



Frequency Restoration Process

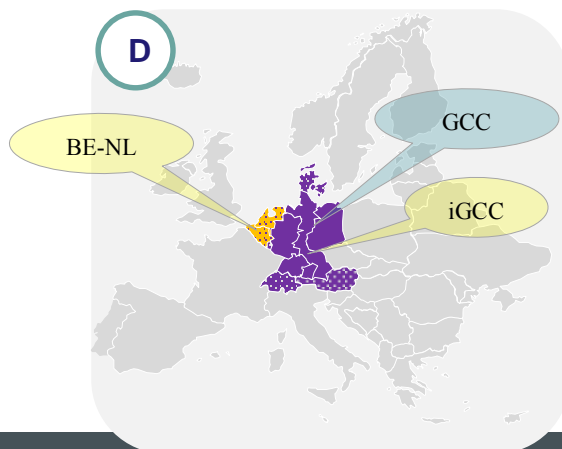
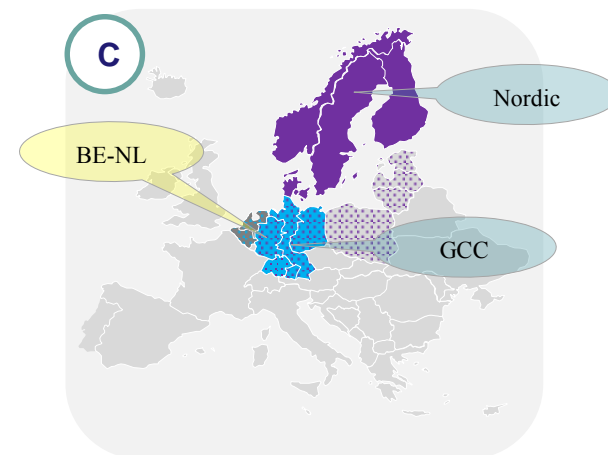
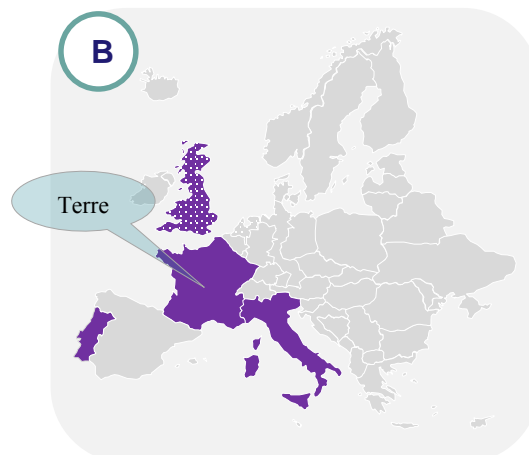
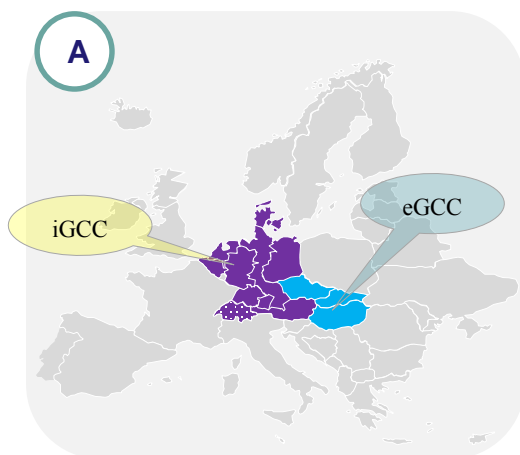
- Cross-border balancing project Elia-TenneT



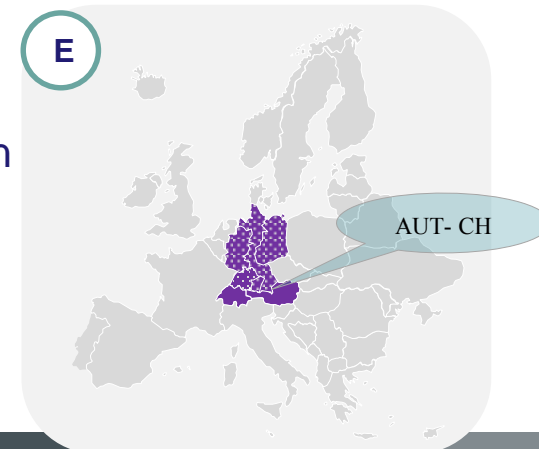
Pilot projects

EU context

- 8 EU pilot projects in total



- A. Imbalance Netting (IN)
- B. Replacement Reserve (RR)
- C. Manual Frequency Restoration (mFRR)
- D. Automatic Frequency Restoration (aFRR)
- E. Frequency Containment Reserve (FCR)



Pilot project BE NL

Contribution to the target model

The BE-NL pilot project is assessing the exchange of aFRR and mFRR between 2 different Bidding Zones & LFC blocks.

Hence our pilot project is able to assess :

- the **impact on local TSO responsibilities** (link between FRR & ACE quality)
- **the target model of the NC on balancing**; XB exchange of aFRR and mFRR:
 - the impact of the settlement pricing mechanism of different products
 - **Impact** on the imbalance pricing per LFC block
 - The complexity of having a different ways of using of aFRR and mFRR
 - Required level of harmonization
 - **Definition of standard products**
- The optimal use of remaining XB capacity (after ID markets) between 2 different Bidding Zones by different products
- Cost benefit analysis of the target model

Pilot project BE NL

introduction



- Pilot project consist of 3 steps:
 - Step 1 comparison of processes and functionalities (finished 2013)
 - Step 2 Market design scenarios (almost finished/ report being drafted)
 - Step 3 cost benefit analysis and Go/No Go decision for implementation (scoping started)
- Step 1 of the pilot project is finished. Results were presented in a common workshop to stakeholders and published on the websites of both TSOs
- After Step 1 it was decided that the **scope for step 2 is the exchange of balancing energy for aFRR and non-contracted manual FRR balancing energy.**
- **Simultaneously: Step 1 with 4 German TSOs, results expected by Mid-September**

Pilot project BE NL

introduction; step 2

Starting point definitions

- Reactive balancing market design
- FRR process and TSO responsibilities

Market design assumptions (to be assessed on CBA step 3)

- Exchange of aFRR balancing energy (product design, bid- and activation processes, merit order activation, cross border exchange,...);
- Exchange of mFRR balancing energy (product design, bid- and activation processes, cross border exchange,...);
- Use of cross-zonal transmission capacity for the exchange of balancing energy; and
- Settlement of balancing energy and imbalance settlement (harmonisation issues, pricing options)

On June 13th of 2014 TenneT and Elia organized a stakeholder workshop to present and discuss the intermediate findings of Step 2 of their pilot project.

Detailed slides are published on websites of both TSOs

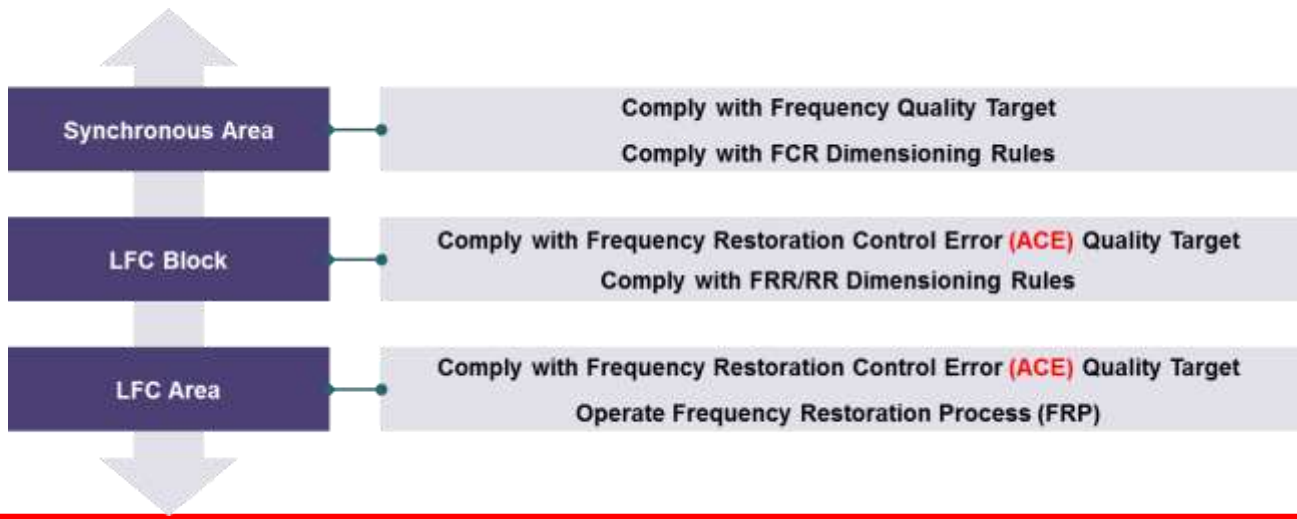
<http://www.elia.be/en/about-elia/Users-group/ad-hoc-taskforce-balancing/Cross-border-Balancing-Belgium-Netherlands>

Starting point 1: TSO LFC responsibilities



Scope of pilot project:

- “Design and evaluation of a harmonised reactive balancing market with XB optimization of Frequency Restoration while keeping control areas, bidding zones and regulatory oversight intact.”

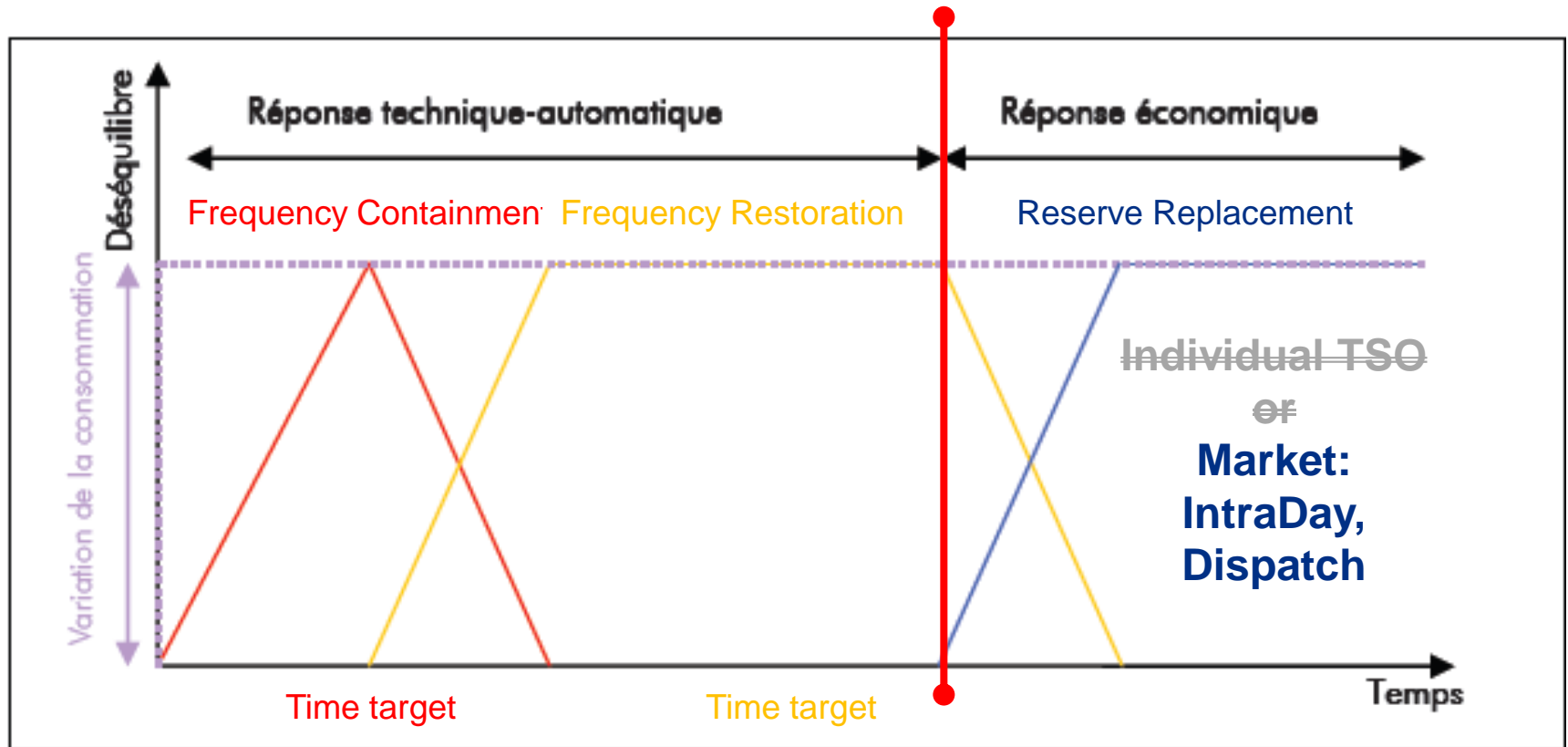


Conclusion: Elia and TenneT NL operate an LFC Block coinciding with the LFC Area.

- TenneT NL and Elia individually responsible for the dimensioning of FRR for their LFC Block;
- TenneT NL and Elia individually responsible to achieve satisfactory FRCE (ACE) regulation quality for their LFC Blocks.

Potential impact product harmonization (aFRR, mFRR ramp rates) on capacity volumes / capacity price
Exchange of bal. en. shouldn't materially affect ACE quality of Connecting TSO (~ link capacity volumes)
→ Exchange of balancing energy ⇔ potential impact on capacity costs ⇔ link with access tariffs!!!

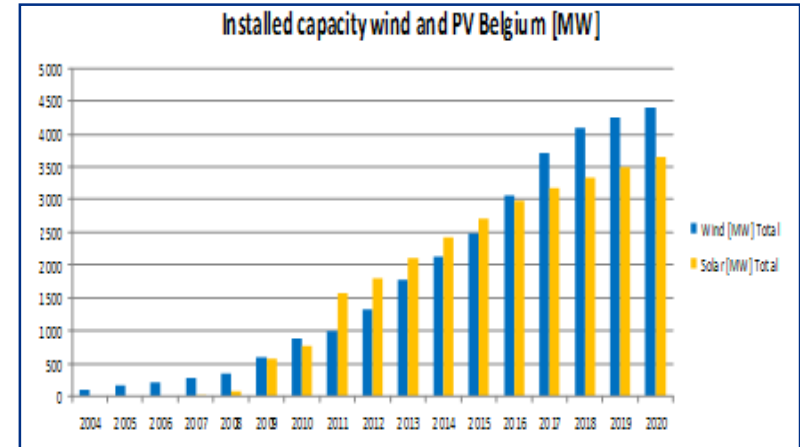
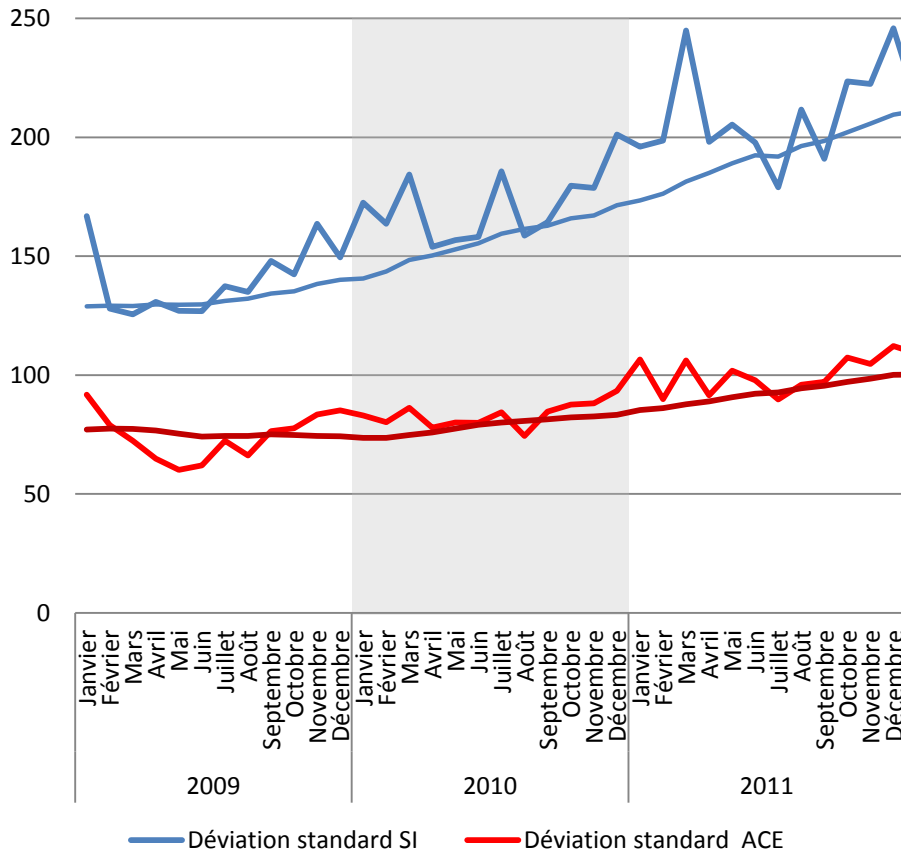
Starting point 2: Imbalance Settlement Period and reactive TSO design



- Reactive design: MARKET responsibility to restore the deployed FRR
- TSOs do not make use of Replacement Reserves (market role)
- Imbalance price is an important (LOCAL) tool to incentivize market parties in doing so
- Reactive design => imbalance settlement period of 15'

Evolution system imbalance Belgium

Evolution of standard deviation SI et ACE 2009 - 2014



Action points:

- Diversify the AS assets (RES & Load)
- Realise XB synergies

But first of all

- Improve the system imbalance

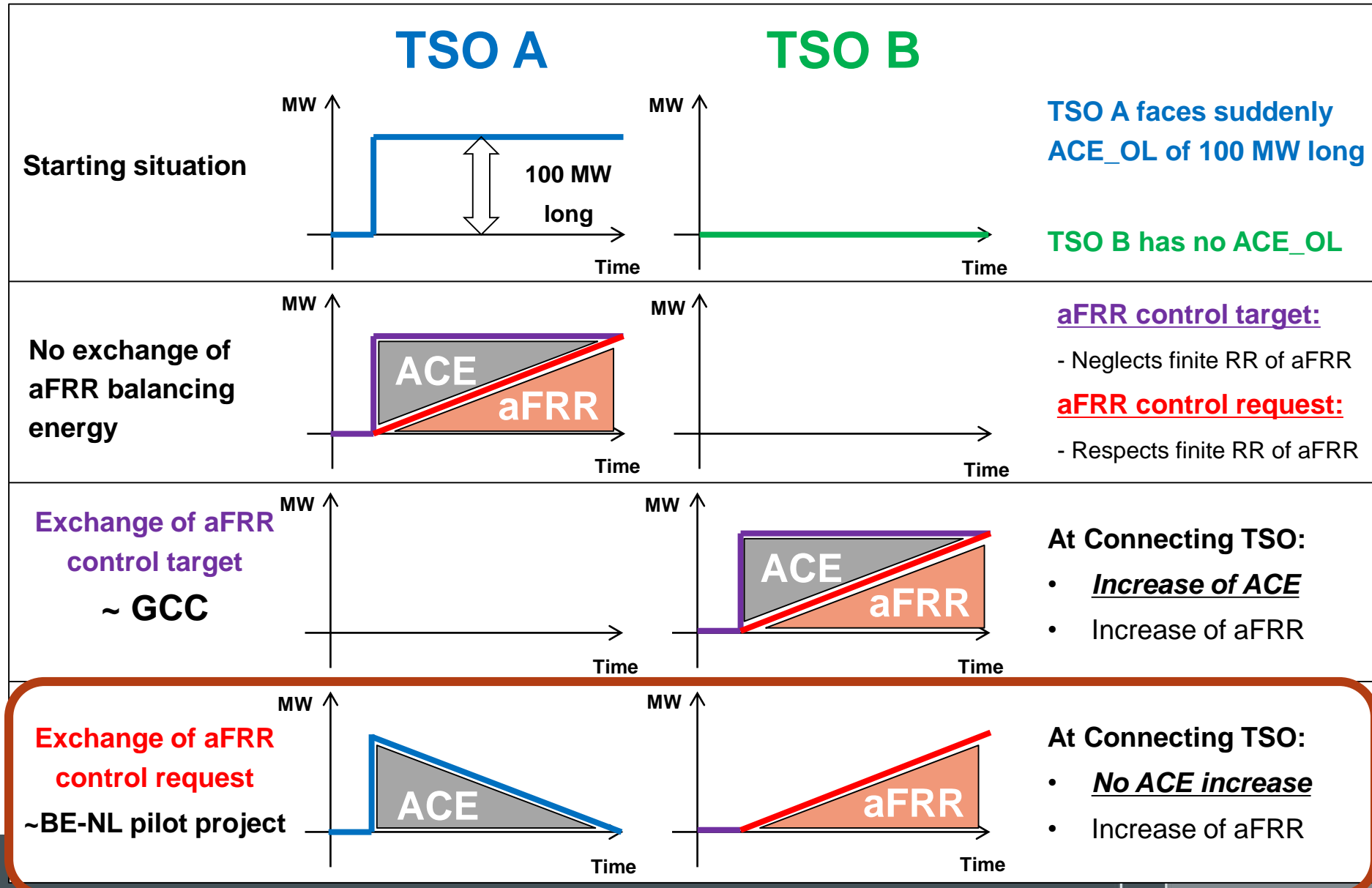
If not “fighting a losing battle” ?

aFRR: identified design assumptions and harmonisation prerequisites

- **Merit order activation aFRR**
 - Potential impact on aFRR capacity volumes, price and procurement costs
 - Feasibility and acceptability for Elia to investigate
- **Harmonization of aFRR ramp rate towards 7,5 minutes**
 - Potential impact on market liquidity and aFRR capacity prices
 - Feasibility and acceptability for TenneT to investigate
- **Exchange of balancing energy of contracted and non-contracted aFRR bids**
- **Portfolio based bidding / target gate closure time of max. 1 hour before delivery**
- **TSO can activate more aFRR bids than offered on local MOL**
 - Prior access for Connecting TSO
- **Exchange of aFRR control request (vs. control target)**
 - Exchange of control target (~GCC) cannot be replicated for CMOL-based exchanges of aFRR between separate LFC Blocks
- **Settlement and pricing → discussed in Settlement and pricing presentation**

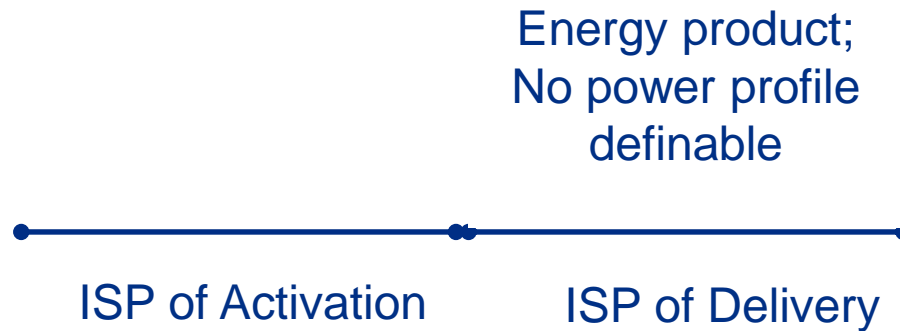
Exchange of aFRR control target vs request

Simplified example

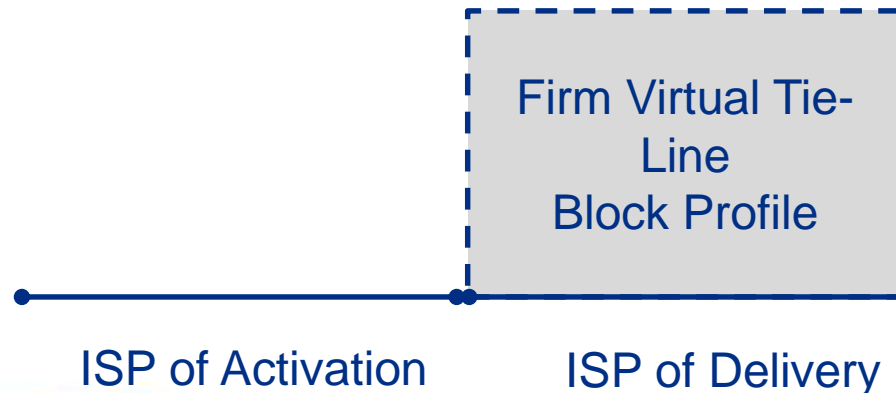


mFRR: identified design assumptions and harmonisation prerequisites

- Only **non-contracted mFRR bids** (contracted bids already shared)
- **Schedule activated, mFRR energy product**



- **Schedule activated, firm power profile exchanged over the border**



Allocation of capacity: identified assumptions

- Use of remaining commercial capacity after ID markets
- Decision order in time for XB exchange of balancing energy:
 - First decision for mFRR, then for aFRR, then for iGCC
- Capacity interdependencies:
 1. Imbalance netting, affected by
 2. aFRR, affected by
 3. mFRR
- Capacity allocation on the basis of:
 - Efficient use of flexibility / Compliance with frequency quality target parameters / Cost-effectivity

Settlement of balancing energy



Different approaches: pay-as-bid (BE) and cross-product marginal pricing (NL)

There are 2 options for Cross-Zonal pricing:

- Cross-zonal pricing; in this option the settlement price in one control area might be set by the price of a bid activated for another control area.
- Local pricing; in this option the settlement price in one control area might **not** be set by the price of a bid activated for another control area.

There are 2 options for pricing between aFRR and mFRR products:

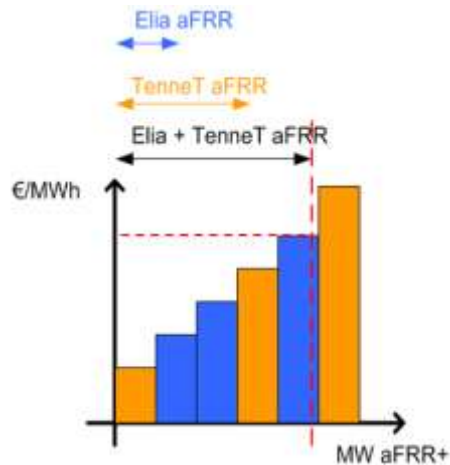
- Cross-product pricing; in this option the settlement price of one type of product might be set by the price of a bid of another type of product.
- Pricing per product; in this option the settlement price of one type of product might **not** be set by the price of a bid of another type of product

NC on EB requires “marginal pricing” unless TSOs demonstrate more efficient scheme

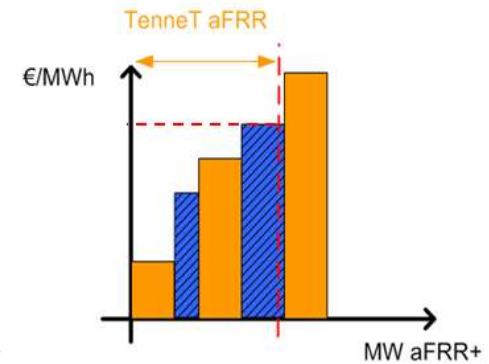
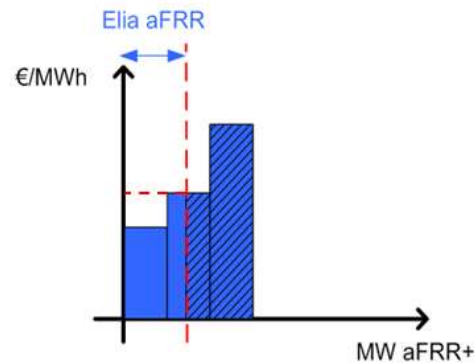
		Local	Cross Zonal
Elia ←	Pay-as-bid pricing	Pay-as-bid	#N/A#
	Marginal pricing per product	Local marginal pricing per product	Cross-border marginal pricing per product
Tennet ←	Marginal pricing across products	Local marginal pricing across products	Cross-border marginal pricing across products

Settlement of balancing energy: Local vs XB pricing

Cross border pricing



Local pricing



Cross-border pricing: one single imbalance price over uncongested area

- BRPs might balance themselves out over uncongested area use non-allocated cross-border transmission capacities
 - TSOs have no correct view on the remaining X-zonal capacity for exchange of balancing energy (iGCC, CMOL).
 - Incompliant with **Local TSO responsibility to balance the LFC Block** (BRPs causing an imbalance in one LFC Block to resolve an imbalance in another LFC Block.)

Imbalance netting will not resolve the bilateral issue between the 2 involved TSOs (proportional netting)

Local pricing: imbalance price reflects ACE_OL (balancing actions) of the individual LFC Block

Working assumption: local pricing ensures that BRPs are incentivized to balance per LFC Block

Conclusions settlement & pricing



Cross-border exchange of balancing energy should preserve:

- Correct incentives for BRPs to be balanced per LFC Block (ACE quality, cross-zonal capacity)
- The principle that imbalance settlement covers balancing costs
- Correct incentives for re-active market design (preserve single imbalance pricing)

Working assumption for exchange of aFRR balancing energy between LFC Blocks/BZ is local pricing

NC on EB only requires harmonization of “main features” of imbalance settlement

- Already harmonized for BE-NL (single marginal pricing, promote self balancing,...)

Working assumption: Only harmonise imbalance settl. features required for XB exchange of balan. ener.

Cross-border exchange of balancing energy should preserve incentives given to BRPs to support system balance

- Only for pure single pricing with 1 imbalance perimeter per BRP incentive to support system balance
- TenneT currently applies double pricing in some cases of infra-Qh bi-directional regulation
- Cross-border exchange of balancing energy might increase # of Qh with counter-activations

Working assumption is harmonization towards pure single pricing with 2 regulation states

Cross-product pricing of balancing energy requires local pricing to ensure ex-ante firmness of CMOL

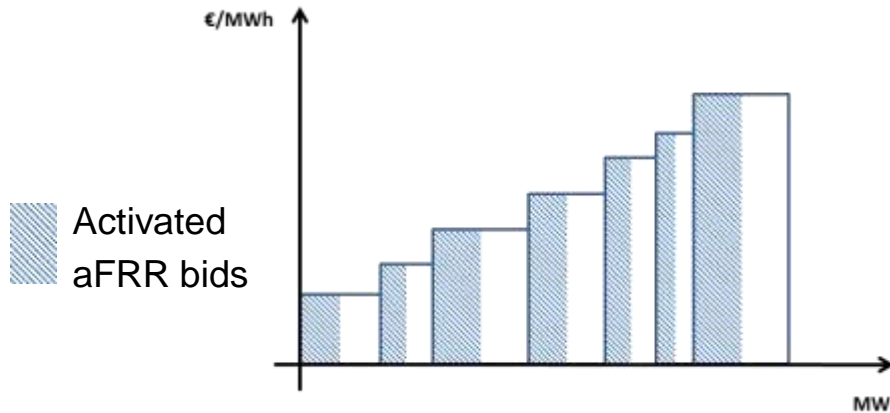
- If aFRR balancing energy price affects the mFRR price, it is possible that the mFRR price changes after activation (due to activation of more expensive aFRR)
- As such the CMOL isn't firm ex-ante, which might result in sub-optimal activation ex-post
- This can be resolved by local pricing

Backup slides aFRR

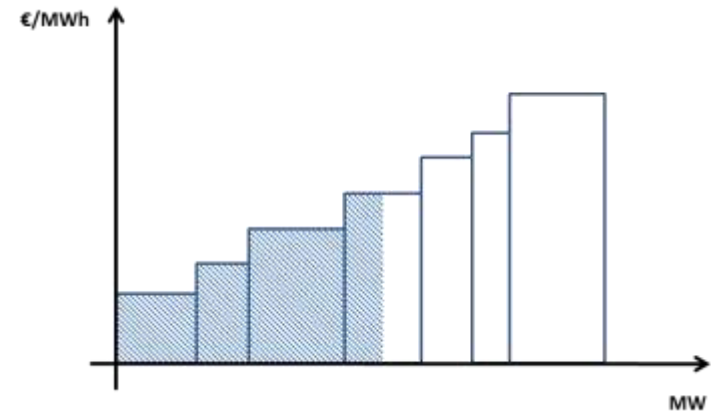
aFRR status quo: key aspects



Elia: pro-rata aFRR

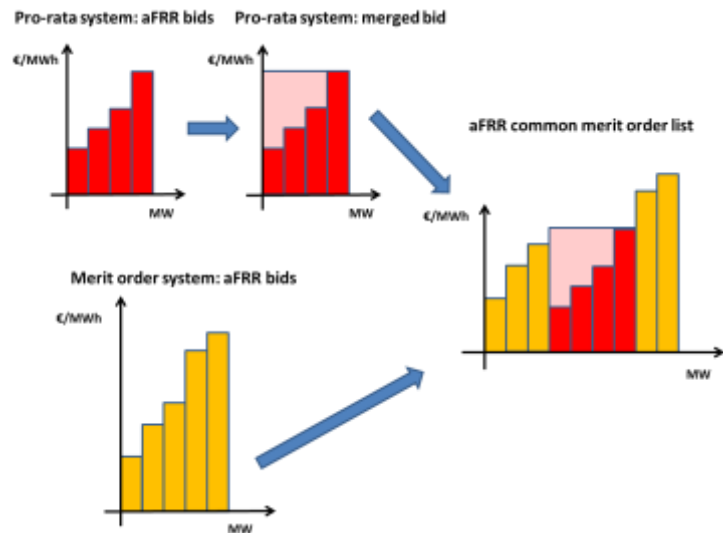


TenneT: merit order aFRR



	Elia	TenneT
Activation scheme	Pro-rata: <ul style="list-style-type: none"> All bids activated in // proportional with bid size 	Merit order: <ul style="list-style-type: none"> Only cheapest bids are activated
(aFRR) imbalance settlement price	Independent of activated aFRR volume	Progressive ~ activated aFRR volume
aFRR full activation time	7,5 min (imposed by Elia)	Defined by BSP <ul style="list-style-type: none"> TenneT accepts bids ≤ 15 min
aFRR regulation speed	Constant and maximum over entire aFRR activation range (// activation of all bids)	Depends of activated aFRR volumes <ul style="list-style-type: none"> Low activated aFRR volume = slower
Competition for aFRR activation (energy price)	No: // activation of all bids <ul style="list-style-type: none"> Cap / floor on aFRR energy prices D-1: select ≤ 150 MW of cheapest bids Pay-as-bid scheme 	Yes: real-time competition for activation <ul style="list-style-type: none"> No cap/floor* All aFRR bids selected Cross-product pay-as-cleared scheme

Compatibility PR & MO scheme: XB exchange of aFRR balancing energy



- ✓ Pro-rata: // activation of all aFRR bids (no price notion)
- ✓ Pro-rata = merit order with 1 “merged” bid
- ✓ Integration of PR scheme on CMOL is sub-optimal:
 - ❖ Activation order of bids;
 - ❖ Progressivity of imbalance price;
 - ❖ ≠ regulation speeds;
 - ❖ Compatibility with different pricing mechanisms/rules;
 - ❖ *No enduring solution (GE also MO aFRR scheme...)?*
 - ❖ ...
- ✓ Exchange between MO schemes is optimal

- Exchange of aFRR between PR and MO scheme is sub-optimal from economic point of view
- **Working assumption for pilot: exchange of aFRR balancing energy between merit order schemes**
 - Most in line with (current) target model for aFRR and therefore investigated solution
 - **Negative outcome working assumption → investigate exchange between PR and MO scheme**

aFRR ramp rates: options (2)



Definition of standard aFRR product: harmonized ramp rate

No definition of standard aFRR product: exchange of (virtual) standard aFRR product over the border

Option 1: // activation of slower bids to 'simulate' standard product for exchange

Option 2: no // activation of slower bids to 'simulate' standard product for exchange

	Harmonization of aFRR ramp rate	No harmonization of aFRR ramp rate
Reciprocity	Optimal Depends also on bidding process, settlement,...	Sub-optimal Settlement & pricing / activated energy per bid,...
Level playing field for BSPs	Yes	No
Robustness / complexity	More robust / less complex	Less robust / more complex
Extendibility	Possible but requires harmonization	Easier (no harmonization) but becomes more complex if more different aFRR ramp rates
Sustainability	Compliant with NC on EB (standard products)	Incompliant with (current!) target model for aFRR / definition of std products in NC on EB

Non-harmonization of aFRR ramp rates for exchange is sub-optimal

Working assumption for pilot: harmonization of aFRR ramp rates (standard product)

- Most in line with NC on EB and therefore investigated solution
- **Negative outcome working assumption → investigate non-harmonization option**

aFRR ramp rates: options (3)



Four options were identified to harmonize the aFRR ramp rates:

- ≤ 5 min *or* $\leq 7,5$ min *or* ≤ 10 min *or* ≤ 15 min
- **Preferred option (Elia and TenneT) for aFRR ramp rate harmonization: $\leq 7,5$ minutes**

TenneT considers increasing ramp rate from ≤ 15 min to $\leq 7,5$ min IF acceptable impact on:

Evaluation criterium	Explanation
aFRR capacity procurement costs	<ul style="list-style-type: none">• Higher ramp rate = lower liquidity; less offered volumes (higher prices)<ul style="list-style-type: none">• Global aFRR energy market \Leftrightarrow capacity market requires XB transm. capacity• Higher ramp rate = less (same) aFRR capacity for same (better) FRCE quality
aFRR energy prices	<ul style="list-style-type: none">• Lower ramp rate = less energy delivered by BSP (negative impact);• Lower ramp rate = more flexibility for BSP for passive contribution (positive impact);• Lower ramp rate = more competition (positive impact)
aFRR energy bids liquidity	Stricter ramp rates lead to less market liquidity (less free bids);
Extendibility	Is the proposed ramp rate extendible to other countries (CoBa extension)? <ul style="list-style-type: none">• E.g. GE with 5 min

Working assumption for the pilot: harmonization of aFRR ramp rates towards $\leq 7,5$ min

Survey was sent out to BE and NL market parties

- More thorough analysis required in next stage

Negative outcome of working assumption: investigate options without harmonization

Activation process: (simplified) functioning of secondary controller



Secondary controller is a PI controller having the ACE of the LFC Block as an input:

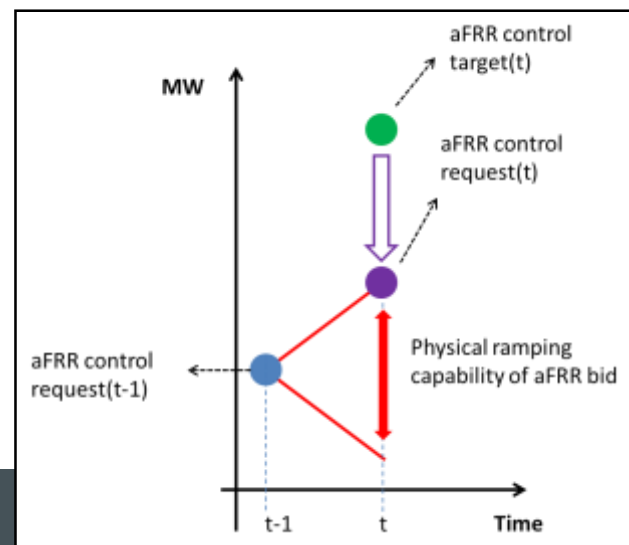
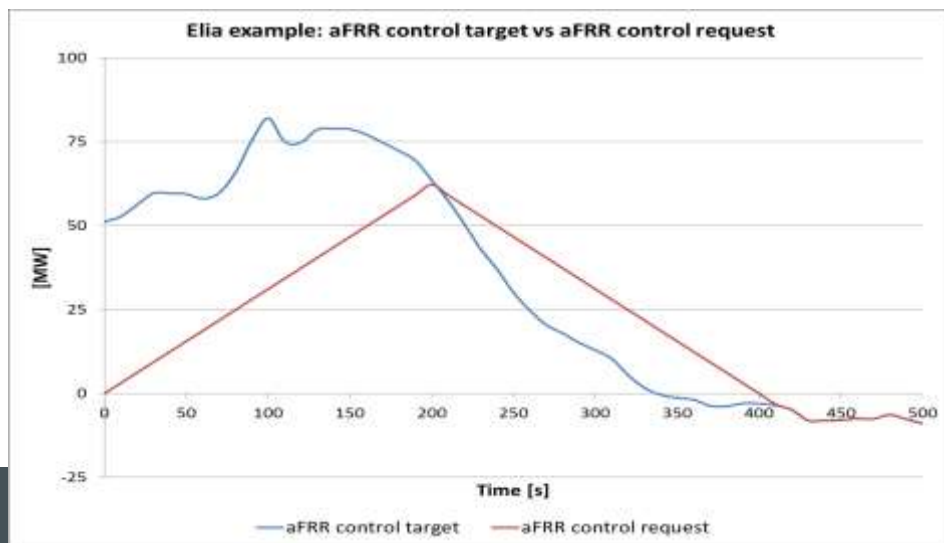
The outcome of the PI controller is the **desired aFRR activation**, the so-called **aFRR control target**:

- does NOT respect the ramping rate constraints of the aFRR bids / cannot necessarily be physically delivered

A second calculation is performed to define the **aFRR control request**:

- respects the limited ramp rate of the aFRR bids / can be physically delivered (in case of perfect activation)
- **aFRR control request is sent by both Elia and TenneT to the BSPs that deliver aFRR**

The aFRR control target and control request are calculated typically every 4 – 10s



Backup slides settlement

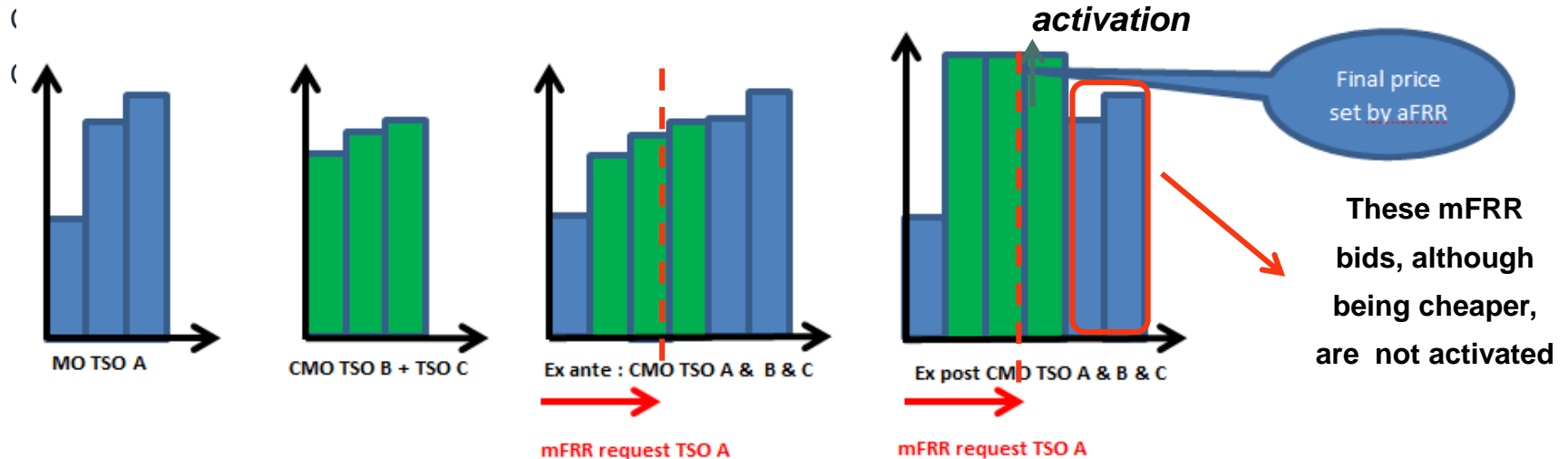
Settlement of balancing energy: cross product pricing; ex ante CMO

Cross-product cross border pricing requires more complex solutions for XB integration

- Especially for cooperation for one specific balancing process as the bid price on the CMO is not firm ex ante.
- Reminder FG Balancing (NEIF + 2years RR; NEIF +4 years mFRR; NEIF + 6 years aFRR)
- Same issue remains applicable on LT as different configurations of CMO's are possible

Ex-post price increase of mFRR bids at TSO B & C due to simultaneous aFRR

Example



Cross-product pricing requires local pricing to ensure (ex-ante) firmness of CMO

Settlement of balancing energy: cross border pricing: control strategies

Local TSO controllers define the volume and amount of bids to be activated

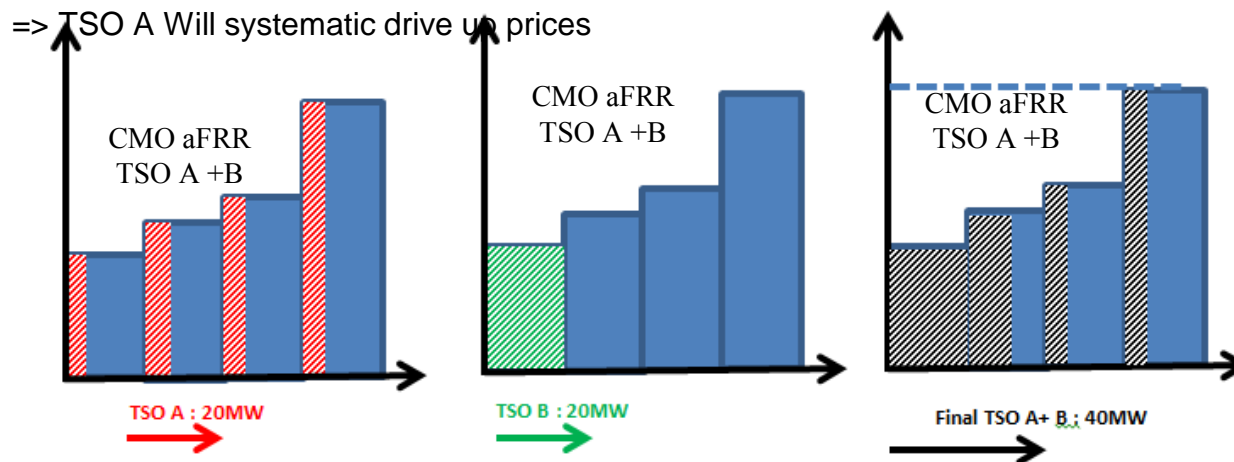
- Due to different system dynamics and ACE Quality targets TSO might react differently to the same imbalance by activating more balancing energy or more bids in parallel for higher ramp rate
- This will affect marginal price

Cross-border pricing requires harmonisation of control strategies

- Mutual impact of activation strategy of TSOs on each others imbalance prices

Example (assumption merit order activation)

- TSO A: activate faster bids in parallel to increase ramping speed; dynamic system
- TSO B: avoids the activation of bids in parallel; stable system



Cross border pricing is not easy to combine with different control strategies

Settlement of balancing energy: Cross border pricing: wrong local incentives to BRPs

Cross-border pricing might trigger wrong BRPs reactions to imbalance prices

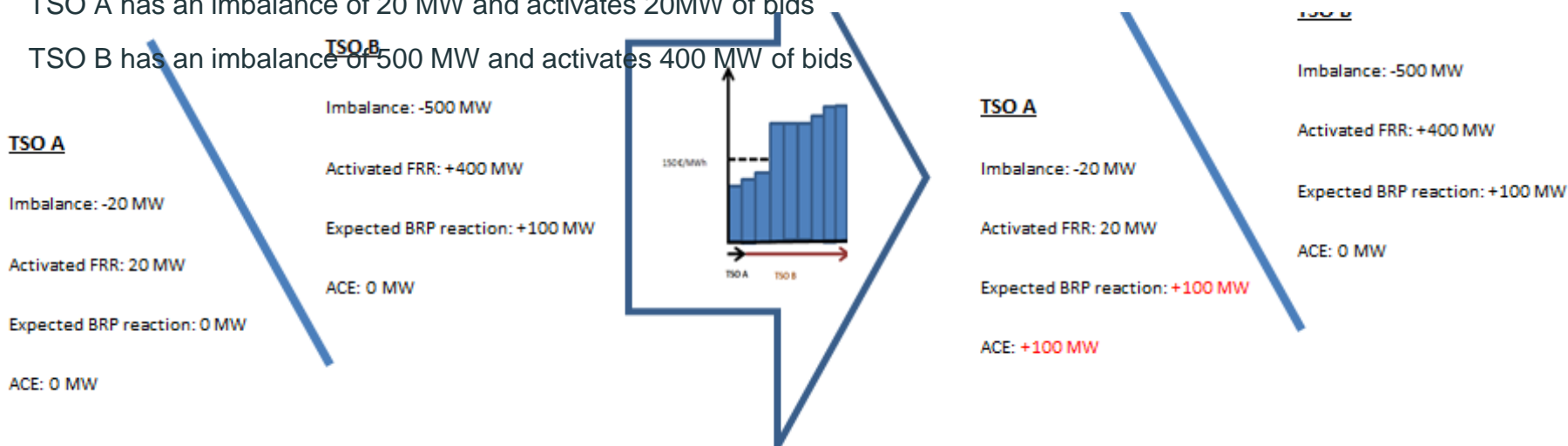
- Single marginal imbalance pricing in combination with close-to-real time encourages the market to support the system imbalance based on economic signals
- In case of cross-border pricing the economic signals will not reflect anymore the imbalance of the LFC Block; hence local TSO responsibility and ACE quality shall be affected

Example

BRPs react (passive contribution of +100MW) on imbalance price exceeding +150 €/MWh

TSO A has an imbalance of 20 MW and activates 20MW of bids

TSO B has an imbalance of 500 MW and activates 400 MW of bids



In a re-active market imbalance prices are a 'local control' tool for the TSO
Cross border pricing is affecting the local signals of this 'control tool'