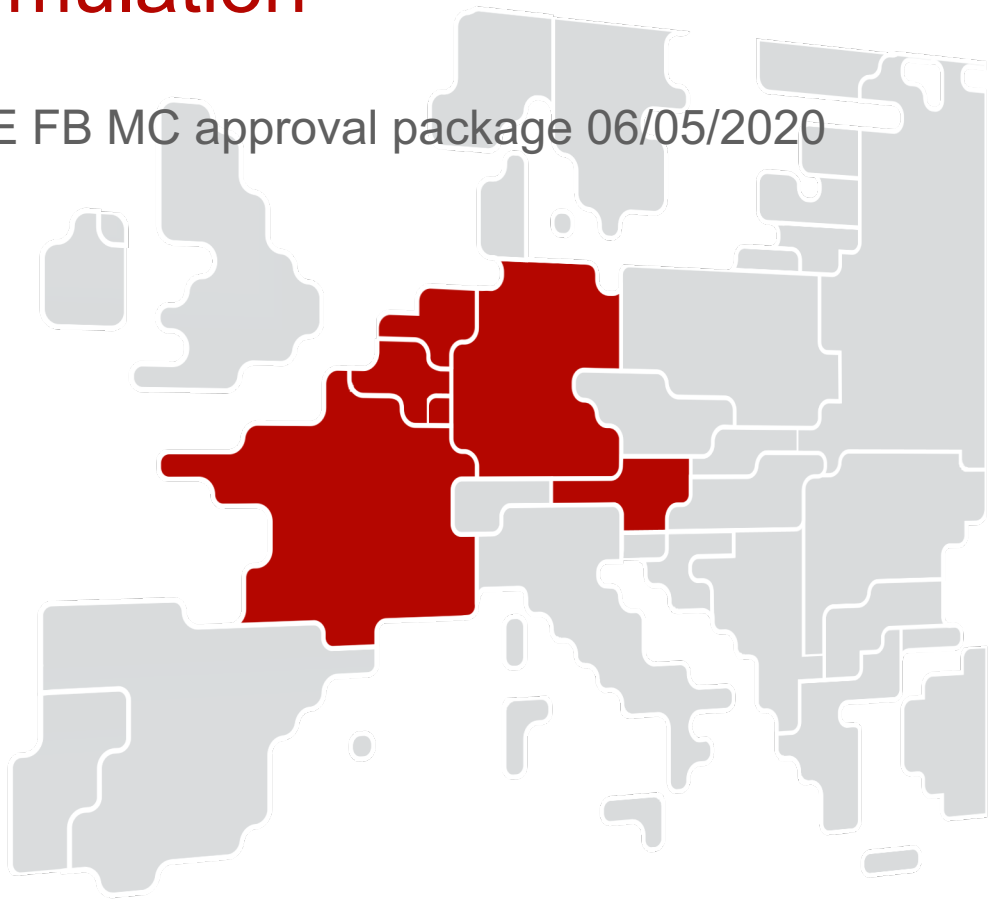
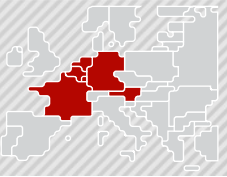
Annex 14.30 - Pedagogical information on Extended LTA formulation

Submitted as part of the CWE FB MC approval package 06/05/2020



About this document



This document explains the methodologies used for LTA inclusion. This document aims to provide an overview of the changes that are expected considering the performance upgrades for CWE. It consists of the following:

- Reminder of current approach
- Improved virtual branches
- Extended LTA

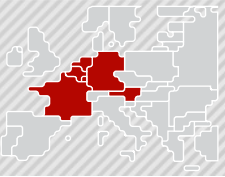
By means of a high-level introduction, the performance mitigations will significantly reduce the amount of constraints needed for the capacity calculation. This in turn improves performance on both capacity calculation ad allocation side. The improved performance allows the market coupling algorithm to find more optimal solutions, possibly increasing the social welfare.

The implementation of the performance upgrades are expected in Q4 2020

- Improved virtual branches can be expected as of ALEGrO go-live
- Extended LTA with a new release of the market coupling algorithm around Q4 2020

Update CWE methodologies for CEP and ALEGrO implementation

Introduction and current approach



Updates to include changes related to performance mitigations:

- As informed during the CCG of 03/04, performance challenges of FBCE & Euphemia with additional borders became apparent with the preparations for the implementation of ALEGrO: there was lack of scalability of the IT system.
  - The issue: the number of virtual branches which are created for the LTA inclusion process is exponentially linked to the mathematical dimensionality.

Current process

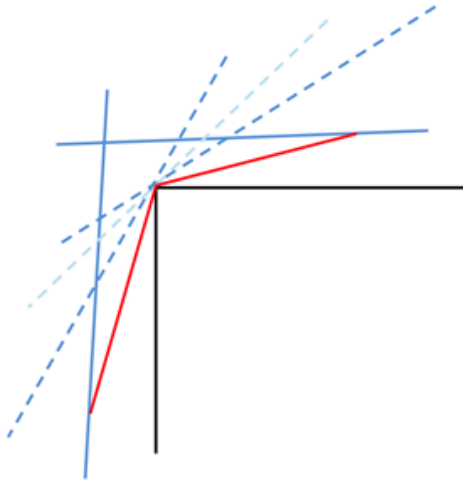
- Currently each real branch is replaced by its virtual counterpart in case the LTA corner creates an overload– leading to a high number of duplicate virtual branches. Hence, the number of virtual constraints generated during the LTA inclusion can be significantly reduced by removing this duplication step
- With the current approach, each virtual branch will be scaled with the corresponding RAM. It will lead to non-physical PTDFs for the virtual branches.
- A detailed example can be found in the annexes of the slides.

TSOs accordingly developed updates of the methodology to perform the LTA inclusion in order to improve performance and the reasons why both are needed:

- Improved virtual branches – Reduction of virtual constraints
- Extended LTA inclusion – Novel way of doing LTA inclusion in the Market Allocation part

Improved virtual branches

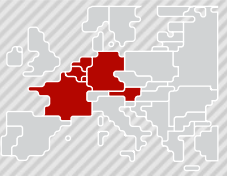
- CWE TSOs developed the Improved virtual branches in order to reduce the number of virtual branches. Improved Virtual Branches will not create duplicate as it was the case in the current LTA inclusion.
- Detailed example can be found in annex.
- The Virtual branches will not be scaled with the RAM like in the past.
- For the sake of transparency,
  - The most limiting line (Highest LTA margin) will give its name to the newly constructed branches (virtual branches).
  - The other lines will be shifted similarly to an application of FAV while with the current approach they were deleted.
- Moment of application: ALEGrO technical go-live



ALEGrO technical go-live will happen a bit prior the commercial go-live with ALEGrO constrained to 0.

Update CWE methodologies for CEP and ALEGrO implementation

Extended LTA inclusion



An R&D track with N-SIDE under SDAC governance successfully elaborated an alternative way for LTA inclusion directly in Euphemia.

- In the extended LTA inclusion process, the market coupling algorithm now receives two domains (one FB domain with MinRAM and one LTA domain) representing the flow-based Capacities of the CWE region.
- Euphemia does not recalculate the flow-based domain (it does not create an LTA included domain). Instead, the “Balas formulation for LTA inclusion” allows Euphemia to choose which combination of both domains creates most social welfare, where the share of the LTA domain and the share of virgin FB domain is expressed with a factor alpha.
- Mathematical formulation can be found in *Annex 14.29 – Extended LTA formulation*

Extensive analysis has shown that the implementation of the ‘Balas formulation’ (Extended LTA inclusion) **yields the same market coupling results** as LTA inclusion via improved virtual branches:

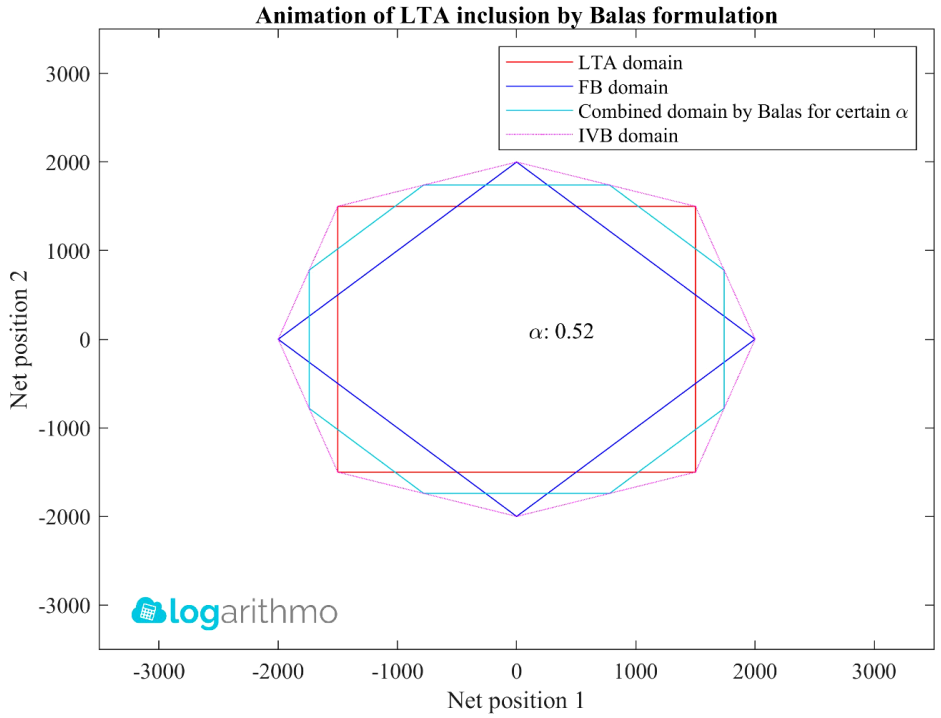
- The min max net position of the FB domain correspond
- In addition, running market coupling simulations generated comparable welfare
- Minor differences have been observed due to rounding and because the ‘Balas formulation’ is more precise than the virtual branch creation
- Summary of the analysis can be found in annex.

It has been demonstrated that the Extended LTA formulation delivers significant gain in the performance of Euphemia.

- Extended LTA will be used from the introduction of Euphemia 10.5 onwards.
- Even after the switch towards Extended LTA, the improved Virtual Branches Process will be kept for transparency (Final Flow-Based domain), ID ATC extraction, ATC extraction SA … *Improved Virtual branches is not scalable to a large number of BZs (e.g. Core)*

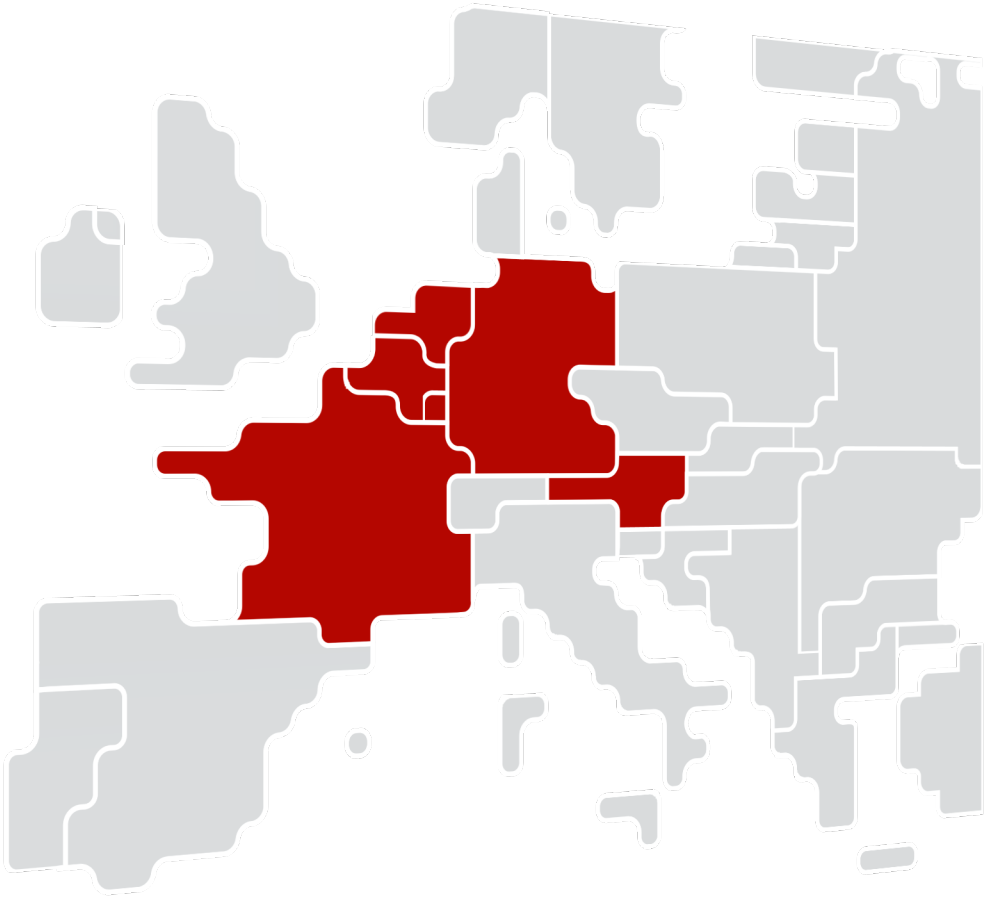
Video exemplifying the extended LTA inclusion method

- https://fileserver.logarithmo.de/s/dJNRbzsDQjcKLi6



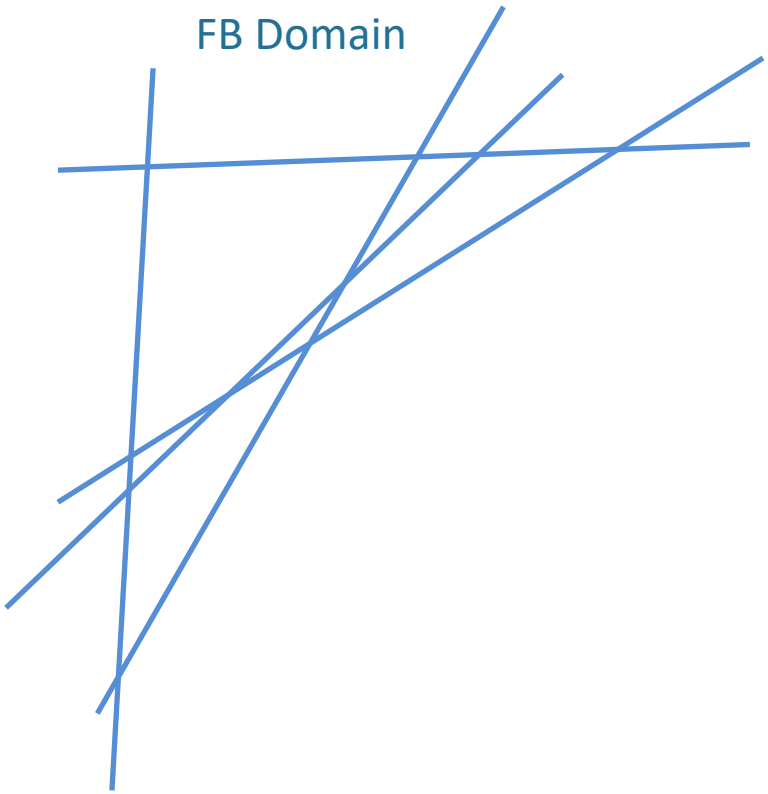
- The current link shows an animation of how extended LTA inclusion works. You can find in blue and in red, the FB domain and the LTA domain respectively which would be given as inputs to the market coupling as explained in the previous slide. The pink domain represents the domain created thanks to LTA inclusion done with virtual branches.
- As you can see in the animation, the cyan domain is the linear combination of the blue and the red domain considering different values of alpha (LTA - alpha=1 & FB - alpha=0). The animation shows that the set of feasible market coupling points will be the same as for the Virtual Branches approach.

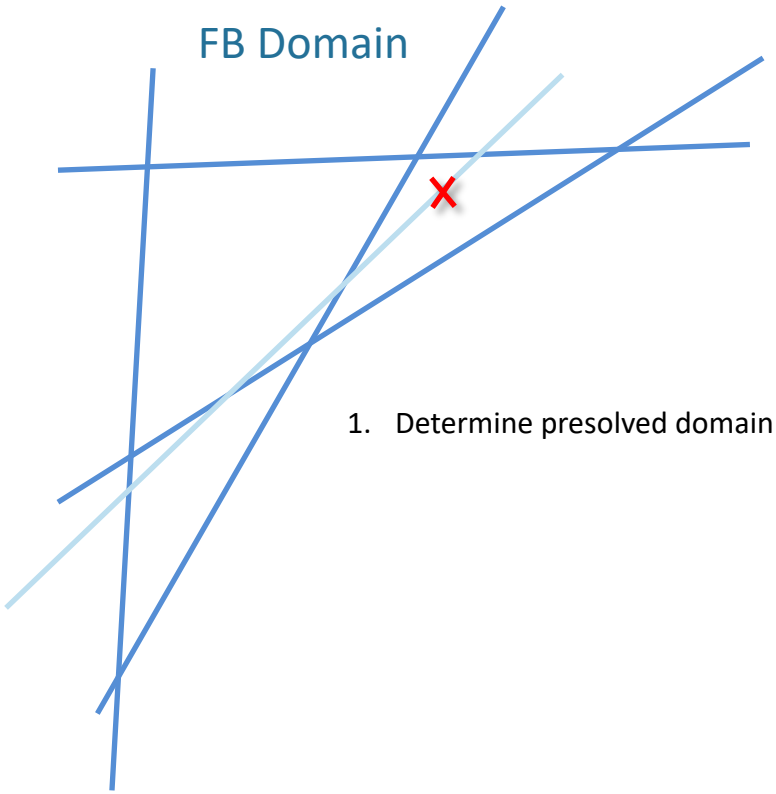
Annex – Current LTA



Update CWE methodologies for CEP and ALEGrO implementation

Introduction and Current approach

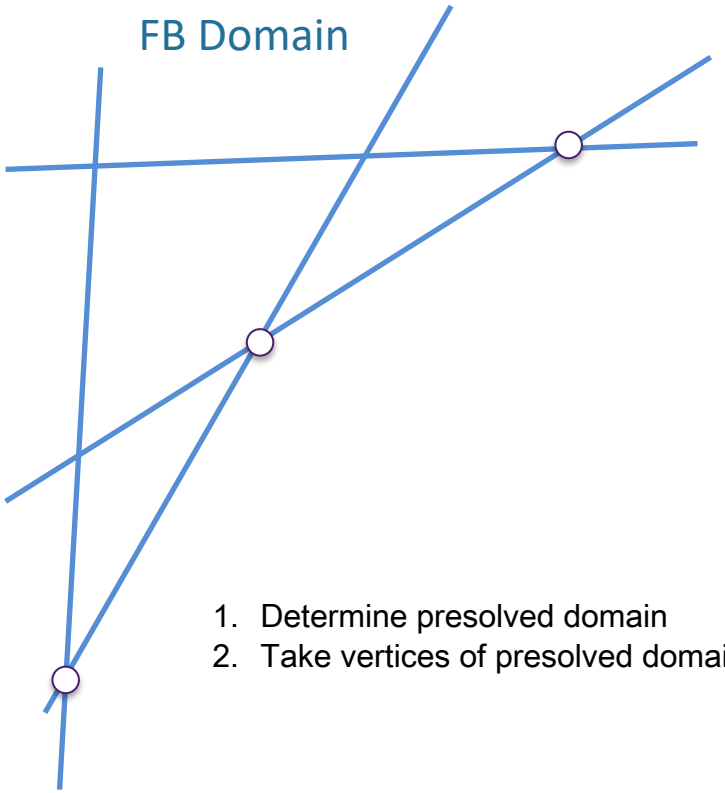




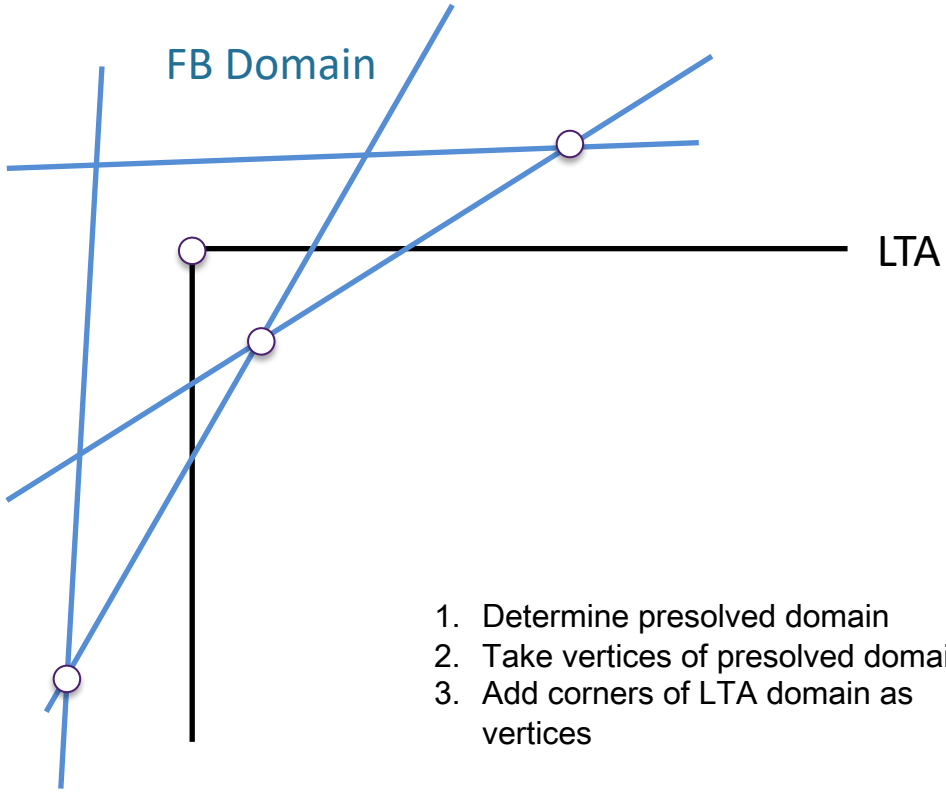
1. Determine presolved domain

Update CWE methodologies for CEP and ALEGrO implementation

Introduction and Current approach



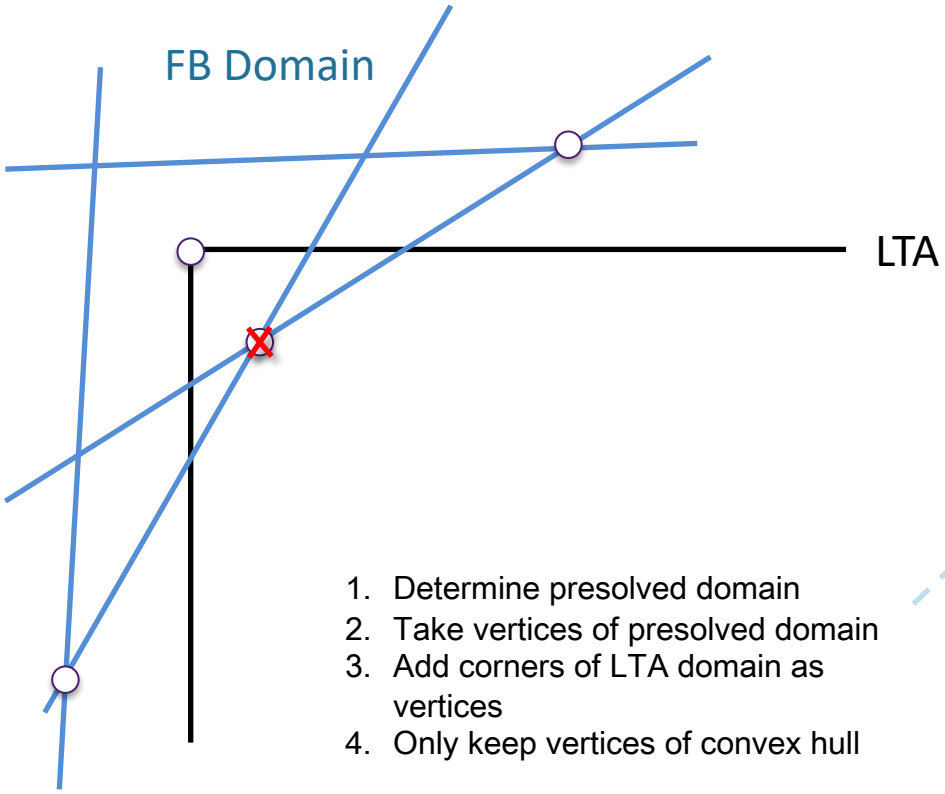
1. Determine presolved domain
2. Take vertices of presolved domain



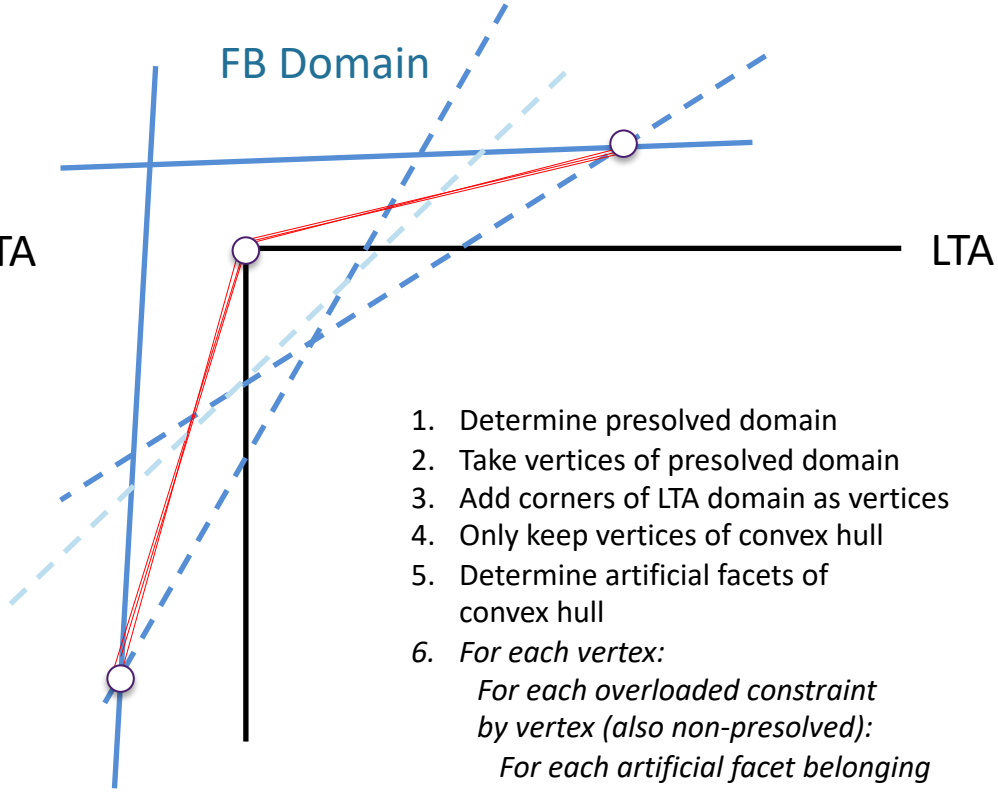
1. Determine presolved domain
2. Take vertices of presolved domain
3. Add corners of LTA domain as vertices

Update CWE methodologies for CEP and ALEGrO implementation

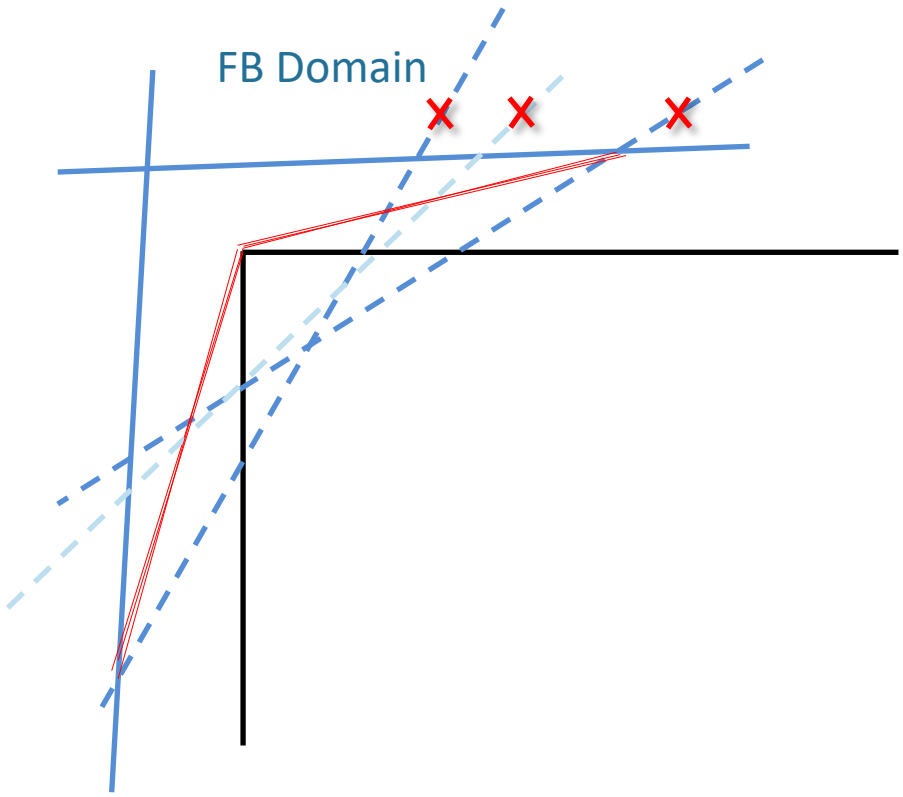
Introduction and Current approach



1. Determine presolved domain
2. Take vertices of presolved domain
3. Add corners of LTA domain as vertices
4. Only keep vertices of convex hull



1. Determine presolved domain
2. Take vertices of presolved domain
3. Add corners of LTA domain as vertices
4. Only keep vertices of convex hull
5. Determine artificial facets of convex hull
6. *For each vertex:*
   For each overloaded constraint by vertex (also non-presolved):
   For each artificial facet belonging to vertex:
   Add a virtual branch based on artificial facet but scaled to constraints desired RAM



1. Determine presolved domain
2. Take vertices of presolved domain
3. Add corners of LTA domain as vertices
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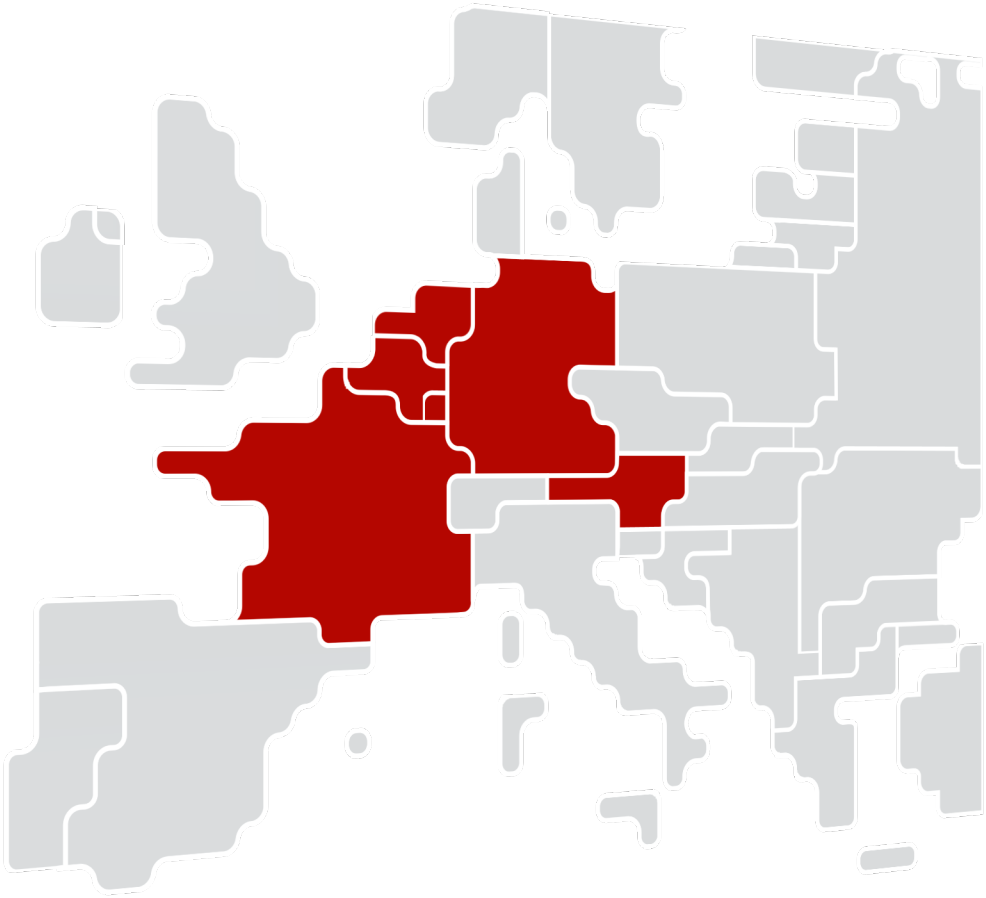
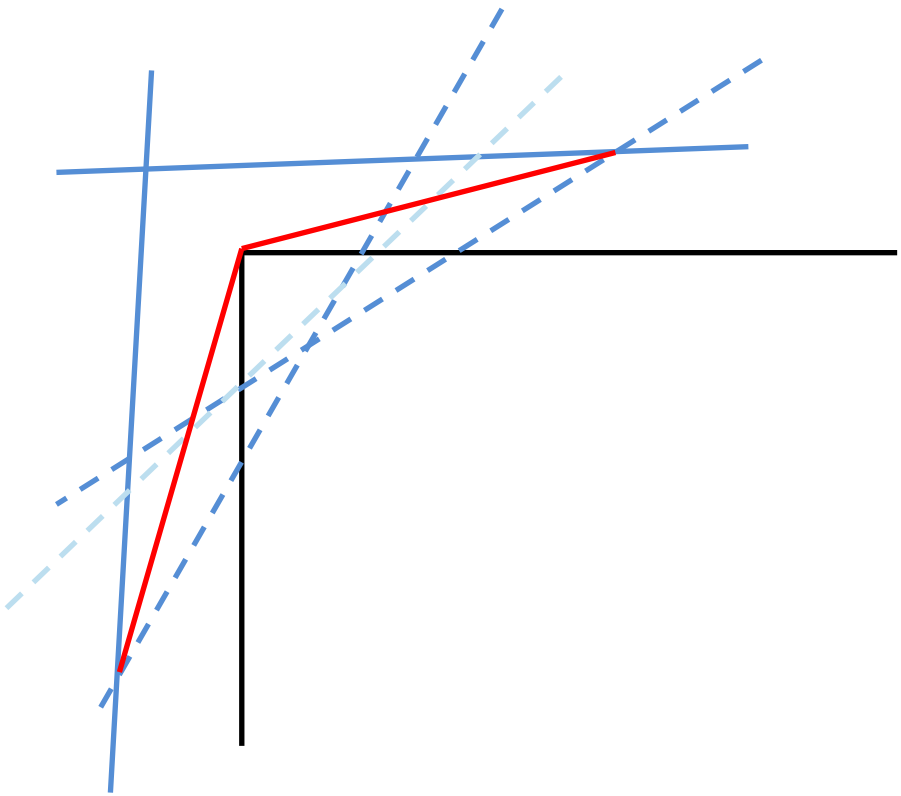
5. Determine artificial facets of convex hull
6. *For each vertex:*
   For each overloaded constraint by vertex (also non-presolved):
   For each artificial facet belonging to vertex:
   Add a virtual branch based on artificial facet but scaled to constraints desired RAM
7. Delete overloaded constraints

Annex – Improved Virtual Branches



Update CWE methodologies for CEP and ALEGrO implementation

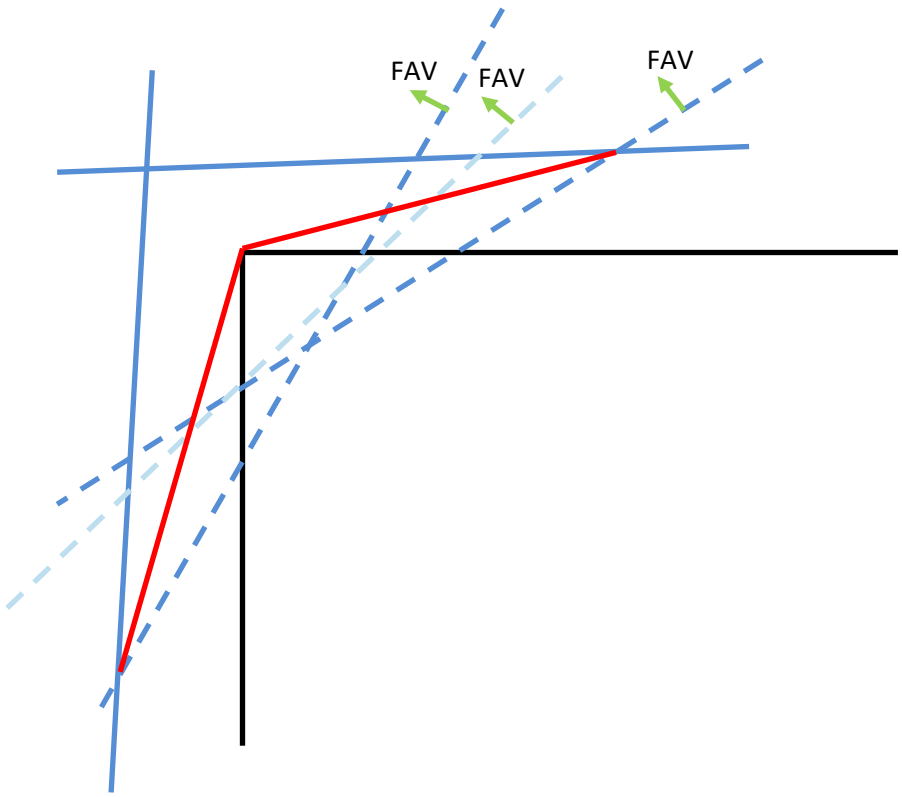
Improved Virtual Branches



1. Determine presolved domain
2. Take vertices of presolved domain
3. Add corners of LTA domain as vertices
4. Only keep vertices of convex hull
5. Determine artificial facets of convex hull
6. *For each artificial facet:*
   Add a virtual branch (only once!)

Update CWE methodologies for CEP and ALEGrO implementation

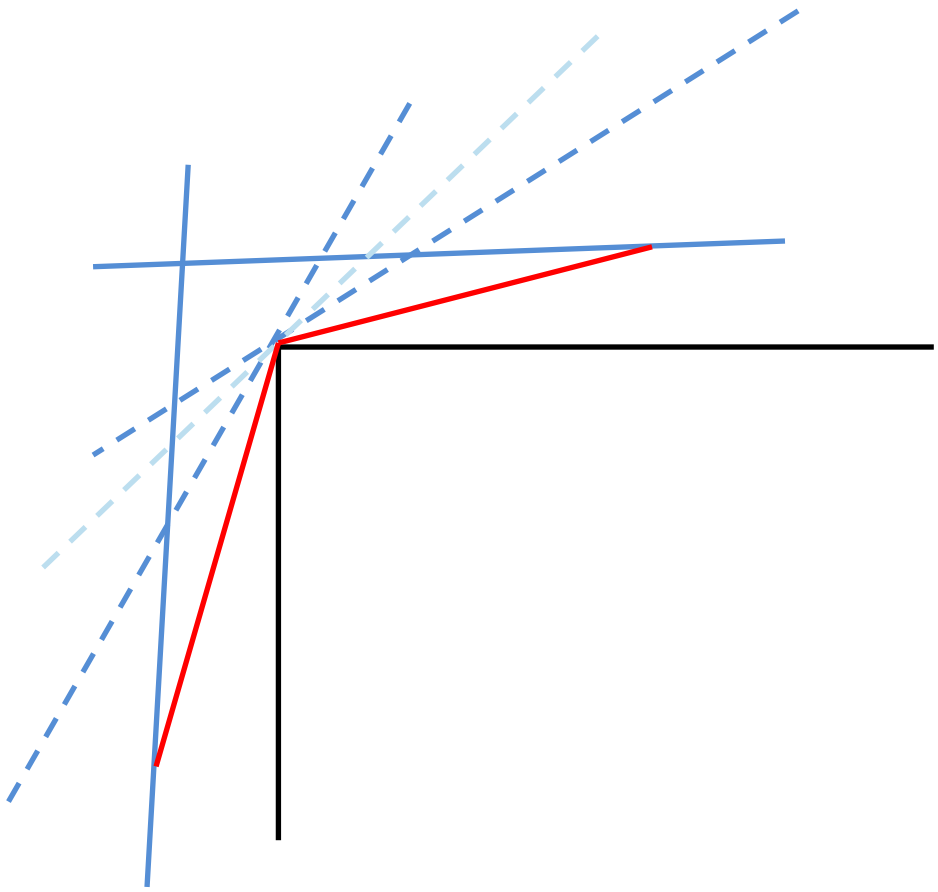
Improved Virtual Branches



1. Determine presolved domain
2. Take vertices of presolved domain
3. Add corners of LTA domain as vertices
4. Only keep vertices of convex hull
5. Determine artificial facets of convex hull
6. *For each artificial facet:*
   Add a virtual branch (only once!)
7. *For each overloaded constraint:*
   Apply FAV approach with LTA margin for LTA corner with highest LTA overload

Update CWE methodologies for CEP and ALEGrO implementation

Improved Virtual Branches



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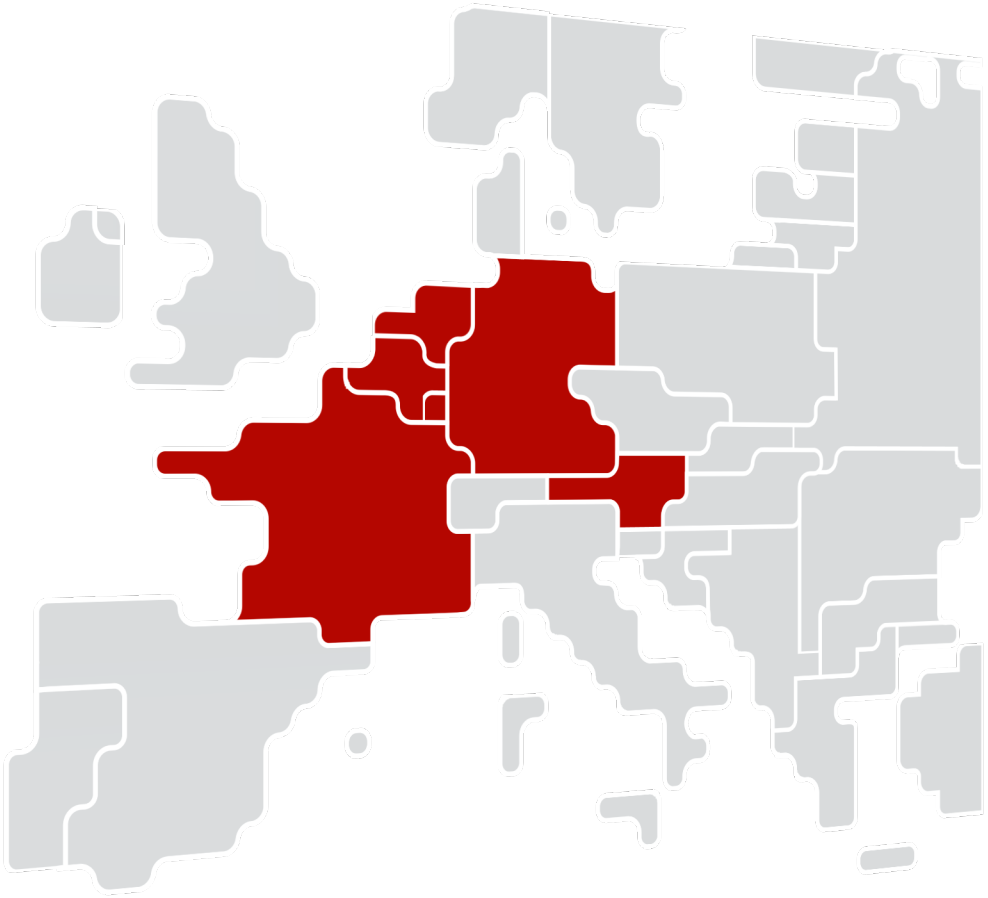
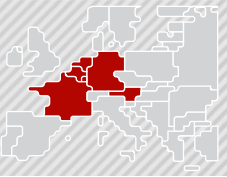
   Apply FAV approach with LTA margin for LTA corner with highest LTA overload

Annex – Comparison IVB and Extended LTA



Validation of Extended LTA inclusion

Capacity calculation - Flow-based domain indicators (Min/Max Net Positions)



Validation of flow-based domain

- Analysis performed:
  - Obtain Min/Max NP from classical Virtual Branch (VB) domain (F206)
  - Obtain Min/Max NP from the Extended LTA inclusion
    - Extended LTA inclusion has been modelled by logarithmo in an optimization prototype
    - F204 virgin domain and LTA domain are used as input domains, and the Min/Max NP are determined by the optimization constrained by the Extended LTA domain formed by these two domains jointly (Balas formulation)
- Key results:
  - **Min/Max NP are almost identical for Extended LTA and VB approach, proving the general applicability of the Extended LTA approach from a CC perspective**
    - Mean deviations of Min/Max NPs are for all bidding zones below 0.02% (< 1 MW)
    - Max deviation of Min/Max NPs is 13MW
      - Even if the deviation is small, it is worth mentioning that this is an extreme outlier for an unlikely market direction, where the VB generation made the FB domain actually too large in the past
    - These slight deviations are due to rounding and small inaccuracies in the creation of Virtual Branches