2022 BALANCING INCENTIVE REPORT

Analysis on the possible optimizations to the estimations and compensations of grid losses.

Report to CREG – 30 June 2022

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1. Introduction

This final report intends to deliver on the deliverable described in the balancing incentive description and will, as foreseen by the incentive, also be published on Elia's webpage and communicated to the market parties (WG Balancing).

While the incentive considers more aspects then those covered by this report, this report deals with the following elements mentioned in the incentive (own translation):

- Analysis of the current forecasting method of regional and federal grid losses
- Analysis of the efficiency of the current method for compensation of the grid losses (compensation in kind for the federal grid losses and procurement for regional grid losses) in comparison with a compensation via procurement for both regional and federal losses.
- A benchmarking with methods of neighbouring TSOs (at least 5 TSOs, including Amprion, Tennet and national Grid) for the forecasting of grid losses and their compensation

The other aspects of the incentive (proof of concept (POC) on forecasting with a test period, assessment of its advantages and – when the POC is positive – an impact analysis and implementation plan) are due for later moments and deliverables.

This final report follows on already earlier interactions between experts of Elia and CREG related to the execution of this incentive, in particular two specific meetings held in April and May 2022. Moreover, this final version also takes into account feedback received from CREG on the earlier draft version of the report.

The remainder of this report is structured as follows. Firstly, a brief technical introduction on the origin of grid losses is provided in order to provide a better technical understanding and illustrate in the technical drivers the impact of the evolution of the grid losses over the years. Secondly, after having described the contours of the currently applied processes for compensating the losses, the analyses on the current forecasting and the efficiency of the current mechanisms are discussed by means of different angles on historical data related to the grid losses. This also includes, as required by the incentive, a view on the efficiency of an alternative way of working with Elia procuring also federal grid losses. Next, the international benchmarking results are provided based on a study conducted for Elia by SIA Partners. The full SIA Partners study results are also annexed to this report. Finally, a possible switch of the in kind compensation by BRPs to procurement by Elia for the federal losses is reflected upon and an Elia proposal for the short- to mid-term with two options is made on how – based on the findings in the earlier sections – the compensation mechanism may evolve in order to more optimally compensate the losses.

2. Description and analysis of the current estimation and compensation approach

2.1. Scope of losses covered

From a mathematical point of view, the power losses are described as the amount of heat per second that develops in a wire carrying a current. These power losses are proportional to the electrical resistance *R* of the conductor and the square of the current *I*. This relation is known as the Joule's Law and is described in the following formula. The resistance of the conductor can be developed taking into account the length of the conductor *l*, the cross-sectional area of the conductor *a* and the resistivity of the material *ρ*.

$$Power\ Losses = R \cdot I^2 = \rho \cdot \frac{l}{a} \cdot I^2$$

From the developed Joule's law, the main variables impacting the total losses on the network can be deduced. The choice of the material has an impact on the resistivity of the material and the cross-sectional area. However, the choice of the material also takes into account other considerations such as the cost of the material, the advantages of the material (e.g., the new HTLS increase the losses but have a significant higher transmission capability than current technology) and the disadvantages (e.g., the weight). The length of the conductor affects the power losses, or in other words: the distance between the production centre and the load affects the power losses. The increase of decentralized production will lead to a decrease of the losses, especially at the regional level. The last term is the current squared, which means that for an increase of a factor 2 of the flow, the losses are increased by a factor of 4.

From a practical point of view, the active electrical losses on the network consist primarily of:

a) Losses due to the magnetization of transformers once they are energized. These losses are called "iron losses" or "no-load losses"
b) Losses due to the heating of windings in transformers when the current is flowing through them. These losses are called "copper losses" or "load losses".
c) Losses due to the heating of conductors in overhead lines and underground cables as a result of the power transmitted by such equipment. These losses are called "copper losses" or "load losses".

While the "iron losses" remain relatively constant, the "copper losses" depend on the square of the current transmitted by the equipment. These losses also depend on the manufacturing characteristics of the equipment (length of the circuit, cross section of the conductors and type of materials used in the conductors). Consequently, active electrical losses on the network correspond to power that is dissipated in the form of heat, by natural ventilation or by forced cooling in order to keep the operating temperatures of equipment below the specified manufacturer's limit.

Belgium's federal electricity network consists of equipment operating at nominal voltages of 380, 220,150 and 110 kV. The equipment considered consists of overhead lines, underground cables, HVDC cables[1], phase shifting transformers and power transformers, which connect these voltages. The federal losses are calculated taking into account the above-mentioned equipment excluding any equipment that is part of users network connections.

Elia's regional electricity network consists of equipment operating at nominal voltages of 70, 36, 26 and medium voltage (15 kV and below). The equipment considered consists of overhead lines, underground cables and power transformers. The regional losses are calculated taking into account the above-mentioned equipment excluding equipment that is part of users' network connections.

Schematically, the grid can be represented as follows:

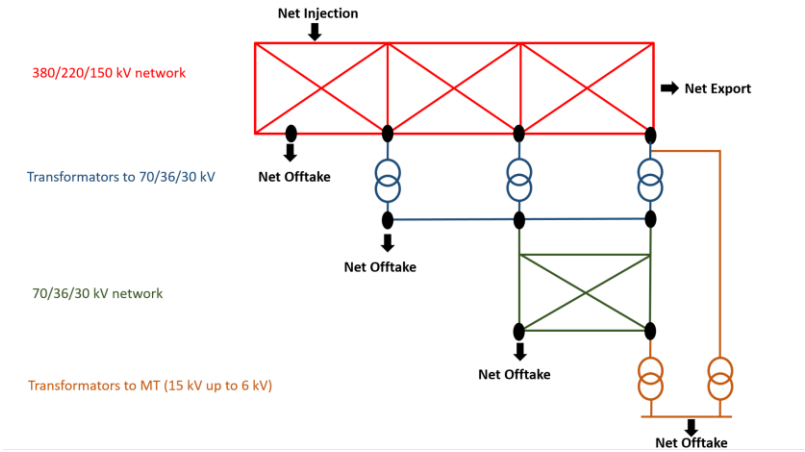

Figure 1. Schematic view on the Belgian grid.

The way to calculate the losses in the system starts from the integration of the system measurements, which consist of the voltage profile (magnitude and phase) at each node of the grid. Then, using the equivalent electrical circuit for each element (lines and transformers), we can calculate with the state equations all the variables of the system and find the power flow associated to each element.

1 The active losses in the Nemo Link HVDC are not taken into account. A separate framework covers these losses.

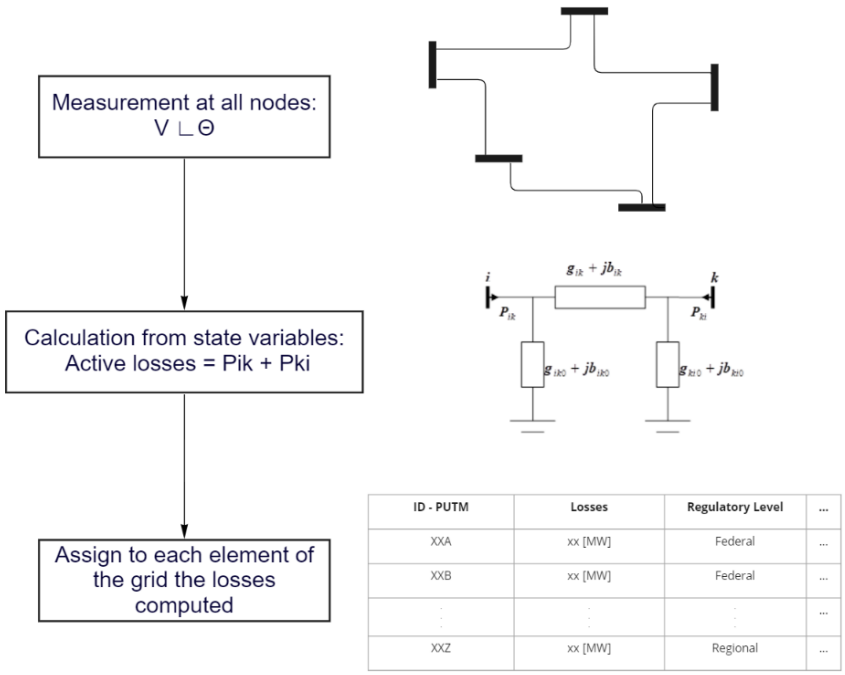

Figure 2. Losses Calculation Process.

The losses are then calculated from a simple subtraction of the active power received and the active power delivered by each element. The computation is aggregated over a 15-minute period for each element and stored in a database for further use.

2.2. Description of the two-fold compensation mechanism

In this section the approach for the compensation of the regional losses as well as the approach for the federal losses are described. It aims to sketch a clearer view on the current way of working as applicable for several years already.

Note that the approaches for the compensation of the losses are rooted in legislation at regional and federal level. At regional level, the applicable Flemish, Walloon and Brussels' legislative texts mandate Elia to procure the necessary volumes on the market. For the federal losses, the federal grid code determines the obligation for the BRPs to compensate for these losses, based on which the exact methodology is further detailed in the Terms & Conditions BRP.

Finally, the activities related to the compensation of the losses are obviously also part of the regulated activities of Elia which are controlled by the CREG. In this context, Elia reports already for several years to CREG on a regular basis on different aspects linked to the compensation of the losses. This includes the volumes procured by Elia and the costs linked to it, the supply gap and the delta in compensation by BRPs of the federal losses (the so-called 'écart de compensation des pertes fédérales en nature par les BRP' or 'ardoise'). Furthermore, CREG has laid an incentive ("influencable cost") on Elia targeting that Elia would buy at the best possible market prices for the long-term contracts.

In addition, at European level the so-called inter-TSO compensation mechanism foresees in a redistribution of costs linked to losses resulting from international exchanges. The contours of this mechanism and how it relates to the approach of covering the losses at national level are explained at the end of this section.

2.2.1. Regional approach

This section describes the regional approach. At first the process leading to the determination of the volumes procured regionally is described. Next, the procurement process itself is discussed.

2.2.1.1. Volume determination

The volume that Elia has to procure in order to cover the regional losses is determined based on the historical losses and the forecasted evolution of the regional losses. The forecast of the regional losses is estimated by Elia based on simulations taking into account several parameters as for example the evolution of the load and the evolution of the installed decentralized production. From this input, Elia generates a time series for the regional losses for the next year.

From this time series, Elia optimizes the procurement of the regional losses. To perform this task, Elia has two degrees of freedom per month:

- A fixed volume which is constant for each day of the considered month (=baseload volume)
- A fixed volume to procure which is added to the baseload volume during the peak periods (=peakload volume). The peak periods are each weekday from 8 a.m. to 8 p.m.

The baseload volume is rather constant from one year to another one. The regional losses are highly correlated to the consumption. The baseload consumption is not significantly evolving each year which allows to forecast it rather well. An important factor that can affect the baseload volume could however be the temperature. For example, if we have a milder winter than the previous year, the load level could be lower. This information is not available in a monthly or yearly forecast and can lead to an over-or under procurement.

The peakload volume is more complex to determine. There is a trade-off between an over- and an under procurement of the regional losses during peak periods. An additional volume of 5 MW procured during the peak periods can reduce the losses not covered, but can also increase the over-procurement (cf. section 2.3.2). In the last years, the regional losses are mainly evolving due to the increase of the decentralization production. This increased complexity for the volume determination process of the losses during the peak period is highly linked to the decentralized production (mainly solar production).

2.2.1.2. Procurement process

Pursuant to Belgian regional legislation, Elia Transmission Belgium (“Elia”) has to purchase the losses incurred on its regional grids (70 to 30kV). The current tariff methodology foresees that Elia receives an incentive for reducing as much

as possible the unit price of energy purchased to compensate grid losses, meaning to purchase when market prices are most favourable. The objective of this incentive is to stimulate Elia to act as a good housefather.

In order to achieve the aforementioned objective, Elia applies a strategy that spreads the risk over time and that still allows Elia to try to get better prices than buying indiscriminately without being too speculative.

Volumes purchased by Elia and fees charged by power exchanges historically did not justify to place orders directly on the market. Therefore, Elia purchases its grid losses volumes via auctions where suppliers qualified in accordance with the European qualification procedure are invited. All market parties are allowed to enter into the qualification process on simple request if they are fulfilling the qualification criteria.

Volumes are purchased up to 3 calendar years in advance. Elia spreads all auctions for Calendar products over the three preceding years and all quarter products over the preceding year; however Elia may deviate from this strategy in case of extreme market conditions.

Example:

- *If 45 MW is to be bought for Calendar year Y, Elia will purchase 15 MW in Y-1, 15 MW in Y-2 and 15 MW in Y-3 with each three auctions for 5 MW spread out over the year, typically in Q1, Q2 or Q3 and Q4. This way the 45 MW is spread across the three preceding years evenly. In this example, Elia may also decide for the Year-1, to buy Calendar product or Quarter products depending on the market attractiveness and trends.*
- *If 10 MW is needed for quarter 4 of year Y (Q4Y), 5 MW will be bought in Q4 Y-1 and 5 MW will be bought in Q3Y. This way the 10MW is spread across the preceding year evenly.*

The purchased volumes are usually bought in blocks of 5 MW (or 10MW if required), as experience has shown that suppliers charge an additional premium for smaller or irregular shaped volumes due to lower market liquidity. Larger blocks (>10MW) make it difficult to maintain the price spread strategy and may limit competition due to lower interest from smaller players.

In order to decide when to perform an auction, Elia has enlisted the support of a specialist consultancy agency that follows market trends, advises on optimal purchasing strategies, provides data based on purchase decision mechanisms and supplies reports and market insights that provide recommendations on when to execute an auction. However, the final purchase decision remains with Elia. The consultancy firm provides daily/ bi-weekly and monthly follow up.

Daily follow up

Elia receives on a daily basis Value at Risk (VaR) reports that show the secured volumes, open volumes, market capitalization based on end of day closing price, baseline volumes and historic auction dates for each year. This allows Elia to review the amount “open to buy” and the impact of changing prices to the total value. Additionally, Elia receives three daily follow up reports (one for each calendar year) with technical trend analysis and hedging recommendations

that allow Elia to assess if that day is a good moment to perform an auction and for what volume. Key metrics here are 20 days and 50 days running average of market closing prices for that CAL product.
The daily follow up also includes general feedback from the aforementioned specialist consultancy agency which states what major events are occurring in the world that might have an effect on market prices.
When the consultancy agency recommends holding an auction, Elia sets up a call to discuss the proposed auction in order to understand the underlying reasons for the recommendation. Elia will then decide to hold the auction or not.

Bi-weekly follow up
On a bi-weekly basis, the consultancy agency sends an update on recommendations for all EU Electricity and gas futures. This report includes:

1. EU Energy market conditions
2. Bullish and bearish drivers for the underlying commodities
3. A short term technical outlook
4. Risk management strategic recommendations

Monthly follow up
Every month a meeting is held between the specialist consultancy agency and Elia in order to discuss all market parameters that are influencing electricity prices. The report is similar to the bi-weekly report but goes into greater detail and allows us to consider actively Elia's short-term purchasing strategy based on market trends, expectations and global geo-political issues that may influence prices.

2.2.2. Federal approach

This section describes the process for the compensation of the federal losses, at least the part which is governed by Elia. First, the overall process is described. Next it is described how the long-term financial neutrality for BRPs, i.e. ensuring they on the long run do not over- neither undercompensate on the federal losses, is ensured.

2.2.2.1. Process

Once per year, Elia has the responsibility to determine the contribution expected from each Balance Responsible Party (BRP), which is expressed in the form of a percentage of net offtake linked to the portfolio of the BRP. The percentage is communicated to the BRPs around June Y-1 and is determined as a result of the following process.

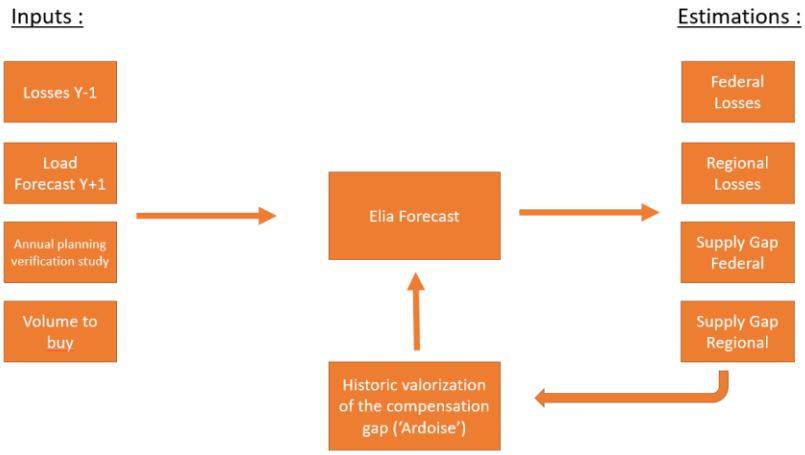

Figure 3. General federal losses compensation mechanism.

In June Y-1, Elia performs a forecast for the next year of the federal and regional losses. The inputs required are the losses of the previous year and the report containing the simulation for the by Elia forecasted evolution of the losses. This report describes the upcoming changes in the Elia network and their impacts in terms of additional federal and/or regional losses. For example, the increase of federal losses due to the commissioning of Alegro was expected to be 85 GWh per year. For the forecasting process, this additional component was equally distributed through the year in order to take into account the impact of this new asset.

Once the federal and the regional losses are estimated, the forecasted load Y+1 is used to determine by a linear regression the net offtake Y+1. Based on this last estimation of the volume that Elia has to procure in order to cover the regional losses (cf. supra) and the same compensation in-kind percentage than the previous year, the residual federal and regional supply gap is calculated.

All the previously calculated variables (federal losses, regional losses, net offtake, federal and regional supply gap) are necessary to update the historic valorization of the compensation gap (so-called “ardoise”, cf. next section). From this first estimation, the compensation in-kind percentage is updated iteratively in order to ensure the long-term financial neutrality. The final compensation in-kind percentage is the one ensuring the long-term financial neutrality. This final compensation in-kind percentage is communicated to the BRPs.

2.2.2.2. Striving for long term financial neutrality for BPRs

The compensation gap values the difference between what the BRPs should have provided in-kind and their actual contribution through the application of the percentage associated with the net offtake attached to their portfolio. The

aim of the long-term financial neutrality is to ensure the value of the compensation gap nets out to zero over a long period.

In a perfect world, the BRP would perfectly compensate the federal losses and the financial neutrality is ensured. In reality, the federal losses and the compensation provided by the BRPs might be different. This can be due to the fact the Y-1 estimated losses deviate from reality, but also because of the volatility of the losses throughout the year that does not fully follow the evolution of the net offtake on which the percentage is applied. Therefore, the BRPs either overcompensate or undercompensate over the period considered.

In case BRPs did not compensate sufficiently in kind the federal losses, the supply gap is added to the system imbalance which can trigger activation of balancing energy by Elia. The balancing energy activation has therefore covered energy that would not have been purchased if the compensation had been perfect. The BRPs have a debt to the system.

An equivalent reasoning applies when BRPs have over-compensated. In this case, the system benefited from the excess energy supplied by the BRPs. Therefore, the system has a debt to the BRPs.

Now it is necessary to value the cases of the over- and undercompensation. This valorization of the compensation gap is decomposed in two parts. The first part is the valorization of the total difference between the federal losses and their associated compensation in-kind by a fixed percentage (volume). The second part is the valorization of the corrected upward or downward activation that Elia had to perform using balancing means (price). A final monthly value in € is considered for the valorization of the compensation gap.

<u>Valorization of the total difference between the federal losses and their associated compensation in-kind by a fixed percentage:</u>

The first step consists in valuing the total difference for a considered month between what the BRPs compensated in-kind by applying the fixed percentage and what they should have actually compensated following the calculation of the federal losses. The difference is calculated based on the following formula for peak (P) and the off-peak (OP) periods.

$$\begin{cases} Compensation\ Gap_P\ (MWh) & = Federal\ Losses_P(MWh) - Net\ Offtake_P\ (MWh) \cdot \%_P \\ Compensation\ Gap_{OP}\ (MWh) & = Federal\ Losses_{OP}(MWh) - Net\ Offtake_{OP}\ (MWh) \cdot \%_{OP} \end{cases}$$

In order to value the compensation gap, Elia considers that the BRPs would have bought or sold this energy at the same price that Elia bought the energy required to cover the regional losses.

$$\begin{cases} Compensation\ Gap_P\ (€) & = Compensation\ Gap_P\ (MWh) \cdot Price\ LT\ regional\ losses_P\ (\frac{€}{MWh}) \\ Compensation\ Gap_{OP}\ (€) & = Compensation\ Gap_{OP}\ (MWh) \cdot Price\ LT\ regional\ losses_{OP}(\frac{€}{MWh}) \end{cases}$$

If the compensation gap is positive, Elia has to recover the resulting amount because the BRPs have not compensated enough. If on the other hand the difference is negative, it means that the BRPs have compensated too much that they will have to recover this amount at a later moment.

This first part considers the total volumes of the month. However, in quarter hour granularity, Elia will have had to make adjustments upwards or downwards using balancing energy in order to cover the positive and the negative difference. Therefore, a second part concerning the valorization of the activation of balancing energy is linked to the supply gap.

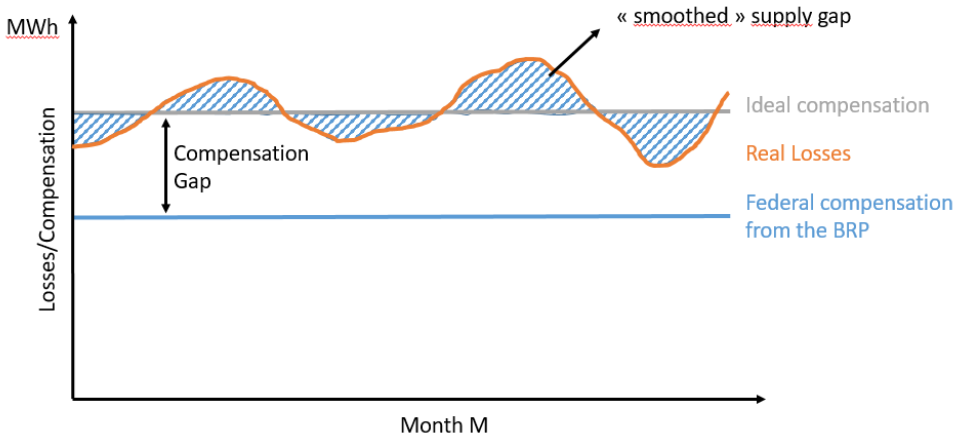

Figure 4. Federal compensation from BRPs..

Valorization of the activation linked to the supply gap:

The first step in the calculation was to value the total difference for a month between the percentage compensation and the actual federal losses. Even if the total in MWh remains the same on average over the month, sometimes it was necessary to activate upwards and sometimes downwards. This total upward volume over the month and the downward volume are equivalent in absolute value, but the upward valuation is not the same as the downward valuation. Indeed, the time of day, the season, or the market conditions also influence the prices.

Since the upward and downward activated volumes cancel each other out, it is necessary to correct the total supply gap by "smoothing" it around its average. For this process, the total supply gap is considered, which is defined as the sum of the federal supply gap and the regional supply gap. A correction is performed later in the process in order to only value the federal supply gap. This allows us to obtain the volumes that, in theory, would have to be activated in the upward and in the downward directions, and whose sum over the month is zero. After this correction, we obtain the corrected supply gap for each direction.

For this part of the valorization, Elia considers four different categories: the upward activation during peak and off-peak periods and the downward activation during peak and off-peak periods. An upward activation takes place when the

corrected supply gap is positive, and a downward activation takes place when the corrected supply gap is negative. For each category the volume considered and the related price, have to be defined. The volume of one specific category is obtained by making the sum of the corrected supply gap. In order to value the volumes calculated for each category, Elia associates the corrected balancing pool prices with them. Indeed, it is the adjustments considered in the pool that will have been used to fill the supply gap of the losses.

There is still one last correction to be made for this second step. Indeed, the total supply gap was considered here. However, in the context of federal losses, it is now necessary to take into account only the part of the corrected supply gap valued above. In order to account only for the valuation in EUR associated with the supply gap of federal losses, a rule of three is applied to the amounts obtained in this second step.

Total Valorization:

The estimated total valorization for the next year is obtained by making the sum of the valorization of the activations linked to the supply gap and the valorization of the total difference between the federal losses and their associated compensation in-kind by a fixed percentage. The total valorization is a final amount, it does not take into account the period considered. The total valorization is calculated per month.

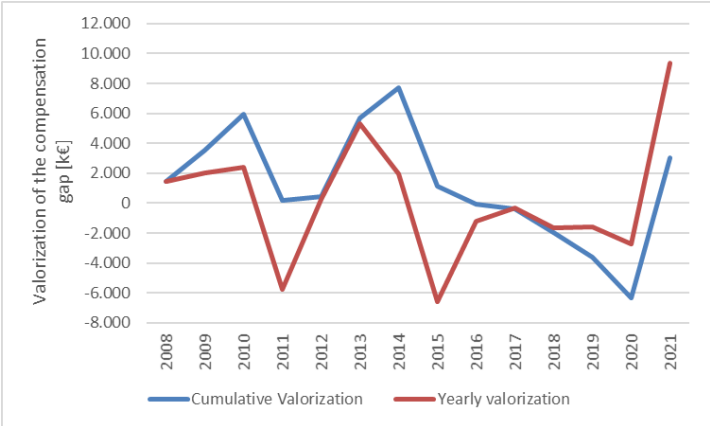

Figure 5: Yearly and Cumulative evolution of the valorization of the compensation gap

In order to ensure the long-term financial neutrality for BRPs, the estimated total valorization for the next year is added to the cumulated status of the compensation gap calculation. The figure 5 shows the evolution of the cumulative valorization of the compensation gap since 2008 and the yearly valorization used to generate the cumulative evolution. Since 2008, the cumulative valorization of the compensation gap has fluctuated around zero, which is the long-term objective of the methodology in place.

The new percentage is fixed based on the forecasts performed per Elia but it also takes into account the cumulated status of the compensation gap calculation. Therefore, the determination of the percentage has a double goal, the need

to cover the federal losses and in addition to ensure the long-term financial neutrality for BRPs for their compensation in kind.

2.2.3. The European level: the inter-TSO compensation (ITC) mechanism

While in each country a losses compensation mechanism is in place to cover the grid losses, it is foreseen by European legislation that a redistribution of costs takes place between the TSOs to compensate for the effects created by international (transit) flows. This mechanism is called the inter-TSO compensation (ITC) mechanism.

In essence the ITC mechanism consists of two parts. Firstly, there is a block focussing on infrastructure costs. For the purpose of this study, it is rather the second block, focussing on cost related to the compensation of losses, that is relevant. In the remainder of this section, only this second block is further addressed.

The ITC mechanism is directly governed by EU Regulation 838/2010. A multi-party agreement among TSOs facilitated by ENTSO-E is in place arranging the practical and concrete execution of the ITC mechanism. ENTSO-E plays a coordinating role and ACER is tasked with the monitoring of the mechanism. The detailed functioning of the ITC mechanism related to losses is available in the yearly ENTSO-E report addressing this matter.[2]

The ITC mechanism linked to losses compensation can be summarized as a mechanism where TSOs that are considered the 'sources' or 'sinks' of international flows, i.e. net importing or net exporting zones compensate costs of zones that are rather 'transited' as a consequence of the international flows triggered by the sources and the sinks. This means that when a zone compared to the other zones in the mechanisms is more considered as a transited country rather than a source or a sink, it will benefit more from the mechanism while the others contribute more to the financing of the mechanism. This is clearly not a fixed situation, settlement of the ITC mechanism happens on a monthly basis and the import/export situation taken into account is obviously based on what is observed on the grid. In recital (6) of EU Regulation 838/2010, the goal is summarized as follows:

> *"(6) Transmission system operators should be compensated for energy losses resulting from hosting cross-border flows of electricity. Such compensation should be based on an estimate of what losses would have been incurred in the absence of transits of electricity."*

Power flows are however not easily decomposed and follow the laws of physics, nevertheless in Regulation 838/2010 the above principles are further translated in more explicit descriptions on how to apply them. It boils down to a calculation 'with and without transit', i.e. the actual flows and losses are compared to a calculated estimation to what would have been the flows and losses without transit. The delta defines the losses caused by the transit flows through the

[2] https://www.entsoe.eu/publications/market-reports/#itc-transit-losses-data-report

grid of the country and are then valued at the relevant cost of losses of that country. For the resettlement the total sum of those costs for transit losses for all considered TSOs is then redistributed over the TSOs in function of their 'contribution' for having caused the transits or not. TSOs who had more transits in principle will receive compensation, TSOs who were causer of transits (source/sink) will pay compensation.

The existence of this ITC mechanism ensures that when a country is affected by international transit flows that cause losses in its grid it is fairly compensated for this. The advantage of this organisation is that irrespective of the approach followed in each individual country, a single way of compensation is in place. In Belgium, any proceeds or costs following the application of the ITC mechanism are a pass-through to the transmission tariffs to the benefit or cost of the end-consumer.

The ITC mechanism and the sourcing of (federal) grid losses are two separate matters. The ITC is an ex post international redistribution of costs. It is not taking into account, nor is it designed to cover the gird losses that occur in real time. The compensation of losses in real time requires a much more operational mechanism. This also implies that the ITC mechanism, together with how it is dealt with in the Elia tariffs, should not impact or drive the assessment of which approach is best followed to compensate the losses at national scale. Therefore, for the remainder of the analysis of this study the ITC mechanism is not further addressed, neither is deemed necessary nor useful to mix the goal of the ITC (i.e. compensation of costs linked to transits) with the assessment of compensation approaches at Belgian level.

2.3. Analysis of the current method of forecasting federal and regional losses

How in today's two-fold mechanism the forecasting is done is already described in the previous sections. As the current compensation approach only consists of long-term calibrated aspects, there is today no short-term forecasting in place that could be analysed.

Nevertheless, the performance of the current losses compensation and in particular to what extent the long-term forecasts are sufficiently effective, can be analysed by looking at the supply gap, i.e., the shortfall or surplus resulting from the compensation done for the regional and federal losses. While in the end, there is only one supply gap of the overall compensation approach, for the purpose of assessing and better understanding the approaches and identifying any potential for improvement, it makes sense also addressing the supply gap from a regional and federal perspective separately.

2.3.1. Historical performance statistics: federal level

As discussed before, Elia establishes a year in advance the percentage by which the BRPs will contribute to the compensation in the federal losses depending directly on the their (net) offtake. To better compensate the losses, the first mechanism was to establish a different factor for peak and off-peak periods over the week (peak: weekdays 8h-20h, off-peak: weekdays 0h-8h 20h-24h & weekends).

Table 1. Federal losses compensation.

Year	Compensation OFFTAKE Factor %		Compensation in kind [GWh]
	Peak	Off-Peak	
2016	1,35%	1,25%	847
2017	1,35%	1,25%	846
2018	1,3%	1,2%	813
2019	1,45%	1,35%	869
2020	1,45%	1,35%	810
2021	1,35%	1,35%	834
2022	1.45%	1.45%	-

This factor was set to a single value for both periods (peak and off-peak) since 2021, mainly driven by the slight over-compensation in the years right before. Ideally, a 100% compensation should be achieved, but the implementation encounters different challenges such as decentralized generation, weather variations, seasonality, cross border exchanges, etc. that renders the calibration of the percentages a difficult task, a fortiori given the inherent uncertainties year ahead. Also, having to summarize the needed compensation in one or two percentages, limits the degrees of freedom towards a more granular approach.

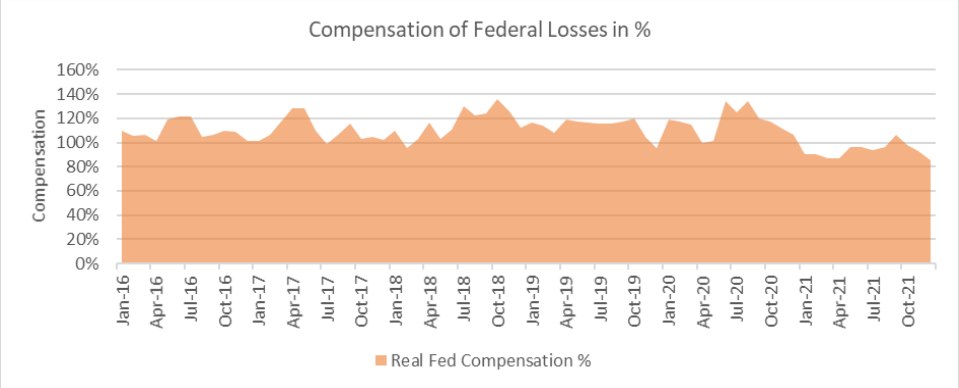

Figure 6. Historical federal losses coverage.

Although, the tendency of the compensation of losses in the federal level tends to be quite stable (in average 110%, which also accounts for the efforts to carefully assess the percentages in view of LT financial neutrality, cf; above), there is a component in the system (not new, but that has drastically changed since 2019) linked to the exchanges between countries. Especially exports are relevant in this context. Indeed, as the compensation in kind is linked to BRPs' net offtake, exports are somehow not fully captured on the radar. In case of a (net) import, this import contributes to feed the (net) offtake on which the percentage for the losses contribution is directly applied. Hence, in case losses on the federal grid occur because of import, there is a rather direct link with the losses compensation, especially insofar (losses linked to) higher imports would correlate positively with higher net offtake. Such direct link is not present in cases of net export. Indeed, when exporting more and causing more losses linked to those international flows, there is not an inherent link with the net offtake that calibrates the compensation of the federal losses. It somehow falls off the

radar and thereby can lead to a considerable federal supply gap when such exports where not (sufficiently) anticipated when calibrating the percentages for a next year.

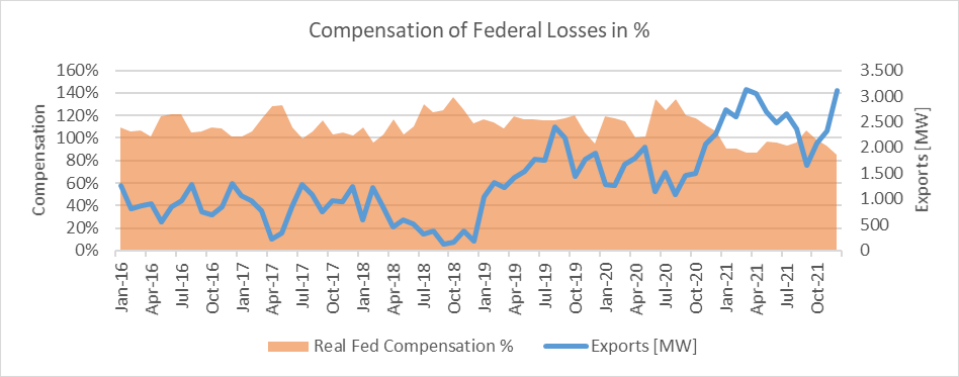

Figure 7. Historical federal losses coverage with historical exports evolution.

As illustrated in the figure above, exports have drastically increased in 2019, with a slight decrease in 2020, and again a steep increase in 2021. Although not directly correlating with net offtake or following a similar pattern throughout a day, a higher peak / off-peak compensation factor could decrease the deficit insofar exports are sufficiently structural and could thereby ensure the LT financial neutrality for BRPs aimed for.

To have a more detailed view on the compensation made by the BRPs, the cumulative distribution curve is provided below. This graph describes the real percentage of time where the BRPs have provided more than enough compensation (leading to a negative supply gap) or whether the BRPs provided less than required (leading to a positive supply gap).

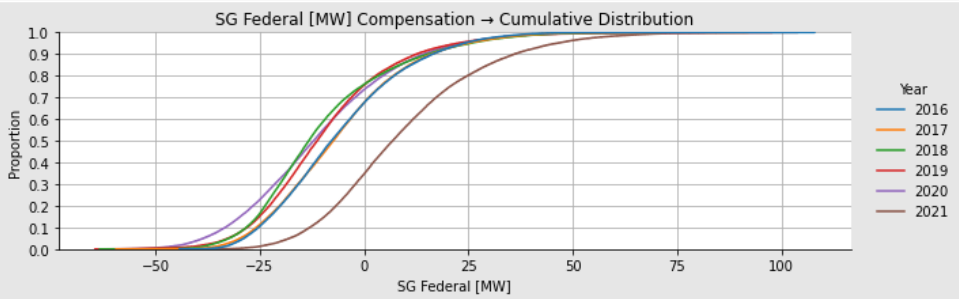

Figure 8. Historical federal losses coverage with historical exports evolution.

The impact of the compensation deficit in the federal losses is clearly visible in 2021, which is atypical compared to previous years. We have transitioned from a situation where BRPs provided more than enough compensation in approximately more than 70% of the time on average (for the period 2016 to 2020), to a situation where they did only provide enough in 35% of the time (in 2021).

Table 2. Enough compensation to federal losses.

Year	BRPs provide enough compensation [% of time]	
	Yes (SG<0)	No (SG>0)
2016	67%	33%
2017	68%	32%
2018	76%	24%
2019	76%	24%
2020	74%	26%
2021	35%	65%
Average	66%	34%

The decrease is mainly related to the contribution of losses caused by energy flows that occur in cross-border trade, particularly (net) export, which made the last year (in 2021) that 65% of the time the compensation made by BRPs was not sufficient. As foreseen in the process for calibration, future calibrations of the percentage applied on BRPs can take this further into account in view of the aim for ensuring a long-term financial neutrality for BRPs.

2.3.2. Historical performance statistics: regional level

Elia establishes in LT (from one year to one month in advance) the amount of power that will be bought to compensate the regional losses. The shorter-term procurement (mainly trimestral, occasionally monthly) helps to adapt to the seasonality / temperature changes during the year. There is also an additional consideration that can be taken into account to buy the energy, which involves the peak and off-peak periods during the week. The average power procured for the regional losses per year, is shown in the following table.

Table 3. Regional losses compensation.

Year	Losses Bought [MW]	Losses Bought [GWh]
2016	53	466
2017	53	465
2018	53	465
2019	42	366
2020	47	411
2021	49	431

Historically, the compensation of the regional losses has been relatively stable, the last 2 years on average 80% of the regional losses has been compensated (2020 - 2021) through LT procurement. In addition, the period between 2016 – 2018 shows a fairly steady behavior regarding the quantity of losses compensated. But now, an increasing struggle materializes when matching long-term purchases with daily losses patterns. For this, within the limits of the long-term procurement, we rely strictly on the quality of forecasts and the historical weather conditions over the seasons.

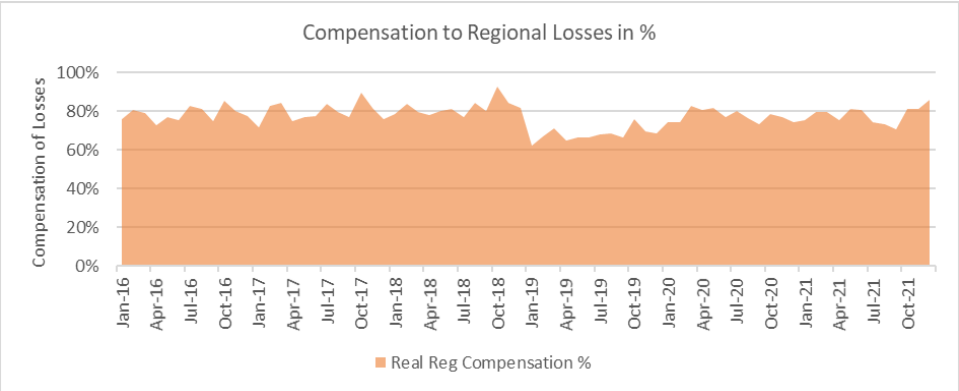

Figure 9. Historical regional losses coverage.

When looking at the amount of losses compensated over the last few years, it has been fairly stable, with the exception of a small decrease in 2019. It's important to recall that there may be an additional procurement process during the year to adjust the compensation strategy on a shorter term (monthly basis), and historical trends and load/weather forecasts are used to make decisions and adjust the compensation mechanism.

By analysing specifically the lower compensation on the regional side, it is linked directly to the losses that were bought at that time. The losses procured in long term (in 2018 for 2019) for the summer period were lower than usual.

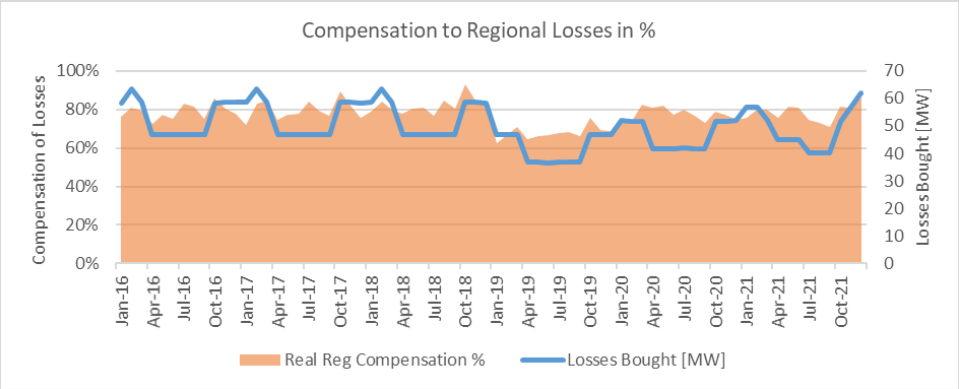

Figure 10. Historical regional losses coverage with historical losses bought evolution.

The strategy to reach a good compensation is very challenging. In most of the cases, the base compensation (bought in LT) is fairly close to the lower limit of the losses. Now the next step of the challenge is to manage an adequate extra compensation for the peak hours, which will be impacted especially by the decentralized generation (mainly solar) and the weather conditions (extremely hard to estimate in Y-1 or even M-1).

At all times, Elia has sought a careful approach in determining the volumes to be procured, as an overcompensation not only inflates cost (more bought and a need to then activate downward balancing means) but may also be perceived

as more impacting on market functioning. Such cautious strategy limits the amount of energy that will be injected into the grid, limiting the impact that this energy could produce in the system imbalance.

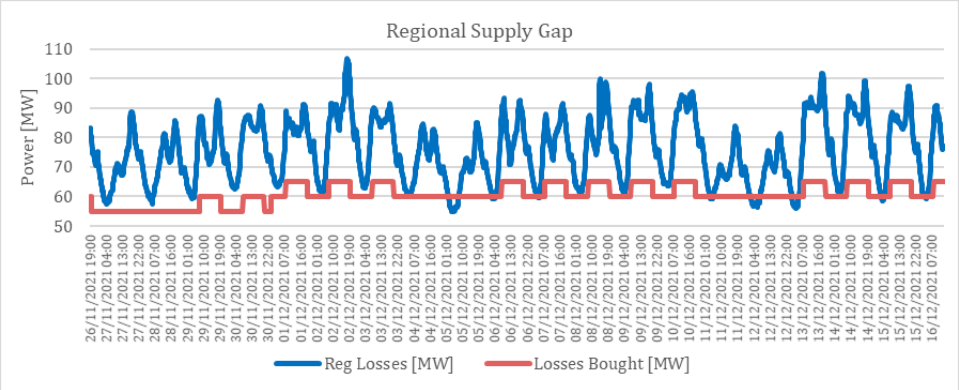

Figure 11. Typical regional compensation - 3 weeks.

As mentioned before, the current strategy can be tuned monthly, which will be useful to respond to the seasonality and general weather conditions during the year. This remains however a very difficult task, as month ahead (including leaving time to procure on the market) future weather patterns and system conditions remain hard to accurately forecast. Also, it is important to mention that even the addition of a small amount of compensation (e.g., 5 or 10 MW) can have a significant impact on the system. For example, there are periods where the purchased losses, other than the ones already mentioned where the baseload is fairly constant and adequately estimated, the extra losses purchased in the long term respond adequately to the peak periods during the day.

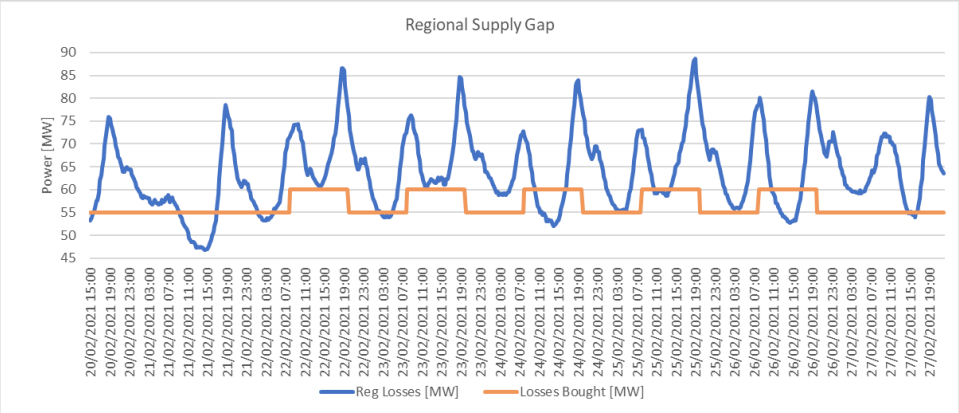

Figure 12. Good regional compensation - 1 week.

To have a more detailed view of the global response of the compensation considered for the regional level, the cumulative distribution curve is generated. This graph describes the actual percentage of time in which Elia has bought more than enough compensation (leading to a negative supply gap) or whether Elia has bought not enough (leading to a positive supply gap).

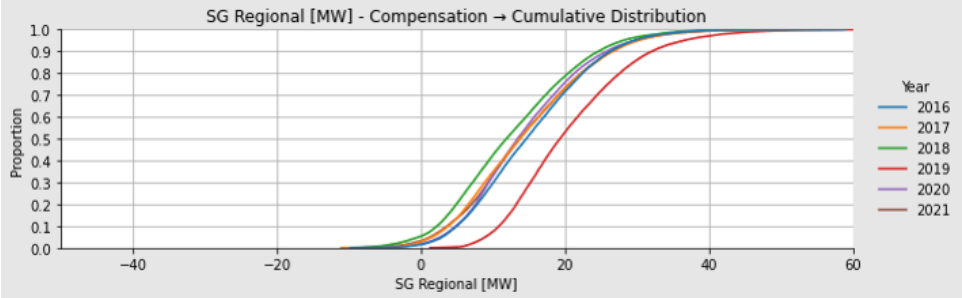

Figure 13. Cumulative distribution curve - SG regional.

Table 4. Enough compensation to regional losses.

	Enough compensation bought [% of time]	
Year	**Yes (SG<0)**	**No (SG>0)**
2016	1%	99%
2017	3%	97%
2018	5%	95%
2019	0%	100%
2020	2%	98%
2021	3%	97%
Average	2%	98%

On average, the overcompensation reached a maximum in 2018 of a 5% of the time over the complete year. As part of the exercise, we can analyze the hypothetical effect of having had extra compensation at the time, with a simple extra compensation of 5 MW (i.e., more energy purchased by Elia to cover the losses), the overcompensation will increase to ~20% of the time over the entire year (e.g., 2018), clearly leaving the tail of the distribution.

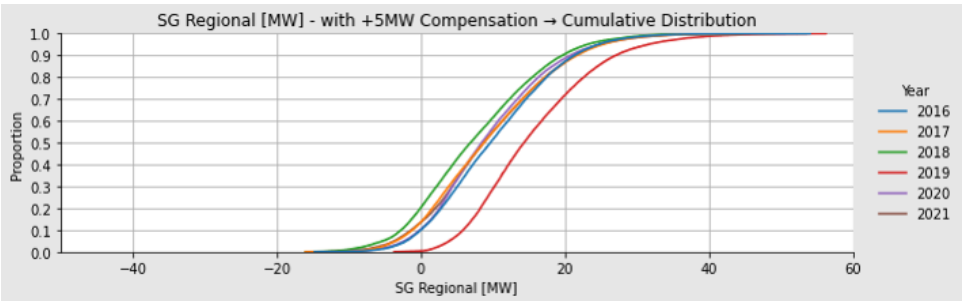

Figure 14. Cumulative distribution curve - SG regional with extra +5MW of losses bought.

2.3.3. Drivers of the losses

There are several factors that drive grid losses. These are mainly related to local centralized production, decentralized generation, local consumption of electricity, and energy exchanges with other countries. In addition to the major challenges faced in weather forecasting (sun, wind, rain, clouds, temperature, humidity, etc.), we also face decentralized generation (metered and unmetered). It plays an important role in the distribution of energy flows, making the modelling of the system much harder. As also already hinted upon in the incentive description, forecasting the impact of international flows is far from evident.

The first step is to identify the main variables that trigger losses. The idea is to look for strong relationships between these variables and the losses, and thereby establish a starting point for the next part of the analysis through the report (and towards the development of the forecasting proof of concept). For example, in the graph underneath depicting 11/12/2021, we can see a typical profile where there are different production sources (such as wind, solar, and small units – NCNR, Non-CIPU Non-Renewable), but also an important amount of exports, which will impact directly by increasing the losses in the grid.

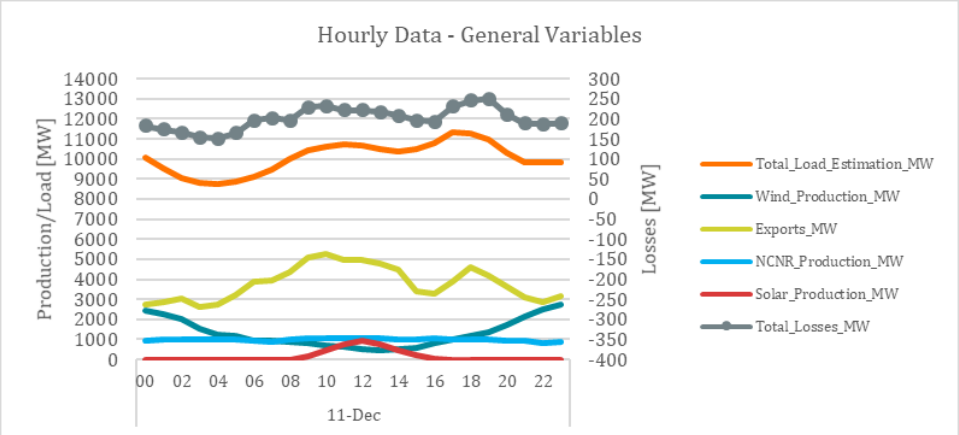

Figure 15. General daily data.

We can see a slight correlation between Total_Load&Losses and Exports&Losses. In a single day it is difficult to see any structural correlation between the other variables and the losses, so we have to look at longer periods and go a bit further down a level where the losses are aggregated by regional and federal levels, as done by the correlation matrices below.

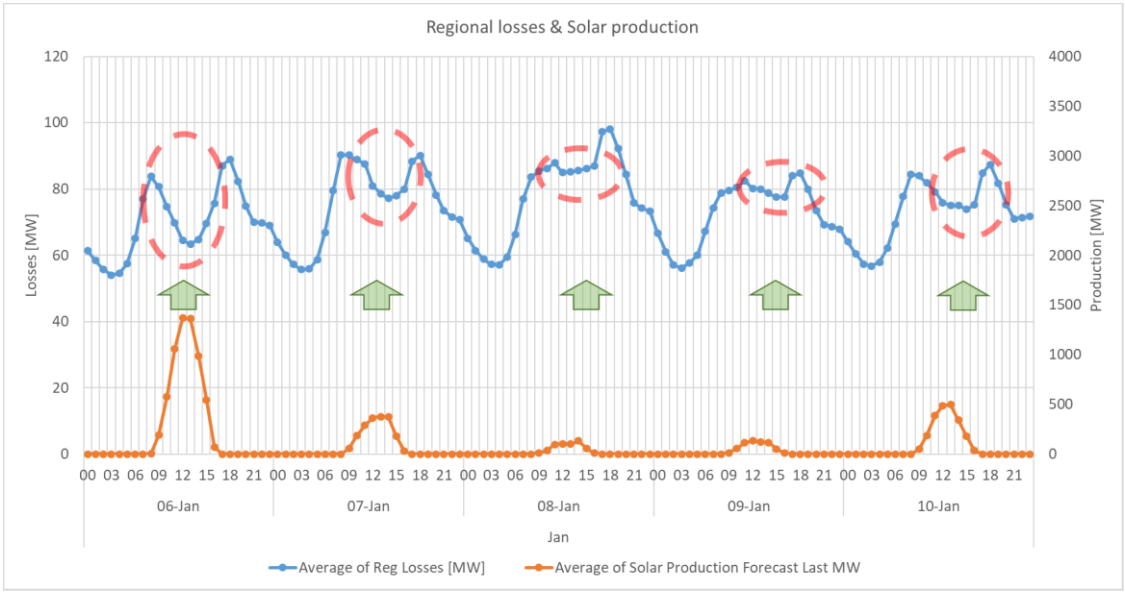

Figure 16. Solar production effect on regional losses for a week in January 2020.

Cf. the above figure, by taking a longer period, we can already detect some correlations between the data. For example, we take days with similar load demand patterns (Monday to Friday), but with different solar generation profiles. We can already spot that when the solar production is higher, a larger decrease is detected on the regional losses. To confirm this more structurally, a correlation analysis is done.

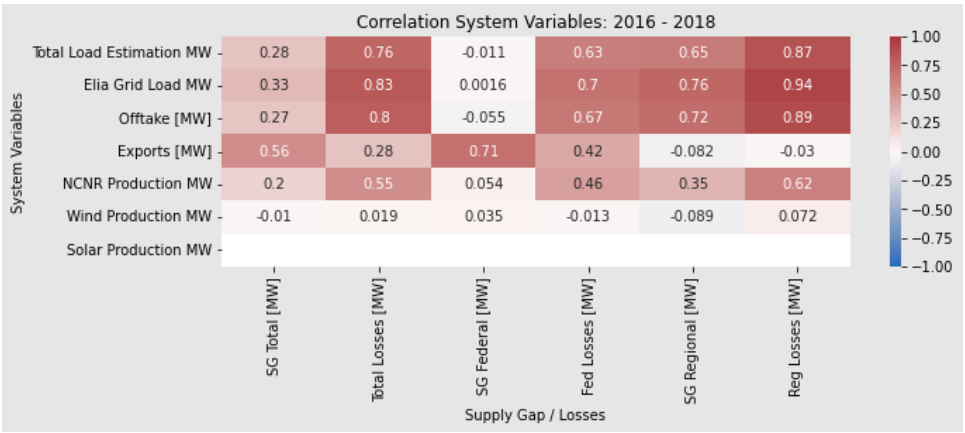

Figure 17. Correlation general variables 2016-2018.

Also, to detect clear relations between the data and how these relations evolved over time, we first look at the data over a three-year period (2016-2018). We see quite a strong relation between the regional losses and the local production/load. Also, we can confirm that there is a strong link between the exports and the losses.

But now, the evolution of technologies, the increasing demand of electricity, the resizing of installations and the changes in the transmission/distribution infrastructure must be taken into account in the analysis, as they bring several changes in the distribution of flows in the electricity grid that could end up increasing or decreasing some of the existing correlations.

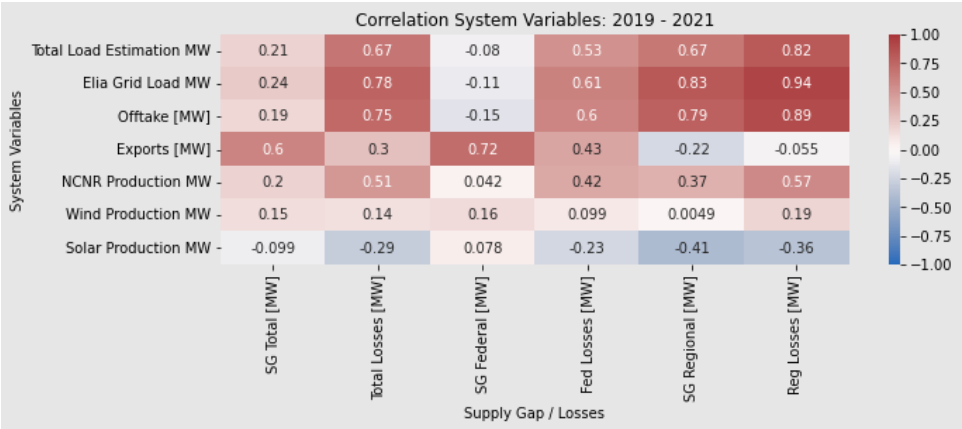

Figure 18. Correlation general variables 2019-2021.

For this part we now consider the last 3 years (the period 2019-2021), in addition to maintaining the correlations found previously, the relationships with renewable energies show a significant increase. Of course, the studied period varied along different aspects which makes it hard to neutralize one element for analysis, it was for instance also a period characterized by the covid pandemic. Nevertheless, such correlation analysis provides useful insights. In general, the correlation with load was reduced for federal losses, which partly corresponds to the effect of decentralized generation (and also distributed sometimes at lower voltage levels) that avoids the strict load dependence of centralized generation (e.g., nuclear facilities and large natural gas units). This also links the importance now of solar generation and its impact on losses, which with a negative correlation indicates how this type of production helps the system by reducing losses. In contrast, we have the effect of centralized offshore wind farms that by increasing installed capacity will indeed have a direct (positive) correlation with losses as flows on transmission lines to shore increase, and with it the federal losses. In conclusion, the link to estimate losses has become more complicated and looking primarily at load is no longer sufficient, and this is likely to get worse in the future. The energy transition clearly impacts the drivers of the grid losses.

If we look directly at the evolution of load over several years, we do not see an obvious increase in energy consumed/produced. This is because on the one hand, we have the increase in load due to the number of users (e.g., more houses, more buildings, etc.), but on the other hand we also have the effect of more efficient technologies and infrastructures.

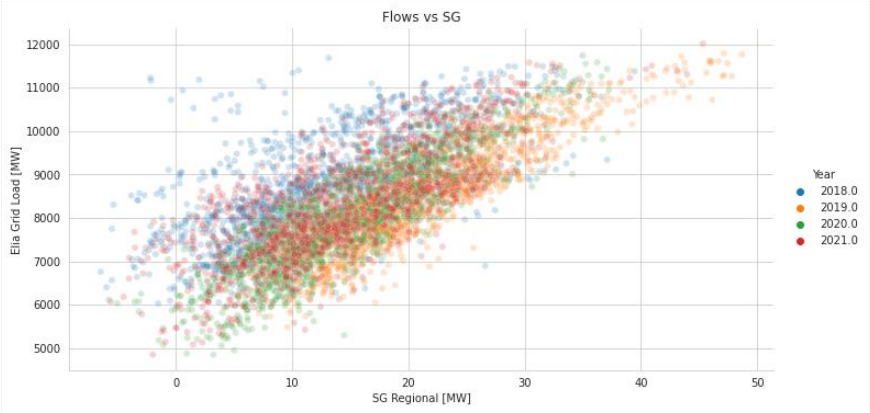

Figure 19. Elia load vs SG regional evolution.

Now, if we look directly at the evolution of electricity exchanges between countries, we see a clear increase in the exports registered in the Belgian hub. International flows are not likely to decrease, but its direction (import/export) could vary over time.

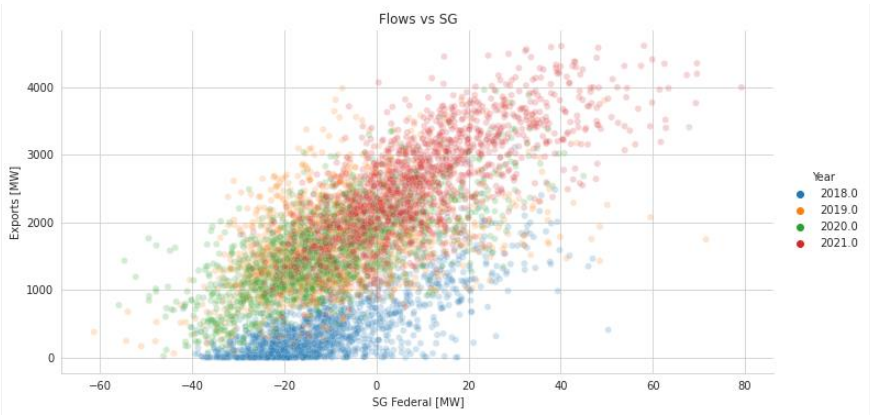

Figure 20. Exports vs SG federal evolution.

2.3.4. Link between supply gap and BRP Imbalance

In the following graph, we aim, from an historical point-of-view, to analyse the link between the supply gap (SG) and the system imbalance, denoted SI. For the sake of completeness, we first start by redefining some concepts explained in the sequel. Supply gap is defined as the difference between measured losses and losses covered. In case of positive value, we face to an under-procurement of losses while a negative value implies an over-procurement of losses. The impact of the supply gap on the system imbalance has two potential outcomes depending on the direction. The supply gap can help, meaning reduce, the system imbalance if the direction of the SG is in the opposite direction to the one of BRP imbalance. While, if both, SG and BRP imbalance, are in the same direction, the SG deteriorates the SI.

Over the five last years (2016 – 2021), the total supply gap helps the system to reduce the system imbalance 51,6% on average. This result can be deduced from the combination of the two green parts in the plot. Contrariwise, the SG increases the system imbalance in 48,4% of the time (red part). Further details about the federal and regional monthly average ratio between positive or negative SG has been already developed in section 2.3.2. In terms of volume, the total supply gap is positive, therefore undercompensated, 66% of the time. On average, the SG power is around 10 MW but high variations have been observed over the whole period. For example, in the most recent period spanning from September 2020 to end of 2021, we witnessed an under procurement of the losses due to a positive supply gap (average: 24,18 MW in 2021), mainly explained by an increase of exports.

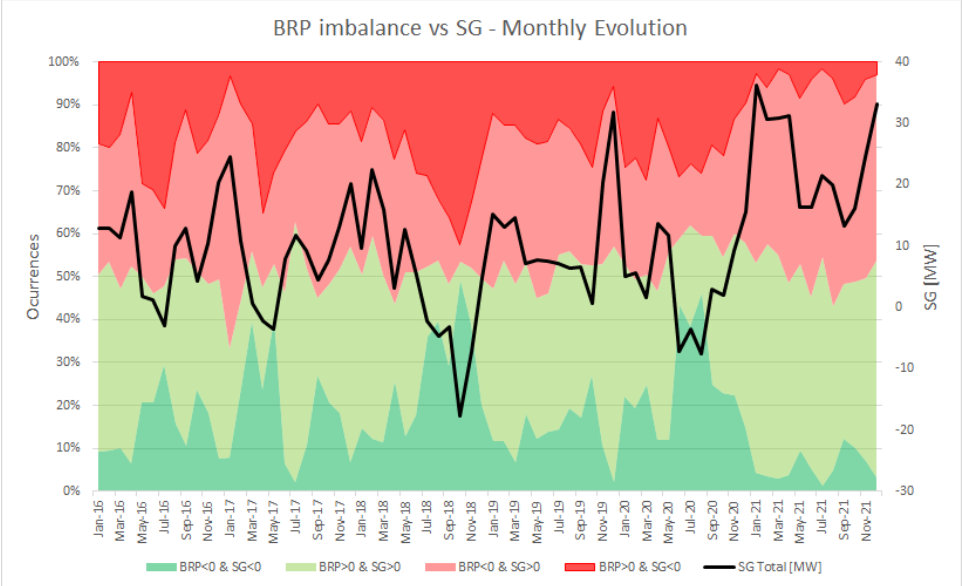

Figure 21. Occurrences - BRP imbalance vs SG.

The following table shows the evolution of the monthly average supply gap for the three components (total, federal and regional). As explained above, the average total supply gap is the highest in 2021. For the federal SG, BRPs over compensated (however, the effect of taking the LT neutrality is also to be kept in mind) except the last year (positive SG means that the losses were under compensated).

Table 5. Supply Gap evolution.

Year	Total SG [MW]	Federal SG [MW]	Regional SG [MW]
2016	9,48	-5,84	15,3
2017	8,71	-5,90	14,61
2018	3,22	-9,57	12,79
2019	11,52	-9,22	20,74
2020	4,09	-10,51	14,60
2021	24,18	9,55	14,63
Average	**10,20**	**-5,25**	**15,45**

In the previous graph and table, we emphasized the evolution of the supply gap over years and the impact its direction can have on the system imbalance. However, nothing has yet been mentioned about the magnitude of this impact. To complement the analysis, we decompose our BRP imbalance / Supply gap into four different parts and analyse how much the SG contributes (or not) to the system imbalance. Each zone is represented by two conditions: one on the BRP imbalance, another on the SG. When BRP imbalance is smaller than 0, it means the system is tight while SG smaller than 0 indicates that the SG is long (overprocurement). In the three following graphs, the vertical axis denotes the average (per month) SG power, expressed in MW, and is defined as the difference between losses and procurements.

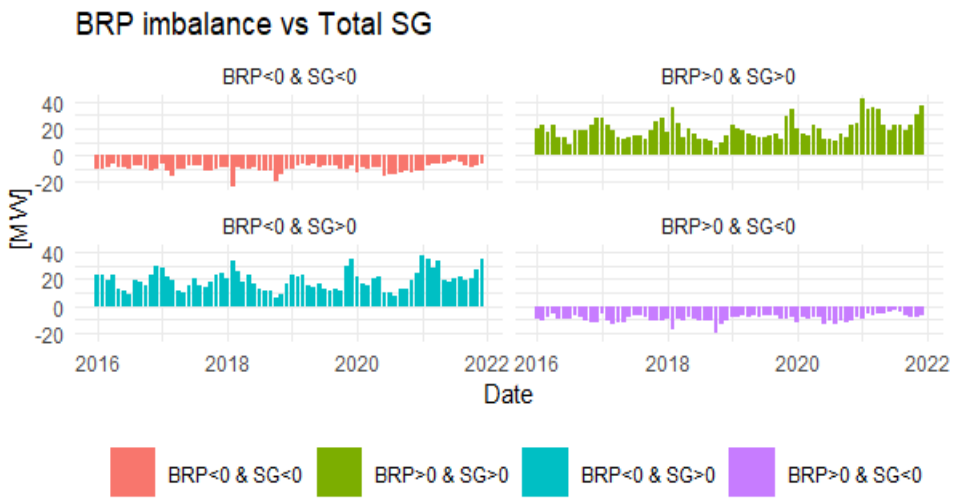

Figure 22. Power – BRP imbalance vs SG total.

To connect the dots between the different graphs, let us consider an example with the first spike 'January 2016' (first peak from the top-left graph (BRP < 0 & SG < 0). This zone indicates that the system is tight (BRP < 0) while the SG is long (SG<0), then it helps the system imbalance with 13MW on average, 10% of the time (green part in Figure 21. Occurrences - BRP imbalance vs SG.). On the bottom left, we are still tight but the SG is also tight leading to a deterioration of the system imbalance with a magnitude of 23 MW 30% of the time (shadow red color in Figure 21. Occurrences - BRP imbalance vs SG.). From a general perspective, we observe that when we are short in SG, off-diagonal plots, the quantity of MW is higher than the situation where we are long (diagonal graphs). Then, the missing quantity to cover the losses is larger when SG is positive rather than its negative counterpart.

The same decomposition can be applied to the federal and the regional level leading to the following illustrations. The interpretation of the 4 subgraphs remains unchanged with respect to the one developed for the total supply gap above. In the regional SG case, it has to be highlighted that there are many months where, in a specific (e.g. BRP < 0 and SG <0) zone, the occurrence never happens and is therefore represented as a null value.

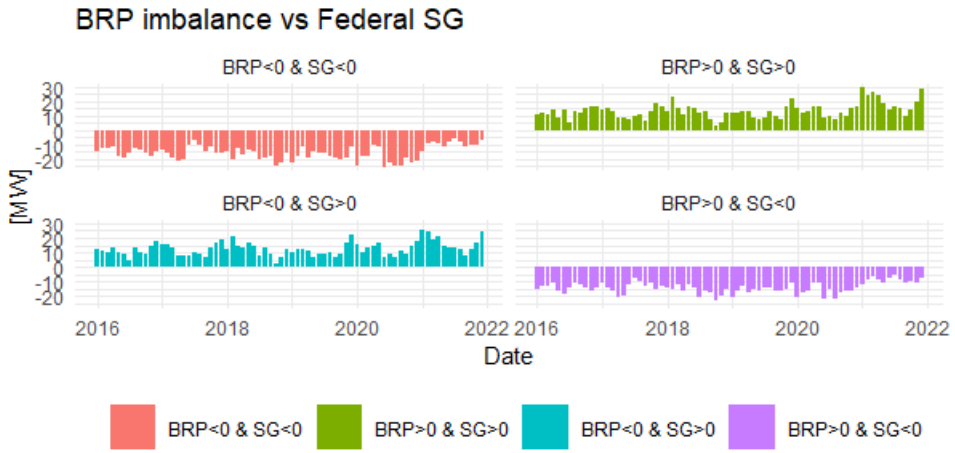

Figure 23. Power – BRP imbalance vs SG federal.

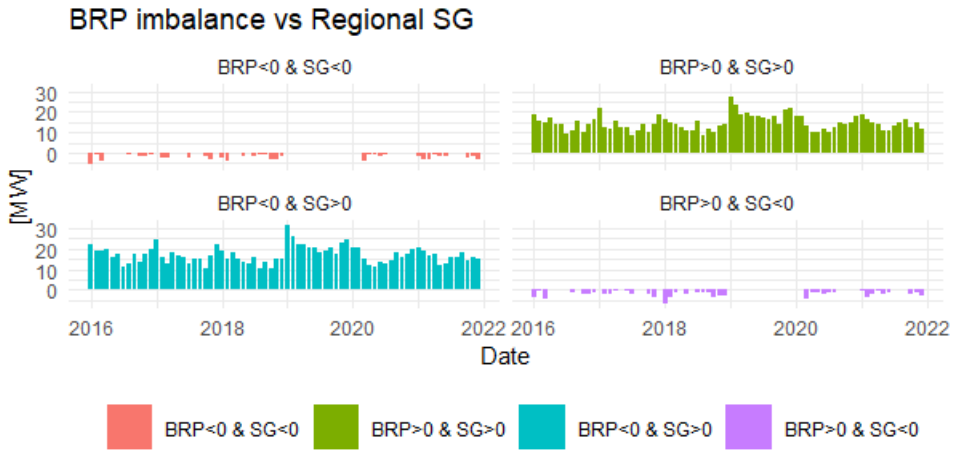

Figure 24. BRP imbalance vs SG regional.

To conclude, the link between supply gap and historical position of BRP shows that the supply gap helps the system imbalance 51% of the time. We also point out that, on average, total SG is typically positive across years indicating that the long-term elements of the compensation approach rather led to under-procurement of losses.

Finally, it is important to realize that the way the supply gap affects the system has evolved over time. As mentioned above, the supply gap is part of the system imbalance. Balancing energy is used to deal with the system imbalance, hence also with the supply gap. The organisation – and particularly the pricing – of the imbalance mechanism has evolved over time (and is still evolving). In particular, the pricing of aFRR activation and how it affects the imbalance price towards BRPs has changed. When in the past there was no merit-order based pricing (also not pay-as-bid, but rather proportionate pricing) a small change in volume activated did not truly change the imbalance price (at least when

it remained within the boundaries of aFRR activation and did not for instance trigger mFRR activation, which is anyhow more rare). Today, with a merit-order based pricing, any change of supply gap (even a single MW) could trigger a change in the imbalance price as it implies a step (up or down) in the activation merit order. While the way of compensating losses has remained stable over time, the market on which it interacts has nevertheless evolved. This may be a useful element to keep in mind, and an extra driver to aim to limit the supply gap. When doing so, the system imbalance can more and more reflect *only* the BRP imbalance.

2.3.5. Concluding reflections on the forecasting efficiency

As mentioned before, the current losses forecasting practice by Elia is driven by the needs of the two-fold compensation mechanism, which is bound to a long-term view to be calibrated. With respect to the forecasting and the observed (in)accuracy, two things are key to distinguish and to keep in mind, also in view of potentially changing the compensation approach.

- **Granularity limitations:** While the losses to be compensated vary from one moment to another with a significant volatility e.g. during a day or across seasons, both compensation mechanisms today applied are bound by a limited granularity (i.e. degrees of freedom) that inherently limits the accuracy of covering the losses. This is even true in a context of perfect foresight.
    - For the federal losses, the calibration of the required contribution has historically been summarized in maximum two percentages only differing between peak and off-peak periods. This leaves only two degrees of freedom to summarize the rather complex behaviour of the federal losses. Although by working with a percentage there is at least an implicit granularity as the contribution in absolute terms follows the pattern of the net offtake on which the percentage is applied, this still does not allow to capture key drivers (even if perfectly known at the moment of calibration, quod non). This is particularly relevant in view of aiming to keeping the supply gap under check. From a longer term perspective the mechanism of ensuring the LT financial neutrality for BRPs adds to some extent an intertemporal degree of freedom. However, by aiming then for this LT financial neutrality we also deviate from what would have been the best estimate for a future percentage when only addressing the question from an (expected) losses compensation need for a next period.
    - For the regional losses, the procurement through long-term contracts allows for some more seasonal granularity, historically typically applied at quarterly level took place and occasionally also at monthly level and for a differentiation between baseload and peakload contracts. Also, here the degrees of freedom are insufficient to cover for hourly and daily changing patterns.

- **Evolving losses drivers:** There are clearly multiple drivers of the losses, several important ones exhibiting strong volatility from a shorter term (hours or days) perspective. This is for instance true for solar production or international flows, whose impact on the overall system has only been growing the last few years (and is not likely to change soon). Relying solely on a longer-term approach becomes more and more difficult and

less accurate given this strong short-term volatility of key drivers for the losses, both at regional and federal level.

Based on these reflections and the preceding analysis, according to Elia it becomes beneficial to consider short-term forecasting in view of potential short-term procurement to overcome both the granularity issues and the effects of the evolving losses drivers with the goal of better covering losses and in particular limiting the supply gap. Both are getting increasingly pronounced and suggest that improvement to the losses compensation mechanism may be beneficial.

2.4. Analysis of the efficiency of the current compensation method compared to a compensation by procurement of federal and regional losses together

While the incentive invites Elia to analyse the efficiency of the current compensation method in comparison with a full procurement by Elia of both federal and regional losses, it is not straightforward to conduct such analysis. Indeed, how to measure the efficiency of one approach over another?

One way could be to address the question from a volume perspective, i.e., whether the current two-fold mechanism functions well together or whether the mechanisms tend to work rather against each other. Another, at first sight obvious, way is to address the comparison from a cost efficiency perspective. This boils down to whether Elia could procure cheaper or more cost-efficient than BRPs would for their compensation obligation?

Both angles are not easy to analyse as there is no counterfactual information available, neither would it be straightforward to define a meaningful kind of simulation. There is also no public view available on how BRPs particularly deal with their obligation to deliver in kind and how they organize their sourcing on this, which moreover can be organized differently by each individual BRP in view of its procurement strategy, risk management, portfolio...

The next two sections nevertheless try to provide some insights based on the observation of historical data complemented with further qualitative reflections.

2.4.1. Do the two Belgian approaches efficiently co-exist?

For this section, total losses are analysed, instead of separating them into the regional and federal side. Note that this is based on historical data, where the two-fold compensation strategy has been used for regional and federal losses. It is to be noted that in the current mechanism, the de facto final step of the losses compensation is common to both mechanisms. Indeed, surpluses and shortfalls from the regional and federal losses are brought together in real-time into a single supply gap that becomes part of the zone's system imbalance. While for analytical and design purposes it makes sense to analyse regional and federal separately, in real-time any mismatch boils down to the same system.

From this perspective, the overall losses coverage ratio varies around 100%, rather tending towards an under-compensation, but overall the ratio of losses has remained rather stable over time. A small decrease can be observed for the last year (2021).

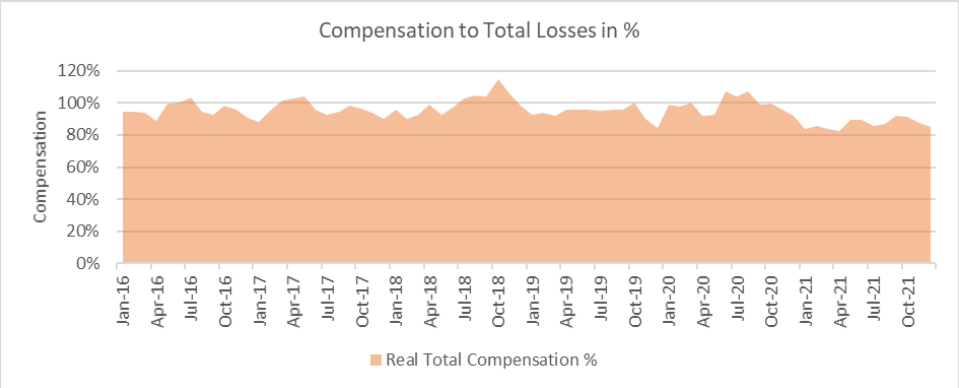

Figure 25. Historical total losses coverage.

Considering the entire period (2016-2021), the system has passed from an average losses coverage of 77% at regional level and 110% at federal level to an overall losses coverage of about 95%, which is a rather high percentage especially based on long-term mechanisms only. This is a first general indicator for evaluating the combined strategy, but clarifying that it is a rough indicator of the perceived performance, due to the net interactions of the federal and regional level.

To have a more detailed view of the compensation considered for the total losses and its volatility throughout a year, the cumulative distribution curve is shown below. This graph describes the actual percentage of the time in which the losses have been either compensated more than enough (leading to a negative supply gap) or whether the losses have been compensated insufficiently (leading to a positive supply gap). Note that for the years 2016-2020, about 80% of the observations fall within a range of -15 MW and +34 MW. Exceptionally, the (absolute) value of supply gap can be larger. As also observed earlier, 2021 shows a different pattern.

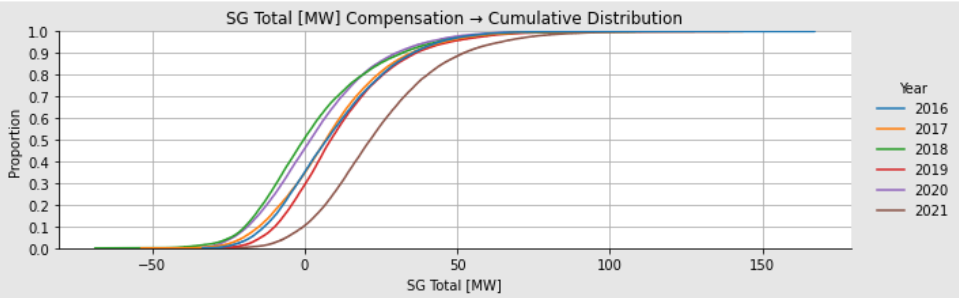

Figure 26. Cumulative distribution curve - SG total.

Table 6. Supply Gap total general statistics.

SG TOTAL [MW]			
Year	P10	mean	P90
2016	-13	9	35
2017	-15	9	35
2018	-19	3	32
2019	-10	12	36
2020	-19	4	30
2021	0	24	52

The perspective of the total supply gap enhances the compensation perception of the system, due to a lower performance perception of the system when compensating the regional losses. In other words, historically (except for 2021), regional and federal supply gaps tended to balance each other.

On average, an evolution can be observed from the over procurement in the regional level during 2% of the time (as seen in the section: Historical performance statistics: regional level), and in the federal level of 66% of the time (as seen in the section: Historical performance statistics: federal level), to a 34% of the time with more than enough compensation in the global system (federal and regional). In the same way, on average, regional and federal losses have been under-compensated in 66% of the time.

Table 7. Enough compensation to total losses.

	Enough compensation [% of time]	
Year	**Yes (SG<0)**	**No (SG>0)**
2016	35%	65%
2017	35%	65%
2018	51%	49%
2019	29%	71%
2020	46%	54%
2021	10%	90%
Average	**34%**	**66%**

To conclude, federal and regional losses and their compensation approaches have behaved differently in the past but most of the time in a way that balanced each other. Supply gaps can sometimes lead to a ‘netting’ that thereby reduces the resulting impact on the system imbalance.

2.4.2. Would Elia be able to procure more cost efficiently than BRPs?

Assessing from a cost perspective the efficiency of the current two-fold approach compared to Elia procuring both regional and federal losses is far from being straightforward. A counterfactual analysis is difficult and remains arbitrary.

2.4.2.1. General reflections

It is very difficult to assess what the true cost of the in-kind compensation by BRPs is. For instance, at what price have they sourced the necessary volumes to deliver on their obligation? Also, to what extent would such price be better or worse than the price Elia was able to secure?

It is at least true that BRPs in principle dispose of more possibilities to source the volumes and simply from this fact would have more opportunities to outperform Elia. While Elia in the current way of working is bound by long-term forward contracts for baseload and peakload, BRPs at least can also have access to short-term markets (DA/ID) and integrate that in their strategy to secure the necessary volumes. While Elia's market access would be enlarged to other markets (e.g. DA market access), Elia remains by principle more limited than a BRP that could foresee an access to *all* market fora more flexibly than Elia could in the context of a regulated framework. From this perspective, Elia can *at best* match the performance of BRPs, but being (and likely to remain) subject to more constraints won't be able to outperform BRPs structurally.

For sure, it can be expected that BRPs do not source separately the volume needed for delivering on their losses compensation obligation, but that they rather integrate it in their entire portfolio to be secured on the market or through own production. The percentage to be provided is also known about 6 months before that start of the delivery year and has generally not fluctuated significantly (i.e. always between 1 and 2%). This latter aspect of covering losses through own production portfolio, is also another difference between the possibilities that (some) BRPs have compared to Elia. Also, the integration of sourcing the contribution for the losses together with their other needs of their portfolio (i.e., the offtake of consumers themselves) is a difference with Elia whose sourcing needs are limited to the volumes of the losses, depriving it from a potential synergy. Also from this perspective *at best* Elia can only match the performance of BRPs insofar there would be a fully perfect arbitrage taking place at all levels of the market and in relation to all individual portfolios. Insofar this assumption isn't sufficiently met in reality. Elia – being confronted with less potential for a synergy with other activities – is subject to more constraints than BRPs and will not be able to outperform BRPs structurally.

The above reflections take place at principles level and result in Elia *at best* being as efficient as Elia – by the nature of its role and activities – is confronted with more constraints than BRPs when it comes to procuring energy. It is, however, impossible to assess to what extent these constraints would in reality cause a material efficiency difference between Elia and BRPs in procuring or providing energy for covering grid losses.

2.4.2.2. View on the historical value of short versus long term procurement

Notwithstanding the general reflections discussed in the previous section, it is analysed at which price losses have been sourced by Elia compared to what could have been the price (or cost) in case the same volumes would have been sourced day ahead. This does not imply Elia suggesting that BRPs would fully source day ahead, it is rather to develop two more extreme strategies that could have been followed.

Note that both times this excludes of course the volumes in the supply gap as this would otherwise result in a false comparison. It are two more extreme strategies to secure the volumes, any other strategy could aim to optimize by procuring both long-term and spot and would result in a weighted average of these more extreme cases shown.

From the graphs below it becomes clear that, for the regional losses procured by Elia, Elia was able to secure prices on the forward markets that outperformed the equivalent day ahead prices. This is an indication that the price diversification by contract forward over different timeframes has been rather cost efficient given how the market prices have evolved over the past years, in particular the evolution of forward prices versus (resulting) spot prices in the context of the currently ongoing energy crisis (cf. infra).

Obviously, in case enduring price increases occur and these are also structurally reflected over time in forward prices, also the cost at which Elia can secure volumes on the forward market will increase. In 2018, the higher cost at DA prices may be explained by the more tight winter situation that was not yet reflected in forward prices at which Elia was able to contract in the 1 to 3 years ahead of this period. Similarly, in 2021 the energy price crisis is already reflected in DA prices, but wasn't as such anticipated in forward prices in the years before. In contrast, DA prices were slightly lower than contracted forward prices for 2019 and 2020, this may be due to a downward impact of the covid-19 crisis on the DA prices that was not anticipated by forward prices in years before.

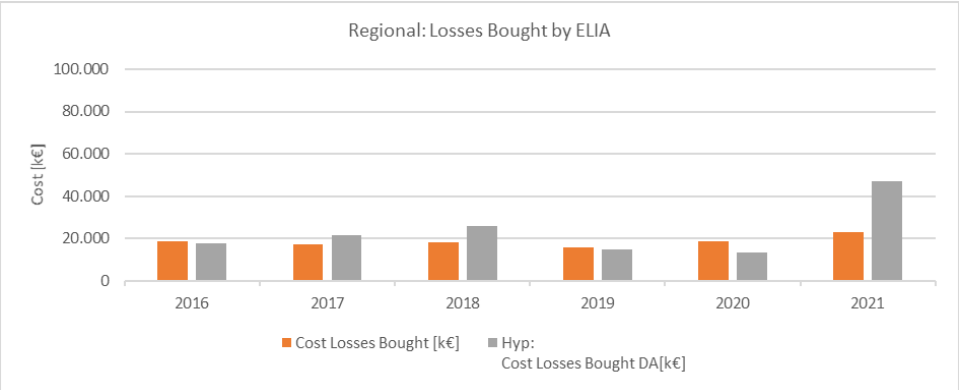

Figure 27. Losses bought by ELIA.

The second graph illustrates the same price (or cost) effect when applied on federal losses, which logically returns a similar pattern as observed for regional losses. As a side-note, from the second graph a measure of the total cost of

the federal losses compensation can be observed (excl. any cost that could be associated to the supply gap). If procured at the same prices that Elia was able to secure for the past years, it would amount to more than 30 M€/year for the period before the energy crisis, if today's price trend remains or when at least a structural price increase remains (as today expected for the years to come when looking at forward prices), this can be significantly more than 30 M€/year. Not surprisingly, as the federal losses represent a higher volume share than the regional losses (which is furthermore expected to increase in the years to come), this budget is more than the double of the regional losses budget.

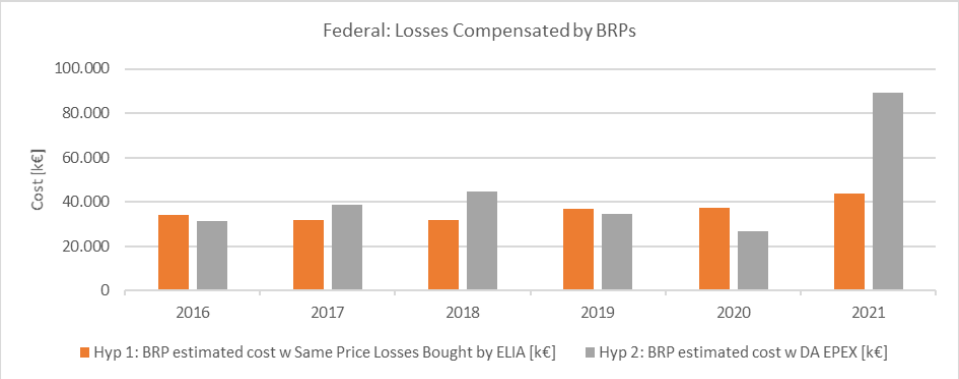

Figure 28. Losses compensated by BRPs

More specifically, historically, the losses purchased by Elia in LT have shown a rather stable price behavior in the last years, which is not the case for the electricity market prices (forward, spot and imbalance price) which show a rather fast increase as from the second half of 2021. This means that the long-term secured volumes contracted for delivery by the end of 2021 (and also for 2022 so far) have been highly beneficial as they avoided the high costs of having to compensate in the short term. This can be clearly observed from the figure below.

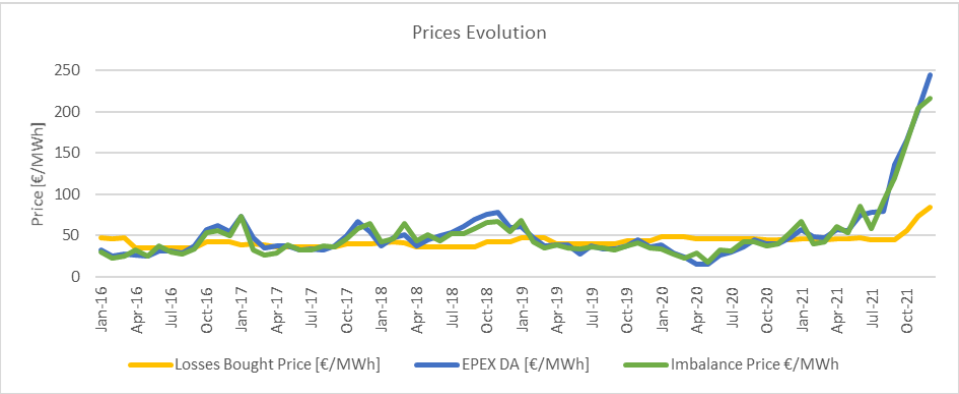

Figure 29. Electricity market prices evolution.

The slight price increase of the losses bought at the end of 2021 corresponds to the additional losses procured by Elia closer to the delivery period to cover the losses during the winter. Still, the average price remained significantly lower in comparison to the historically high spot prices registered on the electricity market in December 2021 (and still continuing in 2022).

Table 8. Prices evolution.

	Losses Bought Price [€/MWh]			EPEX DA [€/MWh]			Imbalance Price [€/MWh]		
Year	P10	mean	P90	P10	mean	P90	P10	mean	P90
2016	35	40	47	20	37	59	7	35	69
2017	35	37	39	27	45	71	5	42	80
2018	36	39	42	33	55	79	2	53	95
2019	40	42	47	25	39	56	3	39	77
2020	45	46	48	14	32	50	1	34	68
2021	45	52	71	40	104	217	-3	100	258

Finally, the energy in the supply gap also comes at a cost for the system. This is always at spot (imbalance) prices. Note from the table above that the difference between average day ahead and imbalance prices is historically rather limited. Volatility of imbalance prices is however higher. From a pure energy price perspective, there is as such not a big difference between relying on day ahead sourcing or the supply gap. This obviously neglects that in real-time liquidity may be less, the available flexibility consumed to cover the supply gap is then no longer available to the system and that part of the resources used to deliver on the energy in the balancing market are available following a reservation by Elia.

While for the longer term secured volumes, we can still benefit from price levels from before the energy crisis, spot prices are today already higher. Insofar prices are expected to remain structurally high(er than before the crisis) this will be reflected in forward prices and ultimately also in the cost of volumes secured through long term contracts for delivery in the future. While with the current crisis there is an advantage linked to having contracts already concluded in the past, other events could potentially lead to an unexpected reduction in spot prices that today is not anticipated in the forward prices. In such case, long-term contracts secured at higher prices would turn out less beneficial than spot prices. Of course, such cost evolutions are inherent to the overall followed price risk management strategy of diversification through buying at different moments spread over the multi-year period ahead of delivery.

3. Lessons learned from practices of other TSOs

In order to perform a benchmarking of approaches taken by different TSOs as required by the incentive, Elia worked together with SIA Partners (hereafter: SIA). SIA is a consultancy firm with significant energy-industry expertise across Europe.

In the course of this study, SIA assessed the workings of five different European TSO's as well as Elia. The selection of these participating TSOs was based on the CREG's requests, their respective voltage levels (similar to Elia's 30 kV to 380 kV level) and the contacts that SIA Partners had with the TSO that could facilitate the output quality. CREG specifically requested to have Amprion, Tennet and National Grid on board, leaving the remaining TSOs in the benchmarking to the choice of Elia. Together with SIA, the requested (and the other) TSOs have been contacted. Amprion and National Grid responded positively to the request. Notwithstanding having actively sought their participation, Tennet preferred not to participate in this project. In order to nevertheless benefit from a wide group of TSOs, a fifth alternative TSO was added. Swissgrid, RTE and Red Electrica (REE) complement Amprion and National Grid. SIA also looked into Elia as a sixth TSO in their study in order to allow for a more a pertinent assessment in view of the overarching goal of the study.

The study follows a mostly qualitative approach where the TSOs were taken through an extensive structured survey after which the answers were later deepened and assessed in an interview with the relevant TSO experts. The main results as well as the results of the comparative analysis were later shared with the benchmarked TSO's.

The findings of SIA, i.e. the executive summary as well as the extensive slide pack, that serves as main output of the SIA study, are attached to this report (cf. Annex A). The remainder of this section deals with the lessons learned by Elia from the SIA study.

3.1. Losses Procurement strategies

3.1.1. Two compensation strategies are used by the analyzed TSOs

A first look into the benchmarking analysis reveals that, within the selected range of TSOs, different losses compensation strategies and time scales of procurements are used to compensate the losses on the grid.

We can identify two clearly different compensation strategies applied:

- "in-kind" compensation mechanism: National Grid, REE, and
- "procurement"-mechanisms: Amprion, RTE, Swissgrid.

The former in-kind compensation mechanism works through an injection of an additional amount of energy by market parties, on top of their nominated offsets, in order to cover the losses. The latter mechanism, i.e., procurement by the TSO, relies on the procurement of energy using forward (everything from multi-year until month/week ahead) and/or spot contracts (day-ahead/intraday/real-time), allowing the TSO to secure volumes from multiple years ahead to

close(r) to real-time (day-ahead & intraday). While typically most of these positions are secured on a long-term basis through forward contracts, the considered TSOs fine-tune further in day-ahead or intraday markets.

When looking at the TSO's in the survey a mix of mechanisms is being used, with procurement being done both in the long and short term, in order to cover the losses and minimize the remaining supply gap. It can be noted that although both mechanisms are used by the benchmarked TSO, Elia is the only TSO in panel combining both.

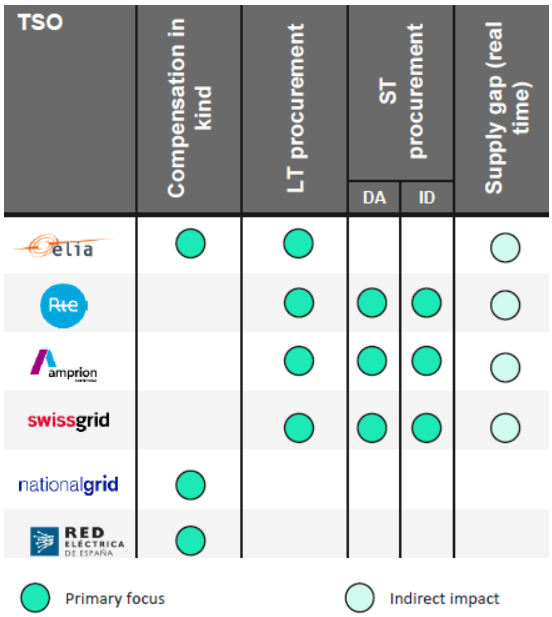

Figure 30. Procurement strategy TSO's (SIA Partners, 2022).

3.1.2. All considered TSO's combine long- and short-term aspects in their compensation strategy

Both the "in-kind" as the "procurement" strategies provide the studied TSOs with the ability to cover long- and short-term aspects in their losses compensation.

Elia's in-kind compensation, where BRP's inject an additional amount of energy on top of their nominated offtakes, calculates this additional amount on a fixed percentage which is determined on a yearly basis and the same percentage for the entire control zone. Differentiation between peak and offpeak periods is in principle possible and has occurred in earlier years (see section 2.3.1). Similar to this approach, but more granular, National Grid makes use of an in-kind mechanism where the delivering and off-taking trading units will scale up/down their generation/offtake based on a factor that requires a different calculation based on seasonal and geographical parameters. A more short-term approach is taken by RED Electrica, who adds an hourly TDLA (transmission and distribution losses adjustment) calculated for each grid node on top of the, by the regulator provided, TDLR (regulated transmission and distribution losses), which is calculated on a yearly basis.

The granularity of this in-kind approach covers a factor range from yearly (Elia) to hourly (Red Electrica). Important is to take into account the fact that this increased granularity is accompanied by a higher complexity, including the need for shorter term forecasting but also BRPs being able to integrate shorter-term varying obligations into their operations.

TSOs who make use of the procurement compensation approach generally (except for Elia) make use of a combination of long-term and short-term products. Notwithstanding differences in the frequency of trading, the TSOs use tenders for their long-term procurement, like Elia. According to RTE, the long-term procurement through the use of tenders is becoming more difficult due to the energy crisis which increases price volatility in the market. Alternative long-term procurement options, such as power purchase agreements (PPAs) for instance to also address sustainability goals are today not observed among the studied panel.

In order to compensate for the short-term losses, participating through power exchanges in the market coupling (DA/ID) is used. In this spot market, all participating TSO's interact in both the day-ahead as the intraday market.

TSO	Tenders	OTC	Buy on SPOT market		Sell on SPOT market		Other
			DA	ID	DA	ID	
elia	Regional losses only						
Rte	●		●	●	●	●	● EDF obligations & capacity market
amprion	●		●	●	●	●	
swissgrid	●		●	●	●	●	
nationalgrid	Not applicable						
RED ELECTRICA DE ESPAÑA	Not applicable						

Figure 31. Compensation strategies.

As mentioned earlier, Elia is today only making use of the long-term tendering approach. Spot market access has so far not been considered and Elia is today not truly active on the spot market for other reasons (there is only one strictly arranged access to the intraday market in the context of redispatching). The other TSOs however actively complement the long-term approach with a short-term compensation on the market in order to more effectively reduce the supply gap. National Grid and RED Electrica do not use any direct procurement approaches.

3.1.3. TSOs procuring losses act directly on the power exchanges

As seen in the Figure 31. Compensation strategies., most TSOs make use of short-term trading to cover their losses and thereby to also reduce their supply gap. In order to do so efficiently, these TSOs have direct market access so they can both procure and sell volumes close to delivery, they do not work through an intermediary or a market party. In order to obtain access to both the intraday and day ahead market and thereby avoid influencing these markets, some

of these TSO's have set up the necessary processes and checks and balances. This may include limiting access to specific procurement information and/or automation of processes (e.g. from forecasting to procurement).

Important to note is that this short-term procurement strategy is subject to market liquidity, which might differ between countries. Especially with regards to the current energy crisis, market liquidity could induce that market parties consider high risk premiums on the market and thus result in higher prices.

3.1.4. Short-term, losses compensation is only possible with good quality short-term forecasting

When looking at the forecasting approaches of the TSOs, an almost unanimous benefit is seen in the forecasting of long-term grid losses, as it is reported as a calculation which provides an easy help to properly decrease the price risk. But as a general decrease in accuracy of these long-term forecasts can be observed, due to cross border exchanges, which are hard to forecast, and the increasing influence of renewable energy generation, most benchmarked TSOs have decided to complement this approach with a short-term forecasting which could help in their compensation strategy to cover more granularly and thereby precisely.

Clear benefits, such as a more granular dealing with price and volume risks, can be drawn from of the usage of short-term procurement to reduce the supply gap. An accurate short-term forecasting strategy will be seen as a necessary enabler of this. As shown in the figure below, the TSOs forecasting strategies are heavily linked to their procurement strategies. This is also the case for Elia today, where no short-term forecasting is in place in absence of a short-term component of the losses compensation approach.

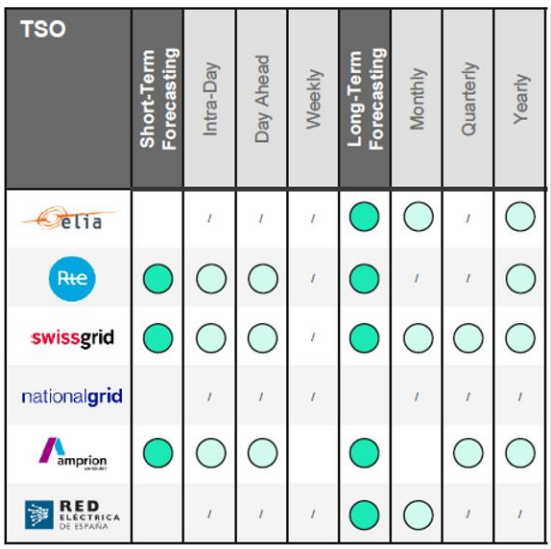

Figure 32. Forecasting strategy (SIA Partners, 2022).

Whilst a combination of long-term and short-term forecasting is needed to cover the supply gap more accurately, the forecasting accuracy remains a key factor for the cost management and risk management of loss coverage strategies. Hereby it should be underlined that all the TSOs with a short-term forecast remain to have a forecast error/supply gap, as can be seen in the figure below. The goal is to reduce this supply gap in the best way possible, but it should be noted that it won't disappear entirely.

TSO	Forward procurement?	Volume LT procurement	Volume ST procurement	Market Access?	Volume supply gap	Year of Data
elia	Regional Losses	100%	0%		Not available	2020[1]
RTE		Not Available	Not Available	EPEX	1%	2020[2]
swissgrid		77%	17%	EPEX	6%	2020[1]
amprion		Not Available	5-15%	EPEX	4%	2020[1,3]
nationalgrid		/	/		/	/
RED ELÉCTRICA DE ESPAÑA		/	/		/	/

Figure 33. Supply gap optimization.

To reduce the forecast error and to deal with the changes in the energy market context, the different TSOs are continuing to improve their forecasts. The incentive to do so differs for each TSO, as they all use different forecasting algorithms which need adjustment, but the general goal is to minimize the supply gap and strengthen the accuracy. In this regard, some of the TSO's indicate that they would see use in the introduction of an intermediate forecast (e.g. week ahead).

National Grid and RED Electrica do not utilize any short-term or long-term forecasting models due to the fact that all losses are compensated through the in kind mechanism. They justify this approach by saying losses represent a small share of the demand and the high volatility of the losses makes for the need of a highly complex forecasting model. In order to help BRPs in efficiently covering their losses, Red Electrica publishes estimations of the TDLA one month ahead, but also – based on further estimations which is *de facto* a short term forecasting - two days ahead. The estimated TDLA are based on historical losses for each hour. However, the influence of the grid node is not considered in the estimated losses coefficients.

3.1.5. Other observations

The SIA benchmarking started from a rich survey and thereby also resulted in other interesting observations. They can be found back in annex, but two are particularly high-lighted here.

- The increasing **influence of cross border flows** in the losses remains a challenge for the six TSOs. All of the benchmarked TSOs are currently looking for means to integrate these flows into their forecasts. Two examples of mitigating measures can be seen with Amprion, who is making a large but complex simulation of the European grid, to integrate these flows into their long-term forecasts, and Swissgrid, which uses historical NTC values for their forecasts.
- All investigated TSOs indicated that GHG emissions stemming from grid losses are a relevant aspect for them. For the time being, none of the benchmarked TSO's compensate for the greenhouse gas emissions caused by their losses coverage and procurement strategy. This is due to the lack of regulatory incentives, which currently fail to cover the TSO's potential additional costs of sustainability aspects. Most of the TSO's are looking into the possibility of green procurement through green PPA's, guarantees of origin or CO2 offsetting. Amprion is a frontrunner with the installation of self-generating renewable energy plants used to cover the losses. Note that also Elia is planning to do so in approach towards 'greener substations'. Elia's biggest contribution to GHG reduction is to enable a successful energy transition. At the same time, Elia is convinced to also improve its own GHG footprint, which is mainly driven by the grid losses. Elia reflected this in the Elia Group-wide ActNow program (covered in section 4.1.2). Elia is looking for mechanisms that have a real and tangible impact on the GHG emissions related to its grid losses.

4. Further optimizing the losses compensation approach

Based on the findings of the previous sections, this section aims to propose improvements to the current losses compensation approach. For this purpose, first the key considerations for such approach for the next years are discussed in order to set the scene and define the useful contours for an improved compensation approach.
Having set the scene, proposals for change are considered. Firstly, it is assessed to what extend a switch from compensation in ind by BRPs to procurement to Elia would be conceivable. While on the short to mid-term this is recommendable, for a longer-term perspective a number of considerations leading to boundary conditions are identified. Secondly, changes to the approach on the short to mid-term are proposed, focussing on overcoming the main limitations of the current approaches (cf. also section 2.3.5) and targeting solutions with shorter-term procurement.

This report, and in particular this section, aims to describe the proposed approaches themselves. The pathway for a potential roll-out (both from a regulatory framework perspective as well as from an IT and process implementation perspective) will be covered in later steps foreseen in this 2022 balancing incentive context. Indeed, it is foreseen that by 15/12/2022 – assuming a positive Proof of Concept on short-term forecasting – an impact assessment and implementation plan will be developed. Already in this section, a first, high-level, non-exhaustive view on major steps is provided in order to better appreciate the proposal.

4.1. Setting the scene for future losses compensation

Improvements to the current losses compensation approach should be made such that the changes bring an added value to the system and at the same time are such that it allows for potential future further evolutions. Elia considers therefore that the following aspects should set the contours for any future losses compensation approach and a change process linked to getting there:

- Limit the supply gap
- Avoid collateral damage due to change
- Already foreseen evolutions
- Allow for improving the sustainability of the losses compensation

4.1.1. Limit the supply gap

Limiting the supply gap (i.e. any real-time shortfall or surplus in a losses compensation approach) is generally beneficial to the system.

Avoiding a supply gap entirely is obviously not realistic, any losses compensation approach in the end targets to cover the losses in real-time, but the losses are very dependent on the system conditions at a specific moment and vary accordingly. Appropriate forecasting can clearly be beneficial to fine-tune any volumes covered through a compensation strategy, but a forecasting error – and hence a resulting supply gap – remains unavoidable. Short(er)-term fore-

casting in combination with a sufficient dynamic – in a sense of being able to act or adapt closer to real-time – compensation approach clearly helps to limit the supply gap. This is in line with the approaches observed at other TSOs in the SIA benchmark.

The impact of limiting the supply gap emerges through the functioning of the real-time market. Indeed, as the supply gap de facto becomes a part of the system imbalance, which is then solved through the activation of balancing means, any reduction of the supply gap resonates positively in the imbalance context. While of course (cf. supra) the supply gap can help the zone by reducing the system imbalance, avoiding as much as possible that the supply gap "pollutes" the system imbalance renders the real-time market "cleaner" and adds to a clearer real-time price signal overall.

Moreover, in a context of merit-order activation and its consequent effect on the determination of the real-time (imbalance) price, avoiding the effect of the supply gap benefits even more compared to past years where for instance aFRR was priced through proportional pricing. In such proportional pricing, the activation of small volumes (as most of the time the supply gap is about small(er) volumes) did not necessarily led to an imbalance price effect. Note that at all times, irrespective of the effect on the imbalance price determination, the activated volume results in a cost for the system. In case mFRR activation was affected or triggered due to the supply gap, the effect was also in past years already more pronounced through the applied (merit-order based) marginal pricing, but overall the activation of mFRR is far less frequent than aFRR.

In conclusion, an improved losses compensation strategy clearly benefits from a shorter to real-time forecasting and fine-tuning of the losses compensation. It not only results in a better coverage as such with a reduced supply gap, also the indirect effects on the real-time market and pricing of a reduced supply gap are clearly beneficial to the system in terms of reducing system imbalances, cleaner and clearer real-time price signals, etc.

4.1.2. Avoid collateral damage due to change

When changes to the losses compensation approach are considered, it is important to assess to what extent change has collateral or transitory effects. Is there a cost linked to changing? Elements to address include:

- **Financial effects:**
    - **Tariff effects**: given that today a two-fold compensation approach is applied with different effects on market actors and how it is translated into transmission tariffs, any changes may induce changes to tariffs as well. This can imply a change in the costs covered by Elia tariffs, but also more fundamental changes in which kind of costs are borne by which kind of actors. BRPs are today responsible for covering the federal losses and thereby bear those costs, while the costs for the procurement of regional losses are covered through the tariffs charged upon access holders. Any change in the current way of working needs to take into account the effects it could create in the tariff context. Switching the market role responsible for bearing a certain cost (for instance BRP versus access holder) should be carefully considered. However, it is in the context of setting a tariff structure not Elia's role to take a final judgement on such change.

In addition, any such switch or other change that impacts tariff structure, tariffs and the way costs are born by Elia require careful reflection and should result in a stable and clear framework to operate. Insofar significant changes to the current losses compensation approach would be envisaged, these reflections and the establishment of a stable and clear framework have not yet taken a start and should anyhow be planned well in advance.

- **End consumer effect**: although it can be fairly assumed that the end consumer in the end bears the total cost of the losses compensation (either through Elia tariffs or via its BRP), changing the way losses compensation costs are translated into tariffs is to be done cautiously and with sufficient foresight for consumers. This is particularly true in case the compensation in kind via the BRPs would be altered and e.g. shift partly or entirely to Elia. Indeed, when Elia would pick up a larger share of the losses compensation, the Elia tariffs will cover this (let's for the sake of argument assume that it would increase the cost level and translate in the same way as the current procurement cost for regional losses). Elia tariffs are set and regulated by CREG and very transparently defined and included in the invoices. In return to such change of Elia tariffs, the costs invoiced by BRPs for the in kind compensation of the losses should alter in the same way. This is however part of a commercial contract and price-setting between the BRP and his client. As far as Elia can tell there is today no 1-on-1 control possible on an equivalent change in the BRP invoice. It may even be that today this cost linked to the compensation of the losses is not transparently dealt with in all contracts with a BRP, rendering it more difficult for a consumer to track and impact it.

  Insofar there is a sufficient competition between BRPs in all segments of the energy market (residential, large consumers,…), there may be a chance that BRPs would equivalently reduce their invoices driven by competitive forces. However, it goes beyond the competence of Elia to assess and take a strong view on the level of competition between BRPs required to achieve this and how that relates to today's competitive situation.

  It would anyhow require sufficient time for consumers to re-negotiate and take into account such a change into its commercial contract with the BRP. Hence, the final decision to such changes should be taken and fully confirmed well in advance to allow such dynamic between the consumer and its BRP to take place. It would be safe to assume that a few years advance notice is recommended. The risk of *not* foreseeing sufficient advance notice is that on the one hand Elia tariffs would already include a change (i.e.. an increase) while on the other hand consumers do not yet benefit from an equivalent decrease in their BRP-contract. This would mean a double payment for the consumers, which is clearly to be avoided at all times. Insofar the risk is considered material, it may be opportune that a monitoring on the impact of the BRP-invoice is put in place. It goes however beyond Elia's competence and view on market information (i.e. Elia has no insight in the commercial contracts between a BRP and an access holder) to establish such a monitoring.

- **Phasing-in timing aspects**: next to the standard needs for sufficient implementation time to develop the necessary framework and tooling for any change that may take place, built-in in a compensation approach there may be a need to ensure timely decision-making. For instance, in case smaller or larger volumes would

have to be procured by Elia via long-term contracts, a sufficient time is needed to phase-in such volume changes. In view of a price risk diversification Elia typically starts procuring 3 years ahead of actual delivery. Any final decision to change such aspects of a compensation approach is hence to be taken several years ahead (at least 3 and assuming a stable and clear framework is in place) in order to maintain the price risk profile as applied in the past.

In conclusion, the above effects are particularly relevant in view of potential changes on the short to medium term and indicate that when more radical changes would be envisaged on the longer term (such as abandoning the compensation in kind approach), transitional effects are a key concern to be managed. Each of these effects or risks identified may potentially be overcome and could rather be considered as boundary conditions in terms of overall acceptability. They raise the need for a careful reflection, an assessment of boundary conditions to be fulfilled by the relevant entities and a weighing of potential remaining negative effects with the overall added value a change would bring to the system.

4.1.3. Already foreseen evolutions

When considering changes to losses compensation approach, any concrete changes for which the discussion has already been initiated before should not be overlooked and when still deemed useful and adding value, to be integrated. In particular, discussions on changing the compensation in kind regime in case of multiple BRPs active on a single access point are already taking place and deemed useful to pursue. This is even more to be considered insofar the compensation in kind mechanism remains a structural element of the overall compensation approach (cf. section. 4.2).

4.1.4. Allow for improving the sustainability of the losses compensation

As mentioned in section 3.1.5, a clear framework to address and improve the sustainability of the losses compensation approach is missing both in Belgium as for the TSOs considered in the SIA benchmark. Recently, German network operators published a position paper in which they ask for changes in energy law to be able to source grid losses with green energy via Guarantees of Origin. Outside the set of benchmarked TSOs, Tennet indicated in its yearly report that it buys and cancels GoOs for the entirety of its Dutch (and over half of its German) grid losses in the Netherlands. As this field is gaining attention by TSOs and among stakeholders throughout Europe, the regulatory framework & incentives should keep the door open for TSOs to reduce the GHG footprint of their grid losses compensation.

Obviously, reducing the losses in the first place is a key objective. However, it is clear and generally accepted that when transporting electrical energy from one place to another there will always remain a part of ‘unavoidable’ losses, cf. also the mere physics of the system as described in section 2.1. Purely focussing on the reduction of losses without keeping in mind the bigger picture of welfare created by transmission investments, appropriate technology choices, etc. would result in a suboptimal bias and is to be avoided. Consideration of transmission losses in all these choices for investments, technology, etc. when trading off costs and benefits, is however important and already the case today.

Increased attention on the sustainability of a losses compensation approach targets reducing the emissions linked to the compensation of the 'unavoidable' losses. Different approaches can be imagined to improve or ensure this sustainability, such as considering 'green' sourcing (e.g. through Green PPAs concluded with renewable energy providers) or Guarantees of Origin.

Elia's ActNow program ambitions to address this sustainability aspect throughout the next years. While it goes however beyond the scope of this report (and the goals set by the incentive) to develop such sustainable approaches further and to assess which approaches suit best, it is to be ensured that any approach put forward does not unnecessarily block such evolutions to take place and complement the proposed compensation approach. From this perspective, it remains for instance relevant to maintain (and definitely not close the door for) a longer term procurement as already the case today. This may for instance enable the use of green PPAs which are typically concluded for multiple years (periods ranging from 3 to >10 years are not uncommon). Guarantees of Origin are rather alongside a compensation approach and does not impede any long or short term procurement.

4.2. Elia proposal for changing the design of the compensation approach

Taking into account the above-described contours when considering changes to the losses compensation approach currently applied and the observations from the analyses and the SIA benchmarking, Elia proposes an improved design with two possible options.

For this new design Elia targets a priori the shorter to medium term, i.e. next few years for its roll-out, precise timing details will be further developed in an implementation plan considered at a later stage (i.e. by the end of this year, cf. description of the incentive governing this study). This timescale also corresponds with the upcoming tariff period 2024-2027.

Firstly, it is considered to what extent the compensation in kind by BRPs for the federal losses could be abandoned and taken over by a procurement by Elia. Next, the evolution towards a shorter term procurement is addressed.

4.2.1. Considerations on a potential evolution of the compensation in kind mechanism

Elia considers that the current two-fold losses compensation approach has sufficiently good characteristics to continue to serve as a basis, at least for the short and mid-term. It would however benefit from being complemented with additional elements (cf. next sections) to further improve it. Fundamentally changing the in kind approach on the short to mid-term is hardly conceivable, not the least because such change would require several years advance notice for end consumers to renegotiate with BRPs, for a stable and clear framework to be put in place in time to allow Elia to start years ahead procurement of newly to Elia allocated losses volumes.

For the longer-term (≥ 2028), a more open question exists and a broad perspective is required. Such analysis should not take a purely theoretical perspective on what would be the best mechanism. Indeed, there is no tabula rasa. Considering alternative approaches inevitably requires a change from an existing situation to a new one. As pointed out above in section 4.1, drastically changing the longer-term oriented components, in particular the in kind compensation by BRPs, comes with significant transitional effects and a potential 'cost of change'. These have to be accounted for carefully and could at least be considered as boundary conditions to be fulfilled. Insofar not entirely fulfilled, it is clear that any remaining negative risk should be deemed sufficiently small that it does not outweigh the perceived benefit of changing the approach. At least the following elements are to be weighted:

Firstly, in terms of advantages of switching from BRPs to Elia, whether BRPs or Elia provide on the volumes to be covered, does not entail a considerable cost efficiency gain. Elia is not necessarily more efficient in securing better prices than BRPs, many of them being commercial market parties with energy sourcing being a core activity. Elia has not a 'better' market access than BRPs (even if improved with an access to selected market segments such as the DA market) and – notwithstanding good historical performance - there is no structural reason why Elia's "traders" or "buyers" would perform better than the market parties'. In general (cf. section 2.4.2.1), Elia is confronted with more constraints than a BRP or market party in its procurement activity and could ceteris paribus therefore at best match their performance insofar the constraints would not be limiting. In contrast to what Elia would do, it could be that BRPs do not charge end consumers at wholesale prices but rather at commercial prices, thereby potentially including a contribution to their margin. One could wonder to what extent this effect is material or negligible, as it would be a margin on the 1 to 2% *extra* volume that a BRP is required to deliver to serve 100% of net offtake. The opportunity to take a margin obviously also depends on the actual level of competition between BRPs. Elia does not see any further effects (VAT, impact on other tariffs,…) that would impact how costs are transferred from BRPs to an end consumer that would yield a benefit in the eye of Elia providing on the losses compensation rather than BRPs.

Secondly, considering the volumes to be covered, changing from an in kind provision by BRPs to procurement by Elia shifts the burden of forecasting from BRPs to Elia. While BRPs today have to forecast their individual net offtake at portfolio level (on which then the percentage of in kind provision is applied), Elia would rather have to forecast the losses at an aggregated system's level. It remains to be seen to what extent that would in practice become more efficient, e.g. from the perspective of more accurately covering the losses which is equivalent to minimizing the supply gap. As illustrated through the international benchmark and as also implied by CREG in the phrasing of the incentive, accurate forecasting of the federal losses may not be straightforward. The link with international flows and how the market acts at European scale is hard to accurately forecast. The results of the Proof of Concept being put in place by Elia in the summer of 2022 may shed a first view on this matter and allow for a first assessment in terms of potential gain. Note that at least for the short to mid-term period, for the BRPs and any interested party in general, Elia already puts at disposal its forecasting information related to the drivers on which the BRPs have to apply their percentage for providing on the losses compensation. Elia already publishes its own forecasts linked to offtake (insofar BRPs do not also dispose of own (and potentially better) forecasts related to their own portfolio), solar and wind power.

Thirdly, Elia picking up the responsibility for the federal losses would induce a significant budget to be added to the Elia tariffs. Federal losses representing roughly 1 TWh and today's stated forward prices for 2025 (no public stated forward prices for 2028 or later are available) exceeding 100 €/MWh, quickly results in a >100M€ yearly cost. While as such the fundamental cost does not alter when switching entity procuring it, the shift towards Elia-tariffs only makes sense insofar an equivalent reduction in the BRP-invoice towards the end consumer can be guaranteed. As mentioned before, this is not necessarily straightforward to guarantee or monitor, thereby risking a remaining double payment in the eye of the end consumer. Cf. section 4.1.2, Elia is also not in a position to assess in how far competition among BRPs is such that across all market segments the equivalent cost reduction would automatically occur as a consequence of competitive forces.

Fourthly and linked to the previous aspect, it is true that working through Elia may result in a gain in cost transparency of the cost of losses compensation. Question remains what the concrete benefit of such increased cost transparency would be, if it remains uncertain whether it would result in fully equivalent – potentially non-transparent – cost reduction at BRP side. Cf. section 4.1.2, it may be opportune that a monitoring on the reduction of the BRP-invoice is put in place in case the compensation in kind would be abandoned in order to follow-up on the risk of double payment by end consumers. Of course, it remains to be seen how to act in case monitoring would reveal that the end consumer is not equivalently benefitting from a cost decrease at BRP-side. Any rollback-scenario is anyhow hardly conceivable.

Finally, from the international benchmarking it can be observed that not only in Belgium a mechanism of in kind compensation is currently applied, also in the UK and Spain – albeit with implementation differences – in kind compensation by market parties is in place (and currently not on the table for changing as far as Elia based on the SIA benchmark can tell).

In conclusion, while some of the above discussed effects may fade away with a sufficient advance notice for a switch towards procurement by Elia, it is yet unclear whether all risks would sufficiently disappear and whether the advantages would create a sufficient added value to overcome any remaining negative effect. From an Elia perspective, this then implies that for considering a mechanism change that would lead to Elia taking over from the BRPs the procurement of federal losses, there are a number of conditions to be fulfilled and appropriately assessed. Elia is however not in the position to provide the necessary assessment on these conditions. Will BRPs equivalently reduce their costs? Is competition between BRPs on the Belgian market strong enough and a sufficient condition to ensure the cost reduction? Is there a sufficient additional gain in terms of reducing the supply gap in case Elia would forecast (especially also in addition to the options for improvement already proposed in the next section)? Anyhow, a sufficient multi-year advance notice is a condition sine qua non both for end consumers to allow renegotiation and for Elia to ensure the LT procurement. Also, a clear and stable framework is to be put in place well in advance.

Notwithstanding the proposal to maintain the compensation in kind at least for the short to mid-term (and even more in case it remains on the long term), Elia proposes to pursue the improvement to the mechanism for cases where multiple BRPs are active on a single access point (cf. infra).

4.2.2. Key improvement: add short-term forecasting and market access

The key improvement to the current compensation approach identified throughout this study, both resulting from the analyses and from the international benchmark, is an evolution towards an approach that allows also for a shorter-term compensation of losses complementing already existing long-term procurement. Such shorter-term losses compensation requires good-quality short-term losses forecasting to be in place. Notwithstanding any inevitable remaining forecasting error, short-term compensation would not only result in an improved compensation *an sich*, i.e. a better coverage, but also in a more limited supply gap. A more limited supply gap implies also a reduced impact on the balancing of the zone, the real-time market and price formation.

For this purpose, Elia proposes that – like several other European TSOs – Elia can act on the spot market to procure part of the volumes needed to compensate losses. In a first step, and assuming a good-quality forecasting of losses becomes available (to be judged upon further once proof of concept results become available), Elia proposes to develop such activity linked to the day ahead market where it more easily can act as a price-taker. Upon positive evaluation and insofar also intraday forecasting would become available and demonstrate extra added value, extension towards intraday could be considered at a later stage.

As mentioned above, Elia considers it more prudent to particularly rely on 'buy' actions on the spot market, which would imply that particularly the long-term volumes procured by Elia are to be dimensioned correctly (i.e. not too much). Note nevertheless that following the SIA benchmark, Amprion, RTE and Swissgrid are entitled to both 'buy' and 'sell' orders on intraday and day ahead markets.

4.2.2.1. Maintaining long-term procurement

Elia proposes to continue to rely on the practice for regional losses to secure long-term contracts via tenders as this contributes to the management of the price risk, as also demonstrated in the historical analysis (cf. supra). The international benchmark also illustrates that at least a partial long-term coverage of losses can be considered a best practice.

Also, insofar such approach would be considered appropriate in the future, strategies to render the losses compensation approach more sustainable may also rely on alternative longer-term procurement arrangements, e.g. in case of relying on green PPAs in a multi-year context.

Nevertheless, when combined with a shorter-term compensation (cf. next section), an assessment of the volumes covered by long-term procurement is useful. Indeed, when part of the losses can be covered through short-term actions, the calibration objective underlying the setting of the long-term volume may alter. As several drivers resulting in the observed real-time volatility of grid losses can be better forecasted closer to real-time, e.g. day-ahead, the long-term procurement should avoid to be overly ambitious and to result in over-procurement.

In Elia's view, and notwithstanding the fact that other TSOs with short-term market access are taking buy and sell actions on short-term markets, there could be a preference to limit the risk of over-procurement through forward contracts as this directly limits the need to resort to potential 'sell' orders on the market. In case of careful determination of volumes to be procured long-term (i.e. not too much), it may limit Elia's role when acting on the spot markets to mostly (or only) "buy" actions.

4.2.2.2. Two options for determining the volume to procure on the short-term

In the Belgian constellation, a relevant question is which volume Elia would procure on the spot market. Elia puts forward two options:

- **Option 1: Based on short-term forecasting, Elia procures the volume necessary to complement the full compensation of the <u>total</u> losses**, i.e. considering both the regional and federal losses.
  In this option Elia would forecast on the short term the regional and federal losses, as well as the expected contribution in kind by the BRPs. Combined with the already known long-term secured volumes through forward contracts for the regional losses, the volume to contract on the spot market is known.

  Option 1: Volume to be procured SPOT = Forecast (federal losses) + Forecast (regional losses) – Forecast (Contribution by BRPs) – Known(Already LT secured volume)

  Note that from a forecasting perspective, the main challenge is on forecasting the losses, both regional and federal. Also forecasting the latter BRP contribution – being based on a small percentage of the consumption measure – is a less challenging forecasting aspect as Elia already disposes (and publishes) load forecasts and given that the BRP contribution is based on a small fixed percentage of consumption, the forecast error on the consumption forecast in principle only propagates in a minor way into the overall forecast error of the losses.

  Visually, the overall proposed mechanism taking into account the nuance of option 1 can be summarized as follows.

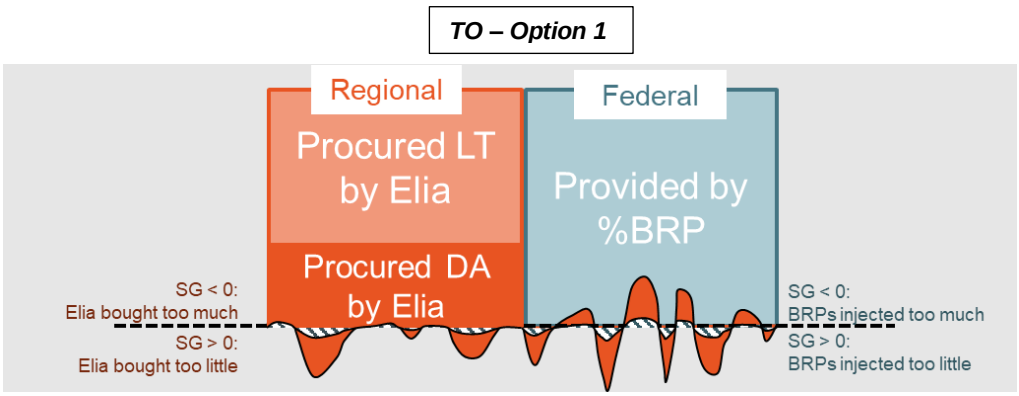

Figure 34. Compensation strategy - option 1.

Compared to the current mechanism as displayed in the figure below, the key differences become visually clear:

- The supply gap, indicated by the striped area, is reduced as a consequence of short term forecasting and procurement. There remains a (smaller) supply gap as consequence of an unavoidable forecast error, which then limits impact towards the balancing market and real-time prices.
- A smaller volume procured long-term by Elia to avoid overcompensation, i.e. small enough that the fluctuations of the DA volume procured by Elia (coloured in dark orange) have a limited risk of becoming negative and would require a “sell” rather than “buy” action.

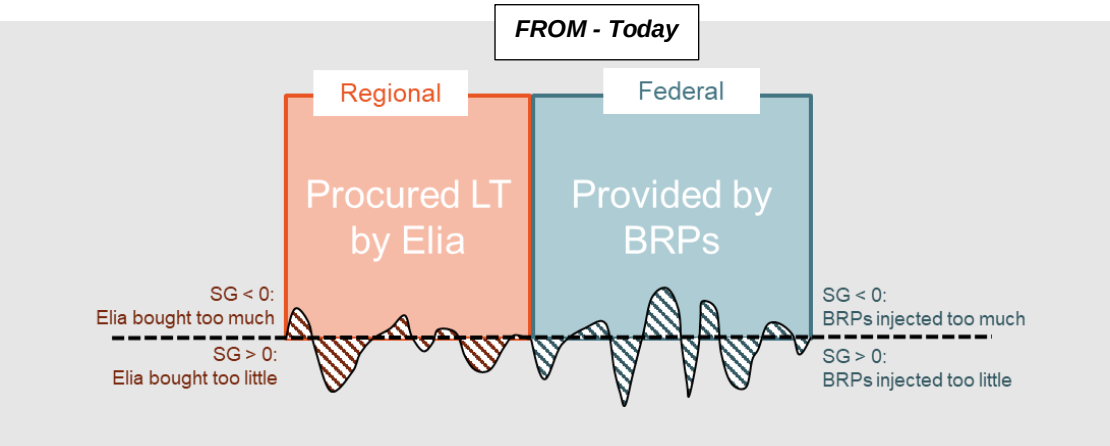

Figure 35. Compensation strategy - AS IS.

- **Option 2: Based on short-term forecasting, Elia procures the volume necessary to complement the full compensation of the <u>regional</u> losses**, i.e. the federal losses are left out-of-scope for complementary short-term procurement by Elia.

In this option Elia would forecast on the short term the regional losses. Combined with the already known long-term secured volumes through forward contracts for the regional losses, the volume to contract on the spot market is known. The federal losses remain to be covered solely by the compensation in kind by the BRPs. No further tuning on the shorter term is foreseen for the federal losses compensation in this option.

Option 2: Volume to be procured SPOT = Forecast(regional losses) – Known(Already LT secured volume)

In a similar visual representation, option 2 could be summarized as follows:

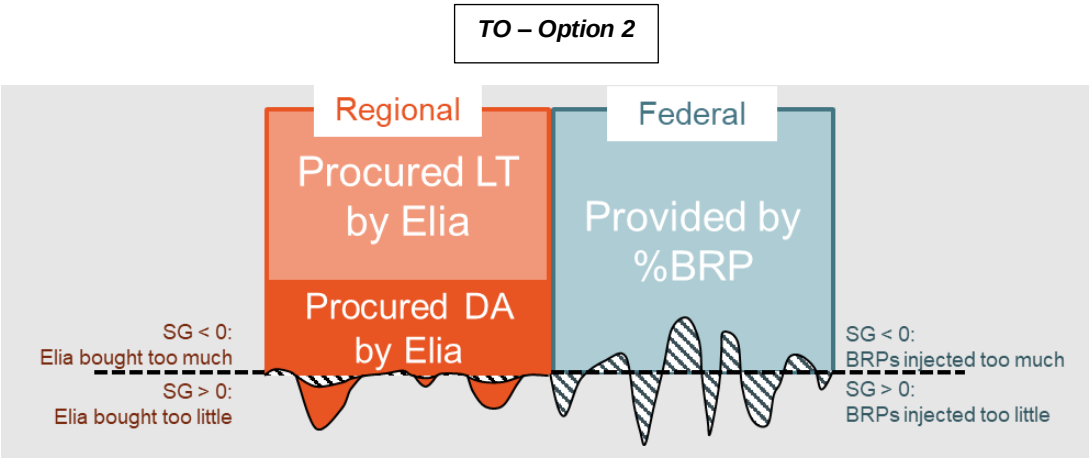

Figure 36. Compensation strategy - option 2..

The key difference compared to option 1 is observed in the fluctuations covered by DA procured by Elia and the striped supply gap remaining unchanged compared to today's mechanism for the federal losses.

While both options have many things in common, their differences result in different benefits.

- Option 1 would be able to reduce more significantly the supply gap as it covers the entire losses scope including the federal losses, which is beneficial from a system and market functioning perspective as the impact on the real-time market and price are more limited.
- However, option 2 provides a cleaner treatment between regional and federal losses. All actions directly related to procuring volumes for losses compensation remain linked to the regional losses, i.e. within the boundaries of the current way of working and how it could be translated towards the tariffs. Option 1 would imply Elia explicitly procuring volumes (federal supply gap) that also serve the compensation of the federal losses, which is currently foreseen to be covered (and financed) via the BRPs. In today's system, this federal supply gap is sourced – and valued - via imbalance (see above), for which Elia activates balancing energy. Interfering with this clean split would alter the need for a specific treatment in view of maintaining the financial neutrality of BRPs, as part of the direct cost of procuring on the spot market would have to be imputed to the BRPs

(requiring potentially a modification in the tariff structure). While of course such arrangements and frameworks can also change, it is important to keep a close eye on this, also in view of the acceptability of any solution for the involved actors.

- Finally, option 1 clearly also requires a good-quality estimation of the federal losses. Federal losses being more impacted by international flows and knowing that – as also confirmed by other TSOs in the international benchmarking – forecasting those flows is far from evident, it remains to be seen whether a sufficient quality can be reached. The proof of concept results expected for later in 2022 as foreseen by this incentive may provide a first good indication on this. Option 2 does not require this as it does not require federal losses to be estimated on the short term.

4.2.3. Improvement to the compensation in kind by BRPs

Each grid user connected to the Elia grid has access to this grid at the condition that its access point is registered in the balancing perimeter of a BRP. Accordingly, the offtake/injection measured at the level of this access point is well allocated to the BRP. Today, in most cases, only one BRP is responsible for each access point. But according to the current access contract, schemes exist for the possibility to allow for a sharing of the balancing responsibility by designating more than one BRP to an access point. As these schemes were deemed to be not sufficiently developed to the potential need of all market parties, Elia provided a study in June 2021 towards the feasibility of having multiple BRPs on a single access point. This study received positive feedback from the participating market parties. However, an implementation of the results could also provide an impact on the calculation of federal losses, which is deemed beneficial by the concerned market parties.

Currently, Elia requests BRPs with a net offtake position to provide an extra amount of energy for compensating in kind the losses on federal level. This is applied as a percentage on the net offtake position (netting) of the BRPs per access point. This kind of netting is today not performed when there are multiple BRPs on a single access point, leaving a BRP responsible for the offtake of a demand unit to compensate for the losses based solely on the gross offtake of this demand unit. Both Elia and the market parties involved in the 2021 study considered the principle of netting the losses at the access point for all existing and new configurations to be more correct and fair.

Elia will further analyse in more detail the practical implementation needed to apply this rule, and more particularly the way to split the net losses among all the BRPs. In the meantime, besides the delivery of the incentive report to the CREG, an implementation report was made and presented to our "working group balancing".

This improvement to the compensation in kind is deemed overall beneficial and fully compatible with the remainder of the proposed future compensation approach.

4.3. Preliminary high-level view on implementation steps

Although the development of a detailed implementation plan is only foreseen for later and in case the proof of concept yields positive results, a first high-level and non-exhaustive list of aspects is put forward. The goal is not yet to develop a concrete plan or proposal, but rather to trigger a useful feedback and reflection by means of the following list:

- From proof of concept (POC) to robust implementation: a proof of concept is meant to concretely develop an idea and test whether it is realistic and could yield a positive contribution, typically set-up in a faster way and allowing to 'cut some corners'. In the context of the POC on short-term forecasting currently being set up in the context of this incentive, this could mean a strong reliance on manual intervention, accepting stronger risks of data unavailability, less built-in checks and balances, a process design that does not guarantee a 7/7 availability, etc. To go for a robust forecasting that can be used in an operational context on which for instance decisions to buy energy are based is likely to require more industrialized and robust implementation setup.
- Amending the legal and regulatory framework: depending on the final design opted for, more or less changes to the framework are needed. For instance, changes to the T&C BRP cannot be excluded.
- Market preparation: when changes the compensation approach in a way that it may impact on the wider functioning of the energy impact, it seems useful to allow the market to get acquainted with the changes. For instance, a parallel run of the short-term forecasting (once the POC has developed towards a more robust solution), may be considered useful.
- Setting up market access: if Elia would buy volumes on the day ahead (and later potentially the intraday) market, it is necessary to set up this activity. In this context, there may exist a potential synergy with the activities already done by the 50HzT in Germany who already has a front office active on the spot market.
- Adaptations to the long-term procurement, in view of the approach put forward, it is important to timely take into account the change in volume of the long-term procured energy in view of a day ahead procurement.

The above list is clearly high-level and non-exhaustive and does not yet provide in a planning, but it gives a first indication of which things come into mind when going forward with a proposed solution.

4.4. Summary on the Elia proposal

The incentive description underlying this study related in particular to two research questions. On the hand, it targeted the assessment of the relevance of developing a short-term procurement component based on short-term forecasting as part of the compensation approach. On the other hand, the question was raised to what extent procurement by Elia of both federal and regional losses would be more efficient.

Based on the analysis performed in this study, Elia learned that short-term procurement based on short-term forecasting could help mitigating the effects on the balancing market functioning and price formation in real-time caused by the supply gap. This is a fortiori true when taking into account the evolving trends of the main drivers underlying the losses to be compensated which are truly better captured through a short-term approach. Also, such short-term approach would create more degrees of freedom than the current way of working allows for. A more granular approach by means

of more degrees of freedom offered through short-term procurement could clearly help to overcome the limitations of the current approach. As a consequence, on the first research question Elia concludes that it would be beneficial to consider complementing the approach with a short-term procurement component. The foreseen proof of concept on short-term forecasting aims further assessing feasibility of such evolution.

However, based on the analysis and argumentation provided throughout this study, Elia considers that at least for the short to mid-term changing the compensation in kind by BRPs to a procurement by Elia is not possible nor recommendable. At least a multi-year advance notice is needed, next to foresee the implementation and a clear and stable framework. For the longer-term (≥2028), Elia has assessed from a broad perspective whether such switch would be useful. While it remains to be confirmed whether forecasting of federal losses can be done in such accurate way that changing the approach would yield a sufficient advantage (also in view of what could be achieved already on the shorter to mid-term), Elia identified boundary conditions that should be fulfilled in order to avoid or mitigate potential negative effects linked to such switch. Unlike other entities, Elia - by the nature of its role and position in the system - is not well placed to further assess these boundary conditions.

Annexes

A. International benchmark: SIA Partners Executive Summary
B. International benchmark: SIA Partners Report

13/05/2022

TSO benchmark on losses compensation

Updated version following a minor remark of Swissgrid

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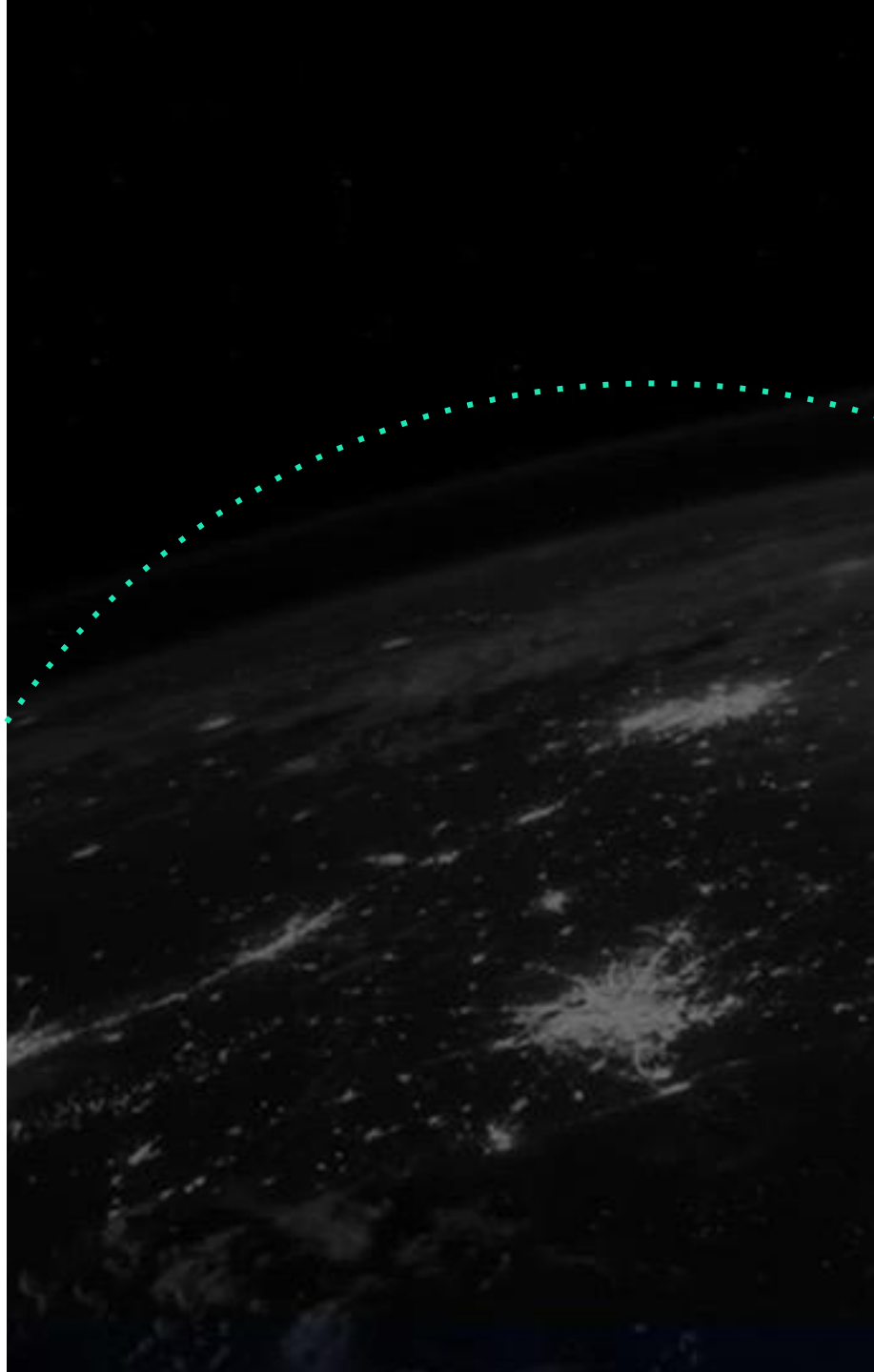


Summary

1. Context
2. Losses coverage strategy of TSOs
3. Losses procurement strategies
4. Losses forecasting models
5. Grid losses monitoring
6. Financing framework
7. Sustainability
8. Summary of key takeaways

1. Context

Sia Partners compared the losses compensation and forecasting approaches of six European TSOs

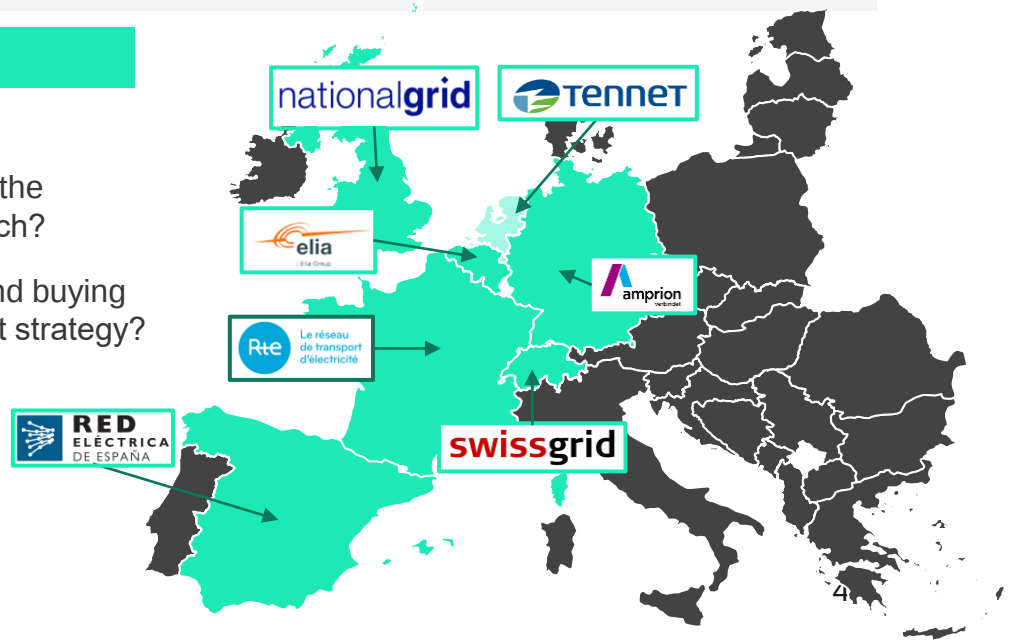
TSO	Voltage levels	Country
elia	36kV – 380kV	Belgium
nationalgrid	132kV – 400kV	UK
Rte Le réseau de transport d'électricité	63kV – 400kV	France
swissgrid	220kV – 380kV	Switzerland
amprion	220kV – 400kV	Germany
RED ELÉCTRICA DE ESPAÑA	220kV – 400kV	Spain

The selection of TSOs is based on the **CREG's request**, their **voltage levels** and the **contacts** Sia Partners has within the TSO as well as their geographical proximity with Elia

- As Elia operates the grid from 30 kV to 380 kV, it is interesting to add TSOs that operate on voltage levels lower than 220 kV.
- To facilitate the engagement, TSOs with which Sia Partners has a close relationship will have priority.
- RTE has been selected considering it's a neighbouring country.
- Tennet has been actively approached to participate but preferred not to participate.

The benchmark is focussed on the 6 following dimensions

1. **Which network losses are covered by the strategy?** (voltage levels, grid elements)
2. **What is the compensation approach?** Which entities have which responsibilities? What is the driving principle of the approach? What's the satisfaction of the TSOs regarding their approach?
3. **How does the market interaction take place?** (if applicable) What procurement process and buying strategy is applied and why? What's the satisfaction of the TSOs regarding their procurement strategy?
4. **What is the forecasting approach used by TSO** (from long-term to short-term)
5. **What is the financing framework?**
6. **Which sustainability aspect are considered?**



The benchmark is based on answers to a predefined survey filled in by the TSO and completed during interviews

5 step process

Benchmark introduction

The material is being shared with the respective TSOs to present the study, the survey and schedule the interviews

Survey fill-in

The survey is up for completion by the TSOs.

Interviews

Interview are organized to go through the survey's questions & answers

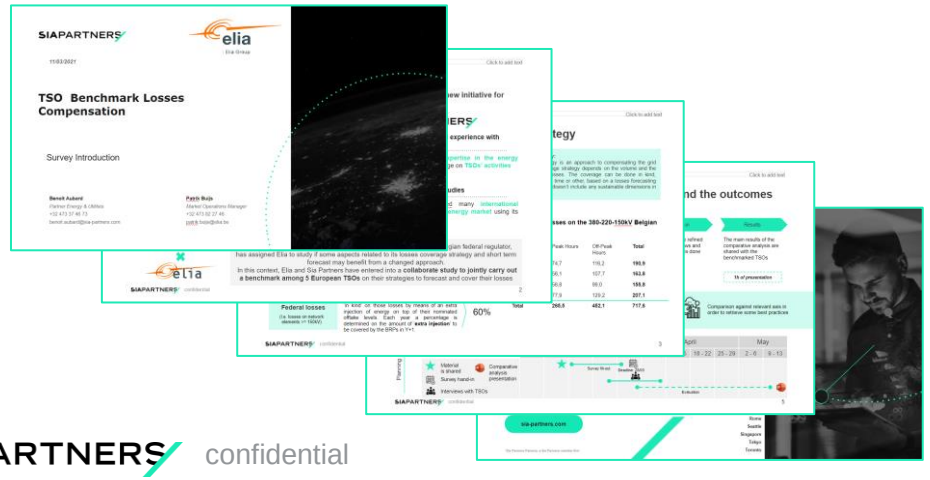
Evaluation

The answers are refined after the interviews and the comparison is done

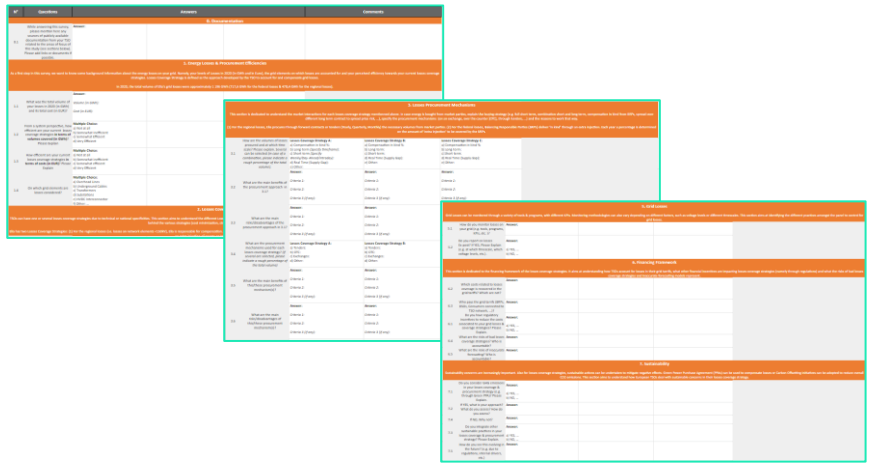
Results

The main results of the comparative analysis are shared with the benchmarked TSOs

The benchmark was introduced through a teaser presenting the context, methodology and timeline of the study



The survey is based on Elia's request and adapted to facilitate comprehension and comparison



2. Losses coverage strategy of TSOs

Elia compensates losses with an in kind compensation of BRP and LT procurement

Description of losses coverage strategies & responsible parties

The Belgian framework makes a distinction between two types of losses for which the compensation strategy is different (dependent on voltage levels):
(1) For the **federal losses** (i.e., Grid losses on network elements at or above 150kV): Balancing Responsible Parties (BRPs) are responsible for the compensation
(2) For the **regional losses** (i.e., Grid losses on network elements below 150kV), Elia should procure the volumes corresponding to the losses.

Perceived efficiency of Losses Coverage Strategies in terms of:

Total volume in 2020 (in GWh): **1196 GWh**

Total costs in 2020 (in EUR): **N/A**

	Losses Coverage Strategies & Time Scale of Procurements	Procurement Mechanism Used	Surplus & Shortfalls	Depending variables	Changes in LPM
Compensation in Kind	For **the federal losses**: BRPs compensate the losses 'in kind' by means of an extra injection of energy on top of their nominated offtake levels. Each year a percentage is determined on the amount of 'extra injection' to be covered by the BRPs. This percentage aims to be financially neutral for BRPs on the long term. ST — LT **100% compensation in kind + supply gap** **Advantages** + Simplicity of the process + Transparent and simple rule of the BRPs + Known in advance, market parties/BRPs can take it into account in their optimization **Disadvantages** - Long term determination of the percentage limits the accuracy for covering losses - BRPs are not treated in a harmonized manner throughout Europe	Tenders / Exchanges / OTC / Others As for the federal losses, 100% of the forecasted losses in the long term are compensated for by the BRPs which inject a given an additional percentage. The gap between the forecasted losses and the actual losses is covered by the imbalance.	The supply gap is the sum of the delta on the federal and regional levels. It takes the inaccuracies of both strategies and is covered by the management of the imbalance. Losses coverage surpluses and shortfalls are implicitly procured on or sent back to the imbalance market.	• Only volume driven but it aims to be financially neutral for BRPs on the long term.	Since 2011: No changes, the federal grid code is complex to change and was just amended in 2019. A possibility has been created to change this rule. *Future:* No concrete changes planned. However, the topic has been on the agenda with stakeholders.
Long-Term Procurement	For the **regional losses**: Elia procures through forward contracts the necessary volumes from market parties. Distinction is made between peak and off-peak and trimestrial and monthly seasonality effects are considered in the forecasted volumes. ST — LT **30% 3Y ahead + 30% 2Y ahead + 30% 1Y ahead + 10% Q&M ahead + supply gap** **Advantages** + Spread of the price risk over time + Simple way of work **Disadvantages** - LT sourcing limits management of supply gap and affects real-time - Difficulty for ST forecasts to identify peak periods - Indirect impact the supply creates on the market	Tenders / Exchanges / OTC / Others Elia covers its losses through tenders. It is not evident for Elia to directly trade on power exchange platforms. The supply gap is dealt with the imbalance. **Advantages** + Competitive process + Simplicity of the process **Disadvantages** - Transaction costs - No real impact on price assuming sufficient market liquidity - No short-term access limit the accuracy		• Volume driven • Price risk spread as 'good house father' and incentive to beat the market by procuring at the 'best moment'	*Since 2011:* No changes, roles, responsibilities and way of working have been the same. *Future:* No concrete change planned yet, but the topic is under study following a CREG incentive, increasing attention on sustainability of losses coverage, limiting the supply gap (the main mean would be the ST loss forecasting & procurement)

	Losses Forecasting Strategy Description	Outsourcing entities	Performance of LFS	Timelapses of LFS	Input Variables	Changes in LFS since 2011
Short-Term	Following a procurement strategy based on long-term components only, no short term forecasting is taking place. However, a proof concept is being developed in the context of a 2022 CREG incentive.	N/A	N/A	N/A	N/A	*Since 2011:* No changes have been made. *Future:* Potential levers include: • Increasing the number of parameters • Including exports (or all flows) • Having a more accurate short-term forecast A change in losses forecasting strategy could happen as a PoC on short term forecast is ongoing. The forecasting approach could change depending on the results of the PoC.
Long-Term	Long-term losses forecasting models are developed both for the federal and the regional losses simultaneously (one year ahead). The mathematical models are mainly based on historical data and climatic variables and consider the evolution of the network. It's based on a detailed modelling and simulation of the grid and the power flows. **Advantages** + Simplicity. One calculation per year based on historical data and grid development estimation. + Known in advance, market parties/BRPs can take it into account in their optimization **Disadvantages** - LT forecasting is inherently limited to the LT character but losses also vary significantly in function of shorter term variables (weather, RES, cross-border flows,...).	Elia does not outsource the development of its losses forecasting models. Elia develops its own models based on its own data.	Actual losses are impacted by shorter term variables (e.g. future weather and network conditions) Performance of LFM is done by analyzing the supply gap through the whole year ex-post.	■ Monthly □ Quarterly ■ Yearly Yearly forecasts are done in June Y-1 for BRP compensation and for the regional losses. Elia follows-up and refines the position in view of losses being monitored in view of potentially adapting the LT procurement of regional losses.	*Yearly:* Climatic, historical losses, offtake/ flow, grid development *Monthly:* Climatic, flows from countries, dispatch of units, load, historical losses	

Elia monitors and reports its losses on all grid elements except its substations

The tool to monitor losses is owned by the market department and the data are based on observed flows. Data on losses are collected per grid element in D+2/D+3. Given that there is no daily coverage strategy, there is no daily follow-up. Losses being part of the tariff, Elia has the obligation to report on losses ex-post. Elia also provides a yearly report to justify the new percentage to market parties. A distinction is made between federal and regional losses.

The financing framework of Elia's losses coverage strategy is heavily driven by regulatory incentives

The cost are retrieved through the tariffs, but the CREG also set an incentive for Elia to have an adequate and cos-efficient procurement strategy. The CREG analyzes the performance of the procurement strategy of Elia against market prices. If Elia outperforms the market, part of the benefits can go to Elia shareholders.

Elia is currently not considering sustainability in its losses coverage strategy but might to do so in the future

Sustainability is currently not considered in the loss coverage strategy of Elia. The framework and the CREG incentivizes on cost efficiency and not on the sustainability aspects. Nevertheless, Elia seeks for potential ways to reduce its environmental footprint. The way Elia might achieve to make its losses coverage more sustainable is currently under investigation as part of it's ActNow program.

LFS: Losses Forecasting Strategy LFM: Losses Forecasting Model

RTE uses a combination of LT procurement and automated ST trading

Description of losses coverage strategies & responsible parties

RTE is responsible for covering all the losses that happen on their network. 100% of the losses forecasted in the long-term are procured via tenders or exchanges on the market. Positions are then automatically adapted by buying or selling on the DA and ID markets based on short-term forecasts. The increasing importance of RES penetration, cross-border flows and changes in the balance of generation centers within the country make long-term forecasting more complex and challenging.

Perceived efficiency of Losses Coverage Strategies in terms of:

Total volume in 2020 (in GWh): **11 023 GWh**

Total costs in 2020 (in EUR): **N/A**

Procurement of the losses

Losses Coverage Strategies & Time Scale of Procurements

RTE buys directly on the market through different channels and at different time frames, enabling a good price diversification. The LT and ST procurement is managed by RTE's team.

ST — LT

100% LT through YA + QA + MA + ST adaptations through Day-Ahead + Intra Day + supply gap

Advantages

+ Regular coverage enables RTE to stabilize the budget and pay an "average market price"
+ RTE has a precise granularity (up to hourly) and an update of forecasts
+ Keep the management of losses internally

Disadvantages

- The regulator defines specific deals that could be improved and adapted to the new market conditions
- The performance of the strategy is subject to market liquidity, which is currently very poor on the short term markets.

Procurement Mechanism Used

Tenders | **OTC**

Organized by RTE or by other parties, such as EDF Obligation d'Achat

Advantages

+ No physical risk (curtailment), no margin calls, no fees, specific products that are not possible on exchanges

Disadvantages

- Counterparty risk, setup, time risk (offers valid for 10 minutes)

Exchanges | **Others**

RTE has a direct market access to EEX & EPEX Spot (Day-Ahead, Intraday and French capacity market).

Advantages

- No counterparty risk, liquidity, easy to use, price reference (settlements, pay as cleared)

Disadvantages

- Curtailment risk, margin calls, fees

Surplus & Shortfalls

RTE adjusts its positions based on the forecast updates of their forecasts. If imbalances remain, they are valued at the imbalance settlement price/

Depending variables

The CRE determines a "reference strategy" which is an automation that simulates purchases over a period of 3 years. RTE's own strategy is compared to it. Depending on the performances of RTE's strategy, RTE receives a bonus or a malus.
RTE also has access to a given volume of ARENH at the French ARENH prices..

Changes in LPM

Since 2011:
There have been changes as the losses procurement strategy can change each year. Originally, there was no intervention on the intraday market or on the capacity market. This allowed to reduce the supply gap and to reduce slightly the cost of the losses coverage (less than 1% compared to previous price)
Future:
The strategy will have to improve to face the change in the regulation but also to consider forecasts and market access. Planned changes include evolution of ARENH and French capacity market (2025), adapting strategy to current market volatility, evolution of regulation.

Short-Term

Losses Forecasting Strategy Description

Having a ST forecast allows to limit the supply gap but increases slightly the financial risk linked to the volatility of the market.

Advantages

+ Enabling to cover physically with a precise granularity 100% of our losses

Disadvantages

- No real disadvantages

Outsourcing entities

RTE does not require the help of external entities to develop its forecasting models as it as it has all the specific skills needed internally. Losses forecast are made by a team next to the dispatchers, in the national dispatching.

Performance of LFS

Timelapses of LFS

- [x] **Intraday**
- [x] **Day Ahead**
- [ ] **Weekly**

Day Ahead forecast and Intraday (up to 3 forecasts a day can be made).

Input Variables

Day Ahead & Intraday:
Climatic parameters, forecasted load, historical losses, hours of the day and type of day

Changes in LFS since 2011

Since 2011:
Changes have been made as losses are becoming harder to forecasts due to the increase usage of renewables, more cross-border flows, lesser correlation between losses and load,…

Future:
Potential leverages include better statistical models, new data, …

RTE plans however to work on new losses forecasting models with data scientists.

Long-Term

Losses Forecasting Strategy Description

RTE makes yearly forecasts based solely on historical losses and transmission network evolution. The correlation between consumption and grid losses is decreasing, making long-term forecasting more challenging. This is mainly due to cross border flows, renewables and geographical distribution of production. RTE would like to take these into account to reinforce their forecast, but it is challenging to model these phenomena.

Advantages

+ Enabling to cover financially 100% of our losses

Disadvantages

- Inaccuracy given all the uncertainties a year in advance

Performance of LFS

Timelapses of LFS

- [ ] **Monthly**
- [ ] **Quarterly**
- [x] **Yearly**

LT forecasts are done at least once a year but can be updated if needed

Input Variables

Yearly:
Historical losses by grid element & major transmission network evolution.
However, they would like to develop better models including load flows, generation, cross border flows,…

RTE monitors and reports its losses on all grid elements

RTE has an obligation to report to CRE for the comparison with the reference strategy of which the target evolves over time. There is an incentive to reduce the overall loss volume even though RTE has few levers to reduce losses. Reporting is given at half-hourly level to the CRE, they are mostly interested in the global value. For transparency reasons, RTE also publishes the actual losses.

The financing framework of RTE's losses coverage strategy is heavily driven by regulatory incentives

The French regulator determines "a reference strategy" and their own strategy is compared to it (volume & price). The "reference strategy" consists of an automation that regularly purchase on the market over a period of 3 years, If RTE lowers the costs compared to the reference strategy, they are financially rewarded with a bonus. On the other hand, if their purchases are more expensive, they are penalized with a malus

RTE has a company-wide sustainability policy

The company has a comprehensive sustainability policy already in place for all its activities. RTE is monitoring the guarantees of origin's market, its maturity and its regulatory environment.

Swissgrid aims to procure on the LT to reduce the price risk

swissgrid

Description of losses coverage strategies & responsible parties

Swissgrid is responsible for the compensation of the losses on its network. The losses are covered via a long-term procurement which is completed in the short term based on short term forecasts. Swissgrid aims to procure between 70 to 80% of their losses in the long term to limit the exposure to price variation on the spot market. Intraday trading is fully automated and aims to reduce the supply gap as much as possible.

Perceived efficiency of Losses Coverage Strategies in terms of:

Total volume in 2020 (in GWh): **917 GWh**

Total costs in 2020 (in EUR): **38.8 million**

Losses Coverage Strategies & Time Scale of Procurements

Swissgrid procures about 75% of it's losses on the long term. About 40% of the losses are procured before the tariffs are fixed such that the real costs can be integrated. The remaining losses are covered on the short term (15-20%) and real time market (5-10%). This strategy is defined in coordination with the regulatory authorities.

ST — LT

LT = 50% yearly (Y+2 and Y+1) + 40% quarterly + 10% monthly base products
ST = day-ahead & intraday
Supply Gap

Advantages

+ Partially ensured plannability when setting tariffs as more than 40% of active losses are procured before tariff fixations
+ High hedging ratio, low exposure to spot market risks
+ Low imbalance volumes (less than 10%) due to fully automatized Intraday Trading and good-performing forecasting models

Disadvantages

- Differences in actual cost and actual income as Swissgrid calculates the required tariff revenues ex ante
- Volume and price differences between the «actual» and «budgeted» situation for the same year regularly lead to differences between the actual costs and actual income for a year

Procurement Mechanism Used

Tenders | **Exchanges** | **OTC** | **Others**

Swissgrid procures the losses in the long term through tenders. Losses procured in the short term are traded on the day-ahead and intraday markets thanks to a direct market access via EPEX Spot. Trades on the intraday market are automated to further improve the position and hence reduce the imbalance. Swissgrid cannot procure electricity in the long term to speculate and sell it back on the ST market.

Advantages

+ High hedging ratio and plannability for the long-term procurement
+ Short term trading gives the possibility to procure/ sell the remaining short-term volumes close to the delivery period and hence reduce imbalances

Disadvantages

- The low liquidity on the Swiss market can lead to higher costs
- Wrong forecasts in the short term might lead to bad trades

Surplus & Shortfalls

In case of under/ over procurement of grid losses, the supply gap is procured via the imbalance. As the imbalance costs is higher, Swissgrid aims to reduce the supply gap as much as possible. These costs are also recovered through the tariffs.

Depending variables

- 70-80% of losses are procured via LT tenders
- Minimum 40% of losses are procured before the tariff fixation
- The share of long/short position in short-term markets is minimized

Changes in LPM

Since 2011:
Swissgrid switched from monthly tenders to the current procurement strategy in 2020.
ST: Before 2014 we had only DA procurement. In 2014 ID trading was adopted. ID was automated in 2020

Future:
Until 2024 Swissgrid doesn't plan any significant changes to the current strategy in terms of procurement mechanisms. From 2023 it's planned to increase the share of LT procurement before the tariff fixation to 55%.

Losses Forecasting Strategy Description

Short-Term

The short-term losses forecasting models are developed intraday and day ahead. The goal is to extend it to weekly forecast as well to cope with potential cyber-attack that would prevent Swissgrid to place orders.

Advantages

+ Input for intraday and day ahead procurement allowing to correct the position and reduce the supply gap

Disadvantages

- Forecasting accuracy is a risk factor, as day ahead and intraday procurement are based on the forecasting results

Long-Term

Long-term losses forecasting models were recently introduced and are used for monthly, quarterly and yearly forecasts. At this stage it's used to have an approximate outlook as the model's performances are still too low to fully rely on it.

Advantages

+ Allows to have a better estimation of the volume to be procured in the long term and hence reduce the price risk.

Disadvantages

- LT forecasting only based on the historical losses which cannot consider new scenarios
- Low accuracy due to the long forecasting horizon

Outsourcing entities

Swissgrid benchmarked multiple providers and selected the best one for ST and LT forecast. It allows Swissgrid to use an AI software model that help improving the forecasting accuracy,

Swissgrid started building their own model to challenge the external suppliers and potentially replace them. They consider the current solution as a black box.

Performance of LFS

The mean absolute error (MAE) is used to measure the performances. Typical MAE are around 10-12%.
The forecast is considered as somehow effective and is challenged by experts.

The performances of the long-term forecasts considered as somewhat inefficient as it only gives an outlook. There is however no metric that is used to measure the performances.

Timelapses of LFS

- ☑ **Intra-day**
- ☑ **Day Ahead**
- ☐ **Weekly**
- ☑ **Monthly**
- ☑ **Quarterly**
- ☑ **Yearly**

Input Variables

- Climatic (temp, wind speed, solar),
- Hours of day
- Type of day
- Seasons
- Flows from other countries
- Load,
- Historical losses,
- Production,
- Net transfer capacity,
- Electricity prices

- Historical losses

Changes in LFS since 2011

Since 2011:
- *2012 started with external forecasting tool*
- *2014 started intraday trading*
- *2020 started LT procurement and introduced intraday trading tool*

Future:
- *Introduce and explore more advanced forecasting methods to improve accuracy and reliability*
- *Development of LT and ST forecasting tools*

Swissgrid monitors losses with a fully automated process and is able to retrieve data with a 5 min timestamp.

Swissgrid collects flows data on grid nodes via the energy management system. Losses are calculated ex-post in a dedicated system. This process is fully automated and updates every 5 minutes. The tool allows Swissgrid to compare the forecasts with the historical losses of the previous days.

All the costs linked to the coverage of grid losses are recovered via the transmission tariffs.

Swissgrid estimates the costs linked to the losses procurement for each tariff period. An estimate is also provided for the procurement of the losses on the imbalance markets. Swissgrid is incentivised by the regulator to be efficient in procurement. Therefore, aims at increasing the social welfare and thus, is incentivised to optimize the procurement strategies in order to reduce the costs and consequently tariffs for our consumers.

GHG emissions are currently not considered in the losses coverage strategy due to the additional costs it induces.

Even if it's a topic of interest for Swissgrid, GHG emissions are not yet considered in the losses coverage strategy.

LFS: Losses Forecasting Strategy LFM: Losses Forecasting Model

Amprion uses a combination of LT and ST procurement to cover their losses

Description of losses coverage strategies & responsible parties

Amprion procures 100% of it's expected losses through forward transactions to have a better view on their procurements. They then adapt their position little by little on ID and DA to limit their exposure to price risk. They have a range of forecasted volume and they estimate the uncertainty range to be between 5-10% depending on several parameters. Amprion's losses procurement strategy is highly regulated which limits their options to change.

Perceived efficiency of Losses Coverage Strategies in terms of:

Total volume in 2020 (in GWh): **2760 GWh**

Total costs in 2020 (in EUR): **141,02 million**

Losses Coverage Strategies & Time Scale of Procurements	Procurement Mechanism Used	Surplus & Shortfalls	Depending variables	Changes in LPM
Amprion uses a combination of scenarios to estimate an initial forecast for the LT procurement done in Q1 Y-2. LT procurement is executed each week in equal tranches, around 2% of the entire expected losses of the entire year from 01/07 Y-2 to 30/06/Y-1 which serves as a good estimate to the load on the grid. As a next step, the procurement is adjusted via DA and ID. ST — LT Every week +/-2% of the expected losses Base Year (~80%), Base Q1 (~10%), Base Q4(~10%) **Advantages** + Reduction of price and earnings risks **Disadvantages** - Uncertainties of the long-term network loss forecast - Changes in price level	**Tenders** **Exchanges** OTC Others Amprion procures the losses in the long term through tenders published on a customized platform . Losses procured in the short term are traded on the day-ahead and intraday markets thanks to a direct market access via EPEX Spot. Trades on the spot market are automated to further improve the position and hence reduce the imbalance. **Advantages** + Realization market prices by tenders and EPEX **Disadvantages** - Tenders have to be published at least 3 weeks before the respective tender submission period on the network operator's website	Amprion manages their surpluses and shortfalls via the imbalance.	• The procurement mechanism depends on the forecasted volume or on the short-term forecast • There is no price cap and the balancing deviations often have a much larger price than the short-term market.	Since 2011: • The losses coverage approach is adapted every four years, together with the tariffs. However, it remains minor changes only. *Future:* • Amprion wants to implement a mid-term management • Amprion is preparing for the next tariff period as the current one ends in 2023. Negotiations with the regulator are ongoing about possible adjustments, but no major changes are considered.

	Losses Forecasting Strategy Description	Outsourcing entities	Performance of LFS	Timelapses of LFS	Input Variables	Changes in LFS since 2011
Short-Term	Amprion's short-term forecasting strategy are load flow-based models. Data is used from the market information. **Advantages** + Adjusting the procurement to short-term forecast through 1-h and 15 min structure **Disadvantages** - The difference can only be adjusted on the short term, there is a lack of mid-term management	No other entity is involved in the forecasting model.	☹ 😐 ☺ 😄	■ **Intra-day** ■ **Day Ahead** ☐ **Weekly**	Load-flow based models • Weather • Crossborder Flows • Generation Data • Load • Others	*Since 2011:* • *Continuously developed the individual forecasting models and systems by improving the forecast quality and quantifying the uncertainty range* *Future:* • *Continue developing individual forecasting models and systems*
Long-Term	Amprion uses a fundamental process that models all the power plants in Germany and different European grids. They use different variables such as commodity prices, estimate the load on the grid, …. **Advantages** + Reducing the main commodity-risk by early procurement of the expected volume during the fixed timespan **Disadvantages** - Uncertainties of the forecast and lack of accuracy result in price/ earnings-risks		☹ 😐 ☺ 😄 The model is very complex and the complete analysis considering different scenarios require about 3 weeks. Amprion would like to simplify and accelerate the calculations.	☐ **Monthly** ☐ **Quarterly** ■ **Yearly**	• Structure of European electricity systems • Weather • Consumption • Commodity prices • Cross border capacities • Network and powerplant operations optimization	

Amprion monitors and analyses deviations by utilizing individual tools and reports

Amprion does weekly deviations between LT procurement and ST management and actual network losses including commercial impact and more variables.

The costs linked to the coverage of grid losses are recovered via all grid operators (DSOs, consumers connected to TSOs grid) on a bonus/ malus principle

The costs recovery is regulated by FSV Netzverluste and is directly taken into account. Amprion is accountable in case the reference price aren't met. There is a bonus/ malus framework for good and bad management of losses in place. The reimbursement is based on the reference price and in the end everything is recuperated by the tariffs through DSOs and the consumers

The German legal framework forces Amprion to procure energy on the most favorable way possible without consideringg the GHG emissions caused by losses

Amprion sees this change as TSO and DSOs aim to adapt laws and regulatory frameworks to enable procurement of green energy or guarantees of origin. In addition to this, Amprion has small-scale self-generation plants based on renewable energies.

Losses management in GB is an ex-post process delegated to Elexon

nationalgrid

Description of losses coverage strategies & responsible parties

Losses on the GB transmission grid are compensated via the imbalance. Losses are shared ex-post between Delivering and Offtaking Balancing Mechanisms (BM) Units, based on a Transmission Loss Multipliers (TLMs), composed of a Transmission Loss Factor (TLF) and Transmission Loss Adjustments (TLMO), calculated by Elexon (a third-party in charge of the settlement in GB). The TLM scale-up/down the generation/offtake of the units. Elexon oversees how much energy generators and suppliers say they will produce or consume and compare it to the actual level. Part of this includes the management of grid losses. Currently, 45% of the losses are covered by the Delivering Trading Units and 55% by Offtaking Trading Units.

Perceived efficiency of Losses Coverage Strategies in terms of:

Total volume in 2020 (in GWh): **6560 GWh**

Total costs in 2020 (in EUR): **328 Million £ (~394 Million EUR)**

Losses Coverage Strategies & Time Scale of Procurements	Procurement Mechanism Used	Surplus & Shortfalls	Depending variables	Changes in LPM

• The process is managed by Elexon, a third party responsible of all settlement activities.
• A dynamic compensation in kind mechanism is applied in which losses are distributed between generators and suppliers.
• The settlement process and therefore the losses compensation process is extensively described in the Balancing and Settlement Code (BSC) ensuring high transparency for all the market parties. The BSC is discussed with market parties and approved by the regulator.
ST — LT
Dynamic compensation in kind supervised by Elexon
Advantages
+ Process for distributing the losses is very detailed
+ Transparent process that is agreed by all BSC parties
+ It incentivizes generators to be built closer to demand
Disadvantages
- Elexon estimates the TLM based on historical losses volumes which could reduce the accuracy.
	Tenders / Exchanges / OTC / Others
	• No procurement mechanism is used as losses are compensated in real time via the imbalance.
	• Losses are allocated to Delivering and Oftaking trading units based on a Transmission Loss Multipliers (TLM) that will scale up/down the metered volume of each units. The TLM is composed of two other factors:
	  • The Transmission Loss Factor (TLF) that adjusts the factor considering the geographical position of the unit.
	  • Transmission Loss Adjustments (TLMO) that adjusts the factor based on the total metered volumes of delivering and off taking trading units.
	• Delivering trading units are responsible for 45% of the losses while overtaking trading units are responsible for the remaining 55%. The different arises from the metering point of the losses (HV side of the transformer for generators and LV side for the consumers)
		All losses are compensated by the delivering and offtaking trading units. Part of the losses can be compensated upfront based on the estimated TLMs, but the remaining is covered via the imbalance settlement process.	The driving principle of this model is to allocate losses to individual generation and demand units as fairly as possible based on their contribution. However, National Grid is not incentivized to minimize the losses. When reinforcing the network, National Grid was incentivized to transition to low loss conductor & low loss transformers.	*Since 2011:*
				No changes have been made in the losses coverage strategy on National Grid's side. However, for Elexon, since the 1st April 2018, TLF values differ based on geographical location.
				Future:
				No planned changes. Concerned parties could raise modification and suggest changes on how the losses are applied but it will take several years to really change it.

Losses Forecasting Strategy Description	Outsourcing entities	Performance of LFS	Timelapses of LFS	Input Variables	Changes in LFS since 2011
National Grid does not forecast losses as they are not involved in the losses management process. However, Elexon is implicitly forecasting the grid losses when estimating the TLMs using historical losses. TLFs are published on the 31st of December and go live on the 1st of April. Estimated TLMOs are published in January. **Advantages** + Simple to replicate and to gather the source data on a year-by-year basis. + It gives a fairly accurate prediction **Disadvantages** - It can't take into account unexpected events.	Data is collected and procured by Elexon.	N/A	N/A	Historical Values	*Since 2011:* No changes were made. *Future:* No changes are planned.

National Grid monitors its losses ex-post and reports them annually to OFGEM, their regulator

Elexon data is used to report the grid losses to their regulator, OFGEM, due to the high quality of their metering data. Meters are maintained and calibrated regularly. Elexon calculates the losses based on the information provided by BSC parties and National Grid. Losses are communicated on a yearly basis.

All the costs linked to the coverage of grid losses are allocated to Balancing Mechanisms Units.

Elexon is in charge of allocating to grid losses to Delivering or Offtaking Trading Units, hence by reducing their injection or offtake. Currently 45% of Transmission Losses are allocated to Delivering Trading Units, and 55% to Offtaking Trading Units.
As a nonprofit organization, Elexon retrieves its operating costs through monthly charges to BSC parties.

Sustainability aspects are currently not considered in the losses coverage strategy.

Sustainability aspects are currently not considered. Even if the losses are not managed by National Grid is remains part of the scope 2 emissions. It is possible that sustainability concerns of losses will be considered in the future as it has an environmental impact but it's up to the government to decide. National Grid has no influence on the decision.

Red Electrica uses only compensation in kind by suppliers

Description of losses coverage strategies & responsible parties

In Spain, all the losses that happen on the network are covered through a compensation in kind mechanism by the BRPs. Positions of BRP are scaled up/down based on losses coefficients : TLDR (Regulated Transmission and Distribution losses) and TDLA (Adjustment Transmission and Distribution Losses). Losses coefficient takes the voltage levels, positions in the grid and hour types into account and are calculated on a hourly basis. Estimates of the losses coefficients are published beforehand such that BRPs can consider them in their optimization. Positions are then corrected ex-post based on actual losses coefficients that considers the measured losses. A distinction is made between voltage levels and time of consumption but not geographies.

Perceived efficiency of Losses Coverage Strategies in terms of:

Total volume in 2020 (in GWh): **3908 GWh**

Total costs in 2020 (in EUR): **N/A**

	Losses Coverage Strategies & Time Scale of Procurements	Procurement Mechanism Used	Surplus & Shortfalls	Depending variables	Changes in LPM
Compensation in Kind	In Spain, the BRPs must purchase the losses whenever they buy energy. The added volumes that BRPs must inject on an hourly basis is determined by losses coefficient. Losses are then implicitly included in the volume consumers buy. A distinction is made between voltage levels and time of consumption. Actual coefficients also consider the grid node. Consumer in low voltage levels will need to cover more losses than consumers in high voltage levels. The same applies to peak and valley hours. ST — LT **Dynamic Compensation in kind by BRPs + ex-post adjustment at the imbalance price** **Advantages** + Compared to other TSOs, REE is not exposed to volume price risks **Disadvantages** - No disadvantages were mentioned	Tenders / Exchanges / OTC / Others Transmission and distribution losses are allocated to each Balance Responsible Parties (BRP) for each imbalance settlement period. This happens through the calculation of an hourly coefficient based on two coefficients established by the regulator and by the TSO. The coefficient multiplies the metered consumption by these two coefficients: • TDLR (Regulated Transmission and Distribution Losses): A yearly coefficient set out by the NRA for different voltage levels and hour types (peak, valley). • TDLA (Adjustment Transmission and Distribution Losses): An hourly coefficient calculated in the TSO settlement process which considers the estimated or actual losses.	All losses are compensated by BRPs. Part of the losses can be compensated upfront based on the estimated losses coefficient, but the remaining is covered via the imbalance settlement process.	The driving principle in Spain is that consumption needs to account for the losses. Hence when a supplier buys energy it need to buy the losses and when a consumer buys energy, losses are implicit in the volume and the price.	Since 2011: No changes were made at the TSO level. At the DSO level, smart meters were introduced. *Future:* No concrete changes planned.

	Losses Forecasting Strategy Description	Outsourcing entities	Performance of LFS	Timelapses of LFS	Input Variables	Changes in LFS
Monthly	In order to help BRPs in efficiently covering their losses, Red Electrica publishes estimations of the TDLA one month ahead, two days ahead. The estimated TDLA are based on historical losses for each hour. However, the influence of the grid node is not considered in the estimated losses coefficients. **Advantages** + No advantages were mentioned **Disadvantages** - No disadvantages were mentioned	N/A	N/A	Losses coefficients are published one month ahead & two days ahead to assist BRPs in their compensation. They real values are published ex-post.	Mainly based on Historical Values	Since 2011: No changes were made. *Future:* No concrete changes planned.

REE monitors its losses ex-post and reports them to their regulator

When monitoring its losses, REE makes no distinction between its grid elements. They only measure the volumes at each boundary point for generation and for consumption, and between transmission and distribution. This enables REE to calculate a real value for the losses.

All the costs linked to the coverage of grid losses are allocated to BRPs.

Volumes of losses are included in the total volumes that BRPs purchase. Similarly, the volumes that consumers purchased are also implicitly implied. There is only a difference in the voltage levels and the time of consumption.

Sustainability concerns are somewhat considered in their losses coverage strategy of REE.

In general, REE has a sustainability plan in which it is compensating all its emissions. They have a responsible person that manages the sustainable strategy of REE.

3. Losses procurement strategies

Half of the TSOs from the panel uses a combination of LT and ST procurement to cover the losses and minimize the supply gap

2 strategies are applied by Elia : compensation in kind for the grid >= 150 kV and LT procurement for the grid < 150kV

Compensation in kind BRPs inject an additional amount of energy on top of their nominated offtakes to cover for the losses. The additional injection is based on a fixed percentage determined yearly by Elia.

LT procurement Elia procures the volumes corresponding to the losses in the LT with Y-3, Y-2, Y-1 products.

RTE procures all its forecasted losses in the long term and adjust its position in the short term to reduce the supply gap

RTE procures 100% of its forecasted losses with LT procurement with Y-2, Y-1, Quarterly and Monthly products. The position is adapted in day ahead and intraday to consider forecast errors made in the LT. This strategy aims to minimize the costs, the back and forth on the market and the supply gap.

Amprion procures small volumes weekly starting in Y-2 to compensate their losses and adjust their position in the ST

Amprion procures 100 % of the expected losses in the LT. Expected losses are based on LT forecasts considering multiple hypotheses. Starting in July Y-2, they procure about 2% of the yearly losses every week until June Y-1. They adjust their position in DA and ID to reduce the supply gap as much as possible. Their goal is to reduce the price risk by having an early and steady procurement to have procurement costs that are similar to the reference price.

Swissgrid procures 80% of the forecasted losses in the LT and the remaining 20% in the ST considering forecast errors

About 80% of the forecasted losses are procured in the LT with Y-2, Y-1, quarterly and monthly products. About 40% of the forecasted losses are procured 1,5 years ahead such that the real costs can be integrated in the tariffs. The remaining 20% are procured in day ahead or intraday. The goal is to have a good view of the costs in the LT and to minimize the procurement costs and imbalance costs caused by the supply gap.

Losses on the GB network are via a compensation in kind mechanisms. Elexon is actively involved in the process.

In GB, losses are covered by a Dynamic Compensation in kind mechanism where the losses are allocated to delivering and offtaking trading units. Their generation/offtake is scaled down/up based on Transmission Losses Multipliers (TLMs) which are calculated for every seasons and differ for each geographical zones. The TLM is composed of two parameters; a Transmission Loss Factor (TLF) and Transmission Losses Adjustments (TLMO). Estimations are provided such that trading units can consider them upfront.

Red Electrica has a compensation in kind approach where the BRPs inject more based on estimated losses coefficients

A dynamic compensation in kind mechanism is applied. BRPs inject an additional amount of energy. This additional injection is based on a losses factor that is composed of 2 elements : the TDLR calculated by the regulator on a yearly basis and the TDLA calculated for each hour and grid node and considering the actual losses. The position of BRPs is scaled up/down based on the actual losses factors and the difference is settled through the imbalance. An estimation of the losses coefficient is also provided such that BRPs can take them into account.

TSO	Compensation in kind	LT procurement	ST procurement		Supply gap (real time)
			DA	ID	
elia	●	●			○
Rte		●	●	●	○
amprion		●	●	●	○
swissgrid		●	●	●	○
nationalgrid	●				
RED ELÉCTRICA DE ESPAÑA	●				

● Primary focus ○ Indirect impact

Key Takeaway

- Except Elia, all TSOs using **LT procurement combine it with ST procurement** to adjust their position and reduce the supply gap as much as possible.
- Two of the three TSOs applying compensation in kind mechanisms base the process on estimated losses factors which are recalculated ex-post to adjust the positions.
- The granularity applied to losses factor range from yearly factor (Elia) to hourly factor (Red Electrica)

TSOs that procures energy use tenders for their LT procurement and trade on the markets in the ST

TSO	Tenders	OTC	Buy on SPOT market		Sell on SPOT market		Other
			DA	ID	DA	ID	
elia	● Regional losses only						
Rte	●		●	●	●	●	● EDF obligations & capacity market
amprion	●		●	●	●	●	
swissgrid	●		●	●	●	●	
nationalgrid	Not applicable						
RED ELÉCTRICA DE ESPAÑA	Not applicable						

Key Takeaway

- **Tenders are used for LT procurement while exchange on the market are used for ST procurement.**
- TSOs that have a SPOT market access are all adjusting their positions by **buying and selling on the Day-Ahead & Intraday market.**
- OTC are not used by the benchmarked TSOs to procure energy.

- Generally, tenders are used for LT procurement while procurement on the ST are made via exchanges on the market (EPEX).
- Amprion set up a customized platform to publish their tenders on which market participants answers.
- In France, a large proportion of renewables are subject to the system of EDF Obligations d'Achats. They sell volume on the wholesale market through tenders, to which RTE answers.
- The energy crisis makes it more difficult to procure via tenders according to RTE. This is due to the fact that market parties have to guarantee a price during a given time in a context where price volatility is important.
- Swissgrid and Amprion are highly transparent with their tender process and publish offered vs accepted quantity and prices on their website.
- Besides energy, RTE also has to procure capacity for the most tense days of the year on the French capacity market.

TSOs that have a ST market access are more efficient in minimizing their supply gap

Half of the Benchmarked TSOs have a Short-Term market access:

RTE has a ST market access that is used to reduce imbalances.

While LT tenders enables Swissgrid to benefit from a high hedging ratio and improved plannability, **ST trading enables them to procure or sell volumes close to delivery, thereby reducing the supply gap**. They aim to keep their supply gap below 10%. Swissgrid automated its ID trading but not its DA trading.

At Amprion, **differences between initial LT forecasts and updated forecasts can only be transacted on the ST market**, hence the importance of a ST market access to reduce imbalances. They fully automated their DA trading and partly their ID trading. Amprion believes they could also benefit from a mid-term procurement strategy.

TSO	Forward procurement?	Volume LT procurement	Volume ST procurement	Market Access?	Volume supply gap	Year of Data
elia	Regional Losses	**100%**	**0%**		Not available	2020[1]
Rte		Not Available	Not Available	EPEX	**1%**	2020[2]
swissgrid		**77%**	**17%**	EPEX	**6%**	2020[1]
amprion		Not Available	**5-15%**	EPEX	**4%**	2020[1,3]
nationalgrid		/	/		/	/
RED ELÉCTRICA DE ESPAÑA		/	/		/	/

[1]Answer from the survey
[2]Retrieved based on date made available on https://www.services-rte.com/en/view-data-published-by-rte/losses-on-the-public-transmission-system.html
[3]Retrieved based on date made available on https://www.amprion.net/Energy-Market/Market-Platform/Grid-Losses/

Key Takeaway

- Combining ST procurement and LT procurement enables TSOs to **effectively reduce the supply gap.**
- TSOs that have a short-term market access manage to **keep their supply gap below 10%.**
- Swissgrid and Amprion have a ST market access but uses an **automation to trade** on it to prevent people from leveraging sensible market information.

Generally, TSOs are satisfied with their strategies within the limits of their scope and accept a certain level of uncertainty

In terms of volume, Elia considers its strategy to be somewhat efficient considering the current boundaries set up by the framework. However, a short-term angle is currently not in place and could improve the overall efficiency. For the federal losses, the tariffs for BRPs is not very accurate as it is determined one year ahead. The quality of the forecast along with the fixed percentage can induce important inaccuracies.
In terms of costs**,** for the regional losses Elia finds its strategy to be somewhat efficient as their strategy of slicing the procurement of their forecasts 3 years ahead enables them to spread the price risk over this period. Elia is also incentivized to try to beat the market through the framework in place. Nevertheless, they acknowledge that they could be more efficient if they had access to other markets.

In terms of volume, Even though their forecasting models could be improved, RTE considers its losses coverage strategy to be very efficient in terms of volumes covered. They cover the whole volume estimated by their long-term forecast & adjust their positions based on their short-term forecast.
In terms of costs, RTE considers its losses coverage strategy to be very efficient when speaking about costs. This is because they combine various procurement mechanisms, including direct market access, enabling them to make deals at the fair market price.

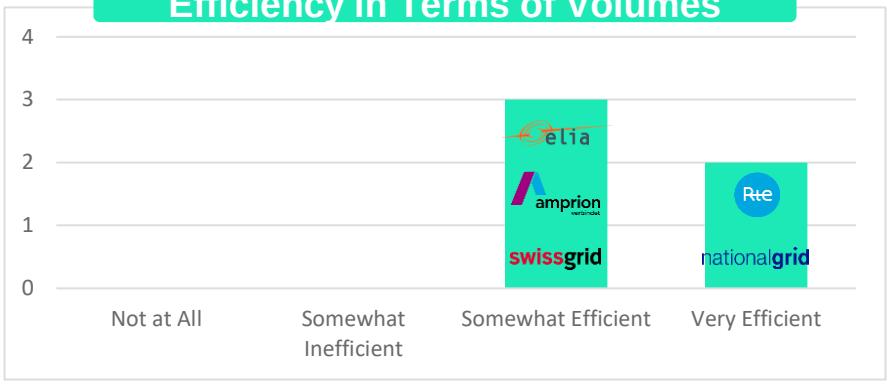
In terms of volume Amprion considers its strategy to be somewhat efficient because they procure the expected losses on the long term and then adjust their positions with short term procurement and hence reduce the gap. An uncertainty margin of +- 5-10% remains mainly because transport activities are hard to forecast. For this reason, Amprion considers that improving their forecast would improve their procurement efficiency.
In terms of cost, Amprion considers its strategy to be somewhat efficient as they are able to limit the price risk thanks to the long-term procurement.

In terms of volume, with its current strategy, Swissgrid ensures that more than 90% of their total losses are procured via long- (tenders) and short-term (day ahead & intraday) markets. Inefficiency of their losses coverage strategy is measured by looking at the percentage of grid losses that is compensated by balancing markets. The strategy is considered efficient when that percentage is below 10% (close to 5% in 2021).
In terms of costs**,** Swissgrid also qualifies its losses coverage strategy as somewhat efficient when relating to costs thanks to their long-term hedging strategy. The procurement is being spread on different time scales which reduces the price risk.

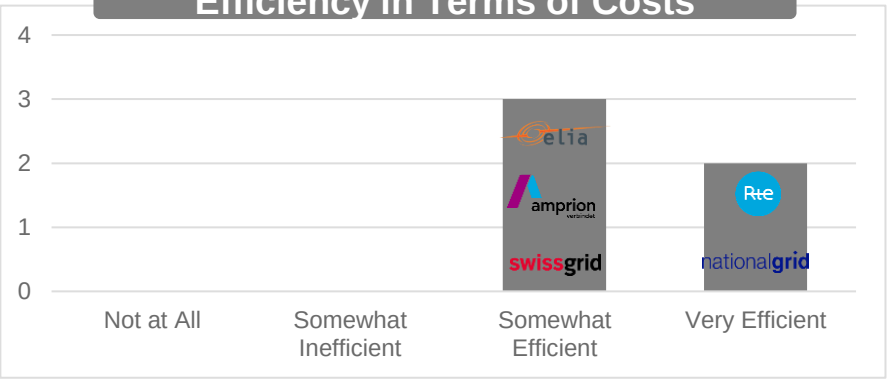
In terms of volume**,** National Grid considers the approach to be very efficient as their process for calculating the losses ex-post is very accurate. This settlement process uses meters that are maintained and calibrated regularly. According to National Grid, the industry is quite satisfied with the settlement process managed by Elexon.
In terms of cost, National Grid considers its strategy to be very efficient as well, mainly because the method is transparent and agreed upon by all parties. The guidelines for recovering losses with Transmission Loss Multipliers (TML) are very clear and efficient.

REE cannot express a sentiment towards the efficiency of the losses coverage strategies as it has no responsibility to cover them. Instead, it's the BRPs, and ultimately the consumers through the tariffs, who bear the responsibility to cover the losses.

Efficiency in Terms of Volumes



Efficiency in Terms of Costs



Key Takeaway

- TSOs consider that their approach is efficient when **the price risk is decreased** (often through LT procurement)
- The perceived level of efficiency is often directly linked to the scope of the regulations imposed on the TSO

The following advantages and disadvantages were mentioned by TSOs

Advantages		TSO	Disadvantages	
Compensation in kind	**LT procurement**		**Compensation in kind**	**LT procurement**
The main benefits of compensating in kind for Elia is **the simplicity** of the process.	Elia's LT procurement strategy is **straightforward and spreads the price risk over a long period of time**.	elia	The main disadvantage is that the percentage fixed on the LT **lacks granularity** given that losses are also driven by shorter-term changing variables.	LT procurement **limits management of supply gap** and affects real-time.
RTE's strategy allows them to have **regular coverage several years in advance**, enabling them to stabilize the budget and pay an "**average market price**". It also enables them to have a **precise granularity** and update their forecasts as they keep the management of losses internal.		Rte	The performance of the strategy is subject to the market liquidity which is currently very poor.	
The main advantage for Amprion on its procurement strategy is the **reduction for price- and earnings-risks**.		amprion	The main disadvantage is **the uncertainty of the LT network losses forecast** and the change in price level on the predetermined time span (Q1 Y-2 – Q2 Y-1).	
By procuring 80% of the forecasted losses in the LT, Swissgrid has a high hedging ratio and thus **lowers its exposure on the spot market risks**. This also ensures a **better plannability** when it comes to setting tariffs.		swissgrid	Swissgrid calculates the required tariff revenues ex ante based on budgeted costs. Volume and price differences between the «actual» and «budgeted» situation for the same year regularly lead to differences between the actual costs and actual income for a year (volume- and tariff-related timing differences).	
The losses are fairly appointed based on metering and they work with a detailed approach for every unit. This procedure is agreed upon by all parties.		nationalgrid	Losses are not really a risk for National Grid. They are not incentivized to minimize the losses.	
Compared to other TSOs, REE is not exposed to volume or price risks		RED ELÉCTRICA DE ESPAÑA	No disadvantages were mentioned	

	Short-Term Procurement	Long-Term Procurement	Compensation in kind
👍	• **Short-term procurement reduces the supply gap**	• **Lower exposure to spot market risks**	• **Simplicity of the process**
👎	• **Subject to market liquidity**	• **Uncertainty of the exact network losses which could reduce the procurement efficiency**	• **Can lack precision if the granularity of the losses factor is not sufficient.**

TSOs active on the short term market tends to separate their process and organization from entities having access to sensitive information

TSO have different needs regarding ST procurement and the associated market activity

Active on the short term market

Uses the short term market to **adjust their positions** based on more recent forecasts

Uses the short term market to **adjust their positions** based on more recent forecasts

Uses the short term market to **procure the remaining 20%** based on more recent forecasts

Could benefit from an access to short term market

Could further reduce the supply gap if a short term procurement would be set up. However, today Elia is not active on short term markets and this would constitute a new activity to be organized and embedded in the way of working.

No short term market access needed

No short term action is required due their specific coverage strategies.

TSO active on the ST market take specific measures to limit access to sensitive information

Process and organization separation

RTE, Amprion and Swissgrid have implemented distinct and separated process between entities that could have access to sensitive market information and those who are in charge of ST procurement.

Automated trading

Swissgrid has an automation for its intraday trading only and Amprion has fully automated its day-ahead trading and partly automated its intraday trading.

Key Takeaway

- Short term procurement is mostly used to **close the supply gap as much as possible** considering the more recent information.
- **Short term forecast is the key enabler** to have a short-term procurement strategy.
- **Process and organization separation as well as automated trading** make sure that the TSO cannot influence the spot markets by using sensitive information.

Past and future changes in the procurement approach are mainly linked to regulatory changes

Past changes	TSO	Future changes and levers for improvements
• **No changes** in the past ten years as the process is described in the Federal Grid Code which is difficult to change and that it has been considered as a rather well performing mechanism for a long time	elia	• The topic of losses compensation is discussed with stakeholders, mainly in relation to the compensation in kind approach • **Short term procurement** is considered as a lever for improvement
• **DA and ID procurement** have been implemented to reduce the imbalance • **Regular changes** are brought depending on market conditions	Rte	• Future changes will be **driven by the future regulatory changes** (end of ARENH, change in capacity market) • The reference strategy should better reflect the market conditions
• The losses coverage approach is **adapted every four years**, together with the tariffs. However, it remains minor changes only.	amprion	• Negotiations are ongoing with the regulator to improve the strategy • **Mid-term forecast** is seen as a lever for improvement.
• **ID trading** has been implemented in 2014 and automated in 2020 in order **to reduce the imbalance**. • Horizon for LT procurement evolved from month ahead to Y-2 and Y-1	swissgrid	• Discussions are ongoing with the regulator to assess the possibility to use alternative procurement methods such as PPAs. • Increasing the share of LT procurement could reduce the price risk.
• **Location of the units** is now considered in the transmission loss factor to better reflect the contribution of the unit to the losses	nationalgrid	• No changes is expected in the future. Changes could occur if concerned parties suggest modifications, but it would take a few years before implementation.
• The approach is driven by the regulation and there has been no change in the past years.	RED ELÉCTRICA DE ESPAÑA	• There is no ongoing discussions to change the current approach.

Key Takeaway

- The coverage approach is often highly regulated and **changes in the procurement approach are often linked to regulatory changes**
- The **implementation of DA/ID trading** mostly occurred in the past 10 years and aims to **reduce the supply gap** but not the procurement costs.

4. Losses forecasting approach

Half of the TSOs are combining ST and LT forecast considering their advantages and disadvantages

TSO	Short-Term Forecasting	Intra-Day	Day Ahead	Weekly	Long-Term Forecasting	Monthly	Quarterly	Yearly
elia		/	/	/	●	○	/	○
Rte	●	○	○	/	●	/	/	○
swissgrid	●	○	○	/	●	○	○	○
nationalgrid		/	/	/		/	/	/
amprion	●	○	○		●		○	○
RED ELÉCTRICA DE ESPAÑA		/	/	/	●	○	/	/

The different losses forecasting strategies of TSOs are heavily influenced by their procurement strategies, hence by the obligations and licenses from their regulators (e.g. obligations regarding time horizons of procurements, granting short-term market access, …). The TSOs listed the following advantages and disadvantages with regards to their ST and LT losses forecasting strategies.

	Short-Term Forecasting	Long-Term Forecasting
Advantages	• Enables to cover the losses with a **more precise granularity** • The information collected from the ST forecasts enables to procure losses that help **limit the supply gap**	• **Straightforward** calculation (except for Amprion) • The information collected from the LT forecasts allows to procure losses a long time in advance to **properly decrease the price risk**
Disadvantages	• **Forecasting accuracy can be a risk factor**, as day ahead and intraday procurement are based on the forecasting results • Can **also increase the financial risk** due to too much back and forth on the market	• Can have a **low accuracy** due to the long forecasting horizons • Uncertainties of the forecast result in **price/earning-risks** • Often **mainly based on historical losses** which limits the accuracy of forecasts

Key Takeaway

- Improving forecasting accuracy and reliability is a key factor for the **cost management** and **risk management** of losses coverage strategies. It helps **mitigate the price risk**.
- Combining ST and LT forecasting strategies enables to **spread the price risk** over time while covering the losses **with a precise granularity**.
- Having a ST forecast can represent a **financial risk caused by too many back and forth on the market**, especially in case of automatic procurement.

Their losses forecasting strategy is aligned with their losses procurement strategies

Procurement	Forecasts
Dynamic compensation in kind (nationalgrid, RED ELÉCTRICA DE ESPAÑA)	**Forecasting Ssrategy:** • As the losses compensation is a process managed by Elexon in the UK, **National Grid does not realize any losses forecasting.** However, **Elexon is forecasting the grid losses when estimating the TLMs.** • A similar approach is used by **Red Electrica when estimating the TDLA one month ahead and two days ahead.** • These **estimated losses factors are used for information only** such that generators/suppliers/BRPs can anticipate the losses. The settlement is realized based on values calculated ex-post based on actual losses.
Compensation in kind and LT procurement (elia)	**Only long-term losses forecasting strategy:** • Elia makes one yearly forecast that is used for the federal and regional losses. 1. **For the federal losses**, the forecasts are used to determine the yearly percentage of additional injection for the BRPs 2. **For the regional losses**, a forecast is made year ahead to ensure the losses procurement. If a potentially large supply gap is expected, Elia refines its position by running another forecast one month ahead based on more recent information and historical data. Elia is also launching **a PoC on a ST losses forecast** which could lead an adaptation of the strategy. .
Combination of LT & ST procurement (Rte, swissgrid, amprion)	**Combination of short- and long-term losses forecasting strategy:** • **RTE, Amprion and Swissgrid are using a combination of LT & ST losses forecasting strategies.** While RTE and Swissgrid have a relatively simple LT forecast mainly based on historical losses and a more intricate ST forecast, the opposite is true for Amprion. • Having a ST procurement based on a ST forecast allows to **limit the supply gap**, but it can **increase the financial risk** if it leads to too many back and forth on the market.

The TSOs are exploring new opportunities to improve their forecasting strategy

- Elia is currently **exploring a PoC to potentially integrate a ST forecast** as their LT forecast can lack precision to ensure a sufficiently accurate procurement of the losses.
- Swissgrid is currently not developing weekly forecasts but would like to do so **for security reasons** (e.g., in case of cyberattacks, it's useful to have placed bids and still be able to procure something based on them. It is also looking to **improve its load flow and transit flow forecasts**.
- Amprion is operating a time consuming LT forecasting model analyzing multiple scenarios. They exploring possibilities to **simplify and accelerate the calculation**.

Key Takeaway

- Losses forecasting approaches are **aligned with the procurement mechanisms.**
- **Accurate losses forecasts are inherent to an efficient losses coverage.**
- ST losses forecasting strategies can be **used for security reason** (e.g., cyber attacks).

All the TSOs develop LT losses forecasting models except in the UK where the responsibility to forecast the losses is delegated to Elexon

Input Variables LT Forecast	elia	Rte	swissgrid	nationalgrid	amprion	RED ELÉCTRICA DE ESPAÑA
Climatic variables	●				●	
Economic growth						
Season						
Flows from other countries	●				●	
Cross border flows					●	
Load	●				●	
Historical Losses	●	●	●		●	●
Historical offtake/flow	●			N/A		
Transmission network evolution	●	●			●	
Structure EU electricity system					●	
Commodity proces					●	
Production					●	
Dispatch of units	●					
Cross border capacities					●	
Power plant operations					●	

Somewhat Inefficient

- Elia makes a distinction between its yearly forecasting models, which occur every year, and its monthly forecasting models. Monthly forecasts occur on rarer occasions, only if they anticipate a very large supply gap. Elia finds that its **decisions are too much influenced by weather and network conditions**, which can lead to inaccurate results.
- For Swissgrid, the integration of LT forecasting models is quite recent. **It's mainly to have an outlook**. They would like to develop it further to see how it could improve procurement.

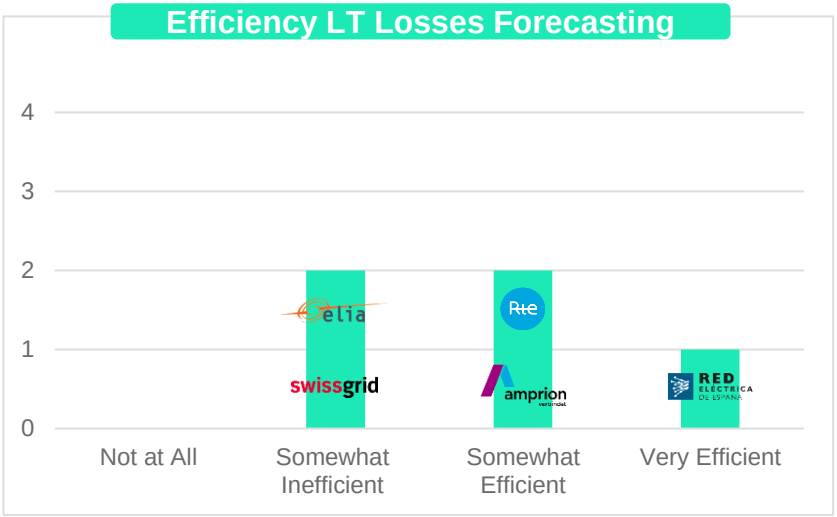
Somewhat Efficient

- Amprion **uses a fundamental model** for its LT forecasts. It models the **whole energy system in Germany and in the different European states**. It's a complex system but it helps to make good forecasts and sensitivity analysis. However, it is quite time consuming to make the calculations, about three weeks are necessary to calculate the different scenarios.

Very Efficient

- To help BRPs in efficiently covering their losses, **Red Electrica publishes estimations of the loss coefficients one month ahead, two days ahead and then the real values ex-post**. Besides providing an estimation of these values, Red Electrica has nothing to do with the process.

Efficiency LT Losses Forecasting



Key Takeaway

- A decrease in the accuracy of LT forecasts is increasingly observed due to **cross border exchanges, which are hard to forecast**. **Renewables and geographical distribution** of production are also increasingly impacting the precision of forecasts.
- Both RTE and Amprion, who are using yearly forecast in the LT and ID & DA in the ST, consider that an **intermediate weekly forecast could be useful**.

Three TSOs are using ST losses forecasting models with different levels of complexity

Input Variables ST Forecast	elia	Rte	swissgrid	nationalgrid	amprion	RED ELÉCTRICA DE ESPAÑA
Climatic variables	N/A	●	●	N/A	●	N/A
Hours of day		●	●			
Type of day		●	●			
Season			●			
Flows from other countries			●		●	
Flows to other countries			●		●	
Load		●	●		●	
Historical losses		●	●			
Technical factors						
Production			●		●	
Dispatch of units						
Net transfer capacity			●			
Electricity prices			●			
Public holidays			●			

After having covered 100% of its LT forecasts, RTE uses their ST forecasts to adjust their positions

- RTE uses its ST forecast to adjust its positions and limit the supply gap. They **did not identify disadvantages** for their ST forecasts besides that they might **miss an intermediate** between their yearly and DA forecasts.

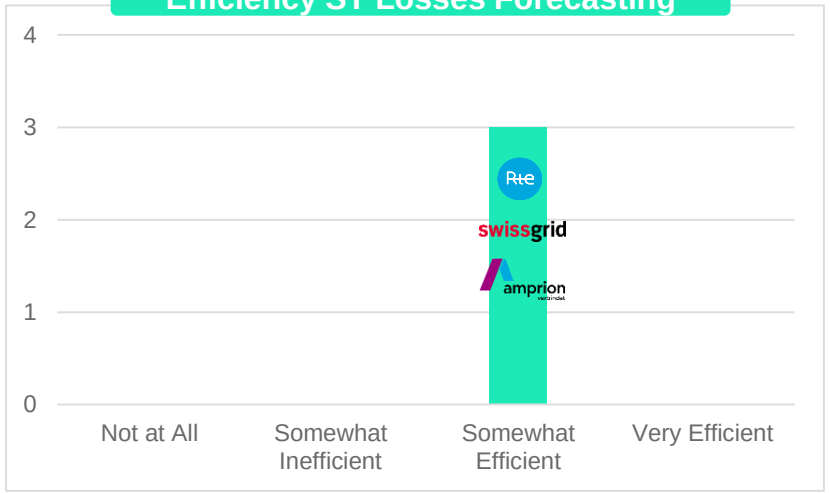
Swissgrid uses a combination of ST and LT forecasting to keep the supply gap below 10%

- **Swissgrid is outsourcing the development of its ST and LT forecasts**. They did a benchmark to test the different companies and selected the best one. They are however trying to **develop improved algorithms internally** namely due to the lack of transparency of the external solution.
- **Cross border flows forecasts are integrated** in their ST forecasts and are based on historical values.

Amprion adjusts its position based on a simpler ST load flow model

- Amprion runs a very intricate LT model to account for whole EU energy market (see slide 23 for input variables). In contrast, their ST forecasts are load flow-based models mainly used to reevaluate their positions to **minimize the supply gap**.
- As one of their responsibility is to connect multiple countries, they **consider cross-border flows** both for ST & LT forecasting.

Efficiency ST Losses Forecasting



Key Takeaway

- Swissgrid is the only TSO who is currently **outsourcing the development of its forecasting models**. They aim to internalize it back.
- At Swissgrid, **cross-border flow forecasts for load flows are based on historical values** and only integrated in ST forecasts.

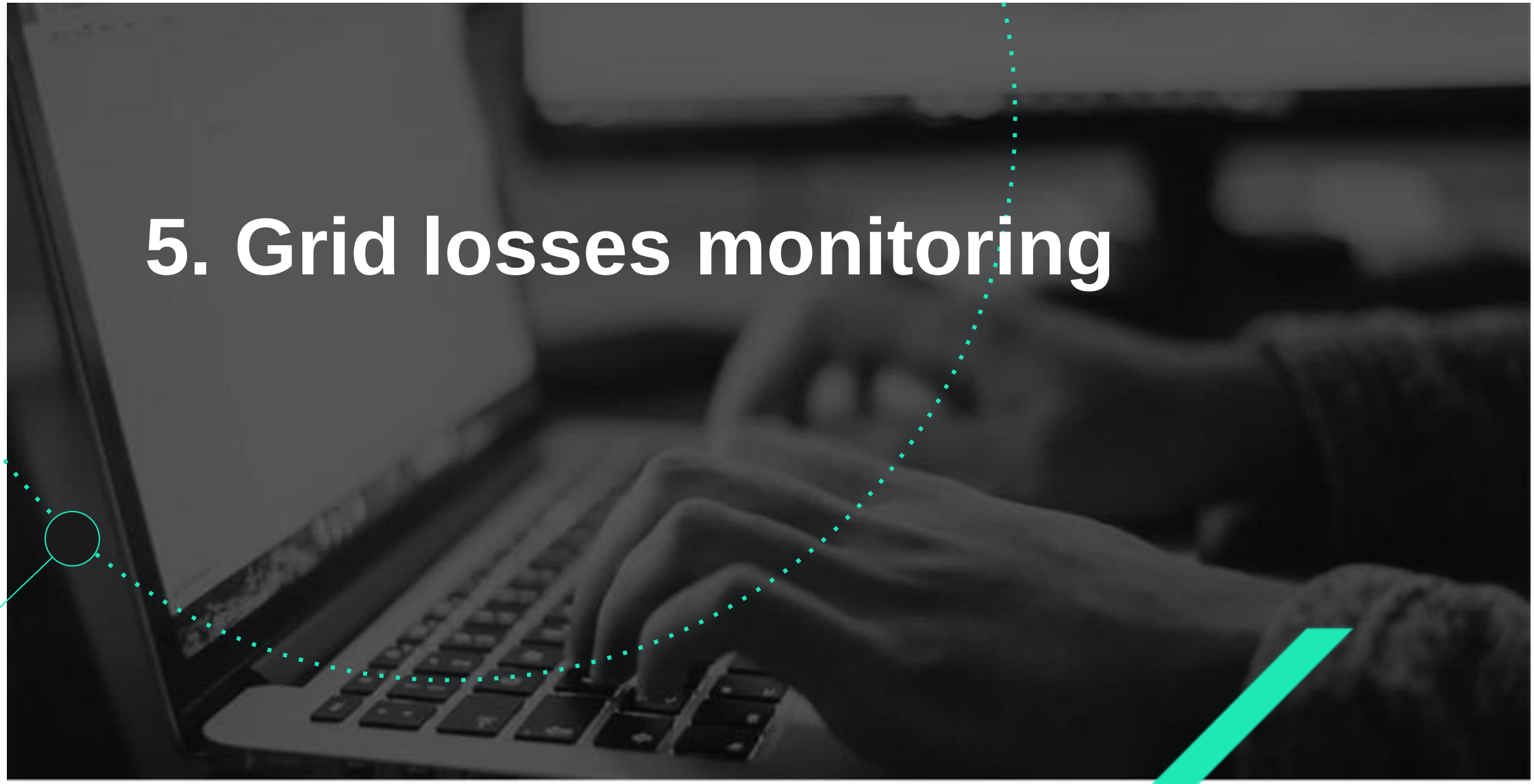
TSOs procuring losses on the long and short term are consistently reviewing their losses forecasting strategies to optimize their procurement

Past changes	TSO	Future changes and levers for improvements
• No changes were made by Elia since the supply gap remained under control.	elia	• Elia is currently exploring a PoC on ST forecasting models. • Improvements could also be made by increasing the number of variables (e.g., crossborder flows).
• Deployment of **ID and DA losses forecasting models**. • Changes have been made as losses are becoming harder to forecasts due to the increase usage of renewables, more cross-border flows decreasing the correlation between losses and load	Rte	
• Improve the quality of the forecasts by **calculating scenarios** to account for the **volatility and uncertainties** of the current environment. • Improvement where mainly made with regards to **commodity prices and weather scenarios.**	amprion	• The purpose of Amprion is to **systematically improve** its losses forecasting strategies by developing more **accurate forecasts and reducing the uncertainty range.**
• In 2012, Swissgrid started with an **external forecasting tool.** • The goals were to improve **the forecasting accuracy**, **balance the open position** in the spot market before the real time and improve cost and risk management by being **less exposed to the fluctuating spot market**.	swissgrid	• Swissgrid is planning to develop more advanced ST and LT forecasting tools and methods to improve the accuracy and reliability of its forecasts. • Should receive the results of an **ongoing LT forecast improvement** in 2022. • **Improving load flow and transit flow forecasts** to grasp other countries.
• No changes were made	nationalgrid	• No changes are planned
• No changes were made	RED ELÉCTRICA DE ESPAÑA	• No changes are planned

Key Takeaway

- TSOs procuring on the long term and short term are **systematically adjusting** their losses forecasting strategies to **improve their coverage processes.**
- TSOs aim at improving the accuracy of its forecasts often **by integrating more parameters** (e.g., cross-border flows, renewables or location of generation and consumption units)

5. Grid losses monitoring



TSO publishes losses data on their website with different granularity

Most of the TSOs publish their losses on their website:

Elia integrates its monitoring of losses in market operations and data is based on observed flows per grid element. Elia publishes annual losses and the percentage for peak and off-peak hours that BRPs must contribute on their website.

Swissgrid uses an energy management system to collect flows data on grid nodes and analyses these data in a fully automated time series management tool that updates every 5 minutes. They publish annual losses on their website.

Amprion uses monitoring and deviation analysis by individual tools and reports. Amprion also publishes their actual losses yearly and the amount of energy procured by their weekly tenders with the associated prices.

RTE uses forecasts, real-time estimates and metering. They also publish the volumes of their forecasted losses per hour per day and their actual losses per hour per day on their website.

National Grid reports losses annually to OFGEM. Elexon calculates the losses based on the information provided by BSC parties and National Grid. They also publish their monthly losses annually.

Red Electrica publishes estimated loss coefficients on their website to help BRPs in efficiently managing their losses. Actual loss coefficients are also provided afterwards.

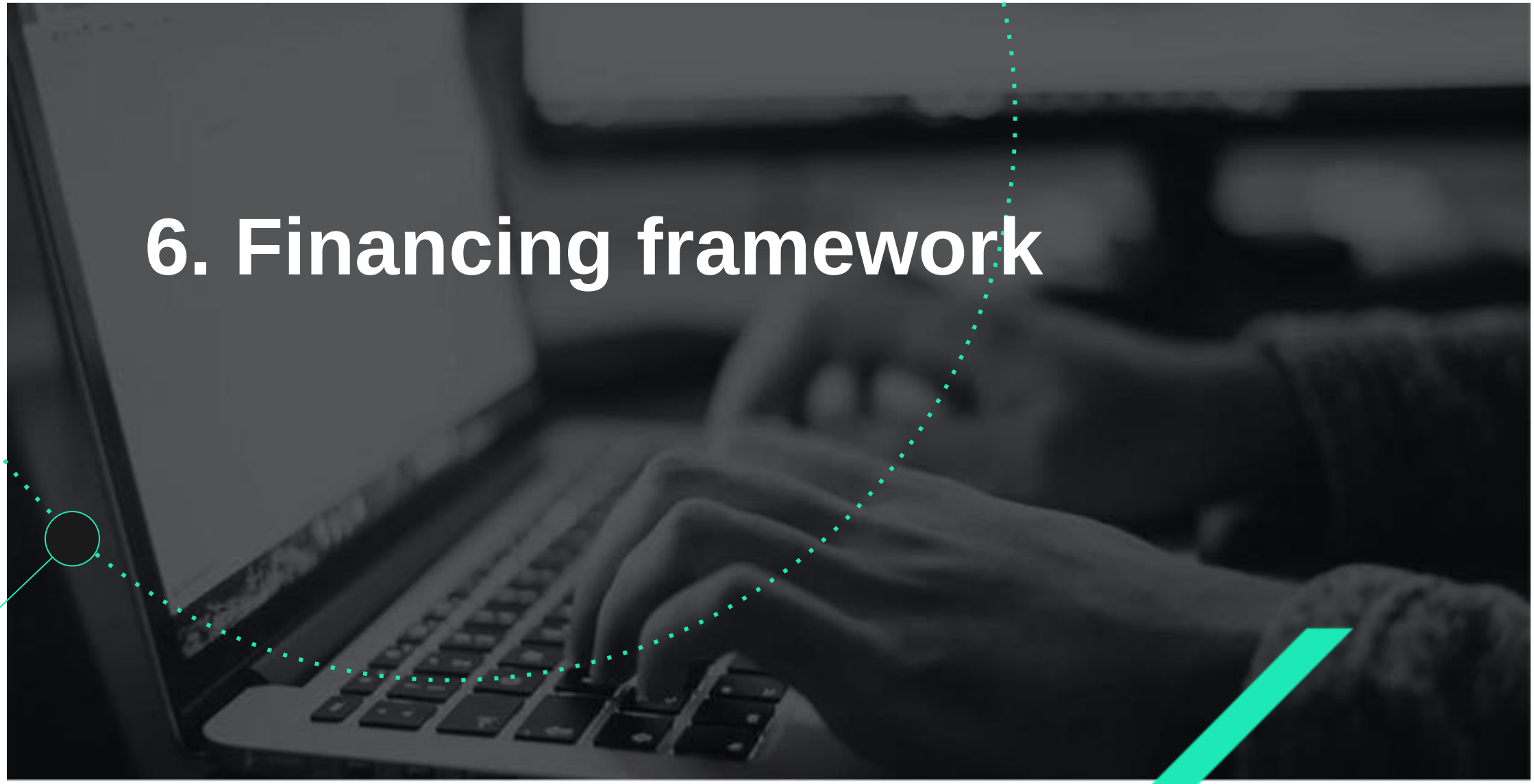
All TSOs account for losses on overhead lines, underground cables and transformers:

TSO	Overhead Lines	Underground Cables	Transformers	Substations	HVDC Interconnectors	Others
elia	●	●	●		●	● Auxiliaries
Rte	●	●	●	●	●	
swissgrid	●	●	●			
amprion	●	●	●	●	●	● Technical operational consumption
nationalgrid	●	●	●	● Stop at LV side of transformers	●	
RED ELÉCTRICA DE ESPAÑA	●	●	●	●	●	

Key Takeaways

- **The monitoring is often linked to forecasting**, using specific tools or outsourcing services.
- Losses on interconnectors are allocated with a **50/50% rule between the countries** or based on the distance towards the border.
- TSOs that procures losses **publishes the actual losses on their website.** Those focusing on compensation in kind generally publishes losses factors estimates and actual losses.

6. Financing framework



Regulators are determining the financing framework of grid losses

Similar Losses Coverage Strategies lead to similar financial frameworks :

Federal Losses: BRPs carry the financial costs. *Regional Losses:* Elia's procurement strategy is benchmarked against market prices. Procurement costs of losses are recovered through tariffs.

100% of the grid losses are recovered through transmission tariffs. Swissgrid is incentivized by the regulator to be efficient in procurement. Therefore, they aim at increasing the social welfare and thus, are incentivized to optimize the procurement strategies to reduce the costs and consequently tariffs for consumers.

Procurement costs are recovered through the tariffs paid by grid users. Reimbursement is based on a comparison with a reference price. They have financial incentives for good/bad management of grid losses.

The French regulator has a reference strategy which simulates buy/sell orders on the market. The strategy of RTE is compared to it. RTE has financial incentives to minimize the risk of their costs compared to the reference strategy.

Losses are carried by delivering (45%) & offtaking (55%) trading units. Elexon is a non-profit organization. It is recovering its operational costs by a monthly billing to BSC members.

Losses are compensated by BRPs. Therefore, it's the BRPs that carry the costs which are ultimately transferred to consumers.

Regulators are heavily influencing the financial frameworks of losses coverage strategies:

	TSO	Financial cost carried by	Financial incentives from regulator	Comparison to reference price/strategy	Costs of losses recovered in tariffs
Compensation in kind	elia	BRPs			
Procurement	elia	TSO then Grid users	●	●	●
Procurement	Rte	TSO then Grid users	●	●	●
Procurement	swissgrid	TSO then Grid users			●
Procurement	amprion	TSO then Grid users	●	●	●
Dynamic Compensation in kind	nationalgrid	Delivering and Offtaking TU			
Dynamic Compensation in kind	RED ELÉCTRICA DE ESPAÑA	BRPs and Consumers			

Key Takeaways

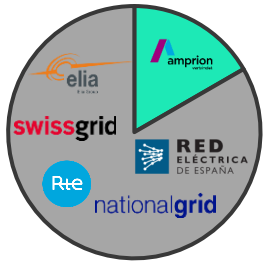
- Except for Swissgrid, TSOs that carry the procurement cost of losses also have **financial incentives to do better than the market.** They are often incentivized by bonuses/maluses for good/bad procurement of losses
- All TSOs that use procurement to cover losses are **recovering the cost of losses through grid tariffs.**
- TSOs that **use compensation in kind mechanisms have no financial incentives** from their regulators.

7. Sustainability

There is no incentive from regulators to compensate the GHG emissions specifically linked to losses

None **of the TSOs of the panel are incentivized to compensate GHG emissions in their losses coverage & procurement strategy**

Do you integrate other sustainable practices in your losses coverage & procurement strategy?



Yes No

elia

- Considering GHG emissions is not foreseen by the regulatory framework, **the framework foresees incentivization based on cost and not on sustainability.**
- Elia might consider ways to improve sustainability of its losses compensation in its ActNow program

Rte

- No, RTE has a comprehensive sustainability policy already in place for all its activities.
- No other sustainable practices are integrated in the losses coverage and procurement strategy.

swissgrid

- Under the current regulation, **additional costs incurred to offset GHG emissions could not be included in the tariff** costs for active losses.
- Swissgrid is looking for **alternative ways to compensate the environmental impact of their grid losses** (through CO2 certificates, CO2 –certified electricity, procurement PPA). This is in discussion with the regulator.

nationalgrid

- This is not applicable for National Grid as they don't procure losses. The possibly to compensate the GHG in the future persists due to the environmental impact. The decision must come from government.

amprion

- In accordance with regulatory requirements, procurement may only be awarded to the most favorable bidder.
- Amprion owns **small-scale self-generation plants based on renewable energies** which currently produces less than 1% of the losses. They also aim to adapt laws and regulatory frameworks that enable them to procure green energy or guarantees of origin.

RED ELECTRICA DE ESPAÑA

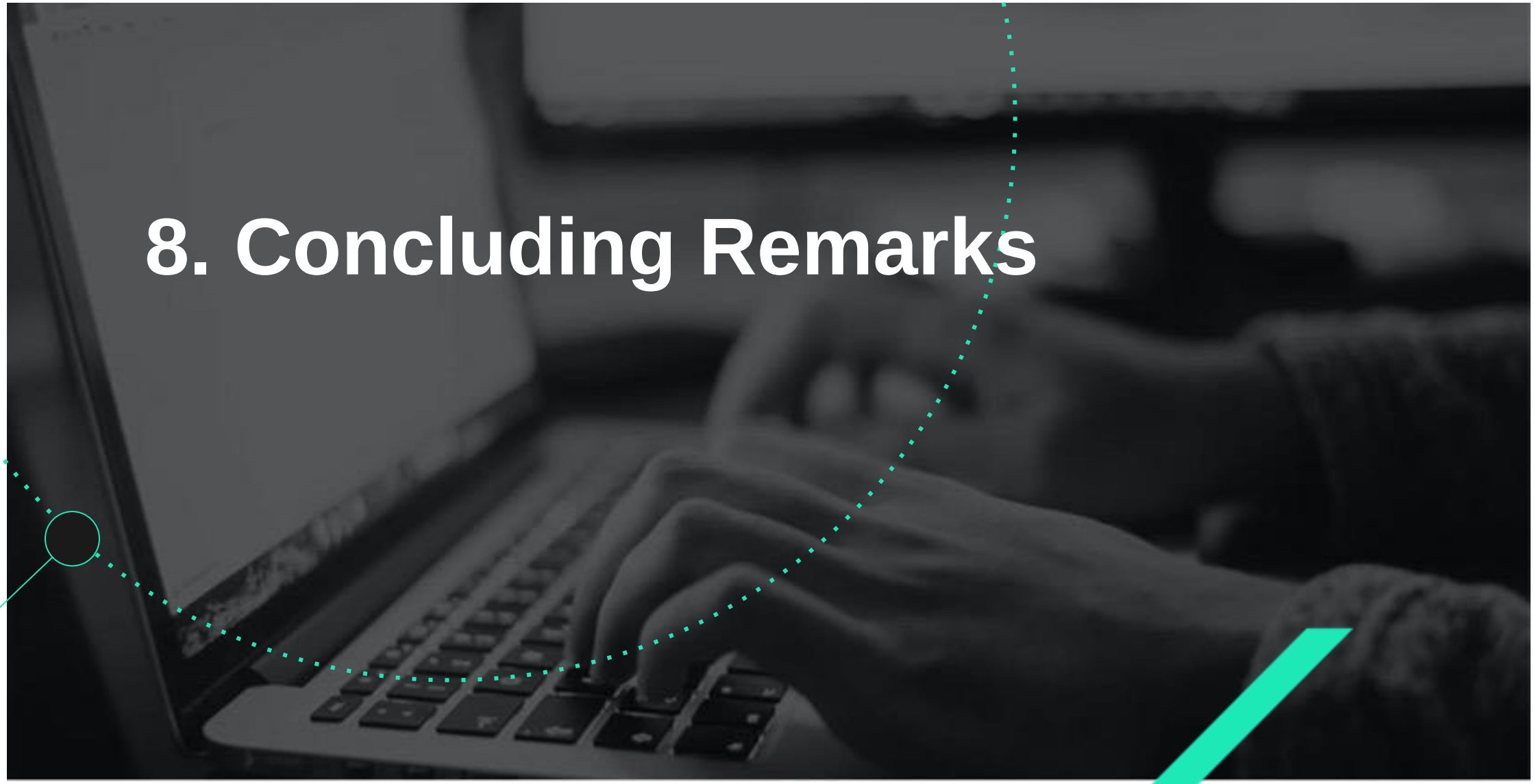
- As part of its sustainability plan, Red Electrica has a strategy to compensate its emissions. However, nothing specific is done to compensate losses.

Note that Tennet Netherlands already **procures guarantees of origin to compensate GHG** emissions of losses

Key Takeaways

- There is **no regulatory incentives for TSOs to compensate the GHG emissions specifically linked to losses**, the current tariff framework does not allow to recover the potential additional costs.
- All TSOs **are looking at ways to improve sustainability aspects** but have to consider the regulatory framework and the associated costs.

8. Concluding Remarks



The study presents a comparative analysis of six TSOs losses coverage strategy

1

TSOs combine short term and long-term procurement

All TSO procuring losses except Elia, use a **combination of long term and short-term procurement**. The **long-term procurement** allows to have a better view on the costs and to **spread the price risk** while the **short-term procurement helps reducing the supply gap**.

2

TSOs use EPEX to adjust their position in ID and DA

When losses are procured, tenders are used for long-term procurement while directly **exchanging on the market is used for intraday or day ahead** procurement.

3

Access to the market comes with specific organizational measures

When TSOs have access to the SPOT market, specific measures and automated trading are set up to limit access to sensitive market information.

4

TSOs with compensation in kind have different granularities

TSO using a compensation in kind mechanism to cover the losses do it with different granularity. Elia has a fixed percentage defined yearly while National Grid and Red Electrica have **a more dynamic approach**: from seasonally for National Grid to hourly for Red Electrica.

5

The losses forecasting models

Long term forecast becomes more and more complex due to the growing importance of cross-border flows, renewable penetration and change in the location of generation and consumption centers. **No TSO have currently overcome this additional complexity.**

6

Outsourcing of the losses forecast is rare among the panel

Swissgrid is the only TSO of the panel that outsourced the forecasting module. **All other TSOs do their forecasting internally**. Swissgrid aims to internalize the activity as well.

7

Considering cross border flows remains a challenge for TSOs

The influence of cross border flows in the losses is increasing and TSOs are looking for means to integrate them in their forecast. Amprion makes a large **simulation of the European grid to integrate them in their LT forecast** and Swissgrid uses **historical NTC values for their ST forecast**.

8

Financing frameworks

TSOs procuring losses are **financially incentivized** to outperform the market via a bonus/malus. The TSOs that use procurement to cover losses **recover the costs of losses through grid tariffs**.
TSOs with **compensation in kind mechanisms have no incentives**.

9

TSOs are not incentivized to compensate the GHG emissions specifically linked to losses

All the TSOs are aware of the GHG emissions caused by losses However, there is **no regulatory incentives for TSOs to compensate the GHG emissions specifically linked to losses**.

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