MARI

Manually Activated Reserves Initiative



TERRE MARI PICASSO French Stakeholders workshop

13th November 2017

Content

1. INTRODUCTION of the MANUAL ACTIVATION RESERVE INITIATIVE (MARI)
2. PRODUCT and PROCESS
3. SETTLEMENT
4. HARMONISATION

Content

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Project Background

MARI project

- The goal is to create a European platform for mFRR
- New project independent from the existing initiatives
- TSOs of the cooperation started working on the principles of an mFRR platform already in 2016
- 5 April 2017 TSOs signed Memorandum of Understanding, which outlines the main design features of the project as well as the governance principles

Other/Previous Initiatives of the involved TSOs

- Common Nordic mFRR market in operation
- Amprion/RTE – proposal for the design of an mFRR market DE/FR
- Explore – proposal for the design of an mFRR market
- AT/DE project for the implementation of an mFRR market
- mFRR discussions in the TERRE framework

Legal Background

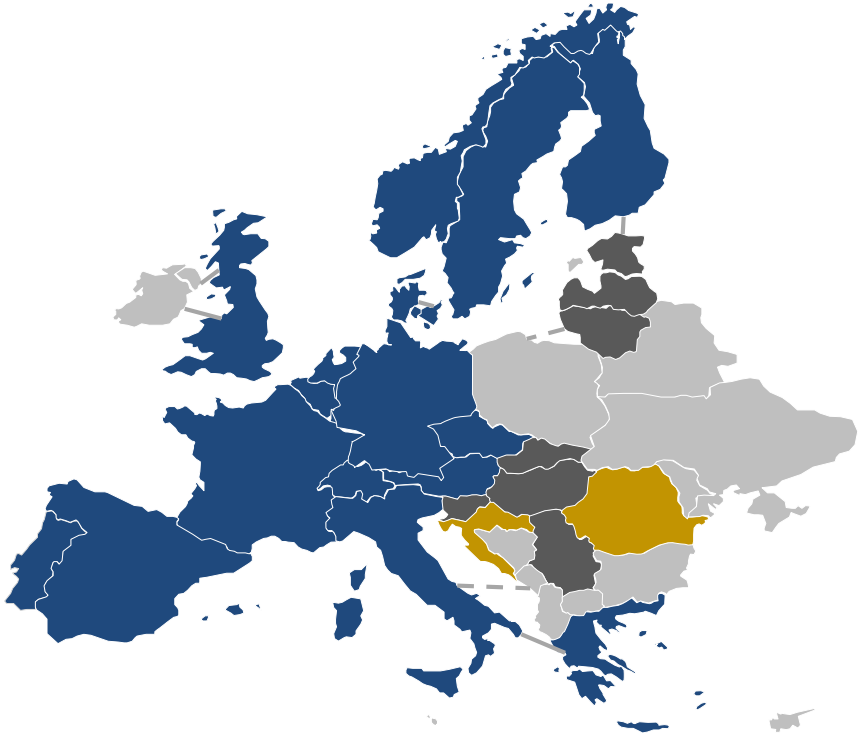
- Guideline on electricity balancing (“GLEB”)
- Guideline on transmission system operation (”GLSO”)
- Regulation 1222/2015, (“CACM”)
- Regulation 1227/2011(“REMIT”)
- Regulation (EC) 714/2009

Involved Parties – TSOs only

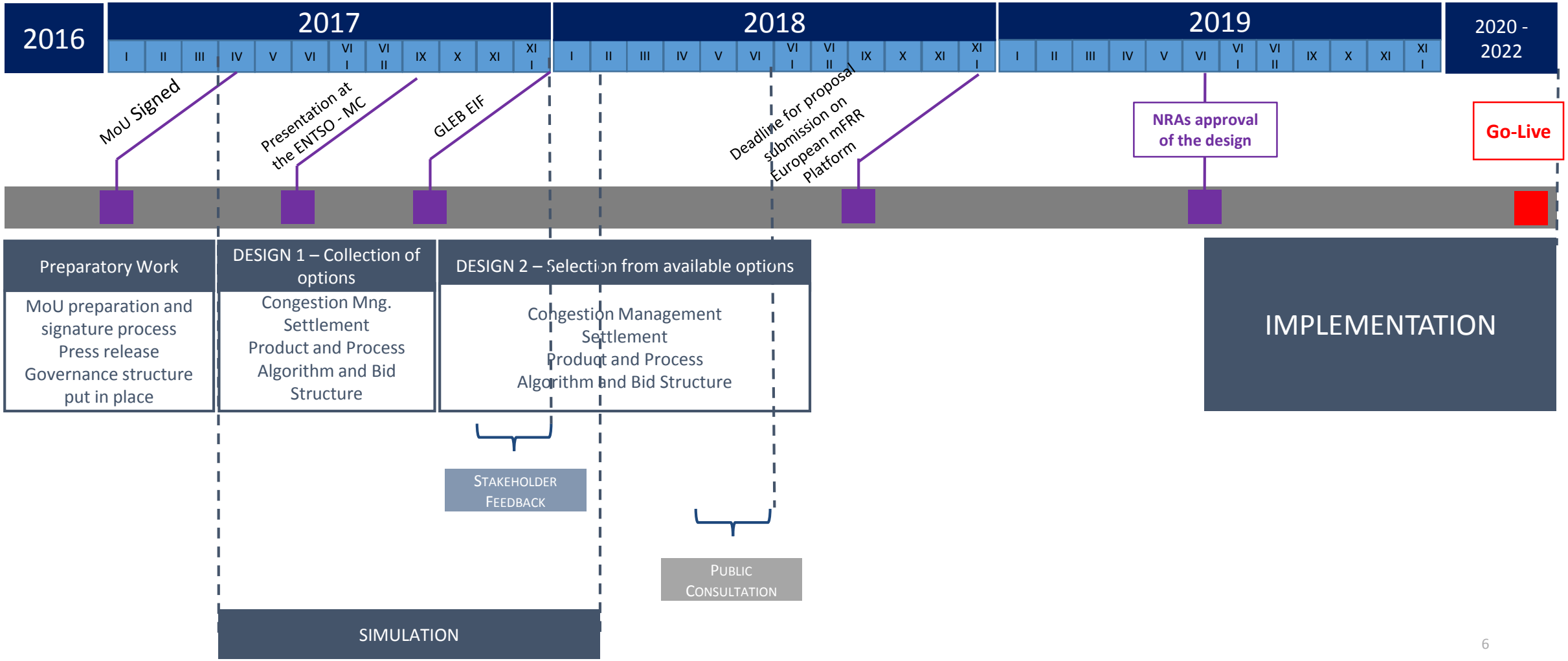
MEMBERS	
AUSTRIA	APG
BELGIUM	elia
CZECH REPUBLIC	ČEPS
DENMARK	ENERGINET
FINLAND	FINGRID
FRANCE	RTE
GERMANY	50hertz, amprion, TenneT, TRANSNET BW
GREECE	ADMIE
UNITED KINGDOM	nationalgrid
ITALY	Terna Rete Italia
NETHERLAND	TenneT
NORWAY	Statnett
PORTUGAL	REN
SPAIN	RED ELÉCTRICA DE ESPAÑA
SWEDEN	SVENSKA KRAFTNÄT
SWITZERLAND	swissgrid

OBSERVERS	
ESTONIA	elering
HUNGARY	MAVIR
LATVIA	AST
LITHUANIA	Litgrid
SERBIA	EMC
SLOVAKIA	SEPS
SLOVENIA	ELES

Countries in Process of Becoming Observers	
CROATIA	HOPS
ROMANIA	Transelectrica



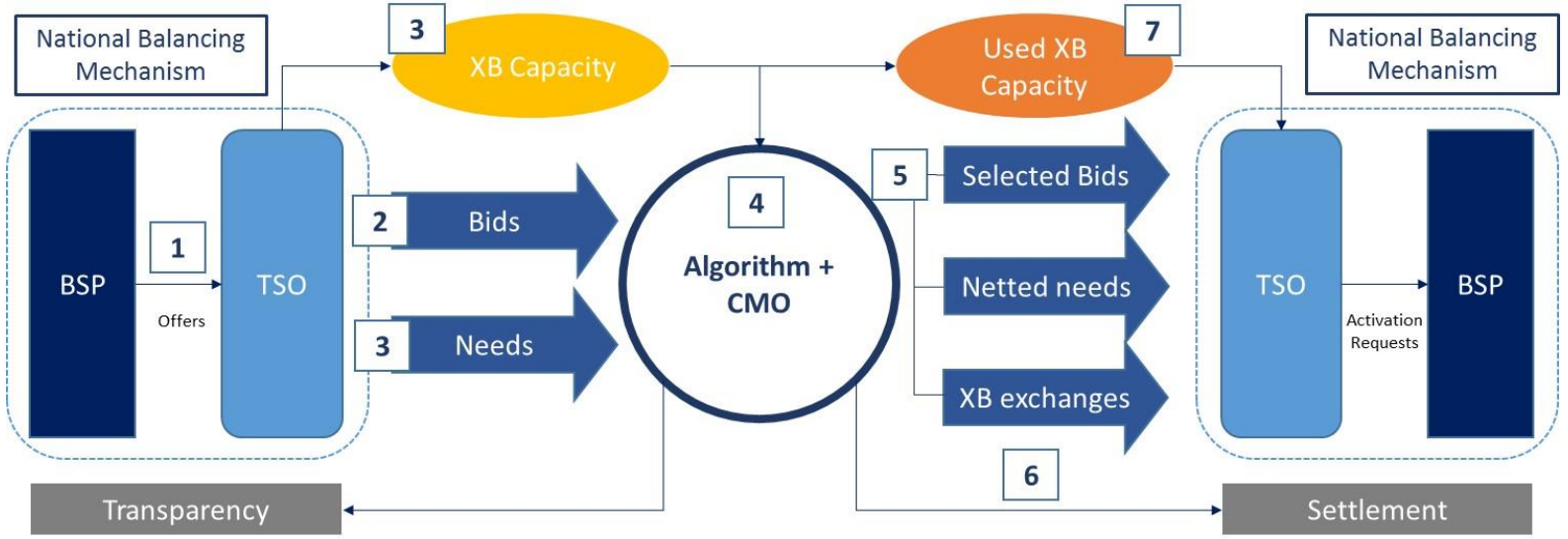
Project Timeline according to the GLEB



Content

1. INTRODUCTION of the MANUAL ACTIVATION RESERVE INITIATIVE (MARI)
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General Process



1. TSOs receive offers from BSPs in local market balance area
2. Forward of coherent mFRR balancing products to mFRR platform
3. TSOs communicate their balancing needs and the available XB transmission capacities (ATC)
4. Optimization of the clearing of balancing needs against BSPs‘ offers
5. Communication of the accepted offers, satisfied needs and prices
6. Calculation of the commercial flows between market balancing areas and settlement of the expenditure and revenues between TSOs
7. The resulting XB schedules and remaining ATC are sent to the TSOs

Product – 1/2

Main Questions

- What should the key characteristics of the mFRR product be?

Product – 2/2

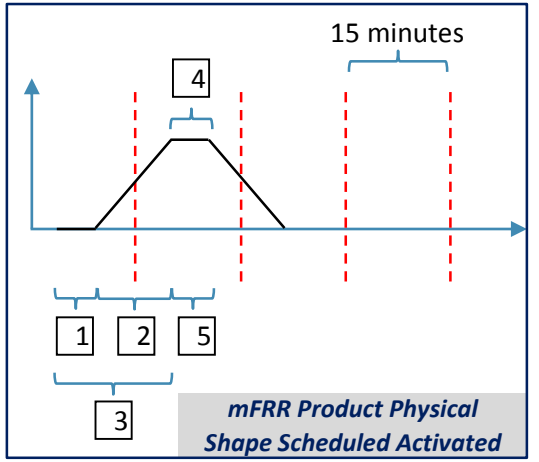
Product Properties

mFRR Product Properties are based on:

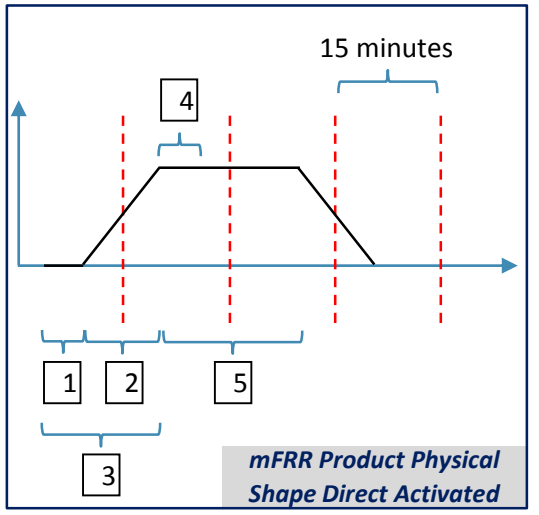
- Key characteristics of standard products from EBGL (Art. 25)
- Further properties

Figures legend	Properties	Incentivized Shape	Accepted Shape *(Exact accepted shape set by the local TSOs)*	RTE Accepted Shape *(within the tolerance of the accepted shape)*
1	Preparation Period	**2.5'**	**0-12.5'**	
2	Ramping Period	**10'**	**0-12.5'**	
3	Full Activation Time	**12.5'**	**0-12.5'**	
4	Minimum duration of delivery period	**5'** *(scheduled and direct activation)*	*(Exact accepted shape set by the local TSOs)*	
5	Maximum duration of delivery period	**20'** *(longest direct activation)* **5'** *(longest scheduled activation)*	*(Exact accepted shape set by the local TSOs)*	
-	Minimum quantity	**1 MW**		
-	Maximum quantity	**9999 MW**		
-	Deactivation period	**10'**	**0-12.5'**	
-	Validity period	**To be analyzed in the next phase of the project**		
-	Mode of activation	**Manual**		

Exact shape accepted by RTE to be provided in further French Balancing Terms and Conditions update (Règles MA-RE)



mFRR Product Physical Shape Scheduled Activated



mFRR Product Physical Shape Direct Activated

Process – 1/6

Timing of the Process

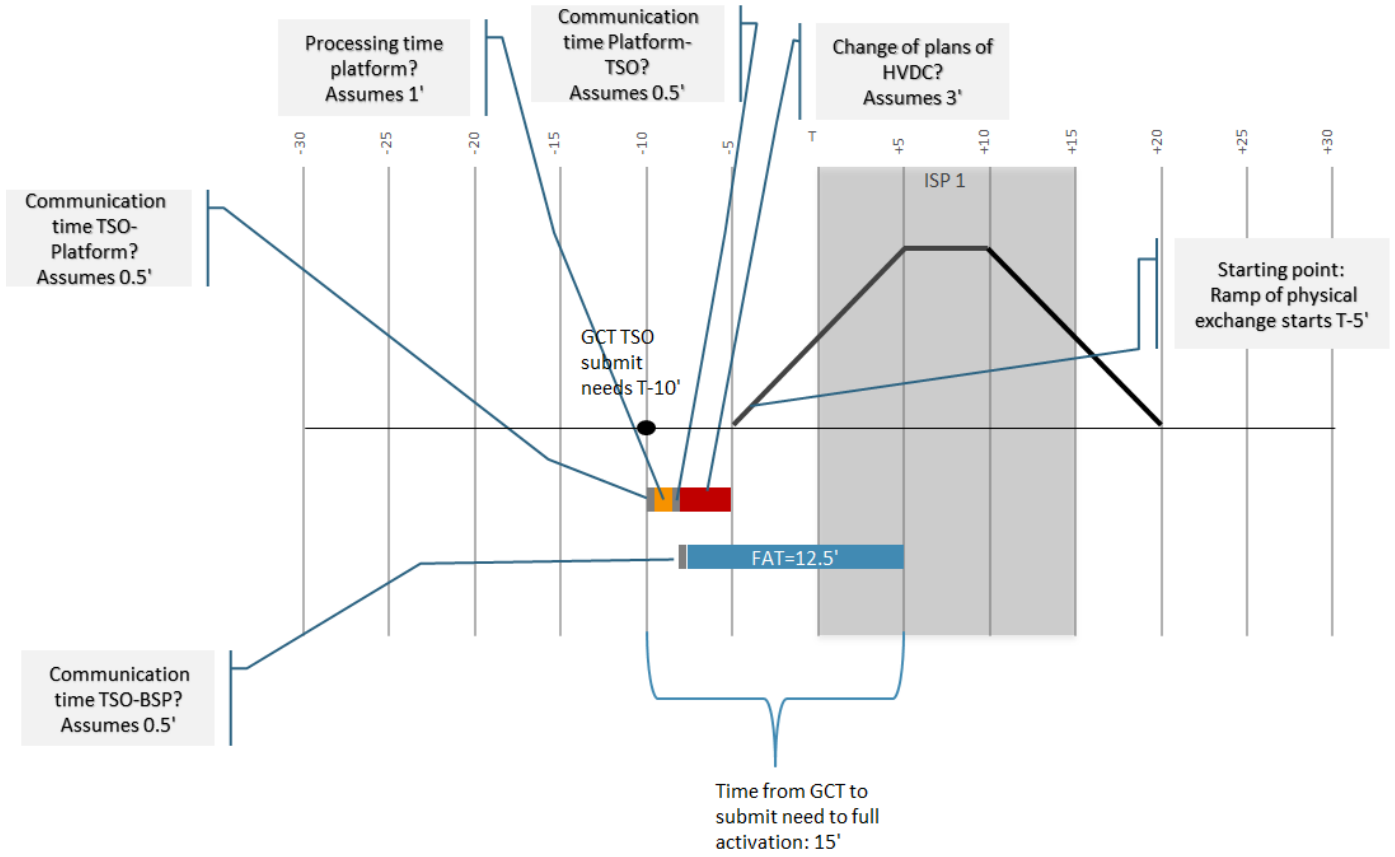
Questions:

- How long will it take from the need of a TSO being submitted to the platform until bids are fully activated?
- When should GCT for the BSPs be?
- When should direct activations be possible in relation to the scheduled activation for the same CMOL?

Process – 2/6

Timing of the Scheduled Process

Starting point: Activation of scheduled bids starts 7.5min before the start of the ISP



Action	Assumed duration
Communication TSO-Platform	0.5’
Processing time platform (algorithm)	1’
Communication Platform-TSO	0.5’
Communication TSO-BSP	0.5’
Change of HVDC Plans	3’

Note: the depicted delivery profile corresponds to the profile of the TSO-TSO cross-border exchange and incentivized shape of the standard mFRR-product.

Process – 3/6

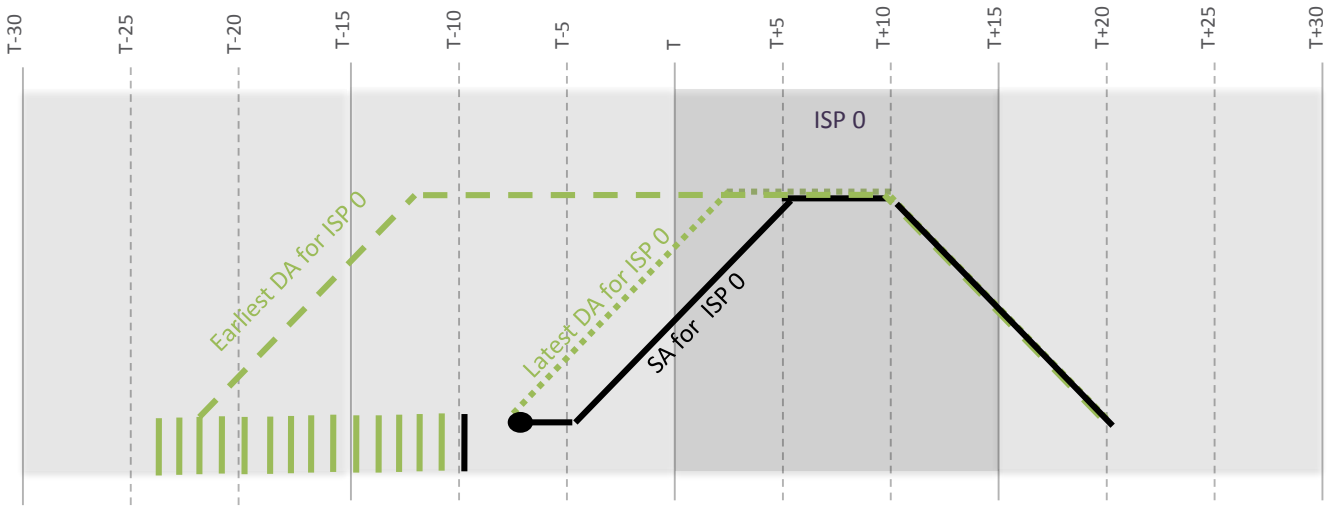
Timing of the Direct Activated Process

- **Base case: direct activation in a continuous manner**
  - However, technical limitations exist to allow a ‘continuous’ process
    - Processing and communications time
    - Change of HVDC plans
  - Note: the base case of a continuous direct activation process is used in the remainder of this presentation to illustrate the different concepts

- **Alternative option: direct activation in cycles**
  - An alternative is to perform the process of direct activation in cycles
    - Allows netting
    - Leaves time for processing
  - Example: 5min cycles
    - Per 15min period: 2 DA and 1 SA
  - Minimal cycle assuming a processing time of 1 minute (cf. SA process) = 1 min
    - Per 15min period: 14 DA and 1 SA (see illustration next slide)

Process – 4/6

Illustration of a DA process with 1min cycles



Direct activations (1min cycles)

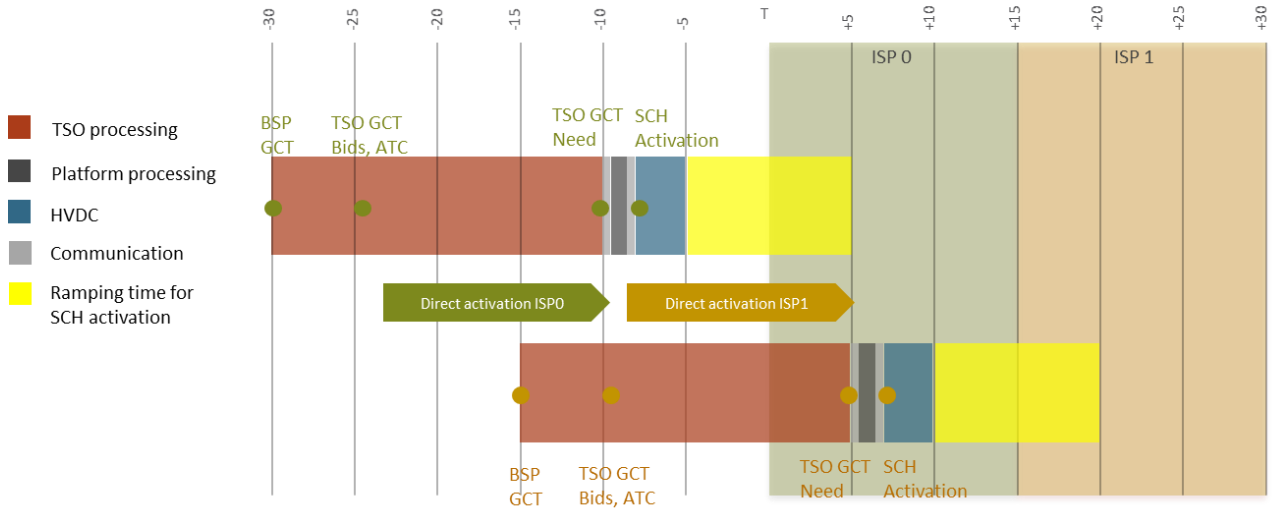
Start processing scheduled activation

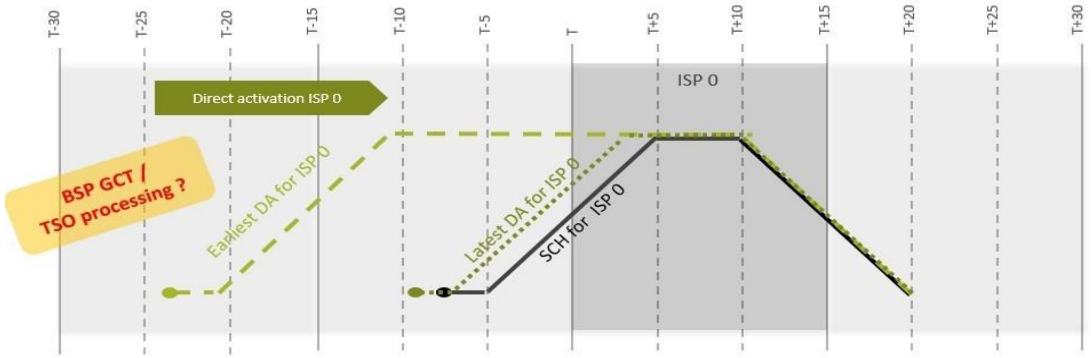
Scheduled activation (Start FAT)

Cross-border exchange

Process – 5/6

Interaction between the scheduled and direct activation process – base case scenario (1/2)





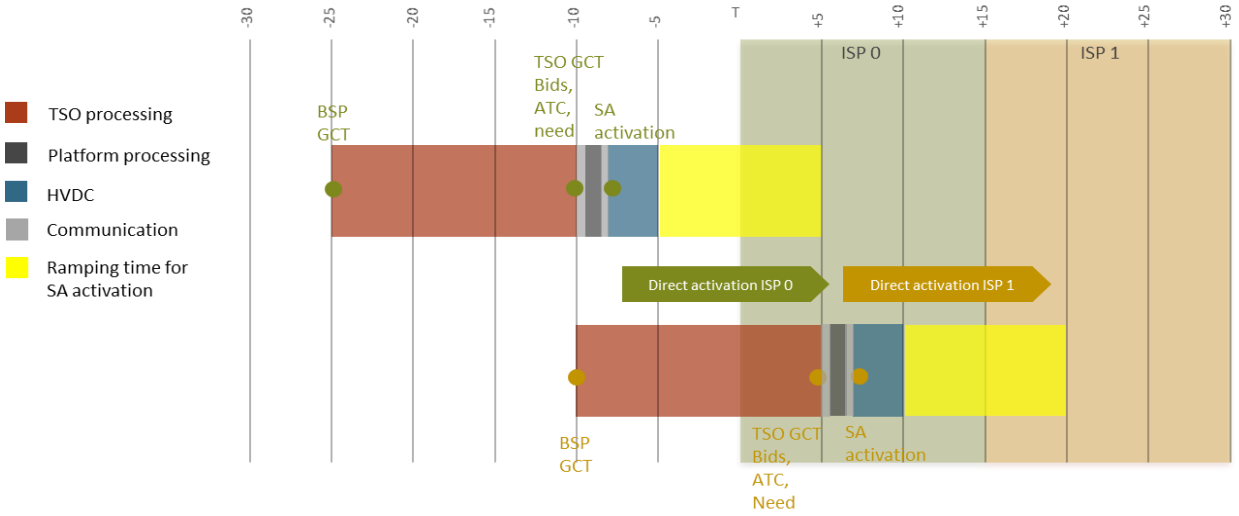
The direct activation process (DA) is assumed to be continuous and can interact in different ways with the scheduled process (SA):

- DA before SA (both for ISP 0)
- DA after SA (both for ISP 0)

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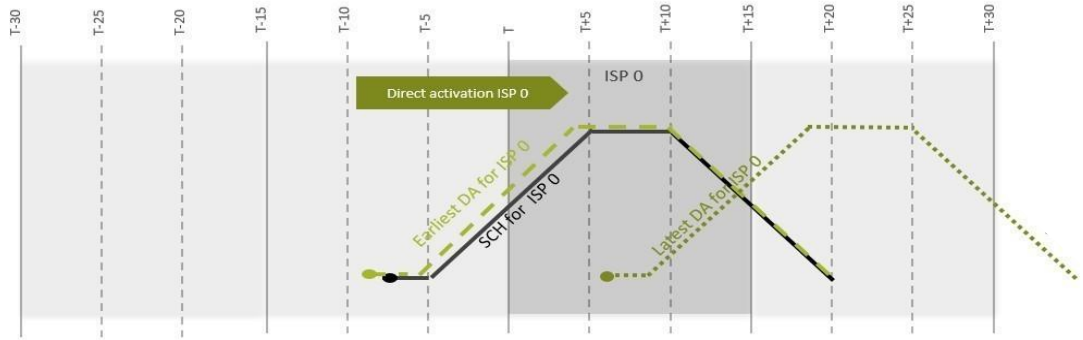
Process – 6/6

Interaction between the scheduled and direct activation process – base case scenario (2/2)



The direct activation process (DA) is assumed to be continuous and can interact in different ways with the scheduled process (SA):

- DA before SA (both for ISP 0)
- DA after SA (both for ISP 0)



- DA before T-7.5' will end in ISP 0
- DA after T-7.5' will end in ISP 1

Bid Structure – 1/4

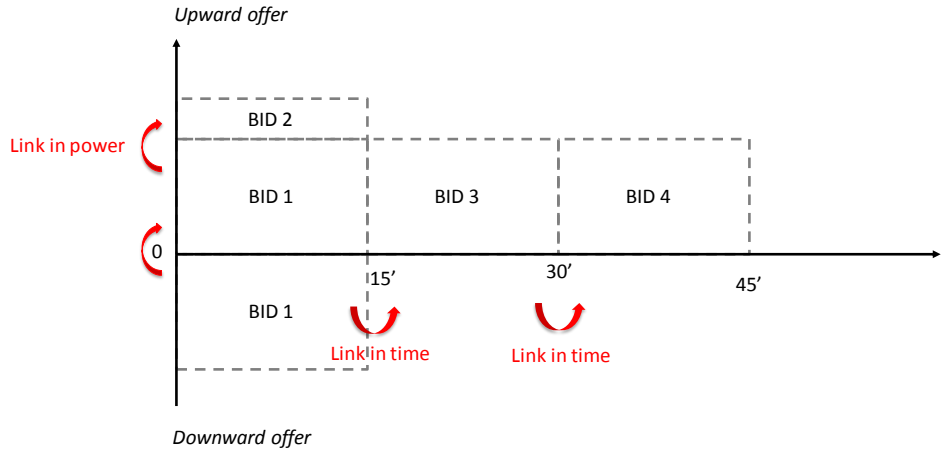
Main Questions

- Should there be the possibility to link bids and if yes, which kind of linked bids?
- What should the maximum bid size for indivisible bids be?
- How should the algorithm consider indivisible bids?

Bid Structure – 2/4

Linking Bids

- In general, bids can be linked in power and in time for economical reasons.
  - Linking of bids in time by BSPs is not feasible because optimization is done per 15' period and not over several periods.
  - Linking in power is feasible and economically advantageous for both BSPs and TSOs. However, not all possible links will be allowed and there will be limits to the possibilities (e.g. max number of linked bids).
  - Different options will be investigated:
    - Linked bid orders
    - Exclusive group orders
    - …



Note:

There exists a need to link bids in time, i.e. over different periods, for technical reasons.
A methodology for this will be developed

E.g.: a scheduled activated bid in ISP0 that is also offered for ISP1 cannot be direct activated at the start of ISP1. Since GCT for BSPs for ISP1 will fall after the clearing of scheduled bids for ISP0, this information must be known to the platform.

Bid Structure – 3/4

Indivisible Bids - Maximum Bid Size

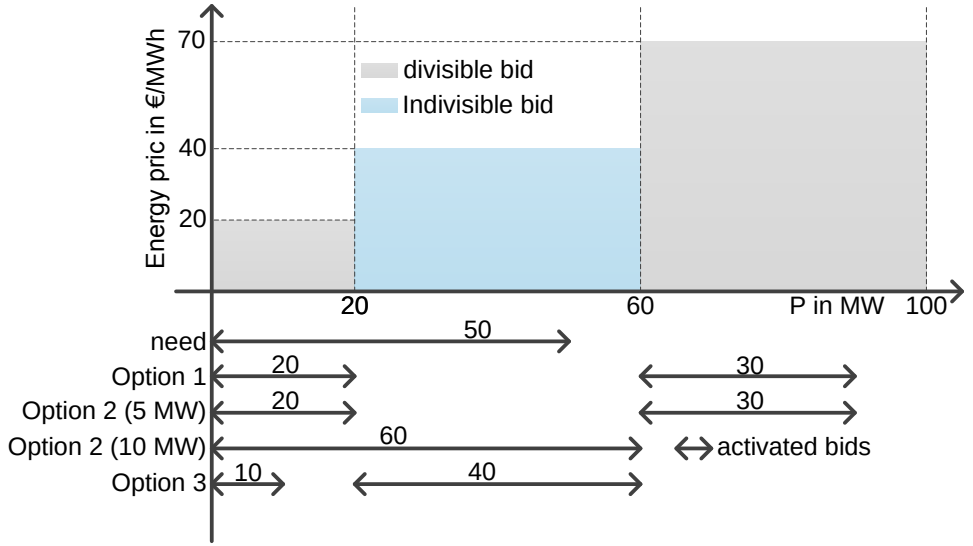
- **Current Situation:** Most of the TSOs in the cooperation allow indivisible bids. Nevertheless, the maximum bid size varies from a minimum of 25 MW (Germany) to a maximum of approximately 310 MW (Portugal).
- **Allow indivisible bids**: Since most TSOs allow indivisible bids, this should be allowed in the MARI cooperation as well.
- **Maximum bid size?:** The determination of the maximum bid size is under discussion

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Bid Structure – 4/5

Indivisible Bids - Algorithm

- There are different options to consider indivisible bids in the algorithm. The activation of indivisible bids is more likely if a tolerance band is applied to the need of a TSO.
- Different options have been studied by TSOs.



Rules for Balancing Need – 1/3

Main Questions

- Should price dependent needs be allowed?
- Should a TSO be allowed to activate a larger volume of bids than the TSO has made available for the platform?

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Rules for Balancing Needs – 2/3

Price Dependent Needs

- For a TSO, price dependent needs may be required:
  - There are several balancing products available
  - Optimized use of these products can reduce balancing cost

- Three options for price dependency are investigated:
  - Inelastic: not priced (the volume is absolutely required by the TSO)
  - Inelastic with a limit price: i.e. TSO sets a max/min price that they are willing to pay/receive
  - Elastic: several request levels with volume and price, demand curve.

- Proposal
  - Design phase will consider price dependent needs
  - Subsequent impact on Timing and Settlement to be assessed

Rules for Balancing Need – 3/3

TSO activation volume

- In normal (non-emergency) conditions there could be two restrictions:
  - A TSO or LFC block can not activate more bid volume than it has made available to the platform
  - A TSO or LFC block can not activate more DA bid volume than it has made available to the platform

- Example
  - TSO1 makes available the following bid volumes to the MARI platform:
    - Direct 50 MW
    - Schedule 100 MW
  - With the above conditions, TSO1 could submit the following needs:
    - A maximum of 150MW in total
    - A maximum of 50MW in direct needs
    - A maximum of 150MW in schedule needs

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Introduction

Main Settlement Principles:

- Settlement process shall be based on marginal pricing (pay-as-cleared)
- In case of congestion, there will be different marginal prices for the same imbalance settlement period (ISP) on both sides of the congested border.
- Direct and scheduled activation of bids will be allowed.

Working Assumptions (for the given examples):

- Trapezoid cross-border exchange profile with 10 min. ramps
- Direct activation takes place ahead of scheduled activation (see figure 2).
- The delivery period (TSO-TSO) is 15 minutes for scheduled activation (SA) and a maximum of 30 minutes for direct activation (DA).

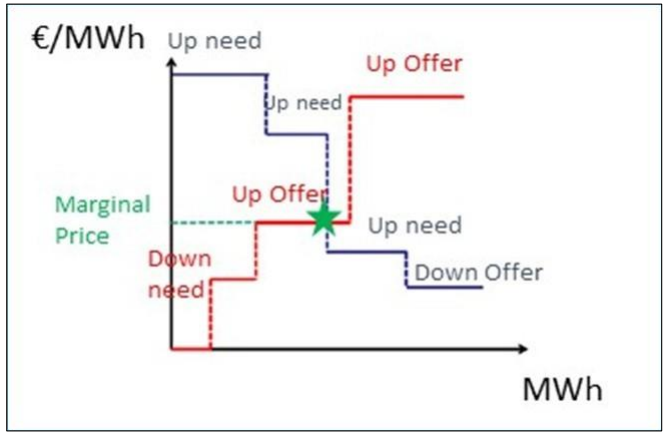


Figure 1: Cost Curve Formed by Bids and Elastic Demands

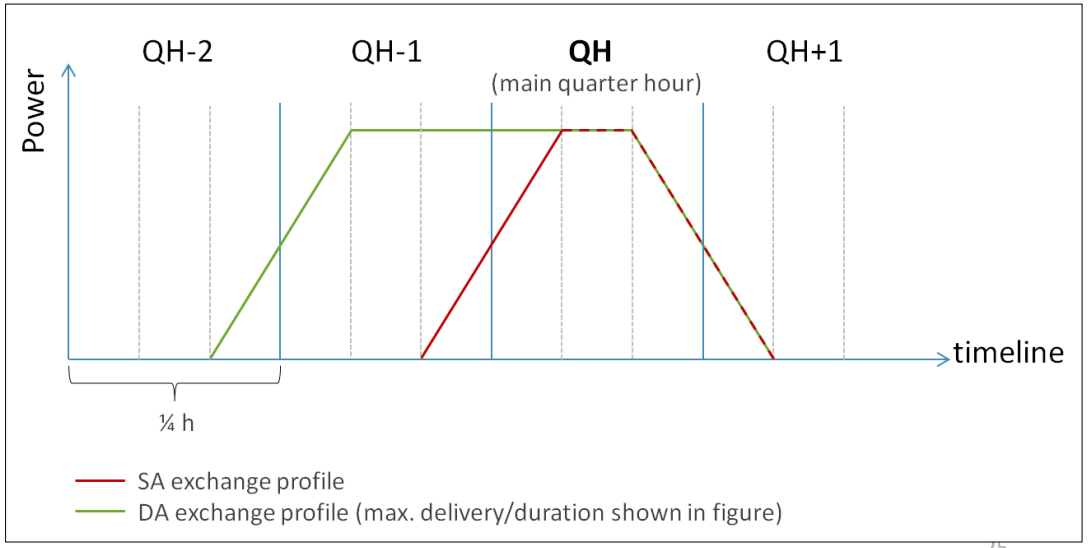


Figure 2: Exchange of direct and scheduled activated energy between TSOs

TSO-TSO Settlement – 1/6

Main Questions

- Which energy volumes and which prices should be applied for settlement?

TSO-TSO Settlement – 2/6

Determination of the Settlement Energy Volume – **Option 1**

- For scheduled activation, the exchanged energy is settled within the main quarter hour (QH), as represented by the red shaded area Vi in figure 3 .

- For direct activation, the same principle applies, i.e. area Vi is independent from the point in time of the direct activation, but all the additional volume exceeding area Vi is settled in QH-1 and is represented by the dark or light green shaded area in figure 4.

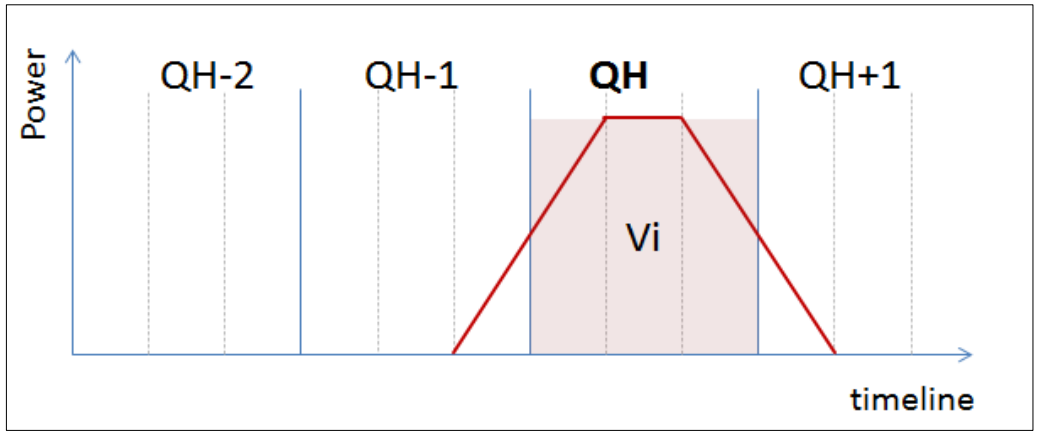


Figure 3: Settlement Energy Volume - Option 1 for SA

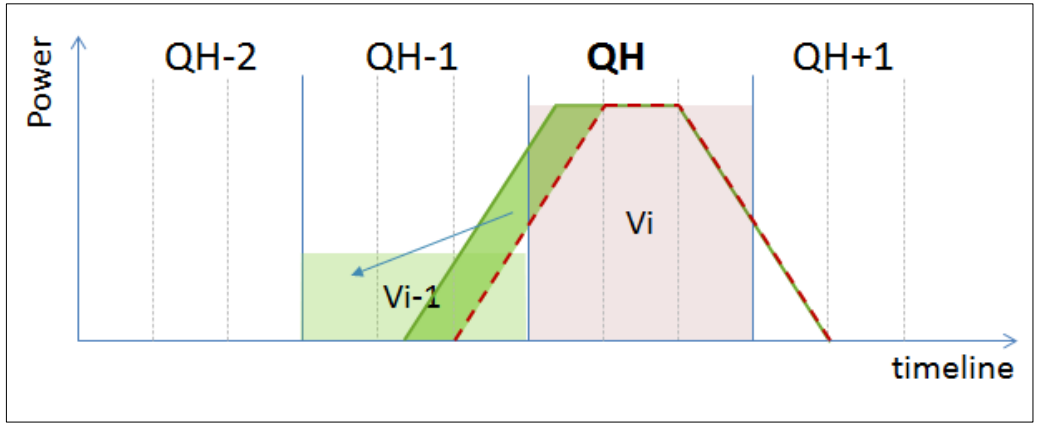


Figure 4: Settlement Energy Volume - Option 1 for DA

TSO-TSO Settlement – 3/6

Determination of the Settlement Energy Volume – **Option 2**

- For scheduled activation, the exchanged energy is settled in each quarter hour affected.
- Not be consistent with the algorithm. Moreover, the number of quarter hours affected is at maximum.

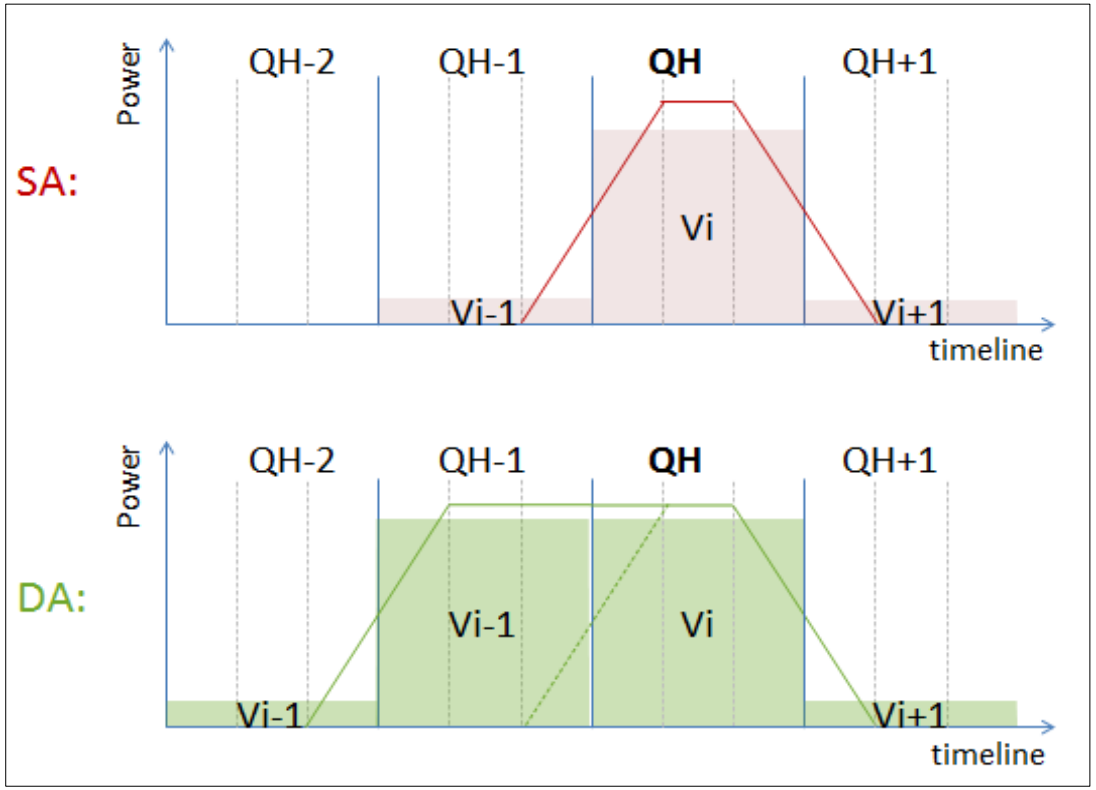


Figure 4: Settlement Energy Volume - Option 2 for SA and DA

TSO-TSO Settlement – 4/6

Determination of the Settlement Price - Criteria

	Criterion	Formula	Relevance
a.	Pay at least a bid price for all energies	For all i $P_{SA\ bid\ j}(QH_i) \geq P_{bid\ SA\ j}$; $P_{DA\ bid\ j}(QH_i) \geq P_{bid\ DA\ j}$	**Must**
b.	Price formulas for DA should not include prices (bid prices or clearing prices) of quarter hours which are not affected by the DA.		**Must**
c.	No financial incentive for TSO to activate sooner (DA before SA). DA bids should at least get what they would have gotten if they were schedule activated.	$P_{DA\ bid\ j}(QH_i) \geq P_{SA\ bid\ k}(QH_i)$ Where QH_i is the main QH for DA bid j	**Must**
d.	No financial incentive for TSO to activate sooner (DA before DA)	The price paid for the first DA bid should not be lower than the price paid for the last DA bid within the same main QH	**Must**
e.	No incentive for TSO to use DA for the next QH instead of SA (DA after SA)	$P_{DA\ bid\ for\ CMOL\ i+1}(QH_i) >= P_{SA\ bid\ from\ CMOL\ i}(QH_i)$	**Must**
f.	Incentives for BSP to submit direct activatable bids = no incentive to submit only SA bids (Important criteria since sufficient availability of DA bids is not ensured; MoU also allows pre-contracted bids to be only schedule activatable)	Allow for $P_{DA\ bid\ j}(QH_{i-1}) > P_{bid\ j}$ Where QH_i is the main QH for DA bid j. Cheaper SA bids should not be paid the same as DA in the main QH: SA should not get extra inframarginal rent.	Important for some TSOs with need for DA to ensure TTRF criteria
g.	Pay all mFRR energy volumes exchanged within the same QH at the same MP (transparency & simplicity reasons)		Nice to have (There can be different prices within one QH as long as BSPs are incentivized to bid at their marginal cost)
h.	Incentives for BSPs to bid at their marginal cost		Important
i.	Limited number of settlement prices for a single bid (simplicity) = 1 price (the same price for volumes in QHi-1 and QHi)		Nice to have
j.	Do not create a « Paradoxically Rejected Bids case » (i.e. SA bids with a price under the most expensive DA bid but over the price of SA need); transparency issue		Nice to have – Important

TSO-TSO Settlement – 5/6

Determination of the Settlement Price – A Options

❍ **A Options**: The clearing price **includes** DA bids for the respective main quarter hour QH_i

$P_{clearing,A}$ (QHi) = Max (activated **SA and DA bids** from CMOL QHi**)**

	A Options:	QH-2	QH-1	QH_i	QH+1
Clearing price		$P_{clearing,A}(QH_{i-2})$	$P_{clearing,A}(QH_{i-1})$	$P_{clearing,A}(QH_i)$	$P_{clearing,A}(QH_{i+1})$
SA Settlement Price	A	$P_{clearing,A}(QH_{i-2})$	$P_{clearing,A}(QH_{i-1})$	$P_{clearing,A}(QH_i)$	$P_{clearing,A}(QH_{i+1})$
DA Settlement Price (for bids from CMOL QH_i)	A1	-	$P_{clearing,A}(QH_{i-1})$	$P_{clearing,A}(QH_i)$	-
	A2	-	Max ($P_{clearing,A}(QH_{i-1})$; prices of DA bids activated for the main QH_i)	$P_{clearing,A}(QH_i)$	-
	A3	**-**	**$P_{clearing,A}(QH_i)$**	**$P_{clearing,A}(QH_i)$**	**-**
	A4	-	Max(prices of DA bids activated for the main QH_i)	$P_{clearing,A}(QH_i)$	-
	A5	**-**	**Max($P_{clearing,A}(QH_i)$, $P_{clearing,A}(QH_{i-1})$)**	**Max($P_{clearing,A}(QH_i)$, $P_{clearing,A}(QH_{i-1})$)**	**-**
	A6	-	Max($P_{clearing,A}(QH_i)$, $P_{clearing,A}(QH_i)$)	$P_{clearing,A}(QH_i)$	-

TSO-TSO Settlement – 6/6

Determination of the Settlement Price – B Options

- **B Options**: The clearing price **excludes** DA bids for the respective main quarter hour QH_i, i.e. the clearing price can be higher or lower than the highest direct activated bid price

$P_{clearing,B}(QH_i)$ = Max (prices of **SA bids** activated for the main QH_i**)**

	B Options:	QH-2	QH-1	QH_i	QH+1
Clearing price		$P_{clearing,B}(QH_{i-2})$	$P_{clearing,B}(QH_{i-1})$	$P_{clearing,B}(QH_i)$	$P_{clearing,B}(QH_{i+1})$
SA Settlement Price	B	$P_{clearing,B}(QH_{i-2})$	$P_{clearing,B}(QH_{i-1})$	$P_{clearing,B}(QH_i)$	$P_{clearing,B}(QH_{i+1})$
DA Settlement Price (for bids from CMOL QH_i)	B1	-	Max($P_{clearing,B}(QH_i)$; prices of DA bids activated for the main QH_i)	Max($P_{clearing,B}(QH_i)$; prices of DA bids activated for the main QH_i)	-
	B2	**-**	**Max($P_{clearing,B}(QH_i)$; $P_{clearing,B}(QH_{i-1})$; prices of DA bids activated for the main QH_i)**	**Max($P_{clearing,B}(QH_i)$; $P_{clearing,B}(QH_{i-1})$; prices of DA bids activated for the main QH_i)**	-

Congestion Rent – 1/3

Main Questions

- How to share the surplus which results in the case of congestions?

Congestion Rent – 2/3

Concept and Formula

❍ Concept:

- **Congestion** is the situation where transmission capacity available between areas is not sufficient to accommodate all the more efficient transactions (optimization of social welfare)
- **"Congestion rent" =** In case of congestion, there is a price difference between the price that an area is "willing to pay" and the price that the other area is "willing to receive" at either side of the interconnector.
- → **Thus, a surplus from the congested interconnection will occur.**

❍ Definition/Formula:

Congestion rent [€] **= Imported volume** [MWh] **x (MP of the exporting TSO** [€/MWh] **– MP of the importing** TSO [€/MWh]**)**

❍ Sharing:



- Congestion rent resulting from mFRR activations = "congestion income" (Regulation 714/2009 article 16-6)?

  Working assumption: Yes → implicit allocation of available capacity in the context of balancing services.

Congestion Rent – 3/3

Possible Sharing Options

OPTION A: Importing TSO

- Distribution of the global congestion rents between importing countries, proportional to their imports.

OPTION B: Exporting TSO

- Distribution of the global congestion rents between exporting countries, proportional to their exports.

OPTION C: All countries

- Sharing of the global congestion rents, proportional to the absolute value of their net position.

OPTION D: Sharing based on existent methodologies currently applied for LT/DA/ID

- First, distribution by interconnector: **proportional to installed cross-border capacity** (or allocated capacity for HVDC) of interconnectors in relevant borders.
- Second, distribution between TSOs/interconnector owners by applying different possible keys: 50/50, 100% to one entity, or other agreements.

OPTION E: Distribution based on CID methodology for DA/ID market ("All TSO proposal")

- First, distribution by interconector: depending on the capacity calculation approach (either NTC or FB)- **Based on a parameter** (agreed between TSOs and approved by relevant **NRA**s) which takes into account the interconnector´s contribution to the allocated capacity
- Second, distribution between TSOs/interconnector owners by applying different possible keys: 50/50, 100% to one entity, or other agreements.

[Net Position (NP) = allocated volumes – TSO needs]

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TSOs would like to propose a list of topics for harmonization to be evaluated by Stakeholders (1/2)

Bid Format	
Considered Aspect for Harmonization	Description
► Maximum bid size	The maximum size of a divisible or indivisible bid, which can be offered at one time.
► Price limits	Existence of maximum and/or minimum price for the bid.
► Requirements for Direct Activated products and for Scheduled activated products	Some TSOs perform mFRR process mainly based on scheduled products, while other would require more direct activated products
► Application of the "expected shape" of a trapezoid with 10 min ramps (up / down)	Although the algorithm optimizes the block of energy, the expected shape to be delivered by the BSP should be a trapeze with 10 min ramps up/down
► Definition of the "accepted shape" of the product	The local tolerance bands for bids accepted by the national TSOs
Settlement of TSO-BSP	
Considered Aspect for Harmonization	Description
► Application of cross border marginal price to the BSP activated bid (= same as TSO-TSO price);	Settlement to the BSP at the XBMP
► Energy settled (energy corresponding to the block of energy offered by the BSP);	Volume of energy taken into account for the settlement to the BSP (energy corresponding to the activated bid)
► Incentives applied to the BSPs:	
► "Desired shape":	Incentive to follow the desired shape (through power profile or through energy schedules), and application of a tolerance band;
► Existence of penalties	Existence of financial consequences (penalty) in case of under/over delivery of the power profile or the energy schedule
► Penalties price principles	Principles/components of the price applied for the penalties.

Settlement TSO-TSO	
Considered Aspect for Harmonization	Description
► Application of cross border marginal price to the energy scheduled and exchanged (Block	Settlement between TSOs at the XBMP for the energy exchanged (scheduled) between them
► Energy settled (blocks of energy converted into the "desired shape" trapezes	Volume of energy scheduled and settled between the TSOs as resulting from mFRR algorithm

TSOs would like to propose a list of topics for harmonization to be evaluated by Stakeholders (2/2)

Other Topics for Harmonization	
Considered Aspect for Harmonization	Description
► Prequalification requirements	Technical, contractual, IT and/or regulatory conditions in order to perform the prequalification process
► IT requirements	The requirements concerning the IT connection between the BSP and the TSO and between the BSP and the units (Redundancy,...).
► Back-up requirements	The requirements concerning back-up units in a pool which shall deliver balancing energy if a unit in the pool has an outage e.g. in some countries at least one back-up unit is required.
► Transfer of balancing obligations	Existence and conditions for the transfer of balancing obligations related to mFRR, between BSPs
► Independent BSP:	Existence of entity of independent BSP
► Scheduling requirements	Balancing energy has to be delivered relative to a reference point which could be a schedule value which is valid for e.g. 15 min. Scheduling requirements can vary concerning the aspect how long in advance a schedule has to be sent and for how long this schedule is valid.
► Real time measurement requirements	This aspects describes how many data in which resolution have to be sent to the TSO in real time.

mFRR gate opening time	
► mFRR gate opening time (BSPs)	Moment from which the BSPs can start sending mFRR bids to the TSOs
► mFRR gate opening time (TSOs)	Moment from which the TSOs can start sending mFRR bids to the mFRR platform
mFRR gate closure time	
► mFRR gate closure time (BSPs):	Moment after which reception of bids from BSPs to the TSO are no more accepted
► mFRR gate closure time (TSOs)	Moment after which reception of bids from TSOs to the mFRR platform are no more accepted
► Nature of mFRR market:	Nature of the mFRR energy market: obligation to offer into the market or voluntary provision.
mFRR need:	
► Reasons for activating bids for other purposes than balancing	e. g. how to solve a congestion
► Transparency	Transparency requirements from Transparency Regulation and from GLEB (common publications and National publications).

Thank you for your attention!

Annex 1: SPECIFICATION of ACTIVATION OPTIMIZATION FUNCTION

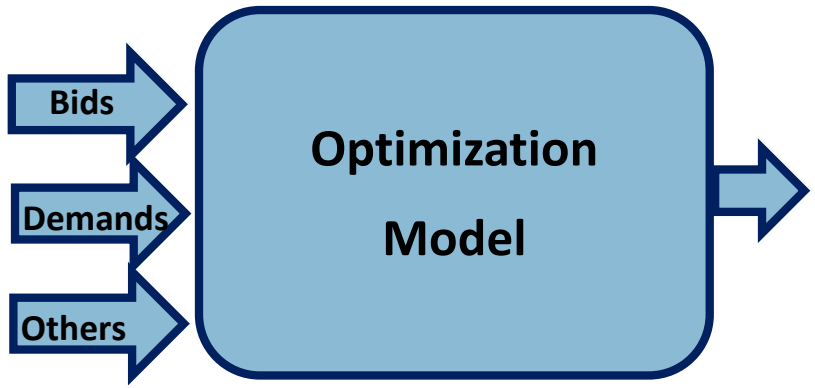
Algorithm Components – 1/4

Main Questions

- What should the objective of the activation optimization function be?

Algorithm Components – 2/4

Inputs	Optimization Model	Output
❍ Bids • Divisible • Indivisible ❍ Demands • Elastic • Inelastic ❍ Power Flow Limits • ATC • Internal Zones	❍ **Objective function** • Maximizing social welfare (i.e., minimizing balancing cost) ❍ **Constraints** • Power balance equation (netting) • Power flow constraints • HVDC constraints	❍ Activated quantities ❍ Satisfied demands ❍ XB marginal prices ❍ Social welfare/Balancing cost



Activated quantities

Satisfied demands

XB marginal prices

Optimal social welfare (Balancing cost)

Computation Time

Multiple Optimal Solution

Feasibility Checks

Algorithm Components – 3/4

Core Optimization Model

Objective:
Maximize social welfare (minimize balancing cost)

Subject to:

1. Power Balance Constraints	→	Activated bids/offers are equal to TSO demands
2. Power Flow Constraints	→	Power flow due to activated bids/offers is within required limits (ATC & internal zones)
3. Divisibility of Bids/Offers	→	Bids can be divisible or indivisible, linked bids, mutually exclusive bids etc.
4. Elasticity of TSO Demands	→	TSO demands can be either elastic or inelastic

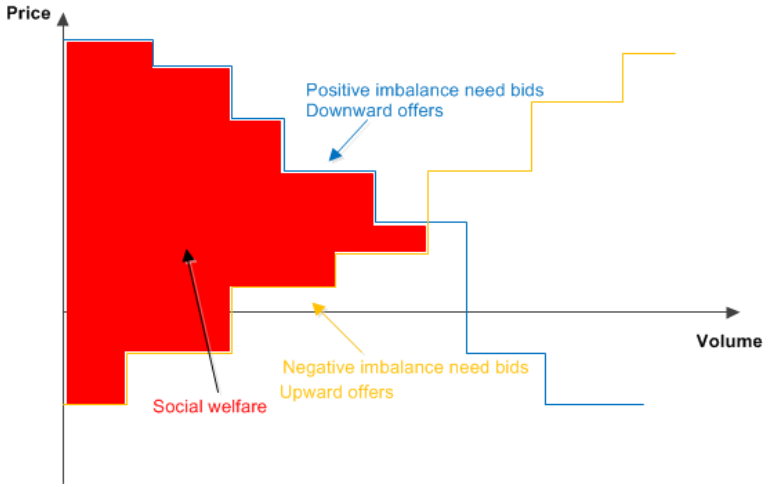
Algorithm Components – 4/4

Main Constraints

- **Maximizing social welfare (i.e., Minimizing balancing cost)**

- Power balance constraint: **Netting of the TSO demands inherently occurs**. The netting of the TSO demands occurs as long as it results in higher social welfare and it does respect other technical constraints, e.g. power flow constraints.

- Power flow constraint: ATC and internal zones → **TSOs with internal zones must also specify the location of their bids & offers**



Unforeseen Rejected Bids– 1/4

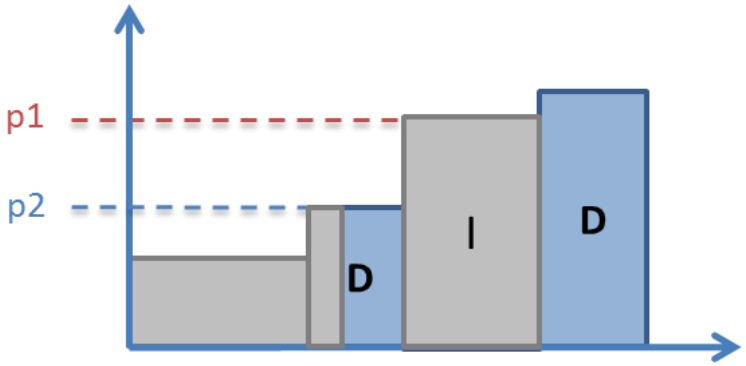
Main Questions

- How unforeseen accepted divisible bids shall be treated?

Unforeseen Rejected Bids – 2/4

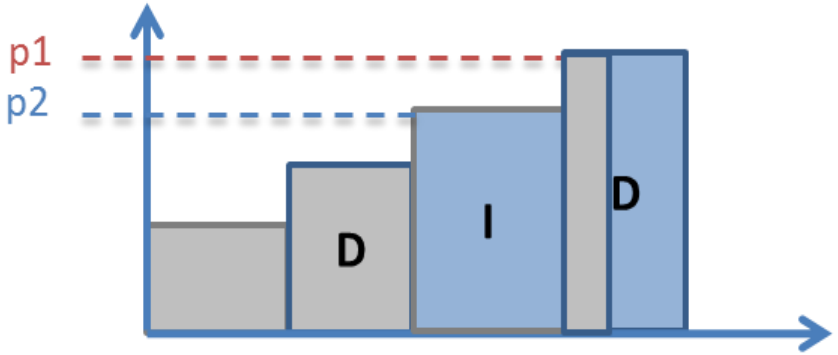
❍ The algorithm handles **complex** bid formats → unforeseen rejected bids

Unforeseen rejected divisible bid



D: divisible bid
I: indivisible bid
accepted part
not accepted part

Unforeseen rejected indivisible bid



Unforeseen Rejected Bids– 3/4

Unforeseen Rejected Divisible Bids - 1/2

INPUT:

TYPE	Quantity (MW)	TSO Demand Price/Offer Price (€/MWh)	Elasticity of Demand	Divisibility of Offers
Demand (TSO 1)	+100	--	Inelastic	--
Demand (TSO 2)	+100	--	Inelastic	--
Upward Offer (UO BSP1)	190	10	--	Indivisible
Upward Offer (UO BSP2)	8	20	--	divisible
Upward Offer (UO BSP3)	10	21	--	Indivisible
Upward Offer (UO BSP4)	2	30	--	Indivisible

OUTPUT:

Type	Output of Balancing Cost minimization (allowing unforeseen rejected divisible bids) Activated Quantity/Satisfied Demand (MW)	Output of Market-Coupling model (avoiding unforeseen rejected divisible bids) Activated Quantity/Satisfied Demand (MW)
Demand (TSO 1)	+100	+100
Demand (TSO 2)	+100	+100
Upward Offer (UO BSP1)	190	190
Upward Offer (UO BSP2)	0	8
Upward Offer (UO BSP3)	10	0
Upward Offer (UO BSP4)	0	2
Marginal Price (€/MWh)	€21/MWh	€30/MWh
Balancing cost (€)	2110	2120

Unforeseen Rejected Bids– 4/4

Unforeseen Rejected Divisible Bids – 2/2

QUALITATIVE ANALYSIS:

Criteria (Algorithm point of view)	Allowing unforeseen rejected divisible bids (Social-welfare Maximization)	Avoiding unforeseen rejected divisible bids (Market-Coupling Algorithm)
Optimal Social Welfare (Minimum Balancing Cost)	Smaller Balancing Cost	Higher Balancing Cost
Complexity Level of Algorithm	Low (Simple) (solving a primal clearing model)	High (Complex) (including a non-linear constraint and solving a primal-dual problem)
Computation Time	Lower computation time	Higher computation time

Computation Time – 1/2

Qualitative Statement

- **Impact of linking bids/offers:**

  → *Linear constraint should be tractable in a reasonable time.*

- **Impact of zones with different resolution (size) in the power flow constraints:**

  → *Linear constraint should be tractable in a reasonable time.*

- **Impact of avoiding unforeseen rejected divisible bids:**

  → Non-*linear constraint may influence computation time.*

Computation Time – 2/2

Quantitative Statement

Need of Simulations:

- **Actual Market Size**
  - Actual number of divisible and indivisble bids
  - ATC & Internal Zones
- **Strong Computation Engine**
  - RAM > 512 GB
  - Processor Clock > 2.9 GHz
- ***Know-how of techniques reducing the computation time***
  - Decomposition & Parallel Computing

Multiple Optimal Solutions– 1/3

Main Questions

- How should multiple optimal solutions be treated?

Multiple Optimal Solutions - 2/3

Case 1: a set of optimal solutions with different marginal prices:

TYPE	Quantity (MW)	TSO Demand Price/Offer Price (€/MWh)	Elasticity of Demand	Divisibility of Offers
Demand (TSO 1)	+100	--	Inelastic	--
Demand (TSO 2)	+100	--	Inelastic	--
Upward Offer (UO BSP1)	190	10	--	Divisible
Upward Offer (UO BSP2)	8	20	--	Indivisible
Upward Offer (UO BSP3)	10	21	--	Indivisible
Upward Offer (UO BSP4)	2	25	--	Indivisible

Type	Solution A Activated Quantity/Satisfied Demand (MW)	Solution B Activated Quantity/Satisfied Demand (MW)
Demand (TSO 1)	+100	+100
Demand (TSO 2)	+100	+100
Upward Offer (UO BSP1)	190	190
Upward Offer (UO BSP2)	0	8
Upward Offer (UO BSP3)	10	0
Upward Offer (UO BSP4)	0	2
Marginal Price (€/MWh)	€21/MWh	€25/MWh
Social welfare (€)	-2110	-2110

SUGGESTION:

Solution A → Optimal Solution with Smaller Marginal Price

Multiple Optimal Solutions – 3/3

Case 2: a set of optimal solutions with same marginal prices

TYPE	Quantity (MW)	TSO Demand Price/Offer Price (€/MWh)	Elasticity of Demand	Divisibility of Offers	Area
Demand (TSO 1)	+100	--	Inelastic	--	Area 1
Demand (TSO 2)	+100	--	Inelastic	--	Area 2
Upward Offer (UO BSP1)	190	10	--	Divisible	Area 1
Upward Offer (UO BSP2)	8	20	--	Indivisible	Area 2
Upward Offer (UO BSP3)	10	20	--	Indivisible	Area 3
Upward Offer (UO BSP4)	2	20	--	Indivisible	Area 4

Type	Solution A Activated Quantity/Satisfied Demand (MW)	Solution B Activated Quantity/Satisfied Demand (MW)
Demand (TSO 1)	+100	+100
Demand (TSO 2)	+100	+100
Upward Offer (UO BSP1)	190	190
Upward Offer (UO BSP2)	0	8
Upward Offer (UO BSP3)	10	0
Upward Offer (UO BSP4)	0	2
Marginal Price (€/MWh)	€20/MWh	€20/MWh
Social welfare (€)	-2110	-2110

SUGGESTION:

Solution B → Optimal Solution with Smaller Energy Exchange between TSOs connections (power flow)

Feasibility Checks – 1/2

- The main source of an infeasible solution is to have a total demand quantity higher than the total quantity of offers/bids.
- **Solution A**: Each TSO is allowed to submit a demand which is not larger than the total bids/offers from the BSPs associated with this TSO. That is, if there are TSOs whose demand is more than their total amount of its associated offers, these TSO are excluded from the algorithm in that interval (both their demands and associated bids).
- **Solution B**: Another alternative solution is that only a part of the demand of this TSO will be satisfied (up to the amount which does not lead to infeasibility).

Feasibility Checks – 2/2

TYPE	Quantity (MW)	TSO Demand Price/Offer Price (€/MWh)	Elasticity of Demand	Divisibility of Offers	Area
Demand (TSO 1)	+10	--	Inelastic	--	Area 1
Demand (TSO 2)	+10	--	Inelastic	--	Area 2
Demand (TSO 3)	+10	--	Inelastic	--	Area 3
Upward Offer (UO BSP1)	10	40	--	Divisible	Area 1
Upward Offer (UO BSP2)	10	50	--	Indivisible	Area 2
Upward Offer (UO BSP3)	7	60	--	Indivisible	Area 2
Upward Offer (UO BSP4)	2	70	--	Indivisible	Area 2

Type	Solution A Activated Quantity/Satisfied Demand (MW)	Solution B Activated Quantity/Satisfied Demand (MW)
Demand (TSO 1)	+10	+10
Demand (TSO 2)	+10	+10
Demand (TSO 3)	0	+9
Upward Offer (UO BSP1)	10	10
Upward Offer (UO BSP2)	10	10
Upward Offer (UO BSP3)	0	7
Upward Offer (UO BSP4)	0	2
Marginal Price (€/MWh)	€50/MWh	€70/MWh
Social welfare (€)	-900	-1460

SUGGESTION:

Solution B → Higher social welfare (due to satisfying a higher demand)

Summary - To be Decided

- The objective function is to maximize social welfare (i.e. minimizing balancing costs)
- Elasticity of TSO demand will be allowed
- Several constraints are to be satisfied: Balance constraints, power flow constraints and HVDC constraints
- Computation time may become a relevant issue when increasing algorithm complexity
- Proposals for dealing with multiple optimal solutions were presented
- Feasibility checks to be implemented as well

Annex 2: CONGESTION MANAGEMENT

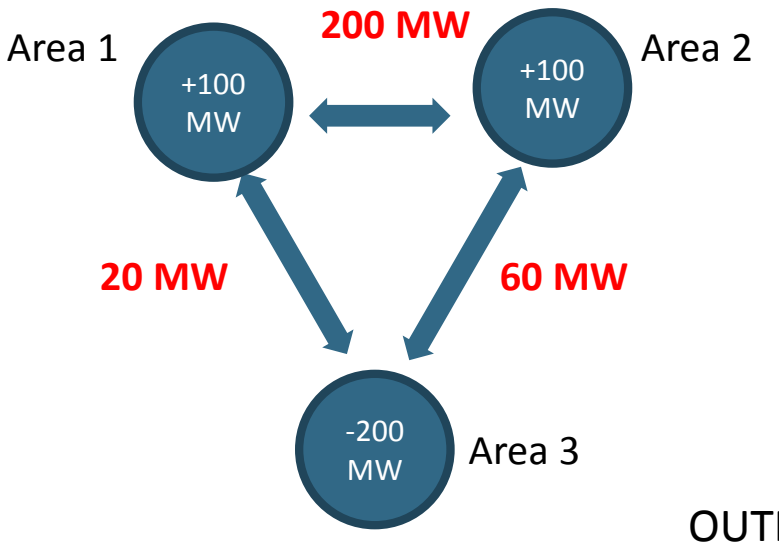
Main Question

- What are the measures available to the TSOs to handle congestions?

Options Overview

1. Limiting ATC
2. Filtering Bids and Re-dispatch
3. Critical Network Element
4. Smaller internal mFRR Zones
5. Several TSOs Build a Cluster

Option 1 – Limiting ATC



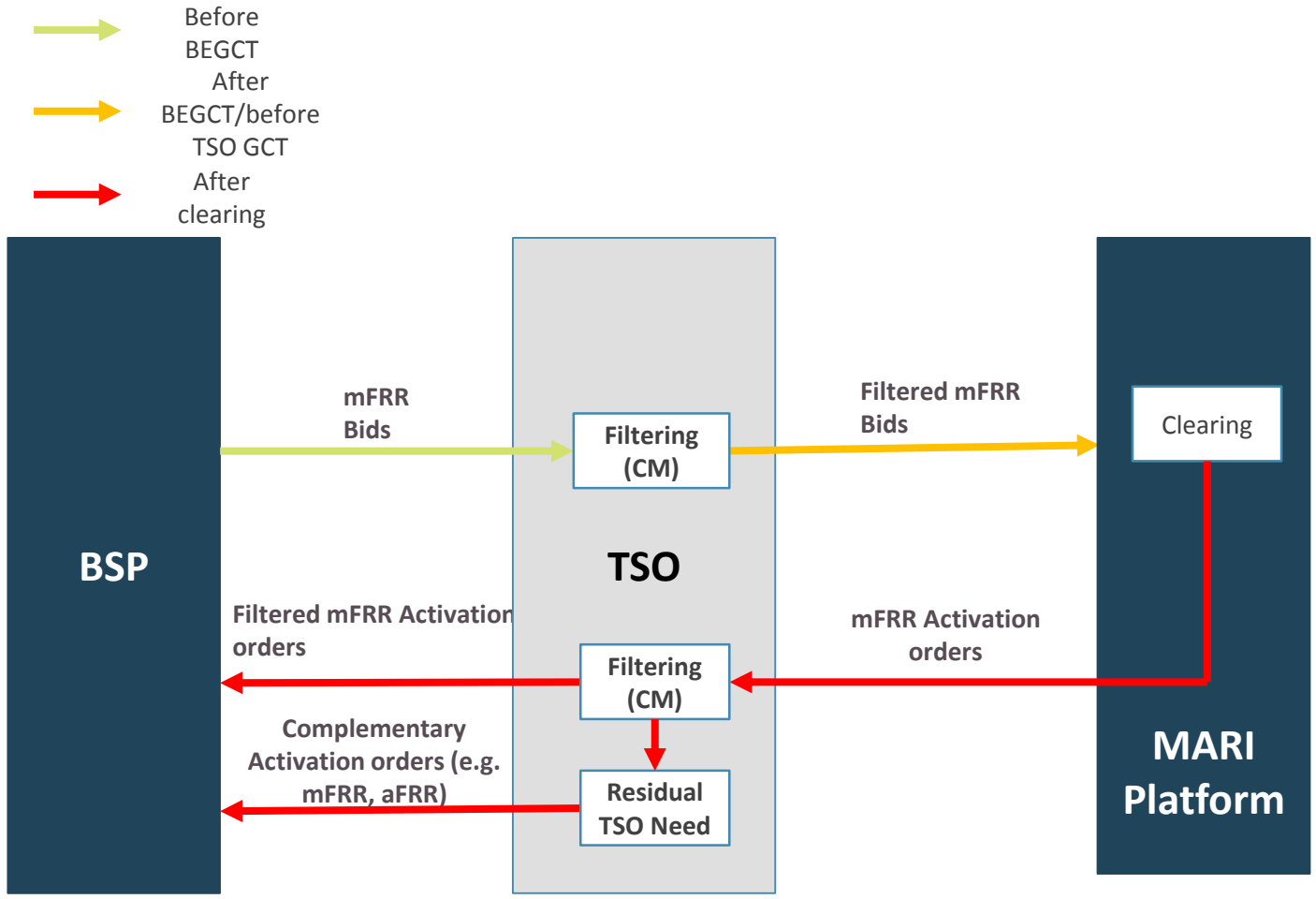
ATC limits are set to the corresponding allocated capacity for each border

TYPE	Quantity (MW)	TSO Demand Price/Offer Price (€/MWh)	Elasticity of Demand	Divisibility of Offers	Area
Demand (TSO 1)	+100	--	Inelastic	--	Area 1
Demand (TSO 2)	+100	--	Inelastic	--	Area 2
Demand (TSO 3)	-200	--	Inelastic	--	Area 3
Upward Offer (UO BSP1)	100	10	--	Divisible	Area 1
Upward Offer (UO BSP2)	30	20	--	Divisible	Area 2
Downward Offer(DO BSP2)	-50	-20	--	Divisible	Area 2
Downward Offer (DO BSP3)	-200	-50	--	Divisible	Area 3

OUTPUT

Type	Activated Quantity/Satisfied Demand (MW)	
Demand (TSO 1)	+100	
Demand (TSO 2)	+100	
Demand (TSO 3)	-200	
Upward Offer (UO BSP1)	100	
Upward Offer (UO BSP2)	20	
Downward Offer (DO BSP2)	0	
Downward Offer (DO BSP3)	-120	
Social welfare (€)	XB Marginal Price (€/MWh)	
-(10*100+20*20+50*50) =-3900	Area 1 & 2: €20/MWh	Area 3: €50/MWh

Option 2 – Filtering bids and re-dispatch – 1/2



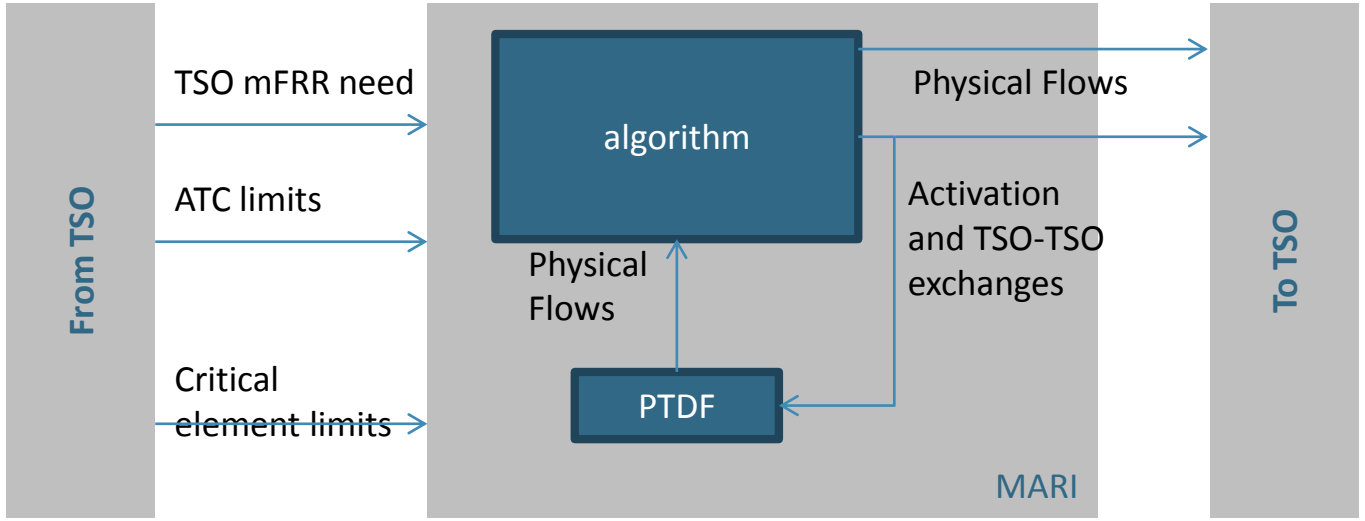
Option 2 - Filtering bids and re-dispatch – 2/2

- **Before clearing (filtering)**
  - BSP will send the mFRR bids to the TSO
  - Each TSO will have the possibility to filter the bids which contain a unit which may endanger network security if activated.
  - The TSO will then send the corresponding bid with status unavailable to the MARI platform
- **Clearing**
  - The algorithm shall only clear with the bids with a status available.
- **After clearing (re-dispatch)**
  - If a congestion appears after the bids were already sent to the MARI platform, then if the bids were selected by the clearing for activation, the TSO has the possibility to block the activation and do re-dispatch if the TSO has the time to do so. Otherwise aFRR (or other complementary activation orders) will have to compensate the non-activation.

Option 3 - Critical Network Element – Objective - 1/2

- **Principles:**
  - The usage of ATC limits shall provide enough security to cover most of the operational cases. However, in some rare cases it may not be sufficient to guarantee enough security for some critical network element influenced by the exchanges of mFRR.
  - In such a case, it would help TSOs to have a real time monitoring of the impacts in terms of physical flows of mFRR exchanges on a predefined set of critical network elements.
  - And then when a situation in real time leads to a congestion on one of the critical elements, a limit of admissible physical flow shall be set on this network element and taken into account by the algorithm in order to guarantee the clearing will not induce higher physical impact on this network element.
  - Once the congestion is relieved, then the limit may be released by the operator.
- **Notes:**
  - The advantage of this approach is that it is needed at least at the first step of a complete flow-based safety domain calculation to be able to manage congestion on critical elements.
  - This approach enables to target the element which is concerned by the congestion (explicit for the operators)

Option 3 - Critical Network Element – 2/2

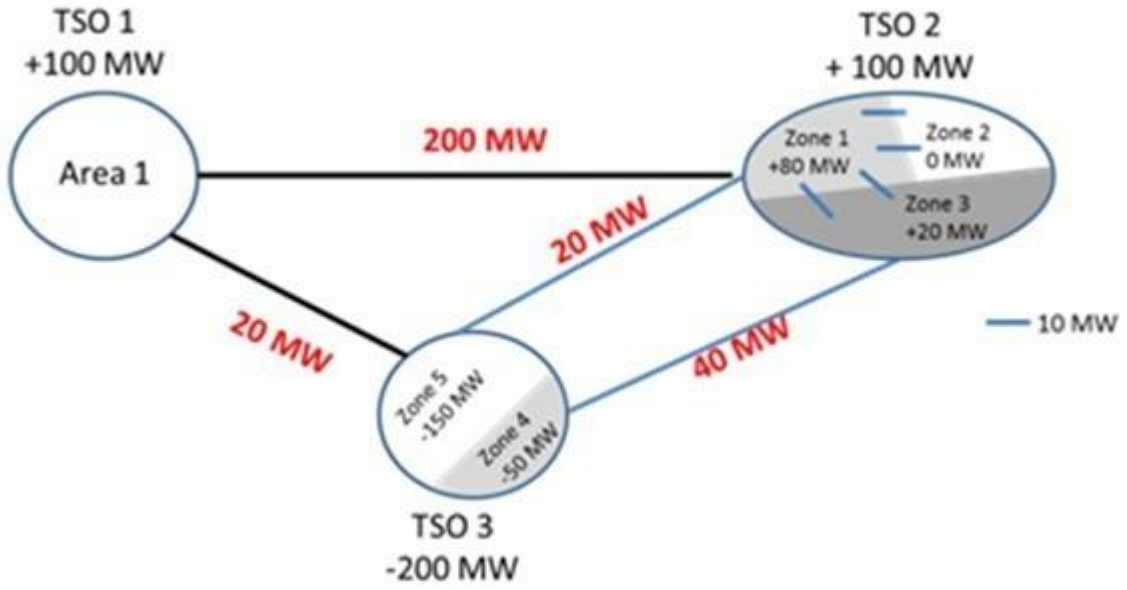


- **Notes:**
  - The critical element limits are additional to the ATC limits
  - A PTDF matrix has to be defined and used by the algorithm to provide:
  - In real time the physical flows induced by MARI activation
  - To integrate a limit when applied on a network element to guarantee the resulting exchanges will not induce higher physical flows than the limit provided by the TSO

Option 4 - Smaller internal mFRR zones

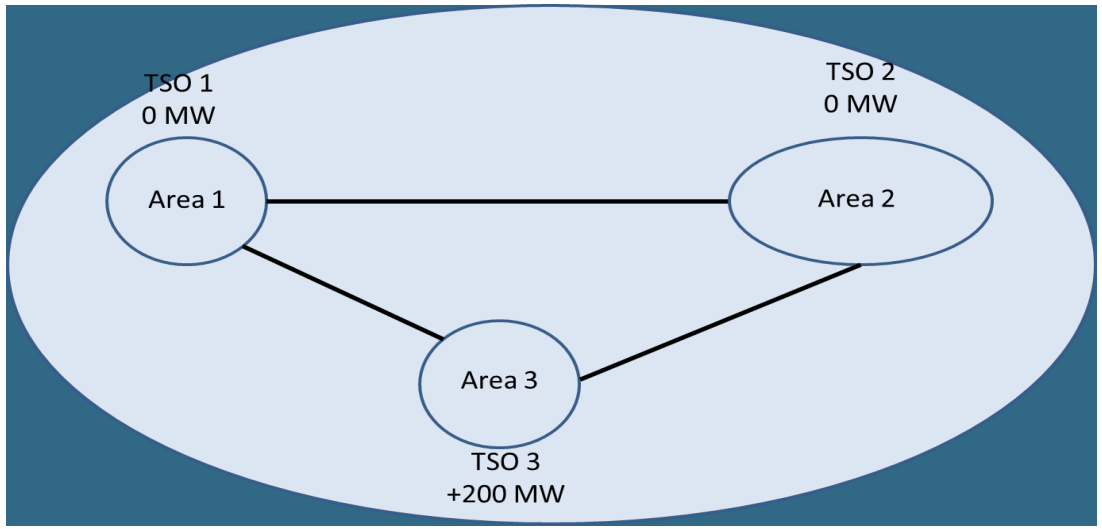
- Some TSOs may need to divide their area into several smaller internal mFRR zones to handle internal congestions within the ID bidding area.

- The algorithm contains a finer network model according to internal congestions than used by the XBID model. TSOs use this option to submit bids and request for each of these smaller internal mFRR zones.



Option 5 - Several TSOs Build a Cluster

- Some TSOs have a need for representing their network model, building a cluster together with other TSOs
- If bids were to be activated within this cluster, bids from a certain TSO would be given precedence over the other TSOs to a certain amount of MWs.
- The inputs to the algorithm include the control zones involved, the priority TSO and the amount of MW to be activated from this TSO



Conclusions and Next Steps

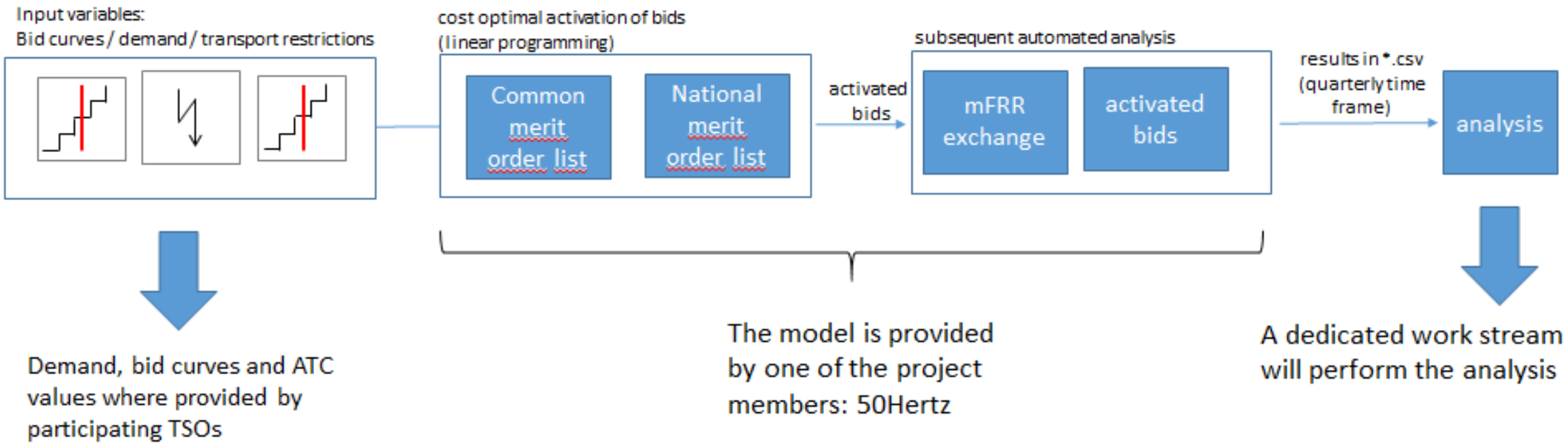
- There are two aspects of congestion management that the MARI WS CM has recognized.
  1. To make sure in the Platform that bids that are activated for balancing purposes are not going to downgrade or endanger the system security. This aspect shall be mandatory for MARI implementation.
  2. TSOs need to activate bids for other purposes such as counter trade/re-dispatch for already identified or occurred congested situations. This aspect is open to further investigation for MARI implementation.
- For the first aspect, the WS CM has interpreted GL EB that same area definition should be used for mFRR as intraday: i.e. same CZC capacities as defined between Intraday Bidding zones.
  - In such a case, to handle internal and external congestion TSOs foresee a need for additional measures. The following measures have been identified so far and will be further analyzed for potential implementation in the MARI project .
    - TSO limits ATC before the mFRR algorithm
    - TSO filters bids (make them unavailable) before the mFRR algorithm
    - Smaller internal mFRR zones in the mFRR algorithm
    - Critical network elements in the mFRR algorithm
    - Several TSOs form a cluster in the mFRR algorithm
    - Re-dispatch the resulting flow after the mFRR algorithm
  - The next step for WS CM is to further evaluate these measures in order to develop a common methodology for congestion management probably based on a combination of these measures.

Annex 3: INFORMATION on SIMULATION

Simulation Goals

- Demonstrate the benefit of the cooperation
- Demonstrate the social welfare impact of the cooperation

Simulation Model: Set-Up



Objective of the model is to compare a Common Merit Order List based activation to a National Merit Order List based activation strategy

Simulation Model: Assumptions

- **Based on historical data (2016)**
  - Demand per bidding zone
  - ATC values
  - Representative bid curves
- **Simulation on a quarter-hourly timescale**
  - All demand and activations are considered scheduled, not direct
  - Netting of up- and downwards demands
- **All bids considered divisible**
  - No quantification of the effect of indivisible bids
- **ATC values only, no flow-based approach**
  - No view on actual energy flows, loop flows,…

Simulations: Status

- 22 TSOs out of 26 current members/observers were modeled
  - Remaining 4 joined the cooperation after data gathering phase or couldn‘t deliver the required data in due time
- First simulation results have been generated, while analysis and post-processing of these results is ongoing.