Explanatory Note on the ELIA LFC Block Operational Agreement

September 14, 2018

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INTRODUCTION

This LFC Block Operational Agreements, hereafter referred to as LFCBOA, applies to the ELIA LFC Block and contains the methodologies listed in Article 119 of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation, hereafter referred to as SOGL.

WHEREAS

A. Subject

The operation of European Load-Frequency Control (LFC) processes is based on geographical areas, where every area has their individual responsibilities with respect to the LFC structure. The superior structure is the synchronous area in which frequency is the same for the whole area. The synchronous area Continental Europe (CE) consists of several LFC blocks, each LFC block consists of one or more LFC areas. An LFC area itself consists of one or more monitoring areas.

Each of these operational areas has its own obligations. A monitoring area has the obligation to calculate and measure the active power interchange in real-time in that area. A LFC area has the additional obligation to fulfil the frequency restoration quality target parameters by using the frequency restoration process. A LFC block is in addition responsible for the dimensioning of frequency restoration reserve (FRR) and replacement reserves (RR). The synchronous area has the obligation to fulfil the frequency quality target parameters by using the frequency containment process.

The structure of the LFC blocks is determined in a common proposal developed by all TSOs of Synchronous Area "Continental Europe", regarding the development of a proposal for the determination of LFC blocks in accordance with Article 141(2) of the SOGL. This document, submitted for consultation on 28/11/2017[1], and subject for approval by all NRAs, defines the ELIA LFC block, previously referred to as a control zone, in which there is only one LFC area and monitoring area, and thus only one TSO, i.e. ELIA.

The LFC Block Operational Agreement is defined in Article 3 of the SOGL, as a "*a multi-party agreement between all TSOs of a LFC block if the LFC block is operated by more than one TSO and means a LFC block operational methodology to be adopted unilaterally by the relevant TSO if the LFC block is operated by only one TSO*". A 'load-frequency control block' or 'LFC block' is defined by the same Article of the SOGL as *"a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC blocks, consisting of one or more LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control."*

The document needs to be compliant with the Synchronous Area Operational Agreement on Load Frequency Control and Reserves (Article 118), hereafter referred to as SAOA, to be drafted by all TSOs (ENTSO-E) by 12 months after entry into force of the SOGL (the SOGL entered into force on 14/9/2017) and to be approved by all NRAs (ACER). It determines amongst others the dimensioning

[1] https://consultations.entsoe.eu/system-operations/lfc-blocks_ce/supporting_documents/171129_LFC%20blocks%20determination%20Proposal%20Final_for%20public%20consultation.pdf

rules for Frequency Containment Reserves or ‘FCR’, and the common operational processes related to controlling the frequency quality in the synchronous area. The ELIA LFC block is part of the synchronous area Continental Europe.

B. Objective

The main objective of the LFCBOA is to determine the dimensioning rules for Frequency Restoration Reserves or ‘FRR’, and specify common operational processes to fulfil the “frequency restoration quality target parameters” by using the frequency restoration process as defined in Article 3 of the SOGL, and specified in Article 143 of the SOGL. The FRCE or ‘frequency restoration control error’ is the control error for the ‘Frequency Restoration Process’ or ‘FRP’ which is equal to the area control error ‘ACE’ of a LFC area or equal to the frequency deviation where the LFC area geographically corresponds to the synchronous area. For the ELIA LFC block, this is therefore equal to the ACE, defined in Article 3 of the SOGL.

The subject matter of the SOGL is to safeguard operational security, frequency quality and the efficient use of the interconnected system and resources as specified in Article 1 of the SOGL, including the rules aiming at the establishment of a Union framework for load-frequency control and reserves. By means of determining the dimensioning rules for FRR and specifying the operational processes to fulfil the load-frequency obligations, the LFCBOA contributes to the objective specified in Article 4 of the SOGL:

a) determining common interconnected system operational planning principles;

b) ensuring the conditions for maintaining operational security throughout the Union;

c) ensuring the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union;

d) promoting the coordination of system operation and operational planning;

e) ensuring and enhancing the transparency and reliability of information on transmission system operation by means of describing the dimensioning rules;

f) contributing to the efficient operation and development of the electricity transmission system and electricity sector in the Union.

Article 119(1) of the SOGL lists the requirements of the LFCBOA. Note that with one TSO in the ELIA LFC block, the cooperation of TSOs within the LFC blocks is not relevant, as is therefore part of the elements to be covered on the LFCBOA. Nevertheless, the definition of dimensioning rules and the operational processes related to ensuring acceptable quality of the ACE of FRCE are relevant and described in this document.

The supporting document has been developed in recognition of the fact that the LFCBOA, which will become a legally binding document after NRAs' approval, inevitably cannot provide the level of explanation, which some parties may desire. Therefore, this document aims to provide interested parties with greater descriptive information and explanation of the methodology text contained in the LFCBOA.

For 2019, the dimensioning of reserve capacity for FRR is conducted in the framework of another document, referred to as “Dossier Volume” determining the volumes of contracted primary, secondary and tertiary reserves, following national legislation, i.e. Article 233 of the Belgian Federal

Grid Code. This document contains the determination of the FRR needs, as well as the FRR means for 2019. In order to ensure compliance with SOGL, the dimensioning rules for the FRR needs are determined in this LFC block operational agreement.

1. General Provisions

1.1. Definitions

For the purposes of this proposal, the terms used have the meaning of the definitions included in Article 3 of the SOGL. When referring to reserves[2], following definitions are particularly relevant :

- 'active power reserve' means the balancing reserves available for maintaining the frequency;
- 'reserve capacity' means the amount of FCR, FRR or RR that needs to be available to the TSO;
- 'frequency restoration reserves' or 'FRR' means the active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value;

1.2. Subject

Article 119(1) of the SOGL provides an exhaustive list of the methodologies and conditions to be developed in the LFC block operational agreement. According to Article 119(1) of the SOGL, the methodologies and conditions according to paragraph a, d e, f, i, j, m, n (Table 1) are not relevant for the ELIA LFC block :

- Elements under a., d., e., f., j. and m. SOGL are not applicable since ELIA is the only TSO in the ELIA LFC Block, or due to the fact that the LFC Block consists in only one LFC area.
- The element under i. is not applicable as RR is currently not applied in the ELIA LFC Block.
- Element under n. is not applicable as reserve exchange for FRR or RR is currently not applied in the ELIA LFC block.

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[2] *Note that when referring to reserve capacity on FRR, ELIA refers to all reserve capacity available to the TSO to cover the needs following the dimensioning rules on FRR defined in the SOGL. However, the commission regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing, hereafter referred to as EBGL, refers to different means to cover these needs for reserve capacity on FRR and ELIA refers to balancing capacity when referring to procured or contracted reserve capacity by means of monthly, weekly, or even daily auctions when relevant. As defined in Article 2 of the EBGL :*

- *'balancing capacity' means a volume of reserve capacity that a balancing service provider has agreed to hold and in respect to which the balancing service provider has agreed to submit bids for a corresponding volume of balancing energy to the TSO for the duration of the contractd*

Note that positive reserve capacity refers to upward capacity to cover production shortages (positive LFC block imbalances), while negative reserve capacity refers to production excesses (negative LFC block imbalances).

Table 1 : Overview of non-relevant methodologies and conditions according to Article 119 of the SOGL

a.	where the LFC block consists of more than one LFC area, FRCE target parameters for each LFC area defined in accordance with Article 128(4);
d.	where the LFC block is operated by more than one TSO, the specific allocation of responsibilities between TSOs within the LFC block in accordance with Article 141(9);
e.	if applicable, appointment of the TSO responsible for the tasks in Article 145(6);
f.	additional requirements for the availability, rELIAbility and redundancy of technical infrastructure defined in accordance with Article 151(3);
i.	the RR dimensioning rules defined in accordance with Article 160(2);
j.	where the LFC block is operated by more than one TSO, the specific allocation of responsibilities defined in accordance with Article 157(3), and, if applicable, the specific allocation of responsibilities defined in accordance Article 160(6);
m.	if applicable, any limits on the exchange of FCR between the LFC areas of the different LFC blocks within the CE synchronous area and the exchange of FRR or RR between the LFC areas of an LFC block of a synchronous area consisting of more than one LFC block defined in accordance with Article 163(2), Article 167 and Article 169(2);
n.	the roles and the responsibilities of the reserve connecting TSO, the reserve receiving TSO and of the affected TSO for the exchange of FRR and/or RR with TSOs of other LFC blocks defined in accordance with Article 165(6);

According to Article 6(3.e) of the SOGL, the methodologies and conditions determined in h., q. and r. shall be submitted to the CREG for approval: the methodologies and conditions in c., q. and r. are specified in paragraph 2, while the methodology in h. is specified in paragraph 3.

Table 2 : Overview of relevant methodologies and conditions according to Article 119 of the SOGL, specified in Article 6(3.e) of the SOGL

c.	ramping restrictions for active power output in accordance with Article 137(3) and (4);
q.	coordination actions aiming to reduce FRCE as defined in Article 152(14);
r.	measures to reduce FRCE by requiring changes in the active power production or consumption of power generating modules and demand units in accordance with Article 152(16);
h.	the FRR dimensioning rules in accordance with Article 157(1);

According to Article 119 of the SOGL the methodologies and conditions in b., g., k., l., o. and p. are specified in Title 4.

Table 3 : Overview of relevant methodologies and conditions according to Article 119, not specified in Article 6(3.e) of the SOGL

b.	LFC block monitor in accordance with Article 134(1);
g.	operational procedures in case of exhausted FRR or RR in accordance with Article 152(8);
k.	the escalation procedure defined in accordance with Article 157(4) and, if applicable, the escalation procedure defined in accordance with Article 160(7)
l.	the FRR availability requirements, the requirements on the control quality defined in accordance with Article 158(2), and if applicable, the RR availability requirements and the requirements on the control quality defined in accordance with Article 161(2);
o.	the roles and the responsibilities of the control capability providing TSO, the control capability receiving TSO and of the affected TSO for the sharing of FRR and RR defined in accordance with Article 166(7);
p.	the roles and the responsibilities of the control capability providing TSO, the control capability receiving TSO and of the affected TSO for the sharing of FRR and RR between synchronous areas in accordance with Article 175(2);

2. Methodologies in accordance with Article 6

2.1. Ramping restrictions for active power output in accordance with Article 137(3) and (4) of the SOGL.

In order to manage the frequency in a synchronous area, there is a need to limit the variation of power injection or withdrawal of the HVDC interconnectors connected towards another synchronous area. Indeed HVDC interconnections are able to deal with nearly infinite ramping rate, which would not be suitable to maintain a constant frequency. Such infinite variations would solicit the FCR on each side, and therefore would weaken the system as less FCR would be available to face a possible outage at the same time. This is not the purpose of FCR and it is preferable to mitigate the impact on the FCR by applying a ramping restriction.

This ramping restriction is also a way to better match the actual physical change in injections or withdrawals by power generating modules or demand, which are also not infinite (even though the commercial trade schedules assume infinite behavior). By this, the impact caused by the variation of power injections or withdrawals on the balance of the LFC block where the HVDC is connected to is limited. While the need for such ramping restriction is present for all synchronous areas, it is especially relevant for smaller synchronous areas such as Great Britain (GB).

Common practice for all interconnectors linking the synchronous area of Continental Europe (CE) and GB is to limit the ramping rate to 100 MW/min. As this may evolve depending on system conditions on both sides, it is proposed to have an approach where the current value is reflected into an agreement for each interconnector. Note that these requirements are common with those set out by National Grid in their LFCBOA for GB.

While the actual value would be defined in agreement, each TSO commits to a non-discriminatory treatment of all interconnectors linking the same two synchronous area. The enforced value will also be published on each TSO’s website.

In order to deal with exceptional situations (such as massive simultaneous flow changes on all interconnectors between GB and CE) in the small GB synchronous area, National Grid requested ELIA to have the exceptional measure to further restrict the ramping rate. This would be done only when the absence of further limitation of the ramping rate would lead National Grid to emergency state or if National Grid is already in emergency. In these conditions, there is an obligation for mutual assistance between TSOs (as described in NC Emergency & Restoration), unless it would lead ELIA itself into emergency. ELIA added similar requirements in the ELIA LFCBOA because the requirements have to be common, but ELIA does not plan to use these additional restrictions. In such cases, a report will be issued in line with Article 14 paragraph 4 of NC Emergency & Restoration.

In the future, it is expected that a more elaborated methodology will be established in order to coordinate the ramping of different cables between two synchronous areas by defining a combined ramping rate restrictions in the SAOA (pursuant to Art. 137(1)). This would be the ideal situation to mitigate the impact on the frequency. We note however that this methodology is not ready yet and the current practice of fixed ramping rate is seen as sufficient at synchronous area level for both CE and GB.

ELIA currently does not implement technological restrictions of power generating modules and demand units to support the fulfilment of the FRCE target parameters of the LFC block and to alleviate deterministic frequency deviations as specified in Article 137(4) of the SOGL. If such measures would be needed at a certain moment in time, the LFC block operational agreement shall be updated after upon completion of the relevant approval process.

2.2. Coordinated actions aiming to reduce the FRCE as defined in Article 152(14)

Article 152(14) of the SOGL requires the LFC block monitor, in this case ELIA (paragraph 3.1), to inform other TSOs of the LFC block when identifying any violation of the FRCE limits identified in Article 152(12 and 13) of the SOGL, and to implement coordinated actions with other TSOs of the LFC block to reduce the FRCE.

Obviously, being the sole TSO in the LFC block, this article is not applicable for the ELIA LFCBOA. ELIA can however apply FRCE measures on an individual basis as specified in paragraph 2.3.

2.3. Measures to reduce the FRCE by requiring changes in the active power production or consumption of power generating modules and demand units in accordance with Article 152(16)

Article 152(16) of the SOGL requires ELIA to specify, in the LFC block operational agreement, measures to reduce the FRCE by means of changes in the active power production or consumption of power generating modules and demand units within their area.

On the one hand, these concern measures which are taken before the measures specified following the emergency states are defined in the Network Guidelines on Emergency and Restoration. The link with procedures defined in the Network Guidelines on Emergency and Restoration is only indirect: only when too high ACE gives rise to frequency deviations do we fall within the activation criteria of Article 18 E&R GL "frequency deviation management procedure" or only if there are overloaded (border) lines, Article 19 "power flow management procedure" may be applied.

On the other hand, these concern measures which are taken after the activation of FRR (aFRR and mFRR) following the processes described in the SOGL for which the reserve process activation structure is defined in Article 140 of the SOGL.

However, in exceptional circumstances, ELIA reserves the right to activate slow start units (units which cannot be activated under the specifications of FRR defined in the SOGL) in combination to activated FRR means are activated following the merit order. This in order to avoid an elevated, or enduring FRCE. This measure is expected to be used under very specific conditions, and ELIA will draft a report for the NRA justifying the decision. ELIA expects that reverting to this measure should only happen in exceptional circumstances (and hence being rare) because adequate imbalance prices should give the Balancing Responsible Parties the right incentives to avoid that their portfolio imbalances are triggering such events.

A typical example is a large storm event whereby it is anticipated that a substantial part of the BRPs will not be able to manage the balance of their portfolio up to a point whereby the available FRR means would be insufficient to ensure secure system operations. As a consequence, preventive actions from ELIA could be required to reduce the imbalance risk to a level manageable by the FRR means for the concerned delivery period.

3. FRR dimensioning methodology in accordance with Article 157 and Article 6

Until 2018, ELIA System Operator (hereafter referred to as ELIA) submitted to the CREG on yearly basis a methodology and the corresponding results for sizing the reserve capacity on aFRR and mFRR. This in compliancy with Article 233 of the Belgian Federal Technical Regulation. The method is historically based on a 'static' dimensioning methodology based on the same methodology presented during the previous years.

ELIA specifies principles of the method, i.e. the FRR dimensioning rules, in its LFCBOA. These rules are compliant with Article 157 of the SOGL. The method for the dimensioning of positive reserve capacity is based on a 'static' dimensioning method conducting a calculation of the required positive reserve capacity on a yearly basis.

As from 2019, ELIA will implement a 'dynamic' dimensioning methodology for sizing the negative reserve capacity in 2019, compliant with SOGL. This method is based on a 'dynamic' dimensioning method conducting a calculation of the required negative reserve capacity on daily basis. The dimensioning rules for negative reserve capacity are elaborated in the LFCBOA in compliance with Article 157 of the SOGL.

In its dimensioning method for positive and negative reserve capacity, ELIA makes a distinction between FRR needs, and the required FRR means (Figure 1):

- **FRR needs** are determined as the required reserve capacity on FRR, as well as the ratio on aFRR and mFRR required covering the expected system imbalances following forecast error risks and forced outage risks, within the ELIA LFC block. The dimensioning rules for the FRR needs are based on the principles described in Article 157 of the SOGL. ELIA (being the sole TSO in its LFC block) is required to have sufficient reserve capacity on FRR at any time in accordance with the dimensioning rules. The dimensioning rules for the FRR needs also determine the maximum sharing capacity which can be accounted in the dimensioning.

- **FRR means** refer to the volumes of the different types of reserve capacity, i.e. aFRR and mFRR, covering the FRR needs following the FRR dimensioning rules. Article 32 of the EBGL defines that the reserve capacity requirements can be ensured by the procurement of balancing capacity, the sharing of reserves and non-contracted balancing energy bids. The procurement of balancing capacity (to be contracted by ELIA) depends therefore on the estimated availability of FRR reserve sharing capabilities and non-contracted FRR balancing energy bids, also referred to as "free bids".

Consequently, when translating FRR needs to the required FRR means, ELIA takes into account the **operational agreements facilitating reserve sharing**. This is accounted in the dimensioning rules compliant with Article 157(2) of the SOGL. Finally, the reserve capacity to be contracted is determined in a **procurement process** compliant with Article 32 (2) and Article 18 of the EBGL.

The method for dimensioning positive (negative) reserve is based on a yearly (daily) calculation of the negative reserve capacity based on a calculation of the FRR needs (section 2) and of the required the FRR means (section 3).

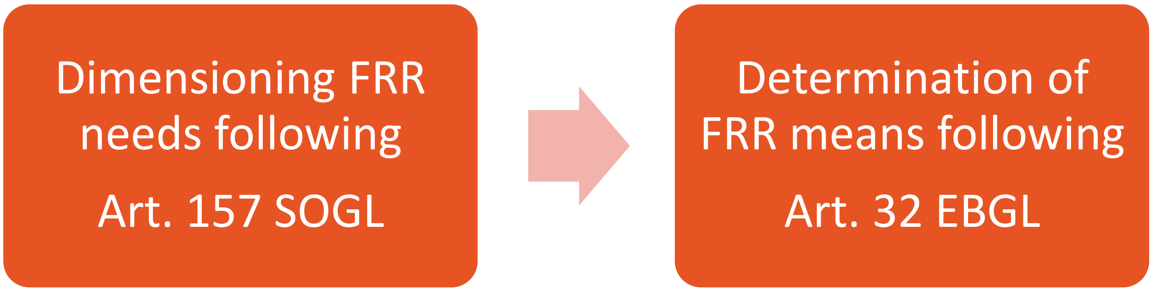

Figure 1 : Distinction between the FRR needs and the FRR means

3.1. Dimensioning rules for positive reserve capacity on FRR

As required by Article 157(2.h) of the SOGL, ELIA determines the positive FRR needs for the next year following the calculation based on a **probabilistic methodology**. This method ensures that the positive reserve capacity on FRR is sufficient to cover the expected positive LFC block imbalances (production shortages) for at least 99.0% of the time. Compliant with Article 157(2.b), ELIA determines the reserve capacity on FRR of the LFC block in a way sufficient to respect the **current FRCE target parameters** in Article 128 of the SOGL. ELIA will monitor and report on the FRCE target parameters, compliant with obligations as LFC Block Monitor (paragraph 4.1), and regularly assess if the methodology and the resulting balancing capacity meets this requirement.

As required by Article 157(2.e) of the SOGL, ELIA ensures that the positive FRR needs are not less than the positive dimensioning incident of the LFC block. The dimensioning incident[3] is defined by Article 3 of the SOGL as the highest expected instantaneously occurring active power imbalance within a LFC block in both positive and negative direction. The result of the probabilistic methodology is for this reason compared with the result of this **deterministic methodology**, also referred to as the N-1, for which the latter determines the minimum FRR needs.

The FRR dimensioning method is explained in detail in three steps:

1. **step 1: determining the probability distribution of the expected system imbalances;**
2. **step 2: determining the probability distribution of the expected forced outages;**
3. **step 3: calculation of the FRR needs.**

[3] Note that Article 157(2.h) of the SOGL requires ELIA to determine the reference incident defined in Article 3 as the maximum positive or negative power deviation occurring instantaneously between generation and demand in a synchronous area, considered in the FCR dimensioning. The TSOs of a LFC block shall determine the size of the reference incident, which shall be the largest imbalance that may result from an instantaneous change of active power of a single power generating module, single demand facility, or single HVDC interconnector or from a tripping of an AC line within the LFC block. In Belgium the positive and negative reference incident are equal to the positive and negative dimensioning incident, respectively.

3.1.1. Step 1: Probability distribution curve of the system imbalances

In the first step, a probability distribution is constructed based on a time series of historic quarter-hourly positive LFC block imbalances. As required by Article 152(2.a), the sampling of the historical time series is determined at 15 minutes, covers an entire year, and never ends earlier as 6 months before the calculation date. In such a 'static' methodology, the time series, and thus the probability distribution curve, is not updated after approval of the methodology. In practice, when the calculation is foreseen to be conducted in the first part of the year, the time period considered corresponds to the calendar year of the year before the calculation date.

In order to select representative data, the time series is filtered to remove periods with forced outages of power plants. This allows to take into account the fact that such events are not representative if assessed over a period of only one year. Note that expected forced outages are taken into account by means of a separate synthetic probability distribution in step 2.

In order to take into account expected system evolutions between the period represented by the historical records and the period for which the FRR needs are determined in the 'static' approach, and respect the FRCE parameters specified in Article 128 of the SOGL. The time series for upward reserve capacity is further processed:

- firstly, a yearly improvement of the system imbalance is taken into account;
- secondly, the prediction errors of onshore and offshore wind power, as well as photovoltaic power is taken into account for the incremental capacity between the year for which the historical data is used, and the year for which the positive reserve capacity is dimensioned;
- thirdly, it is taken into account that part of these prediction errors are resolved by the market following intra-day forecasts, and corresponding market positions.

3.1.2. Step 2: Probability distribution curve of the forced outages

In order to ensure a representative time series of the expected forced outages, a Monte Carlo simulation is conducted representing the forced outages which might occur in the year for which the FRR needs are conducted. This simulation takes into account all forced outages resulting in positive, and negative LFC block imbalances by means of the installed capacity, the outage duration and the outage probability. Note that it is important to include both forced outages that can result in positive (i.e. power plant outages and HVDC-interconnector outages) and negative system imbalances (i.e. HVDC-interconnector outages), as these can compensate when simultaneously occurring.

In the static approach for positive reserve capacity, the probability distribution of the forced outages is calculated only once a year, assuming that all power plants are operational and contribute to the forced outages. A Monte Carlo simulation of 500 years results in a representative time series. In order to allow analyzing the 99.0% percentile in a later step, a power loss probability distribution curve, expected to affect the LFC block imbalances, is calculated based on the outages forced resulting from the simulation.

3.1.3. Step 3: Determination of the FRR needs

The distribution curves are convoluted and the capacity corresponding to the 99.0% percentile is taken to determine the result of the probabilistic sizing method for the positive FRR needs. Note that this is based on probability distributions representing the expected positive LFC block imbalances only.

The result of this probabilistic methodology is compared with the result of the deterministic methodology. The positive dimensioning incident (N-1) typically refers to the outage of a large power plant (e.g. nuclear generation unit). In the static methodology for positive FRR needs, the result of the deterministic method is fixed on a yearly basis, based on the capacity of the largest nuclear generation unit in Belgium[4].

3.2. Dimensioning rules for the negative reserve capacity needs on FRR

The methodology to determine the negative FRR needs is based on the same principles as for the positive reserve capacity needs. The main difference is that the calculation is conducted on a daily basis:

(1) it remains based on a **probabilistic approach**, allowing to determine negative FRR needs cover the expected negative LFC block imbalances (production excesses) for at least 99.0% of the time. It uses the **FRCE target parameters** in Article 128 of the SOGL to assess if the methodology and results cover allow to cover the FRCE criteria.

(2) It compares the result of the probabilistic methodology with the result of this **deterministic methodology**, based on the negative dimensioning incident (N-1), which determines the minimum FRR needs

In this aspect it follows the three steps as defined in paragraph 3.1, as represented in Figure 2.

[4] A study conducted by ELIA in 2017 demonstrated that the possible simultaneous cut-off of offshore wind turbines following the protection measures for wind speeds related to storm should not be considered as N-1, or be treated as forced outage as the instantaneous loss of power plants or a relevant HVDC-interconnectors.

http://www.ELIA.be/en/users-group/Working-Group_Balancing/Projects-and-Publications

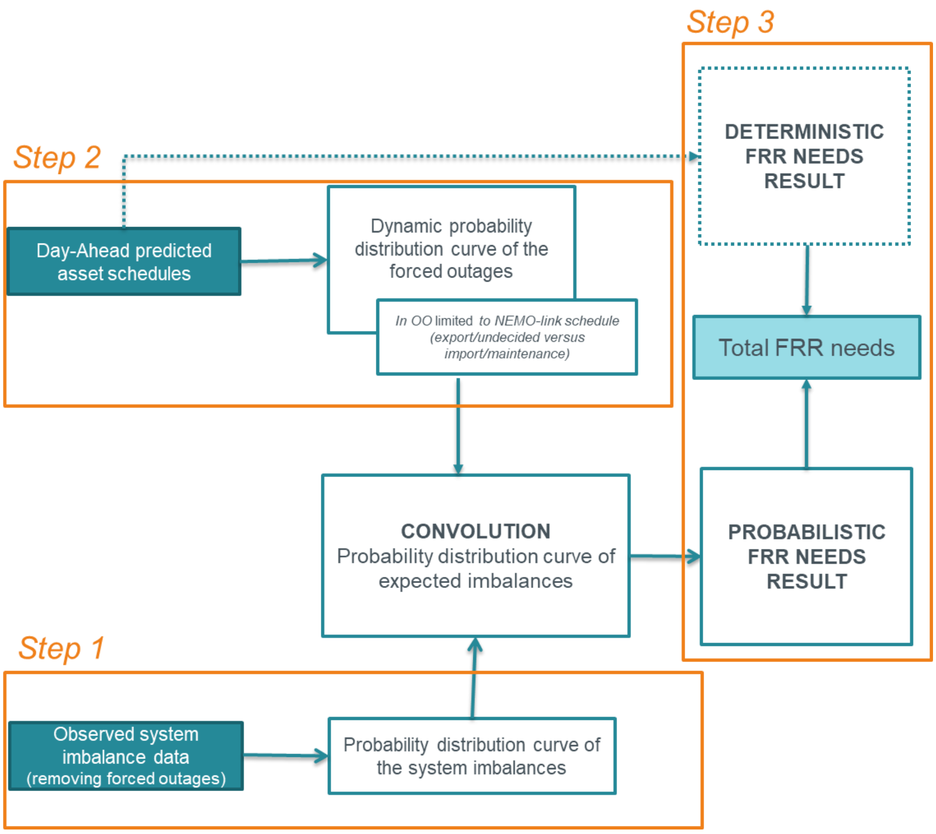

Figure 2 : General overview of dimensioning of the FRR needs

3.2.1. Step 1: Probability distribution curve of the system imbalances

Similar to the static dimensioning method for the positive FRR needs, a probability distribution is constructed based on a time series of at least one year of historic quarter-hourly negative LFC block imbalances. The sampling of the historical time series covers 15 minutes. However, in the dynamic methodology, the time series is now ending not before the last day of the second month before the month for which the reserve capacity is calculated. The calculation for February 1, 2019 uses data until at least 31 December. In contrast to the static methodology for positive FRR needs, the time series, and thus the probability distribution curve, is updated every month, taking into account the latest LFC block imbalances observed.

An important difference with the static dimensioning is that this methodology does not require any extrapolation of the observed system imbalance in order to account for incremental capacity of renewable generation, or potential improvement factors concerning the future LFC block imbalances (following better abilities of BRPs to cope with portfolio imbalances). This is explained as the FRR needs are now determined for the next day, for which latest current system and market assumptions are known and included in the latest historical data of the LFC block imbalances, which are thus representative for the next day for which the FRR needs are dimensioned[5].

Identical to the dimensioning of static upward reserve capacity on FRR, in order to select representative data, the time series is first of all filtered to remove periods with forced outages of power plants. This allows to take into account the fact that such events are not representative if assessed over a period of only one year. The forced outages are again taken into account by means of a separate probability distribution presented in step 2.

3.2.2. Step 2: Probability distribution curve of the forced outages

Similar to the static dimensioning method for positive FRR needs, a Monte Carlo simulation is conducted to build a representative probability distribution of forced outages. The difference with the static method is that this probability distribution is now determined on a daily basis, estimating the forced outage risk of the next day based on the expected schedule of Nemo Link, i.e. the HVDC-interconnector between the ELIA and NGET LFC block. This allows to capture the expected impact of the outage of the interconnector on the LFC block imbalance which depends on the direction of the schedule during the outage (import, export, no flow).

Similar to the positive FRR needs, the simulation takes into account all forced outages resulting in positive, as well as negative LFC block imbalances by means of the installed capacity, the outage duration and the outage probability. Note that it is again important to include both forced outages that can result in positive LFC block imbalances (i.e. power plant outages and relevant interconnector outages) and negative LFC block imbalances (i.e. relevant interconnector outages). In Belgium, the only asset driving the forced outages in negative direction is the HVDC-interconnector between Belgium and the United Kingdom. While the power plant outage risks are all assumed to be fixed in the Monte Carlo analysis, the HVDC-interconnector outage risk varies over time, depending on the schedules export or import position. This position determines four possible results of the Monte Carlo simulation :

- **The interconnector is expected to be scheduled in import or in maintenance**: in this case, the interconnector does not affect the forced outage risk resulting in a positive system imbalance, and the interconnector is removed as a whole from the Monte Carlo analysis (in case of a maintenance), or only from the export-side (in case of a predicted schedule in import).

- **The interconnector is expected to be scheduled in export or indecisive**: in this case the interconnector does affect the forced outage risk resulting in a positive system imbalance, and the interconnector is included as a whole in the Monte Carlo analysis (in case of the predicted schedule is indecisive), or only the import-side (in case of predicted schedule is in export).

Based on the predicted schedule of Nemo Link for the next day, the Monte Carlo simulation determines the probability distribution curve. The challenge lies in predicting the status of the HVDC-

[5] A study conducted by ELIA in 2017 demonstrated that the dynamic dimensioning methodology can be further improved by applying machine learning algorithms to predict the expected LFC imbalance risks and determine the corresponding FRR needs for the next day. This approach is currently being implemented and tested by ELIA.

http://www.ELIA.be/en/users-group/Working-Group_Balancing/Projects-and-Publications interconnector before the market outcome is known. A specific tool based on day-ahead price forecasts for Belgium and the United Kingdom allows to predict the interconnector in import (price BE << price UK), export (price BE >> price UK) and indecisive (low price difference between BE and UK). A maintenance status is communicated to ELIA by the HVDC-interconnector operator in order to be taken into account in the day-ahead calculations.

3.2.3. Step 3: Calculation of the FRR needs with the probabilistic methodology

Similar as in paragraph 3.1, the distribution curves defined in paragraph 3.2.1 and 3.2.2 are convoluted to represent the distribution curve of the negative LFC block imbalances. This is now conducted on daily basis, for each period of four hours of the next day. The required reserve capacity on FRR is thereafter determined to cover 99% of these imbalances, which corresponds to the 99.0% percentile of the probability distribution.

This result is thereafter compared with the dimensioning incident which is related to the predicted schedule of the HVDC-interconnector between Belgium and Great-Britain. The negative dimensioning incident in Belgium refers to the outage of an interconnector (e.g. HVDC-interconnector), at least when not scheduled in import. When the predicted schedule shows a status in export or no accurate forecast could be made, there is no dimensioning incident and the result of the deterministic approach is set at 0 MW. In order to predict the schedule of the interconnector, the same forecast tool as in step 2 is used.

The total negative FRR needs are determined as the maximum of the result of the probabilistic and deterministic method. The method for negative FRR needs is described as semi-dynamic as the FRR needs are only adapted to the forced outage risk. It is noted that the probability distribution curve of the system imbalances does change each month (following an update of the data), while the probability distribution curve of the forced outages change every day following the status of the HVDC-interconnector. As explained in footnote 2, this dimensioning method is foreseen to further evolve towards a full dynamic method estimating the FRR needs for the next day based on machine learning algorithms, as presented in ELIA's study on dynamic dimensioning.

3.3. Determination of the ratio of automatic FRR and manual mFRR

ELIA determines the ratio of automatic FRR (hereafter referred to as aFRR), manual FRR (hereafter referred to as mFRR), time for full activation of automatic FRR and the time for full activation of manual FRR to one that respects the FRCE target parameters in accordance with Article 157(2b). For this purpose, the time for full activation of automatic FRR of an LFC block and the time for full activation of manual FRR of the LFC block shall not exceed the frequency recovery time. Compliant with these specifications, the time for full activation is set in the Terms and Conditions of the BSPs at maximal 7.5 minutes and 15 minutes, respectively for aFRR and mFRR balancing capacity.

The terms and conditions of the BSPs for mFRR specify that the mFRR control power made available must be activated in less than 15 minutes while the terms and conditions of the BSPs for aFRR control power specify that a supplier must be able to activate the Upward and Downward aFRR[6] Control Power Made Available to ELIA, within a maximum delay of 7.5 minutes.

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[6] The Terms and Conditions BSP will refer to secondary control and tertiary control to refer to aFRR and mFRR, respectively.

ELIA uses a probabilistic method based on the method presented in paragraph 3.1 to determine the aFRR requirements, establishing a time series of one year of expected variations between quarter-hours of system imbalances. This is based on the same time series of expected system imbalance for calculating positive FRR needs (without convolution with forced outages). The aFRR capacity is currently determined by the capacity that can cover 79% of the absolute variations of imbalances.

The mFRR is thereafter determined as the difference between the total FRR, and the aFRR.

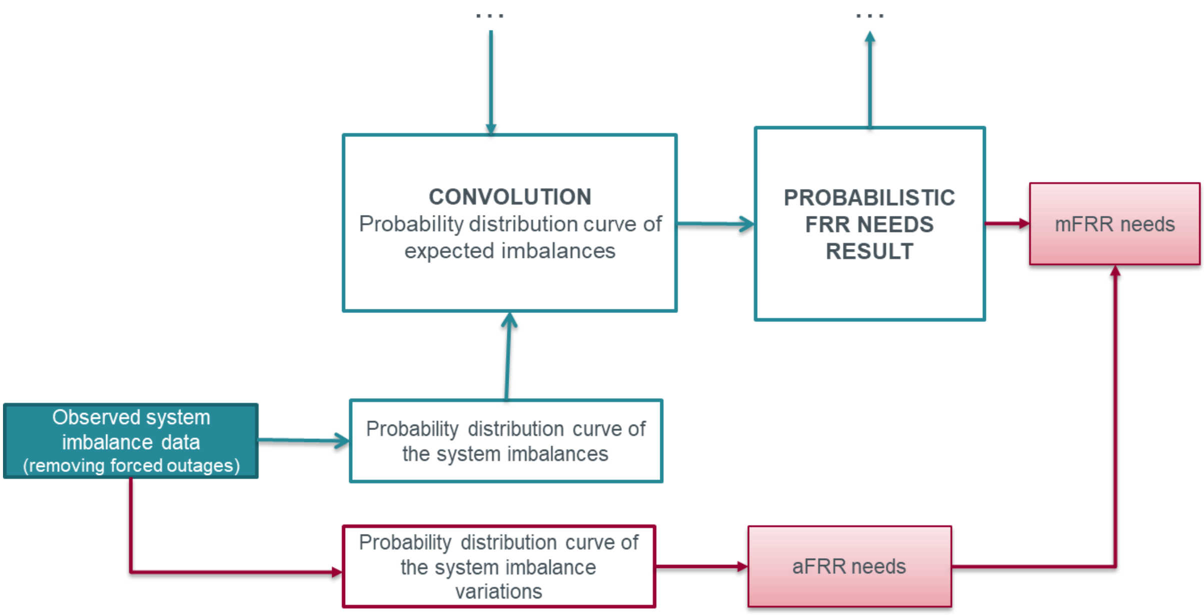

Figure 3 : General overview of dimensioning of the aFRR and mFRR needs

3.4. Determination of maximal reduction of reserve capacity on FRR following sharing of FRR

Article 169 of the SOGL specifies that each TSO of a LFC block has the right to share FRR with other LFC blocks of its synchronous area within the limits set by the FRR dimensioning rules in Article 157 and in accordance with Article 166. It needs to be stressed that such agreements are concluded on a voluntary basis and that there is no obligation on behalf of the TSOs of neighboring LFC blocks to enter into such agreements.

Article 152(2.j and 2.k) of the SOGL allows ELIA to reduce respectively the positive and negative reserve capacity by concluding operational agreements with the TSOs of neighboring LFC blocks, and provided that the latter accept, that allow for the sharing of reserves in accordance with the provisions of Title 8 of the SOGL.

Figure 4 illustrates that the capacity that can be accounted for in the dimensioning is limited by the dimensioning rules in these articles. First of all, article 152(2.k) specifies that for the synchronous area CE, the reduction of the positive and negative reserve capacity on FRR of a LFC block is limited to the difference, if positive, between the size of the dimensioning incident (N-1) and the reserve capacity on FRR required to cover the positive LFC block imbalances during 99 % of the time. Additionally, regarding the sharing of positive reserve capacity, the reduction in reserve capacity may never exceed 30% of the positive dimensioning incident. This limit is not applicable for sharing of negative FRR.

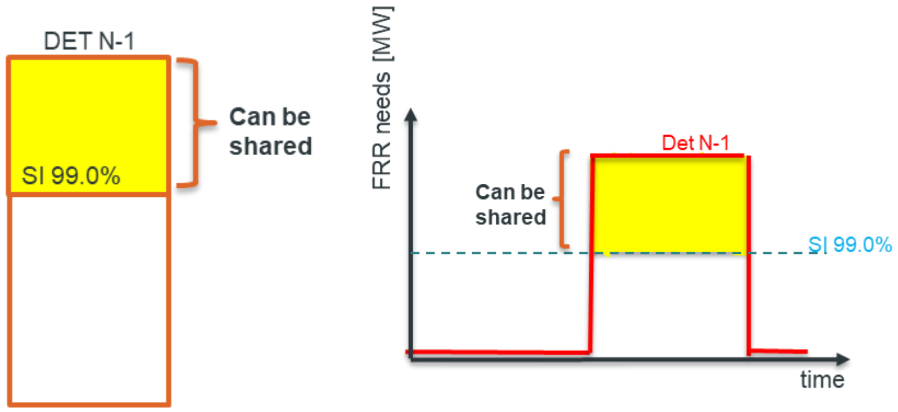

Figure 4 : Visual representation of the maximal sharing potential following SOGL (surface between N-1 and historic LFC-block imbalances for static dimensioning positive FRR needs (left) and dynamic dimensioning negative FRR needs (right)

Note however that in a dynamic dimensioning methodology, which is the case for negative reserve capacity on FRR, the sharing capacity which can be considered will consequently also be determined on a dynamic basis, varying following the 4-hour resolution of the FRR needs. This capacity can vary following the variations in predicted schedule of the HVDC-interconnector, which may results in a variation of the N-1.

As required by Title 8 of the guidelines on system operation, the operational agreements implementing a reserve sharing mechanism shall specify the amount of reserve capacity on FRR eligible for sharing. Moreover the sharing capacity on FRR is also subject to the available cross-border capacity. As a result the overall quantity of reserve sharing that may be taken into account to cover the FRR means is cumulatively limited by following elements:

- **The sharing capacity defined in the operational agreements implementing a reserve sharing mechanism:** only the contracted sharing capacity with neighboring TSOs can be considered for covering the required reserve capacity.

- **Operational security limits:** the shared FRR can be unavailable following restrictions related to operational security as reserve sharing may not lead to power flows that violate operational security limits. ELIA will therefore assess the shared reserve capacity on FRR which can be accounted in the dimensioning.
- **Availability of the shared reserve capacity on FRR:** the shared FRR capacity can be unavailable following the use of the shared capacity by the control capability providing TSO. ELIA will therefore asses the historic availability of the service and can limit the capacity that can be accounted in the dimensioning.

In order to cope with possible uncertainties concerning the above-mentioned elements (it is for instance not possible to run security analysis for a whole year), ELIA can limit the maximum sharing capacity which can be accounted in the dimensioning following SOGL, and hence can propose in its determination of the FRR means following Article 32 (paragraph 3.5) to change the reserve capacity accounted in the dimensioning following modifications in the sharing agreements, or upon modifications concerning available margins on cross-border capacity.

3.5. Determination of balancing capacity to be procured

In compliance with Article 32(1) of the EBGL, ELIA will at least once a year review and define the reserve capacity requirements on FRR for the LFC block or scheduling areas of the LFC block pursuant to dimensioning rules as referred in Articles 127 and 157 of the SOGL. ELIA will therefore conduct an analysis on optimal provision of reserve capacity. This analysis shall take into account the following options for the provision of reserve capacity:

(a) procurement of balancing capacity within control area and exchange of balancing capacity with neighboring TSOs, when applicable;

(b) sharing of reserves, when applicable;

(c) the volume of non-contracted balancing energy bids which are expected to be available both within their control area and within the European platforms taking into account the available cross-zonal capacity.

Under this article, ELIA will determine the balancing capacity for the aFRR equal to the aFRR needs. The aFRR capacity is symmetric meaning that the downward capacity is equal to the upward capacity. In contrast, the balancing capacity for mFRR will result of an analysis of the possible reduction of positive and negative reserve capacity on FRR following the sharing of FRR and the restrictions provided in the SOGL (paragraph 3.4).

After analyzing the historical availability of the volumes of non-contracted balancing energy bid, ELIA may, under certain conditions, account these volumes in the determination of the balancing capacity. However, a precondition is that historical availability is demonstrated to be sufficiently high and can be considered as guaranteed. This is expected to be difficult in a static procurement for positive balancing capacity where the capacity has to be available all year through, particularly for upward mFRR. The sharing capacity and the capacity following non-contracted balancing energy bids for positive reserve capacity is fixed on yearly basis, while these are periodically assessed for the negative reserve capacity. ELIA determines the positive (upward) and negative (downward) balancing capacity to be procured on mFRR as :

- **mFRR+ = FRR+ - aFRR – reserve sharing+ – non-contracted volumes+**
- **mFRR- = FRR- - aFRR – reserve sharing- – non-contracted volumes-**

The procurement of negative reserve capacity on mFRR is also subject to a regular analysis of expected needs and expected volumes of non-contracted balancing energy bids. At the moment of writing, the mFRR needs are adequately covered by sharing of FRR and non-contracted energy bids. However, when analysis demonstrates that non-contracted FRR means are not expected to cover the expected FRR needs, the procurement of contracted negative reserve capacity on mFRR will considered by means of a daily procurement pursuant to Article 18 of EBGL.

4. Methodologies in accordance with Article 119 of the SOGL, but not referred to in Article 6(3.e) of the SOGL

4.1. LFC Block monitor in accordance with Article 134(1)

ELIA will obviously, as sole TSO in the ELIA LFC Block, be the LFC block monitor. It will collect the frequency quality evaluation data for the LFC block in accordance with the criteria application process referred to in Article 129 of the SOGL. This includes the collection of frequency quality evaluation data and the calculation of frequency quality evaluation criteria.

ELIA will provide ENTSO—E, as well as the relevant NRA, with a trimestral report on FRCE quality, within two months after the end of the trimester.

4.2. Operational procedures in case of exhausted FRR in accordance with Article 152(8)

Article 152(8) allows ELIA to specify operational procedures for cases of exhausted FRR in the LFC block operational agreement. The objective of this process is to reconstitute reserves upon extra-ordinary events which are not covered in the dimensioning method. In those operational procedures the TSOs of a LFC block shall have the right to require changes in the active power production or consumption of power generating modules and demand.

In paragraph 2.3, it is explained how that in particular circumstances, in order to avoid large FRCE deviations, ELIA proposes to activate slow start units (units which cannot be activated under the specifications of FRR defined in the SOGL) after all FRR means are activated following the merit order.

ELIA proposes the possibility to use the same mechanism, slow start units, when ELIA assesses the risk that FRR capacity will be depleted upon an extra-ordinary event not accounted in dimensioning, by means of referring to paragraph 2.3. In order to ensure the availability of the capacity in time, ELIA can use this measure preventively, i.e. activate the slow stat units before the FRR capacity entirely depleted.

Similar to the FRCE measures specified in paragraph 2.3, this procedure is expected to be used as last measure, under very specific conditions, and ELIA will draft a report for the NRA justifying the decision. ELIA expects that this measure will be very exceptionally used, because adequate imbalance prices will give the Balancing Responsible Parties the right incentives to avoid that their portfolio imbalances are triggering such events.

4.3. Escalation Procedures in accordance with Article 157(4) of the SOGL

Article 157(4) of the SOGL requires ELIA to have sufficient reserve capacity on FRR at any time in accordance with the FRR dimensioning rules. The TSOs of a LFC block shall specify in the LFC block operational agreement an escalation procedure for cases of severe risk of insufficient reserve capacity on FRR in the LFC block. The objective is to access additional reserve capacity when not meeting the required reserve capacity on FRR following the FRR dimensioning rules.

Two possible causes that may instigate the activation of the escalation procedure are a forced outage of FRR not resolved by the corresponding BRP or the unavailability following congestion reasons. However, the secondary market already allows attaining high availability of FRR products, in combination with penalties for non-availability of the service, and thereby serves as a back-up to transfer FRR obligations in case of a forced outage. In addition, availability of free bids may still result in adequate FRR capacity (sufficient to cover the required reserve capacity on FRR, even if this is not contracted).

If nonetheless a risk of structural and large volumes insufficient reserves still occurs, ELIA might use the existing mechanisms to liberate energy qualified for balancing, i.e. re-dispatch under existing CIPU procedures or ICAROS in future. ELIA has a broader view on available production units, and can therefore (if known sufficiently in advance), re-dispatch between the units capable of FRR delivery and units that are not capable of FRR delivery (slower flexibility) during the concerned period.

This procedure is expected to be used as last measure, under very specific conditions, and ELIA will draft a report for the NRA justifying the decision. Following above-mentioned reasons, ELIA expects that this measure will only be very exceptionally used.

4.4. FRR availability requirements and on the control quality, defined in accordance with Article 158(2) of the SOGL

Article 158(2) of the SOGL specifies that ELIA shall specify FRR availability requirements and requirements on the control quality of FRR providing units and FRR providing groups for their LFC block in the LFC block operational agreement pursuant to Article 119. As single TSO in the ELIA LFC block, ELIA currently specifies the FRR availability requirements and requirements on the control quality of FRR providing units and FRR providing groups in the Terms and Conditions of BSPs.

The availability requirement specified in the Terms and Conditions of BSPs require full availability, i.e. at 100% of the time. This is facilitated by ELIA by means of a secondary market allowing to transfer FRR obligations in case of unavailability, as well as tests and corresponding penalties to ensure availability of the service.

As specified in paragraph 3.3, the control quality is defined at 7.5 minutes full activation time and 15 minutes full activation time for aFRR, respectively mFRR. FRR providing units and FRR providing groups shall demonstrate their compliance with control quality criteria by means of prequalification process as described Terms and Conditions BSP compliant with SOGL Article 158.

4.5. Roles and responsibilities for sharing of FRR in accordance with article 166(7) and article 175(2) of the SOGL

Article 166(7) and 175(2) of the SOGL specifies that ELIA shall specify in the LFC block operational agreement the roles and responsibilities of the control capability providing TSO, the control capability receiving TSO and the affected TSO for the sharing of FRR with TSOs of other LFC blocks.

This as well for potential sharing arrangements with LFC blocks within the same synchronous zone (in this case France, The Netherlands and in the future possibly Germany), and with LFC blocks of other synchronous zones (in this case Great Britain). At this moment, new interconnections with Great Britain and Germany are foreseen, which opens the possibility to have a sharing arrangements if the corresponding TSO agrees to develop these.

TSOs that are sharing reserves should specify among other things the **roles and responsibilities** of the **control capability** providing TSO, the control capability receiving TSO and the affected TSO for the sharing of FRR in the following documents:

- a bilateral operational agreement;
- the Synchronous Area Operations Agreement (all TSOs art 118(1.v), 118(1.w), 171(2) for sharing of FRR between synchronous areas);
- the LFC block agreement (only for each TSO involved in reserve sharing art 119(1.o) and 119(1.p) for sharing of FRR between synchronous areas)

The operational agreements dealing with reserve sharing arrangements are voluntary, bilateral contracts with neighbor TSOs. The involved TSOs should therefore avoid creating unilaterally legislations (e.g. in the LFC block agreement) that could affect the content of the existing contracts.

This could indeed put constraints on the existing agreements that would make them non valid. ELIA should therefore make sure that the information in its LFC block agreement is not restrictive and remains general. In its cooperation with other TSOs, ELIA should ensure that our neighboring TSOs follow this logic as well in their legislation.

From a technical perspective and due to the different nature of the borders (AC or DC), the roles and responsibilities cannot be exactly the same if we go to a lower level of details. Consistency with Synchronous Area Operational Agreement (SAOA) should also be ensured.

ELIA therefore proposes to maintain a light definition of roles and responsibilities in the LFC block Agreement in order to account for the differences in each bilateral contract. Therefore, ELIA refers to the definition given in the SOGL, and does not provide stricter interpretations in this LFC block operational agreement.

5. Final Provisions

Article 6(6) requires ELIA to define a proposed timescale for implementation. All methodologies will enter into force 3 months after approval by the National Regulatory Authority, CREG (not earlier than 1 January 2019) in line with SOGL article 119 (2).

At the entry into force, the dimensioning methodology for reserve capacity for FRR, and the corresponding balancing capacity to be procured for 2019 will already be approved and into force in compliance with the Article 233 of the Federal Grid Code. The dimensioning rules for 2019 are however already compliant with the SOGL and the dimensioning rules specified in this document. ELIA therefore does not expect to update the methodology or balancing capacity following the entry into force of this LFC block operational agreement.

The LFC BOA is published in English, Dutch and French. In case of discussion on interpretation of the methodologies presented in the LFCBOA, the French and Dutch version prevail over the English version