IMPACT OF SHORT-TERM MARKET SEQUENCES ON BIDDING BEHAVIOR OF MARKET PARTICIPANTS

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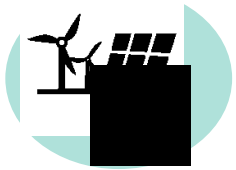
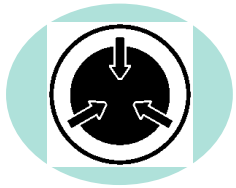
MOTIVATION

Far-reaching reforms in the design of the European balancing markets and their harmonization to:

Increase grid flexibility



Integrate vRES, small-scale providers



Progressive integrate balancing markets

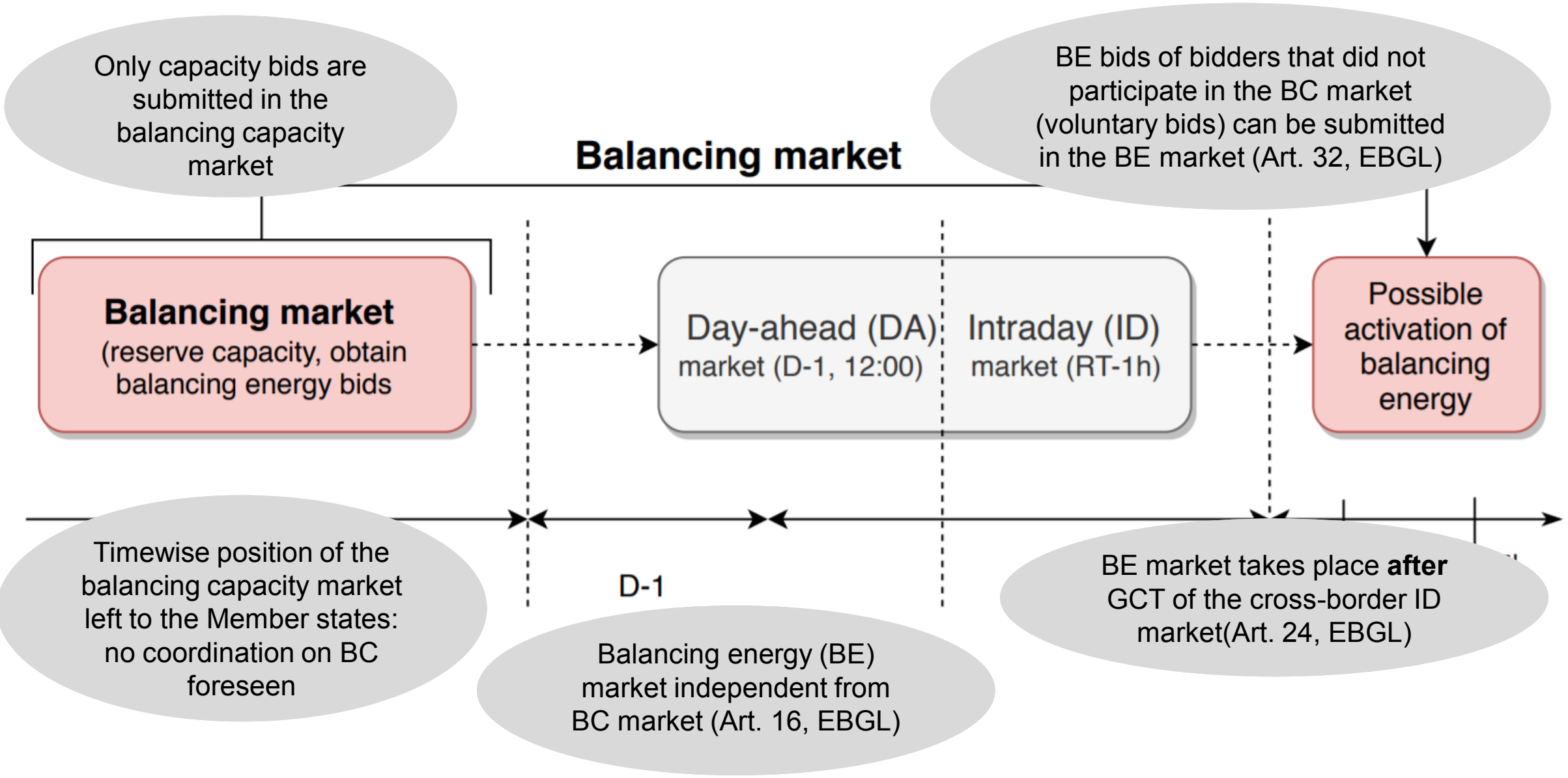
Increase balancing market efficiency

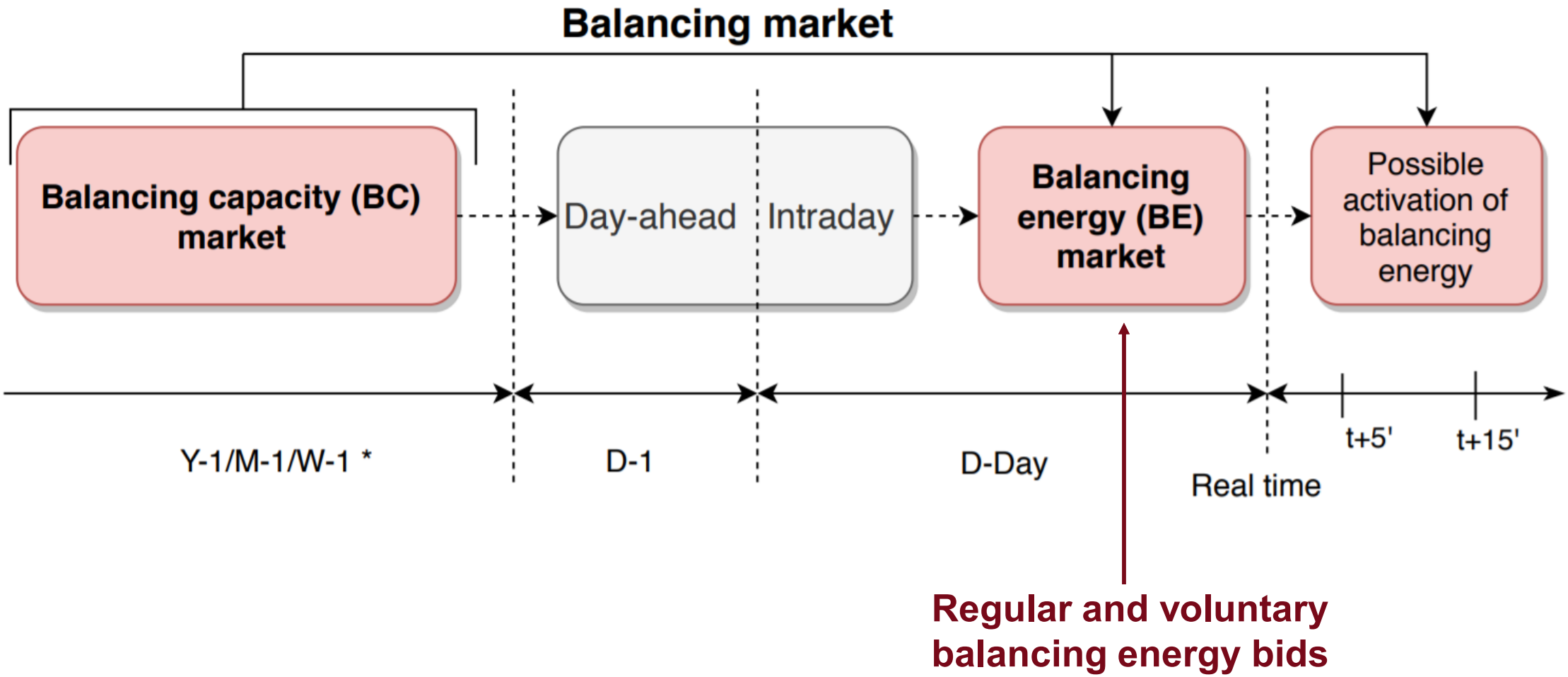
→ **EU guideline on electricity balancing (EBGL)** binding for all Member States, adopted end of 2017

1) Separation of the balancing capacity and balancing energy markets
2) Introduction of voluntary balancing energy bids

→ Changes in market design and particularly market sequences affect the cost structures of balancing market participants, esp. their opportunity costs.

→ What is expected effect market sequences and introduction of voluntary bids on bidding behavior and market outcome?


Only capacity bids are submitted in the balancing capacity market
BE bids of bidders that did not participate in the BC market (voluntary bids) can be submitted in the BE market (Art. 32, EBGL)
Balancing market
Balancing market
(reserve capacity, obtain balancing energy bids
Day-ahead (DA) market (D-1, 12:00)
Intraday (ID) market (RT-1h)
Possible activation of balancing energy
Timewise position of the balancing capacity market left to the Member states: no coordination on BC foreseen
D-1
Balancing energy (BE) market independent from BC market (Art. 16, EBGL)
BE market takes place **after** GCT of the cross-border ID market(Art. 24, EBGL)


Balancing market
Balancing capacity (BC) market
Day-ahead
Intraday
Balancing energy (BE) market
Possible activation of balancing energy
Y-1/M-1/W-1 *
D-1
D-Day
Real time
t+5'
t+15'
Regular and voluntary balancing energy bids

APPROACH

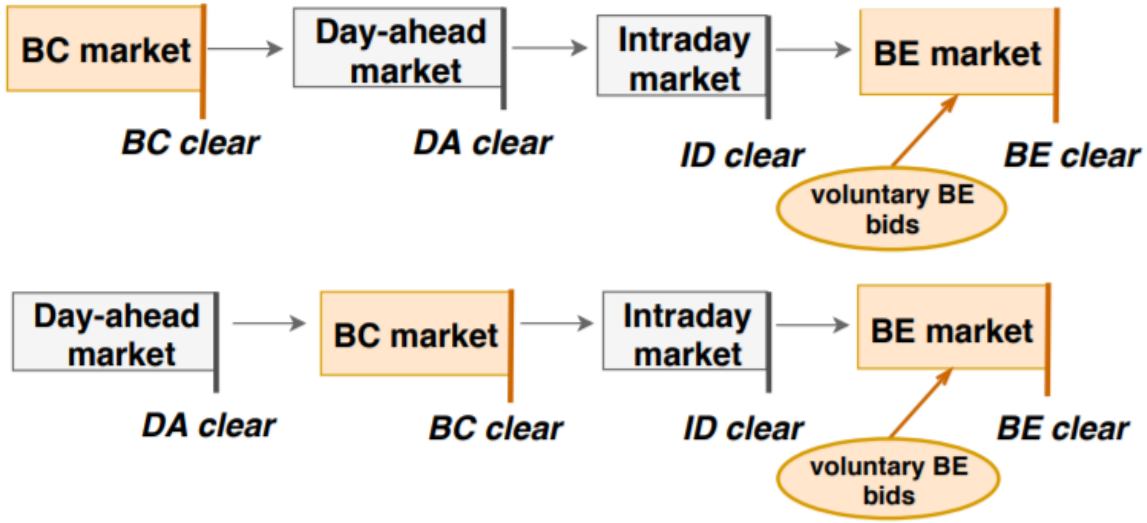
Method: Classical decision theory to illustrate the underlying incentive structures of balancing service providers under different market sequences for the analysis of **3 use cases:**

Case 1: Current design: joint market for balancing capacity (BC) and energy (BE)

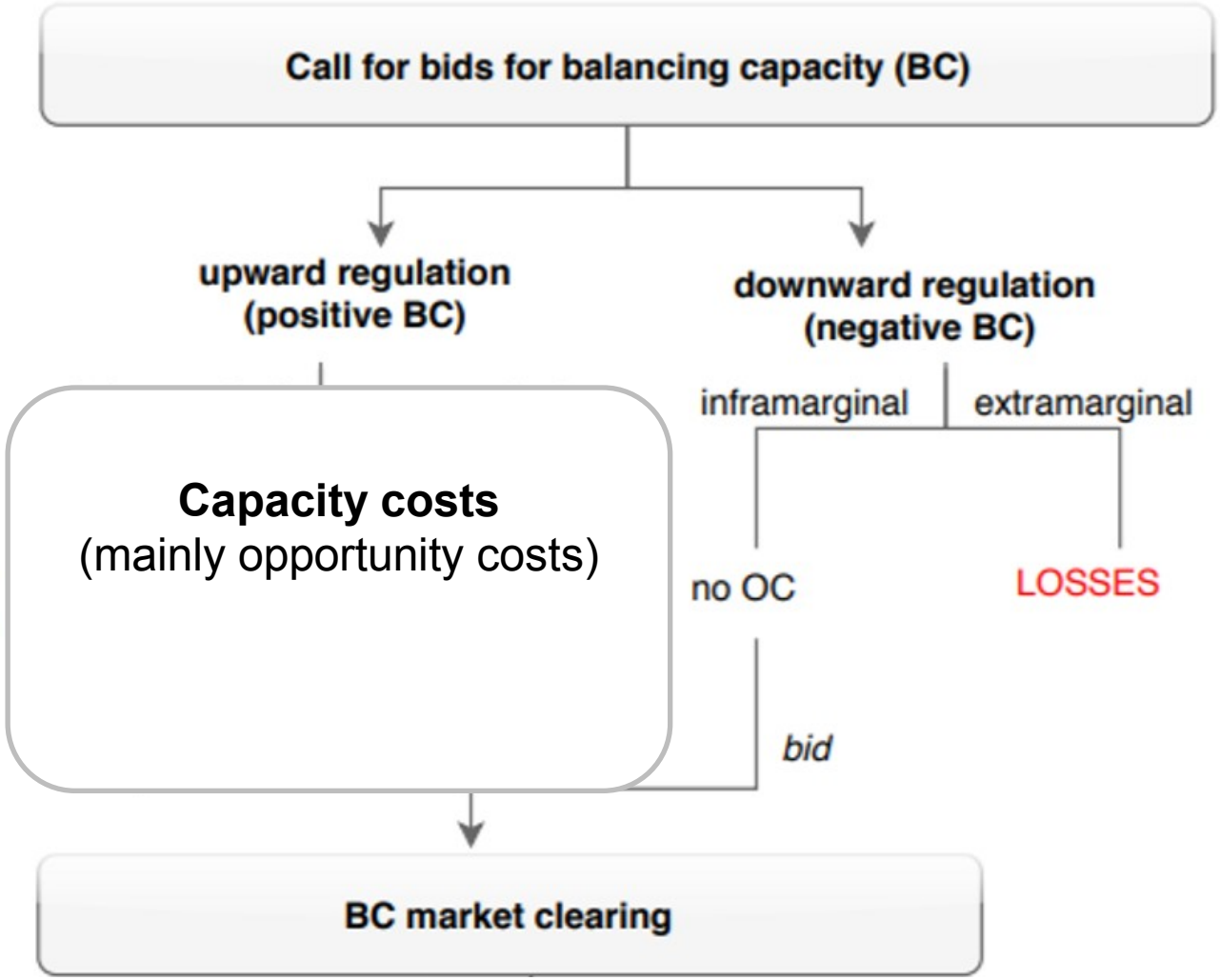
Alternative design options: Split markets for balancing capacity and energy:

Case2: Day-ahead market cleared **after** the GCT of the balancing capacity market

Case3: Day-ahead market cleared **before** the GCT of the balancing capacity market



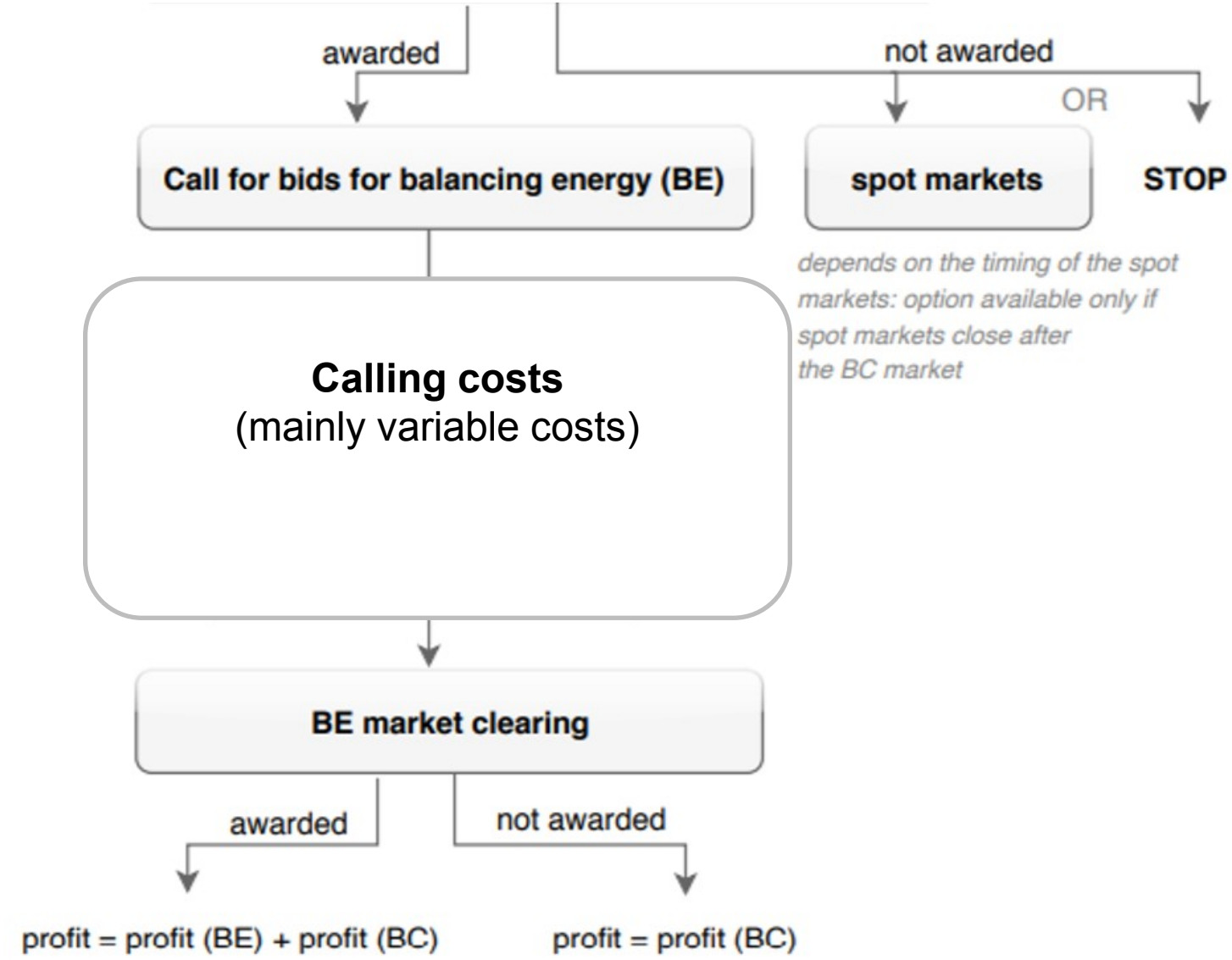
BIDDERS' COST STRUCTURES



Time-related influencing factors:

1. Bidding frequency
2. Bidding period
3. Frequency of market clearing

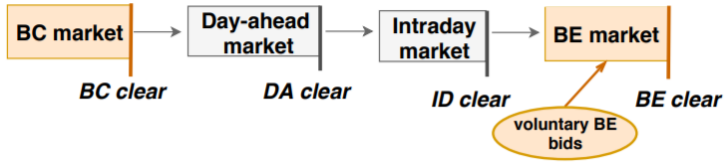
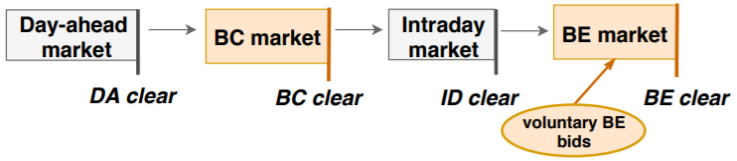
BIDDERS' COST STRUCTURES



Time-related influencing factors:

1. Bidding frequency
1. Bidding period
1. Frequency of market clearing

OVERVIEW OF THE USE CASES

Joint BC+BE market	Split BC-BE markets: BC ahead of DAM	Split BC-BE markets: BC clears after DAM
		
Only prequalified balancing service providers are allowed to participate Activation: merit order Pricing rule: Pay-as-bid		
Bid in the joint market consists of: 1. Bid volume 2. BC price 3. BE price → BC price bid determines who gets awarded	Bid in the BC market consists of the Bid volume and BC price (no BE price!) Bid in the BE market consists of: 1. Volume awarded in the BC market 2. BE price or 1. Voluntary bid volume 2. Voluntary bid price → Regular and voluntary bids form a single merit order	
	BC market precedes the DA market	BC market follows the DA market

JOINT BC+BE MARKET

Joint BC+BE market	Split BC-BE markets: BC ahead of DAM	Split BC-BE markets: BC clears after DAM

Bidder's expected profit from the participation in the joint balancing market:

$$E[\pi(b_C, b_E)] = H(b_C) \cdot q \cdot [(b_C - c) + (b_E - k) \cdot d \cdot G(b_E)] .$$

Theoretically optimal capacity and energy bids are given by:

$$b_C^* = c - (b_C^* - k) \cdot d \cdot G(b_E^*) - \frac{H(b_C^*)}{h(b_C^*)} ,$$

$$b_E^* = k - \frac{G(b_E^*)}{g(b_E^*)} .$$

Notation:

- $H(b_C)$: probability of BC bid accepted
- $G(b_E)$: probability of BE bid called
- $E[\pi(\cdot)]$: expected profit
- b_C: BC bid [Euro/MW]
- b_E: BE bid [Euro/MWh]
- d: reservation period [h]
- c: capacity costs [Euro/MW]
- k: calling costs [Euro/MWh]
- q: bid volume [MW]

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Capacity costs under current design are given by:

$$c = \max\left((p_{DA} - VC) + \varepsilon_{DA}; (p_{ID} - VC) + \varepsilon_{ID}\right)$$

Notation:

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- ε_{ID} price uncertainty related to the ID market
- p_{DA} (expected) price of the DA market [Euro/MWh]
- VC variable costs of a power station [Euro/MWh]
- ε_{DA} price uncertainty related to the DA market
- p_{ID} (expected) price of the ID market [Euro/MWh]

SPLIT BC-BE MARKETS: BC AHEAD OF DAM

Joint BC+BE market	Split BC-BE markets: BC ahead of DAM	Split BC-BE markets: BC clears after DAM

Bidder's **expected** profit from the participation in the joint balancing market:

$$E[\pi(b_C, b_E, b_{VE})] = E[\pi(b_C, b_E)] + \left(1 - H(b_C)\right) \cdot E[\pi_{VE}(b_{VE})] .$$

Two types of bidders in the BE market: regular BE bidders and voluntary BE bidders
Difference? Whether or not a bidder participated in the BC market

BUT! Both regular and voluntary BE bidders can submit a voluntary BE bid!

Expected profit from the **voluntary BE bid** is given by:

$$\pi_{VE}(b_{VE}) = G(b_{VE}) \cdot (b_{VE} - k) \cdot d \cdot q .$$

Notation:

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SPLIT BC-BE MARKETS: BC AHEAD OF DAM

Joint BC+BE market	Split BC-BE markets: BC ahead of DAM	Split BC-BE markets: BC clears after DAM

Bidder's expected profit from the participation in the joint balancing market:

$$E[\pi(b_C, b_E, b_{VE})] = E[\pi(b_C, b_E)] + \left(1 - H(b_C)\right) \cdot E[\pi_{VE}(b_{VE})] .$$

Theoretically optimal capacity and energy bids are given by:

$$b_C^* = c - \underbrace{(b_E^* - k) \cdot d \cdot G(b_E^*)}_{\text{Expected profits from the BE bid}} - \underbrace{\frac{H(b_C^*)}{h(b_C^*)}}_{\text{„bid-shading“}} + \underbrace{\frac{E[\pi_{VE}(b_{VE}^*)]}{q}}_{\text{Additional opportunity costs}} ,$$

$$b_E^* = b_{VE}^* = k - \frac{G(b_E^*)}{g(b_E^*)} .$$

Notation:

- $H(b_C)$: probability of BC bid accepted
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SPLIT BC-BE MARKETS: BC CLEARS AFTER DAM

Joint BC+BE market	Split BC-BE markets: BC ahead of DAM	Split BC-BE markets: BC clears after DAM

Bidder's **expected** profit from the participation in the joint balancing market:

$$E[\pi(b_C, b_E, b_{VE})] = E[\pi(b_C, b_E)] + \left(1 - H(b_C)\right) \cdot E[\pi_{VE}(b_{VE})] .$$

Theoretically optimal capacity and energy bids are given by:

$$b_C^* = c - (b_E^* - k) \cdot d \cdot G(b_E^*) - \frac{H(b_C^*)}{h(b_C^*)} + \frac{E[\pi_{VE}(b_{VE}^*)]}{q} ,$$

$$b_E^* = b_{VE}^* = k - \frac{G(b_E^*)}{g(b_E^*)} .$$

Difference from the previous design lies in the calculation of capacity costs:

$$c = (p_{ID} - VC) + \varepsilon_{ID} .$$

EFFECT OF CHANGES OF MARKET SEQUENCES

Introduction of a standalone balancing energy market alters the market sequence, affecting costs structures of bidders and their expected profits.

Splitting of the BC and BE markets *per se* does not remove the link between them:

In bidders' optimal bidding strategies, expected profits from the BE bid are still considered in the formulation of a BC bid.

The change rather stems from:

1) Increasing bidding frequency in the BE market
2) Introduction of voluntary bids

Position of the balancing capacity market affects the magnitude of bidders' opportunity costs

High temporal gap between BC and DA markets implies:

- higher risk premiums
- risk of distorted assignment of bidders to the BC and DA markets

In Case 3 (BC market follows DA market), BC bidders do not face any opportunity costs

Pure profit

Incentive to provide maximum capacity as BC

REGULAR VS. VOLUNTARY BALANCING ENERGY BIDS

Theoretically optimal regular BE bid and voluntary BE bid are identical

Yet, calling probability beliefs are **not** the same: in the market equilibrium bidders with the lowest opportunity costs (relatively high variable costs) are awarded in the BC market

Information advantage of regular bidders vs. voluntary BE bidders:

A bidder who was not awarded with the BC bid obtain information about its competitors in the BE market.

A rational BSP will include this information when formulating her voluntary BE bid

Higher markup $G(bVE*)/g(bVE*)$ on her variable cost basis k → higher voluntary BE bid compared to the regular BE bid.

Information advantage is limited as

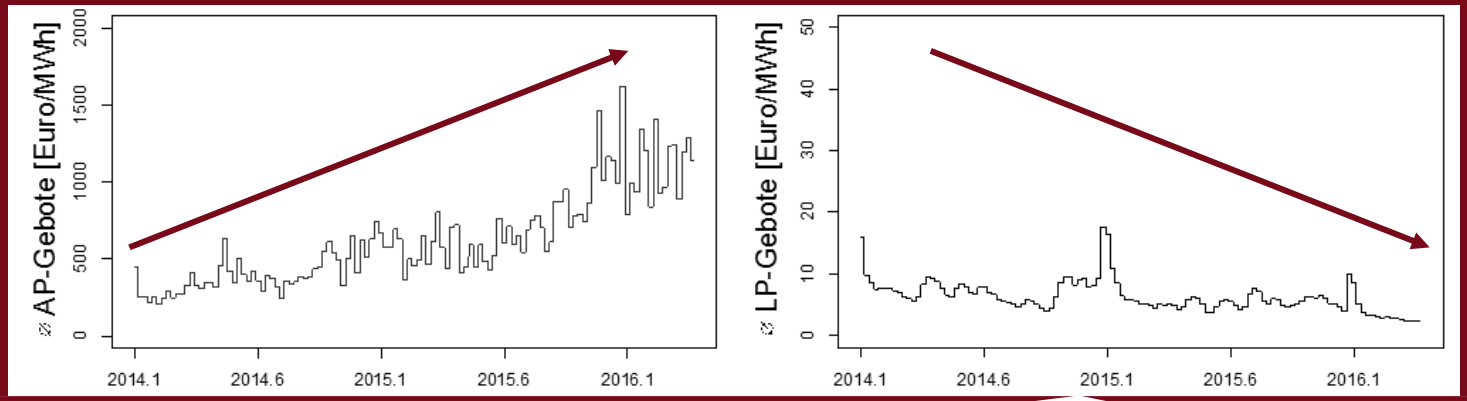
- the bidding timeframe is the same for regular and voluntary bids
- all the bidders are informed about the results of the BE market *ex post*

Markup limited due to:

- trade-off between additional profits and the position in the BE bid merit order
- a number of voluntary bids that did not take part in the BC market will be placed in the BE market

EFFECT OF VOLUNTARY BALANCING ENERGY BIDS

Introduction of voluntary bids is expected to reduce the effect of BE bids "subsidizing" BC bids



Source: Ocker, F., Ehrhart, K.-M. und Ott, M. (2018): Bidding Strategies in Austrian and German Balancing Power Auctions, Wiley Interdisciplinary Reviews.

Decreasing BE bid prices are to be expected

In the **theoretically efficient market equilibrium**, bidders with the **highest** variable costs and hence lowest opportunity costs are selected
No more empirically observed **extremely high awarded BE bids** (substantially exceed profits from the DA market)
Increasing competition from bidders with low variable costs set a **virtual cap on the bid prices of regular bidders**

Increasing BC bid prices

As the expected profit from the BE bid decreases → **less bid shading** (dependent on subjective assessment of own competitive position

A new trading option (voluntary bid) creates new opportunity costs.

THANK YOU!

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