Request for amendment on Elia's LFC block operational agreement

October 4, 2019

THE BELGIAN TRANSMISSION SYSTEM OPERATOR, TAKING INTO ACCOUNT THE FOLLOWING,

Whereas

1. Pursuant to Article 6(3)e and Article 119(1) of Commission Regulation (EU) 2017/1485 Article 119 of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL), Elia submitted a proposal regarding the Elia LFC block operational agreement (LFCBOA) to the relevant regulatory authority, the Commission for the Regulation of Electricity and Gas (hereinafter "CREG") for approval. The CREG approved the proposal on 27 May 2019.
2. In accordance with Article 7(4) of the SOGL, Elia may, in its capacity as responsible for drawing up a proposal for conditions or methodologies, request that this LFCBOA be amended.
3. This document is a request for amendment developed by Elia System Operator (hereafter referred to as “Elia”) regarding the methodologies and conditions included in the LFCBOA for the Elia LFC block.
4. Elia will consult the stakeholders on the draft proposal in accordance with Article 11 of the SOGL. This consultation has taken place from October 4, 2019 until November 4, 2019.
5. The LFCBOA is compliant with the common proposals provided for under the Synchronous Area Operational Agreement developed by all TSOs of each synchronous area according to Article 118 of the SOGL, hereafter referred to as SAOA.

SUBMITS THE FOLLOWING MODIFICATIONS FOR APPROVAL TO THE CREG:

Article 1. Timing for implementation

Article 15 of the LFCBOA which is currently into application is moved towards TITLE 1 "General Provisions" in a separate Article 2 and replaced by:

"The LFCBOA will enter into force after its approval by the National Regulatory Authority, CREG, at the same day as the Terms and Conditions for balancing service providers for manual Frequency Restoration Reserve (mFRR). Until that date, the methodologies and results of the previous version remain valid."

This modification will also result in a modification of the article numbering throughout the document.

Article 2. Dimensioning Rules for reserve capacity on FRR

Article 7 and 8 of the LFCBOA which is currently into application are replaced by a new Article 8:

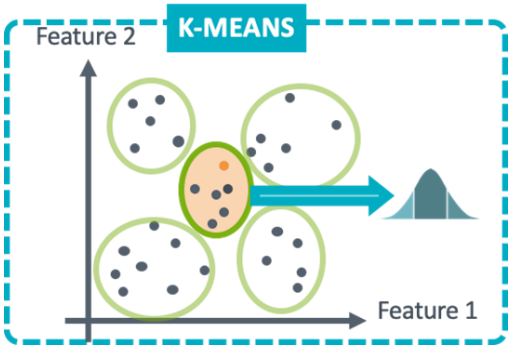
"Article 8 - Dimensioning rules for reserve capacity on FRR

1. *Elia dimensions the required reserve capacity on FRR on a daily basis in accordance with the minimum criteria set out in Article 157(2) SOGL on the basis of:*
    a) *a dynamic **probabilistic methodology** further specified in paragraphs 2 to 7 and in line with Article 157(2)b of the SOGL;*
    b) *a dynamic **deterministic methodology** based on the dimensioning incident further specified in paragraph 8 and in line with Article 157(2)e and 157(2)f of the SOGL;*
    c) *a **minimum threshold** based on the historic LFC block imbalances further specified in paragraph 9 and in line with Articles 157(2)h and 157(2)i of the SOGL.*
2. *The probabilistic methodology is based on a convolution of two distribution curves, one representing the **prediction risk** (paragraph 3) and another representing the **forced outage risk** (paragraph 5). This methodology has been designed to cover 99.0% of the LFC block imbalance risk. After the convolution, the new distribution is decomposed in a distribution of potential positive LFC block imbalances, and a distribution of potential negative LFC block imbalances. This calculation is conducted for each-quarter hour of the next day, and the 99.0% percentile of each probability distribution curve determines the minimum positive and negative required reserve capacity.*
3. *The probability distribution representing the **prediction risk (PE)** is based on historic LFC block imbalances. The LFC block imbalances are based on consecutive historical records with a resolution of 15 minutes and includes a period of two years, ending not before the last day of the second month before the month of the day for which the reserve capacity is calculated. The time series is filtered to remove periods with a forced outage of NEMO Link or generating units with a loss of power larger than 50 MW (until the end of the forced outage but limited to 8 hours after the start of the forced outage), periods with exceptional events (e.g. market decoupling) and periods with data quality problems (e.g. missing data).*

4. *The prediction risk is modelled for each quarter-hour of the next day based on the probability distribution of the LFC block imbalances specified in paragraph 3. Four methodologies to determine this selection of LFC block imbalances are implemented:*

   a) ***STATIC PE*** *in which the probability distribution of the LFC block imbalances is determined once per month (the month before the month of the day for which the reserve capacity is calculated) based on all historical records specified in paragraph 3. The distribution remains constant and valid for the next month.*

   b) ***KMEANS PE*** *in which the historical records specified in paragraph 3 are categorized in a set of clusters. These clusters are determined the month before the month of the day for which the reserve capacity is calculated based on a predefined list of features (i.e. categories of observations that exhibit close system conditions: onshore, offshore, photovoltaic, total load predictions, time of day, predicted solar and load gradients and temperature). To determine the set of clusters, a "k-means clustering" machine learning algorithm is used*[1]*. The k-means algorithm allocates a set of all observation in the historical records specified in paragraph 3 into disjoint clusters, each described by the mean μ_j of the observations in the cluster, such that the within-clusters sum-of-squares is minimized in the space of features. This is illustrated in the following figure for a simplified case with 5 clusters and 2 features. The implementation considers 15 clusters and 8 features.*



$$\sum_{i=0}^{n} \min_{\mu_j \in C} (||x_i - \mu_j||^2)$$

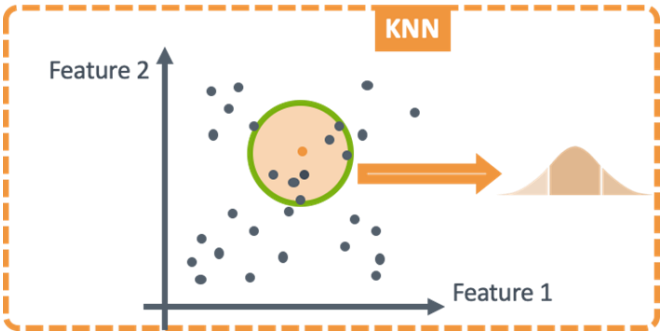
   In each cluster, the probabilistic distribution of LFC block imbalances of the periods associated with each cluster is calculated. During the day-ahead calculation of the FRR reserve capacity needs, it is determined for each quarter-hour to which cluster the corresponding day-ahead prediction of features is associated. This determines the relevant LFC block imbalance distribution representing the prediction risk.

   c) ***KNN PE*** *in which in which the historical records specified in paragraph 3 are categorized based on an unsupervised nearest neighbour algorithm*[2]*. The*

[1]Specified in the Scikit-learn library for Python programming. https://scikit-learn.org/stable/modules/generated/sklearn.cluster.KMeans.html where parameters are determined as: sklearn.cluster.KMeans(n_clusters=15, random_state=0). All other parameters are set at their default value.

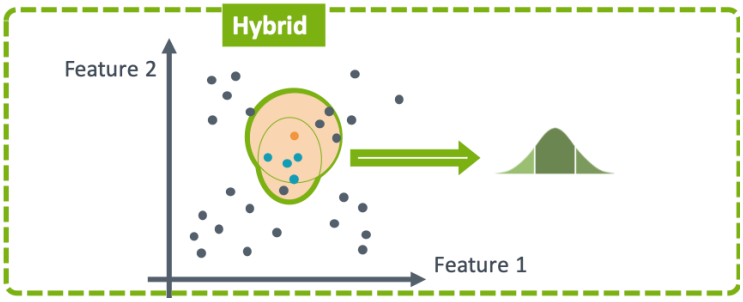
[2]Specified in the Scikit-learn library for Python programming https://scikit-learn.org/stable/modules/generated/sklearn.neighbors.NearestNeighbors.html#sklearn.neighbors.NearestNeighbors where parameters are determined as: sklearn.neighbors.NearestNeighbors (n_neighbours=3500). All other parameters are set at their default value.

principle behind nearest neighbor methods is to find a predefined number of training samples closest in distance to the new point, and predict the label from these. The number of samples in in this case a user-defined constant (k-nearest neighbor learning, i.e. 3500). This distance is calculated based on the same predefined list of features as with KMEANS PE This method is illustrated on the following figure with 7 neighbors and 2 features, the orange dot being one of the periods being sized.



During the day-ahead calculation of the FRR reserve capacity needs, the relevant LFC block imbalance distribution representing the prediction risk is calculated based on the relevant 3500 nearest neighbours.

d) ***HYBRID PE*** *method combines KMEANS PE and KNN PE method where observations belonging to the relevant cluster of the KMEANS PE calculation and to the relevant neighbourhood of the KNN PE calculations are used to determine the probability distribution, as illustrated on the figure below. Some observations (blue dots) are selected by both KNN and KMEANS methods, whereas other observations are selected by only one of the two methods (black dots in orange areas).*



To avoid giving more weight to features with large order of magnitude, the distance between two observations in KMEANS PE and KNN PE is computed as the Euclidean distance between the corresponding vector of features: $d(obs_1, obs_2)^2 = \sum_{j=1,\dots,\#features}(f_{1,j} - f_{2,j})^2$*.. Therefore, each feature is scaled by means of a normal scaler and defined as* $f_{i,j,scaled} = \frac{f_{i,j} - mean(f_{all,j})}{std(f_{all,j})}$ *where* $f_{i,j}$ *is the value of unscaled feature j for the i-th observation, and* $f_{all,j}$ *is the set of all observations of feature j.*

*All probability distributions of the LFC block imbalances used in this paragraph have been modelled with a **Kernel Density Estimator**[3] with imbalance steps of 5 MW (from -2500 MW to 2500 MW)*[4]*.*

5. *To calculate the probability distribution representing the **forced outages risk (FO),** a distribution curve is calculated representing the probability to face a shortage or surplus capacity following forced outages (including HVDC-interconnectors with Great Britain). This is based on two approaches:*

   ***a) STATIC FO** in which the probability distribution curve is determined analytically once a month taking into account the rated capacity of each generation unit larger than 50 MW and the rated capacity of the interconnectors with Great-Britain, the duration with which a forced outage is assumed to impact the LFC block imbalance is assumed to be 8 hours and the probability (expressed below as outages per year) per technology type of facing a forced outage:*

Technology type	Forced outages per year
Nuclear	1.6
Classical	6.1
CCGT	5.2
GT	2.8
TJ	2.2
Waste	1.3
CHP	3.5
Pumped storage	1.9
NEMO-link (per side)	2.0

   ***b) DYNAMIC FO** where the probability distribution curve is determine daily for each quarter-hour of the next day taking into account :*

   - *the available capacity of each generation unit taking into account latest information concerning the rated capacity and unavailability of (part of) the installed capacity due to unavailability known at the moment of prediction ;*
   - *the predicted schedule of the HVDC-interconnector for the next day based on a prediction of the day-ahead price difference between Great Britain and Belgium. This is derived from the algorithm specified in paragraph 6. Also limitations on maximum capacity, known at the time of the prediction, are taken into account;*
   - *the probability of outage and duration of impact of a forced outage on the LFC block imbalance is the same as in the STATIC FO.*

6. *The day-ahead price difference between Belgium and Great Britain is determined for each-quarter-hour of the next day based on a machine learning method taking into account total demand, wind and photovoltaic forecasts. For each quarter-hour the next day:*

[3] Specified in the Scikit-learn library for Python programming https://scikit-learn.org/stable/modules/generated/sklearn.neighbors.KernelDensity.html#sklearn.neighbors.KernelDensity where parameters are determined as klearn.neighbors.KernelDensity(bandwidth=rule of thumb, kernel='cosinus')

[4] Specified in the Scikit-learn library for Python programming https://scikit-learn.org/stable/modules/generated/sklearn.neighbors.KernelDensity.html#sklearn.neighbors.KernelDensity where parameters are determined as KernelDensity(bandwidth="rule of thumb", kernel='cosinus'). All other "Rule of thumb" is specified in https://en.wikipedia.org/wiki/Kernel_density_estimation#A_rule-of-thumb_bandwidth_estimator

- *Price_BE – Price_GB > 7, the interconnector is considered in import ;*
- *Price_BE – Price_GB < -7 , the interconnector is considered in export ;*
- *-7 € <Price_BE – Price_GB < 7, the interconnector is considered as uncertain and both import and export direction are covered,*

7. *Elia will determine the reserve capacity needs for every quarter-hour based on the convolution of the HYBRID PE and DYNAMIC FO method. If a technical problem occurs with the calculation of the prediction risk, Elia will fall back first to a KNN PE and thereafter to a STATIC PE. Similar, if due to technical reasons, the DYNAMIC FO is not available, the STATIC FO is taken. The STATIC FO combined with the STATIC PE prediction risk will be the monthly fall-back value.*
8. *For each-quarter hour of the next day Elia determines the required positive and negative reserve capacity on FRR in order that it is never less than the positive and negative **dimensioning incident** of the LFC block, as specified in Article 3 and Article 157(2)d of the SOGL. The potential cut-out of the offshore wind power park following a storm are not considered as dimensioning incident. The dimensioning incident is determined for each quarter-hour of the next day:*
    a. *for the positive dimensioning incident based on the highest value of available power of a generating unit (taking into account unavailability and maximum capacity modifications known at the time of the day-ahead dimensioning) or the predicted schedule of the HVDC-interconnector with Great-Britain (taking into account unavailability and capacity reductions known at the time of the day-ahead dimensioning), determined in paragraph 6;*
    b. *for the negative dimensioning incident based on the predicted schedule of the HVDC-interconnector with Great-Britain taking into account unavailability and capacity reductions known at the time of the day-ahead dimensioning), determined in paragraph 6.*
9. *For each-quarter hour of the next day, ELIA determines the required positive and negative reserve capacity on FRR in order that it is sufficient to cover at least the positive and negative **historic LFC block imbalances** for 99.0% of the time in line with Articles 157(2)h and 157(2)i of the SOGL. These thresholds are determined based on the consecutive historical records specified in paragraph 3 and before removal of any periods as discussed in paragraph 3.*
10. *Pursuant to Article 157(2)b of the SOGL, Elia ensures to respect the current **FRCE criteria** in Article 128 of the SOGL. This analysis is conducted ex post based on the reporting on FRCE quality specified in Article 11.*
11. *The required positive and negative reserve capacity on FRR is calculated each day before 7 AM for every period of 4 hours of the next day by means of the maximum value of the positive and negative reserve capacity on FRR over all quarter-hours of the corresponding period.*
12. *Pursuant Article 157(4) of the SOGL, TSOs of a LFC block shall have sufficient positive and negative reserve capacity on FRR at any time in accordance with the FRR dimensioning rules."*

Article 3. Determination of the ratio of automatic FRR and manual FRR

Article 9 of the LFCBOA which is currently into application is replaced by:

"Article 9 - Determination of the ratio of automatic FRR and manual FRR

1. *Pursuant to Article 157(2)c of the SOGL, the TSO of a LFC block shall determine the ratio of automatic FRR (hereafter referred to as aFRR), manual FRR (hereafter referred to as mFRR), the aFRR full activation time and mFRR full activation time in order to comply with the requirement of Article 157(2)b of the SOGL.*

    a) *Elia determines the automatic FRR full activation time and manual FRR full in Article 12.*

    b) *The required reserve capacity for FRR is determined by means of the probabilistic methodology described in Article 8.*

2. *The aFRR needs are determined based on the LFC block imbalance variations which are determined as the difference in potential LFC block imbalances over two subsequent periods of 15 minutes. The probability distribution of the LFC block imbalance variations is based on two years of LFC Block imbalance values (from July 1, 2017 to June 30, 2019). The sampling of the historical records covers 15 minutes, and includes a full year period, ending not earlier than 6 months before the calculation date.*

3. *The potential LFC block imbalances used for the aFRR needs calculation are based on :*

    a) *an extrapolation of the historic LFC block imbalances by adding forecast errors following the incremental renewable capacity installed of offshore wind power, onshore wind power and solar photovoltaics power between the year for which the reserve capacity is sized, and the period represented by the historical values of the LFC block imbalances. The incremental renewable capacity will be based on latest projections as shown below :*

Months	2017-18			2018-19			2020		
	PV	Onshore Wind	Offshore Wind	PV	Onshore Wind	Offshore Wind	PV	Onshore Wind	Offshore Wind
jul	3.426	1.808	878	3.788	2.113	1.010	4.805	2.666	1.759
aug	3.458	1.829	878	3.817	2.141	1.091	4.858	2.688	1.759
sep	3.490	1.851	878	3.846	2.169	1.179	4.911	2.710	1.759
oct	3.523	1.872	878	3.875	2.198	1.179	4.964	2.731	1.759
nov	3.555	1.894	878	3.903	2.226	1.179	5.017	2.753	1.759
dec	3.587	1.915	878	3.932	2.254	1.179	5.070	2.775	1.840
jan	3.616	1.943	878	3.974	2.276	1.179	4.486	2.535	1.920
feb	3.645	1.972	878	4.016	2.297	1.207	4.539	2.557	2.001
mar	3.673	2.000	878	4.057	2.319	1.225	4.592	2.579	2.085
apr	3.702	2.028	878	4.099	2.340	1.326	4.645	2.600	2.169
may	3.731	2.056	878	4.141	2.362	1.442	4.698	2.622	2.253
jun	3.760	2.085	937	4.183	2.384	1.529	4.752	2.644	2.253

    b) *An overall system imbalance improvement of 2% is taken into account. Furthermore, an improvement of the forecast accuracy following intra-day predictions is assumed to be 35% for each technology, and the ability of the BRP to adjust is portfolio is assumed to be 100% in case of wind and PV.*

4. *The required positive and negative (symmetric for both directions) reserve capacity on aFRR is determined to cover 79% of the LFC block imbalance variations. It is determined as a fixed value at 151 MW.*

5. *Elia will present in a next version of the LFC BOA a new methodology to assess the aFRR needs. While awaiting the implementation of this new methodology, Elia will limit the symmetric aFRR needs at the same value as in 2019, i.e. 145 MW.*
6. *Pursuant to Article 157(2)b of the SOGL, Elia ensures to respect the current **FRCE criteria** in Article 128 of the SOGL. This analysis is conducted on the reporting on FRCE quality as specified in Article 11. This analysis is conducted every year in the first trimester in line with Article 157(2)a of the SOGL.*
7. *Elia determines the required positive and negative reserve capacity on mFRR each day before 7 AM for every period of 4 hours of the next day as the difference between the required positive and negative reserve capacity on FRR and aFRR."*

Article 4. Determination of the reduction of reserve capacity on FRR following the sharing of FRR

Article 10 of the LFCBOA which is currently into application is replaced by:

"Article 10 Determination of the reduction of reserve capacity on FRR following the sharing of FRR

1. *Pursuant to Article 157(2)j of the SOGL, the TSOs of an LFC block may reduce the positive reserve capacity on FRR of the LFC block resulting from the FRR dimensioning process by concluding a sharing agreement with other LFC blocks in accordance with provisions in Title 8 of the SOGL. Elia takes into account the restrictions specified in Article 157(2)j of the SOGL for the CE synchronous area:*
    a. *the reduction of the positive reserve capacity shall not exceed 30% of the size of the positive dimensioning incident (currently determined at 1039 MW), i.e. 312 MW;*
    b. *the reduction of the positive reserve capacity on FRR of a LFC block shall be limited to the difference, if positive, between the size of the positive dimensioning incident and the reserve capacity on FRR required to cover the positive LFC block imbalances during 99.0% of the time based on the historical records referred to in Article 157(2)a of the SOGL. Based on the historical records specified in 0(2), the maximum positive reserve capacity which can be shared is determined at 547 MW (1039 MW - 492 MW).*
2. *Pursuant to Article 157(2)k of the SOGL, the TSOs of a LFC block may reduce the negative reserve capacity on FRR of the LFC block, resulting from the FRR dimensioning process by concluding a FRR sharing agreement with other LFC blocks in accordance with the provisions of Title 8. ELIA takes into account the restrictions specified in Article 157(2)k of the SOGL for the CE synchronous area:*
    a. *in periods when NEMO-link is foreseen to be in export, or when the prediction is indecisive, the reduction of the negative reserve capacity on FRR of a LFC block shall be limited to the difference, if positive, between the size of the negative dimensioning incident and the reserve capacity on FRR required to cover the negative LFC block imbalances during 99.0% of the time based on the historical records referred to in Article 157(2)a of the SOGL. Based on the historical records specified in Article 8(2), the maximum negative reserve capacity which can be shared is determined at 560 MW (1024 MW - 464 MW);*

b. *in periods when NEMO-link is foreseen to be in import, or in maintenance, the reduction of the negative reserve capacity on FRR of a LFC block shall be limited to the difference, if positive, between the size of the negative dimensioning incident and the reserve capacity on FRR required to cover the negative LFC block imbalances during 99.0% of the time based on the historical records referred to in Article 157(2)a of the SOGL. Based on the historical records specified in Article 8(2), the maximum negative reserve capacity which can be shared is determined at 0 MW;*

3. *Pursuant to Article 157(2)g of the SOGL, Elia can determine possible geographical limitations for sharing of reserves with other LFC blocks to comply with the operational security limits (represented by the remaining ATC after intra-day). Elia also take into account the restrictions defined in the FRR sharing agreements due to possible violations of operational security (network congestions within Elia's LFC block) and the FRR availability requirements (availability of the sharing service) as specified in Article 157(2)b.*

4. *In accordance with Article 166(3) of the SOGL, the reserve capacity available for FRR sharing shall be determined in an agreement with each TSO. Elia also defines the tasks and responsibilities of the control capability providing TSO, the control capability receiving TSO and the affected TSO for sharing FRR as specified in Article 166(7) of the SOGL (parts of FRR within the synchronous zone) and Article 175(2) SOGL (parts of FRR between synchronous zones) in Article 13."*