Explanatory document to the All continental European TSOs' proposals for Common settlement rules for exchanges of energy in accordance with the Articles 50(3) and 51(1) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

18/06/2019

Contents

1. Introduction

According to the guideline on electricity balancing ("EBGL"), all TSOs of a synchronous area shall develop within 18 months after entry into force a proposal for common settlement rules applicable to intended exchanges of energy as a result of the frequency containment process and/or ramping periods according to Article 50(3) of the EBGL and a proposal for common settlement rules applicable to all unintended exchanges of energy according to Article 51(1) of the EBGL.

The current explanatory document serves to describe the scope and content of the following documents:

- "All Continental Europe TSOs' proposal for common settlement rules for all unintended exchanges of energy in accordance with the Article 51(1) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing", hereafter referred to as the "CCU".
- "All Continental Europe TSOs' proposal for common settlement rules for intended exchanges as a result of the frequency containment process and ramping period in accordance with the Article 50(3) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing", hereafter referred to as the "CCFR".

The common settlement rules applicable to these exchanges of energy shall be known jointly as Financial Settlement of KΔf, ACE and ramping period (FSkar). FSkar will replace the current 'compensation programme', formerly outlined in the Operational Handbook Policy 2c, which is based on the integral of the power control error ΔP over the settlement period, that is, the difference between the measured actual power interchange of an LFC area or LFC block and the scheduled programme (including virtual tie-lines, if any). This is known as unintentional deviation within the framework of the compensation programme. This unintentional deviation is currently compensated in kind in the following compensation period. FSkar will perform this settlement financially and replace the compensation programme.

ΔP consists of ACE, KΔf and ramping periods. KΔf, which corresponds to the frequency containment process, and the ramping periods are intended exchanges. ACE equals the truly unintended exchange of energy. The EBGL requires dividing ΔP into its intended parts (KΔf and ramping period) and unintended part (ACE), as shown in Figure 1. The proposal for settlement of the intended parts is presented in the CCFR; the proposal for settlement of unintended exchange is presented in the CCU.

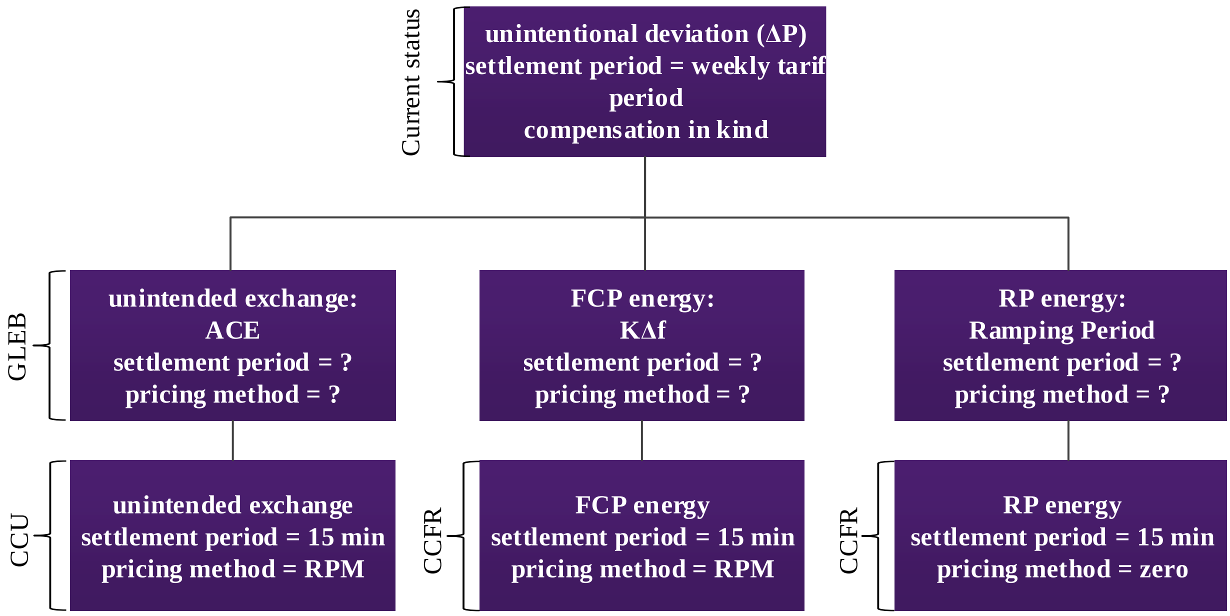

Figure 1: Unintended exchange, FCP energy and ramping period energy according to the EBGL

Chapter 2 describes some basics and definitions of the different energy exchanges which are the subject of this explanatory document and the common settlement rules.

Chapter 3 gives an overview of the proposal for settlement contained in the CCU and CCFR. The high-level design, the functions and the TSO-TSO settlement period are described. Additionally, the rules for the determination of the volumes of energy exchanges and the pricing rules are described. How the methodology reacts in case of critical network situations is also shown.

Chapter 4 presents a short analysis of performed simulations, which served as basis for the methodology

Chapter 5 presents a timeline for the implementation of FSkar. Additionally, possible changes to the pricing rules within the framework of the reviewal mechanism as foreseen in the EBGL are presented in this chapter as well.

Chapter 6 presents a summary of the current status of metering changes in CE to adapt for the TSO-TSO settlement period.

The required data exchange as well as other dispositions regarding the data are presented in chapter 7.

The annexes provide a mapping between the CCU and CCFR and this explanatory document, and a list of abbreviations.

2. Basics and definitions

2.1. The EBGL and the scope of the CCU and CCFR (Article 1)

The EBGL, which entered into force on 18 December 2017, differentiates between intended and unintended exchange. The intended exchanges of balancing energy between TSOs arise as a result of one or more of the following processes:

- Reserve Replacement Process (RR) according to Article 50(1)(a) of the EBGL;
- Frequency Restoration Process with manual activation (mFRR) according to Article 50(1)(b) of the EBGL;
- Frequency Restoration Process with automatic activation (aFRR) according to Article 50(1)(c) of the EBGL;
- Imbalance Netting Process (IN) according to Article 50(1)(d) of the EBGL;
- Frequency Containment Process (FCP) according to Article 50(3)(a) of the EBGL;
- Ramping Period (RP) according to Article 50(3)(b) of the EBGL.

For the first four processes settlement rules have to be developed by all TSOs within one year after the entry into force of the EBGL, and are not the scope of the CCU or CCFR. For the last two processes settlement rules have to be developed within 18 months after the entry into force of the EBGL for every Synchronous Area and between asynchronously connected TSOs which use these processes between Synchronous Areas. The proposal for SA CE corresponds to the CCFR. The proposal for exchanges between Synchronous Areas is not the scope of the CCFR.

Unintended exchange is the net metered energy exchange over a finite period which is not exchanged as a result of any of the processes summarised under intended TSO-TSO exchange in the EBGL nor as the result of ANES in the SOGL. This definition is implied but not explicitly given in Article 51(1) of the EBGL. The proposal for the settlement of unintended exchange shall be developed within 18 months after entry into force of the EBGL and is presented in the CCU for SA CE. A proposal for unintended exchanges between asynchronously connected TSOs is not the scope of the CCU.

2.2. Definitions (Article 2)

The aim of this chapter is to provide definitions for the different energy exchanges, which are relevant for the CCU and CCFR.

Instantaneous values ΔP, KΔf, P_{RP} and ACE

At first, some definitions are made and afterwards Figure 2 illustrates the difference between the processes.

Table 1. Definition of ΔP, K-factor, ACE and ramping period

ΔP	–	Difference between the ANES including Virtual Tie-Lines, and the real-time power exchange of an LFC area or block. Refers to the definition of power control error in the SOGL.
K-factor	–	K-factor represents the assumed reaction of a LFC area/block to a frequency deviation. Defined in the SOGL as a value expressed in megawatts per hertz ('MW/Hz'), which is as close as practical to, or greater than the sum of the auto-control of generation, self-regulation of load and of the contribution of frequency containment reserve relative to the maximum steady-state frequency deviation.
ACE	– –	Area Control Error Defined in the SOGL as sum of the power control error ('ΔP') and the frequency control error ('KΔf'), that is the product of the K-factor of that specific LFC area/block and the frequency deviation
P_{RP}	– – –	Ramping Period Difference between the step scheduled exchange and the ramped scheduled exchange Equals zero in all the minutes that fall out of the ramping period (±5 minutes around the shift)

The connection between the instantaneous or real-time values of ACE, ΔP, Ramping Period (P_{RP}) and KΔf is:

$$\Delta P = ACE + P_{RP} - K\Delta f$$

Positive values for $\Delta P, ACE, P_{RP}$ and $-K\Delta f$ mean that the LFC area/block is exporting energy and has a surplus of power.

The connection between the instantaneous values is illustrated in Figure 2 for a TSO whose ANES increases.

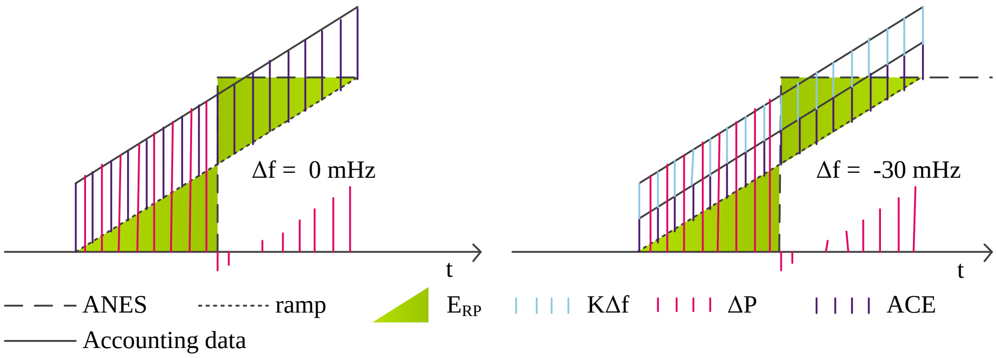

Figure 2: Illustration of the connection between ACE, ΔP, Ramping Period (E_{RP}) and KΔf for a TSO whose scheduled power interchange increases and whose BSPs deliver aFRR and mFRR with a constant bias. Illustration in case of no frequency deviations (left side) and negative frequency deviations (right side).

In case of negative frequency deviations, ACE is always smaller than ΔP; in case of positive frequency deviations, ACE is always bigger than ΔP.

Energy volumes for ramping period energy, FCP energy and unintended exchange

The integral of the quantities above corresponds to energy values in MWh. The integral ∫ΔP corresponds to unintentional deviation as formerly defined in the Operational Handbook. The integral ∫ACE corresponds to unintended exchange (E_{ue}) in accordance to Article 51(1) of the EBGL. The integral $\int P_{RP}$ corresponds to ramping period energy (E_{RP}) in accordance with Article 50(3)(b) of the EBGL. Finally, the integral -∫KΔf corresponds to FCP energy (E_{FCP}) according to Article 50(3)(a) of the EBGL.

In the following, ∫ACE + ∫KΔf corresponds to the sum of the unintended exchange and the FCP energy ($E_{ue} + E_{FCP}$).

The energy volumes for ramping period energy, FCP energy and unintended exchange are to be settled financially according to the EBGL and are the subject of the CCU and CCFR.

2.3. Example

It is assumed that there is a synchronous area with two TSOs, respectively LFC areas. Both LFC areas have the same K-factor (800 MW/Hz), the same inertia and the same amount of FCR, which is 100 MW fully activated at a frequency deviation of 200 mHz.

For the example, it is assumed that in the LFC area of TSO A there is an outage of a power plant of 100 MW. Figure 3 illustrates the chronological sequences of FCR, ACE, etc. after the outage of the power plant. It is assumed that besides the outage of the power plant there are no deviations from the ANES between the 2 TSOs. Moreover, it is assumed that the K-factor is exact.

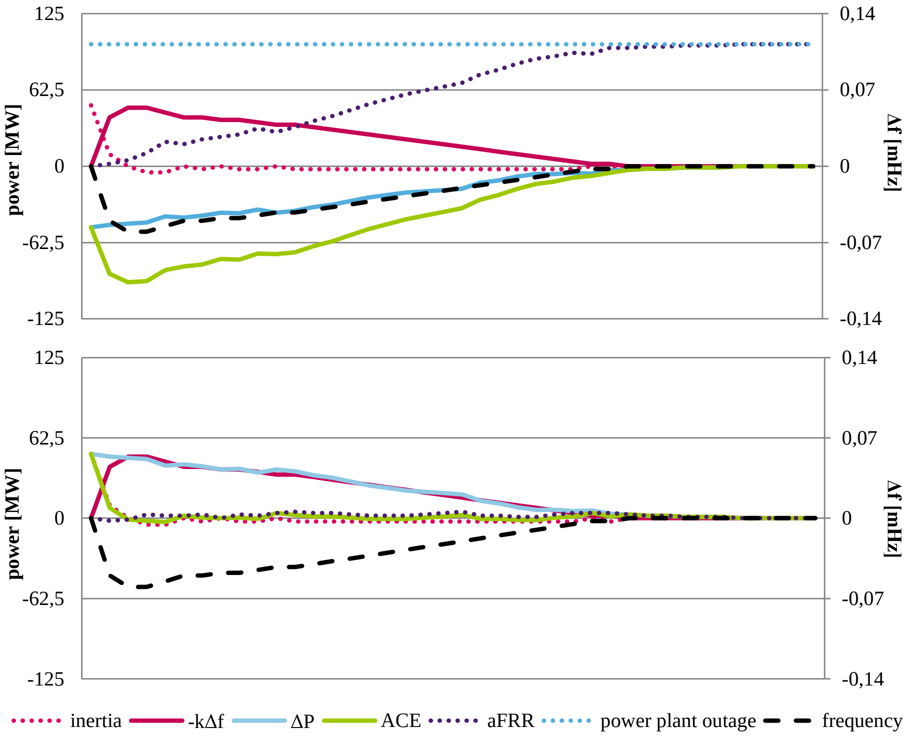

Figure 3: Example for the chronological sequences of FCR, ACE, etc. after an outage of a 100 MW power plant in the LFC area of TSO A

From Figure 3, it can be seen that inertia is the first power which has an effect on frequency followed by the power-frequency response (KΔf), stabilising the frequency. Afterwards aFRR brings frequency back to its nominal value.

From Figure 3, the following conclusions can be drawn:

– The sum of ΔP over all LFC areas is always zero.
– The sum of ACE and KΔf over all LFC areas is also zero under the assumption of perfect K-factor, as long as there is enough KΔf available.
– The sum of ACE over all LFC areas is zero only if there is no frequency deviation.
– The sum of KΔf over all LFC areas is zero only if there is no frequency deviation.
– The ACE of one TSO can be balanced with the ACE of other TSOs.

3. Overview of FSkar

3.1. High-level design (Articles 3 and 5)

Figure 4 illustrates an overview of the workflow for FSkar. There are three main tasks done for FSkar: accounting, settlement and invoicing.

The data that needs to be collected for each TSO-TSO settlement period are:

- the ANES, which are obtained from the verification platform (VP);
- the accounting data, upon which neighbouring TSOs agree for each TSO-TSO settlement period, including VTL exchanges;
- the average system frequency deviation;
- the K-factor for each LFC area/block.

A more detailed explanation of the data exchange is given in chapter 7.

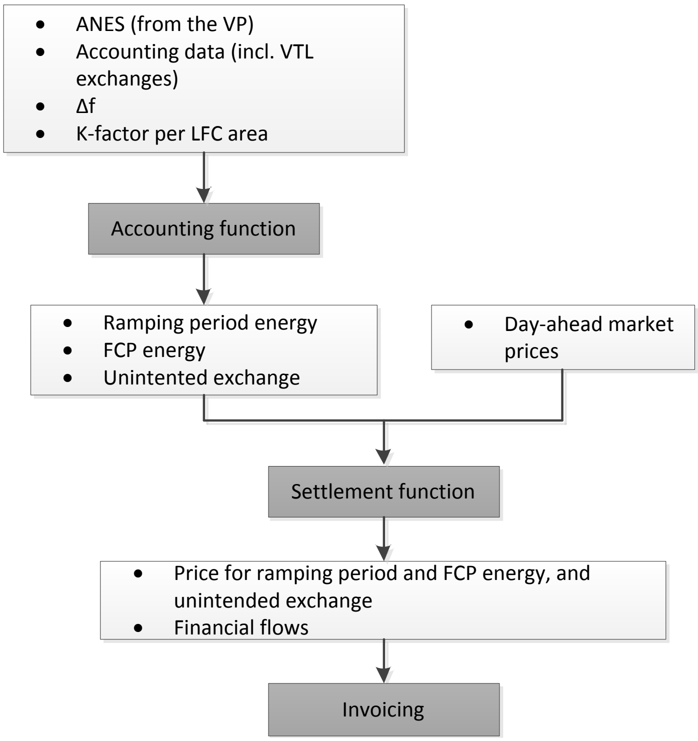

Figure 4: Data flow and setup of accounting and settlement functions

With the collected data as input, the **accounting function** calculates the following energy exchanges: ramping period energy, FCP energy and unintended exchange. The calculation is described in chapter 3.4.

The objective of settlement is to calculate prices for ramping period energy, FCP energy and unintended exchange. For this, the **settlement function** uses as an input the amounts of energy exchange as well as the day-ahead market prices. The pricing rules, based on which the prices are calculated, are described in chapter 3.5.

Additionally, the financial flows between TSOs are to be determined. **Invoicing** is then performed based on these financial flows.

Accounting and settlement will be performed as a rule on an LFC area-level. Alternatively, some LFC areas of a single LFC block might agree upon common settlement for their combined areas. This includes the case where all LFC areas of a single LFC block agree upon settlement on LFC block level.

The specific entities which will be entrusted with the accounting and settlement function and invoicing tasks or the process to appoint them is not in the scope of the CCU and CCFR.

Consistency with proposals for financial settlement between synchronous areas and the TSO-TSO settlement of intended exchanges of energy from imbalance netting, aFRR, mFRR and RR is to be maintained.

3.2. Functions (Article 5)

As described in the previous chapter, there are two main functions for FSkar: accounting and settlement. In the CCU and CCFR, they are further divided into CCU and CCFR accounting and settlement functions. Table 2 explains the differences between them.

Table 2: CCU and CCFR accounting and settlement functions

	Input	Output
CCFR accounting function	k-factors Average frequency deviation ANES	Intended exchanges: ramping period and FCP energy
CCU accounting function	Accounting data ANES Volumes of ramping period and FCP energy (output of CCFR accounting function)	Unintended exchange
CCFR settlement function	Day-ahead market prices Average frequency deviation Volumes of ramping period and FCP energy (output of CCFR accounting function) Volumes of unintended exchange (output of CCU accounting function)	Price for FCP energy Financial flows due to exchange of FCP energy
CCU settlement function	Day-ahead market prices Average frequency deviation Volumes of ramping period and FCP energy (output of CCFR accounting function) Volumes of unintended exchange (output of CCU accounting function)	Price for unintended exchange Financial flows due to unintended exchange
Invoicing task	Financial flows due to exchange of FCP energy and unintended exchange	Invoices

The need for a differentiation between CCU and CCFR accounting and settlement function arises from the fact that the CCU and CCFR are proposals pursuant to different articles of the EBGL: Article 51(1) and 50(3) respectively. As such, the CCU and CCFR are independent proposals, although interlinked. In this explanatory document, on the other hand, both CCU and CCFR accounting functions are considered together as the accounting function, being performed by the same accounting entity. The same applies for the settlement function.

3.3. TSO-TSO settlement period (Article 6)

A TSO-TSO settlement period of 15 minutes has been agreed upon. The TSO-TSO settlement period corresponds to the time unit, for which accounting and settlement of ramping period energy, FCP energy and unintended exchange is performed. For each TSO-TSO settlement period, the volumes of these energy exchanges as well as a price are calculated.

A 15-minute period is in line with the balancing market time unit and the imbalance settlement period. Furthermore, the effort and resources needed are limited compared to a TSO-TSO settlement period of 5 minutes.

However, a TSO-TSO settlement period of 5 minutes has some advantages too and in the future using a TSO-TSO settlement period of 5 minutes can be reconsidered through the reviewal mechanism, described in CCU and CCFR Article 4(2)h.

The CE TSOs shall also keep in mind that the Market Committee has made the remark that enforcing a TSO-TSO settlement period of 5 minutes in the future is likely. It is recommended to TSOs that, in case of needing to change their meters to go for a granularity of 15 minutes, implementing meters that allow for 5 minutes too would be advisable, to be ready for a 5-minute granularity if agreed in the future. Such a possibility is foreseen in CCU and CCFR Article 4(3).

3.4. Volume determination (Article 7)

The governing equation for the determination of energy exchanges is as follows:

$$E_{ex} = E_{sch} + E_{VTL} + E_{FCP} + E_{RP} + E_{ue}$$

The value E_{ex} is the exchanged energy between two LFC areas/blocks as reflected in the accounting data. The accounting data should also include the exchanges per virtual tie-lines (this is shown separately through E_{VTL} for clarity). This VTL exchanges may include but are not limited to aFRR exchanges and imbalance netting.

Scheduled energy exchanges, E_{sch}, refers to the energy corresponding to the sum of the ANES for each LFC area/block, as obtained from the Verification Platform. The ANES include external commercial trade schedules and external TSO schedules, in accordance with the SOGL.

The difference between the scheduled energy exchanges and the accounting data corresponds to the sum $E_{FCP} + E_{RP} + E_{ue}$. The value of each of these terms is to be determined by the accounting function for each TSO-TSO settlement period as described below.

3.4.1. Frequency containment process energy

The energy exchanged as a result of the frequency containment process E_{FCP} is to be calculated as follows:

$$E_{FCP} = -K * \Delta f$$

The K-factor k is a value determined per LFC block by the SG SF; each LFC block can determine the K-factors of its own LFC areas. This value can be additionally modified by the FCR Cooperation. The average frequency deviation Δf is the simple average value of the frequency deviations in the Synchronous Area per TSO-TSO settlement period.

3.4.2. Ramping period energy

Cross-border exchanges of energy are performed based on ANES derived from external TSO schedules and external commercial trade schedules. ANES are ramped. The agreed ramping rules within CE are applied every time the scheduled exchange changes, from 5 minutes before the schedule shift until 5 minutes after the schedule shift, according to the proposal according Article 136 of the SOGL for CE reflected in the Policy on Load Frequency Control and Reserves of the SAFA.

Consequently, ramping power is exchanged cross-border according to these predetermined fixed rules and therefore energy is intentionally exchanged between each TSO and all TSOs, as illustrated in Figure 5.

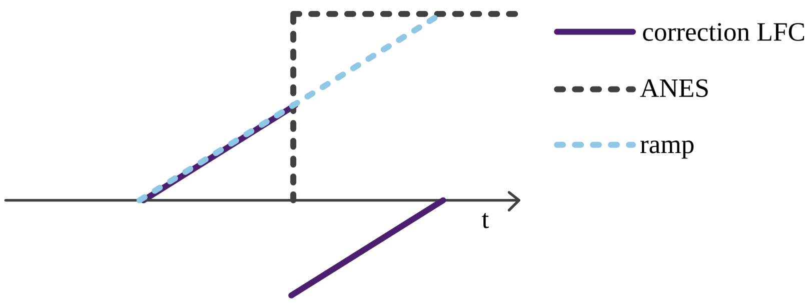

Figure 5: Illustration of a Ramping Period

For each TSO in the SA CE, for each change in ANES within this synchronous area, the energy accounted for in the pre-schedule ramp (-5 minutes) matches the energy in the post-schedule ramp (+5 minutes), but for its sign. Furthermore, for each change in ANES within this synchronous area, the energy accounted for in the pre-schedule ramp adds up to zero over all TSOs in SA CE. It is a perfect zero-sum volume game and the volumes can be calculated exactly based on the ANES change and the ramping period.

3.4.3. Unintended exchange

The unintended exchange E_{ue} corresponds to the difference between E_{ex} and all other intended exchanges of energy.

$$E_{ue} = E_{ex} - E_{sch} - E_{VTL} - E_{FCP} - E_{RP}$$

3.5. Pricing rules (Article 8)

It is possible, according to the EBGL, to set different pricing rules for ramping period energy, FCP energy and unintended exchange. The CCU and CCFR, however, set a zero-pricing rule for ramping period energy and the same reference price model for FCP energy and unintended exchange for all SA CE.

3.5.1. Pricing method for ramping period energy (Art. 8(1) of the CCFR)

Different pricing options were studied for ramping period energy. It has been agreed upon, that the price for ramping period is EUR 0 /MWh. The reason for this is that this pricing rule does not cause financial risks, it is simple and the effort for applying it is low. Other pricing rules were investigated. However, since the turnover for the most expensive pricing rule would have only been around EUR 2 million in SA CE, the effort to implement a pricing rule is considered as too high compared to the turnover.

3.5.2. Pricing method for FCP energy and unintended exchange (Art. 8(1) of the CCU and Art. 8(2) of the CCFR)

The CCU and CCFR set the same price for FCP energy and unintended exchange. Pricing rules with separate prices for FCP energy and unintended exchange were investigated but deemed less appropriate.

The pricing method proposed for settlement of FCP energy and unintended exchange is shown in Figure 6. There are two components to the pricing method, which will be explained in the following: the reference price and the frequency dependency.

For the purposes of financial settlement of intended exchanges as a result of FCP and ramping periods, and unintended exchange, the following frequency ranges are relevant:

- Adequate frequency range, where the absolute value of the average frequency deviation Δf is less than 20 mHz. In this case, the pricing method is frequency independent.
- Frequency-dependent range, where the absolute value of the average frequency deviation Δf lies above 20 mHz.

Reference price: Article 8(1)(a) of the CCU and 8(2)(a) of the CCFR

The selected reference price is calculated for each TSO-TSO settlement period for all TSOs as the weighted average of the day-ahead market prices of the Bidding Zone or Bidding Zones for LFC areas/blocks. The weighting is done according to the amount of unintended exchange and FCP energy which was exchanged by the LFC area/block over each TSO-TSO settlement period t. Justification of this selection of a reference price is given in 4.5.4 of this document.

The reference price sets the price for FCP energy and unintended exchange in the adequate frequency range.

For the calculation of the reference price the following quantities are needed:

1. Day-ahead market price for LFC area/block m, $DAMP_m(t)$: Since a day-ahead market price is determined per bidding zones and not LFC area/block, an equivalent day-ahead market price must be determined for each LFC block, in case the LFC block does not coincide with a bidding zone. The details are discussed in chapter 3.5.3.

2. The volumes of unintended exchange and FCP energy for the LFC area/block m and the TSO-TSO settlement period t, $(E_{ue} + E_{FCP})_m(t)$: This is calculated by the accounting function and the result is used as an input for the settlement function.

The reference price for the TSO-TSO settlement period t is calculated as follows:

$$Price_{ref}(t) = \frac{\sum_m DAMP_m(t) * (E_{ue} + E_{FCP})_m(t)}{\sum_m (E_{ue} + E_{FCP})_m(t)}$$

Frequency dependency: Article 8(1)(b) of the CCU and 8(2)(b) of the CCFR

The frequency dependency can be seen in Figure 6. When the absolute value of the average frequency deviation over the TSO-TSO settlement period t, $\Delta f(t)$, exceeds 20 mHz, a slope of 2 EUR/mHz is applied to the price (see chapter 4.3). The frequency dependency is stopped at 100 mHz; by greater frequency deviations, the price is equal to the one calculated for a frequency deviation of 100 mHz. This avoids the occurrence of extreme prices (see chapter 4.4).

The final price for unintended exchange and FCP energy is then calculated as follows:

$$Price_{UE,FCP}(t) = \begin{cases} Price_{ref}(t) - 2\,€/mHz * (-100\,mHz + 20\,mHz) & \Delta f(t) < -100\,mHz \\ Price_{ref}(t) - 2\,€/mHz * (\Delta f(t) + 20\,mHz) & -100\,mHz \leq \Delta f(t) < -20\,mHz \\ Price_{ref}(t) & -20\,mHz \leq \Delta f(t) \leq 20\,mHz \\ Price_{ref}(t) - 2\,€/mHz * (\Delta f(t) - 20\,mHz) & 20\,mHz < \Delta f(t) \leq 100\,mHz \\ Price_{ref}(t) - 2\,€/mHz * (100\,mHz - 20\,mHz) & \Delta f(t) > 100\,mHz \end{cases}$$

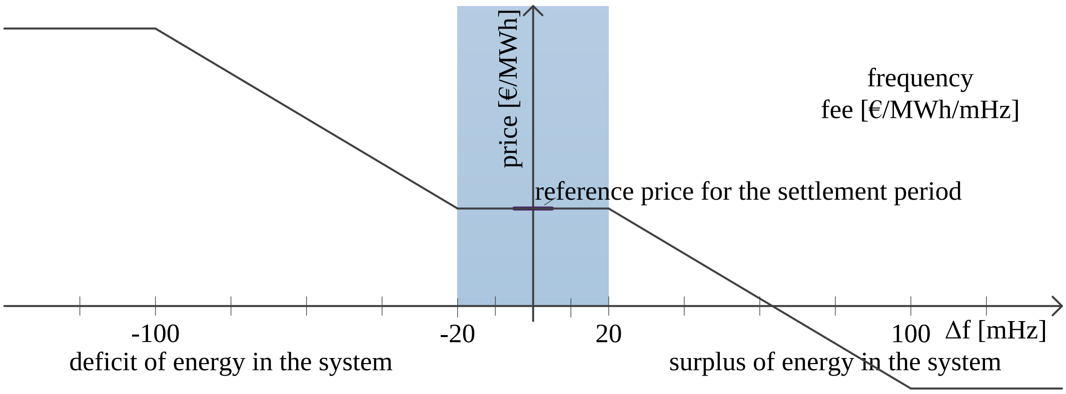

Figure 6: Illustration of the proposed pricing method with a stop of the frequency dependent part at a frequency deviation of ±100 mHz

In case of an HVDC system connecting two TSOs of the synchronous area continental Europe, the frequency-dependant component may be not applicable.

3.5.3. Determination of the day-ahead market price for each LFC block

ACE and unintended exchanges are defined per LFC area/block, since the LFC controllers aim to reduce the real-time value of ACE to zero for its respective zone. For this reason, accounting and settlement of unintended exchange can only be performed on an LFC area/block-level and a day-ahead market price is needed for each LFC area/block. Day-ahead market prices are determined however on a bidding zone level. To overcome this, an equivalent day-ahead market price to be used for each LFC block is determined in Article 8(1)(a) of the CCU and Article 8(2)(a) of the CCFR as follows:

- LFC blocks which consist of one LFC area with one day-ahead market price: The bidding zone corresponds to the LFC area and the LFC block. Therefore, no special disposition is needed. For each LFC block, the day-ahead market price of the corresponding bidding zone can be used. This is currently the case of LFC blocks BE, GR, AT, CZ, BG, HU, ES, PT, FR, SK, CH, TR, NL, IT and RO.
- LFC blocks with several LFC areas, each with unique day-ahead market price: This is, for example, the case of the LFC block TNG+TTG+AMP+50HZT (Germany) + DKW (Denmark West) + LU (Luxemburg). The LFC block consists of four LFC areas. There is one day-ahead market price for Germany and Luxemburg and one day-ahead market price for Denmark West. In this case, Article 8(1)(a)(i) applies: the weighted average LFC block price is calculated by weighting the day-ahead market prices of the LFC areas with the respective notified K-factor of each LFC area. Example calculation for DE-DKW:

$$DAMP_{DE-DKW} = \frac{k_{DE} * DAMP_{DE} + k_{DK} * DAMP_{DKW}}{k_{DE} + k_{DKW}}$$

- Case LFC Block SMM (EMS-CGES-MEPSO): The SMM LFC block consists of three LFC areas. Only one LFC area (RS) has a day-ahead market price. In this case, Article 8(1)(a)(i) applies as follows: LFC areas which do not have a day-ahead market price are not considered in the calculation of the average weighted price for the LFC block. In the specific case of SMM, this means that only the price from RS is considered and equals the average price of the LFC block SMM for calculations.

  This is also the case for the LFC block PL/UA, where only PL has a day-ahead market.

  In the case of the LFC block SHB, the LFC area BA has no day-ahead market price, so the price for the LFC block is calculated as the weighted average of the prices of SI and HR, weighting by the k-factors of SI and HR. Example calculation for SHB:

$$DAMP_{SHB} = \frac{k_{SI} * DAMP_{SI} + k_{HR} * DAMP_{HR}}{k_{SI} + k_{HR}}$$

- An LFC area, which includes several bidding zones: This is the case of the LFC block/area IT. The LFC block consists of one LFC area with several bidding zones and therefore day-ahead market prices per LFC area. In this case, Article 8(1)(a)(ii) applies and the TSO operating the LFC area may decide which price or prices to utilise for defining the day-ahead market price of the LFC area. Weighting with the k-factors is not possible, since k-factors are only defined for LFC areas or blocks.
- Case LFC Block AL: There is no day-ahead market price for the LFC block/area. In this case, Article 8(1)(a)(iii) applies: the imbalance settlement price for that LFC block for that TSO-TSO settlement period is used instead of a day-ahead market price. In the case of dual pricing, an average price is calculated.

3.5.4. Usage of day-ahead market prices (Article 9(2))

The EBGL requires that the prices for unintended exchange shall reflect balancing energy prices. The pricing method used is not directly based on balancing energy prices, because main pricing principles are not harmonised yet and prices, which were generated under different pricing principles (e.g. pay-as-bid and marginal pricing) cannot be considered together without distortions. The fact that common balancing platforms will not be available before implementation of FSkar or, at the most, they will be at a very early phase (with not much experience), is an additional reason for basing the pricing method initially on day-ahead market prices. Attempting to use balancing prices from the beginning could therefore lead to high financial risks and arbitrary prices due to unforeseen market issues.

To meet the implementation deadline as required by the EBGL, the pricing method RPM (reference price model) uses day-ahead market prices. Additionally, day-ahead market prices reflect balancing energy prices, as required by the EBGL, because it is very likely that the prices for balancing energy are also high in case of high day-ahead market prices. This is especially true if free bids for balancing energy are allowed. Additionally, the pricing method RPM is depending on the frequency deviation. The frequency dependency of the pricing rules reflects the balancing energy prices too, because balancing prices should increase with increasing frequency deviations as prices resulting from pricing methods depending on frequency deviation do too.

Nevertheless, there is an intention to use balancing prices to determine the prices for FCP energy and unintended exchange in the future. Therefore, using balancing energy prices shall be reconsidered in the reviewal mechanism after the platforms for balancing energy are implemented.

3.6. Sign convention

To avoid misunderstanding, the sign convention applying to energy volumes is the following:

- A positive energy volume corresponds to an export of energy by the TSO, i.e. if the TSO is long, the unintended exchange is positive.
- A negative energy volume corresponds to an import of energy by the TSO, i.e. if the TSO is short, the unintended exchange if negative.

The prices obtain their sign from the mathematical formulas in chapter 4.5.2.

The settlement amount per TSO-TSO settlement period, corresponding to the multiplication of the energy volumes (of unintended exchange and FCP energy) and the price (for unintended exchange and FCP energy), are therefore governed by the following sign convention:

- A positive settlement amount corresponds to a payment **owed** to this TSO: an export of energy when the price is positive leads to a gain.
- A negative settlement amount corresponds to a **payment** from this TSO: an import of energy when the price is positive leads to a cost.

This sign convention is consistent with the sign convention for the TSO-TSO settlement of intended exchanges of energy.

3.7. Single pricing

It is worth noting that, in the future, a single price in SA CE for unintended exchange and FCP energy shall be kept, due to the fact that it is a zero-sum game. In this sense, the financial flows should only cause redistributions among the SA CE TSOs, and the same price should be used for the same kind of energy. In addition, keeping a single price would reduce the complexity.

3.8. Critical network situations

In the following, various critical network situations are described and it is analysed if and how they have to be considered concerning FSkar.

3.8.1. Inter-area oscillations

Analysis

In the SA CE system, a series of unfortunate circumstances can trigger an inter-area oscillation. Some parameters that can encourage inter-area oscillations are high power transport over long distances or too high impedance, e.g. caused by an unexpected line opening.

Each factor is usually not critical itself, but the combination can influence the system stability and decrease the general damping.

The SA CE system shows two main oscillation modes:

- North-South mode: frequency oscillating within about 250 mHz.
- East-West mode: frequency oscillating within about 150 mHz.

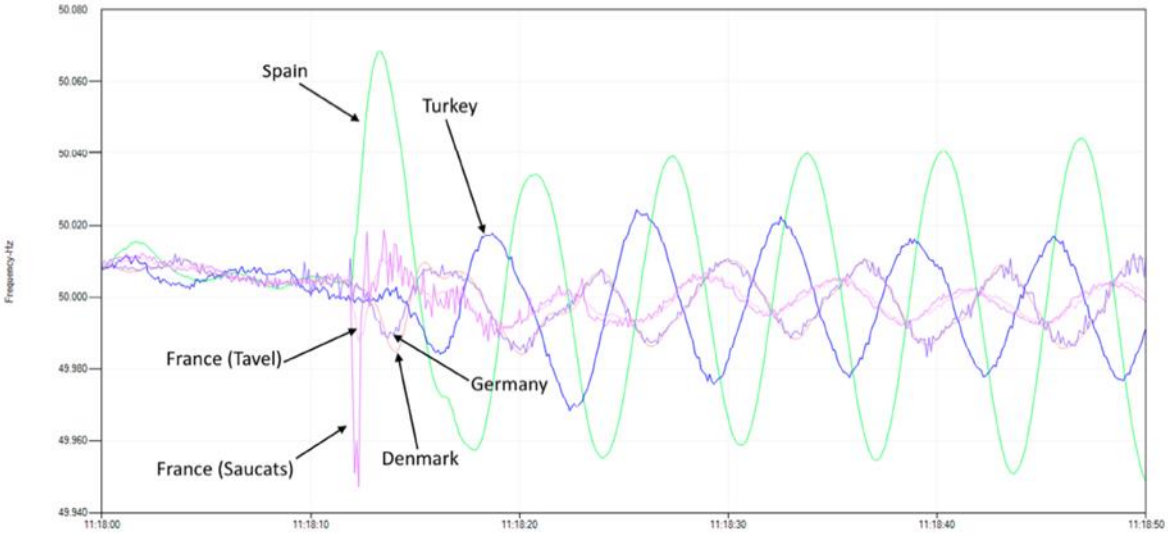

Figure 7: Frequency in different locations of SA CE at East-West mode oscillation on 1st December 2016 (ENTSO-E analysis of CE inter-area oscillations of 1st December)

Figure 7 shows the frequencies at different places in SA CE during the last East-West mode oscillation which was triggered by an unexpected opening of a 400kV line in France. The highest frequency deviations of 140 mHz peak-to-peak were recorded in the Iberian Peninsula. After 5 minutes, the oscillation was completely damped by reduction of schedule exchanges between Spain and France.

Conclusion

Since inter-area oscillations occur only rarely with short-term frequency deviations and numerous measures started to prevent the oscillations, they shall not be considered for the development of a pricing method. Moreover, inter-area oscillations almost level out over the settlement period of 15 minutes which is an additional reason not to consider them.

3.8.2. Network split (Article 8(3))

Analysis

Since 2000, there have been the following big network splits:

- 28/09/2003: Italy's black out
- 04/11/2006: UCTE
- 14/1/2012 and 8/05/2012: Turkey
- 30+31/03/2015: Turkey (31: black-out)

By this, one can see that network split happens rarely and represent an exceptional situation.

If there is a network split, the TSOs affected by it switch to an emergency state. According to the ENTSO-E Network Code on Emergency and Restoration, a TSO is entitled to suspend market activities during emergency state or black out. Additionally, the TSO is entitled to suspend the operation of its processes impacted by such suspension. The suspended market activities may include, inter alia, the schedule energy and cross-border capacity.

Figure 8 shows the different types of network splits. Situation A) illustrates the system in a normal state with 4 LFC blocks in one synchronous area. Situation B) shows the network split of one LFC block (LFC Block 4) and the other LFC blocks are still in one synchronous area. Situation C) is an example for a network split which causes formation of two sub synchronous areas.

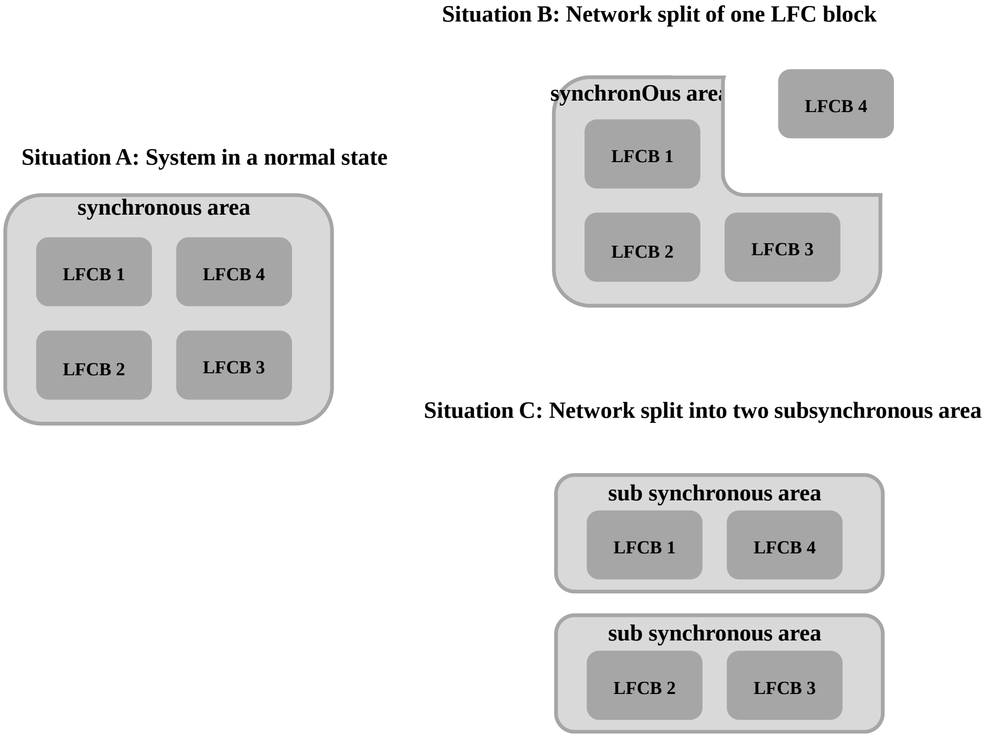

Figure 8: Different types of network splits

Conclusion

No changes will be introduced during a network split of one LFC block (situation B). If the network split affects more than one LFC block (situation C), FSkar will be done without the frequency dependent part. The reason for this is that the situation C occurs rarely and suspending the frequency dependency avoids determining which frequency metering should be used in the sub-synchronous areas, since there are several system frequencies in this case.

3.8.3. Alert state and emergency state

Analysis

In the SOGL, the following definitions for normal, alert and emergency state can be found concerning frequency deviation.

Normal state:

– frequency is within standard frequency range of ± 50 mHz
– frequency is within a frequency range of ± 50 mHz to ± 100 mHz for less than 15 minutes
– frequency is within a frequency range of ± 100 mHz to ± 200 mHz for less than 5 minutes

Alert state:

– frequency is within a frequency range of ± 50 mHz to ± 100 mHz for more than 15 minutes
– frequency is within a frequency range of ± 100 mHz to ± 200 mHz for more than 5 minutes

Emergency state:

– frequency is within a frequency range higher than ± 200 mHz

Conclusion

The motivation behind looking at alert and emergency states is that financial risks should be avoided by eventually proposing amendments to the pricing method in this situation. Nevertheless, large frequency deviations rarely occur. Therefore, it has been agreed upon not to add any features to the pricing method as a result of alert or emergency states, since these extreme situations are already included in the frequency dependency part.

4. Simulations

4.1. Introduction

Several simulations were performed in order to define the common settlement rules. In this chapter, a small description of the performed simulations is presented.

Ten different pricing methods were initially taken into consideration. After a first analysis, three promising pricing methods were identified. In order to determine the most appropriate pricing method, simulations were carried out for all three pricing methods and compared in detail. Based on the evaluations, the pricing method reference price model (RPM) has been agreed upon.

The main advantages of the pricing method RPM are that it is considered to create most appropriate prices at both normal and large frequency deviations and that it is the best one in avoiding perverse incentives and possibilities to arbitrage. By avoiding perverse incentives, the RPM provides incentives to have a good unintended exchange behaviour (Chapter 5.5).

4.2. Description of simulations

The simulations were done for 3 years (2014-2016).

Data description:

- The simulations were carried out with data on LFC block-level.
- Frequency: the 15-minute frequency data from Vulcanus is used.
- FCP energy and unintended exchange: Were calculated based on metering period of 15 minutes. The ΔP values of all LFC blocks (difference between ANES and actual metered data) are available. The ramping periods were calculated based on the ANES using the ±5 minute ramp for SA CE. The FCP energy was calculated using the frequency data and the reported K-factors for the LFC blocks in SA CE. With this it was possible to calculate the remaining unintended exchange.
- Day-ahead market price data: Have been collected for the different LFC blocks. Day-ahead market prices were not available for all LFC blocks and some LFC blocks have two or even more day-ahead market prices. In the following, used workarounds are described.
    - For Albania and Bulgaria (LFC blocks OST and ESO, respectively), imbalance settlement prices are used instead of day-ahead market prices.
    - For Germany and West Denmark (LFC block TNG+TTG+AMP+50HZT+DKW+LU), the weighted average day-ahead market prices were used. Weighting was done with k-factors.
    - For Italy (LFC block Terna), the day-ahead market prices of the northern bidding zone were used.
    - For Poland and Western Ukraine (LFC block PSE + Western WPS), only the day-ahead market prices from PL were used.
    - For Slovenia, Croatia and Bosnia and Herzegovina (LFC block SHB), only the day-ahead market prices from Slovenia were used from 2014 to February 2016. Afterwards, the weighted average day-ahead market prices from Slovenia and Croatia were used.

- For Serbia, Montenegro and FYR of Macedonia (LFC block SMM), HUPX prices were used until February 2016. Afterwards, the day-ahead market prices from Serbia were used.
- For all other LFC blocks, a day-ahead market prices could be used without the need for a workaround.
- In some cases, K-factors were needed to calculate an average weighted day-ahead market prices. K-factors were taken from subgroup system frequency.
- 15-minute day-ahead market prices were needed for simulations. If day-ahead market prices were only available with a resolution of 30 minutes or one hour, it was assumed that day-ahead market prices in the quarter hours within those 30 minutes or one hour have remained constant.

- The simulations were conducted with MATLAB.

The purpose of the simulation was to calculate the price for unintended exchange and FCP energy for each 15-minute period. Additionally, the amount of FCP energy and unintended exchange was calculated for each LFC block and, by multiplying these with the respective prices, the resulting cashflows for each LFC block could be calculated.

4.3. Analysis and proposal of parameters

Different parameter combinations for the RPM were evaluated. The variable parameters in this model are the adequate frequency range (±20mHz in Figure 6), and the slope in the frequency-dependent range (2 €/mHz in Figure 6). An additional (optional) parameter is the frequency at which the frequency dependency is stopped (100 mHz in Figure 6).

Table 3 shows the result of the evaluation. The parameter combination is marked by *slope_frequency without slope*. If available, the third parameter is the frequency stop. The results of simulations were analysed according to the following criteria:

- Financial risks (avoid high prices and turnover): the parameter combination with the highest turnover for all LFC blocks in SA CE was assigned a score of -1. The combination with the lowest turnover a score of +1. All other combinations were assigned a score between -1 and +1, proportional to the turnover.
- Appropriate incentives to have a good unintended exchange behaviour. For this criterion the TSOs gave individual scores following a survey which were averaged.
- Disadvantage small or big LFC blocks: The average prices for unintended exchange and FCP energy were calculated for each LFC block in SA CE. It was determined that no parameter combination represents any advantage for big or small LFC blocks. As a result, all combinations were assigned a score of 0.

Comparing the results of the evaluation, it could be observed that a slope of € 4 /MW/mHz should not be used, because the financial risks are too high and in addition the incentives to have a good ACE behaviour were rated as inappropriate

The parameter combination 1_00, 2_10 and 2_20 received the best scores. A mark-up, respectively mark-down in the case of small frequency deviations, is considered as inappropriate, so a frequency range without slope should be used for small frequency deviations. Thus, the combination 1_00 was not discarded.

Table 3. Evaluation results for the different parameters

	Weighting	1_00	1_10	1_20	2_00	2_10	2_20	4_00	4_10	4_20

Financial risks: avoid high prices and turnover	0,45	0,856	0,897	0,899	0,445	0,746	0,855	-1	0,134	0,621
Appropriate incentives to have a good ACE behaviour (not too high nor too low)	0,5	0,075	-0,2	-0,25	0,125	0,25	0,3	-0,38	-0,11	-0,28
Disadvantages to small or big LFC blocks	0,05	0	0	0	0	0	0	0	0	0
Sum		**0,42**	0,30	0,28	0,26	**0,46**	**0,53**	-0,64	0,00	0,14

To determine which value (±10 mHz or ±20 mHz) is adequate for the frequency range without slope, the distribution of the absolute values of the frequency deviation for the years 2014, 2015 and 2016 was analysed:

– 46% of all 15-minute frequency deviations from 2014 to 2016 are above 10 mHz.
– 17% of all 15-minute frequency deviations from 2014 to 2016 are above 20 mHz.

A mark-up, respectively mark-down, of approximately 17% of all prices is considered appropriate. Since the parameter combination 2_20 additionally received the best scores, it was decided to use these parameters.

Furthermore, according to the SOGL, FCR providers are requested to start providing the FCR at the frequency deviation of ±20 mHz. This range results from the sum of the "minimum accuracy of frequency measurement" (±10 mHz) and the "maximum combined effect of inherent frequency response insensitivity and possible intentional frequency response dead band of the governor of the FCR providing units or FCR providing group" (±10 mHz for SA CE), as defined in the SOGL Annex V. Since one of the goals of implementing FSkar is to reward TSOs with a correct FCR response, this is an additional argument for the adequate frequency range of ±20 mHz.

If, in the future, the settlement period is changed, the size of the deadband should be reconsidered as well, since balancing effects over 5 minutes are smaller than over 15 minutes.

4.4. Reducing the risk of extreme prices

A price cap to avoid extreme prices will not be applied for the following reasons: Since the extreme prices occur only rarely, the turnover caused by extreme prices is relatively low compared to the turnover of the year. Furthermore, a cap on prices might give incentives to those LFC blocks with high day-ahead market prices to import unintended exchange energy. Additionally, other mechanisms and platform do not use price caps and according to EBGL caps for payments or prices are not allowed unless TSOs agree upon a harmonised maximum price. Moreover, using a cap prices would distort the true state of the market in SA CE, because high reference prices caused by high day-ahead market prices in some LFC blocks would simply reflect the prices for energy.

However, the frequency dependent part of the prices for FCP energy and unintended exchange at a frequency deviation of ±100 mHz in order to limit high prices caused by extreme frequency deviations, and therefore limit also the financial risks to TSOs.

To check whether no other workaround is necessary, it will be monitored in the reviewal mechanism explained in Chapter 6.2 of this explanatory document if too many TSOs are long in order to profit by FSkar. This might be possible, because the TSO expect high prices for FSkar based on the day-ahead market prices known before. If this occurs, a modified workaround may become necessary.

4.5. Risk of arbitrage

There is a residual potential for individual TSO arbitrage, that would be detrimental to the frequency restoration objectives of SOGL, at the expense of the joint frequency quality and system security, and thus at the expense of the other TSOs. Even though the RPM is rated as the best pricing method to avoid possibilities to arbitrage, there is still a residual risk of arbitrage. However, this risk is considered to be limited because FSkar is, by definition, a zero-sum game and only leads to distributional effects. This means that some TSOs will face a positive cashflow and others a negative cashflow. Moreover, it is impossible to predict the exact settlement prices. The input parameters to calculate the settlement prices are the day-ahead market prices weighted by the unintended exchange volume and the frequency deviation. Since only the day-ahead market prices are known in advance, the exact settlement prices cannot be determined in real-time.

To minimise this risk, it was discussed to make ACE in each settlement period costlier than the costliest balancing energy activated anywhere in the synchronous area in that settlement period, incentivising compliancy with the SOGL. Nevertheless, the following arguments led to the final decision.

Financial risk for all TSOs

In the evaluation, simulations were used to estimate the financial impact of different settlement methodologies. In two of the considered methodologies, the settlement price was based on the costliest imbalance price. Imbalance prices were used since actual balancing energy prices from the costliest balancing energy bids that were activated were not available.

Simulations for 2014 showed that the turnover of these methods is much larger than the turnover of all other considered methods. For illustration; the turnover of the chosen RPM-spot method was simulated to be around M€ 70, while for the methods based on the costliest imbalance price this was respectively around M€ 225 and M€ 500. The financial risk for TSOs induced by a reference price based on actual maximum balancing energy prices would be much higher than with spot prices, especially if market designs and pricing methods are not harmonised. For example, in the German and Austrian LFC blocks, balancing energy bid prices for aFRR up to € 100,000 /MWh can be observed nearly permanently on the German- and Austrian merit order lists (MOL). In other LFC blocks, maximum balancing energy bid prices, almost never exceed a few hundred €/MWh, either through another market design or through effective regulation. Exposing all TSOs to such common excessive price risks, that are outside their span of control, is regarded as unacceptable, especially for small TSOs that run large ACE risks due to large deterministic events.

Risk of an individual TSO influencing the price

For settlement methodologies where the price is based on the costliest activated balancing energy bid, the influence of one single TSO action on the common settlement price can be very big and volatile. For example, activating a € 100,000 /MWh balancing energy bid by a TSO would not only raise the balancing energy cost within its control area, but also the cost of settling its own remaining ACE, and that of all other TSOs. Of course, by not activating such a bid both these effects would be avoided, but the frequency restoration process objective would not be attained. The Reference Price Method on the other hand is based on spot market prices which cannot be influenced by individual TSOs actions.

Risk of energy control instead of power control

If prices for unintended exchange are too high, there is the risk that TSOs may be tempted to perform energy control, even if this is not allowed by Articles 143(1)(a) and 145(4)(c) of the SOGL, rather than power control, which means that individual TSOs may try to compensate their ACE from the first part of the settlement period in a later part, contrary to the frequency restoration objective and making frequency unstable.

Not the only measure

TSOs have the legal obligation to balance their ACE to zero within TTRF and respect some quality indicators. Additionally, the SOGL foresees a monitoring of the ACE and frequency quality in annual reports.
Unintended exchange is by definition a zero-sum game. By this, FSkar only has distributional effects which means that some TSO will face a positive cash flow and others a negative cash flow within the same settlement period.

Compliancy to the SOGL cannot be enforced only by FSkar. On the other hand, financial settlement of ACE should not be obstructive to fulfil the SOGL frequency restoration objectives.

Impossible to predict the exact settlement price

Although day-ahead market prices are known before real time, the settlement price of the RPM uses a weighted average of spot prices in the concerned area. These weights are based on the volumes of FCP energy and unintended exchange of each LFC area/block which is not known upfront. Moreover, the frequency deviation, which is an input parameter for the pricing method as well, is not known in advance. The price from the RPM can therefore not be known precisely in advance.

5. Planning implementation (Article 4)

5.1. Timetable of implementation

The following timetable shows the time which is needed to implement the different processes and systems for FSkar.

Table 4: Implementation timetable of FSkar

Task	**2019**				**2020**				**2021**				**2022**			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Development of FSkar Business requirement specifications and Implementation Guide	■	■	■	■												
Inclusion of FSkar in the SAFA for SA CE		■														
Submission for approval common settlement rules		■														
Approval of the common settlement rules by NRAs				■												
Change of meters	■	■	■	■	■	■	■									
Change of IT systems for meters	■	■	■	■	■	■	■	■								
Adjustments accounting systems					■	■										
Implement settlement system					■	■	■	■								
Implement publication					■	■	■	■								
Go-live of FSkar								■								
Reviewal mechanism																■

The CCU and CCFR shall be submitted to regulators by 18 months after the entry into force of the EBGL, i.e. by 18 June 2019. Regulators have 6 months since submission of the proposals to decide on its approval.

A survey to all SA CE TSOs showed that changing meters and the associated IT systems will take up to 2 years. This survey is further described in chapter **Error! Reference source not found.**.

5.2. Reviewal mechanism and possible evolutions of the pricing method

Using balancing energy prices

Article 4(2)(g) of the CCU and CCFR includes a reviewal mechanism for the FSkar, where the settlement rules are reviewed regarding their effectiveness and appropriateness. The main reason for introducing this reviewal mechanism is the need to re-evaluate the use of day-ahead market prices instead of balancing energy prices. In order to calculate the reference price, balancing energy prices could be used instead of day-ahead market prices. These prices could be taken directly from the platforms for exchange of IN, aFRR, mFRR and RR. Since TSOs balance their system with balancing energy and not with energy bought on day-ahead markets, the reference price could be more cost reflective.

The point in time for the reviewal mechanism has been set at one year after the last go-live of the balancing platforms. It is considered that one year is enough for gaining experience in the balancing platforms and to avoid risks due to unforeseen market or IT issues during the implementation of the platforms. Due to this, there will be enough experience and data gained to consider using balancing energy prices in the FSkar methodology. In addition, there will also have been experience gained in FSkar so that other aspects of the methodology can be reconsidered, if needed.

Once the platforms are operational and there is market data available to analyse it, it shall be investigated if and which balancing prices should be used in order to calculate the reference price.

Slope and frequency range without slope

The most important parameters of the reference price methods are the slope (EUR 2 /MHz) and the frequency range without slope (20 mHz). It might be that based on operational experience or new analyses, a new combination of parameters is deemed reasonable. By this, it shall be investigated if another combination of parameters (slope and frequency range without slope) is more useful.

Others

There could be other reasons that lead TSOs to evaluate changes through the reviewal mechanism. For example, if in the future it is observed that TSOs are exposed to high financial risks because of FSkar, possible amendments to the pricing methodology can be investigated, such as price caps or further reducing the frequency deviation at which the slope stops.

6. Metering

The implementation of FSkar in SA CE will imply changes for some of the metering devices installed in the interconnections, to increase the granularity of metering data to a TSO-TSO settlement period of 15 minutes. Eventually, changes affecting IT will be necessary too. Furthermore, it is possible that the required granularity will be shorter than 15 minutes in the future. Consequently, it is useful to know the minimum granularity capability available for the existing meters.

In order to have the information on the existing interconnectors, the scope and timing of the changes foreseen, a survey was conducted to all TSOs from SA CE in July 2017. According to the responses received, most of the metering devices had a current granularity set to 15 minutes (78%), followed by a 19% of the devices with a longer granularity setting of 1 hour. For those devices that were going to require changes, on site reconfiguration and physical replacement were the most frequent expected changes (61%). The expected timeframe for these changes was up to 2 years.

At the end of 2018, a new survey was conducted among those TSOs that required metering changes. The information on those devices with granularity greater than 15 minutes was updated, obtaining as a main result that most of the changes required for the TSO-TSO settlement period of 15 minutes have been already done and, for the pending cases, the changes are foreseen before FSkar implementation date (Dec. 2020).

7. Data

7.1. Data exchange overview

Figure 9 illustrates an overview of the data exchange needed for FSkar between the LFC areas, the accounting and settlement entities, the verification platform, the platforms for balancing energy, and the SG SF.

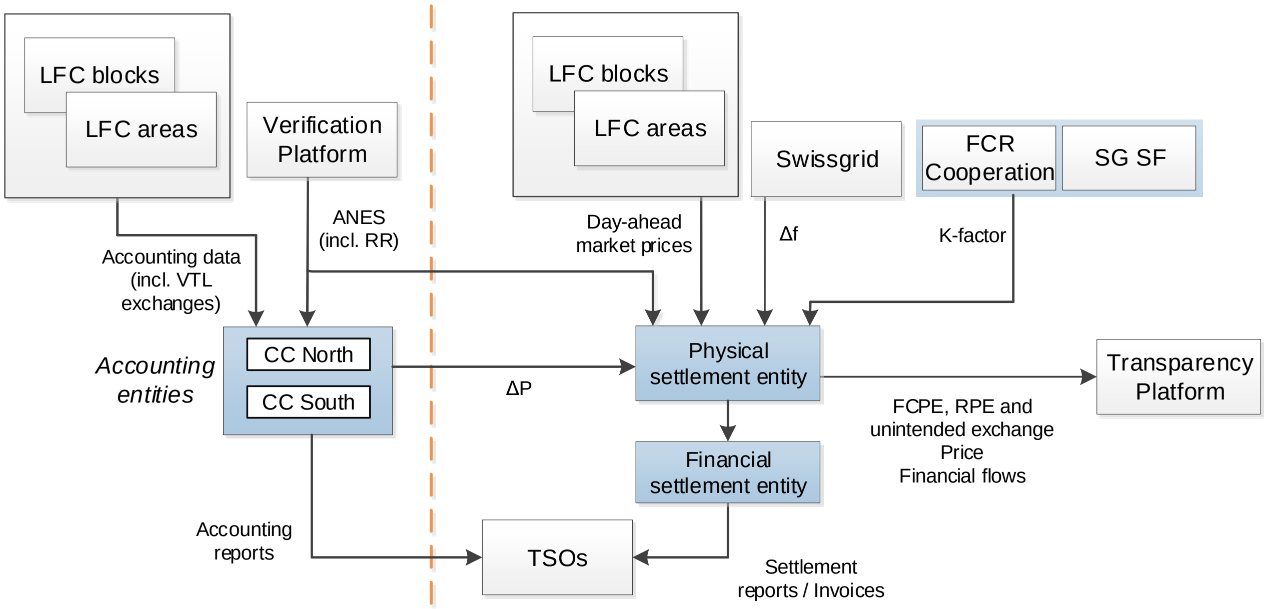

Figure 9: Data exchange between different entities for FSkar

Table 5 describes the individual exchanges in more detail.

Table 5. Data exchange with entities and transparency platform

Data	Explanation
	Data sent to accounting entities
ANES (incl. RR)	Will be sent once per day. 15 min verified values. Details in chapter 7.6
Accounting data	Will be sent once per working day. 15 min values. Details in chapter 7.5
	Data sent to settlement entity
ΔP	Will be sent once per week. 15 min verified values. Calculated by the accounting entity
Δf	Will be sent once per week. 15 min verified values. Details in chapter 7.2
Day-ahead market prices	Will be sent once per day. 15 min values. Details in chapter 3.5.3
k-factor	For SG SF. Will be sent once per year For FCR cooperation. Will be sent once per week or once per day (depending on the procurement). Details in chapter 7.3
ANES (incl. RR)	Will be sent once per day. 15 min verified values
	Data sent to transparency platform
FCPE, RPE and UE **Price for FCPE and UE** **Financial flows**	Will be sent once per month. Calculated by the settlement entity
	Data sent to the TSOs

Accounting reports	A daily report shall be sent daily. A final weekly report shall be sent weekly.
Settlement reports	Will be sent once per week.
Invoices	Will be sent once per month

7.2. f-measurement

Introduction

The frequency deviation is one important parameter to determine the price for unintended exchange and FCP energy. How to collect, process and distribute frequency data is described in this chapter.

Analysis

- Swissgrid provides the frequency data. The data are received directly from the Load Frequency controller in 1-sec resolution. This data is also used by the platform Vulcanus and are published under the section "frequency statistics" at Swissgrid's website. The argumentation why frequency data from Swissgrid shall be used is as follows: Swissgrid sets the frequency set point and Swissgrid's frequency data are also used in reporting of the ENTSO-E Regional Group Continental Europe (RG CE) committee (LFC report, Vulcanus).
- The Laufenberg node is used for measurement. In case this node is out of operation, there is a priority rule defining from which of the other 22 metering points of Swissgrid to take the data.
- The measurement of the frequency deviation is defined as: (actual – nominal (set point)).
- Available data by Swissgrid: nominal value, ΔT (the duration of frequency deviation within a predefined time frame) and Δf. Only the frequency deviation is needed, in which the nominal frequency is already taken into account.
- Swissgrid's system transforms the data in 15-minute resolution and exports them to Vulcanus. An additional export will be set up for sending the data to Amprion, for validation purposes, and the validated data will be then distributed to the settlement entity.
- The validation process is defined as follows:
  - Swissgrid sends, on a weekly basis, the data of the frequency deviation in a 15-minute resolution to Amprion.
  - Amprion compares the data provided by Swissgrid with Amprion's data for each 15-minute interval.
  - As a first step, Amprion checks whether both measurements for each 15-minute interval lies within the adequate frequency range (currently defined as ±20 mHz). In case both measurements fulfil this condition, then the validation process is completed and the data provided by Swissgrid will be used in the settlement process.
  - In case at least one measurement, either the one from Swissgrid or the one from Amprion or both, lie outside the adequate frequency range (currently defined as ±20 mHz), Amprion checks whether the absolute difference between the two measurements for the respective 15-minute interval is higher than 3 mHz[1].
    - In case the absolute difference is lower or equal to 3 mHz, the data provided by Swissgrid will be used in the settlement process.
    - In case the absolute difference is higher than 3 mHz, the arithmetic mean of the two measurements will be used in the settlement process.

[1] A comparison of the data for the frequency deviation in 15-minute resolution for the year 2016 between Swissgrid and Amprion was conducted. The results showed that the absolute difference between the two data sets was lower or equal to 3 mHz in 99.24% of all measurements in the given year.

- There might be exceptional cases, in which a measurement(s) for a specific 15-minute interval(s) might be missing either from Swissgrid or Amprion, due to potential IT problems. In such cases, the respective measurement(s) of the other TSO shall be used in the settlement process.

7.3. Day-ahead market prices

The following remarks concern the delivery of day-ahead market prices:

- LFC areas send the day-ahead market prices for their LFC areas, if available, to the entity entrusted with the settlement function. The different cases for LFC area/block/bidding zone configuration have been described in Chapter 4.5.
- Since settlement shall be done once per month it should be sufficient to send the day-ahead market price data once a day.
- The settlement entity shall calculate the equivalent prices for LFC blocks according to the rules above established in the CCU, before performing a calculation of the price for unintended exchange and FCP energy for SA CE.
- Prices are sent in EUR/MWh.

7.4. k-factor

SG SF determines once per year the k-factor for each LFC area. This information must be send by SG SF to the settlement entity.

There is an FCR cooperation consisting of Belgium, Netherlands, Germany, Switzerland, Austria and France. Within this FCR cooperation, a common procurement is done. The results of the procurement will lead to a change of the k-factor since FCR is the most important component of $k\Delta f$. The joint k-factor of the participating countries remains however equal to the sum of the k-factors determined by SG SF.

Procurement is done weekly. By this, changes of the k-factor due the FCR cooperation have to be communicated to the settlement entity.

7.5. Accounting data

The accounting data refers to the validated data for metered exchanges over tie-lines, also over virtual tie-lines (VTL), between neighbouring TSOs. For the agreement on accounting data by the TSOs, there is already an established process described in the SAFA. This process is continued and the accounting data is further sent to the accounting entities. Exchanges done through IGCC and PICASSO will be performed through virtual tie-lines and are as such included in this accounting data.

7.6. Aggregated netted external schedules (ANES)

The ANES shall include all exchanges of energy which are performed based on schedules. This includes market exchanges as well as other TSO-TSO exchanges. The ANES are to be taken from the Verification Platform for the purposes of FSkar, since the data on the Verification Platform is already verified. It is worth noting that, at the current time, MARI and TERRE plan on exchanging energy through schedules to be included in the ANES.

7.7. Unintended exchange and FCP energy

There is already a process for calculating unintentional deviation values in the accounting entities for the compensation programme. The accounting entities do already have theANES available. The accounting entities shall send the unintentional deviation to the settlement entity on a daily basis. The ACE, $k\Delta f$ and ramping period volumes will then be calculated by the settlement entity.

7.8. Data delivery setup

- Frequency: the frequency data are already available at the accounting system from Swissgrid. About two months were required to set up the exports to the settlement entity. Moreover, it required some time to set up the validation process at Amprion. This was also estimated to be possible within a few months.
- ΔP: The accounting entities will send the ΔP values to the settlement entity. Based on this information, the k-factors and frequency deviations, the settlement entity will calculate the $\int ACE$ and $\int k\Delta f$ values and ramping period energy values.
- k-factors: for the calculation of $k\Delta f$, the settlement entity needs the k-factors of the different LFC areas or blocks. For this, the values determined yearly by SG SF should be used. Moreover, because of the FCR cooperation a weekly and even daily update might be.
- Day-ahead market prices: Each LFC area, or alternatively, each LFC block monitor (when agreed by all LFC areas of the LFC block), has to set up a data exchange with the settlement entity. Moreover, if the LFC block consists of an area with more than two day-ahead market prices, the LFC block monitor would have to set up an internal process as well, in order to calculate the weighted average day-ahead market price of the LFC block.

8. Annex I: CCU and CCFR mapping

This Annex gives a cross-reference between the articles of the CCU and CCFR and this document, indicating the chapters where more information can be found.

Article 1 Subject matter and scope	Chapter 3.1
Article 2 Definitions and interpretation	Chapter 3.2 and 3.3
Article 3 High-level design of the common settlement	Chapter 4.1
Article 4 Implementation of the common settlement	Chapter 6
Article 5 Functions of the common settlement	Chapter 4.1, 4.2
Article 6 Settlement period	Chapter 4.3
Article 7 Volume determination per TSO-TSO settlement period	Chapter 4.4
Article 8 Pricing rules for TSO-TSO exchanges within synchronous area Continental Europe	Chapter 4.5
Article 9 Publication and implementation of the CCU/CCFR	N/A
Article 10 Language	N/A

9. Annex II: Abbreviations

The following abbreviations have been employed in this document.

EBGL	Electricity Balancing Guideline
TSO	Transmission System Operator
ACE	Area Control Error
$k\Delta f$	Exchange as a result of the frequency containment process
RP	Ramping period
CCU	Common settlement rules for Continental Europe for Unintended exchange
CCFR	Common settlement rules for Continental Europe for Frequency containment process and Ramping period
SOGL	System Operation Guideline
SA CE	Synchronous Area Continental Europe
SG SF	Subgroup System Frequency
FCPE, $\int k\Delta f$	Frequency containment process energy
RPE	Ramping period energy
UE, $\int ACE$	Unintended exchange
ANES	Aggregated netted external schedules
FSkar	Financial Settlement of $K\Delta f$, ACE and ramping period
RPM	Reference Price Model