Study on CWE Flow Factor Competition - Executive Summary

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STUDY ON CWE FLOW FACTOR COMPETITION - EXECUTIVE SUMMARY

QUANTITATIVE AND QUALITATIVE ANALYSIS OF DRIVERS OF FLOW FACTOR COMPETITION AND FAIRNESS IN CWE

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Executive summary of Study on CWE Flow-Factor Competition

Background

Following the approval by CWE National Regulatory Authorities (NRAs), the CWE project partners launched the CWE Flow-Based Market Coupling (FBMC) in May 2015. The main objective of the CWE FBMC is to make the maximum capacity of the interconnections affecting cross-border flows available to market players, while taking into account the physical limits imposed by the transmission network. The CWE NRAs and the CWE project partners encompassing the CWE Transmission System Operators (TSO) and Power Exchanges (PX) are committed to monitoring and, if needed, improving the CWE FBMC methodology. In particular the CWE NRAs have agreed upon to monitor the "flow factor competition" phenomenon (in the following referred to as "FFC") linked to the implementation of CWE FMBC and assess the fairness of this competition in the electricity market.

Objective and structure

The CWE FFC study aimed at analyzing influential factors on flow factor competition and on the effects on fairness. These topics have been addressed in two tasks:

- Task 1: Qualitative and quantitative analysis of the status quo of CWE FBMC and FFC, including the definition of FFC indicators and analysis of extensive historical TSO and PX data.
- Task 2: Evaluation of the fairness of competition comparing the status quo with alternative design policies for CWE FBMC, also comprising FBMC and nodal optimal power flow (OPF) based market simulations.

Analyses of Task 1 - "Analysis and monitoring of flow factor competition"

In the first step of this task, a qualitative analysis of current flow-based capacity calculation (CC) processes by CWE TSOs has been performed, investigating the question "What are drivers and design choices that have an impact on the competition for scarce capacity among bidding zones, and what are alternative design choices?" The design choices, modelling assumptions and TSO specific parameters have been analysed and classified considering their impact on the flow-based domain:

- Impact on zonal PTDFs[1] (like assumed D2CF topology and Generation Shift Keys (GSKs)).
- Impact on Remaining Available Margins (RAMs) (like the base case modelling, remedial actions, Flow-Reliability Margins (FRMs), maximum flow limits (F_{max}), and Final Adjustment Values (FAVs)).
- Impact on the scope of congestion that is managed by day-ahead FBMC (like PTDF thresholds and CBCO selection policies).

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[1] Abbreviations: PTDF: Power Transfer Distribution Factors; D2CF: Two-Days-Ahead Congestion Forecast; CBCO: Critical Branch Critical Outage combination; LTA: Long-Term Allocation

Next, based on the qualitative analysis, **quantitative indicators for FFC** have been defined and evaluated using historical TSO and PX data over the monitored period, in particular:

- **FFC frequency indicators**: monitoring the occurrence of market and network situations and the characteristics of the constraining flow-based domains, in classes like number of hours with…
  - flow-based constraints restricting cross-zonal exchanges in the day-ahead market coupling (in short "restricting the day-ahead market")
  - external constraints restricting the day-ahead market
  - flow-based constraints below 5% sensitivity threshold restricting the day-ahead market
  - LTA inclusion[2] being applied
  - LTA-included branches restricting the day-ahead market
  - pre-congestion[3]
  - the flow-based intuitiveness (FBI) patch being applied
- **FFC severity indicators**: monitoring of shadow prices, which reflect the additional market welfare that could be gained by an increase in transmission capacity of constraining CBCOs.
- Further FFC systematics and FFC sensitivity indicators

The flow-based CC process is based on many parameters that model the flows caused by cross-zonal exchanges and the remaining capacities available for such flows. Some of these parameters require a modelling on their own. Therefore, also the **modelling accuracies** of selected key parameters like nodal positions, GSKs and flows have been investigated based on D2CF, DACF and snapshots data.

The quantitative analyses have been carried out in a first step for a monitoring period of May 31st, 2015 to August, 31st, 2016. An extended analysis covering the time frame until end of November 2016 has been made available to NRAs in a web-based monitoring tool.

Main findings of Task 1 - "Analysis and monitoring of flow factor competition"

General Flow-Factor Competition assessment

During the monitored period, the day-ahead market was significantly influenced by restricting flow constraints. FFC occurred in more than 50% of the hours of the monitored period. Main drivers for the restriction of cross-zonal exchanges in the day-ahead market were flow constraints in the Amprion, Elia and TenneT DE grid areas. A second but less severe driver was the application of explicit import and export limits of bidding zones (through so-called external constraints). Very frequently (85%) LTA inclusion needed to be applied, hence requiring an artificial adaptation of

[2] LTA inclusion is the process of artificial enlargement of the flow-based domain to cover at least the allocated long term capacities.
[3] Pre-congestion here means that the network would be overloaded in a situation without day-ahead exchanges between the CWE bidding zones.

the flow-based domain. In 10% of the monitored hours the network was already pre-congested[3]. Rarely (0.4%) flow constraints with a sensitivity on cross-zonal exchanges below 5% were limiting the market. The FBI patch was applied in 12.4% of the hours and led partially to high deviations in net exchange positions and prices. The resulting lack of price convergence from a constrained grid resulted in the highest frequency of low prices in Germany/Austria/Luxembourg and highest frequency of high prices in Belgium. Where TSOs applied remedial actions to increase capacity for the day ahead market, these were primarily the control of cross-border phase-shifters, less frequently local phase-shifter control and topological actions, and very rarely re-dispatch. It was observed that the relative capacities reserved for reliability reasons (FRMs) deviated significantly between the TSOs.

Monitoring of the reference program and the base case

To analyse modelling accuracies in the CC process, forecasts used for constructing the flow-based domain have been compared with corresponding values modelled after the day-ahead market result from which much more accurate information is available. Here, the forecasted bidding zone net positions in the assumed reference program for the market showed considerable deviations from the actual zonal net positions of the day-ahead market results. Also, considerable deviations between forecasted nodal positions and flows in the base case (D2CF – two days ahead network model based on uncertain information) compared to the day-ahead congestion forecast (DACF - network model with improved information after the market outcome is known) have been observed. Some structural forecasting deviations indicate that base case accuracy could be improved by improved forecast methodologies. This is already being addressed by TSOs in ongoing efforts to improve the D2CF and base case modelling.

Monitoring of Generation Shift Keys

GSKs model the relationship between a bidding zone's net position from the day ahead market and the change in the net value of grid feed-ins and take-offs at the network nodes caused by generators. A proxy for the actual GSKs has been used, based on comparing nodal generation from the D2CF and DACF network models, to investigate how close the GSKs applied by the TSOs come to this. The results show considerable deviations between applied GSKs and the observed GSK proxy, not only in size but also in direction as the observed GSK could also be negative.

Impact of Flow-Based Intuitiveness

Over the monitored period, the FBI patch has shown considerable impact on prices and zonal net positions, even though the impact on market welfare in relative terms is small.

Analyses of Task 2 - "Modelling of alternative design policies and fairness assessment"

In the second task of the study, fairness of FFC has been investigated. The applied definition of fairness has been that FFC is fair as long as it is "based on the true impact of commercial exchanges on the network". In particular, the impact of the FB methodology on the competing cross-zonal trades should not be systematically biased due to assumptions linked to the modelling of the system and the FB parameters.

In order to quantify advantages or disadvantages for bidding zones, a fairness indicator based on the zonal welfare distribution has been defined. The fairness indicator evaluates the impact of a certain design policy in FBMC on the zonal shares in market welfare. Notably, quantitatively assessing fairness in zonal FBMC is difficult as no perfect "fair" reference can be derived for the CWE region based on the existing data. This challenge is addressed in the study by using two different reference models (a model with reference PTDFs and a nodal OPF) and focusing on alternative designs for selected parts of the flow-based model. The selection of these alternative designs together with the dates for which the fairness effects were quantified was done in close cooperation with the CWE regulators.

Six **alternative design policies** (e.g.: "alternative CBCO selection") for FBMC have been **modelled and simulated in a market simulation** for six selected days. This has been achieved by the logarithmo market simulation environment which resembles the real-life PX algorithm "EUPHEMIA", takes historical bid curves as inputs and models the impact of alternative design policies on the flow-based domain. The simulation also allows to simulate a nodal OPF, which optimally selects bids and models network flows considering both each bid's price and topological location. The simulation results have first been evaluated as individual policies (in comparison to the "original FBMC scenario"). Then the simulation results have been compared with the two reference fairness models for investigating their impact on the fairness indicator.

For each alternative design policy, one "relevant" day of the monitored period was selected, creating six selected days for which the fairness evaluation was carried out. As relevant, a day was chosen for which the selected alternative design policy was expected to have a large impact. For example, for the FBI alternative design policy, a day was chosen which had the maximum number of hours with non-intuitive prices for which the FBI patch was applied.

Main findings of Task 2 - "Modelling of alternative design policies and fairness assessment"

Impact of alternative design policies

The following six alternative design policies for FBMC have been modelled and evaluated for the six selected days[4]:

- Scenario "**Seasonal F_{max}**" (which applied a consistent seasonal F_{max}-increase compared to the summer period to all CBCOs) resulted in a welfare increase for all zones, higher exports from DE/AT/LU to FR and a shift of congestion from internal CBCOs to interconnectors.
- Scenario "**Alternative CBCO selection**" (which removed internal CBCOs from the FB domain) resulted in a day-ahead market welfare increase, in particular with higher exports from DE/AT/LU to FR, and more interconnectors and external constraints becoming restricting for the market. Notably, in this scenario a different extent of congestion is managed by the FBMC model, which would lead to increased redispatch costs for managing overloads of internal CBCOs not being quantified in this study.
- Scenario "**Improved base case**" (which was based on reference flows from DACF) resulted in reduced welfare and a shift of congestion to the interconnectors.

[4] Hence the observation is based on 144 hours in Task 2, as opposed to more than 11.000 hours in Task 1.

- Scenario "**No LTA inclusion**" (which applied the flow-based domains without inclusion of LTA corners) resulted in a welfare decrease, absolute increase of all types of constraints being restricting for the market (in particular of interconnectors) and reduced exchanges.
- Scenario "**Flow-based Intuitiveness** (FBI)" (applying the FBI patch as opposed to not applying the FBI patch) resulted in a very small welfare effect, small deviations of net positions with mostly reducing exports from DE/AT and reducing imports in FR
- Scenario "**Alternative GSKs**" (applying a DACF-based GSK) resulted in a welfare decrease for all zones, with more internal branches being limiting for the day-ahead market.

Overall, the scenario "Improved base case" had the most pronounced welfare effect, underlining the importance of ongoing improvements for the base case modelling (cp. findings in Task 1).

General fairness assessment and insights

The impact of the above alternative design policies on fairness of FFC has then been assessed qualitatively and quantitatively. The latter has been achieved by comparing the market simulation results of the individual alternative design policies with corresponding benchmark simulations and hence evaluating the fairness indicators.

From the qualitative assessment it has been concluded that all not physically related adaptations of the FB domain could be a source of unfairness since, according to the fairness definition, ideally the "true" impact of exchanges on the network should be modelled in the FB domain. In particular the adaptations by LTA inclusion and the FBI patch are artificial adaptations of the FB domain and could thus be drivers of unfairness even where this has not been demonstrated by the fairness indicator on the selected days.

Tentatively, policies enlarging the FB domain lead to an increase of fairness indicators in the quantitative fairness assessment, even where this enlargement is artificial. For several policies it has been observed that the fairness impact on individual zones was varying between advantageous and disadvantageous on different days, hence the fairness impact was not structural. The two policies for which a consistent increase of the fairness indicator has been observed were the policies "Seasonal F_{max}" and "Alternative CBCO selection".

The reference model "nodal OPF" resulted in higher exchanges and net positions compared to the current FBMC model, with most prominently increased exports from DE/AT/LU and increased imports in BE and FR. For evaluating the fairness with the nodal OPF as a benchmark, it should be considered that the nodal OPF can already manage a larger extent of congestion than zonal FBMC. The reason is the ability of the nodal OPF to optimally select bids in a nodal granularity (more degrees of freedom than in zonal FBMC) and thus to manage congestion for the same set of CBCOs more flexibly, which enables higher cross-zonal exchanges while at the same time managing internal congestion. Further, the nodal OPF did not apply LTA inclusion, which can require additional redispatch measures in case of current zonal FBMC.

Web-based CWE Monitoring Tool

As part of the study a web-based CWE FBMC Monitoring Tool has been developed which enables to gain insights into FBMC, the location and extent of congestion (e.g. RAMs and CBCO loadings in a European network map), market patterns, generation feed-in as well as FFC indicators. The tool is based on publicly available and hourly updated data from JAO and ENTSO-E.

For access to the latest version of the CWE Monitoring Tool, please contact cwe@logarithmo.de.

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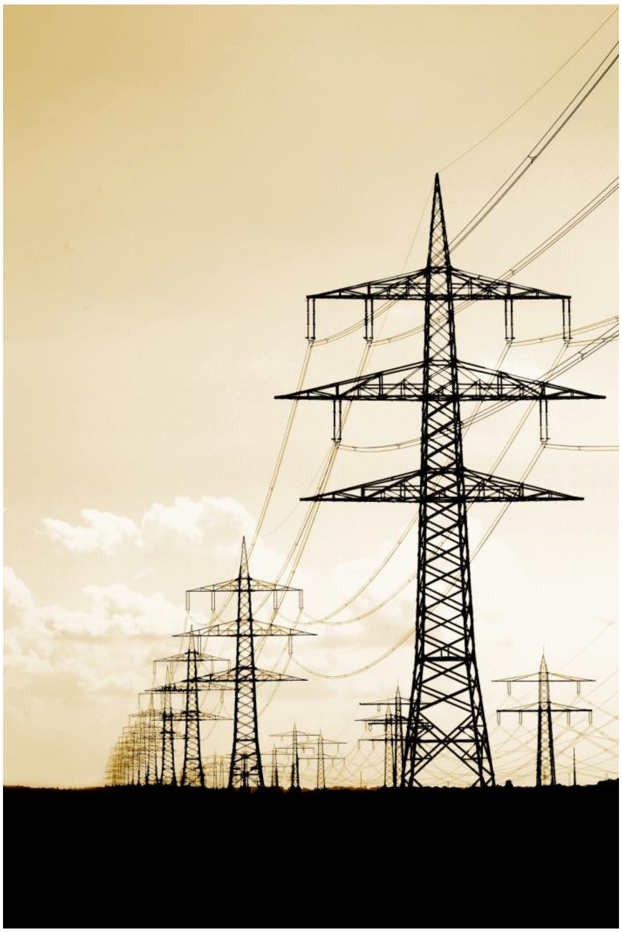

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