Commission de Régulation
de l'Electricité et du Gaz

FB, prices spikes, base case and adequacy patch

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Plan

- Introduction
- Belgian price spikes
- Impact of bidding zones delimitation in a FB environment
- Adequacy patch
- Conclusions

Disclaimer: this presentation only reflects current views of its author and does not necessarily represent the view of CREG

Introduction

- In this presentation,
  - Examine the reasons of the prices spikes observed the 22nd of September in Belgium
  - Make the link with the base case and the definition of bidding zones
  - Present the reasons for an adequacy patch linked to FB principles and bidding zones delimitation

Introduction

- FB congestion management is made in 2 steps in the CWE region
  - Determination of a **Base Case or BC**, (F0 in the CWE region), with zero cross-zonal commercial exchange* between CWE bidding zones
  - A flow based allocation of **remaining transmission capacities** applied on a **simplified model** of the transmission system made of bidding zones and of critical network elements called Critical Branches

* but with some commercial exchanges outside the CWE region and loop-flows, which are flows generated by exchanges inside a bidding zone

Introduction

- The **model** used in FB for the transmission system (bidding zone, CB) has a strong influence on its results
- FB introduces a radical change compared to NTC methods: TSOs behaviour and calculations have a **direct impact on market prices** through PTDFs

Introduction

Belgian price spikes

Impact of bidding zones delimitation in a FB environment

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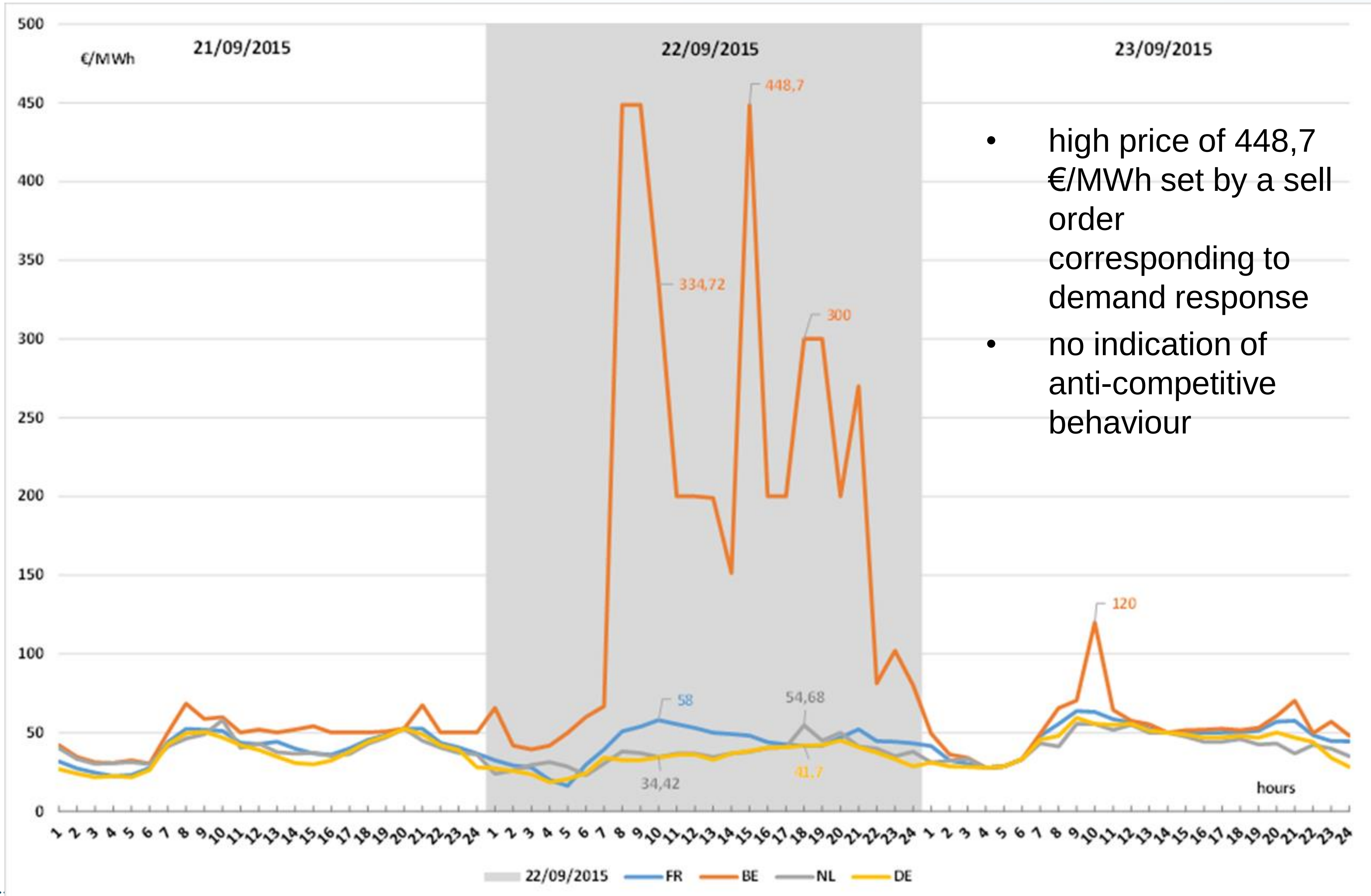
Conclusions

Belgian price spikes

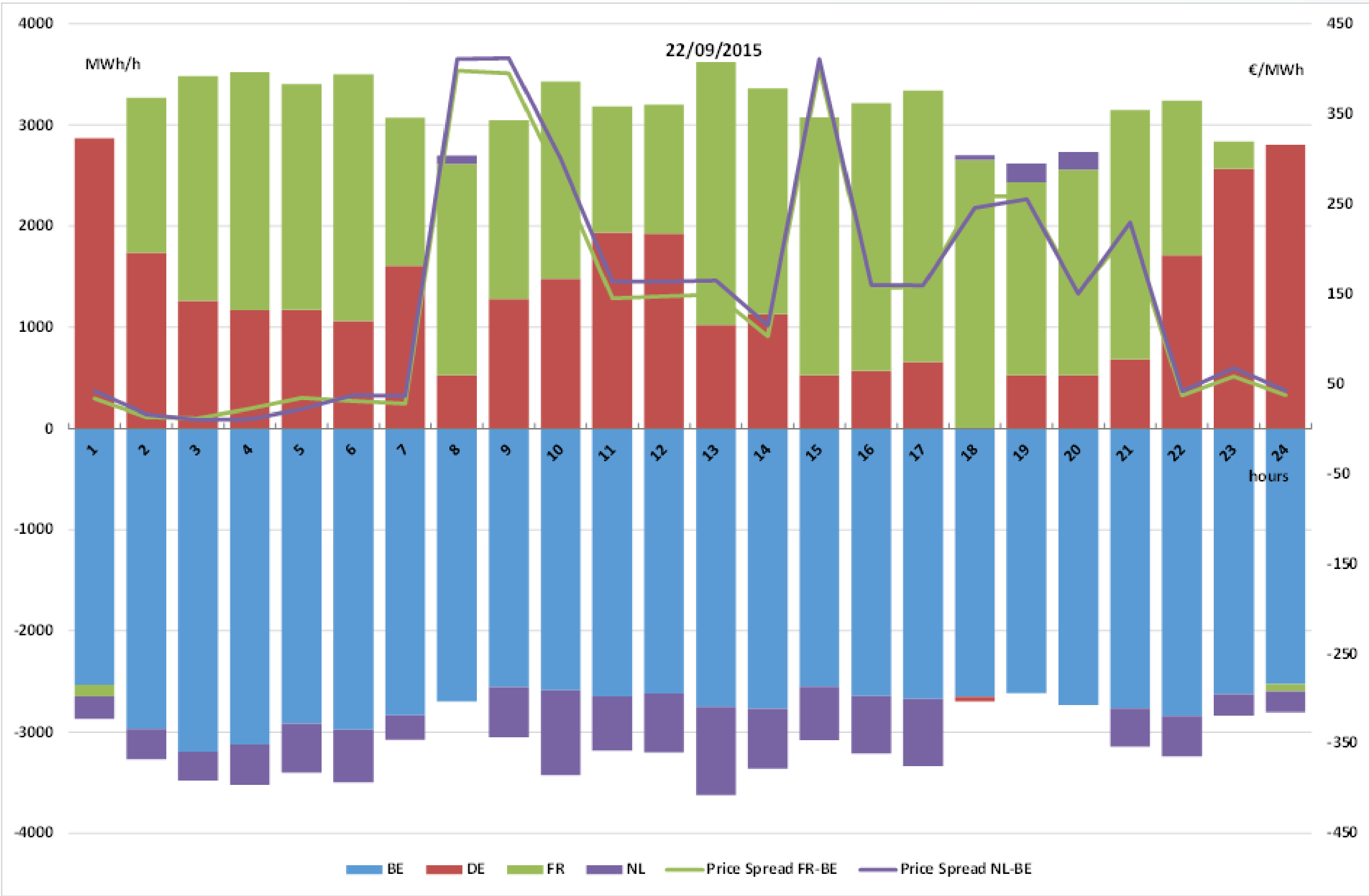
MC day-ahead price of 22nd of September 2015



- high price of 448,7 €/MWh set by a sell order corresponding to demand response
- no indication of anti-competitive behaviour

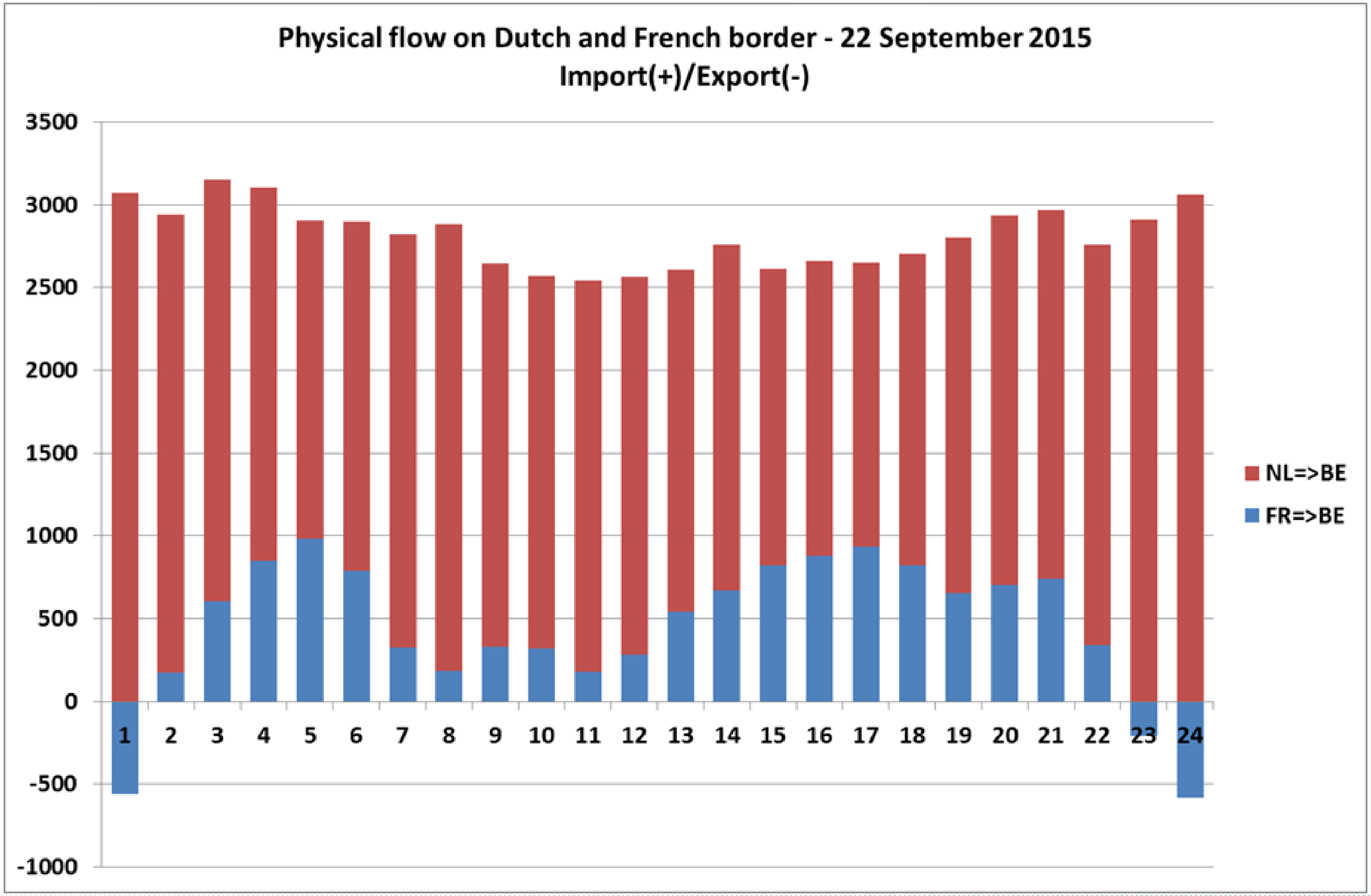
Belgian price spikes

Belgian commercial imports mostly from France: around 2600 MW

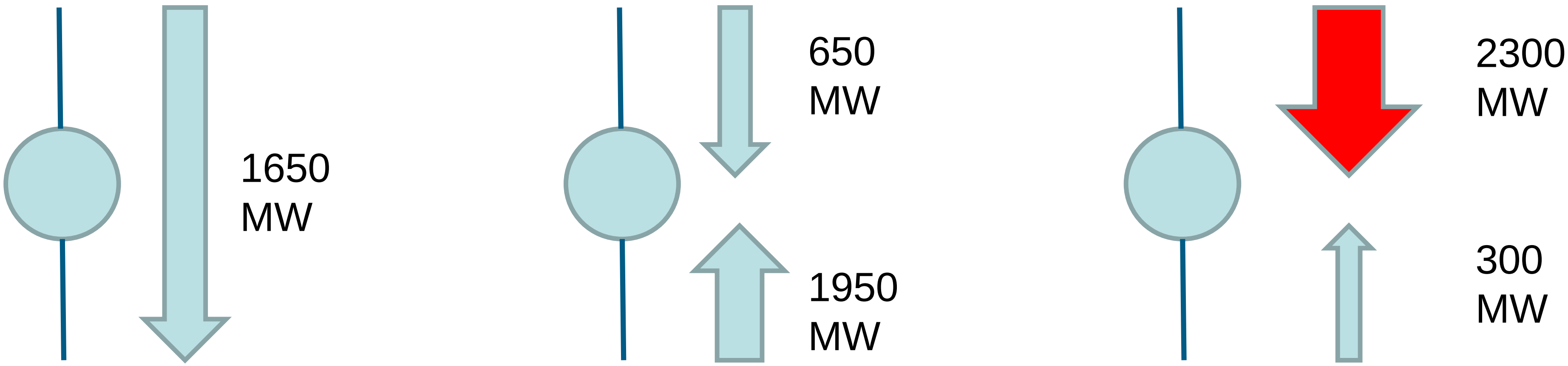


Belgian price spikes

Physical flow mostly from the Netherlands



Belgian price spikes: 22/9 9 am



- North to South loop flows included in the base case
- Reduced capacity of the Dutch-Belgian interconnection (1 PST out of service)

- Flows generated by Belgian imports of 2600 MW from France
- 0,75*2600=1950 on France Belgium interconnection
- 0,25*2600=650 on Netherlands Belgium interconnection

- Physical situation: sum of the flows
- Constrained interconnection: Nl=>B
- For imports coming from France!

Belgian price spikes: analysis

- Non-competitive flows (1650 MW; 72% of the total), of which largest part are loop flows, are the main reasons for the price-spike
- Loop flows = flows resulting from exchanges inside zones are **not managed** by the FB MC, but are in the **base case**
- Loop flows have de facto **priority access** to the transmission capacity on commercial flows between zones

CREG

Belgian price spikes: conclusions

- So even if Belgium is willing to pay 400 €/MWh more for power than other countries, Belgium can only use 28% of BE-Nl interconnexion capacity for importing power. The rest is used to “accommodate internal exchanges” (loop flows)
- Non-competitive flows cannot be out bidden, not even at 3000 €/MWh => risk for SoS (see adequacy patch below)
- Loop flows cause an inefficient and discriminatory use of scarce transmission capacity, non compliant with Regulation 714

CREG

Belgian price spikes: solutions

CREG proposes 5 solutions:

1. **Use PSTs** and internal re-dispatch internal to bidding zones to **limit non-competitive flows in the base case**.
2. More regulating power of PSTs to be used for the market coupling
3. Implement advanced hybrid flow-based market coupling
4. Question non-intuitiveness
5. **Adequate delineation of bidding zones: smaller zones => smaller loop flows & more competition**

CREG working paper:
http://www.creg.info/pdf/Divers/Z1476EN.pdf

Introduction

Belgian price spikes

Impact of bidding zones delimitation in a FB environment

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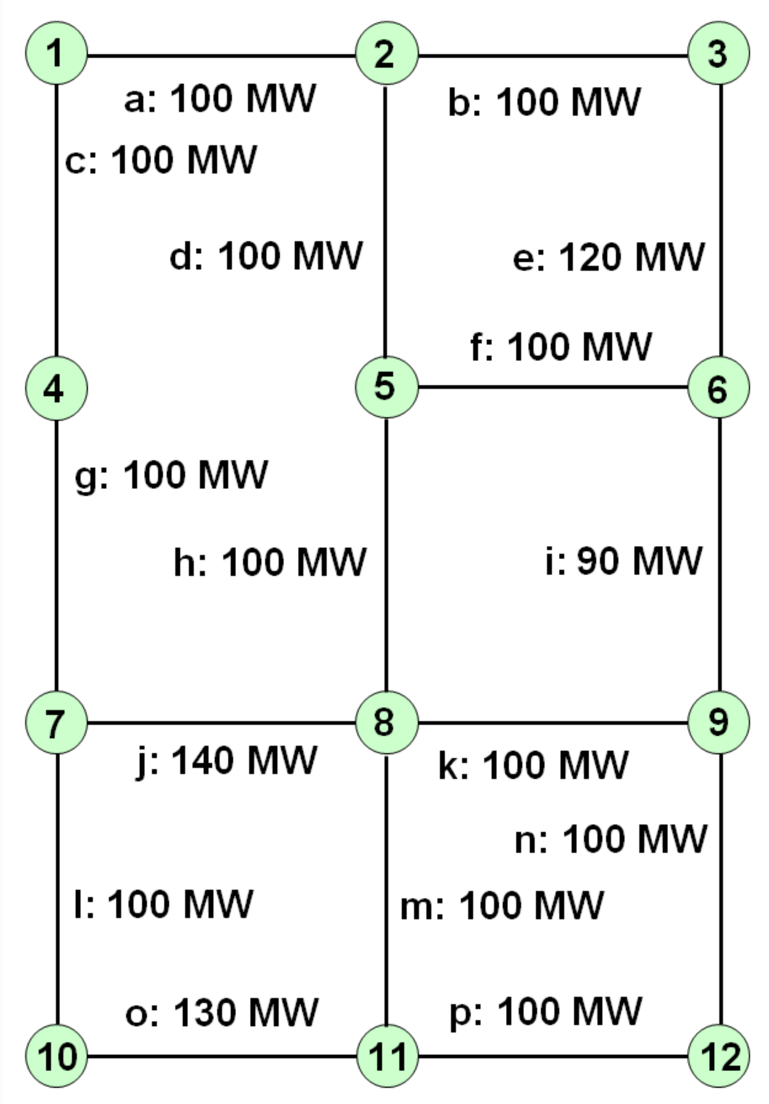
Impact bidding zones on FB & BC

- Show the link between bidding zones delimitation & the loading of the base case and on FB results
- A simplified example* is used to simulate the impact of bidding zone delimitation
  - on the loading of the base case
  - on the size of Flow Reliability Margins (FRM)
  - on the location of critical network elements CB
  - and on the efficiency of the flow-based welfare maximisation market coupling

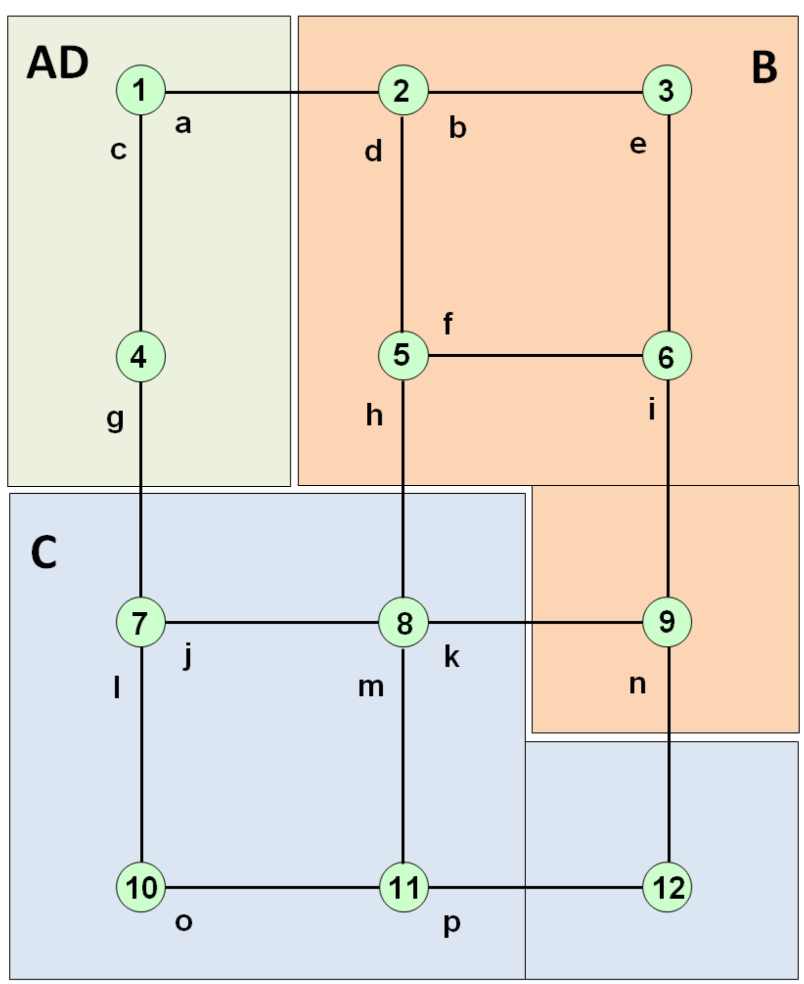
* "Importance of Design Parameters on Flowbased Market Coupling Implementation" Alain Marien, Patrick Luickx, Andreas Tirez and Dominique Woitrin, Technical operation of the markets, Commissie voor de Regulering van de Elektriciteit en het Gas (CREG), presented at EEM13 in Stockholm

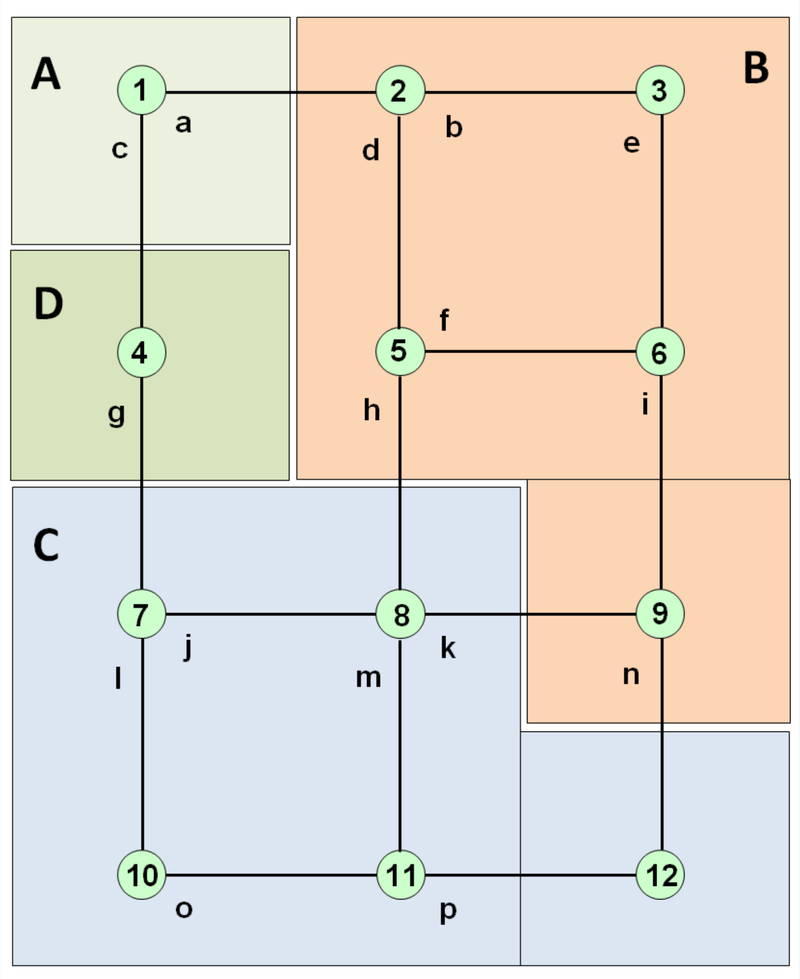
Simplified example: topology

- 12 nodes
  - Labeled with numbers 1,..12
  - Inject or Sell: G MW for €
  - Take or Buy: D MW for €
- 16 lines
  - Letters a,b,c,…p
  - Same resistance
  - Capacity: from 90 to 140 MW: see fig
- 4 countries
  - A, B, C & D (see below)
- 3, 4, 6 & 12 zones modelled



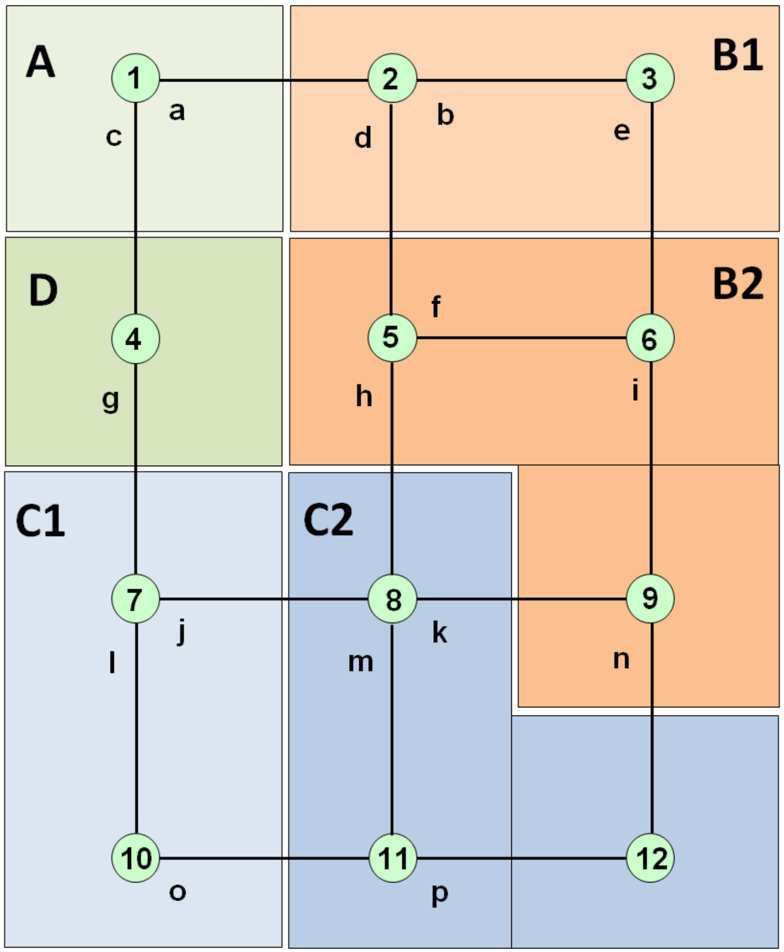
Simplified example: scenario 3 & 4 zones

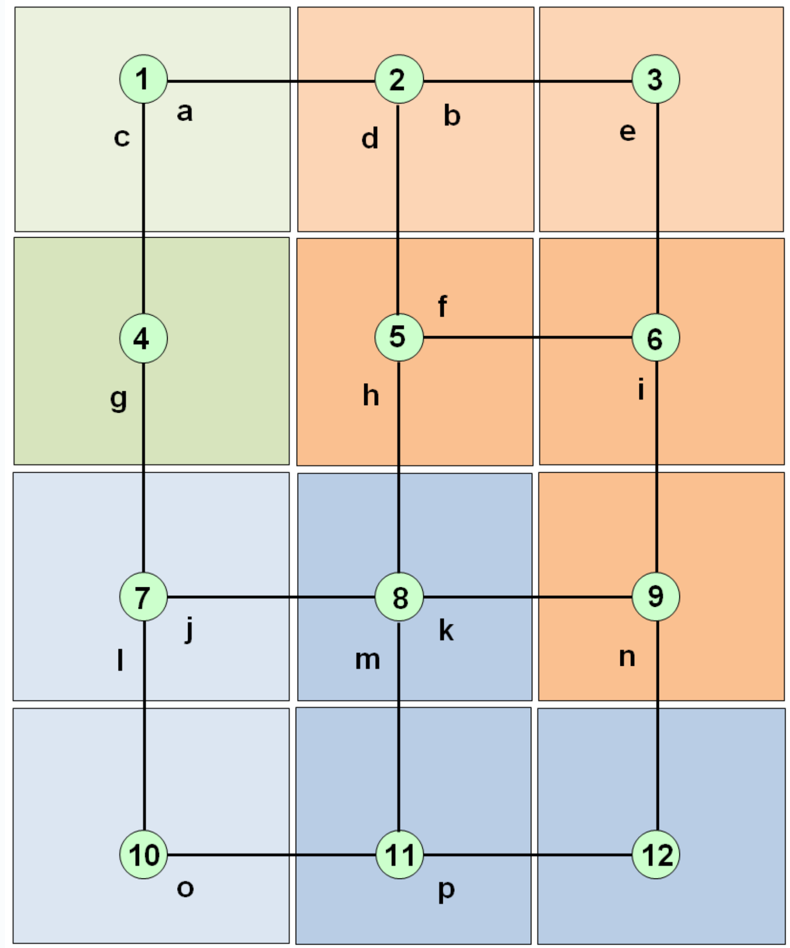




- Zonal division: 3 large zones (merge countries A & D); 4 zones=countries

Simplified example: scenario 6 & 12 zones





- Zonal division: 6 zones: split of large country into 2 zones and 12 small zones

Simplified example: data

Node	Snapshot		Maximum		Price	
	G MWh	D MWh	G MWh	D MWh	G €	D €
1	60	90	78	117	50	100
2	160	60	208	78	50	100
3	160	60	208	78	50	100
4	90	60	117	78	50	100
5	110	130	143	169	50	100
6	110	120	143	156	50	100
7	60	200	78	260	50	100
8	160	80	208	104	50	100
9	60	130	78	169	50	100
10	60	180	78	234	50	100
11	160	60	208	78	50	100
12	60	80	78	104	50	100
Total country B	600	500	780	650		
Total country C	500	600	650	780		
Total	1250	1250	1625	1625		

- Maximum:
  - Maximum volume of offers (G) and bids (D) available at a node

Base Case (BC) construction

- Starting point:
  - A **snapshot** of recent system conditions
  - That includes the necessary adaptations to expected D+2 generation, demand and network situations
- **Principles for the construction of the base cases in this model** (does not necessarily correspond to CWE practices) **:**
  - **BC includes exchanges internal to a zone = min (G,D) with G= generation and D=demand;**
  - **G or D at nodes are reduced proportionally to reach that minimum**
  - **What is left is proposed to the MC**
  - Trade is organised locally (inside a country, zone) first, and what is left (missing), generation or demand is offered to the market-coupling

BC construction: 4 zones

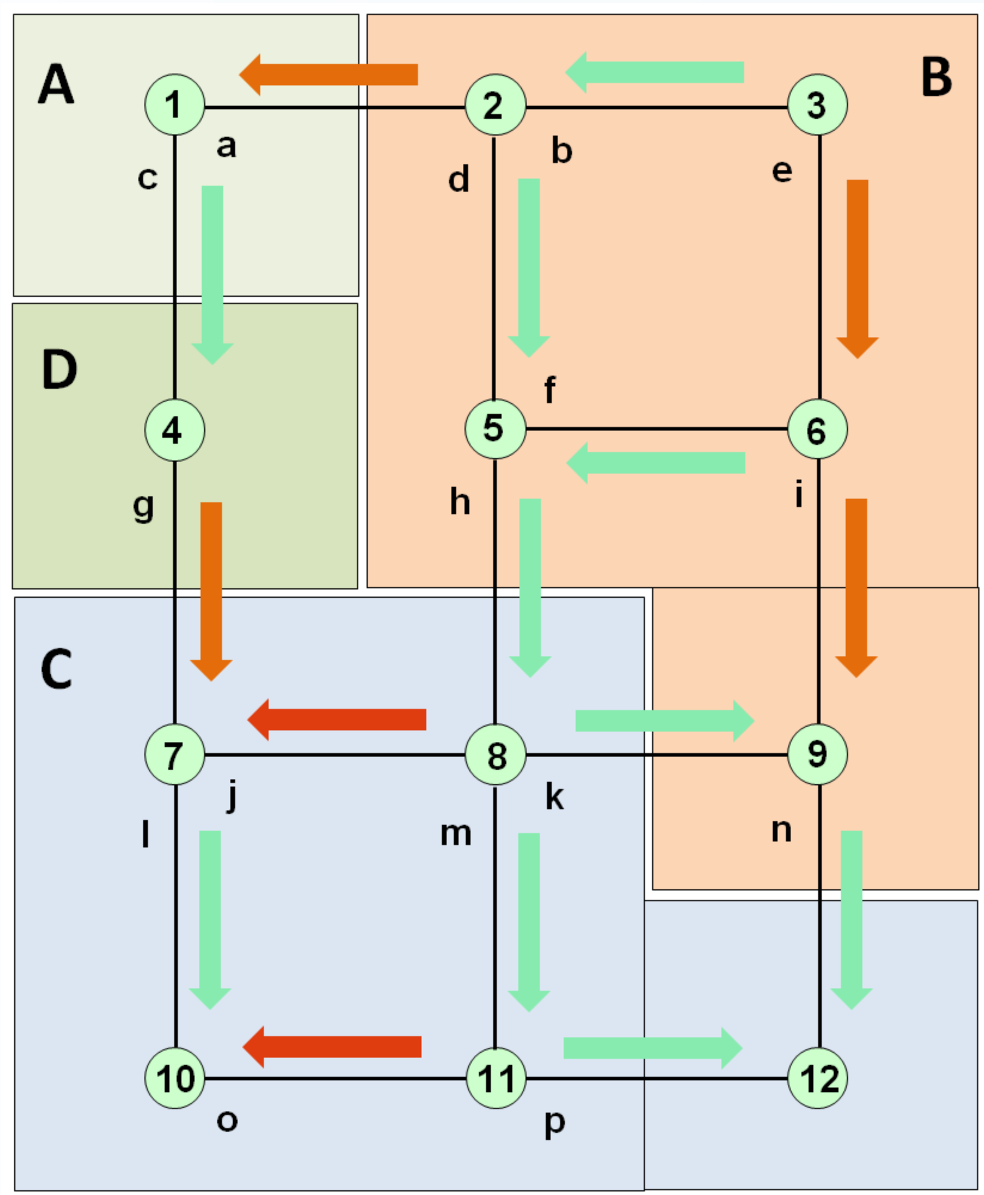
- Generation: 2, 3, 4, 8, 9
- Demand: 1, 5, 6, 7, 10

60
90

90
60

G: 600
D: 500

500
600



Use of the transmission network:

- ≤ 60%
- 60%≤ Use ≤ 80%
- ≥80%; < 100%

BC construction: results

[MWh]	Snapshot		BC 3 zones		BC 4 zones		BC 6 zones		BC 12 zones	
Node	G	D	G	D	G	D	G	D	G	D
1	60	90	60	90	60	60	60	60	60	60
2	160	60	133	60	133	60	60	60	60	60
3	160	60	133	60	133	60	60	60	60	60
4	90	60	90	60	60	60	60	60	60	60
5	110	130	92	130	92	130	110	96	110	110
6	110	120	92	120	92	120	110	88	110	110
7	60	200	60	167	60	167	60	63	60	60
8	160	80	160	67	160	67	93	80	80	80
9	60	130	50	130	50	130	60	96	60	60
10	60	180	60	150	60	150	60	57	60	60
11	160	60	160	50	160	50	93	60	60	60
12	60	80	60	67	60	67	35	80	60	60
Total country B	600	500	500	500	500	500	400	400	400	400
Total country C	500	600	500	500	500	500	340	340	320	320
Total	1250	1250	1150	1150	1120	1120	860	860	840	840

- With the increase in the number of zones:
  - Reduction of the volume of exchanges in the base case
  - Reduction of the risk of pre-congested cases

Flows in the BC

- More zones…
- Less exchanges in the base case: total volume decreases from 1150 MWh => 1120 => 860 => 840 for configurations with 3, 4, 6 and 12 bidding zones respectively
- Computations show less electrical flows in the base case when the number of zones increase: on average, 100% => 104% => 24% => 0% (in a nodal system, if all nodes are balanced, there is no physical flows)
- Location of (most) loaded transmission line vary in function the number of bidding zones

FRM

- Lines capacities offered to the FB MC are reduced (in both direction) by the Flow Reliability Margins (FRM) compared to real time security limits
- FRM taken by TSOs to secure the allocation process have two origins:
  - The absence of adequate locational information on market players bids,
  - The events occurring in the market between capacity calculation and real time (line tripping, power plant outage, wind fluctuation, demand uncertainty,…)
- So we may have “artificial” congestions: the FB MC may limit trade when there is no “physical” real time congestion; an example of this is the “pre-congested case” issue

FRM

- A model* has been developed for the determination of the part linked to the locational uncertainty of these FRM for this simplified example
- The smaller the bidding zone, the lower the locational uncertainty, the lower the FRM
- FRM are equal to zero with a nodal representation of the system
- FRM are a direct consequence of the model of the transmission system used for the FB allocation process

*Same reference as in slide 14

FRM: results (MW)

Line	3 Zones	4 Zones	6 Zones	12 Zones	Average	Ranking
a	22,8	19,7	6,6	0,0	12,3	15
b	44,1	43,1	10,4	0,0	24,4	9
c	31,7	19,7	6,6	0,0	14,5	14
d	42,6	40,6	8,5	0,0	22,9	12
e	44,3	43,2	11,4	0,0	24,7	6
f	37,9	37,8	25,8	0,0	25,3	5
g	22,7	19,7	4,5	0,0	11,7	16
h	33,7	31,8	18,9	0,0	21,1	13
i	48,0	46,8	26,8	0,0	30,4	2
j	43,4	41,3	7,2	0,0	23,0	11
k	41,8	41,2	24,3	0,0	26,8	3
l	45,0	44,1	9,8	0,0	24,7	7
m	37,4	37,0	29,1	0,0	25,9	4
n	36,3	35,8	20,9	0,0	23,3	10
o	45,0	44,1	9,4	0,0	24,6	8
p	47,5	47,0	27,4	0,0	30,5	1
Average	39,0	37,1	15,5	0,0		

- Lines located inside a zone require higher FRM than cross zonal lines
- Uncertainty decreases with the number of zones

Welfare maximisation

- A socio-economic welfare maximisation under FB constraints is applied on this simplified example in order to perform a Flow Based allocation:
- Configurations with 3, 4, 6 & 12 bidding zones are examined
- One hour only, no block bids
- All lines are critical branches and explicitly monitored in the system – 16 linear constraints
- N-1 situations not taken into account: network loading are only indicative
- No losses
- Given current data (same price for all generators and same price for demand), the current optimisation corresponds to a maximisation of the volumes of Generation & Demand

Results

	Generation (offers) MWh			Demand (bids) MWh			Welfare €			Use %
	G BC	G MC	G Total	D BC	D MC	D Total	Welfare BC	Welfare MC	Total Welfare	Transmission Network
3 Zones	1150	229	**1379**	1150	229	**1379**	57500	11433	**68933**	33,05%
4 Zones	1120	264	**1384**	1120	264	**1384**	56000	13192	**69192**	33,60%
6 Zones	860	717	**1577**	860	717	**1577**	43000	35868	**78868**	43,09%
12 Zones	840	785	**1625**	840	785	**1625**	42000	39250	**81250**	52,11%

- Scenarios with 3, 4 & 6 zones are congested, scenario 12 zones not congested
- Total welfare increase with the number of zones, even if the welfare contained in the BC is reduced
- Global liquidity also increases: more exchanges are managed by the MC
- The use of the transmission network increase with zone #: less congestions, more competition

Results

- Observed welfare increase with the number of bidding zones is linked to (in this simplified example and model):
  - The reduction of the FRM
  - The increase in the number of “control variable” (zones) in an (welfare) maximisation process
- BC decisions cannot be undone in the FB allocation stage (FRM,…)

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Adequacy patch

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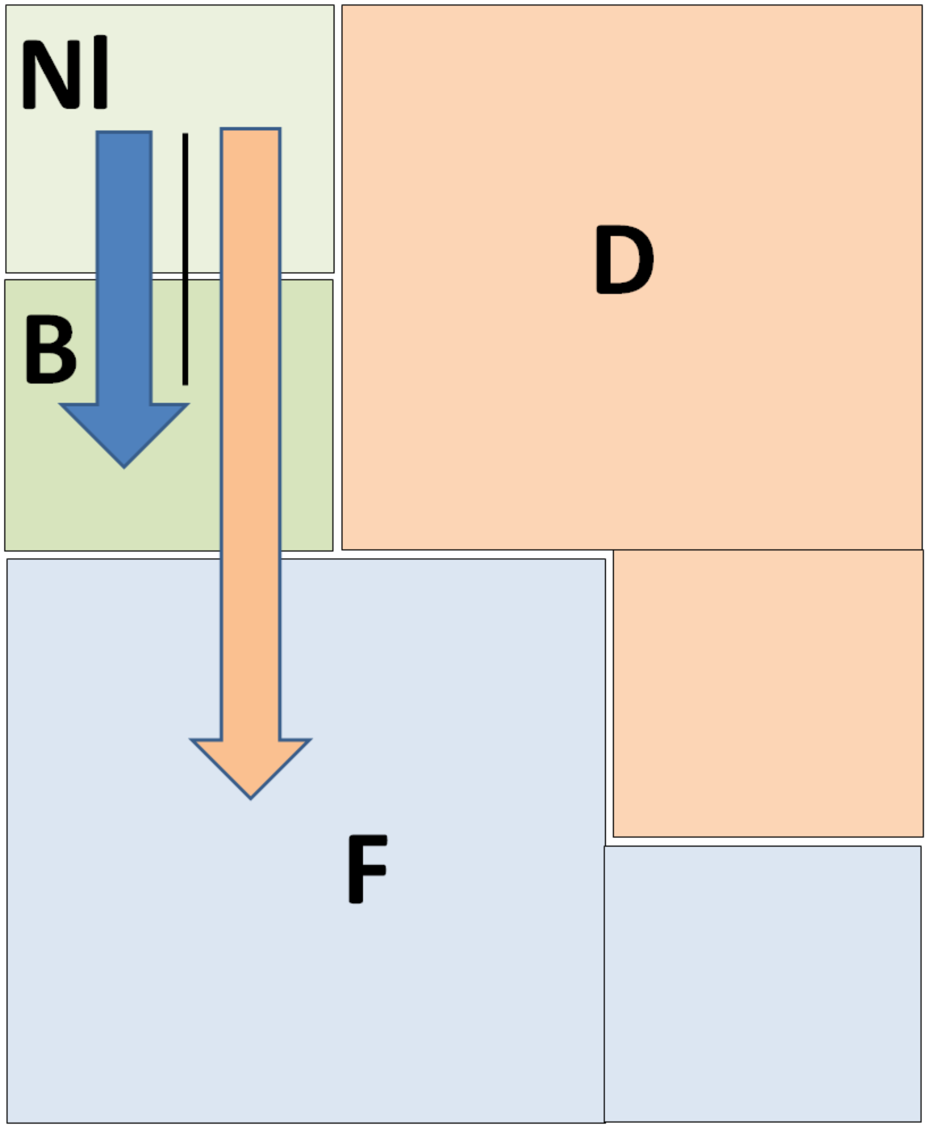
Adequacy patch

- Main goal is to avoid curtailment at 3000€ in importing countries that may endanger security of supply
- An adequacy patch is currently being implemented in the Euphemia algorithm
- Reasons are related to flow based principles, and the mix of small and large bidding zones
- FB MC provides more transmission capacities on average…but, to the contrary with NTC allocation, there is a non zero probability that imports capacities are equal to zero even if you pay 3000€…

Security of Supply & FB

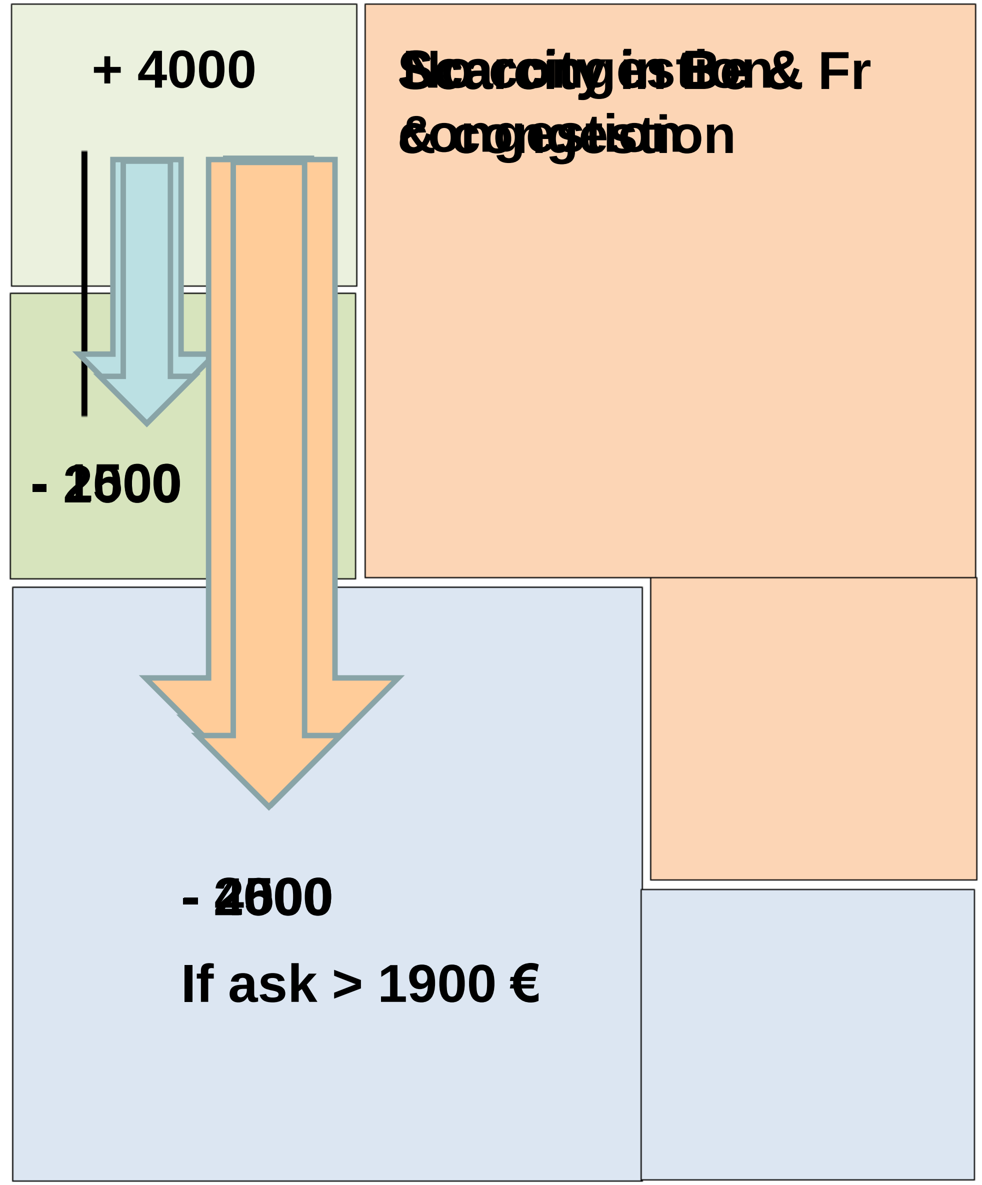
- Focus on:
  - Generation shortage in Belgium,
  - France faces a cold wave
  - The Netherlands has export capabilities
  - Netherlands Belgium interconnection nearly congested (ex. loop flows)
- Prices vs PTDF relation:

$$\frac{P(F)-P(Nl)}{PTDF_{Nl=>F\,onCB}}=\frac{P(B)-P(Nl)}{PTDF_{Nl=>B\,onCB}}$$



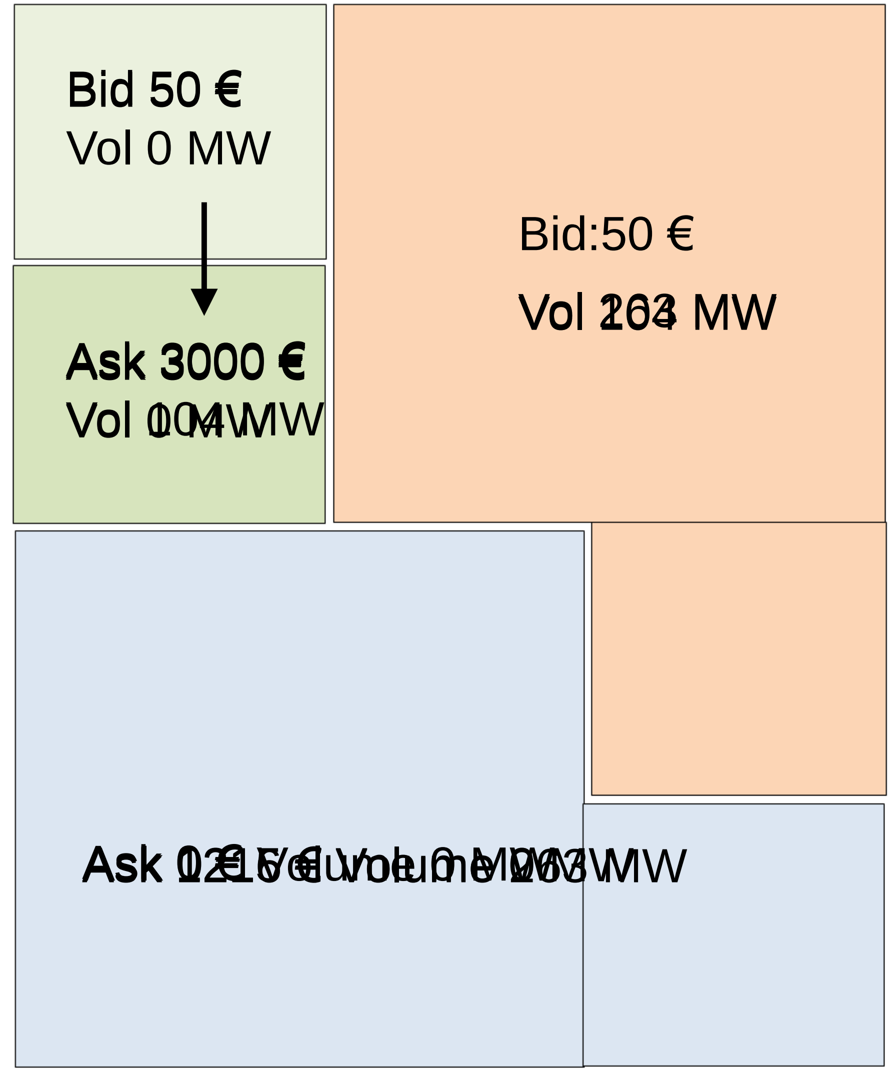
Security of supply & FB

- Typical PTDFs Nl-B/Nl-F ratio for a congestion on the Nl-B : 1,6
- So, if French market players bid above a threshold of 1900 €,
- As Belgian market players cannot offer more than 3000€,
- Requests for imports for France will have full priority on **imports** for Belgium which may be **equal to zero**!
- This will be valid for all French market players, **independently of their location in France**, and for the total demand asked above 1900€
- For a congestion that has nothing to do with the weakness of the transmission system



Impact of locational information

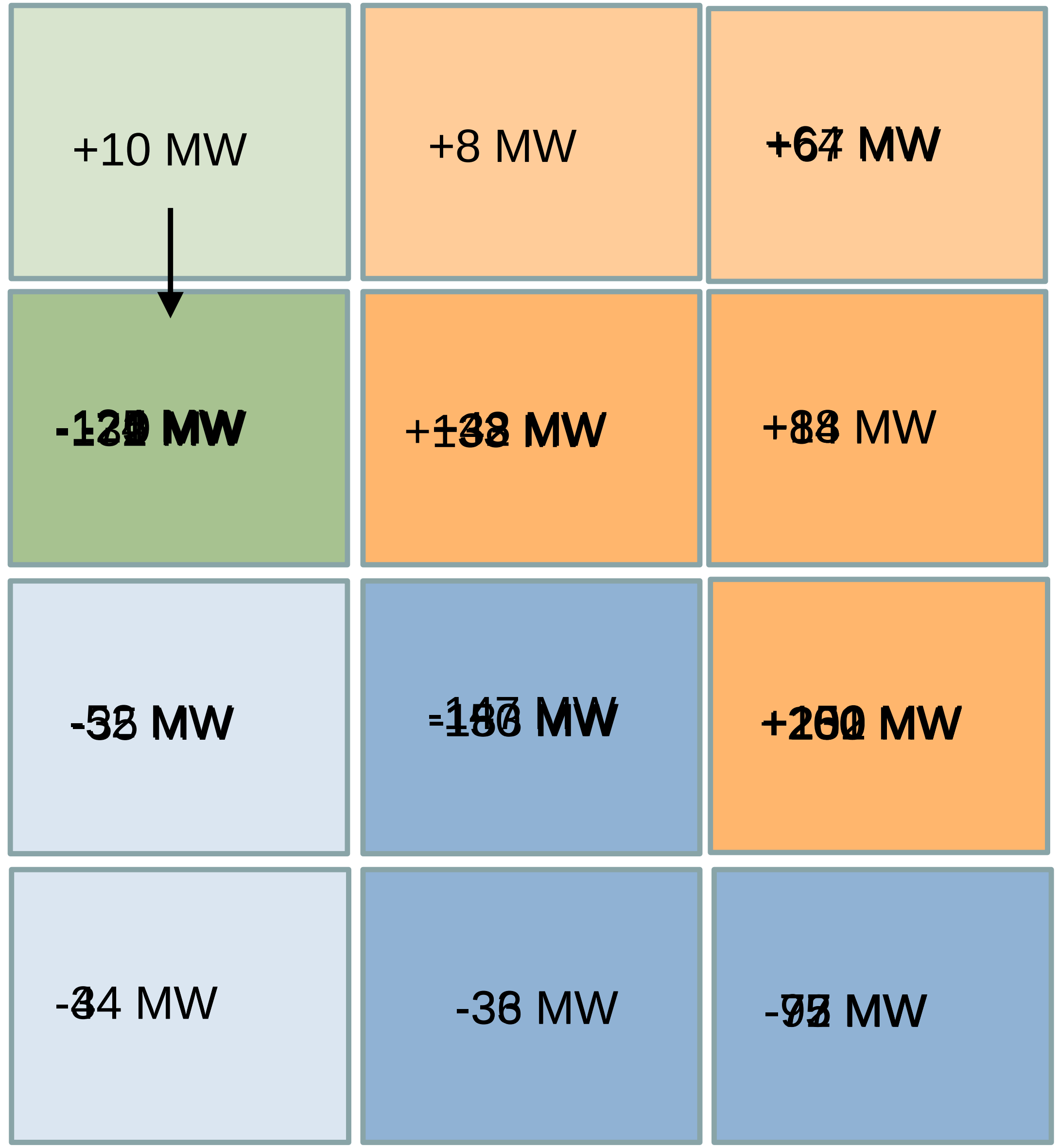
- Simplified model 4 zones = country
- B and F competing for energy in scarcity conditions from Nl and D at 50€
- Congestion XB B-Nl
- FB animation increases ask price in F against 3000 € in B:
  - No generation activated in Nl, as PTDF on the congested network element is too high compared to exports from D
  - At a level above 1216 € (see formula slide), all generation from D is going to F



- “All or nothing” behaviour

Impact of locational information

- Same situation, but better locational information
- Equal generation bids price in D and Nl: 50€
- Equal ask price in F
- FB animation increases F ask price: [illegible] against 3000 € in B
- Generation in Nl above 3000€
- More volume: [illegible]
- Even at 3000€ in F, still import for B
- Gradual B imports reduction in function of network characteristics



Impact of locational information

More accurate locational information (smaller bidding zones):

- Reduces the all or nothing behaviour: still import possibilities for countries bidding at 3000€

- Increases volumes in all areas leading to more competition

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Conclusions

- Base case has played a determinant role in the price spikes observed in Belgium
- Adequate bidding zones delimitation even more important in a FB context than in NTC
- Adequacy patch is a direct consequence of the application of FB principles on bidding zones of very different size
- FB increases transparency on capacity calculation and allocation

Thank you for your attention

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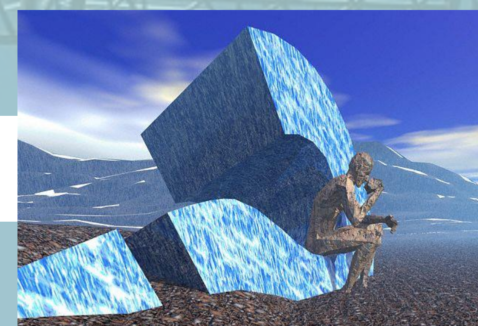
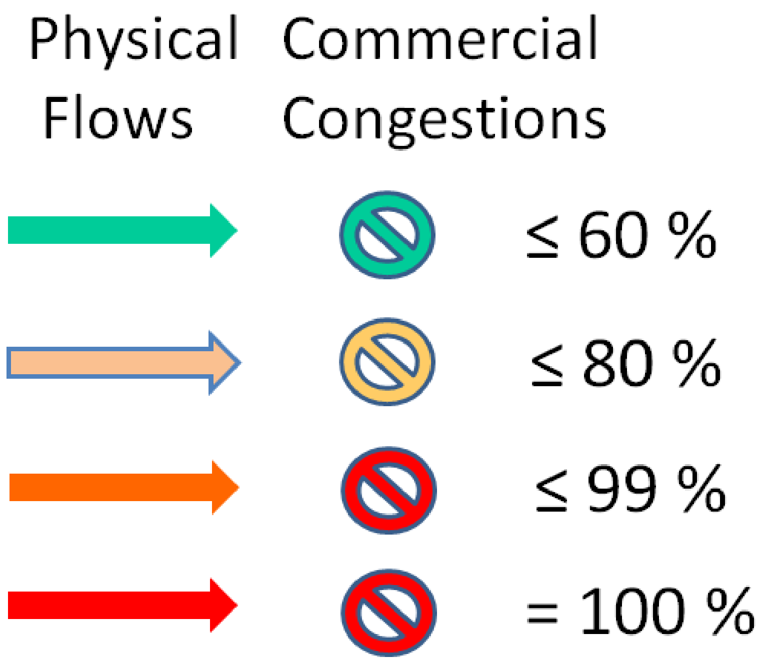


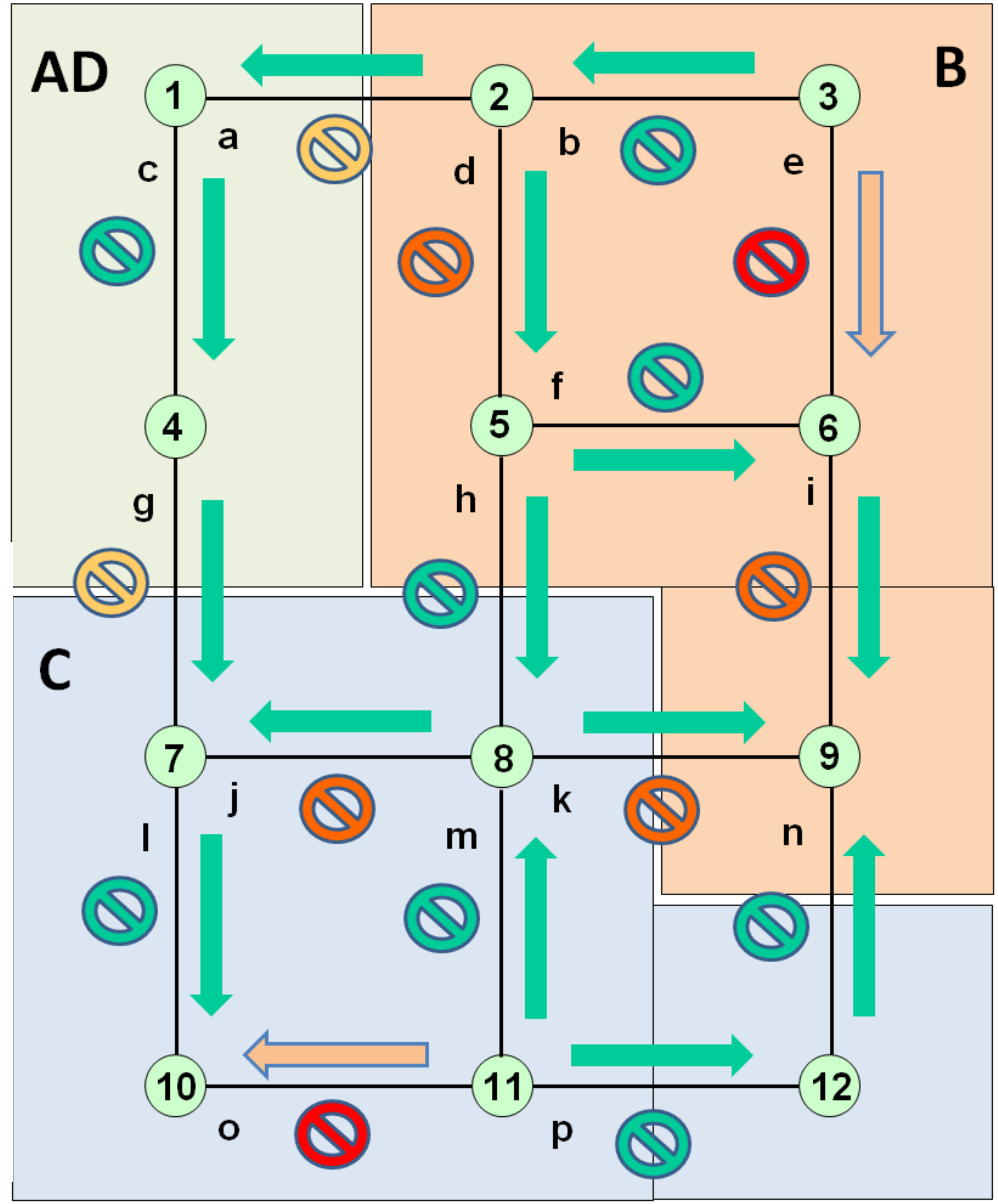
Physical flows vs. Commercial congestions

- Following slides show:
  - for the different zones delimitation:
    - the total flows resulting from the capacity calculation & allocation process
    - the commercial congestions
  - that larger zones increases the number and the frequency of “artificial” commercial congestions

3 zones

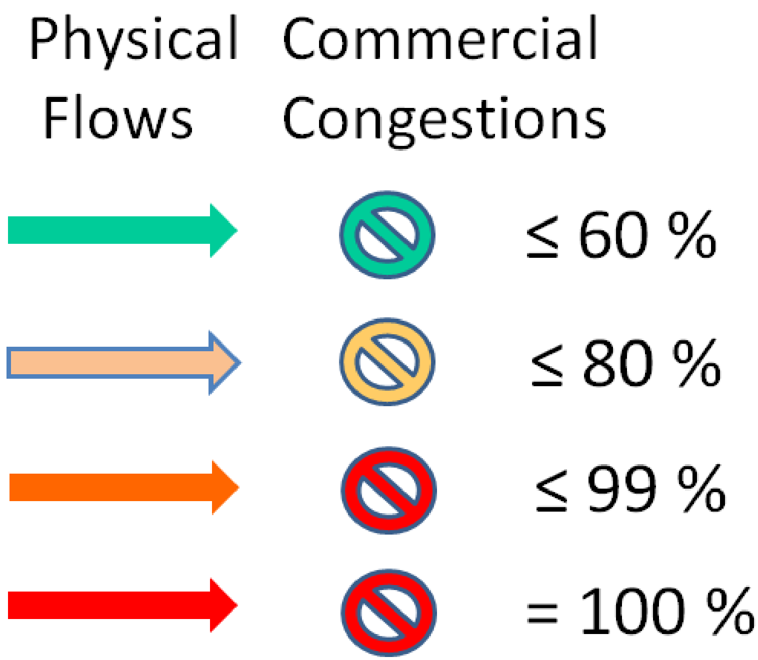
- Low physical loading of the transmission system
- High level of artificial commercial congestions

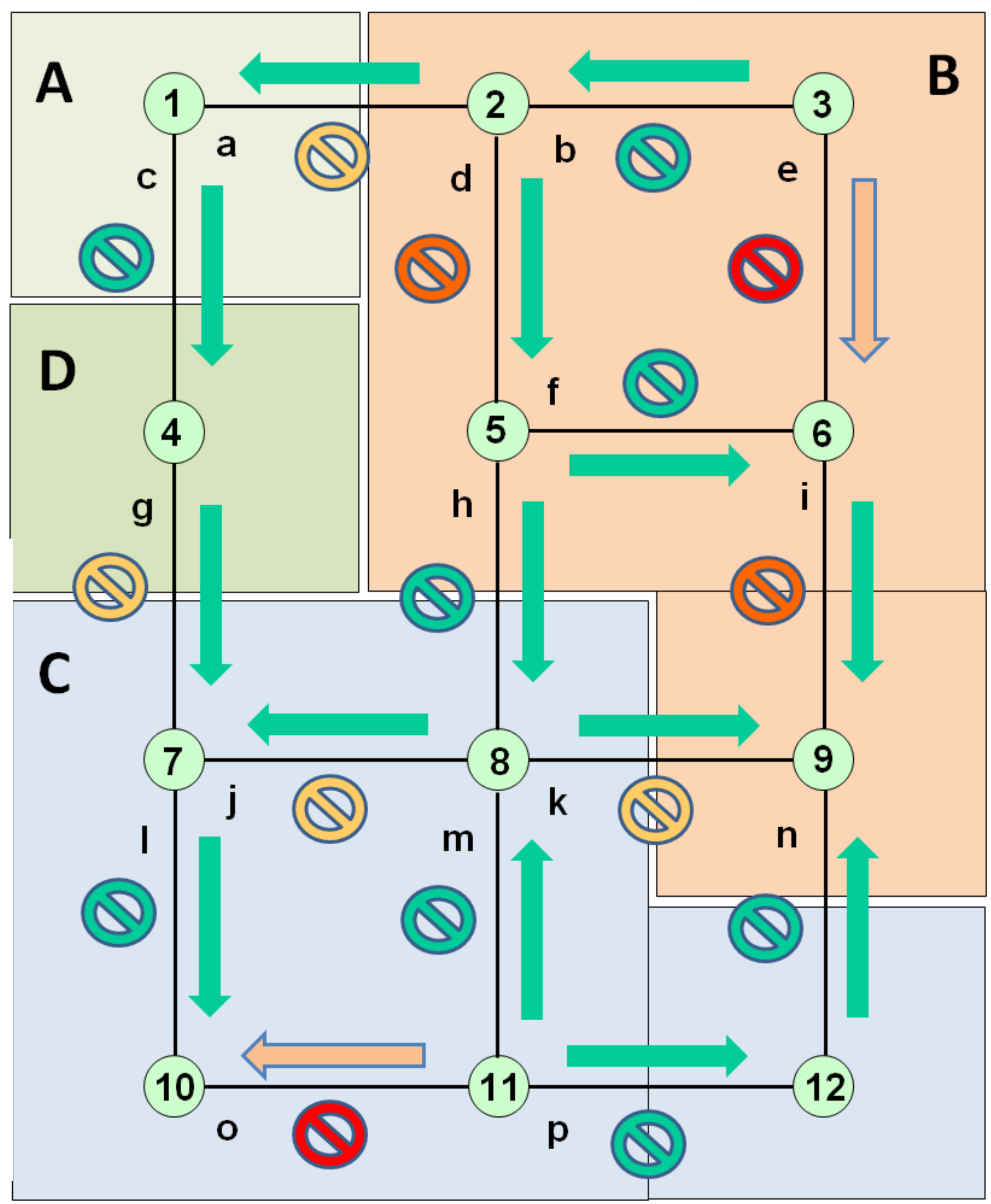




4 zones

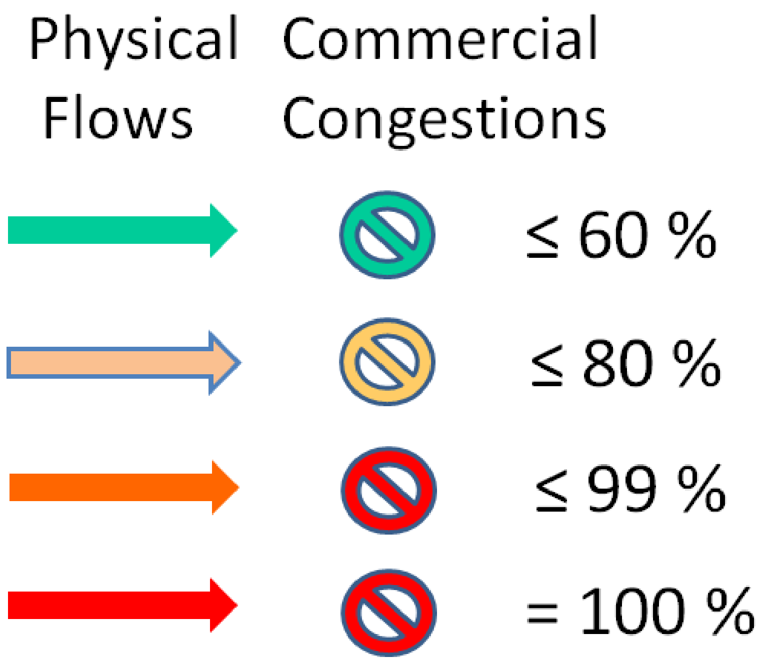
- Low physical loading of the transmission system
- High level of artificial commercial congestions

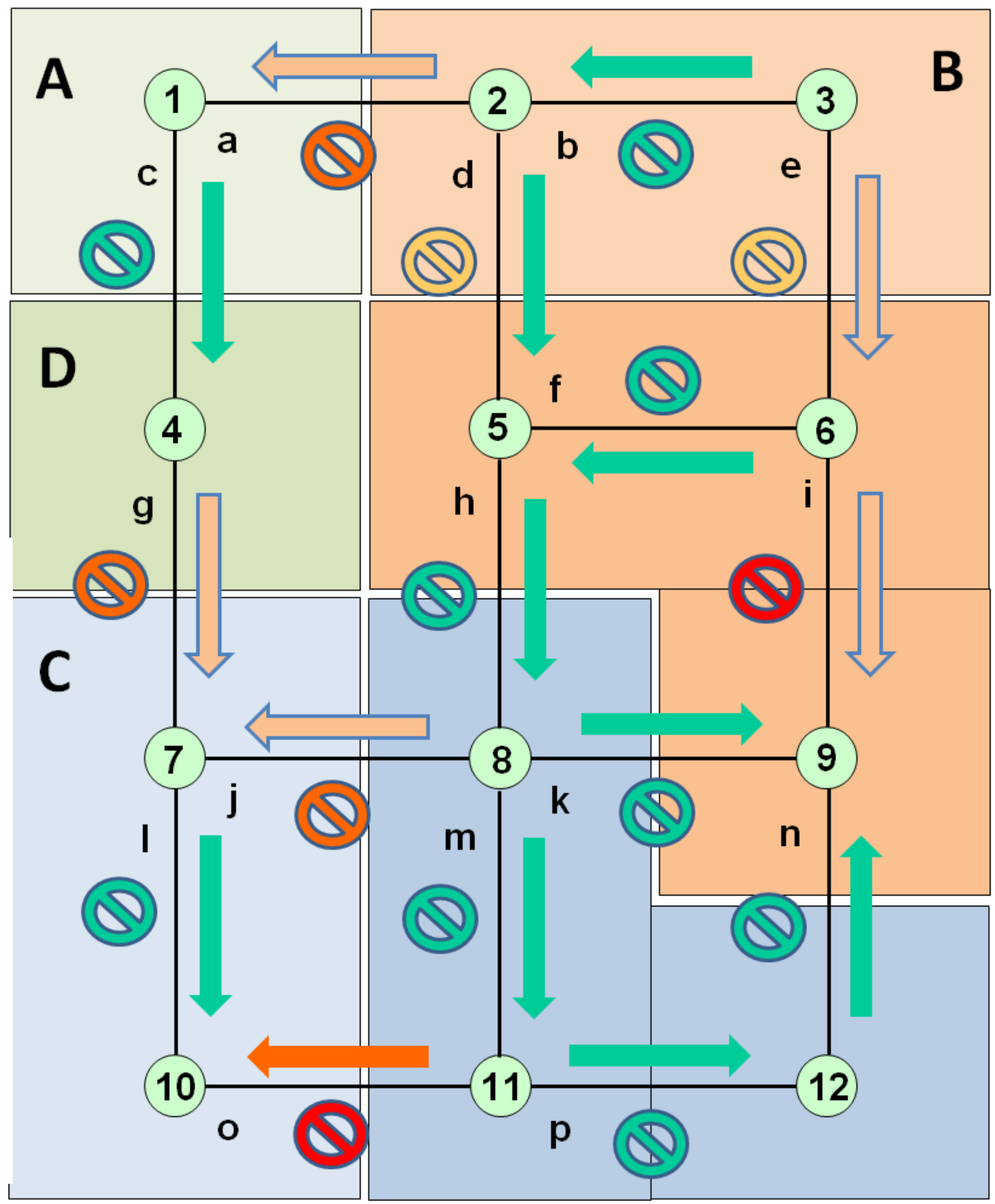




6 zones

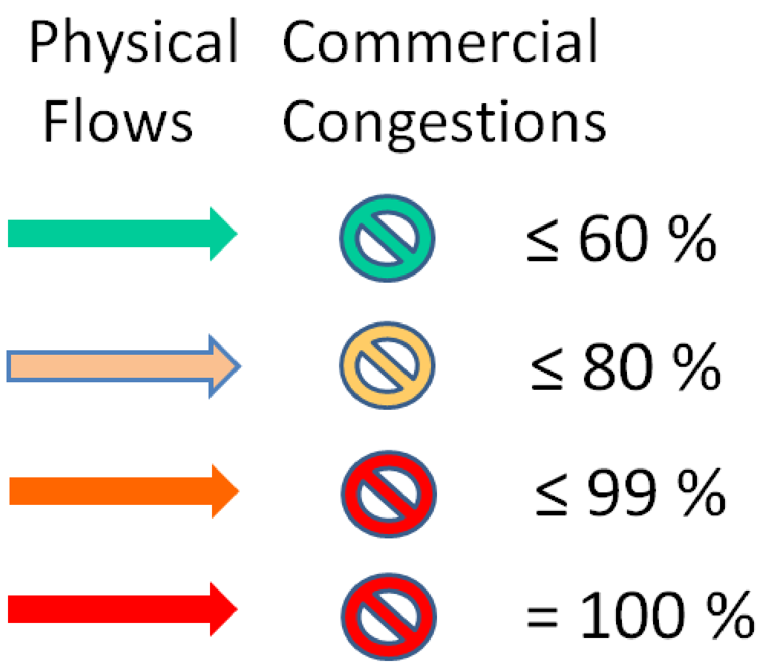
- Increase of the physical loading of the transmission system
- Reduced artificial commercial congestions

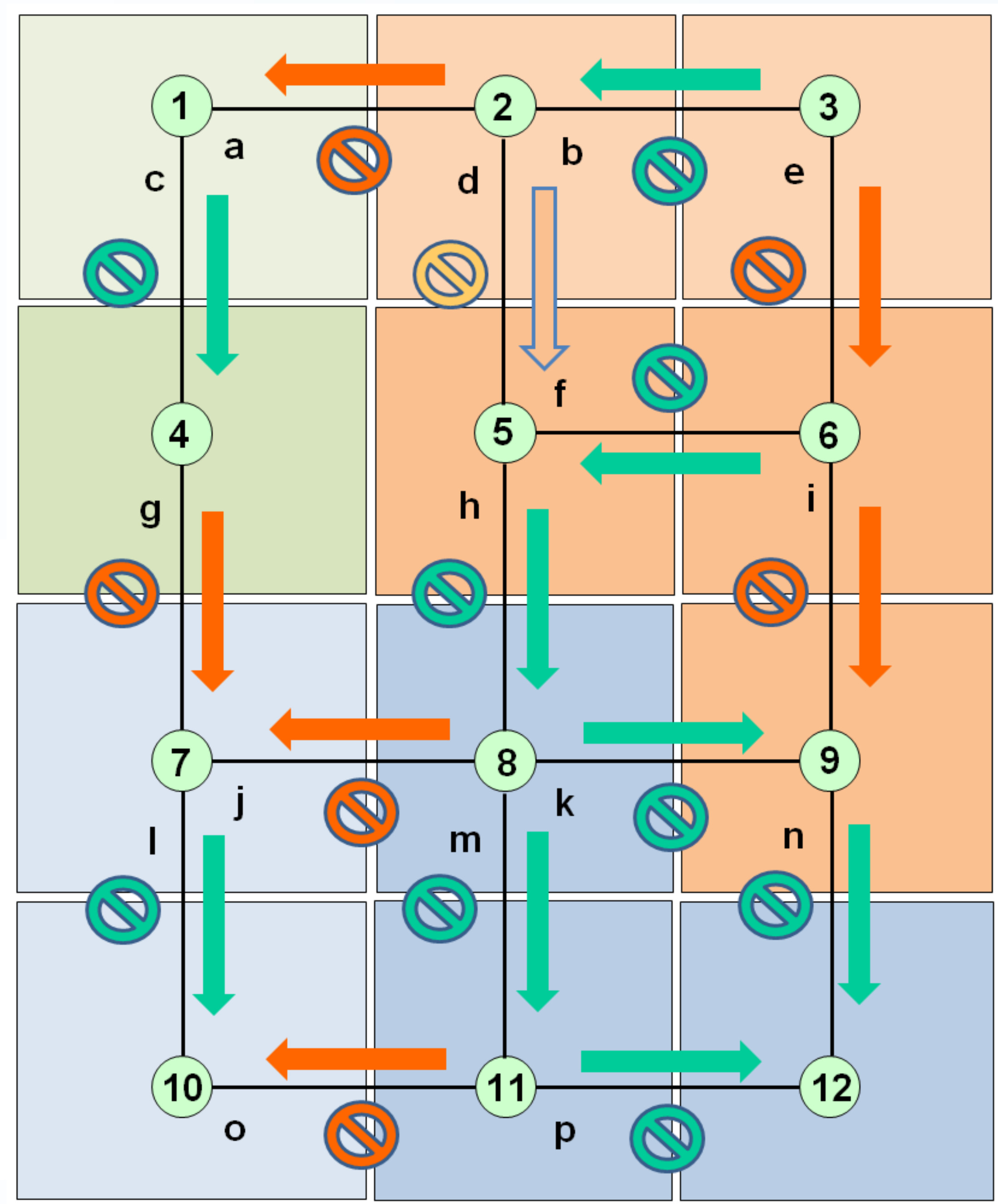


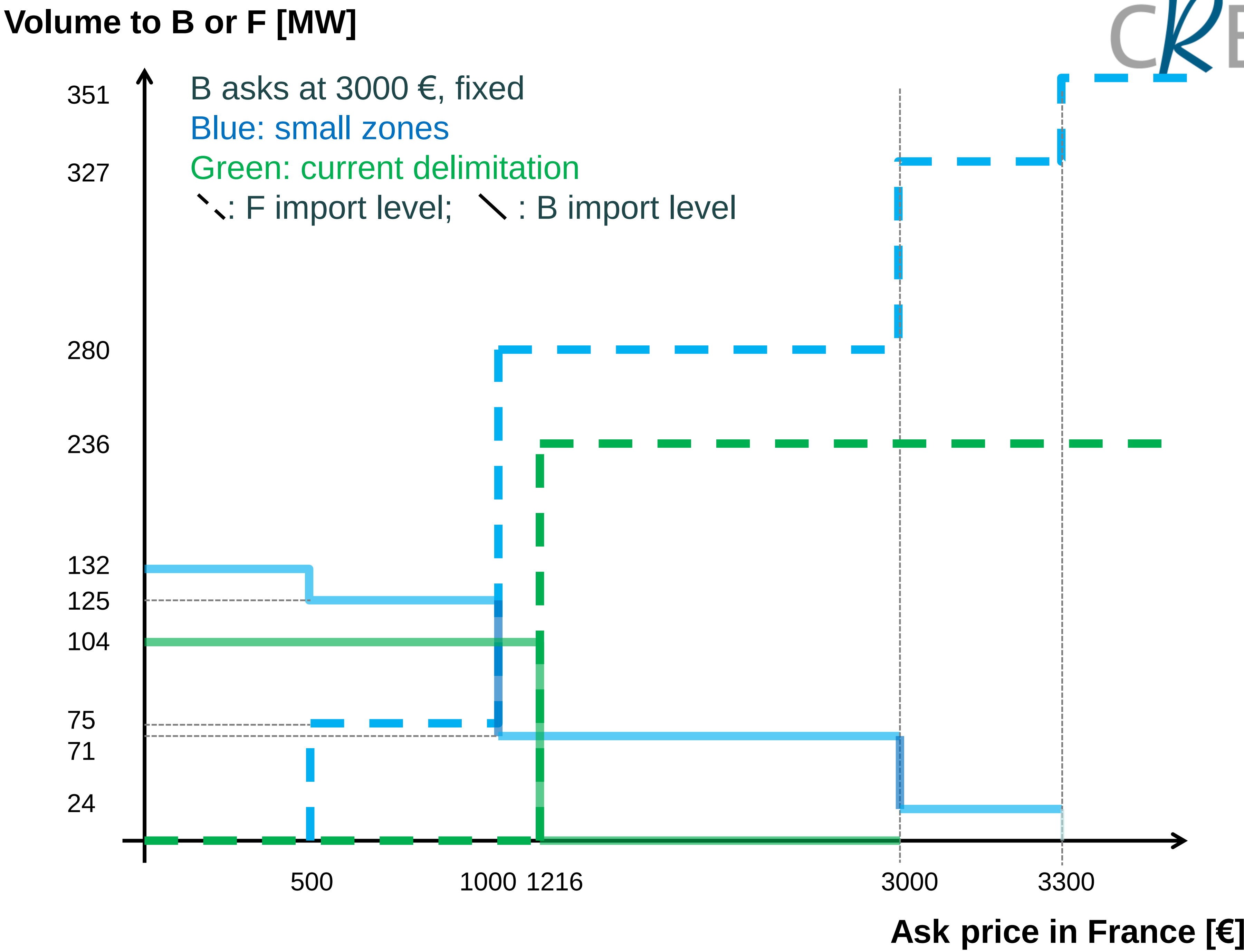


12 zones

- Maximum physical loading of the transmission system
- No artificial commercial congestions






Volume to B or F [MW]
B asks at 3000 €, fixed
Blue: small zones
Green: current delimitation
: F import level; : B import level
351
327
280
236
132
125
104
75
71
24
500
1000 1216
3000
3300
Ask price in France [€]