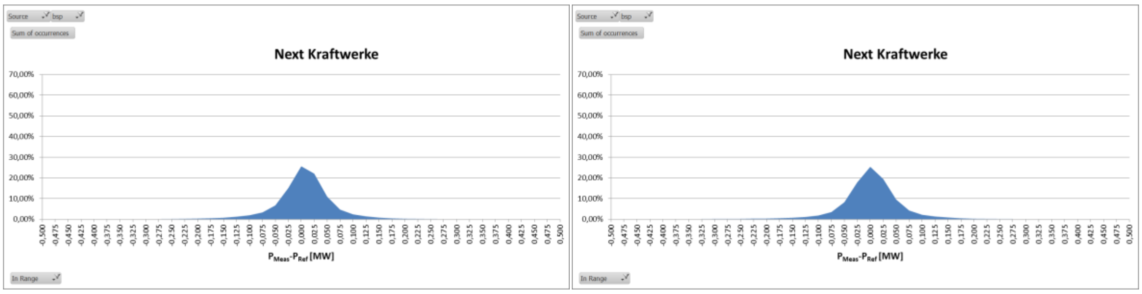
The quality of the baseline A is represented in the graph below for the beginning and the end of the participation phase for Next Kraftwerke. It can be seen that the quality of the baseline A was already good at the beginning of the participation.



Baseline A for the first 3 weeks   Baseline A for the last 3 weeks

Figure 22: aFRR baseline A quality for Next Kraftwerke

The two graphs below show the baseline methodology A and B for Next Kraftwerke. The main difference between baseline A and B can only be observed during an activation and when a unit is lost. For baseline A, the unit is taken immediately out the pool when the unit is lost. For baseline B, the unit is only taken out of the pool after the activation. The baseline quality is only taken considered in cases without an activation and for that reason, the quality of baseline A and B is the same in this analysis.



Baseline A Baseline B

Figure 23: aFRR baseline quality for Next Kraftwerke

The baseline A for a specific day is represented in Figure 24 and baseline B in Figure 25. It is clear that the baseline A is more accurate than baseline B. The peaks results from very short connection losses to the remote control unit of the technical units.

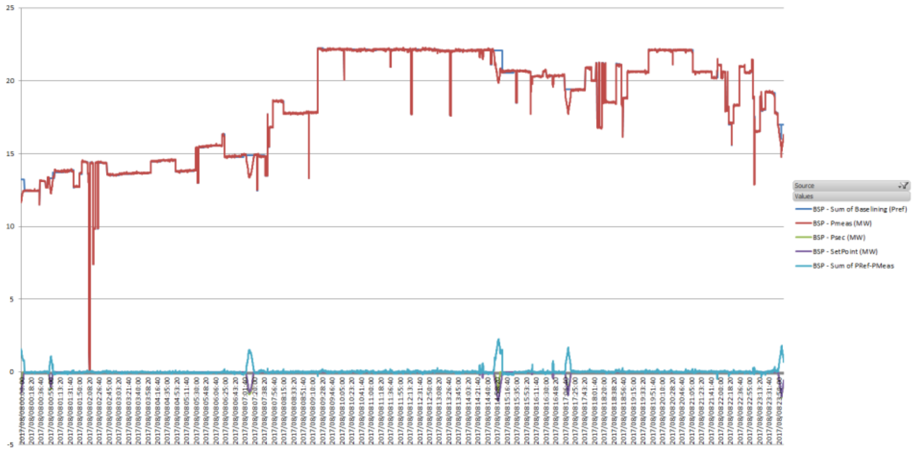


Figure 24: Baseline A of Next Kraftwerke for a specific day during part A.

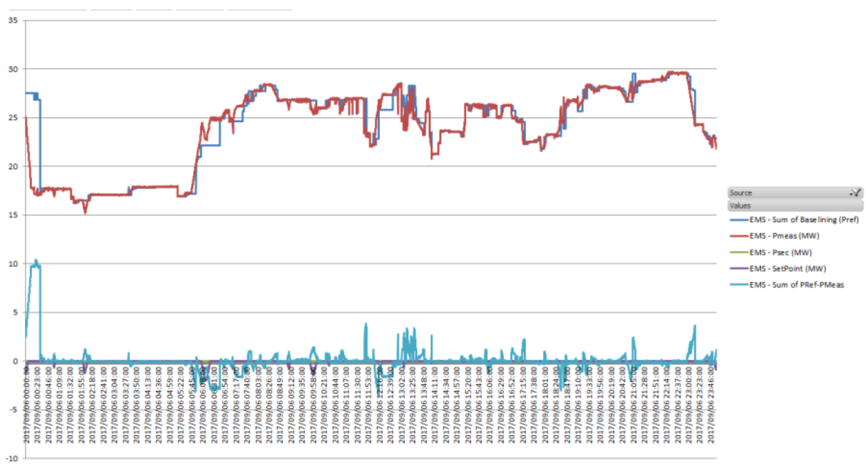


Figure 25: Baseline B of Next Kraftwerke for a specific day during part A.

All three project partners have indicated that an improvement of the baseline is still possible.

7.4. Conclusions

- All three project partners have achieved in the end a baselining methodology with an acceptable level of quality within the scope of the pilot project.
- The set-up of a baseline methodology with a good quality is a time-consuming process at the start, especially when there is no experience in delivering a baseline in real-time.
- A variable baseline on a 4 second basis is required for the accurate delivered aFRR energy calculation.

During the pilot project, Elia has obtained a good insight in the baseline methodology which is an added value for Elia. It is reconfirmed during the participation phase that the baseline is crucial for the aFRR-supplier to dispatch the reserve power and for Elia to calculate accurately the delivered aFRR energy which is used for the settlement, the compliancy calculations, transfer of energy, ... The set-up of a baseline methodology with a good quality is a time-consuming process at the start, especially when there is no experience in delivering a baseline in real-time. Therefore, experience in the past is crucial in order to have a good baseline quality at the start of the delivery of aFRR services.

The current baseline methodology that is used for mFRR, i.e. a fixed baseline on a 15 minute basis, is not applicable for aFRR as illustrated in the example of EDF Luminus where the fixed baseline is improved after the maintenance of the CHP. A variable baseline on a 4 second basis is required for the accurate delivered aFRR energy calculation.

The project partners have investigated a few baseline methodologies and the methodologies have improved. In order to improve the baseline methodology, the interaction with the market parties is important. In the future, Elia will need to consider that there will be a learning curve for the baseline that will occur at the start of the delivery by new providers.

Since it is identified that the baseline is crucial for the aFRR delivery, Elia will set-up in the future strict rules for the quality of the baseline. It will be necessary to prequalify the baseline to ensure the quality. However, the quality of the baseline requires a continue follow-up and therefore, during the participation at the aFRR balancing market, the quality of the baseline will also need to be verified on a regular basis.

Since the baseline is sent one minute in advance, during a foreseen loss of a unit, the baseline is not correct for at least one minute. This issue is identified during the participation phase and needs further investigation in the future for having more insights how to deal with this.

8 The prequalification requirements

All new units have to perform successfully a prequalification test before participating at the aFRR balancing market (chapter 4). For the pilot project, this prequalification test was also required before starting the participation phase. The prequalification test in the scope of this pilot project was adapted to non-CIPU units.

8.1. Set-up of the prequalification tests

The aim of the prequalification test is to check the organisational requirements (i.e. real-time and off-line communication) and to do a successful simulation test (technical requirements). Before performing a successful prequalification test, a number of steps need to be undertaken. In first instance, it is required to set-up a real-time connection between the SCADA of Elia and the SCADA of the BSP since the real-time communication occurs directly between those two SCADAs. After this connection is in place, the parameters that will be exchanged between the BSP and Elia must be configured and tested at both sides. Once this is finalized, a prequalification test has to be organized and executed. Afterwards Elia verifies whether the predefined goals are obtained and feedback is given to the providers.

The organisational requirements for R2 non-CIPU consisted of two parts, i.e. the real-time communication and the off-line communication and mainly did not change with respect to the CIPU approach.

- For the real-time communication, it was required to set-up a secure communication channel between Elia and the provider (set-up of real-time communication between SCADA Elia and SCADA partner). The provider needed to be able to receive and interpret the signals of the SCADA as described in section 5.3.4. A stable real-time communication is crucial. In case the real-time signal is interrupted, this will be considered as a non-compliant delivery and a penalty will be applied.
- For the offline communication, the provider needed to be able to send a day-ahead file (ex-ante) and the day after a file (ex-post) as described in section 5.3.4.

For the technical requirements, the provider needed to simulate the signal as presented in the graph below. This is the simulated signal for a downwards aFRR activation, for an upwards aFRR activation, the inverse signal needed to be followed.

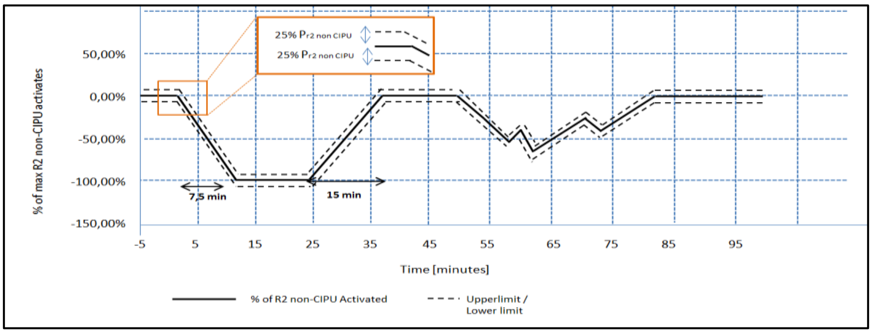


Figure 26: Simulation signal for the prequalification.

A prequalification test was considered as successful in case the following requirements were met:

- The R2 non-CIPU supplied reached the maximum as indicated.
- The deviation was smaller than 25% (2 deviations of 10 seconds are allowed).

For CIPU, a deviation of 7.5% is allowed. In the scope of the pilot project, a larger deviation was tolerated in order to avoid early exclusions of project partners.

8.2. Results of the prequalification tests

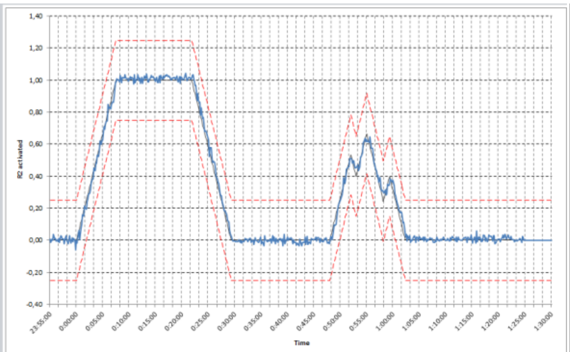
For all project partners, it was needed to do more than one prequalification test. Some partners even needed to perform three tests. For the organisational requirements, the following issues were detected:

- Problems with the set-up of the physical connection
- Problems with the exchanged values.

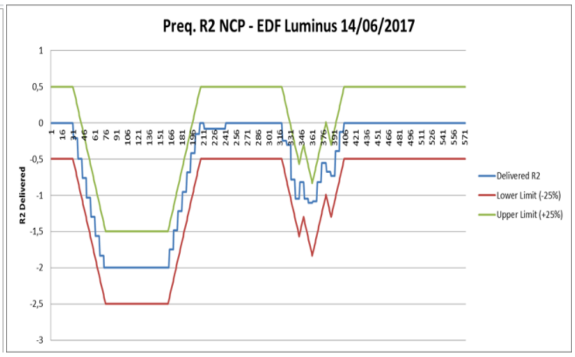
During the simulation test, the follow issues were encountered:

- Issues with the format of the exchanged values
- Error in the system configuration of the pool management
- Loss of a unit during the test

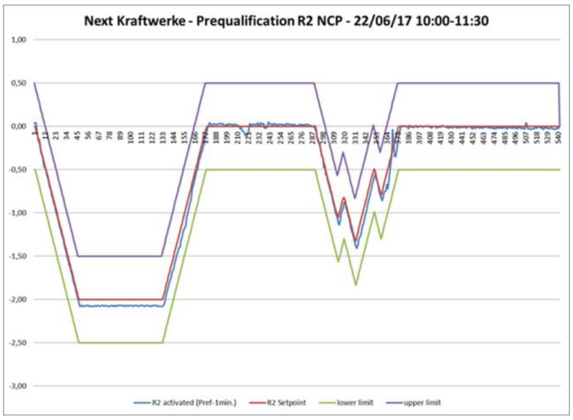
In Figure 27, a successful simulation test is shown respectively for Actility, EDF Luminus and Next Kraftwerke. For those tests, the activated energy (i.e. the delivered energy) stays within the allowed margin.



Successful simulation test for Actility.



Successful simulation test for EDF Luminus



Successful simulation test for Next Kraftwerke

Figure 27: Successful prequalification tests.

It can be seen that during the prequalification test, the values change on a discrete way for EDF Luminus. The reason for this was a configuration at the side of the SCADA of Elia. Some values were only updated each minute instead of each 4 seconds. This issue was detected and solved at the beginning of the participation phase.

We identified that it could be an added value if the SCADA of Elia could send the simulation signal towards the BSPs during the prequalification test. In that way, the full communication chain and the set-up of the real-time communication is completely tested. However, this needs further analyses at Elia side.

8.3. Conclusions

All three project partners have successfully performed a prequalification test. Reasons for failure were not linked to the technical capabilities of the flexibility but rather caused by communication and configuration problems.

All project partners needed more than one simulation test to be successful. For the future, it is required that the baseline is also prequalified. The prequalification of the baseline was not explicitly taken into account in the pilot project. Since in the simulation signal, there are some moments that there is no activation, the baseline was tested during these periods with the same compliancy as for the activations, i.e. 25% in the scope of this pilot project. As already mentioned in the chapter of the baselining, a way of dealing with the loss of a unit should also be applicable for the prequalification test.

9 The results of the participation phase

In this section, the results of the participation phase of the pilot project in which the project partners have effectively delivered aFRR are described. Figure 28 shows how the aFRR activation functions. As already explained in chapter 7, the baseline is crucial for the calculation of the delivered aFRR energy and is sent each 4 seconds one minute in advance. The set-point is sent by Elia each 4 seconds and the measured power is sent each 4 seconds by the provider. The difference between the baseline (reference power) and the measured power is equal to the activated energy. This activated energy is compared with the set-point calculated by Elia.

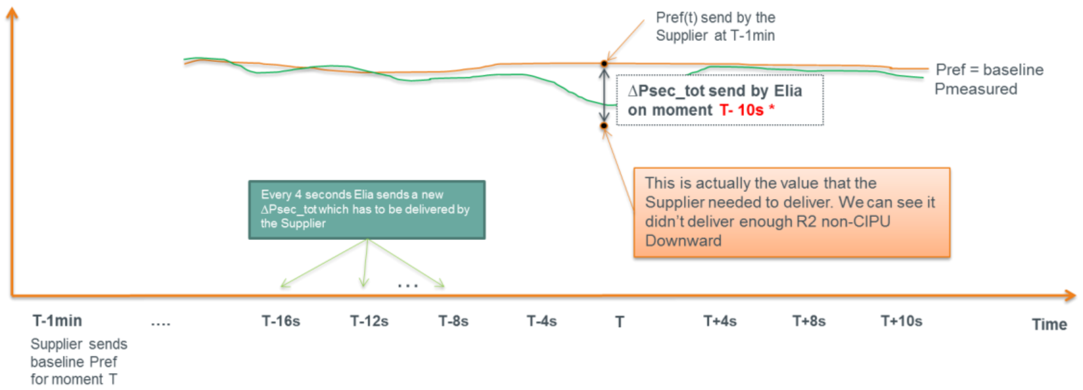


Figure 28: Exchanged signals for calculation of the aFRR delivered energy.

In part A of the participation phase, the R2 non-CIPU bids were only activated after saturation of the aFRR controller. R2 non-CIPU bids were pro-rata activated. In the second part B, the R2 non-CIPU bids were put together in a merit order list with the R2 CIPU bids and both were together activated on a pro-rata basis.

In Table 8, an overview is given of the activated energy during part A. For upwards activations, the energy is positive, for downwards activations, the energy is negative. For the calculation of the activated energy, the over-delivery and the under-delivery can be neutralized. Therefore, the energy capped is added as an additional parameter. For the energy capped, the over-delivery is capped to the requested energy and the under-delivery is taken into account.

For Actility, it should be taken into account that the water pumps were only active from the 5th of August onwards due to the extreme drought in July. As a consequence, the water pumps were not able to react on the activations sent by Elia during the off-peak hours for the first weeks of the participation phase. This explains the difference between the requested and activated energy. The difference for the requested energy between EDF Luminus and Next Kraftwerke is because the delivery period differences due to the two weeks of maintenance of EDF Luminus. For Actility and EDF Luminus, there is an under-delivery during part A, since the activated energy is lower than of the requested energy in absolute values. For Next Kraftwerke, there is an over-delivery since the activated energy is larger than the requested energy in absolute values.

Energy (MWh)	Actility	EDF	NKW
Energy activated	17,50	-86,16	-118,04
Energy capped	17,06	-79,73	-106,30
Energy requested	30,61	-92,26	-106,82

Table 8: Activated and requested aFRR energy during participation phase part A.

Table 9 gives the same parameters for part B. There were more upwards activations during this period than downwards activations. The duration of this phase is limited to three days due to the large amount of energy activated. During part B, for Actility, all water pumps were able to participate which corrected the difference between the requested and activated energy. The energy requested for Actility during the three days of part B is half of the energy requested for part A which took 10 weeks.

Energy (MWh)	Actility	EDF	NKW
Energy activated	17,92	-12,77	-22,19
Energy capped	14,80	-12,87	-16,78
Energy requested	18,33	-17,16	-17,15

Table 9: Activated and requested aFRR energy during participation phase part B.

9.1. The comparison between requested and activated power

In this paragraph, an assessment is made of the quality of the reaction on a set-point sent by Elia. In first instance a histogram is plotted where the difference between the activated power and the requested power is represented for part A. It should be noticed that the quality of the baseline also has an important impact on these graphs since the activated power is based on the reference power, i.e. the baseline.

Figure 29 shows the result for Actility for part A. The green circle indicates the expected result, i.e. a large peak around zero and the orange circles shows where improvements are possible. As indicated in the graph, the left side of the graph indicates under-delivery, meaning that the activated power was below the requested power. At the right side of the graph, there is over-delivery.

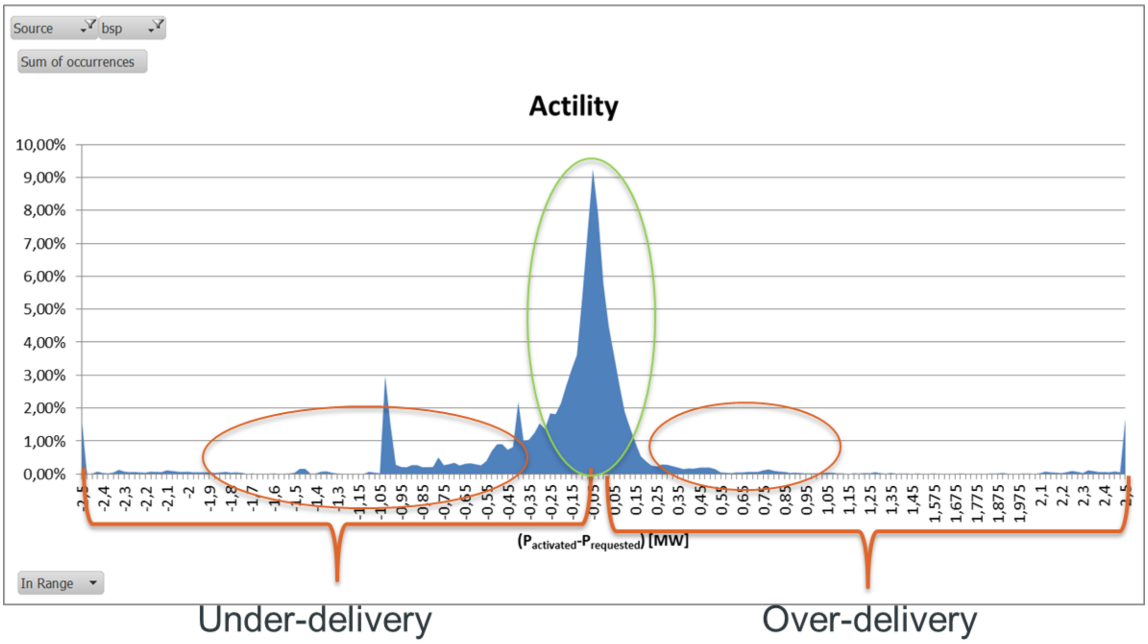
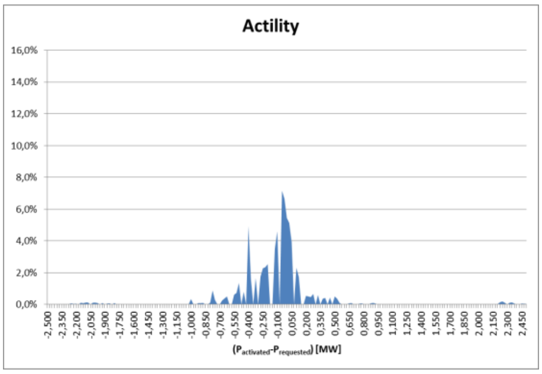
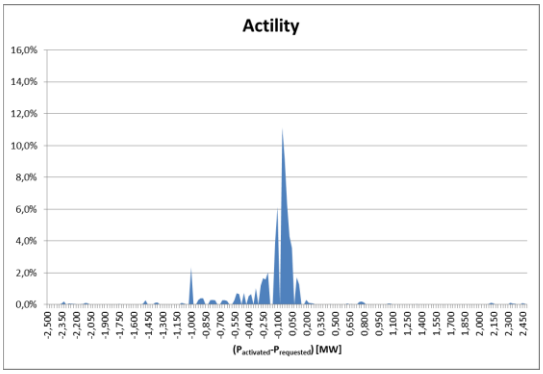


Figure 29: distribution of the activated power versus the requested power.

For Actility, a comparison is made between the quality of the reaction on the set-point before and after the water pumps. Before the introduction of the water pumps, it can be seen that there is a peak at -0,5 MW since the water pumps were not able to deliver the aFRR service. This peak disappears after the introduction of the water pumps as can be seen in the right graph. During the second period (right graph), there were some problems with the connection and some tests are performed during a specific day when a lot of upwards aFRR was requested. This could explain the small peak at the left side of the right graph. In general, it can be stated that the peak has become narrower and higher after the introduction of the water pumps meaning that the quality of the reaction has improved towards the end of the participation phase.



Before the introduction of the water pumps.



After the introduction of the water pumps.

Figure 30: distribution of the activated power versus the requested power before and after the introduction of the water pumps.

The same result is shown for EDF for part A. There is a tendency to under-delivery due to the fact that it was difficult to reach the maximum power before the maintenance and due to the fact that there was a margin on the minimum power and therefore, it was difficult to be compliant with the large activations.

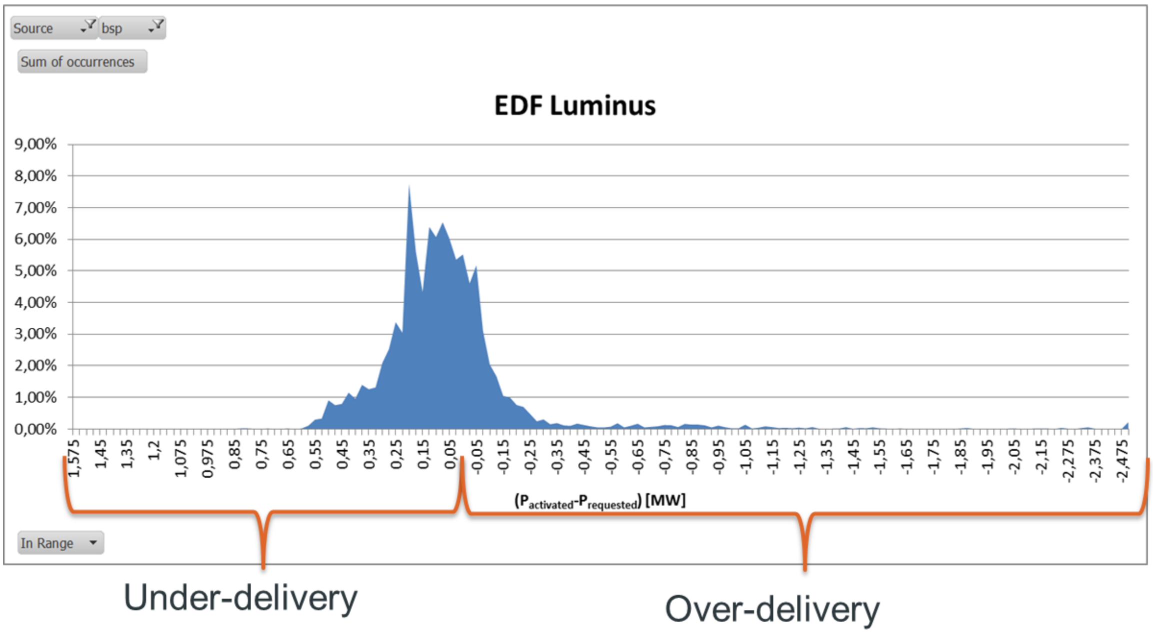
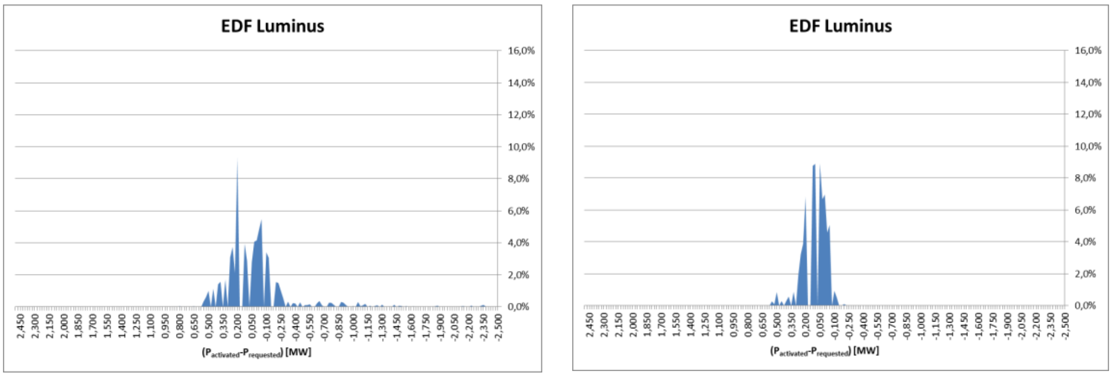


Figure 31: Distribution of the activated power versus the requested power.

Due to the update of the baseline after the maintenance and due to the fact that the maximum power could be reached, the occurrence of under-delivery has decreased significantly. The margin on the minimum power was not solved in part A and therefore there was still some under-delivery. However, due to the improvements the distribution has become significantly narrower.



Before the maintenance After the maintenance

Figure 32: Distribution of the activated power versus the requested power before and after the maintenance.

Figure 33 shows the distribution for Next Kraftwerke. There is a tendency for over-delivery as shown at the right side of the graph for part A.

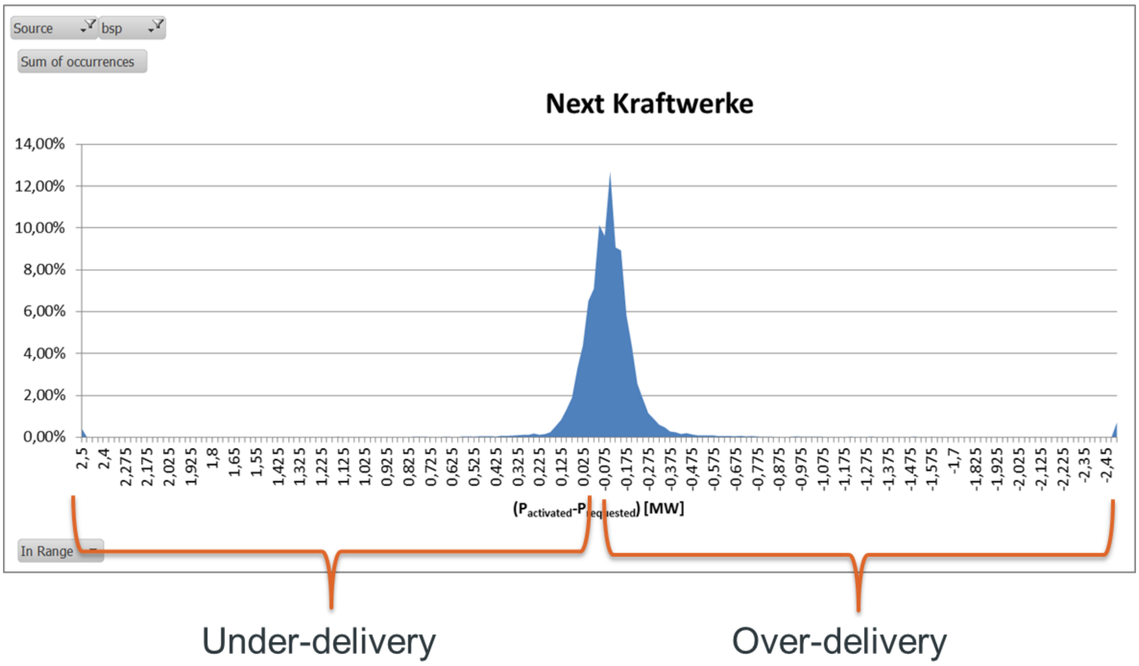
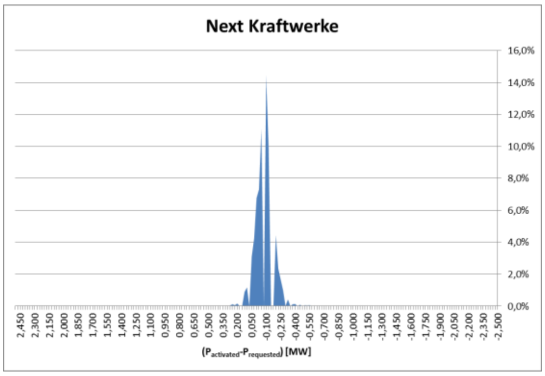
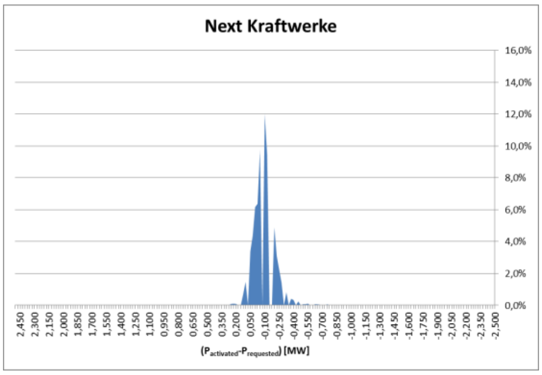


Figure 33: Distribution of the activated power versus the requested.

Figure 34 shows the distribution at the beginning and the end of the participation phase for baseline A. It can be clearly stated that the quality of the reaction on the set-point is already good at the beginning of the participation phase and that the same quality is retained during the whole participation phase.



At the beginning of the participation phase



At the end of the participation phase (with baseline A)

Figure 34: Distribution of the activated power versus the requested power at the beginning and the end of the participation phase.

The figures below give an overview between the difference for the histogram of the activated power and the requested power for part A and B. For Actility, the distribution becomes narrower due to the improvements at the data connection and the improved follow up of the activations. For EDF Luminus, the histogram becomes narrower due to the adaptation of the marge on the minimum power. Therefore, the activation of full contracted volume, i.e. 2 MW down, becomes more compliant. For Next kraftwerke, the baseline A is considered during the part B, but no further adaptations are made, so the same histogram is obtained for part A as B.

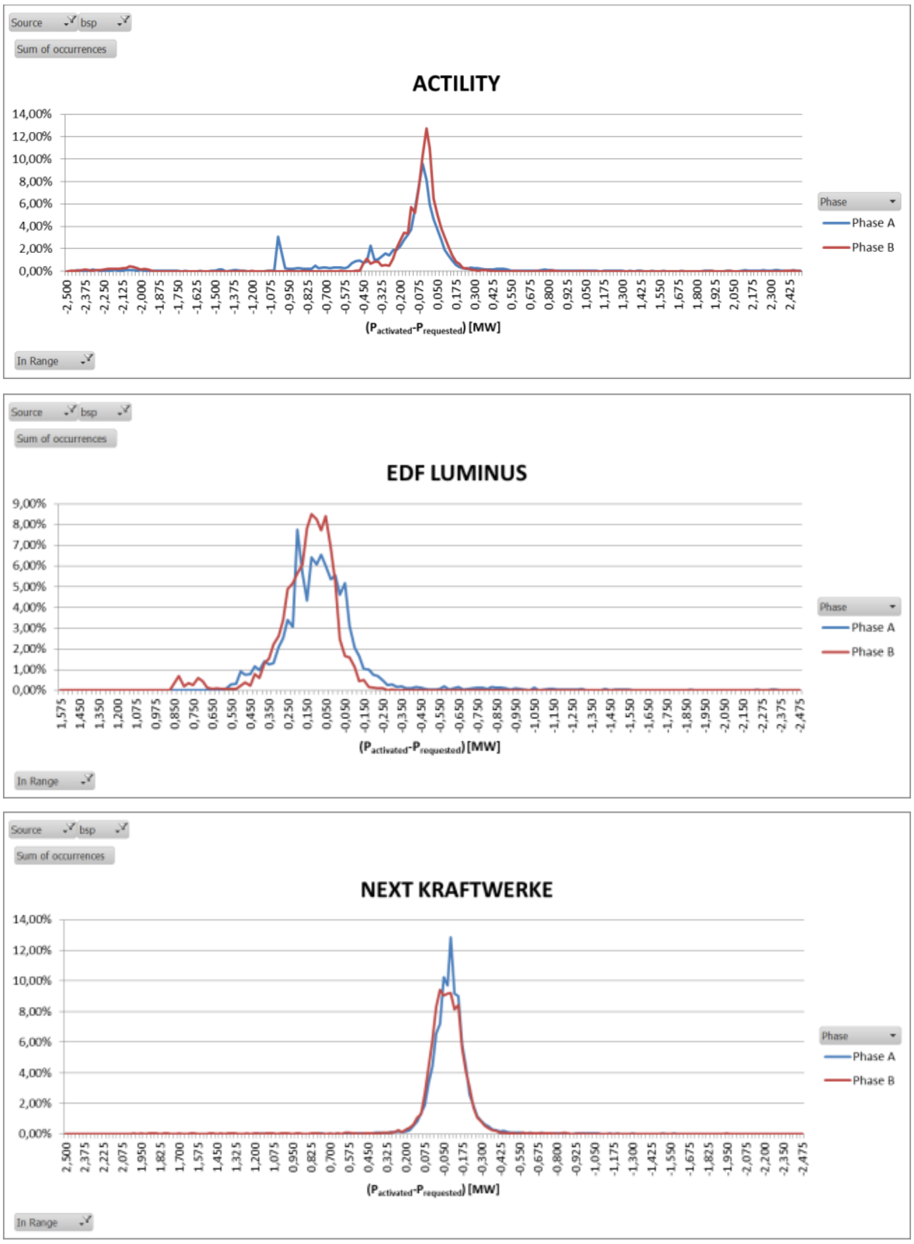


Figure 35: Distribution of the activated power versus the requested per technology for part A and B.

Although the compliancy results of part B of the participation phase are acceptable within the scope of the pilot project, it must be indicated that it highly recommended that a merit order is in place for the aFRR flexibility. Part B only took three days and therefore, no conclusions can be drawn that a pro-rata activation could be feasible for R2 non-CIPU flexibility which participated in the pilot project.

9.2. Some specific cases

In this section, some specific interesting cases are analysed in detail.

Figure 36 shows the activations of one day during part A of Actility. At the middle of the day, there is good follow up of a few activations. Afterwards, there is an introduction of a new unit during an activation. Since the baseline is sent one minute in advance, the correction of the baseline can only be done one minute later. If this occurs during an activation, this can lead to an over- or under-delivery. However, it can be seen on the graph, that the activations are probably good followed up by the units that were delivering the upwards activations. This introduction of a new unit is hard to predict (as also a loss of unit) since this is decided by the grid user. Therefore, this will also occur in the future and is difficult to solve in real-time. Further investigations are required to analyse how to handle these events since it could have an impact on the calculation of the delivered energy. It is also a consequence of having large pools where it could happen more often that units will unexpectedly enter or leave the pool. Around 19h00, there is a shift from units used during the peak hours to units used during the off-peak hours. In contrast with an unforeseen introduction of loss of unit, this shift is foreseen and could be taken into account in the future. In the availability flag, the "on" and "of" schedule on the units is correctly taken into account by Actility. If this parameter is taken into account for the analysis, this problem could be solved. However, as mentioned above, this needs further analyses from Elia side. In general, the reliability increases by distributing the service across multiple suppliers and delivery points.

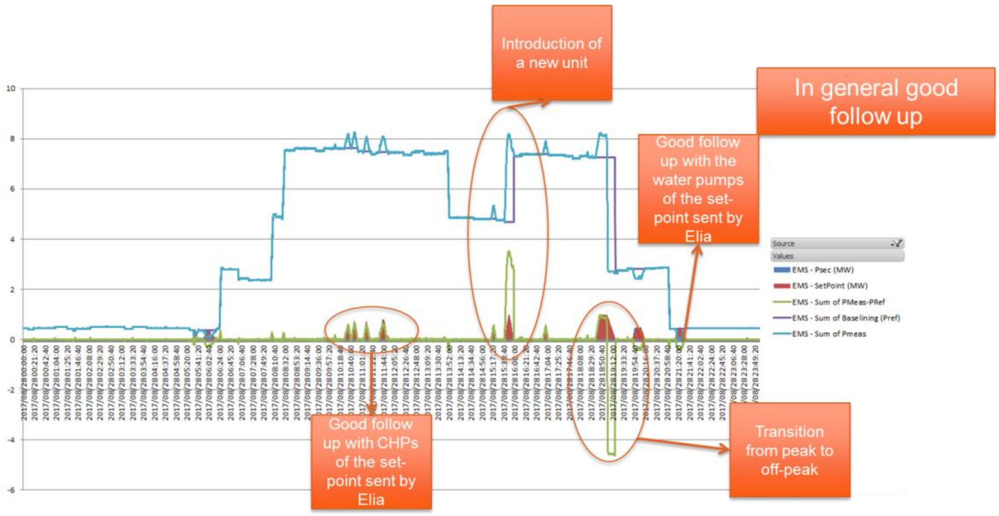


Figure 36: Activations of one day during part A for Actility.

Figure 37 gives an example of a shutdown of a unit during an activation. The event is shown for baseline A in the right graph and for baseline B in the left graph. For the baseline methodology B, the correction of the baseline occurs only after an activation and this explains the larger error. For baseline A, the unit is put immediately out of the pool and the baseline is corrected one minute afterwards. Therefore, the error is smaller. It should also be noted that there are additional units lost with baseline B compared to baseline A but that the handling of the loss of units is different for the two baseline methodologies. For the moment, the shutdown of a unit is often scheduled but not communicated to Next Kraftwerke. In the future, the scheduled shutdown of a unit could be taken better into account in the baseline methodology.

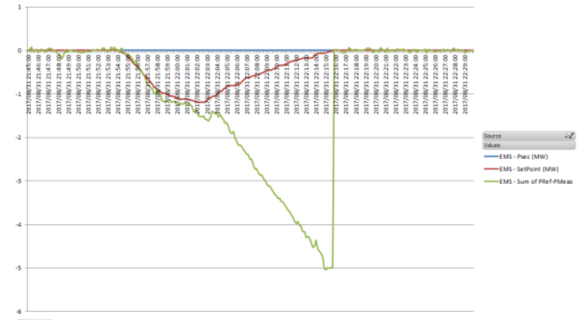
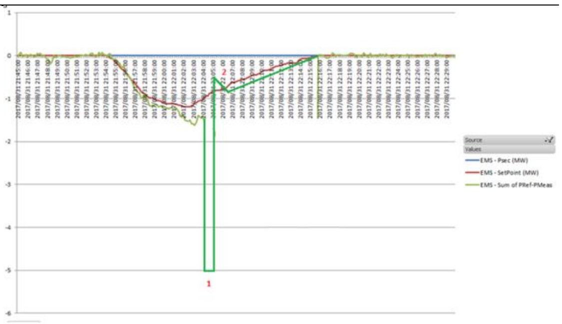
	
Loss of a unit with baseline B	Loss of a unit with baseline A

Figure 37: Shutdown of a unit during an activation for baseline A and B for Next Kraftwerke.

Figure 38 shows a good activation without a loss of unit for Next Kraftwerke. There is a good follow up of an activation of the full contracted power, i.e. 2 MW, by Next kraftwerke during a specific moment during part A.

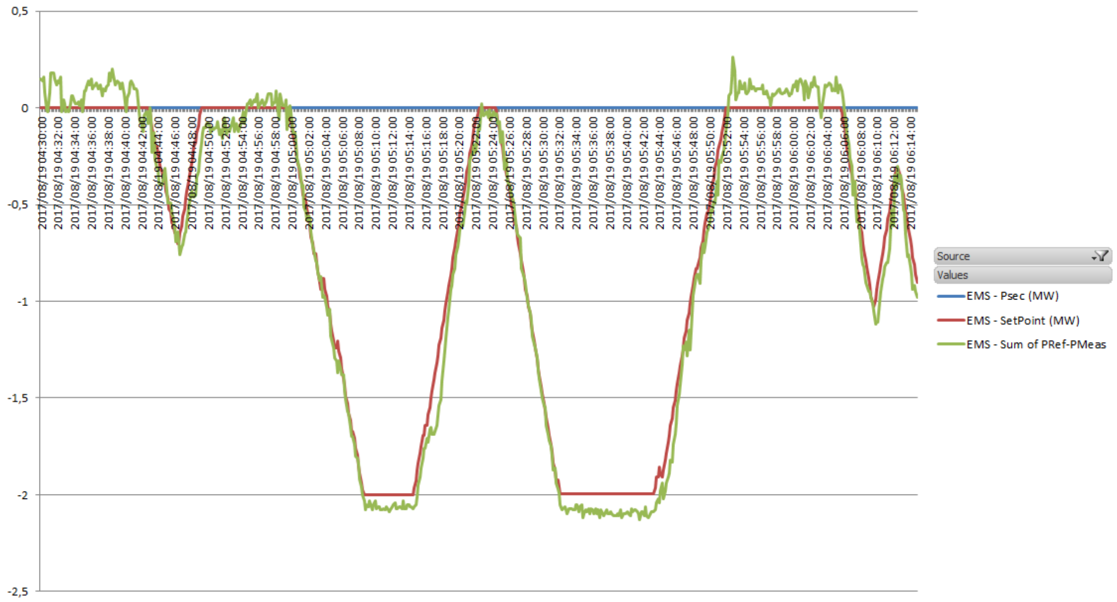


Figure 38: Activation of part A for Next Kraftwerke.

The graph below shows a follow up of an activation of full contracted power of EDF Luminus for part A.

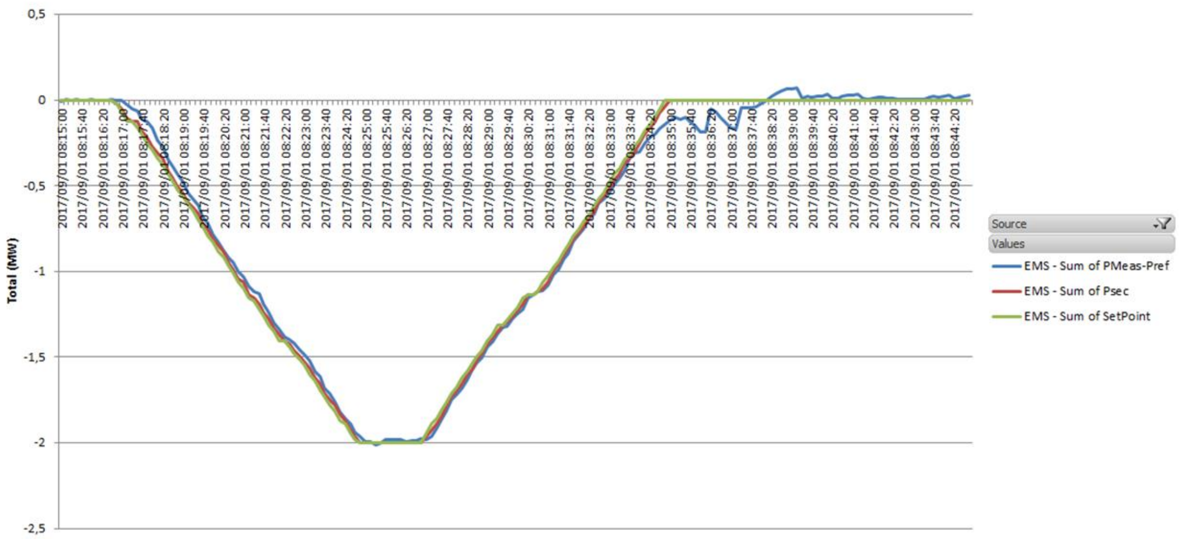
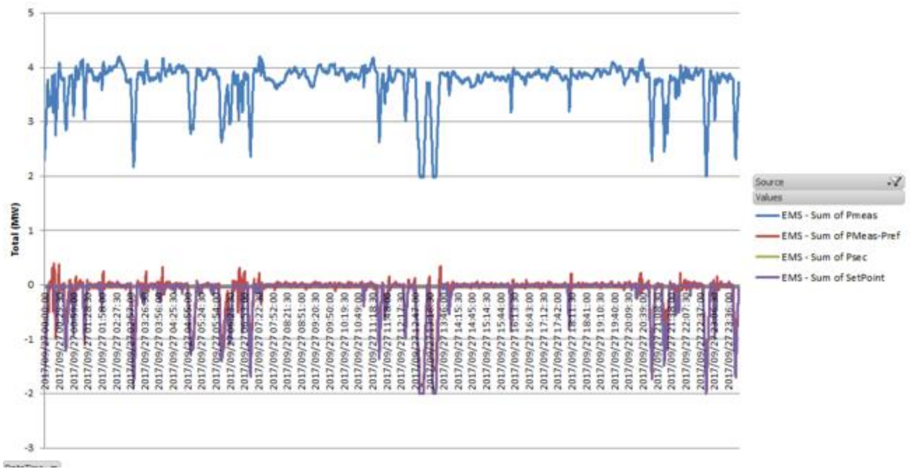


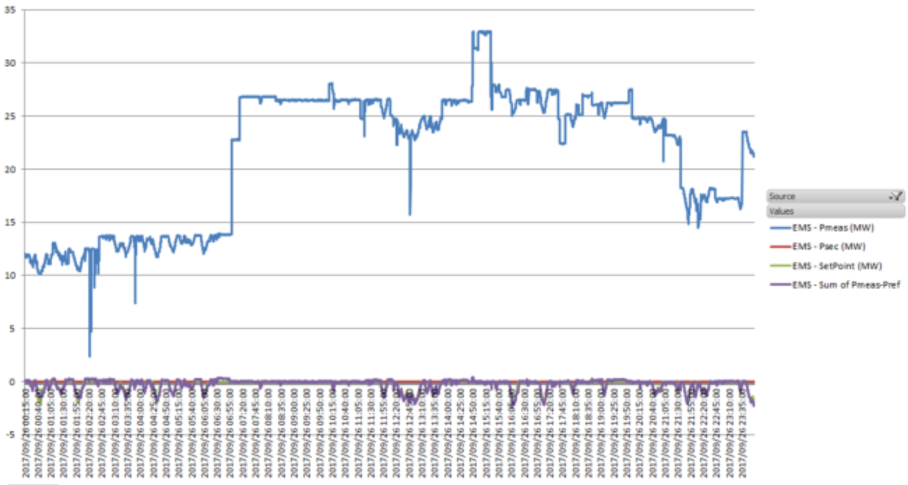
Figure 39: Activation of part A for Next Kraftwerke.

Figure 40 gives a high-level overview of the activations during part B. These graphs below demonstrate that in general the three providers show a good follow-up of the requested activations.

Actility



EDF Luminus



Next Kraftwerke

Figure 40: Activation of part B for all three providers.

The Figure below focusses on the activation by the water pumps. For the moment, the water pumps start reacting when the full offtake of the pumps are requested. This could be further optimized by an earlier reaction of the water pumps.

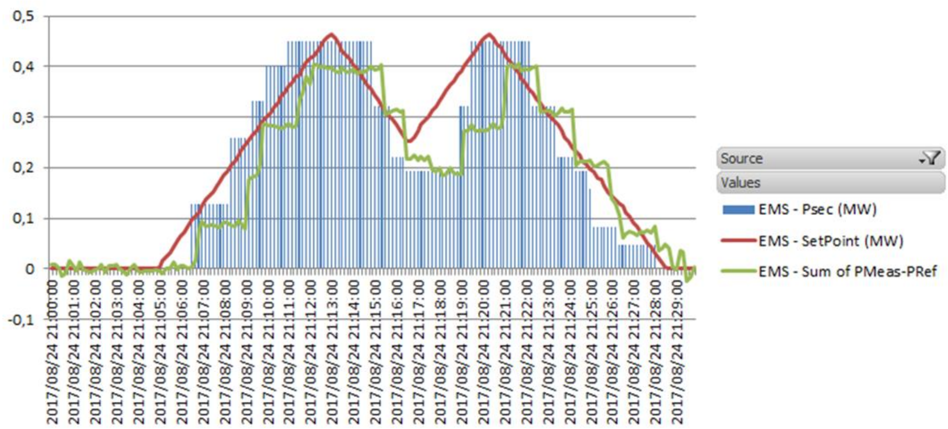


Figure 41: Discrete activations of the water pumps for Actility.

9.3. The compliancy

9.3.1. Calculation of the compliancy

The compliancy is calculated as the error in power delivery in function of the contracted volume. The difference between the activated power and the set-point sent by Elia is the error and this error should be between the agreed limits. Currently, for the CIPU units, the absolute value of the error should be lower than 15% of the bid volume. The compliancy in this pilot project is calculated with a margin of 15% and 30% of the energy bid, i.e. in this context the same as the contracted volume. The 2% outliers of the errors are not taken into account, similar to the compliancy calculation for CIPU

In the table below, the margin in absolute values is represented. The values in the table are showing that the contracted volume has a significant impact on the calculation of the allowed margin for the compliancy calculation. A smaller contracted volume gives also a smaller margin and therefore, smaller volume can be less compliant.

	Compliancy of 15%	Compliancy of 30%
Actility	0,075 – 0,15MW	0,15/0,3MW
EDF Luminus	0,3MW	0,6MW
Next Kraftwerke	0,3MW	0,6MW

Table 10: margin for compliancy calculation

At the left side of Figure 42, the compliancy is calculated with the normal contracted volume for the second half of participation part A (i.e. 1MW during the day and 0,5MW during the night) for Actility. At the right, the contracted volume is upscaled to 2MW during the day and the night (i.e. the same volume as for both EDF Luminus and Next Kraftwerke) during the same period. This means that the margin is calculated based on 2MW and that the error (i.e. the difference between the activated power and the set-point sent by Elia) is not changed. The upscaling of the volume can be seen as a theoretical enlargement of the pool which reduces the error of Actility's pool. This does not take into account the possible additional challenges for managing larger pools. This theoretical upscaling is only performed in the scope of the pilot project.

The graph represents the second half of the participation phase. It can be seen that the size of the contracted volume has a significant impact on the compliancy. The compliancy results for CIPU are also represented on the graph below as a reference. This compliancy results are calculated with a compliancy margin of 15%. As indicated in section 6.1.1, the increase of the amount of water pumps and thus power steps will have this effect on the compliancy.

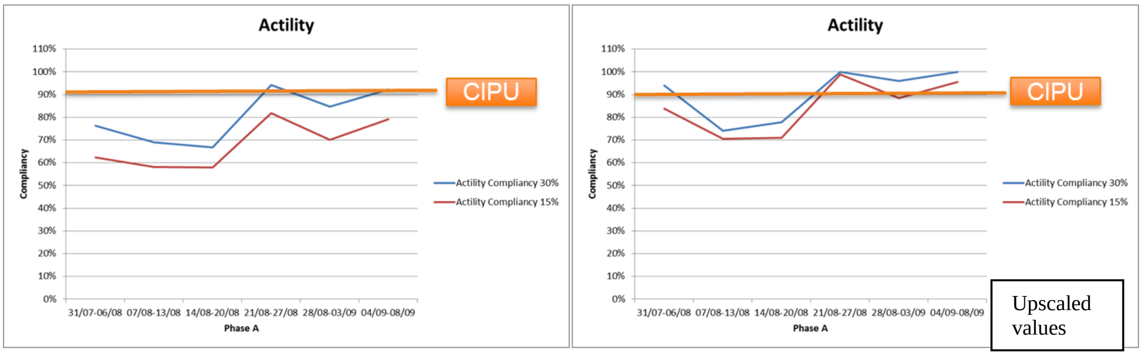


Figure 42: Compliancy for Actility. Left: normal contracted volume, right: upscaling to 2 MW.

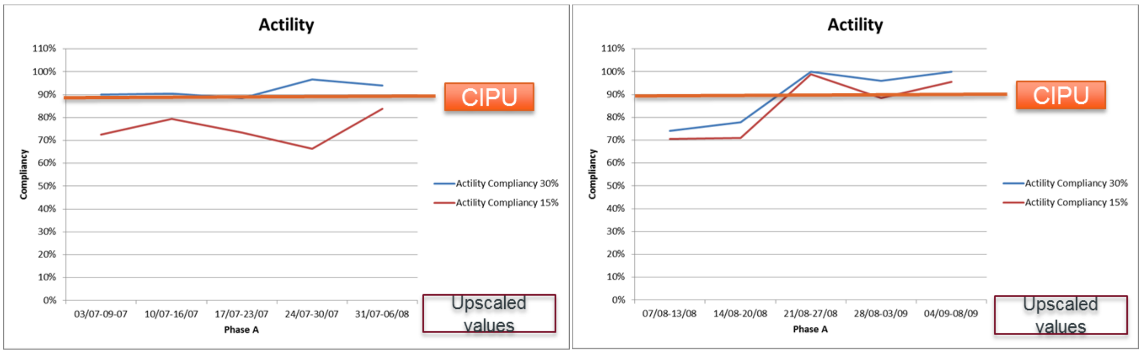
The graph below shows a discrete activation of the water pumps. In this pilot project, the size of the pool of the water pumps is 0,5 MW. If more water pumps would join the pool, the relative size of the discrete steps will be lower and the activations of the water pumps will become more accurate, as also indicated in Figure 14.

It can be concluded that a critical mass is required to deliver an accurate aFRR service. In order to perform a comparison between the different parties of the pilot project, an upscaling of the contracted volume of Actility to 2MW was done.

In the following graphs, the evolution of the results for the compliancy is analysed during the participation part A.

9.3.2. Results for Actility

In the following graphs, the evolution of the results for the compliancy is analysed during the participation part A. In the left graph of Figure 43, the compliancy results (with upscaled values) are shown at the beginning of the participation phase (before the introduction of the water pumps) and in the right graph; the results are shown at the end of the participation phase (after the introduction of the water pumps). In the second half of the participation phase, the compliancy results are significantly improved and have reached the level of the current compliancy results for CIPU units. A steep learning curve can be observed as also indicated in section 9.1 for the comparison between the activated and requested power.



Before the introduction of the water pumps After the introduction of the water pumps

Figure 43: Positive evolution of the compliancy results for Actility during the participation phase part A.

In Figure 44, the compliancy results for part A are represented.

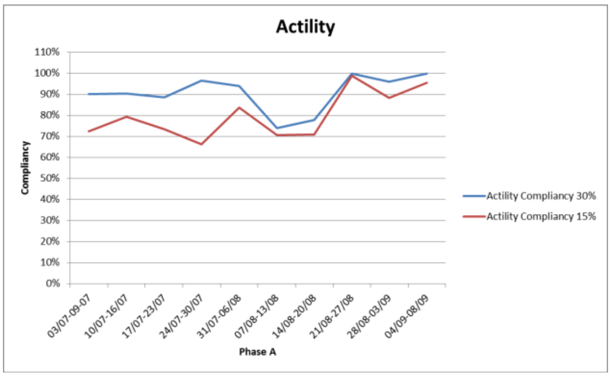
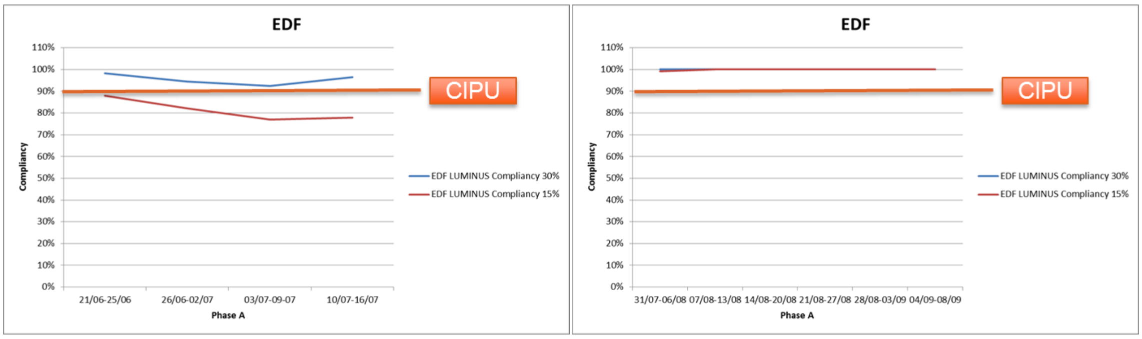


Figure 44: The compliancy results for Actility during the participation phase part A.

9.3.3. Results for EDF Luminus

During the maintenance period of 2 weeks, EDF has improved the quality of the baseline. This improvement has a positive impact on the compliancy results as shown in Figure 45. The compliancy results are similar to the one currently obtained by CIPU. Also here, a learning curve is observed with respect to the compliancy results during the participation phase part A. The same learning curve is also observed in section 9.1 for the comparison between the activated and requested power.



Before maintenance After maintenance

Figure 45: Positive evolution of the compliancy results for EDF Luminus during the participation phase part A.

The graph below gives the compliancy results for the complete part A of the participation phase.

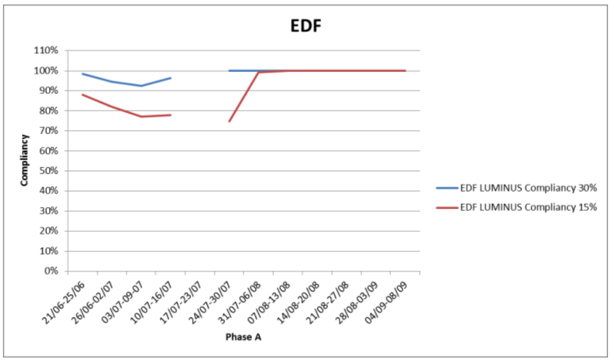
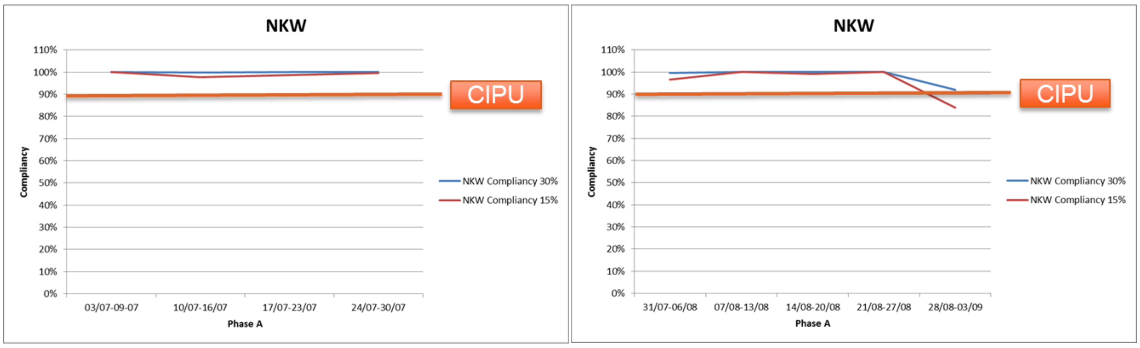


Figure 46: The compliancy results for EDF Luminus during the participation phase part A.

9.3.4. Results for Next Kraftwerke

In Figure 47, the compliancy results for Next Kraftwerke are depicted for the first part and the second part of participation phase (only considering baseline A). As already mentioned in section 9.1 with respect to the quality of the reaction, it can be seen that the compliancy results were already very good at the beginning of the participation phase. This could be explained by the experience Next Kraftwerke already have by delivering aFRR in Germany.



At the beginning of the participation phase part A

At the end of the participation phase part A (for baseline A)

Figure 47: Good results of the compliancy for Next Kraftwerke from the start of the participation phase part A for baseline A only.

The compliancy results for part A of the participation phase are represented in Figure 48.

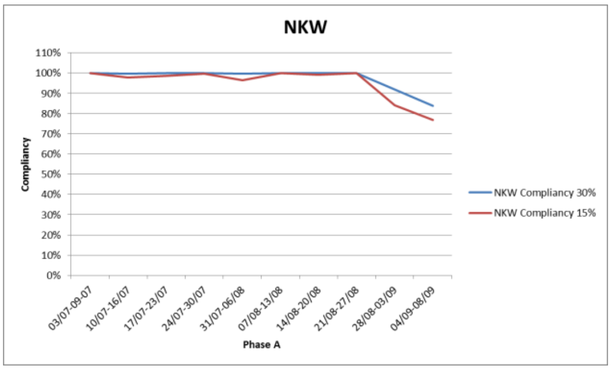


Figure 48: The compliancy results for Next Kraftwerke during the participation phase part A for baseline A and B together.

9.3.5. Results for the overall compliancy

During the participation phase, an evolution towards good compliancy results is observed for all three participants during the pilot project as shown in the graphs above. Elia has observed a learning curve during the participation phase especially in the situation when the provider does not have experience with the delivery of the aFRR services.

Table 11 gives the compliancy results for the whole participation phase, i.e. part A and B together. All three project partners have achieved an acceptable level of compliancy results.

BSP	Compliancy 30% margin	Compliancy 15% margin
Actility (upscaled)	92%	85%
EDF	98%	90%
NKW	98%	96%

Table 11: Compliancy results for part A and B

The compliancy results for 2 CIPU providers are depicted in the table below as a reference. It can be concluded that the compliancy of non-CIPU units gives equally good results with respect to CIPU units.

Provider	Compliancy CIPU (15% margin)
BRP (CIPU) 1	90%
BRP (CIPU) 2	95%

Table 12: Compliancy results for July and August.

9.4. Activation repartition and duration

The idea of this section is to analyse the repartition of the activations with respect to the contracted volume and the duration of the activations for both phases. It is also investigated how the compliancy results are depending on the magnitude of the set-point sent by Elia.

Figure 49 gives an overview of the number of activations per week for each provider. In general the upwards activations (Actility) and downwards activations (EDF Luminus and Next Kraftwerke) are well distributed among the weeks of part A. It is also confirmed that there are sufficient activations during the participation period.

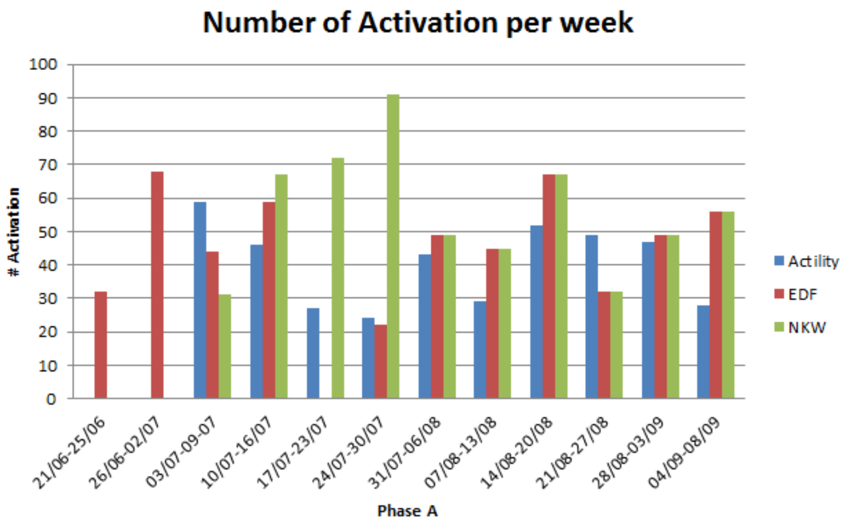


Figure 49: Number of activations per week for part A.

Besides the number of activations per week, also the duration of the activations is an important parameter (Figure 50). There is the same trend for the duration of activations for the upwards and downwards activations. It can be seen that there are a lot of small upwards and downwards activations especially in part A. Long activations are occurring significantly less.

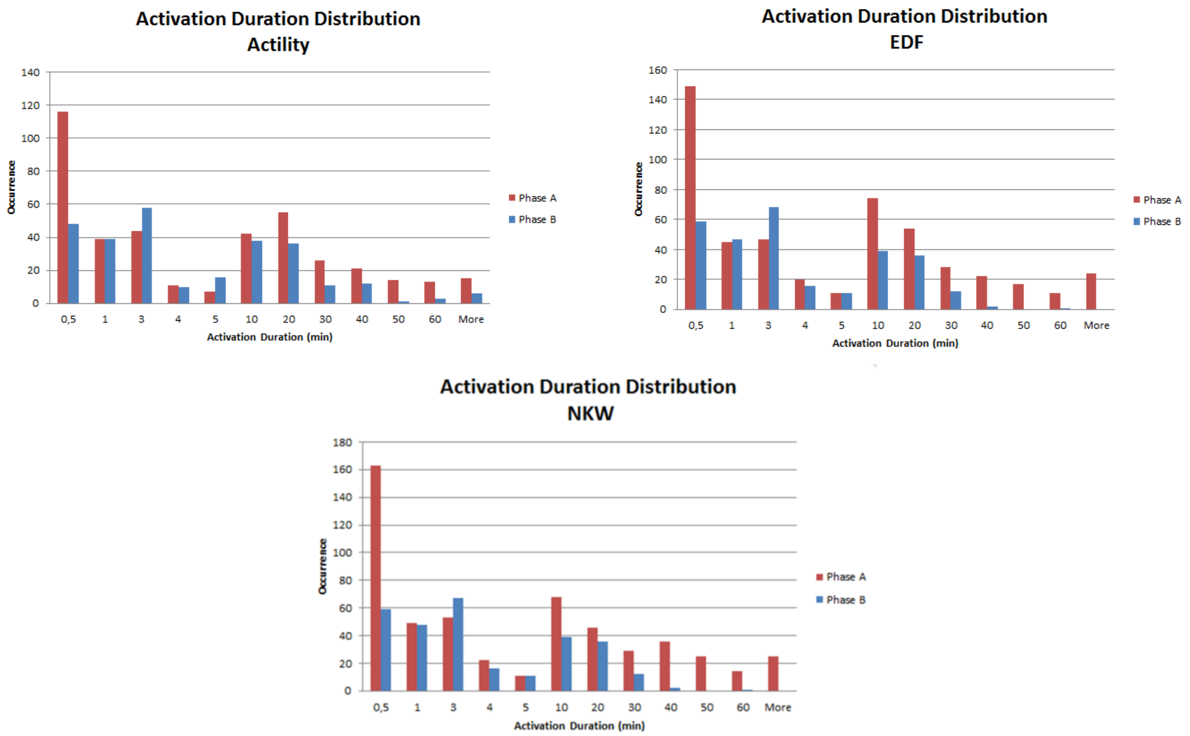
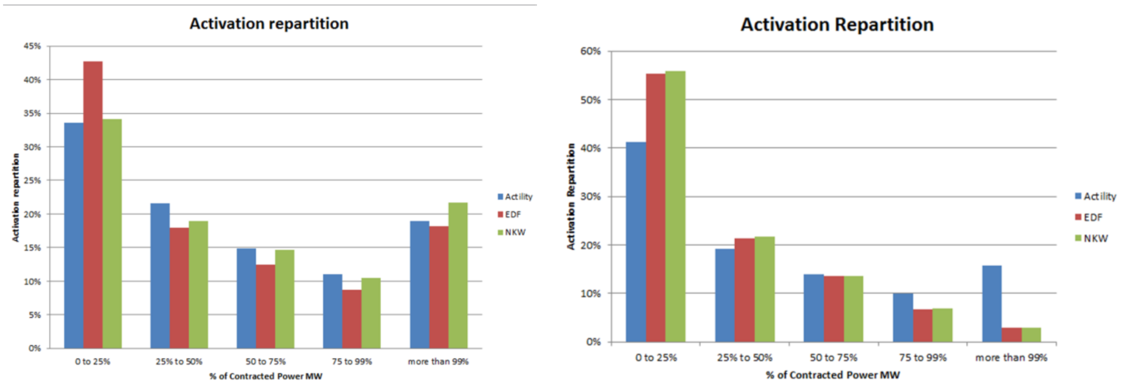


Figure 50: Activation duration for Actility, EDF Luminus and Next Kraftwerke.

In Figure 51, the repartition of the activations is depicted for part A and B. This graph indicates the occurrences of the activations with respect to the magnitude of the activations. The sum of the occurrences for each project partner is equal to 100%. It can be seen for part

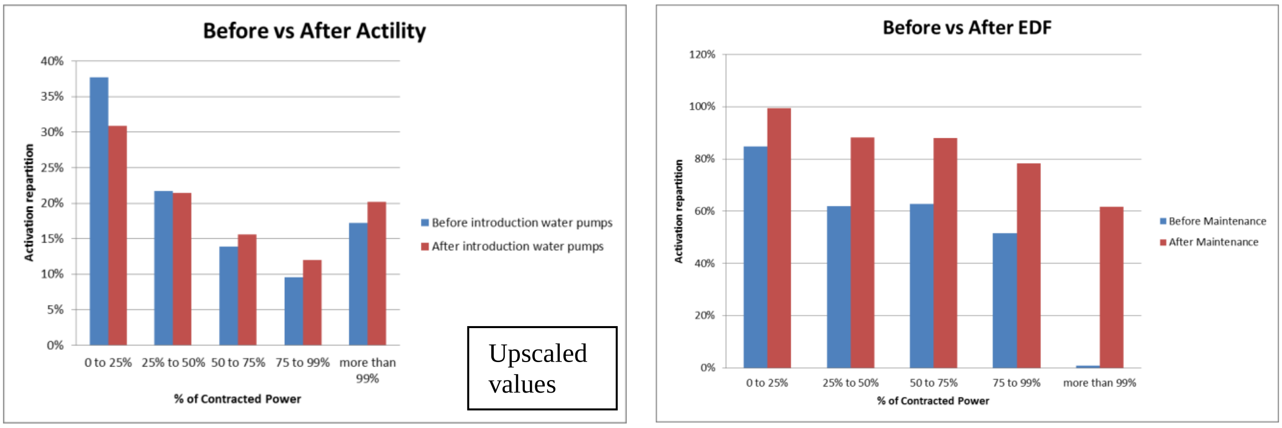
A that small activations (smaller than 25% of the contracted volumes) occur up to 30 to 45% of the time. The occurrence of large activations is around 20%. For part B, the occurrence of small activations is around 40 to 55% and the large activations around 5% for downwards and around 15% for upwards, meaning that there were larger upwards activations with respect to the downwards activations.



Part A Part B

Figure 51: Activation repartition for part A and part B.

Figure 52 reflects the follow-up of the activations with respect to the magnitude of the set-point expressed in a percentage of the contracted volume for the three project partners. For these analyses, a compliancy rate of 15% is considered. Both the introduction of the water pumps for Actility and the maintenance and improvement of the baseline have a significant positive impact on the compliancy results. For EDF Luminus, this is especially the case for large activations. For Next kraftwerke, the quality of baseline A is better than baseline B during an activation and this has also an impact on the quality of the activations as can be seen in the graph below.



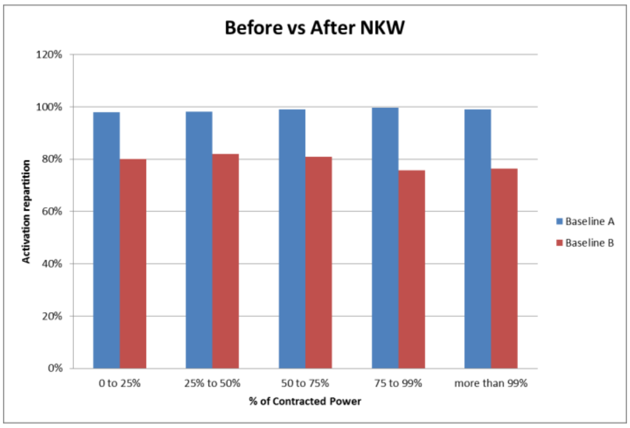


Figure 52: Activation follow-up for part B.

The same analyses are performed for part B of the participation phase. In general, part B is more difficult than part A because the pro-rata activation requires a continuously activation of the pool. Actility have improved the quality of the real-time connection for part B of the participation phase and this has a positive impact on the compliancy results. Also the algorithm for the water pumps has improved.

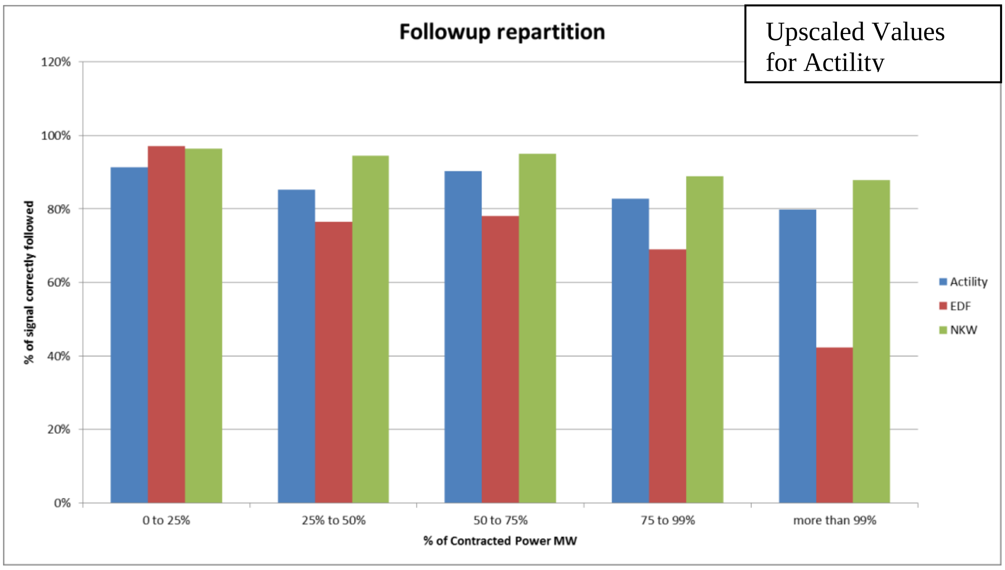


Figure 53: Activation follow-up for part B.

9.5. Encountered problems during participation phase

This section gives a short overview of the encountered problems during the participation phase and improvements that have taken in place due to the close cooperation with the project partners during this phase. This has led to an increased quality of the results. It gives also an insight in the obtained learning curve and the possible improvements for the future.

For the communication side, the most frequently occurring problem was the loss of the real-time connections. This issue happened on a regular basis. During the participation phase, the reliability of the real-time connection was improved. The redundant line, which is standard requirement for R2 CIPU, could reduce the occurrence of this issue significantly in the future. The loss of the connection is not always (immediately) detected by the provider. It could have an added value that this is detected automatically by Elia, so that this issue could be solved in a short notice. It should be noted that an interruption of the real-time signal will be considered as a non-compliant delivery and would lead to a penalty in aFRR framework. Elia will investigate this further.

With respect to the management of the pool, the following issues are identified:

- Loss or introduction of a unit during an activation
- Start-up or shutdown of a unit during an activation
- Bad estimation of the baseline

During the participation phase, the baseline is improved as explained in chapter 7. In this chapter, it is also explained which further improvements could be possible for the future.

9.6. Conclusions

All three project partners have achieved in the end compliancy results with an acceptable level of quality within the scope of the pilot project.

- It appears that a critical mass is required to deliver an accurate aFRR service.
- The quality of the real-time communication is even important as a good reaction of the aFRR flexibility since an interruption of the real-time connection will lead to non-compliant delivery and thus as a consequence to penalties.
- The quality of the baseline has a significant impact on the quality of the compliancy results.
- A learning curve is observed during the participation phase with respect to the quality of the compliancy results.

The compliancy results are calculated based on the contracted volume in this project. For that reason, the contracted volume is determining the margin for the error, i.e. the difference between activated power and the requested power. With a small volume and thus a small margin, it is observed that it is more difficult to reach an acceptable quality level and therefore a critical mass of 1 to 2MW is required to participate at the aFRR services. Otherwise, it will be difficult to participate in the current Rx availability control.

It must be highlighted that there are several problems affecting the quality of the activation. A good baseline is crucial to achieve good compliancy results and therefore, this reconfirms the importance of having a good baseline quality. In case there was a loss of the real-time connection, this is handled as a non-compliant delivery. The loss of a unit during an activation will also lead to a non-compliant delivery. If the start-up or shutdown of a unit is not taken accurately into account in the baseline, the verification of the correct delivery of the aFRR services will be difficult.

The real-time delivery of the aFRR services is a complex operational process. During the participation phase, a learning curve is observed with improved quality results towards the end of the participation phase. It is also observed that having experience for delivering aFRR services has an impact on the quality of the service at the start period.

Elia will analyse in the future alternative solutions for the calculation of the compliancy in order to check whether there are compliancy rules which fits better to the future design. Also an acceptable compliancy rate for the future will be investigated.

10 Market analyses on the integration of non-CIPU in the aFRR market

In this chapter, a high-level market analysis is performed. It must be stressed that the focus during this pilot project was on the technical aspects and therefore, the market aspects are not examined in detail.

It must be emphasized that the analyses in this chapter are only based on the indicative prices that were received during the pilot project. Therefore, no general conclusions can be drawn towards the future on this topic.

10.1. Quality and reliability of the energy bids

In the current aFRR framework, a weekly tender takes place to reserve the required volume for the aFRR reserves. For the holders of the contracted volumes, it is an obligation to bid day-ahead the contracted volume. In the pilot project, 100% availability of the volumes for the whole duration of the participation phase was expected. Therefore, a capacity reservation was not put in place during the pilot project and thus the weekly capacity reservation ability could not be investigated.

However, it is clear that the forecasting of the flexibility week-ahead is more difficult than day-ahead and that for non-CIPU flexibility there is a preference to go from a weekly to a daily tender in order to make a more accurate forecast of the available flexibility. This is for example illustrated by the dryness during the month July and the impact on the availability of the water pumps. Such a situation is difficult to predict on a weekly basis and a daily tender could be of great benefit. The 100% availability during the 3 months of the participation phase is not prerequisite for participating at the future aFRR balancing market.

The day-ahead volumes of the energy bids were only pro-forma (due to the 100% availability). The pro-forma energy bids contain the following information per unit:

- Volume per unit in MW
- Price per unit in €/MWh
- Baseline per unit in MW

Qualitative checks were performed during the participation phase with respect to the correctness and completeness of the energy bids. It was checked whether the offered volumes were in line with the contracted volumes. The day-ahead baseline was compared with the real-time baseline. Since there was a strong focus on the real-time baseline in the participation phase and not on the day-ahead baseline, which is also less relevant, it was not possible to draw relevant conclusions based on this analysis. The three project partners have indicated that the day-ahead baseline could be improved in future. The activation prices which were submitted in the file with the energy bids were used for the competitiveness analysis in section 10.2 and for the calculation of the impact on the imbalance prices in section 10.3. It is also indicated that a balancing energy gate closure time closer to real-time would also have a positive impact on the offered flexibility by non-CIPU.

10.2. Non-CIPU competitiveness analysis

In this paragraph, the competitiveness of the R2 non-CIPU flexibility with respect to the CIPU units is compared for the whole participation phase regarding the activation prices of the energy bids. The activation prices of the non-CIPU bids and CIPU bids are placed in a merit order list. The occurrence of the position of the bids in the merit order list is depicted in the figures below for the period August – September of part A and B. The figures are showing that most of the time, downwards R2 non-CIPU bids are at the end of the merit order list whereas the upwards R2 non-CIPU bids are at the beginning of the merit order. Although it is not visible in Figure 54 due to the very limited numbers, there are some few cases where the R2 non-CIPU upwards bids are at the end of the merit order list.

Often, a load process is designed to follow a specific schedule linked to operational constraints. A deviation of this schedule could lead to high costs. In case of load assets with limited operational constraints, they might have low activation prices for incremental bids since an activation leads to a reduction of the consumption. Incremental bids from non-CIPU generation assets could have from theoretical point also relatively low prices. In the end the activation prices depend on a lot of factors. In any case it is a valid assumption that there is a large potential of assets who could offer a competitive price for incremental bids. However, it is equally valid to assume that these generation assets in total will offer a smaller volume for upwards reserves than for downwards reserves. Otherwise this would imply that these assets would be over-dimensioned. However, there are also situations when these assets run in partial load for longer periods of time. In that case, the delivery of upwards aFRR services could be highly beneficial.

Dependent on operational constraints a decremental bid sourced from a load unit could have a high or low activation price. A decremental bid from a production unit like a biogas plant could have a high price due to the loss of green certificates that must be compensated. Full compensation is possible when the energy buffer is large enough and/or the plant runs in partial load. For the natural gas CHPs, it is possible to adapt the management of the pool so that they can recover the certificates at a later stage by adapting the individual production schedules. This is because CHPs often do not run at full load over a period of a week.

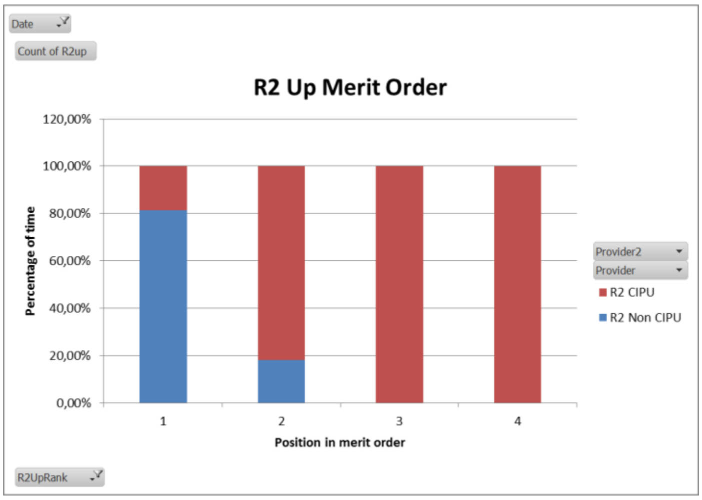


Figure 54: Position in the upwards merit order list.

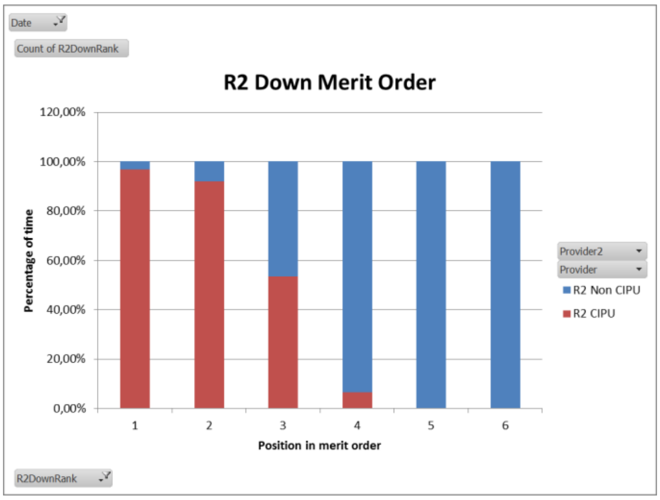


Figure 55: Position in the downwards merit order list

An important remark must be added to these analyses. The prices provided by the project partners are assumed to be the prices for free bids (i.e. without reservation price) and these prices must be considered as indicative without profound analyses. More detailed analyses with respect to the fixed and variable remuneration versus the fixed and variable costs and the opportunity costs are needed. Also a possible cap and floor can have an impact on the price setting. As already mentioned, the focus of the pilot project was on the technical aspects and therefore, a detailed analyse of the prices did not take place in the scope of the pilot project.

10.3. Impact on imbalance prices

In this section, the impact of the activation price of non-CIPU units on the imbalance prices is investigated. The same remark on the validity of the prices as mentioned in the section 10.2 is valid here. For part A of the participation phase, the volume weighted average price of the upwards (downwards) R2 non-CIPU units are calculated in case of an upwards (downwards) R2 non-CIPU activation and are compared with the imbalance prices. If the weighted average price for upwards (downwards) R2 non-CIPU is higher (lower) than the imbalance price, the non-CIPU units will set the new imbalance price. The positive and negative imbalance prices are assumed to be equal and the alpha component is not recalculated. In this analysis, a merit order with marginal pricing methodology is approached. In case of a negative net regulation volume, it is the lowest decremental price that is setting the imbalance price. In case of a positive regulation volume, it is the largest incremental price that is setting the imbalance price.

The competitiveness analysis of section 10.2 has shown that flexibility of the upwards R2 non-CIPU which participated at the pilot project is at the beginning of the merit order list. Therefore, the R2 non-CIPU volume weighted average price of the upwards energy bids will almost never be larger than the volume weighed average price of the upwards energy bids for CIPU. As a consequence, these R2 non-CIPU energy bids will almost never set the imbalance price and thus the impact on the imbalance price is very small.

The downwards R2 non-CIPU bids received during the pilot project, are often at the end of the merit order list as investigated in section 10.2. As a consequence those bids could have a significant impact on the imbalance prices in case the downwards R2 non-CIPU bids are activated. In that case, the downwards R2-non-CIPU bids have a lower price than the downwards R2 CIPU bids, the R2 non-CIPU bids will set the imbalance price (based on the decremental price). The results are shown in Figure 56 for part A from the 1st of August on. Only the situations where the marginal decremental prices were determining the imbalances price are represented. The R2 non-CIPU flexibility is not often activated during part A. The impact on the imbalance prices is zero when there is no activation of the R2 non-CIPU flexibility, which explains the large peak around zero. In case that there is an activation of the R2 non-CIPU units, it can be seen there is a significant impact on the imbalance prices.

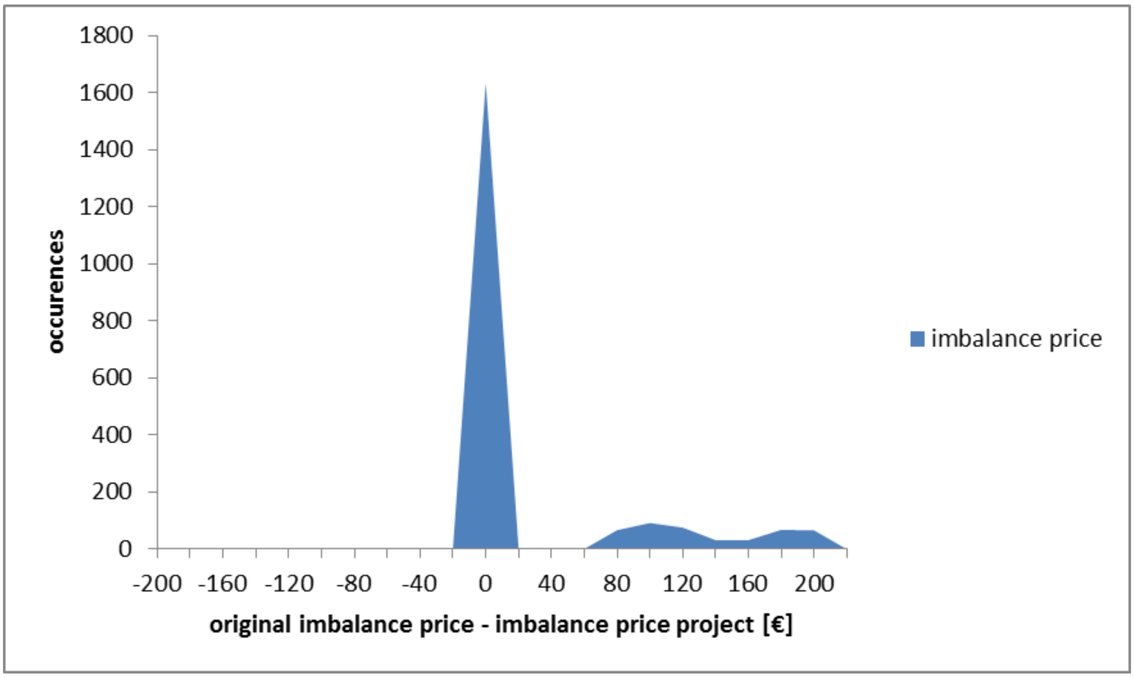


Figure 56: Impact on imbalance prices for part A of the participation phase for downwards activation.

A larger volume of upwards R2 non-CIPU bids with the same activation price – as offered during the pilot project - will have a positive impact on the imbalance price. These units will be placed at the beginning of the merit order and therefore in a merit order activation, the more expensive bids at the end of the merit order will be activated less frequently. A larger volume of downwards R2 non-CIPU bids – as offered during the pilot project - will have almost no impact on the imbalance prices because they are at the end of the merit order list and they will only be activated in case of large imbalances.

10.4. Conclusions

There is a preference for going from a weekly to a daily tender for aFRR capacity for R2 non-CIPU to increase the offered volumes.

Also a balancing energy gate closure time closer to real-time will increase the offered flexibility of R2 non-CIPU.

The activation prices of the R2 non-CIPU bids could have a significant impact on the imbalance prices.

It would be an advantage for the R2 non-CIPU flexibility to go from a weekly to a daily tender for the aFRR capacity and to have a gate closure time for balancing energy bids close to real-time. Both measures would make it easier for these units to forecast their flexibility and to offer more volume to the aFRR market.

The downwards R2 non–CIPU bids, as offered during the pilot project, are most of the time at the end of the merit order list and the upwards R2 non-CIPU bids, received during the pilot project, are most of the time at the beginning of the merit order. As a consequence, the downwards R2 non-CIPU bids could have a significant impact on the imbalance prices for part A. The upwards R2 non-CIPU bids could almost have no impact on the imbalance prices for part A because the R2 non-CIPU prices, as offered during the pilot project, are lower than the R2 CIPU prices and they will not set the imbalance price in this approach for the merit order activation.

It must be emphasized that the analyses in this chapter are only based on the indicative prices that were received during the pilot project and on a diversity of load/demand or supply facilities which is perhaps not representative for the future technologies/flexibilities interested by the future financial model. Therefore, no general conclusions can be drawn towards the future on this topic.

11 Conclusions of the pilot project

- The preparation of the access to the aFRR market, i.e. the set-up of the real-time communication, the configurations managed by Elia and the contractualization, ... is a time consuming process.
- All three project partners have demonstrated that non-CIPU units are technical capable in participating in the aFRR balancing market and thus in delivering aFRR. They have achieved in the end a baseline methodology and compliancy results with an acceptable level of quality. It appears that a critical mass is required to deliver an accurate aFRR service.
- The quality of the required real-time exchange of a very important volume of data is a challenging task
- A significant learning cure is observed with respect to the quality of the baseline and the compliancy results during the participation phase.
- There is a preference for going from a weekly tender to a daily tender for aFRR capacity for R2 non-CIPU to increase the offered volumes. Also a balancing energy gate closure time closer to real-time will increase the offered flexibility for R2 non-CIPU.

Only a limited number of candidates could participate at the R2 non-CIPU pilot project due to the demanding technical and organizational requirements. These requirements were considered as too challenging mainly with respect to the timings for some candidates. It was for example difficult to have on a short notice an agreement with the grid users.

It must also be emphasized that the preparation for delivery at the aFRR balancing market, i.e. the set-up of the real-time connection, the configuration of the connection, the communication tests ..., is a time consuming and complex process for both Elia and the project partners. Also, the necessary contracts between Elia and the aFRR provider and between the aFRR provider and the grid users need to be finalized before the prequalification test can start. This could take a significant amount of time.

Several parameters are exchanged in real-time between the SCADA of Elia and the SCADA of the aFRR provider. The significant increase of the delivery points will also lead to large data exchanges between the aFRR provider and Elia. Within in the scope of the pilot project, there were 15 delivery points delivering 4MW downwards aFRR and 12 delivery points delivering 1MW upwards aFRR. If an extrapolation to 144MW is performed, this would results in a significant increase of delivery points, i.e. between 500 and 1000 delivery points, and an important amount of data which need to be exchanged per day between Elia and the providers (i.e. around 130 000 values per day per delivery point) .

This pilot project has confirmed that the baseline is crucial for the determination of the delivered aFRR energy, transfer of energy,... . A learning curve is observed for the quality of the baseline with improvements towards the end of the participation phase. All three project partners have achieved in the end a baseline methodology with an acceptable level of quality. Having experience with delivering a baseline is clearly an advantage. Elia has obtained a good insight in the baseline methodology. The baseline for mFRR, which is on a quarter-hourly basis, is not accurate enough for aFRR. A real-time baseline is required for aFRR. It should be clarified how the loss or introduction of a unit is handled in the baseline. The baseline is sent one minute in advance and thus an unforeseen introduction or loss of unit can give a wrong baseline for one minute. Since the baseline is key for the aFRR delivery, strict quality rules for the baseline will be needed. These aspects need further investigation.

All three project partners needed more than one attempt for the prequalification tests. The reasons of failure were linked to communication and configuration problems. A specific test for verification of the quality of the baseline should be added in the future. On top of that in the future, the compliancy of the baseline could also be verified on a regular basis during the delivery of aFRR.

All three project partners have achieved in the end activations with an acceptable level of quality which is comparable with the quality level of the CIPU units. Although, an important conclusion is that a critical mass of the aFRR bid volume was required to deliver accurate aFRR services. During the participation phase, a learning curve is observed towards those acceptable levels of quality. Having experience in delivering aFRR is clearly an advantage in this situation. During the participation phase, several problems which have an impact on the quality of the activations are detected. Problems with the quality of the baseline have a direct impact on the quality of the activations. Also a loss of a real-time connection has an impact on the quality results. Therefore, a stable real-time connection is equally important as good compliancy results.

It is clearly an advantage with respect to the offered volumes for aFRR providers with R2 non-CIPU flexibility to go from a weekly to a daily tender for aFRR capacity. Also an intraday balancing energy gate closure close to delivery instead of a day-ahead gate closure time could have a significant positive impact on the offered flexibility for the aFRR energy bids. This could be beneficial to attract more R2 non-CIPU flexibility. The activations prices of the aFRR bids and there place in the merit order (i.e. the combination of CIPU and non-CIPU aFRR bids) can have an impact on the imbalance price. However, it must be emphasized that these prices must be considered as indicative without profound analyses. More detailed analyses by the aFRR providers are required with respect to this topic.

It can be concluded that the real-time delivery of aFRR services is a complex process. It is also assumed that this will also be a time consuming process in the future which could take for a new entrant 6 months up to one year in order to achieve an acceptable quality level.

Based on the results of the pilot project Elia believes that it is desirable that the aFRR market is opened to non-CIPU flexibility. Therefore Elia will develop a new market design for aFRR. The results of this study shall be presented and consulted to stakeholders in the course of 2018.

This pilot project has also revealed some topics that need further detailed analysis such as the baseline quality, the compliancy results and the prequalification test. This will be further analyzed in de design note for the opening of the aFRR balancing market in cooperation with all the stakeholders.

Part 2: Assessment of implications of transfer of energy.

12 Transfer of Energy

12.1. Introduction

Following the amendment to the Electricity Act of July 13 2017[1], Elia needs to establish the Rules for the organisation of Transfer of Energy (hereafter called "ToE-rules"[2]). Elia proposed to implement the transfer of energy via a phased approach, starting with the market for non-reserved mFRR (April 2018) and followed by the market for reserved mFRR (Q4 2018). A next step could consist of the implementation of a transfer of energy for aFRR. This will be described in a concept note that will be publicly consulted in 2018. In parallel, Elia will perform a feasibility study w.r.t the implementation of transfer of energy for aFRR. By the end of December 2018, Elia will deliver a roadmap that will provide a clear indication if, and if so when the transfer of energy can be implemented for aFRR, taking into account the result of the feasibility study.

This chapter, drafted by Elia only, describes the implications of a transfer of energy for aFRR. The following section starts off by explaining the different roles and responsibilities of the market parties that are afterwards applied on two examples.

12.2. The roles and responsibilities of the different market parties

This section describes the relevant market actors that act or are impacted in the context of a transfer of energy and explains their roles and responsibilities. A good understanding of these key players is essential for a clear comprehension of the transfer of energy:

- **BSP**: the Balancing Service Provider offers flexibility for balancing purposes (e.g. R2 non-CIPU control power). In the context of transfer of energy, we refer to demand flexibility as defined in the ToE-rules, i.e. up- or downward modulation of net – offtake at a delivery point.
- **Supplier**: the supplier is the legal or natural person that sells electricity to one or more end consumers; the supplier produces or buys electricity that is sold to the end consumer.
- **Delivery point**: a point connected to the ELIA or DSO-grid or within the electrical installation of a grid user where a balancing service (or strategic reserve) is delivered. This point is linked to a power meter, or its equivalent according to the regional grid codes, that enables the transmission system operator to measure the delivery of the service.
- **BRPbsp**: the Balancing Responsible Party ("BRP") that is associated to the BSP.
- **BRPsource**: the original BRP who has the delivery point, or related access point, in its portfolio.

[1] The Electricity Act can be consulted via this link.
[2] The Transfer of Energy rules were publicly consulted as from 13/11/2017 and can be consulted via this link.

12.3. Transfer of Energy by two use-cases

12.3.1. Delivery of upwards R2 non-CIPU control power by a reduction in net-offtake

The following schematic overview shows the roles of the different market parties in the context of a transfer of energy. The example of a delivery of upward R2 non-CIPU control power is demonstrated, by a delivery point that reduces its net-offtake.

Remark

As mentioned later under section 12.5, the transfer of energy regime is determined on basis of the average net-offtake of a delivery point; if on a yearly basis the average net-offtake is positive then the delivery point is eligible for transfer of energy. Therefore the delivery point hereunder should be considered as one that has a net-offtake > 0.

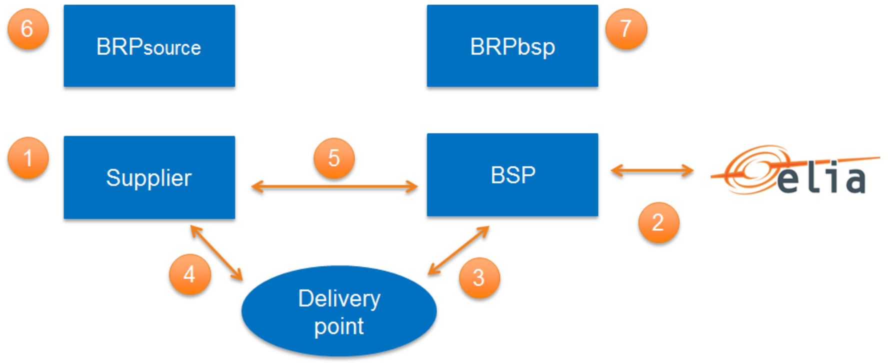


Figure 57: schematic overview

1. The **supplier** buys energy in advance (via the BRPsource) on the electricity market. The amount of energy the supplier buys in advance depends on the estimated energy offtake of each delivery point in his portfolio.
2. Elia activates **upward R2 non-CIPU control power** (i.e. a downwards modulation of net-offtake) via a balancing service provider ("BSP"), who delivers the balancing service to Elia.
3. The **delivery point** reduces his consumption in real-time and thereby delivers R2 non-CIPU control power.
4. By reducing its consumption, **the supplier cannot invoice** this activated energy anymore to his final customer (=delivery point). Nonetheless the supplier **sourced** this **energy** in advance on the electricity market (step 1.).
5. The delivered energy is **financially compensated** between BSP and Supplier, either based on bilaterally agreed price or, in absence of such a bilateral agreement, the BSP and Supplier apply the regulated transfer price. The BSP will thus compensate the supplier for the sourced (but not invoiced) energy due to the activation of upward R2 non-CIPU control power.

6. The balancing perimeter of the **BRPsource** is corrected for the delivered volume of R2 non-CIPU control power. This neutralization is performed in order to neutralize the impact on the balancing perimeter of the BRPsource.
7. The **BRPbsp** needs to take up the balancing responsibility for the activation of the requested flexibility. The BRPbsp is responsible for the difference between the delivered volume and the requested volume of flexibility.

12.3.2. Delivery of downward R2 non-CIPU control power by an increase in net-offtake

The next example shows a delivery of **downward** R2 non-CIPU control power, by a delivery point that increases its net-offtake. As was mentioned in the previous use case, the delivery point is considered to have a positive average net-offtake on a yearly basis.

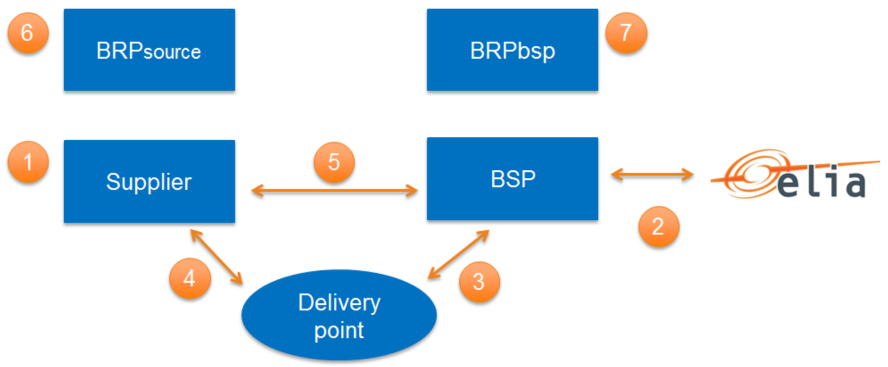


Figure 58: Schematic overview

1. The **supplier** buys energy in advance (via the BRPsource) on the electricity market. The amount of energy the supplier buys in advance depends on the estimated energy offtake of each delivery point in its portfolio.
2. Elia activates **downward R2 non-CIPU control power** (i.e. an upwards modulation of net-offtake) via a balancing service provider ("BSP"), who delivers the balancing service to Elia.
3. The delivery point **increases his consumption** in real-time and thereby delivers downward R2 non-CIPU control power.
4. By increasing its consumption, the **supplier invoices** (sells) this surplus of activated energy to his final customer. However, the supplier **did not source** this **energy** in advance on the electricity market (step 1.).
5. The delivered energy is **financially compensated** between BSP and supplier, either based on bilaterally agreed price or, in absence of such a bilateral agreement, the BSP and Supplier apply the regulated transfer price, the BSP will thus compensate the supplier for the sourced (but not invoiced) energy due to the activation of upward R2 non-CIPU control power.

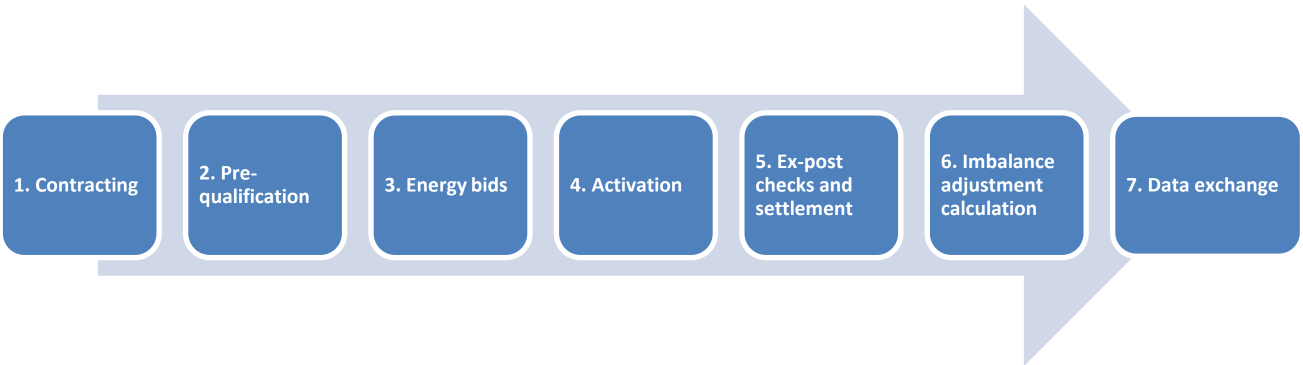
6. The balancing perimeter of the **BRPsource** is corrected for the delivered volume of R2 non-CIPU control power. This neutralization is performed in order to neutralize the impact of the delivery on the balancing perimeter of the BRPsource

7. The **BRPbsp** needs to take up the balancing responsibility for the activation of the requested flexibility. The BRPbsp is responsible for the difference between the delivered volume and the requested volume of flexibility.

12.4. Identification of the impacted processes

This chapter describes the impact of transfer of energy on the overall process of aFRR market provided by non-CIPU units. It is important to mention that only implications and possible challenges related to the transfer of energy are elaborated upon. The actual design aspects of a transfer of energy for the aFRR market will be discussed in detail (and publicly consulted) in 2018. This will be part of the larger overall design of the aFRR-market. Elia will publish this at the end of 2018 in a concept note and according roadmap.

We start off by giving a high level overview of the R2 non-CIPU process and identify the processes on which a transfer of energy has an impact. Those processes that are identified as being affected by a transfer of energy are then furtherly examined in this report.



1. **Contracting**

During the contracting phase the provider of the R2 non-CIPU service signs a contract with Elia. This contract handles the contractual rights and obligations of both parties. Furthermore, both parties agree on the conditions for the provision of the R2 non-CIPU service. Along with the contract, the BSP provides a list of delivery points which will be used for the delivery of the R2 non-CIPU service.

The implications of a transfer of energy on the contracting phase are the following

a) The BSP will inform Elia of those delivery points that operate under a transfer of energy regime.

b) The BSP will need to comply with the terms and conditions, as stated under art. 19 bis §3-5 of the Electricity Act and defined by the CREG.

c) The BSP is required to comply with the terms & conditions stated in the ToE-rules.

These implications are examined further under section 12.5 of this final report.

2. Pre-qualification phase

During the pre-qualification phase Elia verifies whether or not the BSP is able to deliver the R2 non-CIPU from an organizational and technical point of view. On the one hand Elia verifies whether the real-time and off-line communication requirements are fulfilled. On the other hand Elia verifies if the BSP is able to follow the activation signal. The whole pre-qualification procedure is discussed under chapter 8 of the final report.

Whether a delivery point participates under a transfer of energy regime **does not** impact the pre-qualification procedure. Indeed, both communication and technical requirements remain unchanged if a BSP opts to use delivery points that are in market situation with our without a transfer of energy.

However, it is important to notice that the real-time communication that is tested during the pre-qualification procedure forms the basis for the calculation of the delivered energy later on in the process. Therefore section 12.6 is dedicated to the real-time power measurements, explaining

a) The organizational set-up of the real-time communication;

b) The usage of real-time power measurements for ex-post analysis.

Section 12.6 aims to provide a clear picture of the input data that are used for the calculation of the delivered energy.

3. Bidding phase

As discussed under chapter 5.3 of the final report, the participants of the pilot project bid in day-ahead the following information at the delivery point level:

a) Volume per delivery point (MW)

b) Price per delivery point (€/MWh)

c) Baseline per delivery point (MW)

The presence or absence of transfer of energy in the aFRR market does not have any effect on the bidding phase. However, it should be noted that this statement holds under the hypothesis that the same approach remains that was adopted during the pilot project. Thus, based on the current way of working for the aFRR energy bids coming from non-CIPU units, a transfer of energy will not have an impact on the bidding procedure. Therefore, it is not further discussed in this final report.

4. Activation phase

The activation phase, as explained under chapter 5.3 of this final report, consists of the effective delivery of R2 non-CIPU control power. Whether or not a delivery point acts under a transfer of energy regime doesn’t affect the delivery of R2 non-CIPU control power.

However, in parallel to the actual delivery of R2 non-CIPU control power, the BRPsource needs to be informed about the possible impact on his perimeter resulting from the activation of R2 non-CIPU control power by a BSP. The way of working during the pilot project and the future implications of this notification message to the BRPsource are discussed in section 12.7.

5. Ex-post checks and settlement

After the activation phase the current aFRR framework foresees several checks:

a) Activation control: Elia checks every month that the quantity of secondary control power delivered upwards and/or downwards by the provider during month M meets the contractual requirements. Said check is performed by calculating the discrepancy between the energy resulting from secondary control power delivered with the energy resulting from the secondary control power requested.

b) Availability control: Elia checks every month that the provider has made, for each quarter-hour of month M-1, the amount of secondary control power obligations available to Elia during month M-1 in the agreed period.

The same logic was applied during the pilot project, yet the activation control consisted of a compliancy rate check over both phases of the participation period.

During this phase the delivered energy is calculated, which is an essential element in case of transfer of energy as both the imbalance adjustment and the financial compensation between the BSP and the supplier will be based on this delivered energy.

The detailed calculation of the delivered energy per delivery point has not yet been explained in this final report. As this forms an essential input for the imbalance adjustment in the context of a transfer of energy, section 12.8 will discuss more in detail the calculation of this delivered energy per delivery point via the following steps:

a) The need for an accurate baseline for the calculation of delivered energy per delivery point;

b) Delivery points to be taken into account for the calculation of the delivered energy;

c) Detailed calculation of the delivered energy per delivery point

This opens up the path to discuss the imbalance adjustment in the next step.

6. Imbalance adjustment calculation

One of the key elements of transfer of energy is the imbalance adjustment of the BRP's. Therefore section 12.9 explains the modus operandi for the imbalance adjustment of the BRPsource and BRPbsp.

7. Data-exchange

The Electricity Act amendment of July 13, 2017 describes the management of the flexibility data in a market situation with transfer of energy. Under the notion of data management one must understand the data collection, data processing, calculation of the delivered energy, and the final communication of the aggregated energy volumes. For all these tasks confidentiality of the commercial sensitive data is guaranteed.

The exchange of the aggregated data can be subdivided as follows:

a) Data exchange between Elia and the BRP for the imbalance adjustment;

b) Data exchange between Elia and the supplier for the financial compensation between the supplier and the BSP;

c) Data exchange between Elia and the BSP for the financial compensation between the supplier and the BSP.

The exchange of this aggregated data is extensively discussed in the Transfer of Energy rules. In general, aggregated energy volumes are communicated to the BSP, resp. Supplier on a quarter hourly basis and split per Supplier resp. BSP. As these basic principles will remain unchanged for the market of aFRR for non-CIPU units, no further details are given in this final report.

12.5. Contracting phase

In a market situation with transfer of energy as defined in the ToE-rules, the contracting phase between Elia and the BSP will be influenced in the following ways.

a) Transfer of energy regime of the delivery point

The transfer of energy regime is established at delivery point level. Whether or not a delivery point is eligible for transfer of energy depends on the average net-offtake character calculated on a yearly-basis, following art. 19bis of the Electricity Act of July 13, 2017.

b) Obligations of the BSP in a market situation with transfer of energy

As described in the Transfer of Energy Rules, the BSP faces additional obligations if he wishes to participate in the aFRR market with delivery points in a market situation with transfer of energy:

- The BSP is required to have a valid ARP-contract with Elia or needs to be associated with a BRP, the so-called BRPbsp
- The BSP provides a grid-user declaration to Elia in which the grid-user confirms that he has an agreement with the BSP for the delivery of flexibility. Via this way the BSP proves that he has the mandate of the end-user to activate flexibility and that the end-user agrees to share measurement data with the BSP and Elia for the purpose of facilitating the financial compensation between the BSP and the supplier in a market situation with transfer of energy. Next to this declaration the BSP provides information regarding the maximum upwards and downwards power of demand side flexibility that can be activated on a specific delivery point, the so-called reference power. Finally, also the existence of a pass through contract is notified to Elia via this grid-user declaration.
- The BSP is required to comply with the overall terms & conditions stated in the ToE-rules. This includes, inter alia, the verification of the eligibility of transfer of energy regime on a delivery point; for those delivery points that wish to participate in a market situation with transfer of energy the net-offtake character is verified as explained under (a).

12.6. Pre-qualification phase

Section 12.4 concluded that the participation of a delivery point under a transfer of energy regime or not **does not** impact the pre-qualification procedure as such. However, the real-time communication that is tested during the pre-qualification procedure forms the basis for the calculation of the delivered energy, which then forms the basis for the imbalance adjustment. In this chapter we therefore describe more in detail the set-up of real-time data-exchange during the pilot project. First, the organizational set-up of the real-time communication is discussed. Secondly, Elia elaborates on the usage of real-time power measurements for ex-post processing.

12.6.1. Organizational set-up of the real-time communication

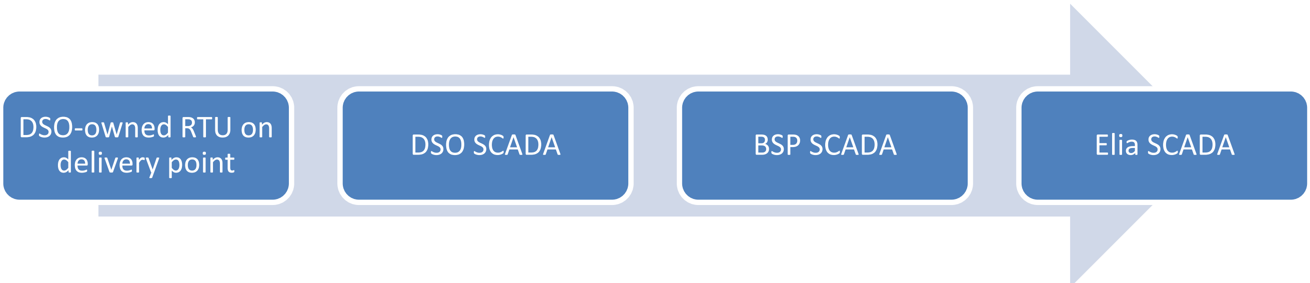
An essential pre-condition for participation in the pilot project was a secure communication channel (a real-time connection) set-up between Elia and the provider of R2 non-CIPU control power. The well-functioning of this secure communication channel was tested during the prequalification phase: Elia and the BSP conducted real-time communication tests via their SCADA-systems, as also described in chapter 8 of this report.

The signals between Elia and the BSP were exchanged on a four second-interval in real-time. Elia observed the following organizational set-up amongst the different project partners:

- Option I: This option was used by all three project partners. All project partners used self-owned RTU's, installed at delivery point to offer real-time power measurements;
- Option II: This option was used for certain delivery points in the portfolio of one project partner, who has worked together with a DSO, to offer Elia real-time power measurements.

I. Real-time communication based on BSP-owned remote terminal units (RTU):

II. Real-time communication based on DSO-owned remote terminal units (RTU):



It becomes clear that a mix of option A) and option B) was used by a project partner; on the one hand they used self-owned RTU telemetry data, on the other hand they used DSO-owned RTU's to exchange data in real-time with Elia. This configuration, allowed the BSP, Elia and the DSO to gather experience with different organizational set-ups for measurement & communication responsibilities. This can be taken into account for the future product design.

12.6.2. Usage of real-time power measurements for ex-post analysis

Real-time exchange data (with a 4-second interval) was automatically stored in an internal database for ex-post analysis. The ex-post tasks performed are the following

- Activation controls in the sense that compliancy calculations were performed for each participating BSP in function of the pre-contracted volume, as explained under section 9.3 of this report;
- Notification message towards the BRP's as explained under section 12.7.

In case real-time communication failed during certain time-intervals when delivering R2 non-CIPU control power, these specific time intervals were considered as a non-compliant reaction. Future design will elaborate on ex-post validation of real-time data including the loss of a real-time communication.

Next to these ex-post tasks conducted during the pilot project, Elia examines further the implications on the use of real-time power measurements for

1. The calculation of the delivered energy;
2. The perimeter correction of the BRPsource and BRPbsp

in the context of a transfer of energy. Elia highlights that for the pilot project the transfer of energy was not operational for aFRR and thus that no aggregated delivered volumes per quarter-hour and per BSP were communicated to the supplier. No perimeter correction for any imbalance caused by the activation of R2 non-CIPU control power

The implications of a transfer of energy for the aFRR market described hereafter do not include specific design aspects related to transfer of energy and are written from a theoretical point of view. The implications described in this theoretical perspective should not be interpreted as a feasibility assessment from Elia. A technical and economic feasibility analysis on the implementation of a transfer of energy on the market segment for aFRR will be published on 20/12/2018.

The next section describes the notification message towards the BRPsource.

12.7. Activation phase

Chapter 12.4 concluded that the participation of a delivery point under a transfer of energy regime or not **does not** impact the activation phase as such. However the BRPsource needs to be informed about the possible impact on his perimeter resulting from the activation of R2 non-CIPU control power by a BSP.

12.7.1. Notification of the BRPsource during the pilot project

The notification of the impacted BRPsource is described for the following two phases of the pilot project

a) Before the participation phase

The impacted BRPsource(s) were informed two weeks before the start of the first phase of the participation period with:

- The message that a R2 non-CIPU activation during the pilot project could cause an impact on their balancing perimeter. No estimated volume was communicated;
- The timing of the participation phase during which an activation could occur.

In order to preserve confidentiality of the participating partners and delivery points, the identity of the participating delivery points and BSP was not communicated to the concerned BRPsource(s).

b) During the participation phase

The notification of the BRPsource(s) occurred on a weekly basis during the participation phase of the pilot project. The communication took place every Tuesday, informing the BRPsource(s) for any effects that occurred in their portfolio due to the intervention of a BSP in the light of the pilot project.

The same approach was applied for part B of that participation phase.

12.7.2. Future notification of the BRP for aFRR

Future design for R2 non-CIPU control power will need to consider the necessity and the practical feasibility to inform the BRP in real-time with regards to the delivery of the requested R2 non-CIPU control power. An essential precondition for this BRP notification message is to have a real-time indication on

- the expected activated volume
- the direction of the quarter-hour imbalance.

However, the R2 set point is a continuous calculation that is reprocessed every time-interval (4 seconds), making it hardly possible to communicate any indication on the expected activated volume in one’s portfolio or direction of activation on a quarter-hourly basis.

In the market for non-reserved mFRR, Elia commits to communicate the expected activated volume to the BRP at its best ability and with the knowledge she disposes of at that moment.

Without such knowledge for aFRR, the notification of the BRP during the quarter-hour of delivery seems ineffective. Per contra, from the moment Elia is able to inform the BRPsource with any relevant information, for example during the quarter-hour directly after delivery, it is considered theoretically possible to inform the BRP with the knowledge Elia disposes of at that moment.

12.8. Ex-post checks and settlement phase

This section examines the calculation of the delivered energy and its implications for the aFRR market. Before describing the actual calculation of the delivered energy, the need for an accurate baseline is highlighted. Although the baseline is not considered to be part of the ex-post checks and settlement phase, Elia believes that it is an essential element which needs proper attention.

12.8.1. The need for an accurate baseline for the calculation of delivered energy

This chapter examines the calculation of the delivered energy and its implications of the transfer of energy principles for the aFRR market. Before describing the actual calculation of the delivered energy, the need for an accurate baseline is highlighted. Although the baseline is not considered to be part of the ex-post checks and settlement phase, Elia is convinced that it is an essential element which needs proper attention.

a) The need for an accurate baseline for the calculation of delivered energy

An accurate baseline is regarded a fundamental corner stone for the calculation of the delivered energy. Elia considers a strict baseline qualification procedure and a continuous follow-up two necessary preconditions to provide sufficient guarantee for a reliable baseline, as discussed under chapter 7 of this report. Once an adequate baseline quality has been established, this baseline can further be used for the calculation of the delivered energy, leading finally to the BRP's imbalance adjustment and a financial compensation between BSP and supplier in the context of a transfer of energy.

b) Delivery points to be taken into account for the delivered energy

Before entering into a detailed calculation of the quarter-hourly delivered energy of aFRR flexibility from non-CIPU technical units (referred to as "Edel" hereafter), one must identify the considered delivery points for calculating the Edel per BSP.

Rather than taking all the delivery points in the pool of the BSP, Elia proposes to consider only those delivery points that are actively steered in real-time by the BSP subsequently to an activation request of Elia. From a theoretical point of view, this can be obtained by looking at the set- point that is sent in real-time from the BSPs to the activated delivery points. This set-point sent in real-time is a translation and split of the set-point sent from Elia to the BSP on portfolio level towards delivery point level. For example if Elia requested 0,2MW of downwards R2 non-CIPU control power, the BSP re-processes this into a set-point of 0,05MW for the first delivery point 0,15MW for the second delivery point, resulting in totally 0,2MW which is equal to the power requested by Elia. In general:

- If the Setpoint ≠ 0 this means the BSP requested the delivery of R2 non-CIPU control power to the delivery point in question;
- If the Setpoint = 0 this means the BSP does not intend to use the delivery point in question for that specific time interval for the delivery of R2 non-CIPU control power.

As a consequence, the delivered volume on a quarter-hour basis will be based on those delivery points that were in a sense notified by the BSP to Elia, under the form of a Setpoint ≠ 0.

12.8.2. Calculation of the delivered energy

The calculation of the delivered energy per delivery point is **not affected by the presence of a transfer of energy**. However, it forms an essential input for the imbalance adjustment of the BRP and therefore needs proper attention. From a theoretical point of view the calculation of the delivered energy can be done based on the difference between the baseline and the 4-seconds measurements Elia received in real-time. This value is then capped with the prequalified power that is provided by the BSP via the grid-user declaration.

For a **downward activation** the delivered energy per delivery point is calculated as follows:

- $Edel_{DP}$ = min ($\sum_{t=0}^{n}$ Pmeasured, DP (t) − Baseline (t); PQP)

And for an **upward activation** the delivered energy per delivery point is calculated as:

- $Edel_{DP}$ = min ($\sum_{t=0}^{n}$ Baseline (t) − Pmeasured (t); PQP)

With

- $P_{(measured,DP)}(t)$: the 4 seconds power measurements that Elia receives in real-time for moment (t)
- Baseline (t) : the reference value communicated by the BSP 1 minute before real-time, indicating the foreseen injection (or offtake) for the considered delivery point
- PQP: the pre-qualified power ("PQP") determined via the NFS-study of the DSO, reflecting the maximum amount of flexibility (=technical limit) of a delivery point

The calculation of the delivered energy only takes place for the time intervals during which the delivery point in question was considered to be delivering R2 non-CIPU control power. It is therefore possible that during one quarter-hour a delivery point is considered to be delivering R2 non-CIPU control power multiple times as explained in the following illustrative example.

Example

This example shows a delivery point that delivers R2 non-CIPU control power by a reduction in net-offtake at the start and the end of a certain quarter-hour. The example demonstrates that the delivery point does not participate between 15:00:12 and 15:14:00. As was mentioned earlier, only those timeframes during which the participation takes place (thus when Setpoint ≠0) are considered.

t	Time	Setpoint ≠ 0	$P_{measured}$	Baseline
1	15:00:00	Yes ≠ 0	1,88	1,9
2	15:00:04	Yes ≠ 0	1,8	1,9
3	15:00:08	Yes ≠ 0	1,7	1,9
4	15:00:12	Yes ≠ 0	1,5	1,9
…	…	…	…	…
216	15:14:00	Yes ≠ 0	1,7	1,8
217	15:14:10	Yes ≠ 0	1,5	1,8
218	15:14:20	Yes ≠ 0	1,4	1,8
219	15:14:30	Yes ≠ 0	1,3	1,8
220	15:14:40	Yes ≠ 0	1,2	1,8
221	15:14:44	Yes ≠ 0	1,1	1,8
222	15:14:48	Yes ≠ 0	1	1,8
223	15:14:52	Yes ≠ 0	0,9	1,8
224	15:14:56	Yes ≠ 0	0,8	1,8
225	15:15:00	Yes ≠ 0	0,7	1,8

Therefore the delivered volume during quarter-hour Qh is calculated as:

Edel=min ($\sum_{t=1}^{t=4}(P_{measured,DP}(t) - Baseline_{DP}(t))$ + $\sum_{t=216}^{t=225}(P_{measured,DP}(t) - Baseline_{DP}(t))$; PQP)

This formula is noted from a theoretical point of view. In this final report, Elia does not contemplate on the practical design. This theoretical assessment clearly exposes **substantial data challenges** like the data retrieval, the storage, the validation, the processing and the final calculation of the delivered energy. An in-depth feasibility study from a technical and economic point of view is therefore crucial to determine the feasibility and the necessary cost and timing at which a transfer of energy for aFRR can eventually be implemented.

12.9. Imbalance adjustment of the BRP

The balancing perimeter of the BRPsource shall be corrected with the volume of flexibility delivered due to the intervention of a BSP, aggregated to the balancing perimeter and on a quarter-hour basis.

The BRPbsp takes balancing responsibility for activated R2 non-CIPU control power. Therefore the BRPbsp is corrected with the difference between the delivered volume of R2 non-CIPU control power and the requested volume R2 non-CIPU control power on a quarter-hour basis. The delivered energy was extensively discussed under section 12.8.2.

No perimeter correction was performed in the light of the R2 non-CIPU pilot project.

12.10. Conclusion

The Transfer of Energy rules provide the framework that is to be followed in market situations with a transfer of energy. Throughout this document these basic principles were applied on the aFRR market for non-CIPU units from a theoretical point of view. Elia made a first analysis on the processes that are impacted by a transfer of energy. To that extent, we have described, from a theoretical point of view, the possibility to implement a transfer of energy for the aFRR market from non-CIPU units and identified the impacted processes. In a concept note and feasibility study that will be delivered by end of 2018, Elia will provide a clear indication if, and if so when the transfer of energy can be implemented for aFRR.