SWE CCR Capacity Calculation Methodology study

Justification of a Coordinated NTC methodology

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Contents

1. Context

1.1. The region

Article 15 of the CACM sets that all TSOs shall jointly develop a common proposal regarding the determination of capacity calculation regions (CCRs). The common proposal shall take into account the regions specified in point 3(2) of Annex I to Regulation (EC) No 714/2009 where the SWE region is formed by the borders Portugal-Spain and France-Spain.
The SWE CCR was approved by all the NRAs on November the 17th of 2016.

1.2. The aim of the study

The aim of the presented study is to comply with Article 20 where the TSOs concerned shall demonstrate that the application of the capacity calculation methodology using the Flow-based approach is not yet more efficient compared to the Coordinated Net Transmission Capacity approach and assuming the same level of operational security in the concerned region.

1.3. The study

This proof is carried out with two different studies based on scenarios used for weekly capacity calculation process.
The first one demonstrates that the element that limited the capacity on one border for the selected scenarios is not influenced by the exchanges on the other border. This demonstrates that Flow-based would not be more efficient assuming the same level of operational security.
The second study demonstrates that the shape of the Flow-based domain is near to be rectangular, which means that there is independence between borders; and its comparison with NTC weekly calculation demonstrates that the Flow-Based domain is not bigger and therefore does not provide more capacity to the market assuming the same level of operational security.

2. The pragmatic Study

2.1. Objective

The aim of this first study is to evaluate the impact of the exchange program of one border on the limiting magnitude detected in the NTC calculation for the other border.

2.2. Studies developed

Firstly, it is convenient to explain that the bilateral agreements between REE, REN and RTE for weekly capacity calculation process establish to use scenarios with null exchange value in both Spain – France and Spain – Portugal borders. The NTC in border A is calculated while the exchange in border B remains null, and vice versa. The exchange value in the studied border is increased until a violation of the security standards is found, not existing available remedial actions to relieve it. The NTC value is found after subtracting a reliability margin, and a limiting constraint for a certain magnitude is identified.

For the present study, the NTC values already evaluated were combined according to the following process:

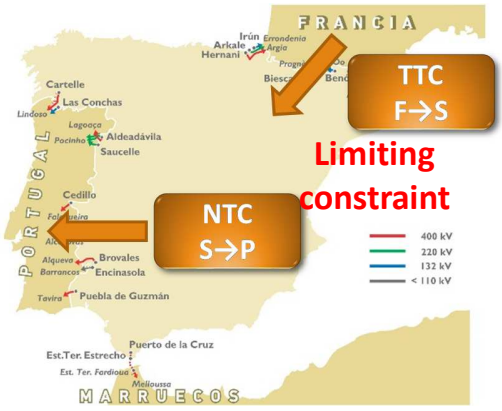
i. Take the initial scenario with null exchange in both borders A and B.
ii. Set the exchange value in border A at maximum value (NTC + RM) with null exchange in border B. In this situation the **limiting magnitude** remains under the admissible operational range; increasing the exchange value in border A would lead to overpass[1] the admissible range.
iii. Increase the exchange value in border B until reaching the maximum value (NTC) for each direction
iv. Check the new value for the limiting magnitude in the border A mentioned in step 2.

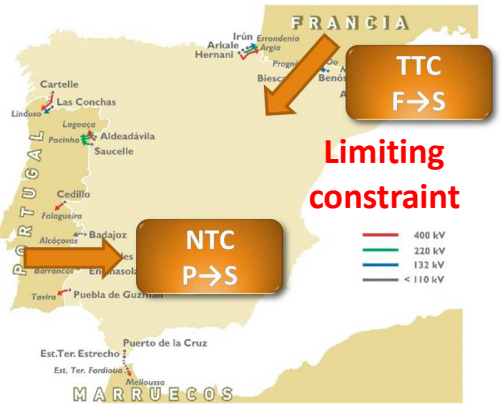
The described process was performed twice per scenario:

- First study: border A is France-Spain border and border B is Portugal-Spain border.
- Second study: border A is Portugal-Spain border and border B is France-Spain border.

[1] This is the basis of capacity calculation: if the exchange value is higher than NTC+RM, the limiting magnitude would overpass the admissible range.

As an example (see the following images), for the first study: the exchange in France-Spain border was set at TTC value from France to Spain and the exchange in Portugal-Spain border was increased until NTC for each direction. The same analysis was performed for the direction from Spain to France.





2.3. Scenarios for the analysis

Scenarios from real capacity calculation weekly process were used because of the quality of these inputs from a well-established process. Additionally, it was decided to consider all transmission network elements as well as the HVDC Sta. Llogaia – Baixas in service.

The capacity values in France-Spain border were considered taking into account HVDC in service for all the scenarios in order to have uniformity of the interconnection facilities in all the scenarios. Therefore, it was needed to include the HVDC in the scenario W26 2015 as the HVDC commissioning was in October 2015, after the mentioned week.

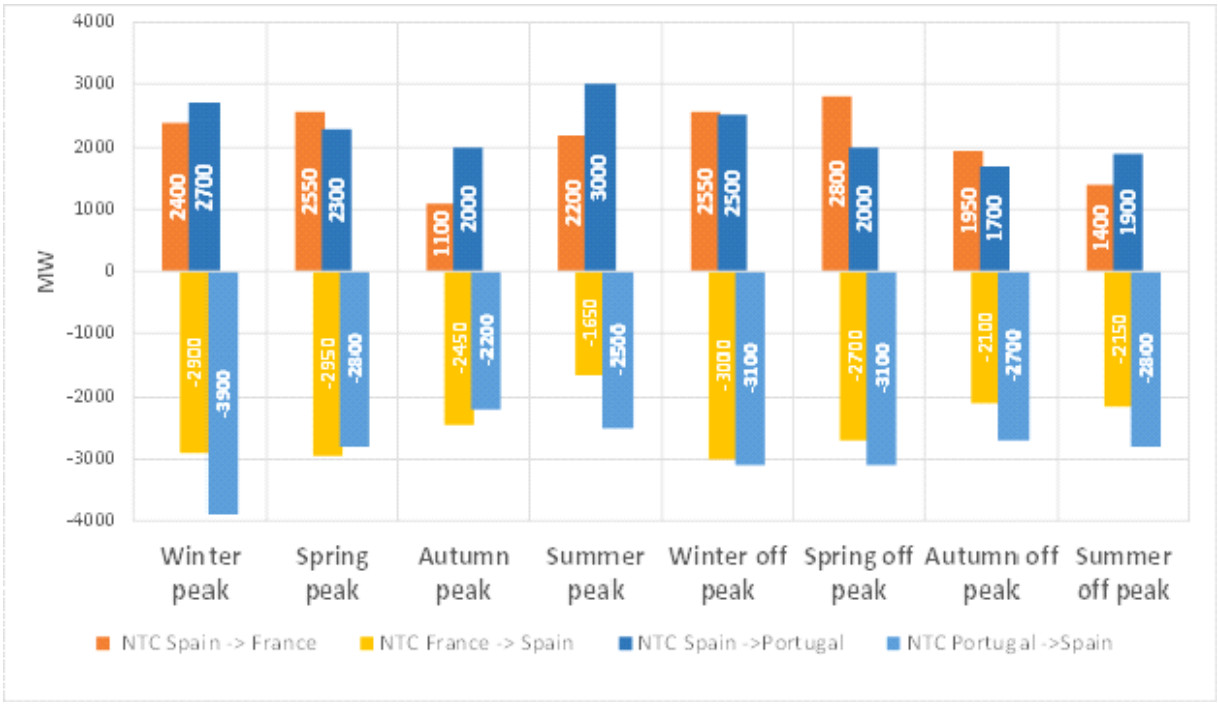
It was also agreed to take into account the update of the Spanish Grid Code (Operational Procedure P.O.1.1) at the beginning of April 2016 for all the analysis, implying the removal of the 400 kV double circuit Vic-Pierola/Bescanó-Sentmenat from the Spanish internal contingency list.

A set of eight scenarios was selected, covering peak and off-peak situations per each season. Peak and off-peak scenarios have to be distinguished because of their different generation and load profiles. The four seasons are studied because the thermal limits of network elements are calculated and set for them within a year, and to cover different seasonal profiles. As a result, this set of eight scenarios provides a good representation of the whole year. The complete list of the scenarios is listed below:

- Summer 2015 week 26 Peak
- Summer 2015 week 26 Off-peak
- Autumn 2015 week 44 Peak
- Autumn 2015 week 44 Off-peak
- Winter 2016 week 4 Peak
- Winter 2016 week 4 Off-peak
- Spring 2016 week 17 Peak
- Spring 2016 week 17 Off-peak

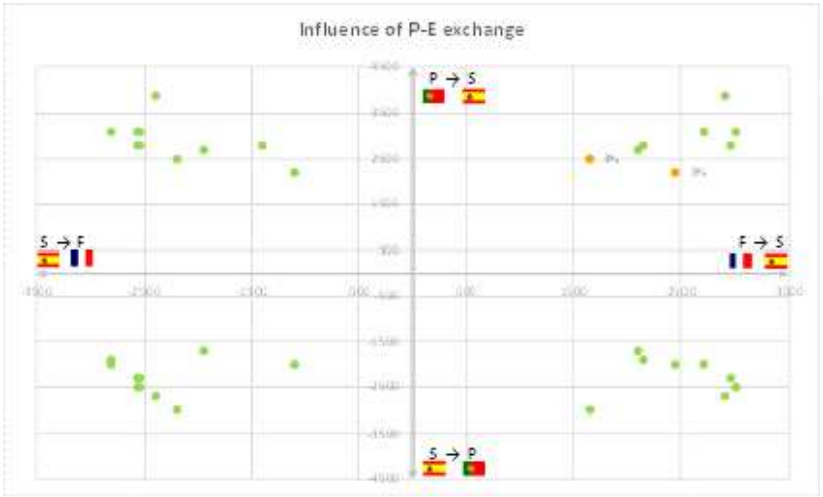
2.4. Results

The methodology explained is applied taking into account the following NTC values.



INFLUENCE OF SPAIN – PORTUGAL EXCHANGE PROGRAM ON LIMITING CONSTRAINT DETECTED IN NTC CALCULATION FOR FRANCE – SPAIN BORDER

Starting with the set of eight scenarios with null exchange value in the Spain- France and Spain – Portugal borders, 32 scenarios were built and analysed following the methodology explained in point 2.2. **Only in 2 scenarios**, the limiting contingency detected in the weekly NTC calculation for France-Spain border lead to values in the checked system magnitude **3% higher than the admissible limit**. For these two scenarios, no reduction of the NTC value would be necessary as these slight increases in the limiting magnitudes could be covered by the reliability margin.



INFLUENCE OF SPAIN – FRANCE EXCHANGE ON LIMITING CONSTRAINT DETECTED IN NTC CALCULATION FOR PORTUGAL– SPAIN BORDER

Starting with the set of eight scenarios with null exchange value in the Spain- France and Spain – Portugal borders, 32 scenarios were built and analysed following the methodology explained in point 2.2. There were **only three scenarios** where the modification in France-Spain exchange implied that after the most limiting contingency, **a system magnitude would reach to a no admissible value**. In these three scenarios, the most limiting contingency was the trip of the 400 kV double circuit Cartelle-Lindoso 1 and 2, and the limiting magnitude was the voltage phase angle difference between the 400 kV substations Cartelle and Lindoso. According to Portuguese Grid Code, the voltage phase angle difference cannot be bigger than 30 degrees and in the identified scenarios reached 31 degrees. It should be highlighted that the power plants connected close to the Portuguese-Spain border had a big influence in the voltage phase angle difference, therefore the influence of the France-Spain exchange variation in the NTC calculation for Portugal-Spain border depends on how the power plants connected close to the Portuguese-Spain border are modified to build the scenario with no null exchange value in the Spain-France border.
This statements highlights the fact that it is not directly one border that impacts the other, but more the location of the production, reducing the interest of a Flow-based approach and focusing on the quality of the GSK methodology in Spain and Portugal.

2.5. Conclusions of the pragmatic approach study

The studies performed show the following two conclusions for the Spain-France and Spain-Portugal borders.

Firstly, in almost all the scenarios the limiting constraint identified in the NTC calculation for one border is not affected by the exchange value on the other border. In the specific cases where the limiting constraint goes out of the admissible range, only a 3% of the admissible limit is reached and it would not be needed a reduction of the NTC, as the slight increase in the limiting magnitude could be covered by the reliability margin. **This sensitivity of one border to the exchange on the other border is then so low that it shows that Flow-based does not provide added value compared to the current NTC methodology.**

Secondly, looking into these specific scenarios, the results are highly influenced by the method applied to modify generation in the Spanish system, especially when generation units involved are placed close to the borders. As a consequence, the generation shift keys for capacity calculation process should be created trying to reflect a realistic increase/decrease of generation. This generation shift can be clearly identified with the merit order GSK which is the methodology applied in Spain and Portugal in CNTC approach. Nevertheless, Flow-based approach does not allow to use merit order GSKs[2], as it only supports proportional GSKs. **This lack of precision would lead to higher level of uncertainties and thus higher reliability margins, leading to lower offered capacity to the market when using Flow-based.**

[2] This idea is explained in chapter 3.

3. The Flow-based study

3.1. Objective

The objective of this study is of two natures. We complete several Flow-based (hereafter FB) calculations and determine domains in order to check both their shapes and areas.
It is relevant to mention that SWE TSOs would need significant research and development to be able to properly integrate all the specificities of the SWE CCR in FB tools, as explained in detail in point 3.3.3. Therefore, we focus on two main indicators that will help us understand and compare FB and CNTC methodologies applied in the SWE CCR. First we have to look at the **shape of the domain** which is the indicator of a mutual influence of the exchange on one border on the other considered border. We will also then **compare the areas** of both CNTC and FB domains and see what is better fit for SWE CCR. In addition we identify what would be necessary to be developed in order to go with a Flow-Based capacity calculation methodology in case that it is necessary in the future.

3.2. The study

3.2.1. Assumptions

Since the operational rules were significantly impacted by the commissioning of the HVDC line, the same rules were applied for all the scenarios:

- Operational security limits effective in April 2016 –even for scenarios before this date (change of security criteria for double circuit contingency by Spanish regulation)–.
- Use of proportional GSK which implies an approximate linearization of REE & REN merit order GSK.
- Only the limiting Critical network elements identified during the weekly calculation were applied.
- FRM is the Flow Reliability Margin, the security margin that is taken per line to cover the uncertainties of forecast scenarios and unintended deviations between control areas. In Coordinated NTC a TRM (Transmission Reliability Margin) is considered, which is a security margin statistically determined for each whole border and not by single element.
- Interconnection with Morocco not considered.

3.2.2. List of scenarios

This study has been done using four of the scenarios used for the pragmatic study: peak and off-peak scenarios from winter (week 4 2016) and spring (week 17 2016) seasons, which are representative of the behavior of the border and when the France-Spain HVDC interconnector was already in service.
These four scenarios are still representative of the behavior of the border since they are from two different seasons and representing peak and off-peak scenarios.

3.2.3. The calculation

For this study, SWE TSOs used the Flow-based functionalities of the tool *Convergence*, used in the past for the CWE CCR Flow-based parallel run in order to determine Flow-based domains.
Inputs from the two weekly calculation processes already in place were incorporated and already determined limiting elements based on those weekly calculations were used. Manual entry and adaptations of the inputs were necessary in order to incorporate them in the tool and allow us to complete a calculation.
As no previous data was available to determine FRM values, SWE TSOs decided to use a value of 10% of the maximum flow available on the grid elements like it was done during the CWE FB parallel run. This value was used for the quantitative comparison with NTC domain.

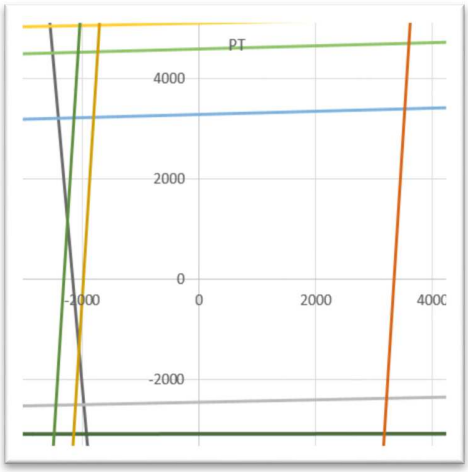
3.2.4. Limitations

Due to a tool constraint, the comparison between extreme positions of the Flow-based domain and NTC in MW is not relevant for the purpose of the study, as the domains are not always centered on 0 MW exchange program because in some cases the basecase scenarios automatically generated by the tool include embed long terms programs. Thus, the most representative analysis is to compare areas of Flow-based domains and the NTC (rectangle) domains offered to the market. It is also possible to compare the available margin on the limiting elements. Practically speaking, the domain has to be validated manually, setting exchange programs by varying generation with proportional GSKs in all the bidding zones; flow on the limiting elements could then be monitored.

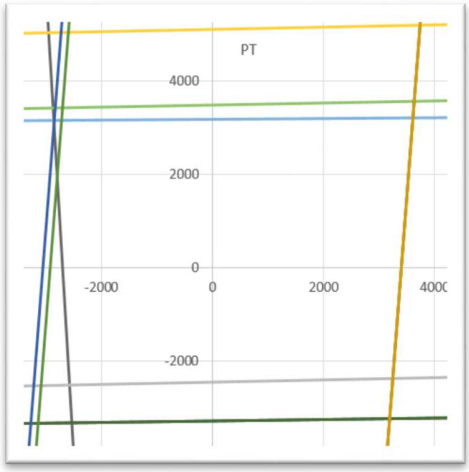
3.3. Results

3.3.1. Domain for each scenario

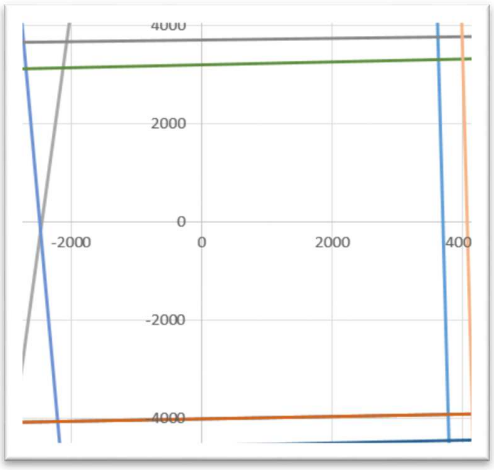
How to read these domains? These domains are based on the net position of Spain, meaning that vertically you can see the exchanges between Spain and Portugal and horizontally the exchanges between Spain and France.
An NTC domain would be represented in this situation by a rectangle with the SP-PT TTC (NTC + reliability margin) as the two horizontal lines and the SP-FR TTC as two vertical lines.



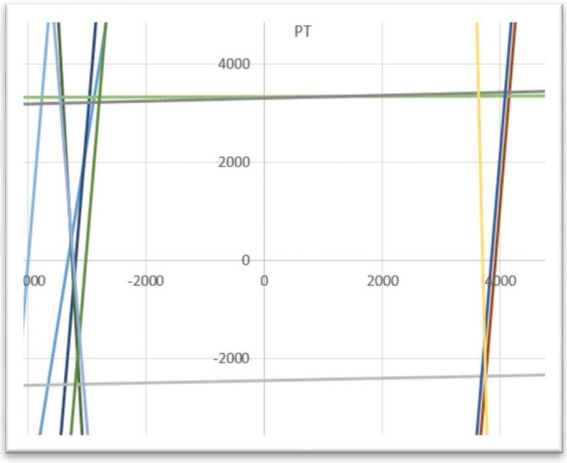
WEEK 4 PEAK SCENARIO – WINTER 2016



WEEK 4 OFF-PEAK SCENARIO – WINTER 2016



WEEK 17 PEAK SCENARIO – SPRING 2016



WEEK 17 OFF-PEAK SCENARIO – SPRING 2016

From a qualitative point of view, we can see on these domains that they are composed of constraints that are **almost or vertical or horizontal, meaning that the influence of one border on the other is really small**. This indicates that the use of these domains would not bring additional capacity to the market.

3.3.2. Quantitative comparison

As already mentioned the extreme values are not to be taken into account, nevertheless it is possible to compare the areas of NTC domains and Flow-based domains for these four scenarios.

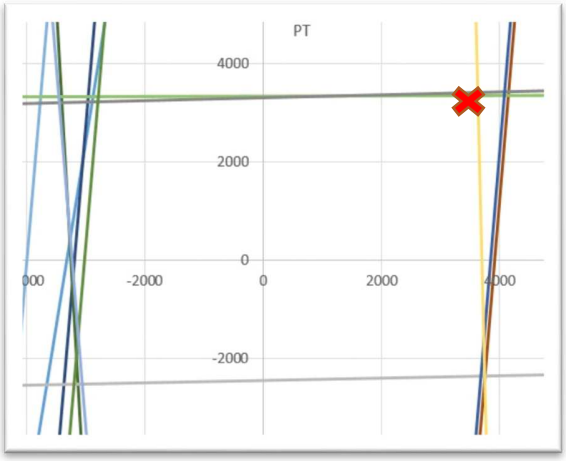
	Week 4 Off-Peak	Week 4 Peak	Week 17 Off-Peak	Week 17 Peak
Ratio areas NTC/FB	92%	112%	90%	108%
Number of hours per year[3]	1203	2421	487	977

We can already see that on average the two methodologies seem to offer very similar level of capacity to the market. NTC domain areas are slightly bigger for peak scenarios, and slightly smaller for off-peak scenarios. As the peak scenarios represent almost the double of hours than the off-peaks scenarios, it is concluded that in this study **NTC provides a slightly bigger level of capacity**, in average. But **this idea is totally reinforced when** we look into details of week 17 Off-peak scenario (the case where the ratio NTC area/FB area is the smallest) and **we observe that the obtained FB domain was in the end not secure**, as it is explained below:

Validation of the FB domain with proportional GSK

Flow-based domains have been generated with proportional GSKs. Validation through a security analysis confirmed that the domains are safe using the proportional GSK.

On the example below, the yellow CNEC is the contingency of line A, applying remedial action B and leading to a load of 100% of the limit of line C.



WEEK 17 OFF-PEAK SCENARIO – SPRING 2016 – AREA NTC / AREA FB = 90%

Validation of the FB domain with merit order GSK

To better reflect market behavior for the Iberian area, we applied the merit order GSKs and performed a security analysis. It is found that in the corner marked with a red cross the load on the mentioned line C is **123% of its acceptable transit**, meaning that this corner of the Flow-based domain **is not safe and this would have led to a much bigger reliability margin on this CNEC, to take the uncertainty of the linear GSK into account.**

Therefore although for week 17 off-peak scenario a bigger FB capacity area is obtained in a first stage, due to the use of proportional GSK some portions of this area do not fulfill the security criteria. It implies that the **actual value for the ratio NTC area/FB in this scenario is significantly higher than 90%**.

[3] Number of hours representing peak and off-peak hours for the corresponding season during capacity calculation in 2016

3.3.3. List of constraints

In addition to the results of the comparison study between Flow-based domains and NTC domains, the technical specificities of the SWE CCR would incur significant R&D costs and delays of the implementation of the capacity calculation methodology due to the following **technical constraints** of the state-of-the-art FB tools:

1. **The GSK linearization**. Both Portuguese and Spanish TSOs currently use an improved merit order GSK that best represents the behavior of the internal market. This GSK approach is totally relevant to obtain realistic results. The merit order GSK methodology is available in CNTC approach, on the contrary the Flow-based allocation requires a linear GSK that imply a change in the GSK methodology for REE and REN with a clear impact on the methodology and the calculation with a lack of quality. This limitation would lead to higher uncertainties thus increasing the reliability margin in Flow-based method.
2. **The HVDC saturation**. The normal mode of operation for the HVDC on the French-Spanish border is the emulation of the behavior of an AC line, excepts when it reaches its 2000 MW saturation. The HVDC saturation is properly managed in CNTC method but this non linearity of the network element is not compatible with the Flow-based allocation.
3. **The voltage phase difference angle constraint**. Due to incapacity of closing a tie-line after its trip on the Portuguese-Spanish border because of a voltage phase difference angle constraint, the capacity on the PT-SP border is frequently limited. This mathematical quantity is currently managed in CNTC method and not taken into account in any Flow-based capacity calculation and would need to be tackled.
4. **Voltage constraint**. The capacity on the SP-FR border can be limited due to a voltage constraint. The voltage check is currently managed in CNTC method and not taken into account in any Flow-based capacity calculation and would need to be tackled.

In conclusion, CNTC gives more capacity for the market and the method can properly take into account all the specificities of the SWE region and for using Flow-based method significant developments would be needed according to the current state-of-the-art.

There are then also **market constraints** to implement the Flow-based methodology, as we have seen it in other CCRs:

1. FB requires to adapt the Power Exchanges Market Coupling tool and procedures in order to take a new Flow-based area into account, different to the current single values NTC values. This has a significant impact in terms of project duration, operations and costs for market players. Indeed if CNTC approach is implemented, the outputs will be the same as today, and Power exchanges would not have to adapt their tools and algorithms to take into account a Flow-based domain (which would lead to performance issues on the market coupling tool).
2. As shown in the result of the FB study, the FRM methodology for FB could lead in the end to higher security margins than a TRM for the CNTC approach, where there is only one margin and not the addition of several margins. This means that even if both CNTC and FB domains were strictly equivalent, the FB domain would end-up smaller than the NTC domain when applying the reliability margins.

3.4. Conclusions of the Flow-based study

Both the shape qualitative aspect of the domains and the quantitative analysis of a comparison of domain areas prove that Flow-based domains would not be bigger or even differently shaped than Coordinated NTC domains. Besides, the required effort to implement the Flow-based methodology would lead to a significantly longer implementation period with risks in term of R&D to integrate constraints which have never been experienced in other CCRs.

This means that if Flow-based were applied while ensuring the same level of operational security, the capacity would be lower or at best equivalent to what a CNTC methodology could bring to the market.

4. Conclusions

Both studies ended with the same first conclusion: **the mutual influence of both borders is almost negligible**. The pragmatic study shows there are only 5 out of 64 scenarios where there is a slight impact (~3% of influence) of one border to the other. The Flow-based study ended with similar results since most of Flow-based domain have a square shape similar to Coordinated NTC approach. Moreover than that, the **CNTC methodology would lead to equivalent or bigger domains** than the FB methodology in the SWE CCR.

Besides, the second conclusion is that the implementation of the Flow-based methodology would induce higher costs and delays due to its **technical limitations with the current state-of-the-art**, in particular: the management of merit order generation shift keys –crucial in SWE region–; possibility to apply remedial actions involving control of the particular Spain-France HVDC interconnector –AC emulation with saturation–; and possibility to check the voltage and voltage phase angle difference. The first and the second limitations would lead to higher reliability margins to cover the non-linearity of the real grid and the proportional GSK approximation in Spain and Portugal, while CNTC method can properly take into account all these specificities of the SWE region with the available tools. No current solution is available for the third limitation when using Flow-based.

Additionally, the CNTC methodology provides an **easier follow-up and zero extra costs for market parties**, given that this approach has less complexity than Flow-based methodology, and its well-known outputs are already being used today.

Therefore SWE TSOs jointly request to apply the Coordinated Net Transmission Capacity within SWE CCR in view of the efficiency of this latter compared to the Flow-based approach, in line with paragraph 7 of the article 20 of the CACM regulation.