
# Flow-based market coupling with integrated redispatch

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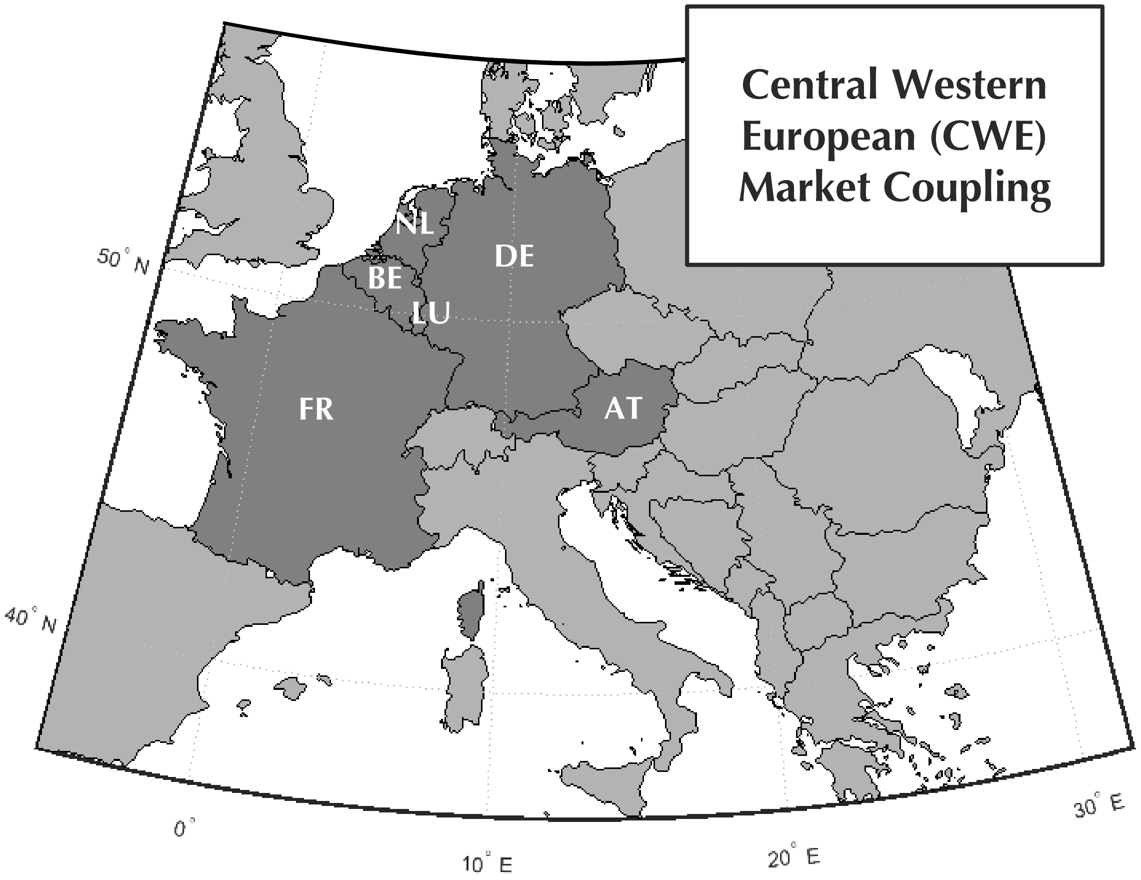
# Background

Coupling of National Power Markets in Europe

- Zonal Market Coupling
  - Integration of national electricity markets on the basis of a zonal pricing approach
  - Shift from bilateral ATC-based to Load Flow-based Market Coupling in CWE in 2015 (CWE FBMC)
- Key issue: commercial exchanges are considered to be too low
  - Change to nodal pricing or bidding zone reconfiguration seem politically not feasible
  - Legislation aims at increasing exchange capabilities by enforcing minimum margins (“minimum RAM”) on critical network elements

➢ However, are there any alternatives to this?

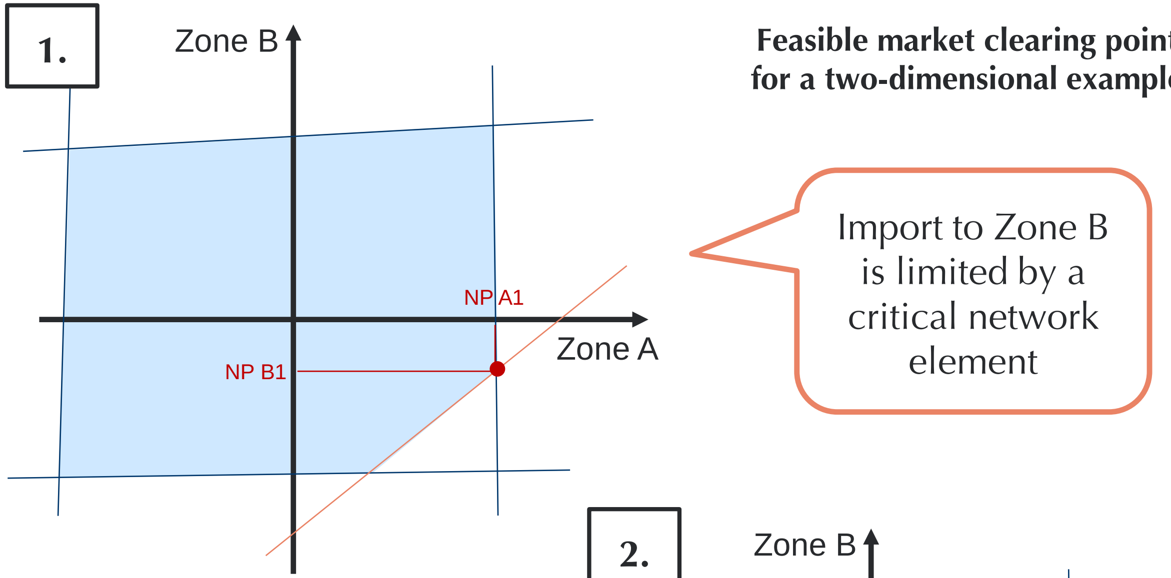


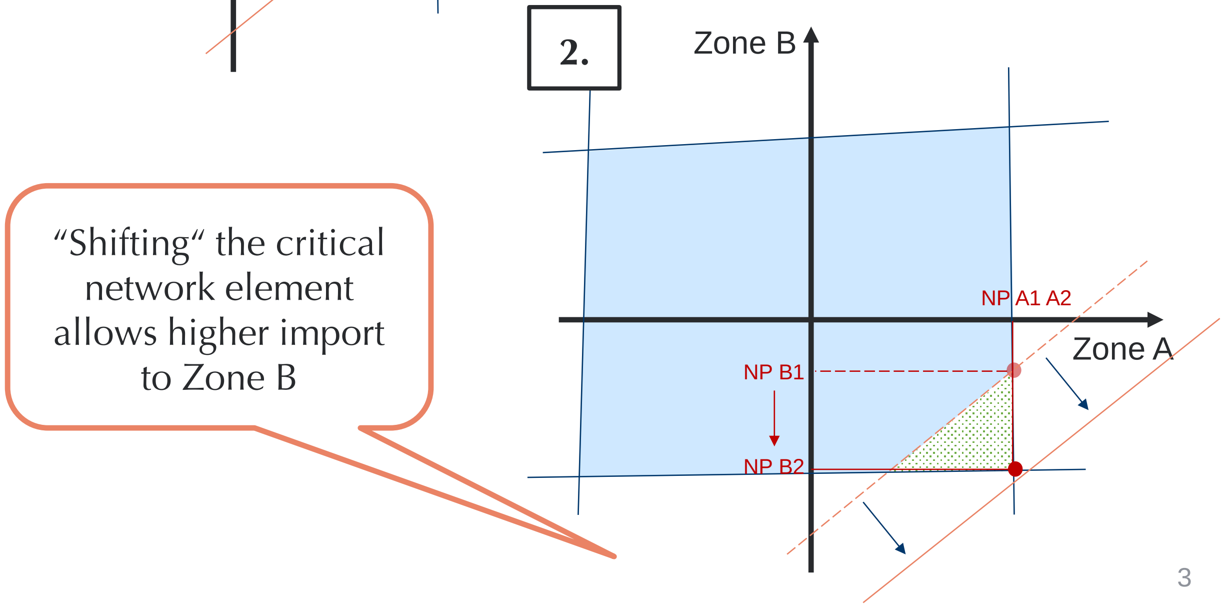
# Motivation

- What are we seeking to achieve?
  - Commercial exchanges are determined by the capacity domain spanned by limiting critical network elements (see 1.)
  - Increasing commercial exchanges requires the relief of congested critical network elements (see 2.)

- **Idea**: incorporate redispatch into the market clearing algorithm to increase commercial exchanges (when efficient)

**Feasible market clearing point for a two-dimensional example**

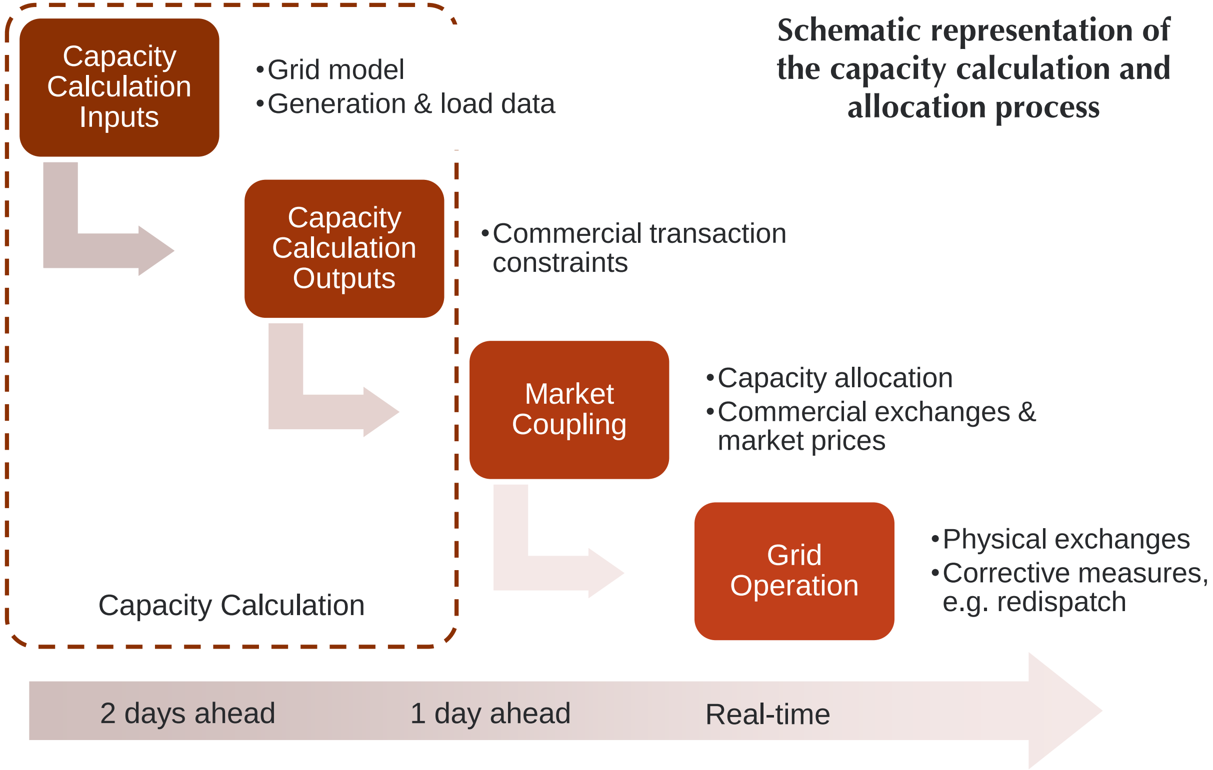


# Capacity Calculation and Allocation Process I

As implemented today

- Capacity Calculation
  - Translation of physical transmission constraints into commercial transaction constraints
  - Capacity domain is optimised using non-costly remedial actions, e.g. topological measures
- Capacity Allocation
  - Determination of commercial exchanges and market prices
- Grid Operation
  - Corrective measures to guarantee feasibility of physical exchanges resulting from zonal market clearing
  - Also costly remedial actions, i.e. redispatch, to relieve potential grid congestion



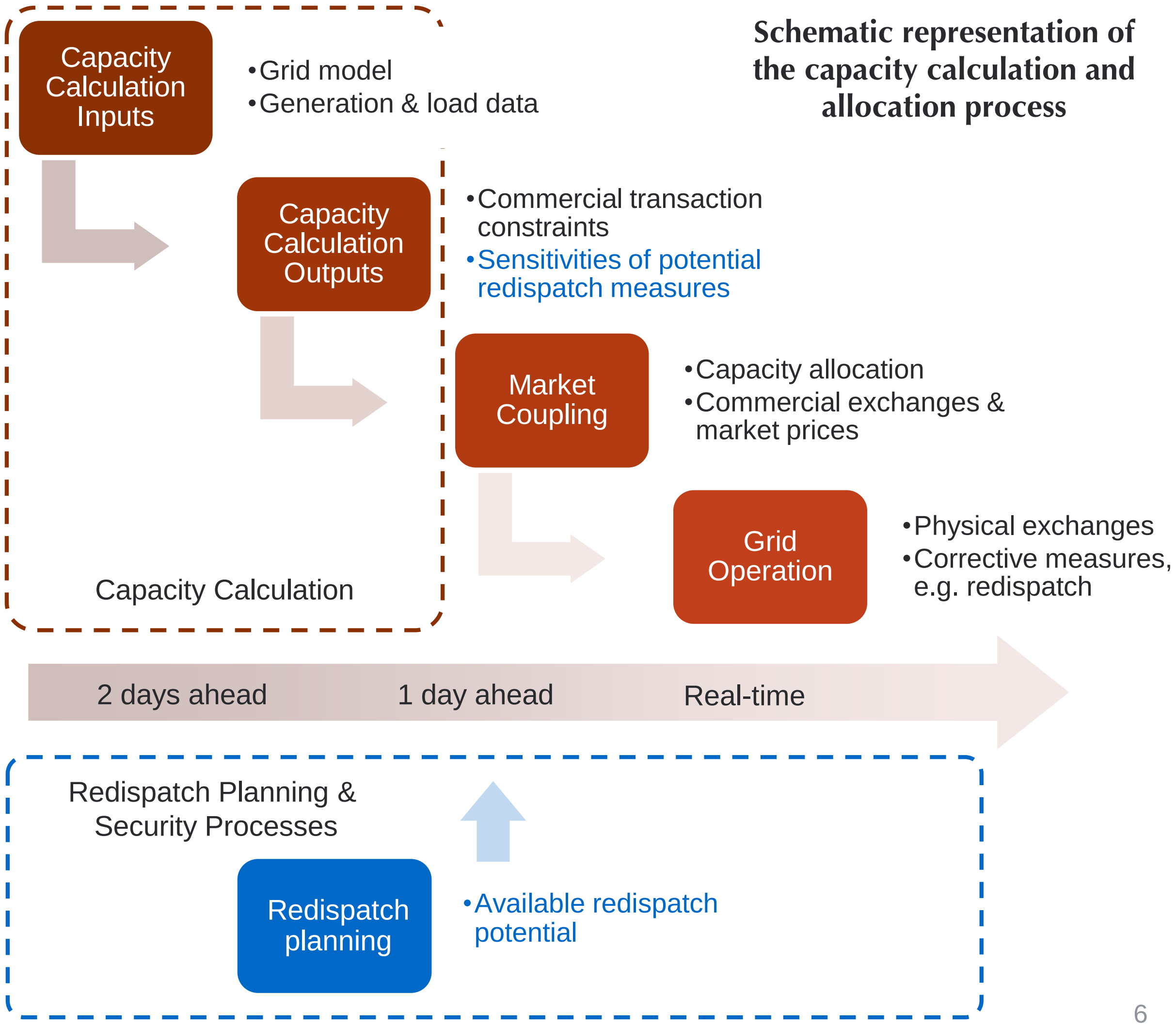

**Schematic representation of the capacity calculation and allocation process**

# Capacity Calculation and Allocation Process II

## Integration of Redispatch

- Different options available, e.g.
  - Redispatch markets
  - Integration of nodal constraints
  - <u>Consideration of redispatch potential</u>
- Redispatch potential
  - Outcome of continuous operational planning processes of TSOs
  - Sensitivities of potential redispatch measures on critical network elements could be determined within the capacity calculation process
- Capacity Allocation
  - Incorporation of redispatch potential and corresponding sensitivities on critical network elements, but no activation of redispatch

**Schematic representation of the capacity calculation and allocation process**

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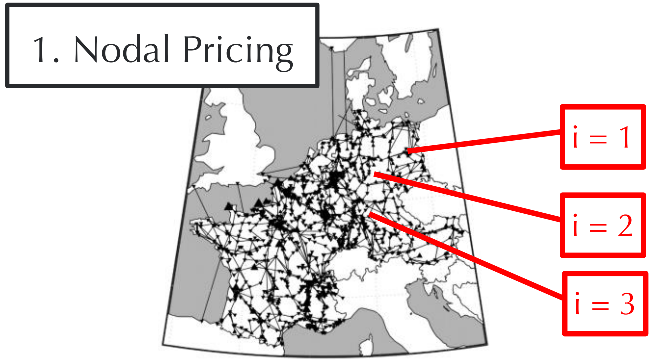
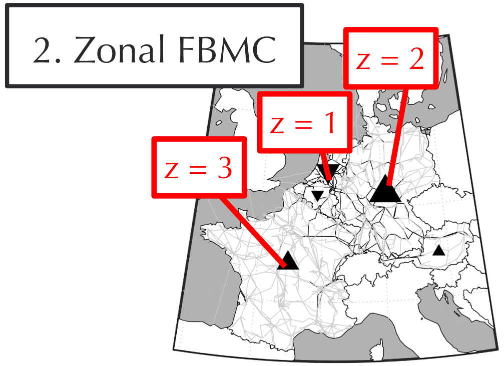
Zonal Flow-Based Market Coupling and Integration of Redispatch




$$-f_{max} \leq \sum_{i \in I} ptdf_i \cdot NEX_i \leq f_{max}$$




$$ram^{NSFD} \leq \sum_{z \in Z} ptdf_z \cdot NEX_z \leq ram^{SFD}$$

Objective: **Minimisation of variable generation cost**

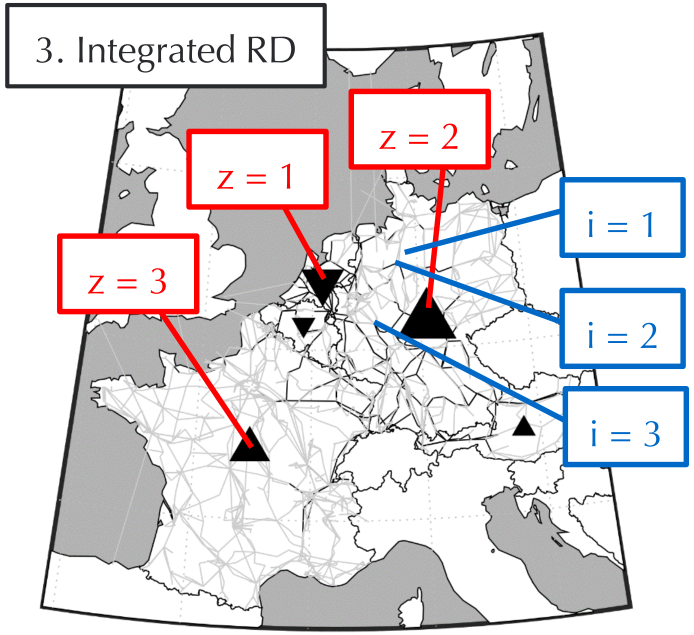
Subject to constraints:

- Generation capacities
- System balance
- …

**Integration of redispatch potential**

Further constraints:

- Balanced redispatch amounts
- $RD^-_{u,i}$ as negative and $RD^+_{u,i}$ as positive variable




$$ram^{NSFD} \leq \sum_{z \in Z} ptdf_z \cdot NEX_z + \sum_{i \in I} \sum_{u \epsilon U^{RD-}} ptdf_i \cdot RD^-_{u,i} + \sum_{i \in I} \sum_{u \epsilon U^{RD+}} ptdf_i \cdot RD^+_{u,i} \leq ram^{SFD}$$

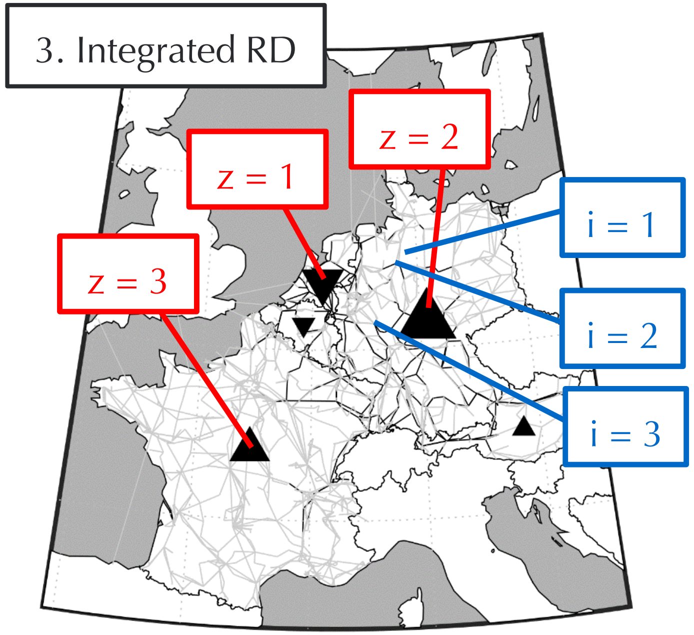


For cases 1. and 2. also see Voswinkel et al. (2019), Felten et al. (2019) and Voswinkel et al. (2018)

# Methodology

Determination of Redispatch Potential

- Sensitivities of potential redispatch measures
  - $ptdf_i$ represents the nodal sensitivity of generation units available for redispatch and connected to node $i$
  - Translation of utilized redispatch potential into a reduced flow on binding critical network elements
- Available redispatch units
  - Availability according to dispatch of case "2. Zonal FBMC"
  - $RD_u^- = -gen_{u,zonal}$; $RD_u^+ = p_u^{max} - gen_{u,zonal}$
- Considered redispatch potential
  - If $ptdf_i \leq q_{0.01}$ or $ptdf_i \geq q_{0.99}$ (for the respective redispatch unit)



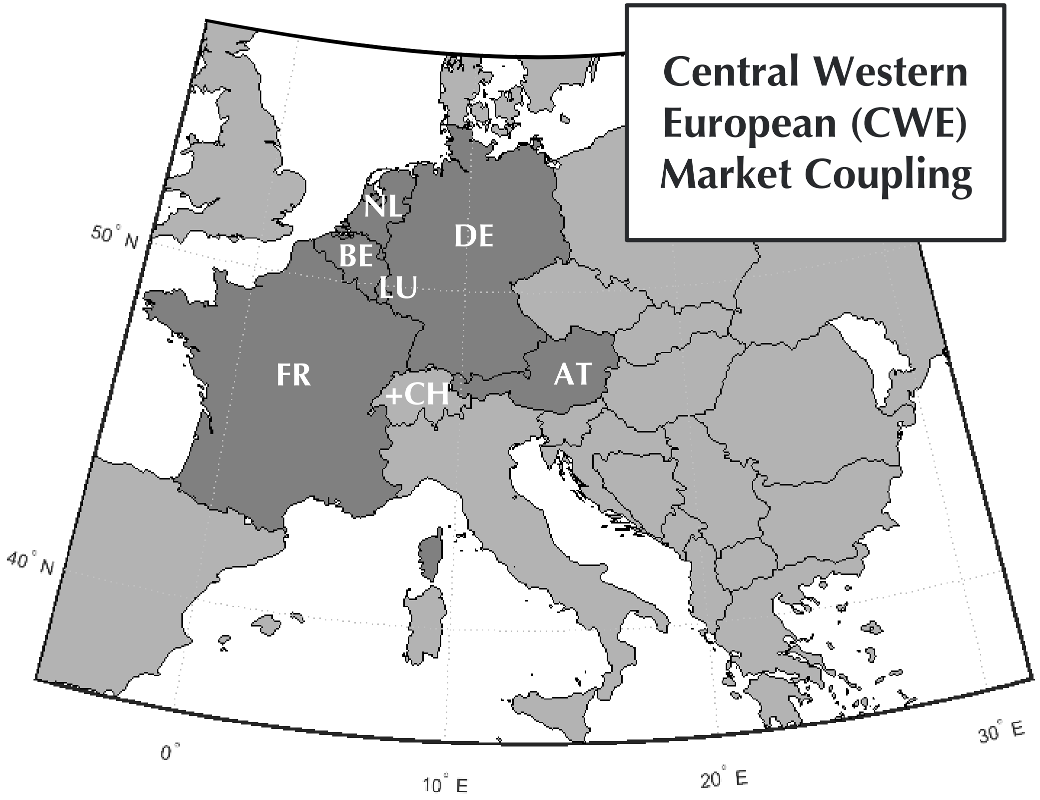

$$ram^{NSFD} \leq \sum_{z \in Z} ptdf_z \cdot NEX_z + \sum_{i \in I} \sum_{u \in U^{RD-}} ptdf_i \cdot RD_{u,i}^- + \sum_{i \in I} \sum_{u \in U^{RD+}} ptdf_i \cdot RD_{u,i}^+ \leq ram^{SFD}$$

# Preliminary Results



## General assumptions for numerical assessment

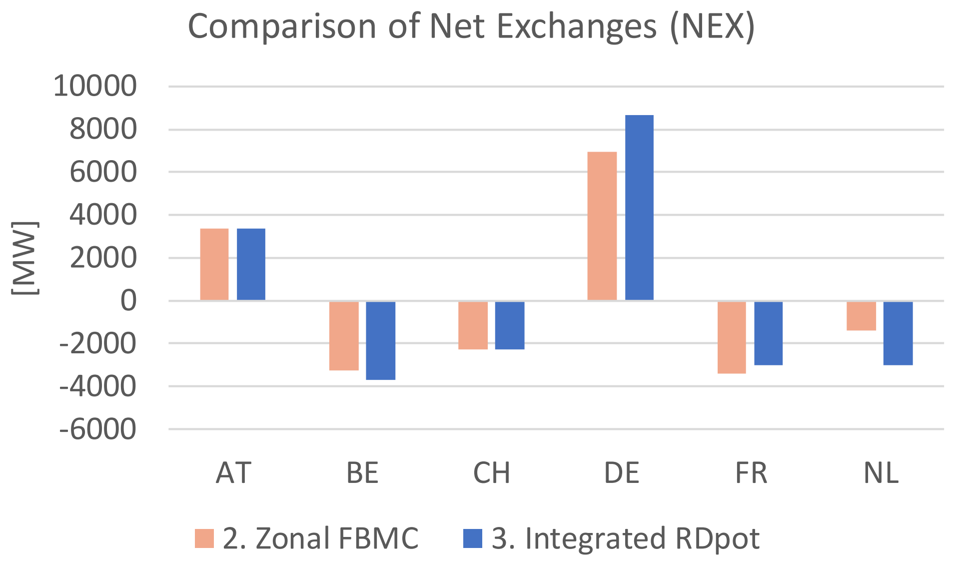
- **Time horizon**: 2020 (selected snapshot)
- **Geographical scope**: Central Western Europe + Switzerland
- **Three cases**:
  1. **Nodal pricing** (reference case)
  2. **Zonal FBMC**
  3. Zonal FBMC with **integrated RDpot** (redispatch potential)
- Redispatch stage
  - Minimization of redispatch amount through penalties to account for startup-costs and inefficiencies ($RD^+$: +30%; $RD^-$: −20%)
- Redispatch potential
  - Available generation units with a high sensitivity on critical network elements
  - Available redispatch potential amounts to $RD^+$: 2853 $MW$, $RD^-$: −5517 $MW$

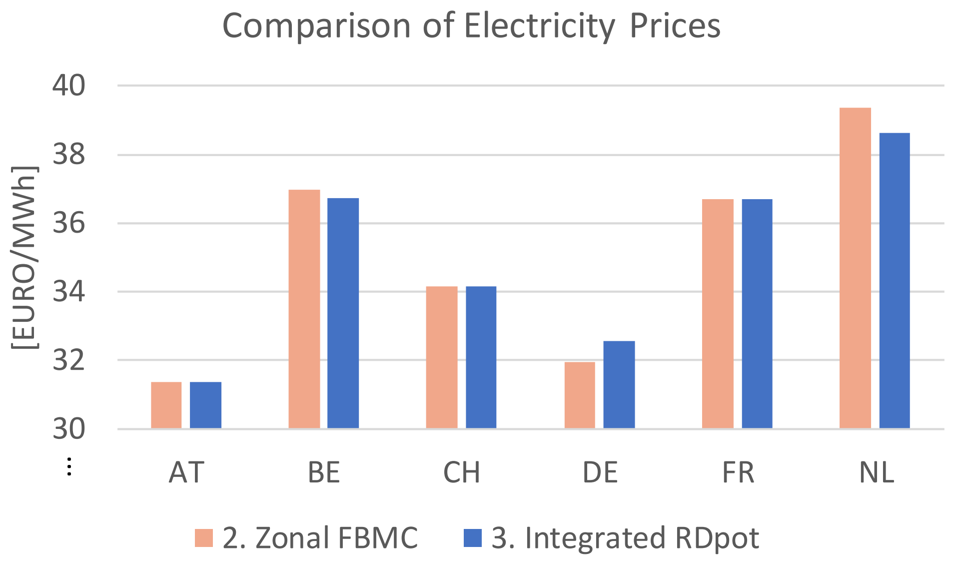


# Preliminary Results

Snapshot: 4 pm, 11th February 2020

- Impact on electricity prices and exchanges
  - Prices converge: decrease in NL and BE, increase in DE
  - Net exports from DE are increased by 1.7 GW
  - Imports to BE and NL are increased by 2.1 GW, while FR imports less




- Impact on costs and redispatch amount

| | | Nodal Pricing | Zonal FBMC | Integrated RDpot |
|---|---|---|---|---|
| [M€] | Total Cost | 2,245 | 2,339 | 2,352 |
| | Market Clearing Cost | 2,245 | 2,163 | 2,119 |
| | Redispatch Cost | - | 0,176 | 0,233 |
| [MWh] | Redispatch Potential | - | - | 586 |
| | Redispatch Energy | - | 2097 | 2494 |

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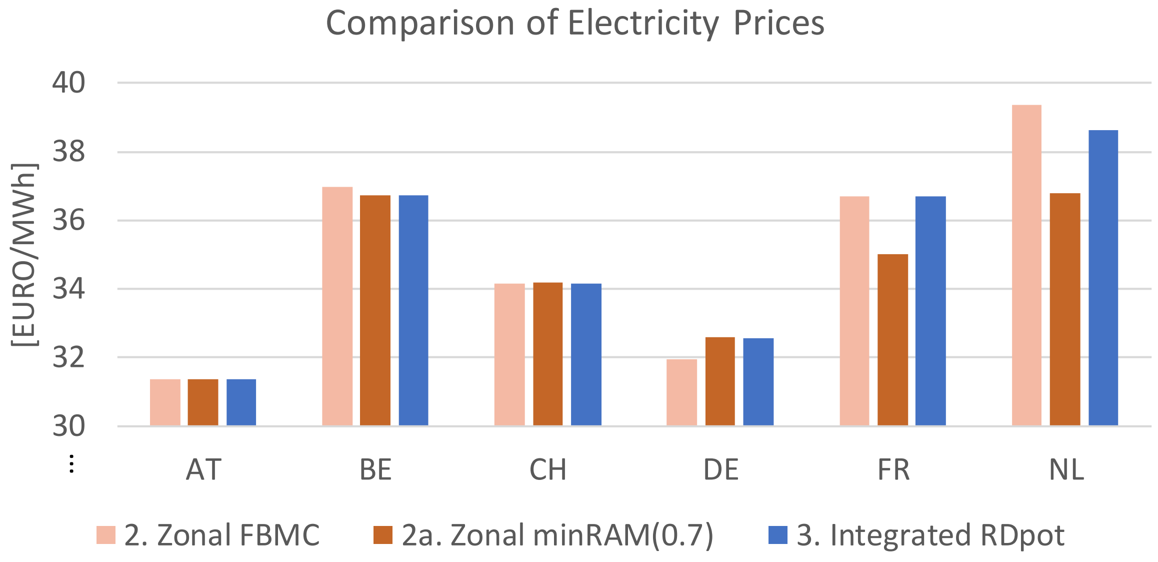
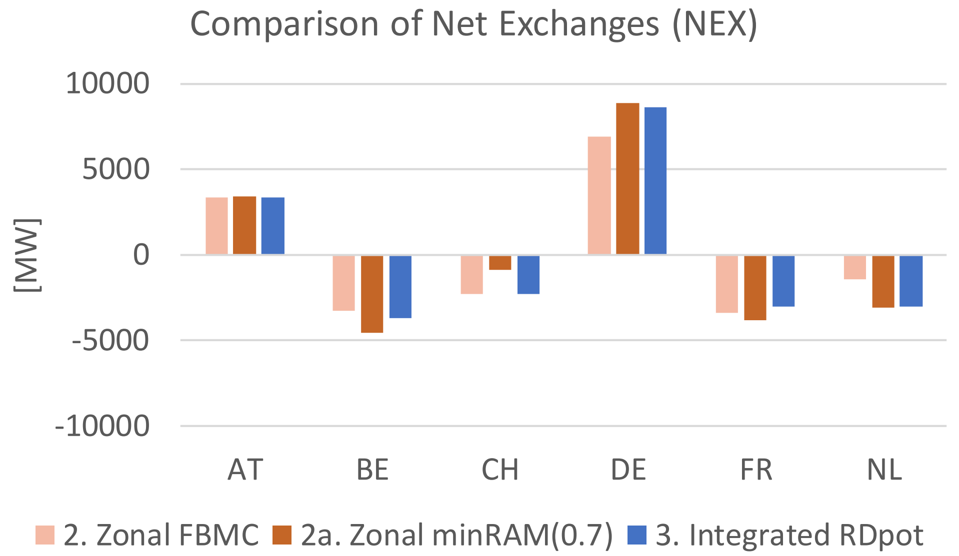
# Extension to zonal FBMC with 70% minRAM



Snapshot: 4 pm, 11th February 2020

- Impact on electricity prices and exchanges
  - Price convergence higher under minRAM
  - Comparable impact on net exports
  - But, zonal FBMC with minRAM less efficient than with integrated redispatch potential




- Impact on costs and redispatch amount

| | | Zonal FBMC | Zonal minRAM | Integrated RDpot |
|---|---|---|---|---|
| | Total Cost | 2,339 | 2,395 | 2,352 |
| [M€] | Market Clearing Cost | 2,163 | 2,147 | 2,119 |
| | Redispatch Cost | 0,176 | 0,249 | 0,233 |
| [MWh] | Redispatch Potential | - | - | 586 |
| | Redispatch Energy | 2097 | 2534 | 2494 |

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# Conclusion

- **Key issue**: commercial cross-border transaction constraints and exchanges are considered to be too low
- **Idea**: incorporate redispatch potential into the market clearing algorithm to increase commercial exchanges (when efficient)
- **Preliminary results**:
  - Integration of redispatch potential can increase cross-border exchanges and align zonal electricity prices (price convergence), but is associated with higher total cost
  - For zonal FBMC with minRAM there is a trade-off between efficiency and higher cross-border exchanges
- ➢ **Next steps**:
  - Extend analysis to a full year
  - Compute sensitivities regarding redispatch potential and penalties

# Thank you for your attention!

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