The below material is attached to the HAR public consultation for information purposes only.
Comments are only expected on the proposed amendments to the HAR methodology wording.

N-SIDE

Collateral Management and Budget Constraints in Long-Term Flow-based Auctions

Final Report, Friday January 30, 2026

Public data

Executive Summary

- Under Long-Term Flow-Based Allocation (LTFBA), collateral requirements mechanically cumulate across borders, leading to a substantial increase in collateral requirements compared to per-border auctions.
- Ex-ante bid filtering based on Maximum Payment Obligations (MPO), including approaches complemented with bid-price caps, overestimates final payment obligations while still possibly exposes TSOs to some settlement risks.
- Optimal bid filtering based on the auction final clearing prices (i.e. the final payment obligations) is technically feasible and can be embedded directly in the clearing algorithm.
- This Proof-of-Concept demonstrates that optimal bid filtering:
  - avoids unnecessary bid rejections for market participants,
  - fully secures TSOs against settlement risk,
  - preserves auction outcomes close to the no-filtering benchmark.

Even though some design aspects still require further assessment or clarification before implementation, the study demonstrates that optimal bid filtering constitutes a technically feasible and structurally robust design baseline

Agenda

- Project Context, Scope & Timeline
- Maximum Payment Obligations (Principles, incl. price caps)
- Optimal Bid Filtering (Principles)
- Optimal Bid Filtering (PoC Results)
- Conclusions & Possible Next Steps

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Project Context & Scope

Public data

Context

- Under the current per-border auction design, the same collateral buffers can be reused across separate auctions, as settlement risks materialize independently on each border.
- Under Long-Term Flow-Based Allocation (LTFBA), all borders are auctioned simultaneously. As a result, collateral requirements mechanically cumulate across borders.
- This purely mechanical effect leads to a sharp increase in required collaterals, raising significant concerns among market participants.
- Various approaches to mitigate this effect have been discussed, most of them relying on ex-ante bid filtering based on Maximum Payment Obligations.
- This study revisits whether some potentially more dynamic approaches may have been prematurely ruled out....

Project Scope

N-SIDE has been tasked to support TSOs to analyze an "improved solution for considering collateral requirements in LTFBA"

→ Project Scope: "*bid rejection due to insufficient collaterals based on clearing price of auction*". (MESC, October 2025)

Objectives

→ Validate the technical feasibility and added value of of the approach through a PoC

→ Assess gains for TSOs & for market participants
(i.e. auction revenues, financial exposure, auction surplus, traded volumes, …)

We firmly believe that the analyses performed in this study can serve the best interests of both TSOs and market participants.

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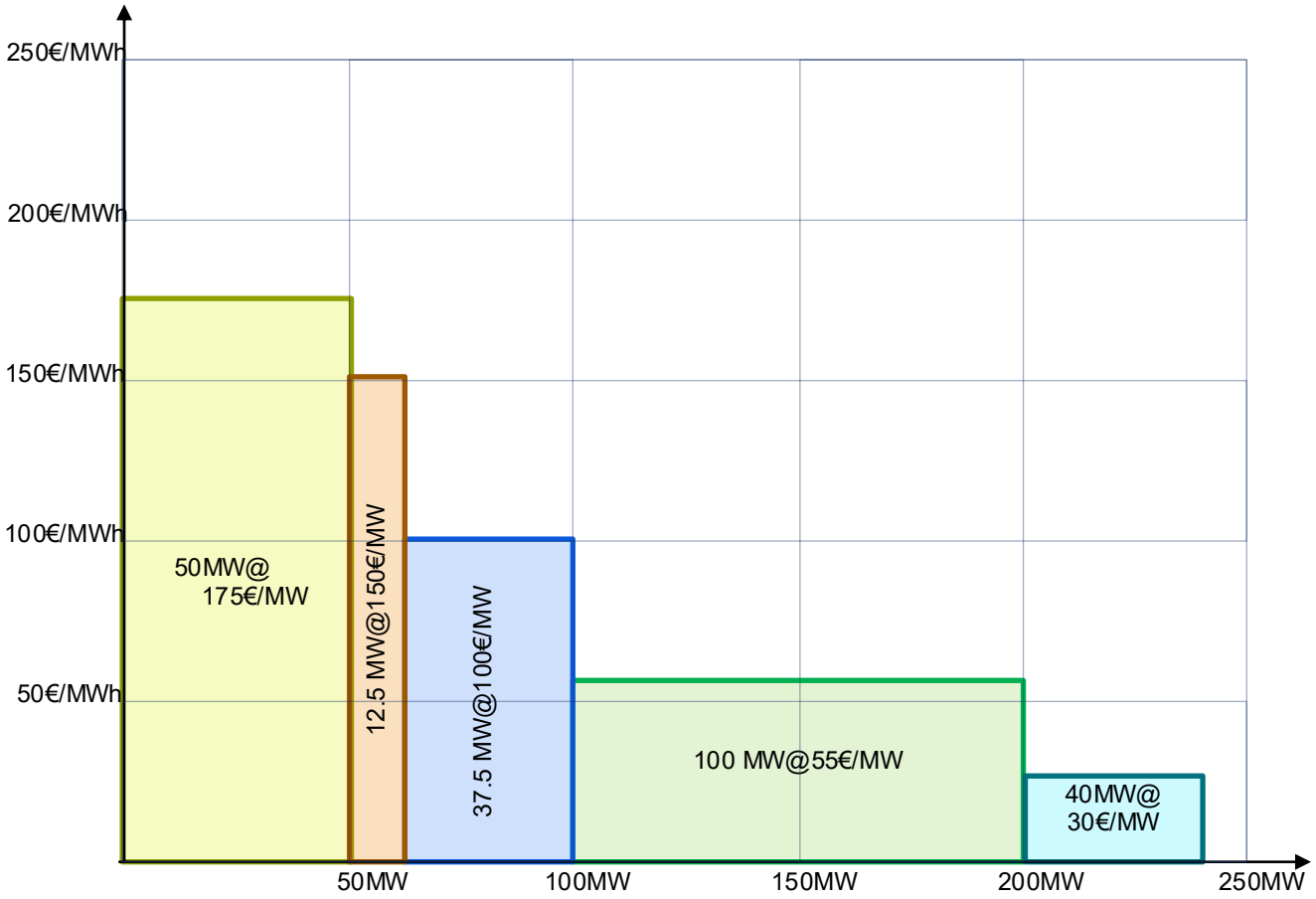
Maximum Payment Obligations

Principles (incl. price caps)

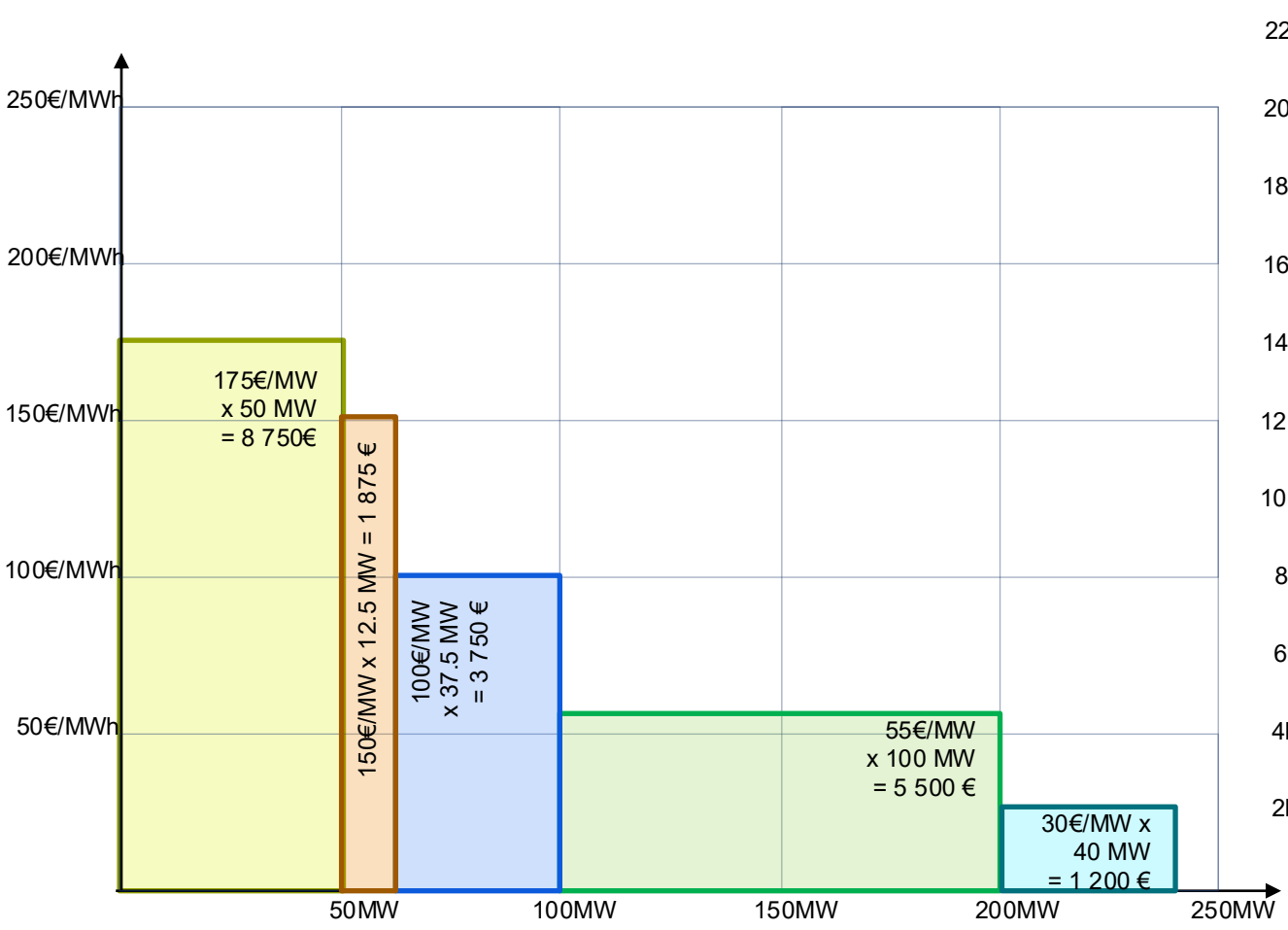
Public data

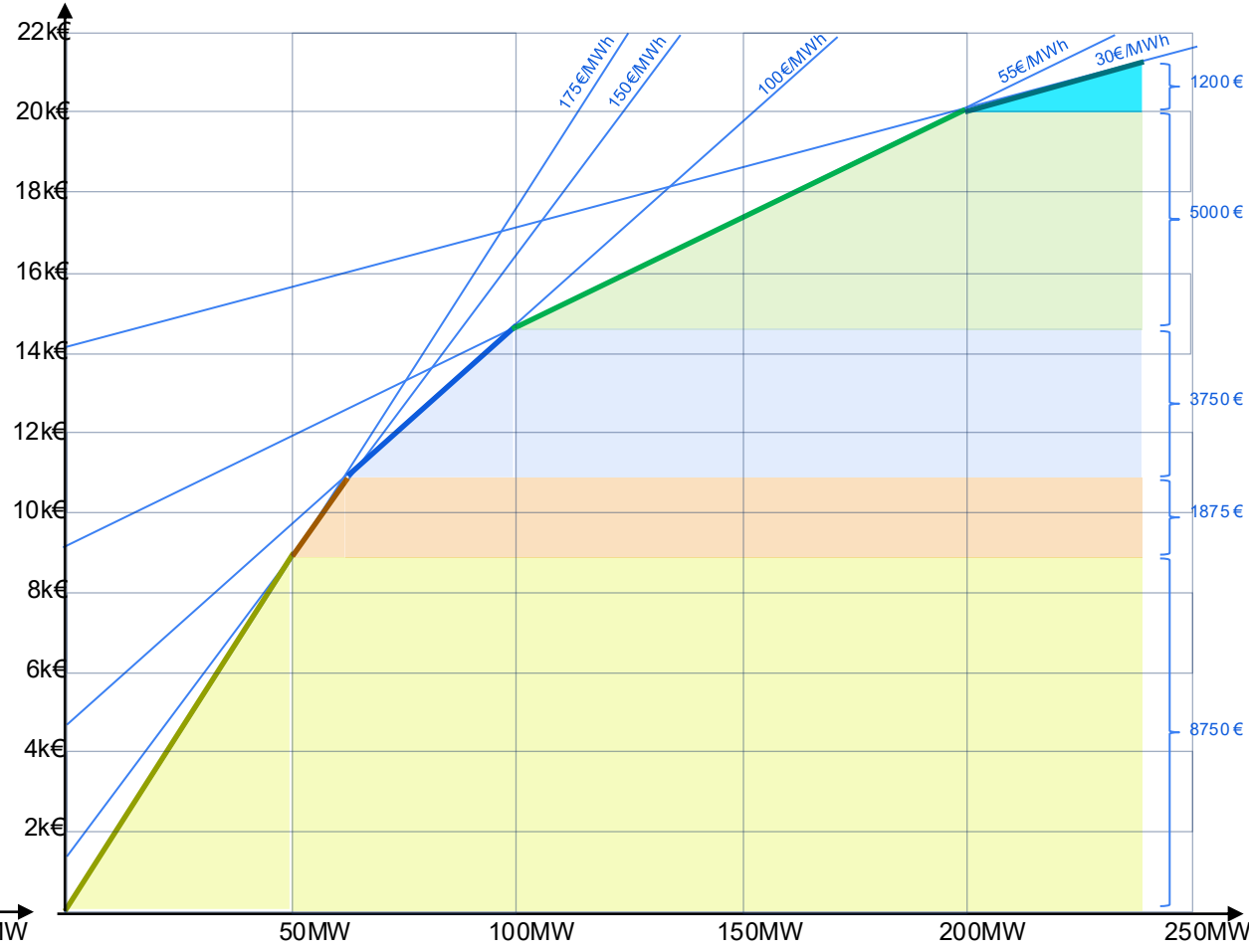
How to filter bids to secure ≤ 10k € of settlement?



Suppose a market composed by 5 bids submitted by a single market participant who posted 10k€ of collaterals

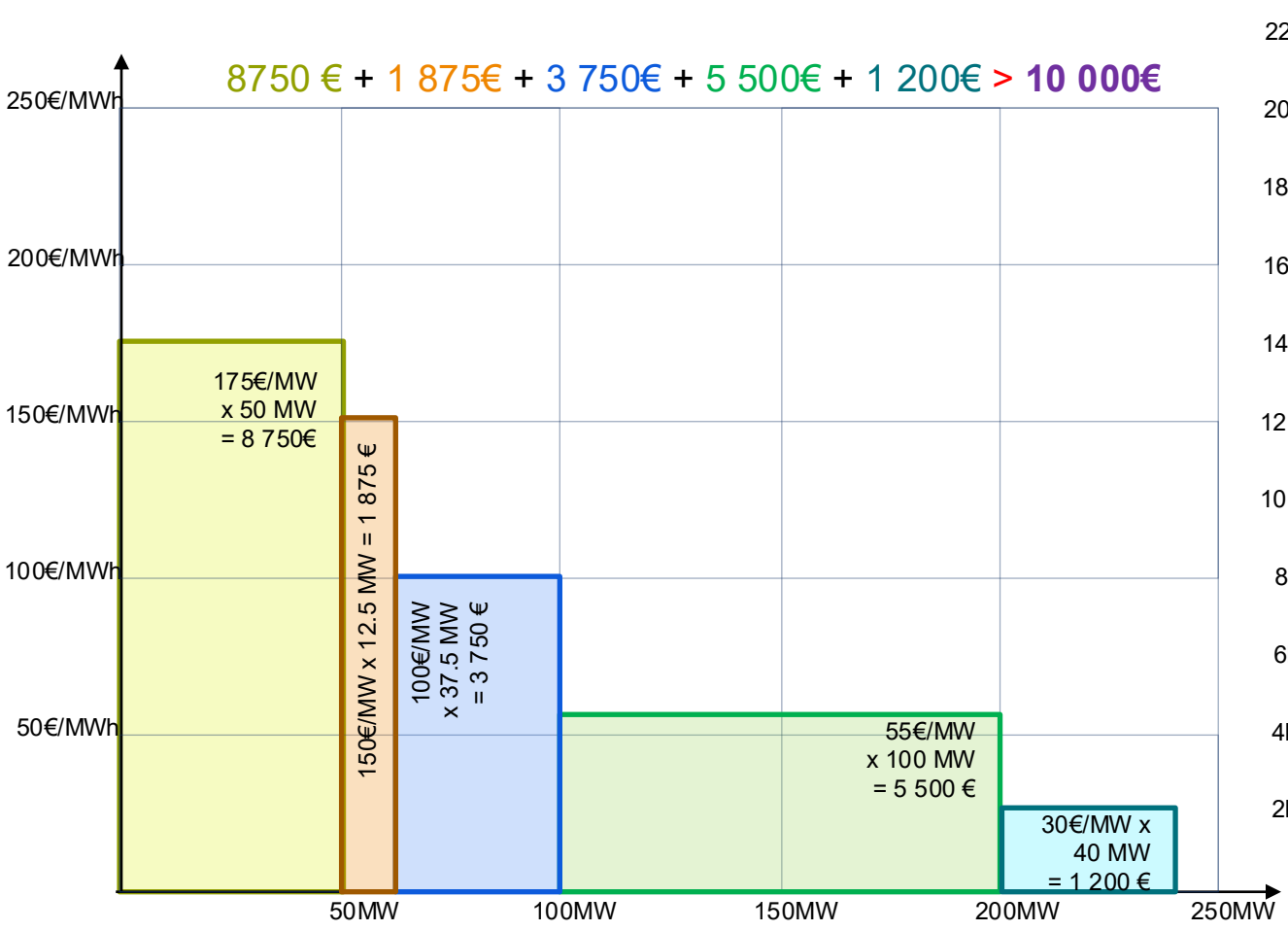
Bid filtering based on total bids' values

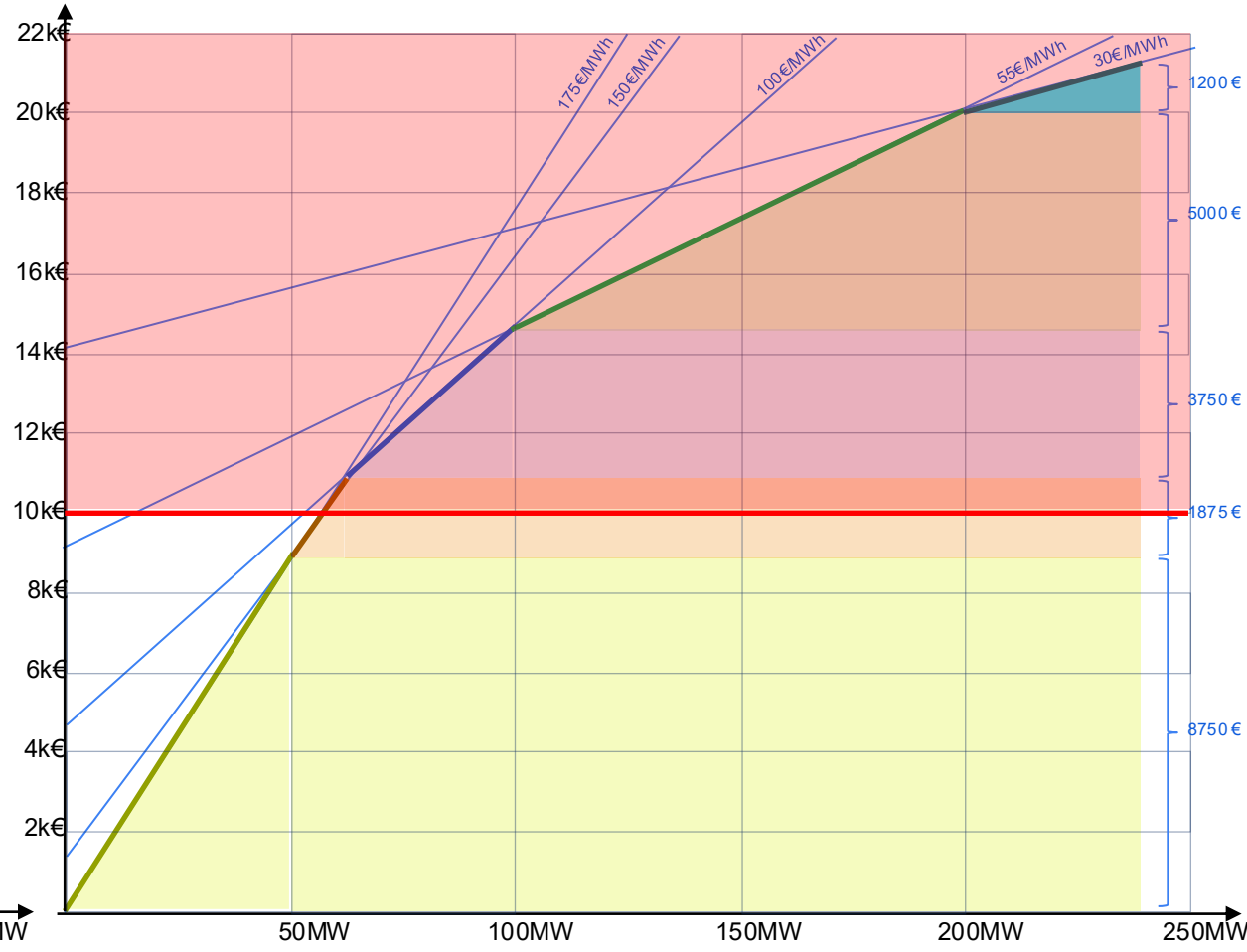




An initial understanding has been that bid filtering was to be based on the total bids' values of a given participant.
The total bids' values is the sum of the surface of all bids: $\sum_i (P_i \times Q_i)$.
Graphically, the right-hand figure is the integral of the left-hand figure (which in turn is the derivative of the right-hand figure).

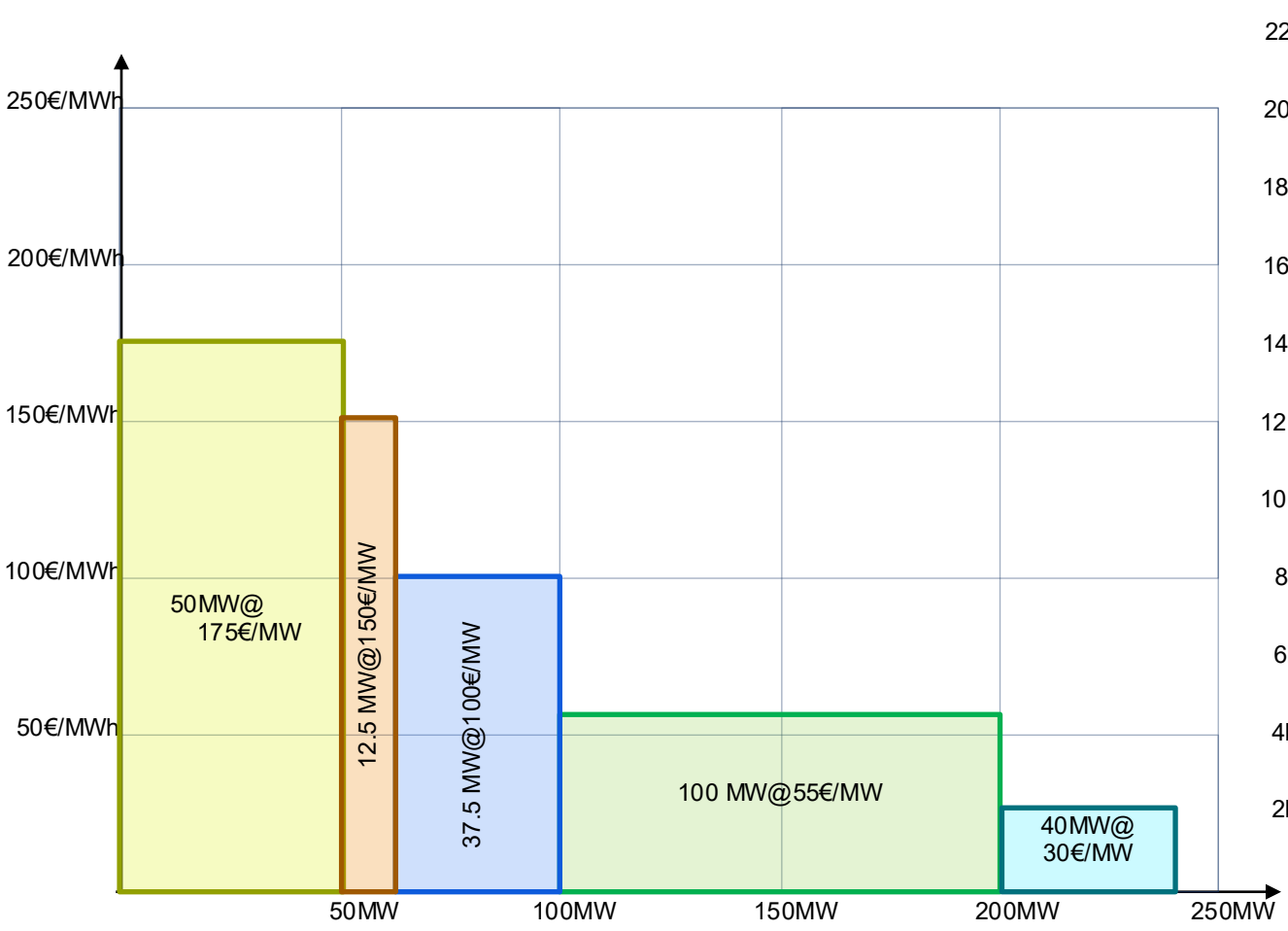
Bid filtering based on total bids' values

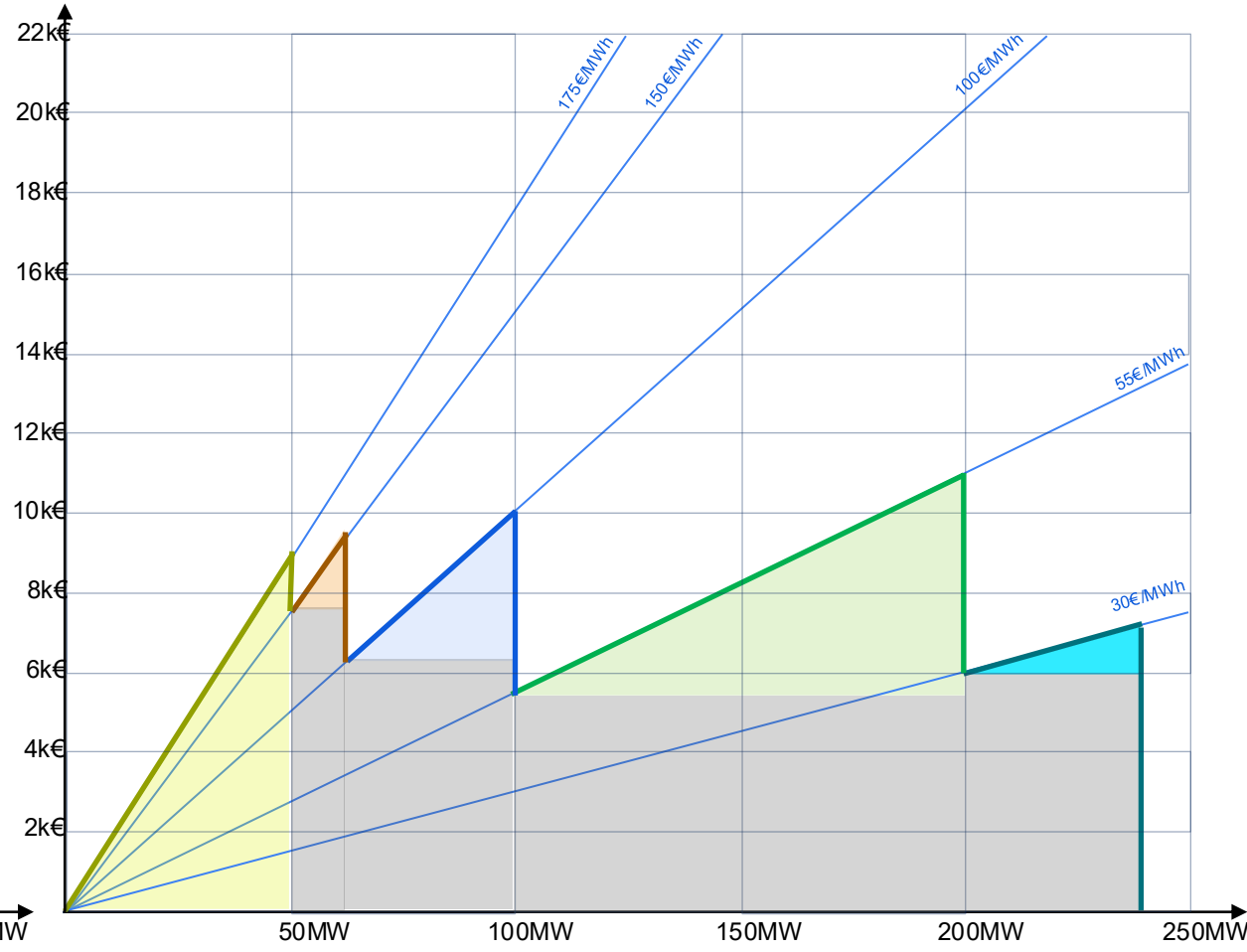




In this example, the sum of the 5 bids' value largely exceeds 10k€, and a large proportion of bids needs to be filtered-out to remain within limits. However, such an approach assumes on « paid-as-bid » settlement principles, while the LTTR auctions are settled « paid-as-cleared ».

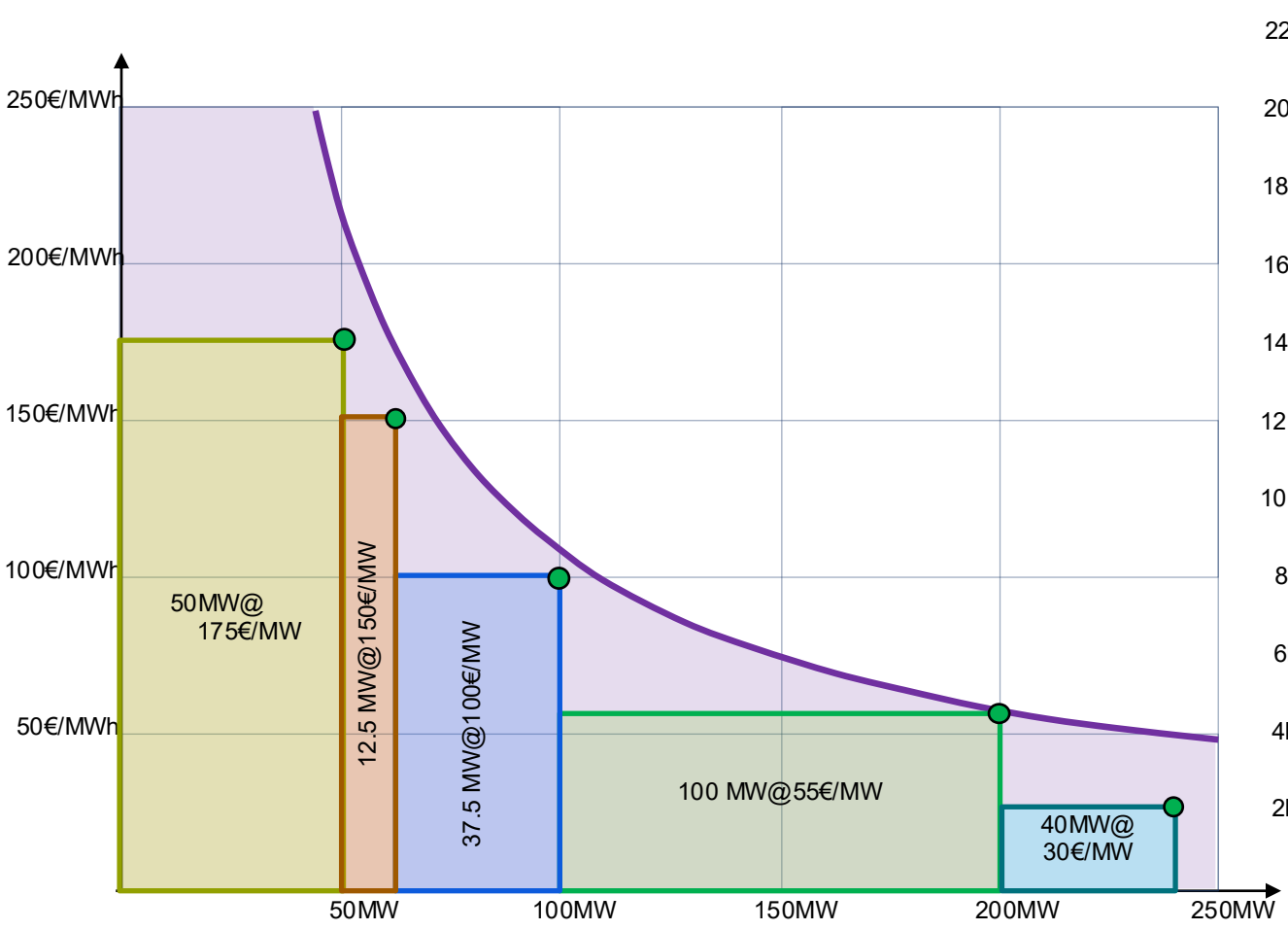
Bid filtering based on payment obligations

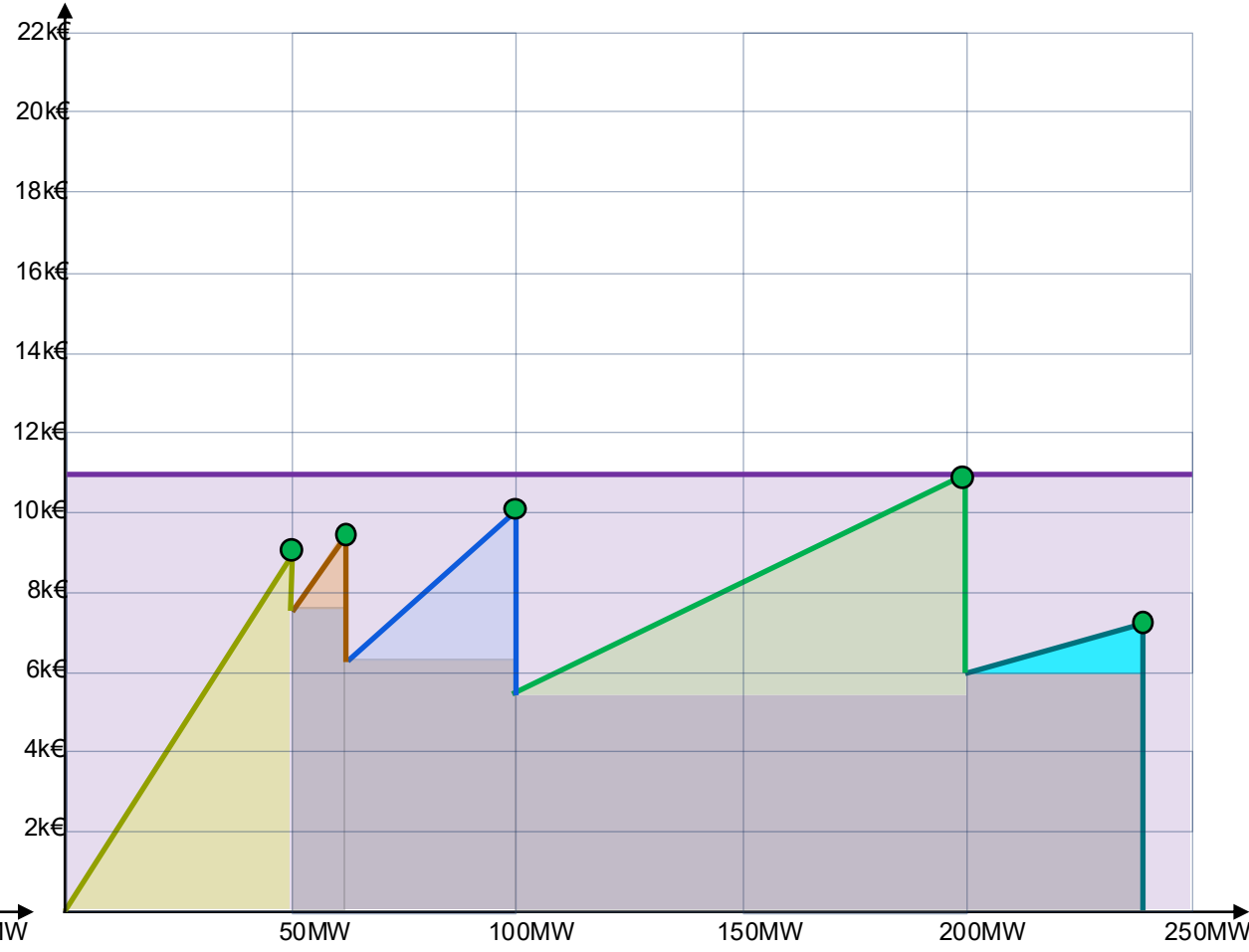




With paid-as-cleared settlement, the participant's payment obligation is the product of the accepted volume AND of the clearing price (~~bid price~~). Each segment in the right-hand figure represents the (piecewise) primitive of the left-hand step function (which though remains the derivative of the right-hand figure).

Bid filtering based on Maximum Payment Obligations (MPO)





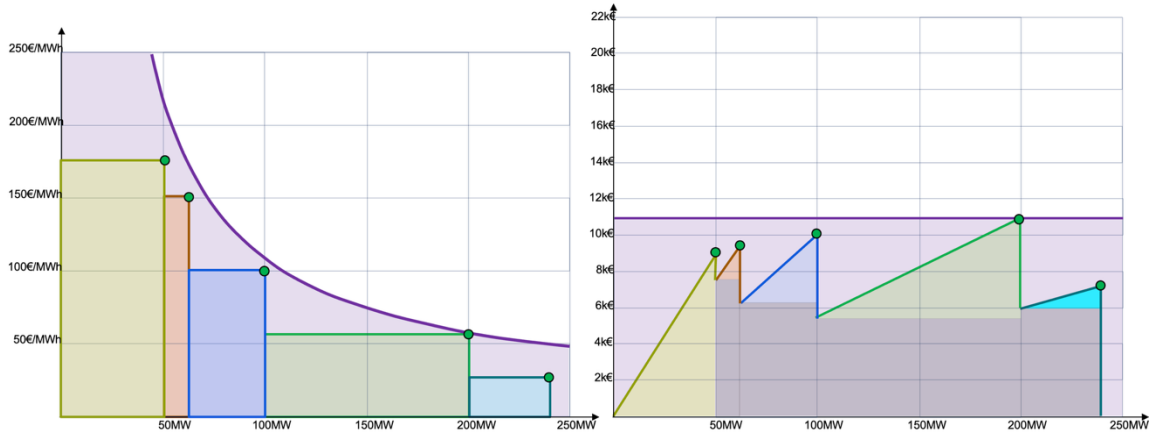
The « Maximum Payment Obligation » is the maximum of the right-hand figure.
In this example, any clearing points in the **purple surface** is fully secured by the corresponding collateral deposit: MPO (€) = 11k €
The **purple surface** on the left-hand figure is delimited by the P (€/MW) ≤ 11k € / Q (MW)

Bid filtering based on Maximum Payment Obligations (MPO)

Collateral requirements should be defined consistently with paid-as-cleared settlement principles. ACER Decision 18/2023 on HAR (see Annex I, page 27) already reflects this principle when using bid filtering bids based on Maximum Payment Obligations (MPO)

$$MPO = \sum_{hours} Max\left[Bid\ Price(1) * Bid\ Quantity(1); Bid\ Price(2) * \sum_{i=1}^{2} Bid\ Quantity(i); \ldots; Bid\ Price(n-1) * \sum_{i=1}^{n-1} Bid\ Quantity(i); Bid\ Price(n) * \sum_{i=1}^{n} Bid\ Quantity(i)\right]$$

A straightforward analysis based on 2025 data shows that MPO-based bid filtering cuts collateral needs by roughly 33% compared to a naïve bid-value/paid-as-bid approach (with no impact on clearing results, prices or credit risks).



Graphically, the MPO is the lowest possible « purple curve » that comprises all possible clearing points

<u>Confirmed approach</u>: Only consider "payment obligations" and discard any approach based on bids' intrinsic values

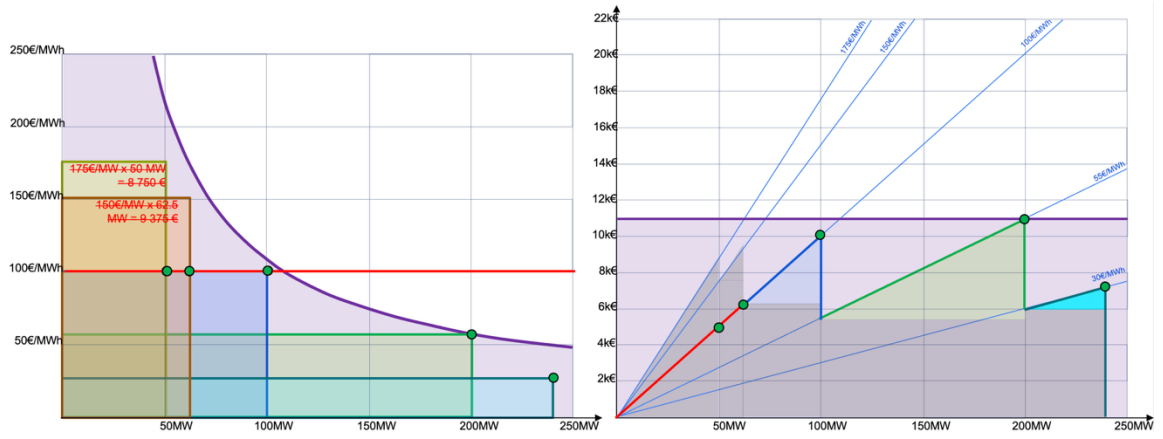
Bid filtering based on MPO with price caps

A contemplated proposal to reduce collateral requirements is to limit/cap the bid prices when calculating the MPO

$$MPO = \sum_{\text{hours}} Max\ [Min(Bid\ Price\ (1); Price\ Cap) * Bid\ Quantity\ (1);\ Min(Bid\ Price\ (2); Price\ Cap) * \sum_{i=1}^{2} Bid\ Quantity\ (i)\ ; \ldots ; Min(Bid\ Price\ (n-1); Price\ Cap) * \sum_{i=1}^{n-1} Bid\ Quantity\ (i)\ ; Min(Bid\ Price\ (n); Price\ Cap) * \sum_{i=1}^{n} Bid\ Quantity\ (i)]$$

Applying **bid-price caps** when calculating the MPO has a **limited impact** on total collateral requirements.

- Based on **2025 bid data** combined with **EEX-based price forecasts** (provided by JAO), bid-price-capped MPOs reduce total collateral requirements by **less than 3%**.
- As a result, bid-price capping **does not materially improve collateral efficiency**, while adding **process complexity** and **potential settlement risks for TSOs**.



Graphically, applying a price cap means limiting the slopes of the first bids in the right-hand figure. Price caps do not necessarily reduce MPO.

<u>Recommendation</u>: Discard the "bid-price-capping" approach and rely instead on <u>optimal bid filtering</u> instead

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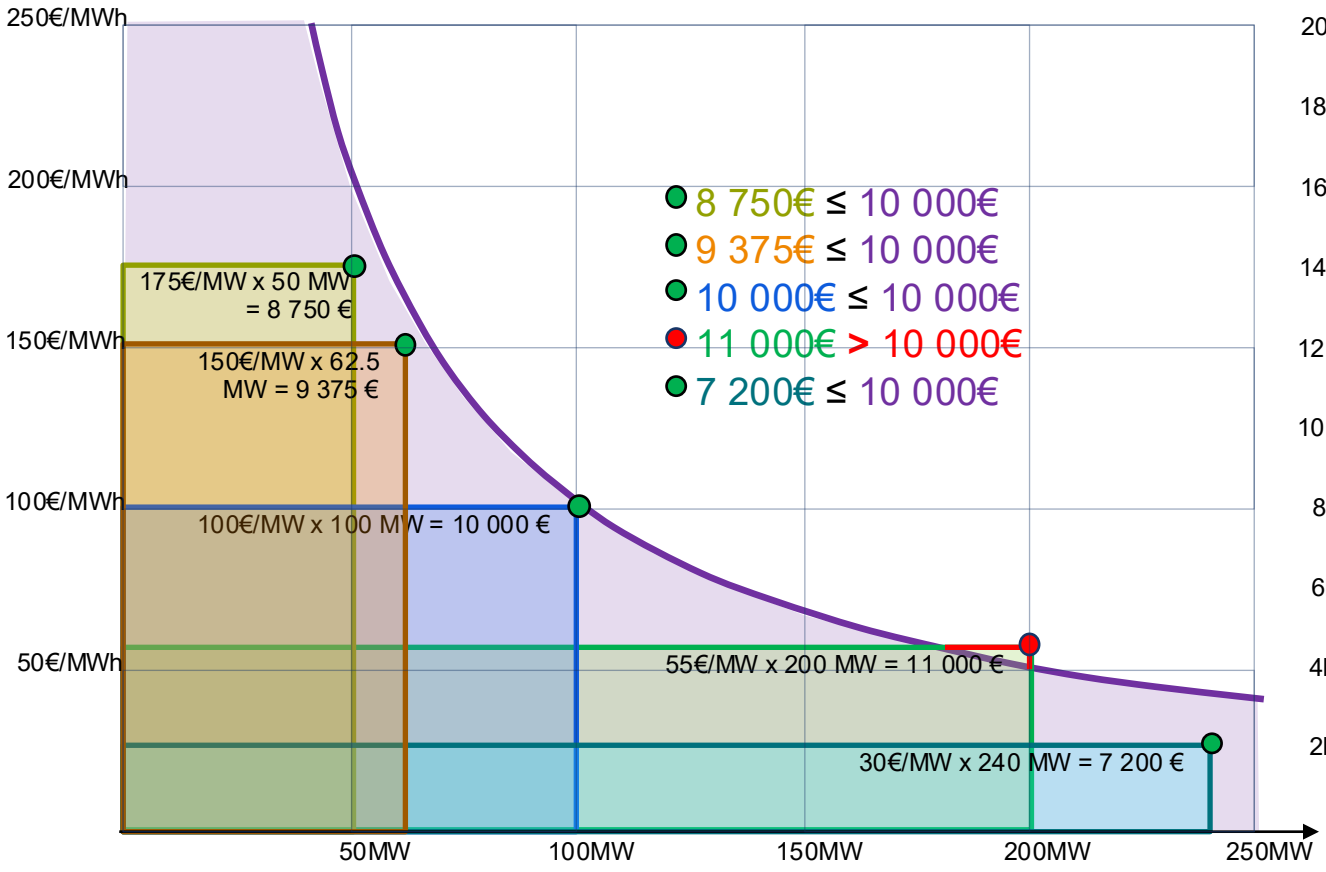
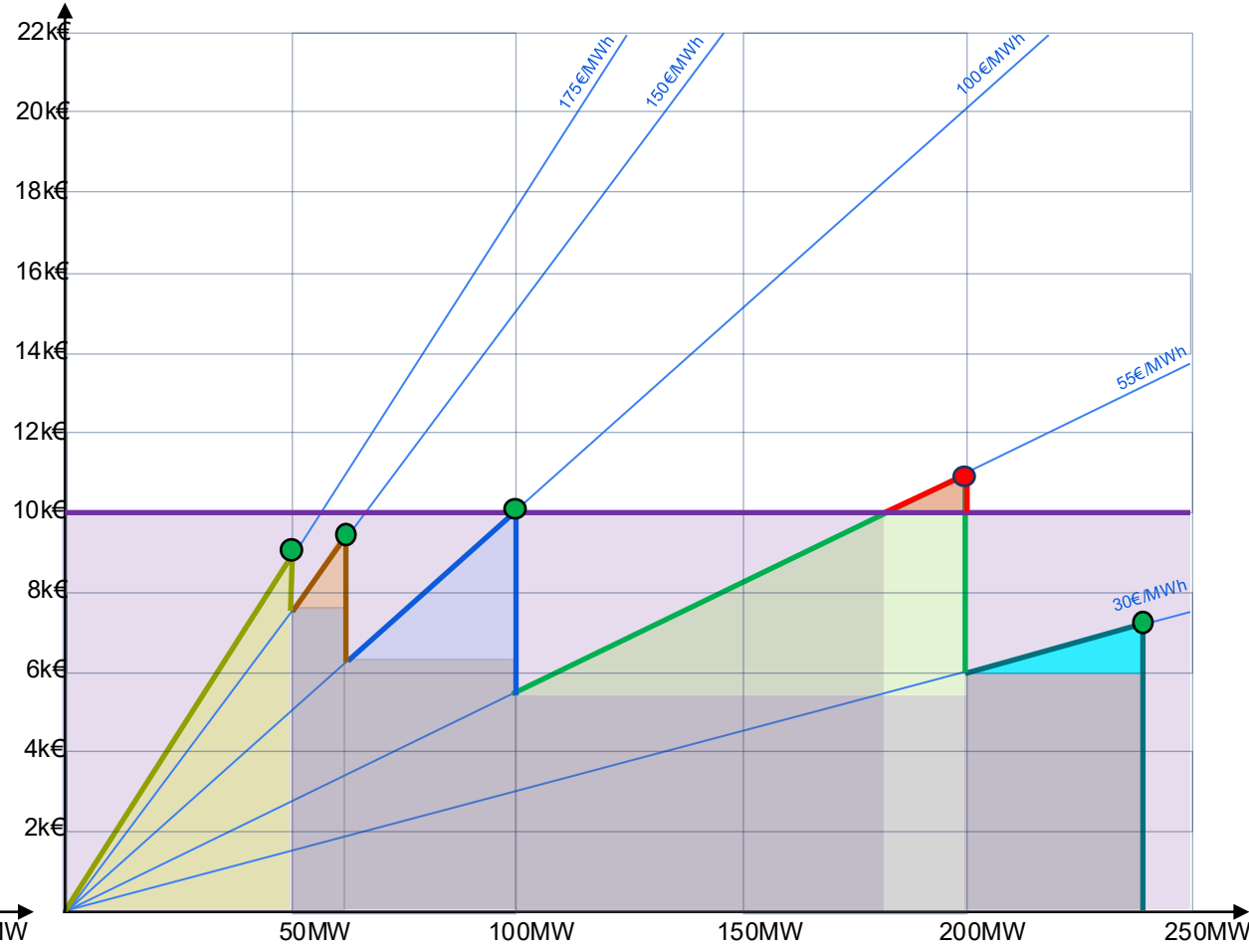
Optimal bid filtering

Principles and key design elements

Public data

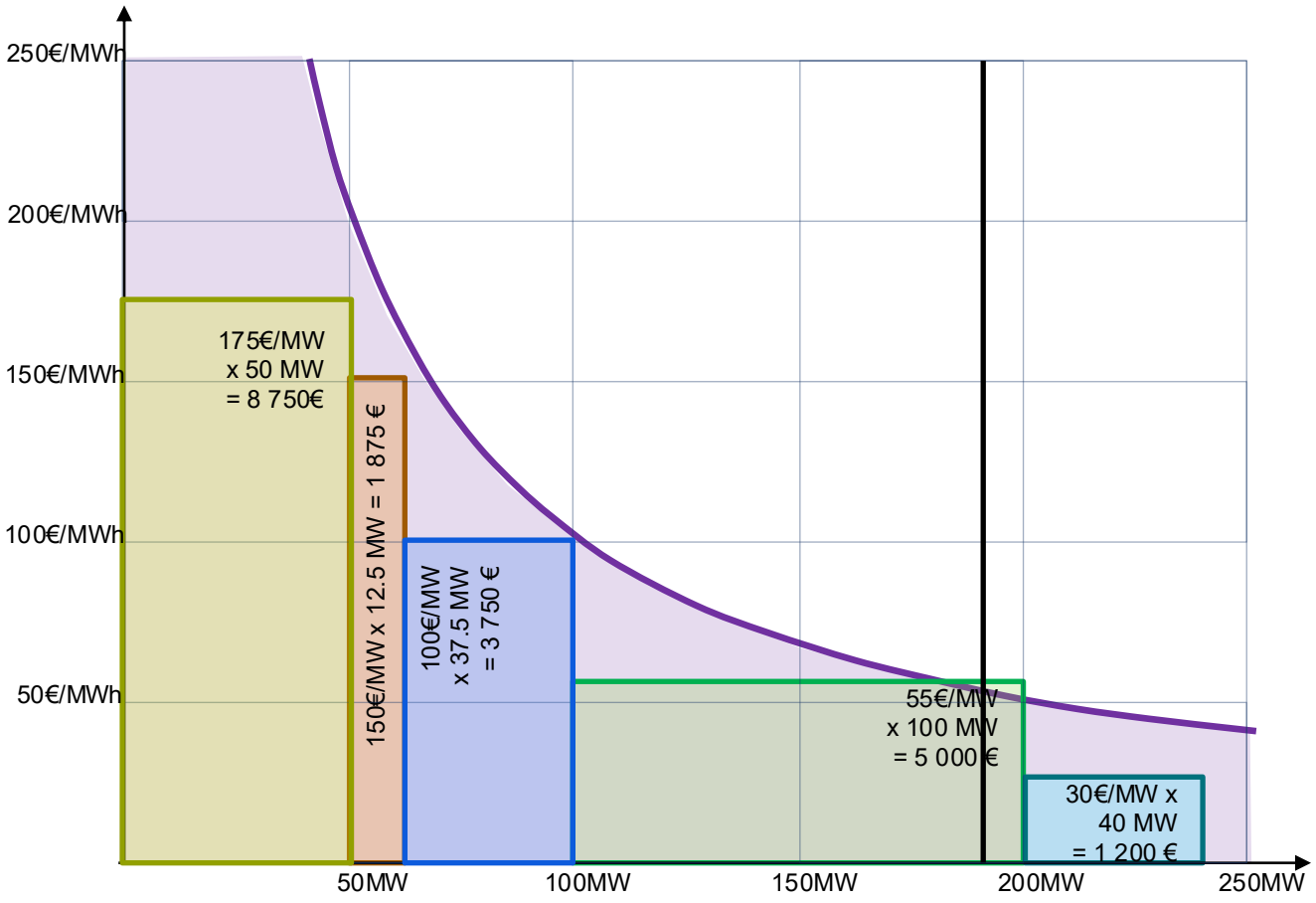
How to best filter bids to secure settlement?





If the collateral deposit (=10k€) is below MPO (=11k€), only the clearing points in the **purple surface** lead to fully secured payment obligations.
From these figures, it is visible that 10 k€ of collaterals is problematic only if the participant clears [181.8, 200[MW.
Optimal bid filtering based on the clearing prices of the auction is an efficient way to filter out bids … only if there are "problems".

Proposed approach: bid filtering based on Final Payment Obligations



- Suppose the demand is 190MW.
- Which bids should be optimally filtered?

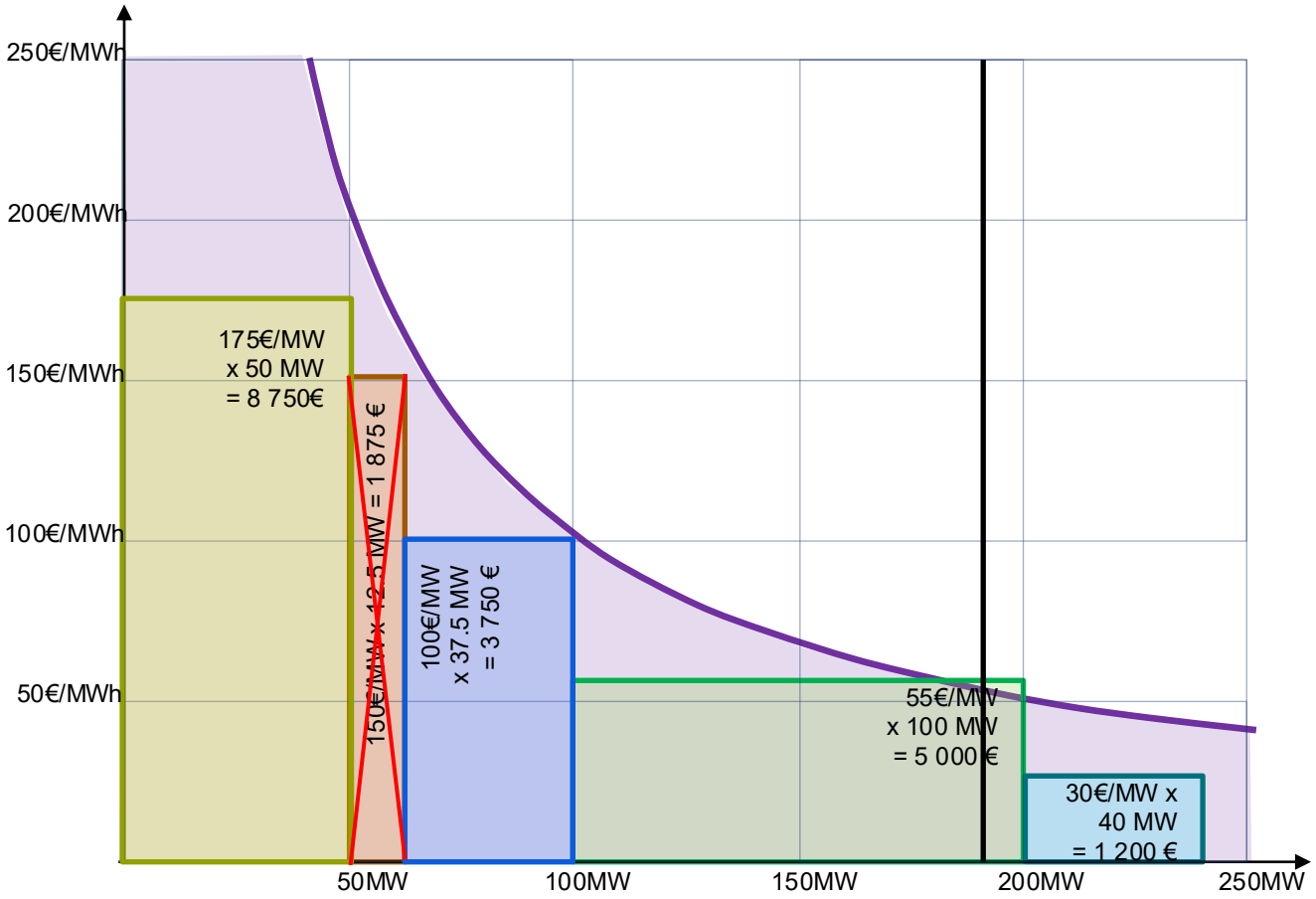
N-SIDE proposes to filter bids based on <u>Final</u> Payment Obligations.

- This approach is inherently dynamic and must be embedded in the clearing algorithm, as bid filtering directly affects clearing results, settlement outcomes, and clearing prices.
- It enables **substantial reductions in collateral requirements**, in particular for **multi-border auctions**, where collateral need to be posted concurrently to cover risks across all borders.

Key market design implications

- By construction, **bid filtering reduces effective demand** and therefore **lowers clearing prices**.
- As a result, dynamic bid filtering during the clearing process may lead to **paradoxically filtered-out bids**, i.e. bids that are excluded by the filtering mechanism even though clearing them at the observed clearing prices would not create collateral shortfalls.
- **<u>How such paradoxes are addressed is an important market design choice</u>** that must be adressed with care.

Surplus optimal bid filtering may have adverse consequences

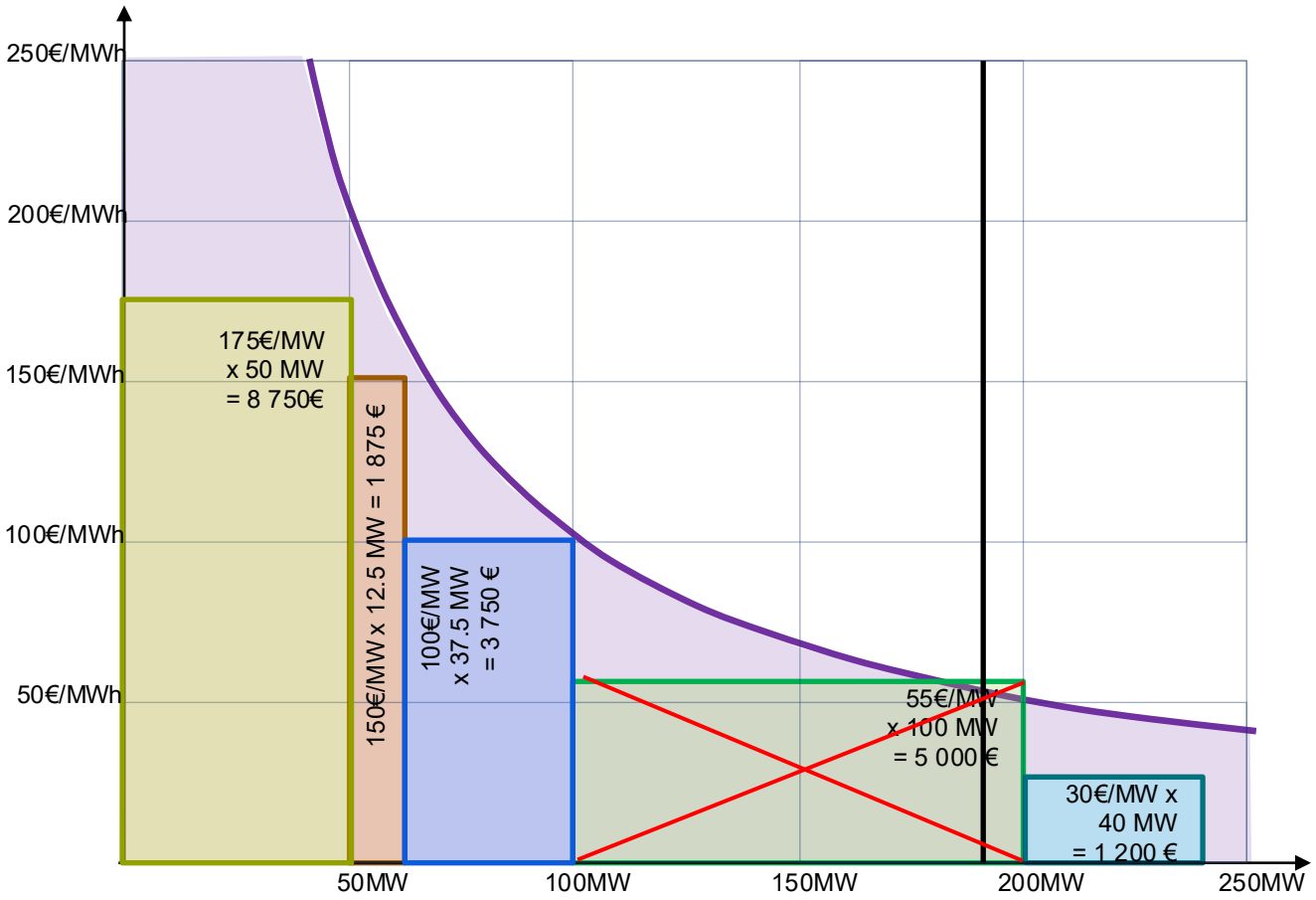


Filtering bids ”somewhere in the merit-order”

- Surely reduces demand
- Therefore very likely also reduces the clearing price

- Filtering **bid 2** is optimal in terms of surplus (because the bid has a small volume), although a highly priced bid is (paradoxically?) filtered out.
- Consequently, the cheaper **bid 3** & **bid 4** are fully cleared while **bid 5** is partially cleared.
- The **only** consequence of filtering this participant is that the price of the same volume of FTRs has been reduced to 30€/MW (~~55€/MW~~).

Filtering large bids has stronger (price) impacts



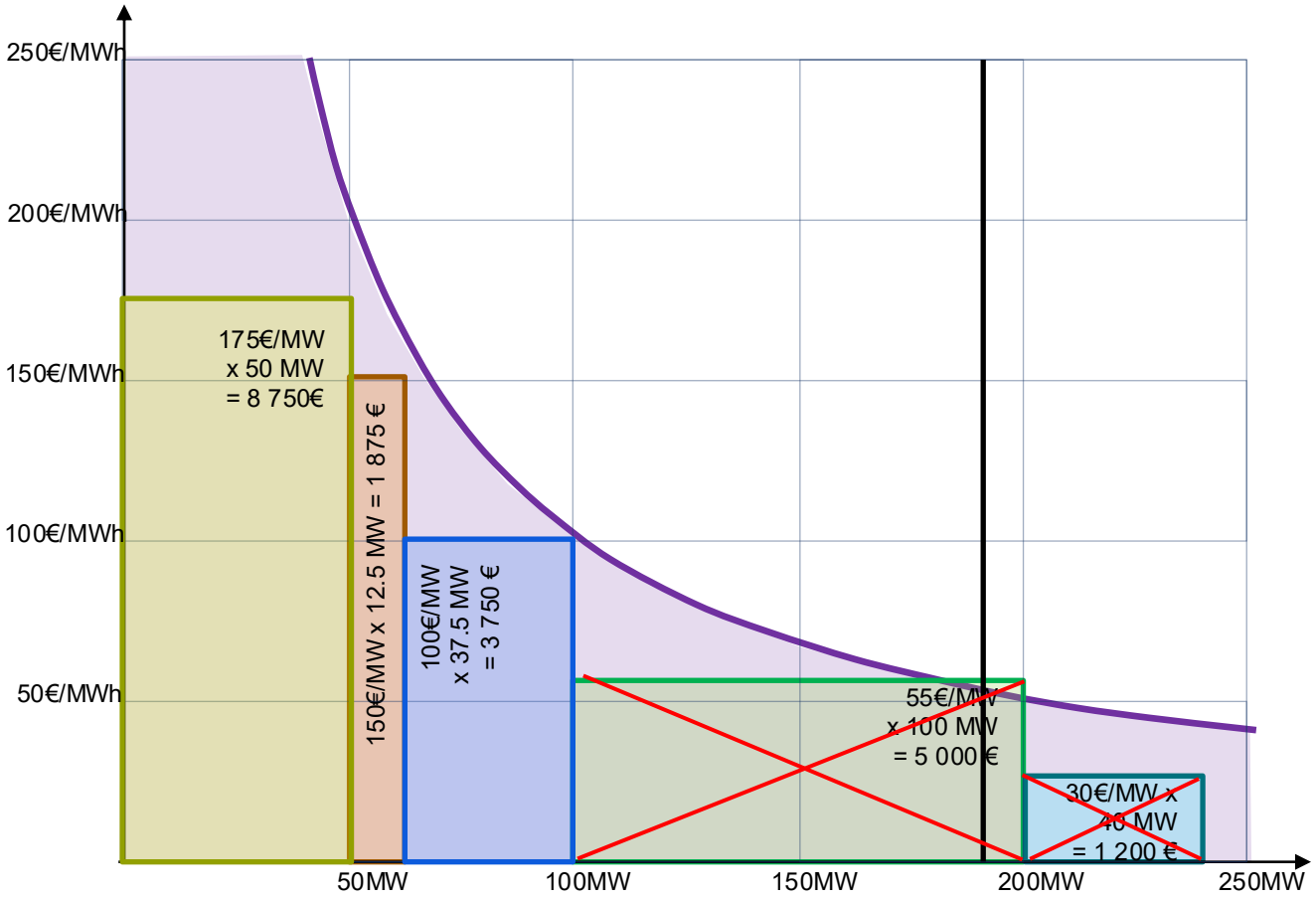
Filtering bids ”somewhere in the merit-order”

- Surely reduces demand
- Therefore very likely also reduces the clearing price
- And possibly reduces the participants’cleared volumes

NB: participants have a tendency to submit large ”opportunistic bids” at low prices.

- Filtering the problematic **bid 4** entails a high cost in the objective function, because it has a large volume.
- Filtering out such a large bid also has a strong downward impact on clearing prices.
- The consequences for this participant is that both clearing prices and cleared volumes have been reduced (in this example **bid 5** can now be cleared fully, although the participant could easily add another large bid at 0€/MW).

Recommended safeguard 1: « merit-order bid filtering »



Filtering bids ”somewhere in the merit-order”

- Surely reduces demand
- Therefore very likely also reduces the clearing price
- And possibly reduces the participants’cleared volumes

NB: participants have a tendency to submit large ”opportunistic bids” at low prices.

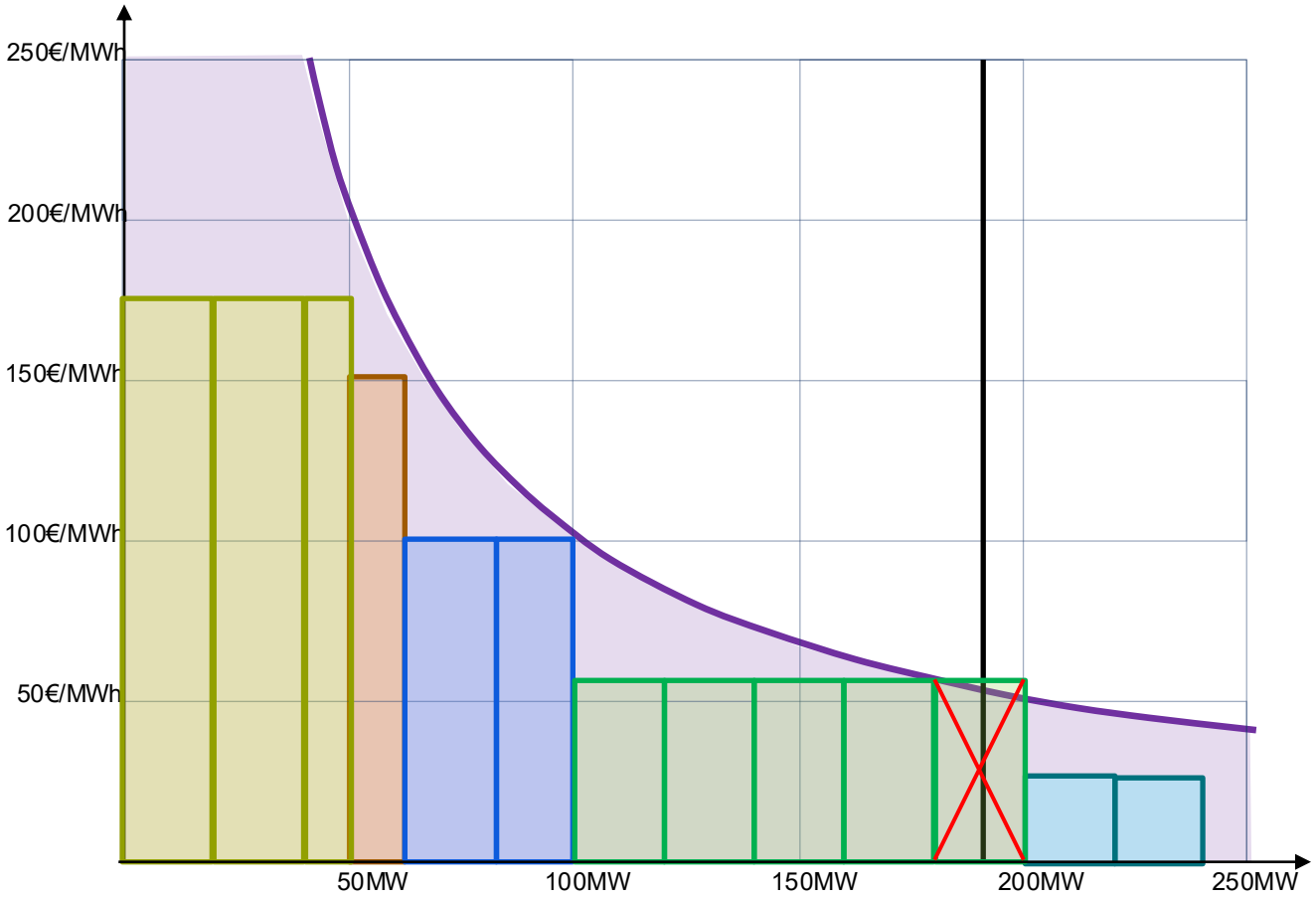
N-SIDE’s view is that, when a participant’s bid is filtered out, it becomes inappropriate that such “opportunistic bids at low prices” become cleared instead of the filtered-out bids (ore more generally that prices simply drop with no further consequences)

This is why N-SIDE recommends to enforce “merit-order bid filtering” per border.

NB: Such a reasoning also suggests that bidding behavior may be influenced by the implemented bid filtering methodology

- « Merit-order bid filtering » means that, if a bid is filtered out, all subsequent (cheaper) bids of the same merit order must also be filtered out.
- « Merit-order bid filtering » prevents clearing prices from falling without a corresponding direct reduction in the participant’s cleared volume.
- In this example, filtering-out **bid 4** implies to also exclude **bid 5** to preserves the merit order principles and avoids intended price distortions.

Recommended safeguard 2: « bid slicing »



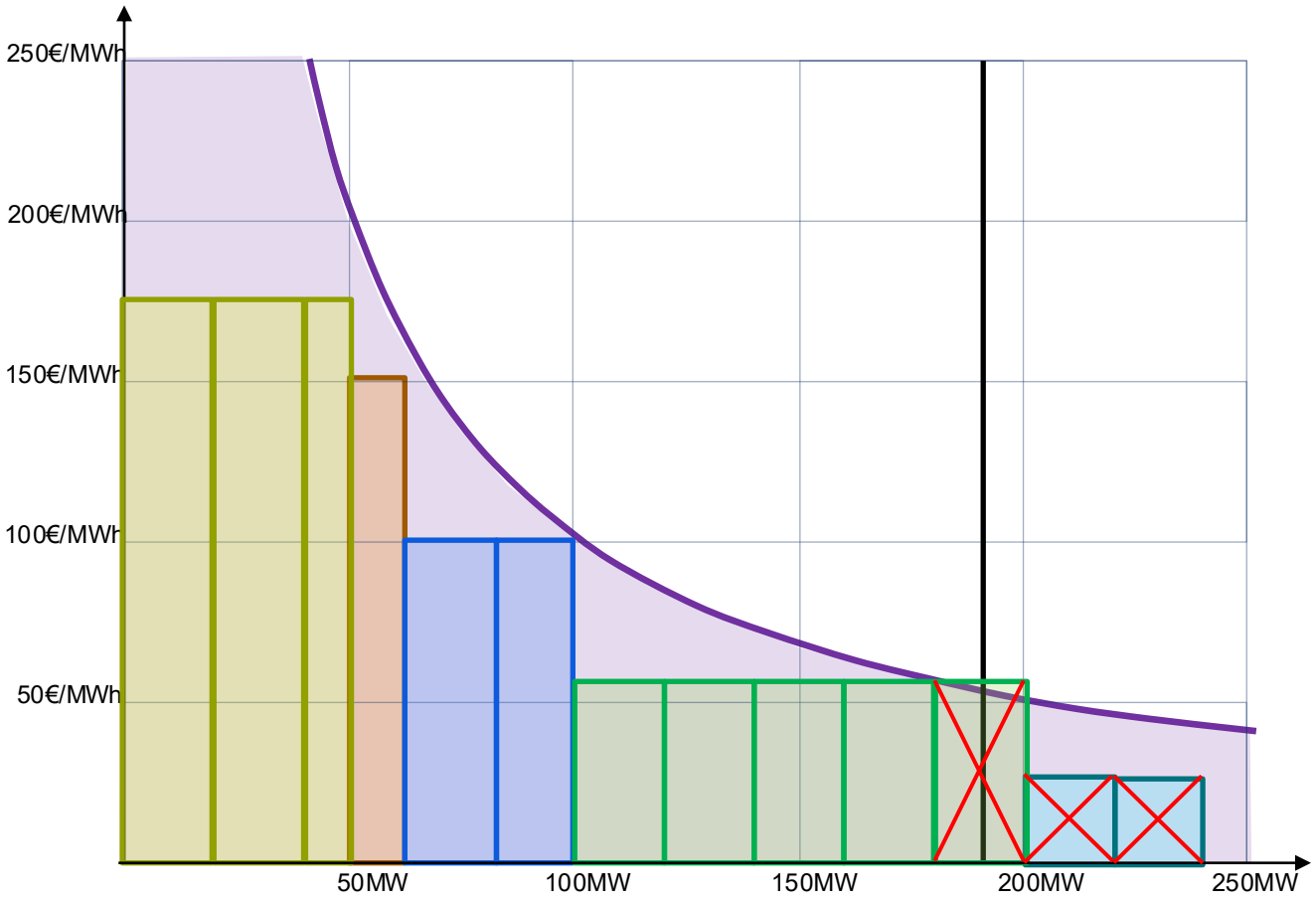
The impact of bid filtering is highly dependent on bids' volumes

N-SIDE recommends to investigate the possibility of mitigating such a volume effect by "slicing" large bids into smaller ones.

NB: Such a reasoning also suggests that bidding behavior may be influenced by the implemented bid filtering methodology

- « Bid slicing » mitigates volume-related effects by splitting bids into capped blocks (e.g. ≤ 20 MW per slice).
- The resulting increase in the number of bids may affect computational performance.
  NB: market participants may also decide themselves to reduce their maximum bid size (i.e. changes in bidding behaviour)

Overall recommendation – design principles



The overall N-SIDE recommendation is to combine:

- **auction-surplus optimization**
  as bid-filtering criterion (i.e. objective function)
- **merit-order bid filtering per border**
  to ensure consistent and principled price formation
- **(possibly) bid slicing**
  to mitigate volume-related effects.

This design:

- relies on an **objective, standard**, and **non-discriminatory** filtering criterion,
- **avoids artificial price reductions** disconnected from actual volume adjustments,
- enforces the **merit order** as a **fundamental principle**, and
- **limits** the undue **influence** of **large bids**.

NB: applying this recommendation may require some further small adaptations of the formulas in the methodology (compared to the ones N-SIDE previously provided)

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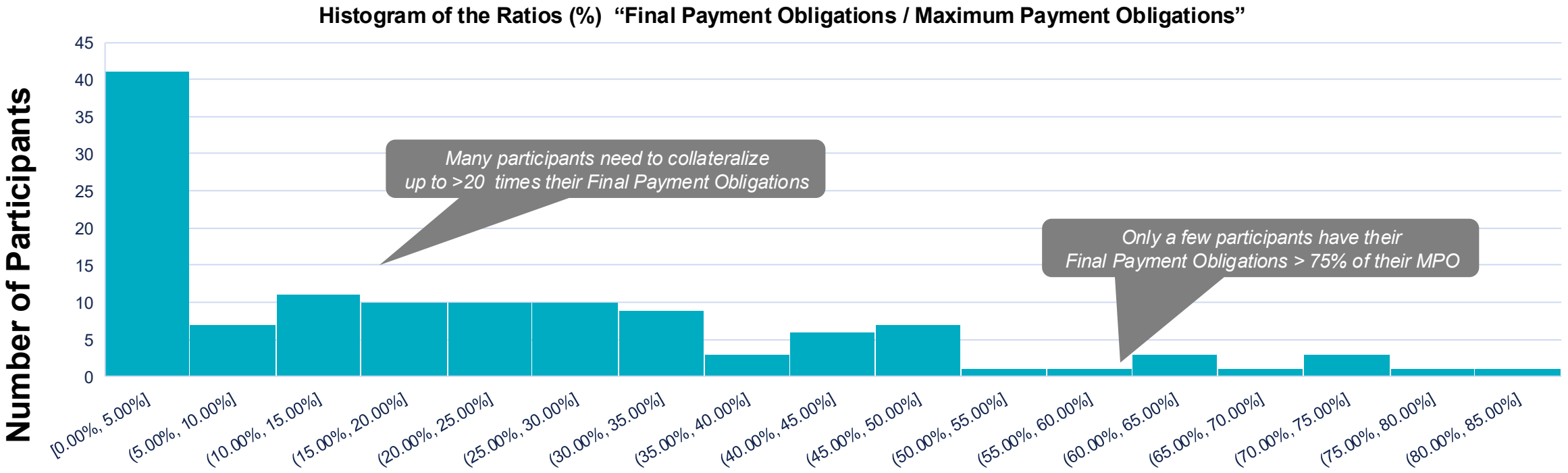
Optimal Bid Filtering

Proof-of-Concept results

Public data

Maximum Payment Obligations by Design Overestimate the Final Payment Obligations

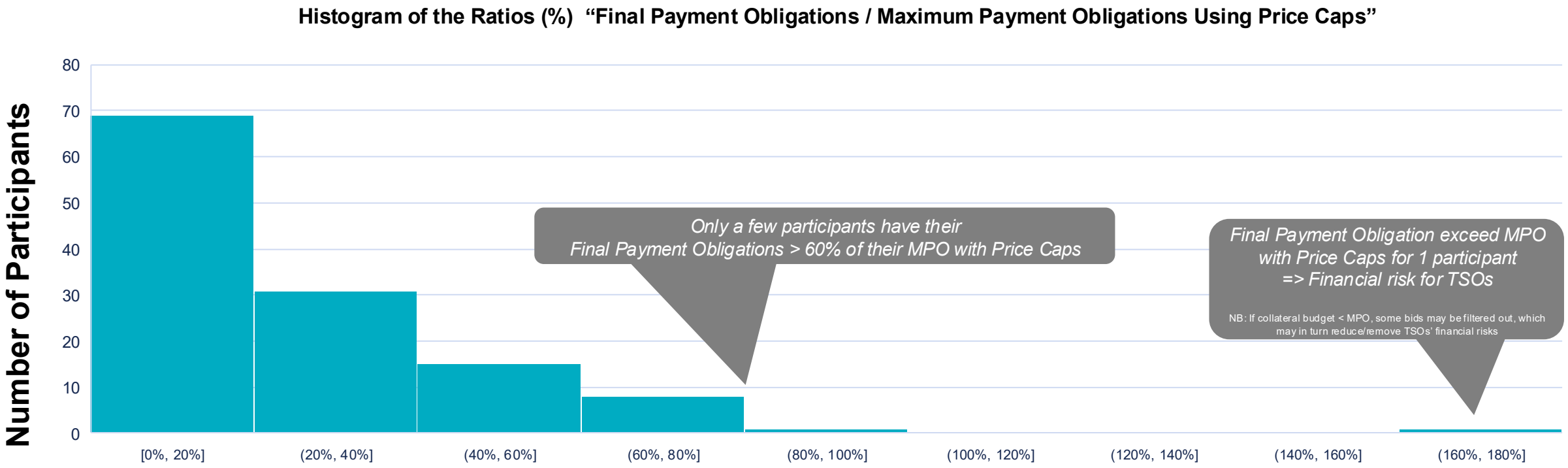
Final Payment Obligations (i.e. actual settlements) without Bid Filtering Are Most Often a Fraction of the MPO



Maximum Payment Obligations are by design too conservative
→'Worst-case scenario' per participant,
→No information on other participant's bids & FB domain

… even when Price Caps Are Applied

Final Payment Obligations (Settlements) without Bid Filtering Are Most Often a Fraction of the MPO
Even when Price Caps Are Applied



Optimal Bid Filtering?

- The previous statistics on settlements vs MPO suggest that one can ***benefit from*** filtering bids ***based on the auction prices.***

- The idea was already considered by ENTSO-E (*) but thought to require a cumbersome, technically challenging and non-transparent iterative process.

- The present study shows that the requirements can be modeled as a well-defined, technically solvable, welfare optimization problem subject to collateral budget constraints.

(*) See page 9 in *Long-Term Market Flow-Based Allocation (LTFBA) High-Level Market Design document (10 December 2021).*

Simulation Setup

4 different filtering models

1. No bid filtering

- Reference scenario

2. Ex-ante bid filtering:

- Participant's bids are excluded as long as MPO > Collateral Budget
- Filtering priority follows "absolute merit order": bids with lowest prices, (irrespective of their borders) are excluded first.
- NB: Other bid filtering priority shouldn't substantially change the results.

3. Ex-ante bid filtering with Price Caps

- MPO is calculated based on capped bid prices
- Otherwise identical as "Ex-ante bid filtering"

4. Optimal bid filtering

- Bids are filtered **only** if Final Payment Obligations > Collaterals
- Filtering priority = auction-surplus maximization
- Merit-order bid filtering: For each participant and each border, a bid can only be filtered-out if all cheaper bids are also filtered-out
- (Bids' data are not altered, i.e. no bid volume slicing or price capping)

4 Main Scenarios Datasets:

1. Scenario 25-FB-1: Yearly bids of 2025 with Flow-based Domain 2025 n°1
2. Scenario 24-FB-1: Yearly bids of 2024 with Flow-based Domain **2024 n°1**
3. Scenario 25-FB-2: Yearly bids of 2025 with Flow-based Domain **2025 n°2**
4. Scenario 24-FB-2 Yearly bids of 2024 with Flow-based Domain **2024 n°2**

In all 4 scenarios: for each participant, Collateral Budgets = 75% of MPO

Price caps 2024 and 2025 provided by JAO

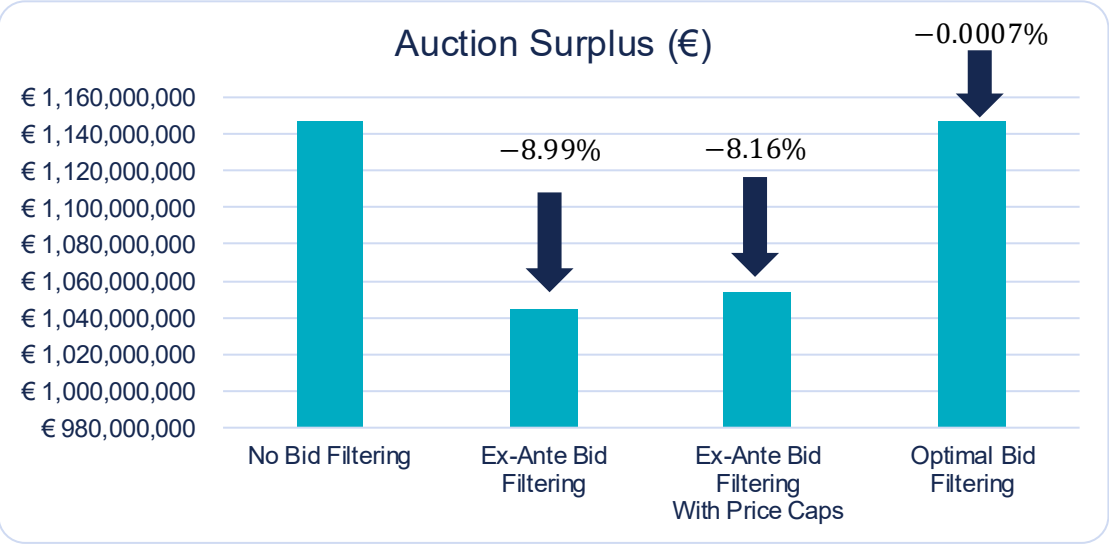
Flow-based Domain 2025 n°1: Y2025_20mR_24TS_Run12-16.05_MinMaxATCshifted

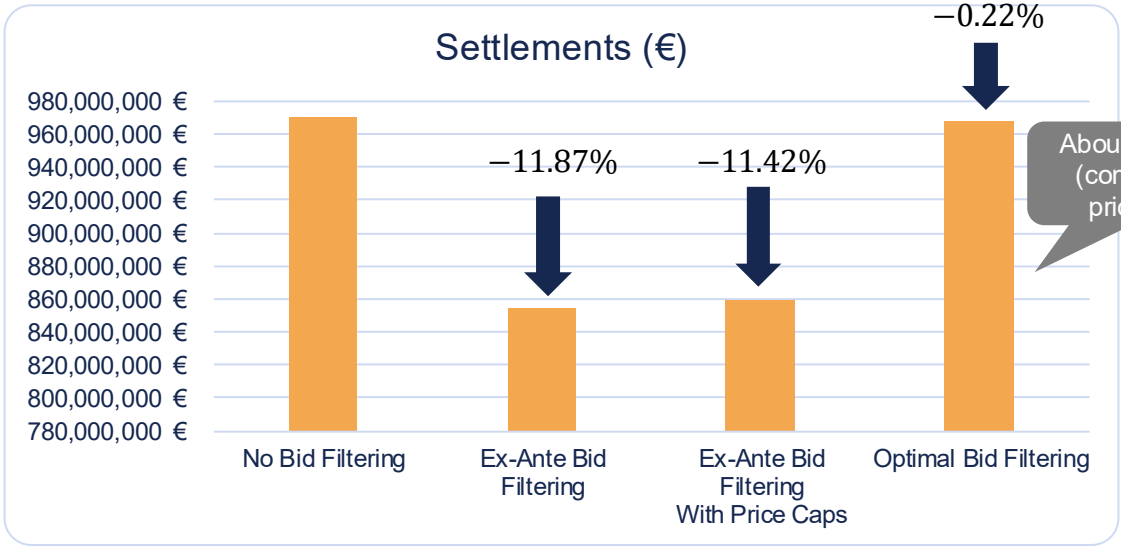
Flow-based Domain 2025 n°2: 20250101-0000-FLT-060-FNL_AMRINCL_ZEROBAL_PRES_MERGED_SPLIT_FBPARAMS-v1

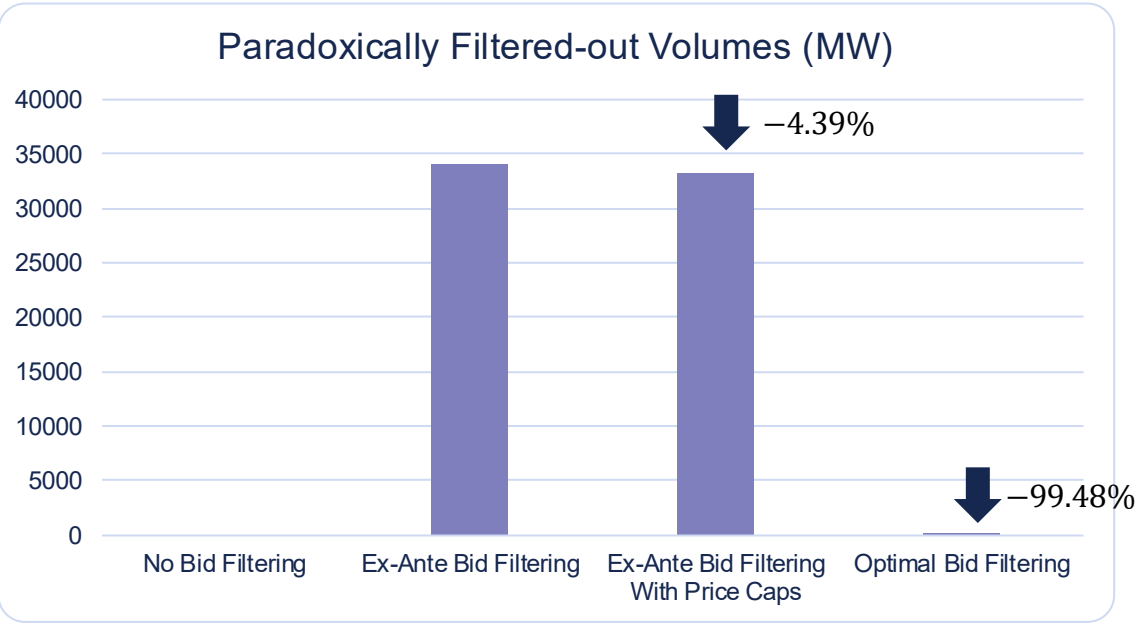
Flow-based Domain 2024 n°1: Seasonal_Shifted_Y2024_MinMaxATC_ZeroBalMinMaxATC

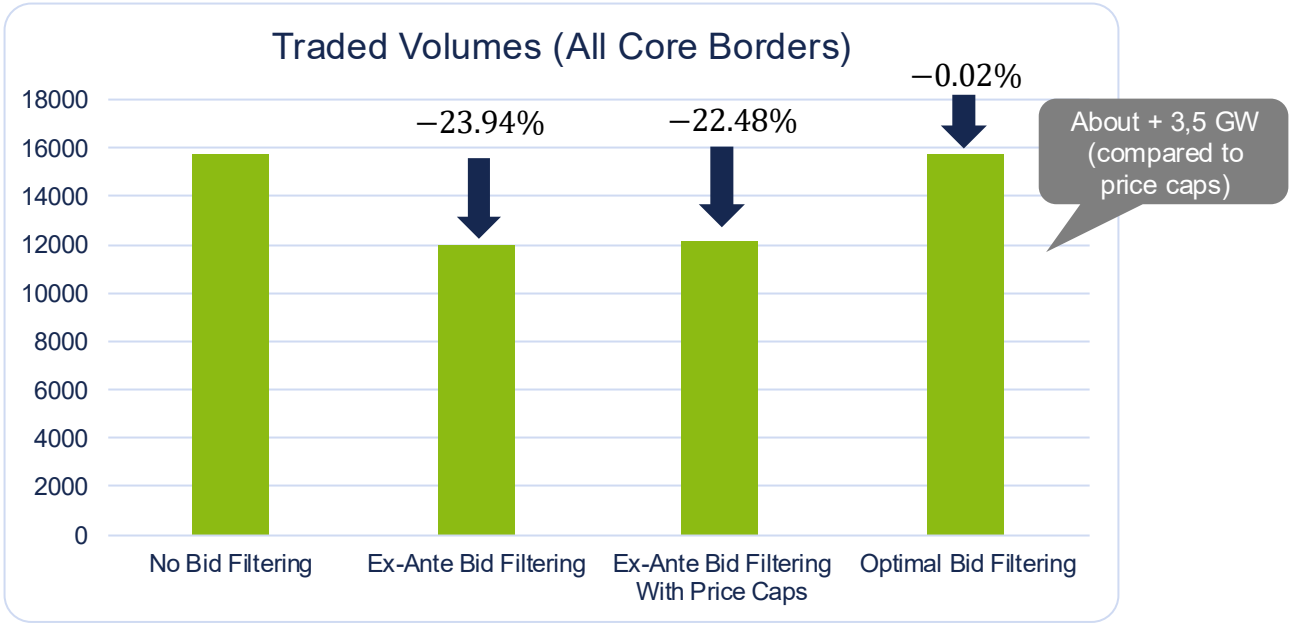
Flow-based Domain 2024 n°2: 20240101-0000-FLT-060-FNL_AMRINCL_ZEROBAL_PRES_MERGED_SPLIT_FBPARAMS-v1

Main KPIs Are Improved with the Optimal Bid Filtering

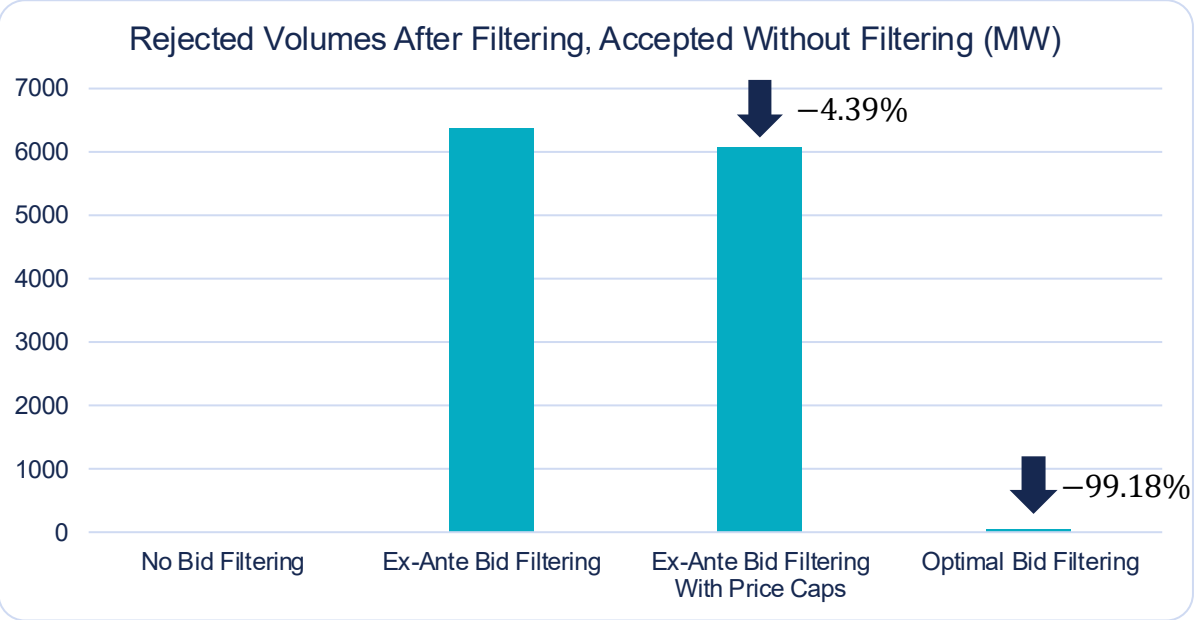


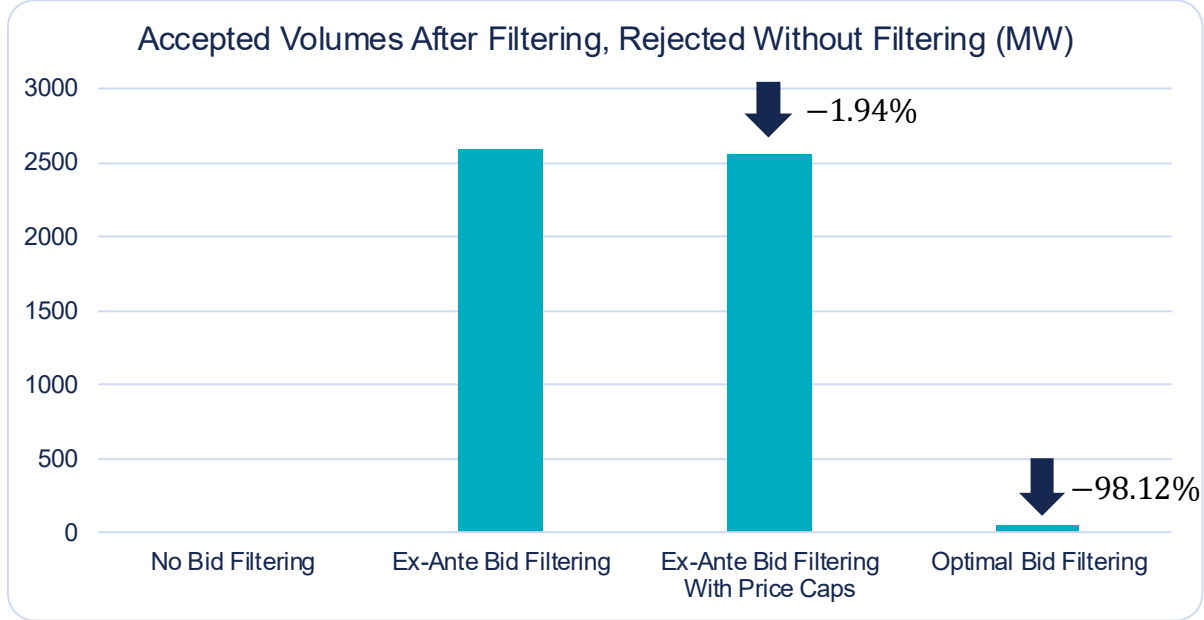






Filtered Volumes are also improved



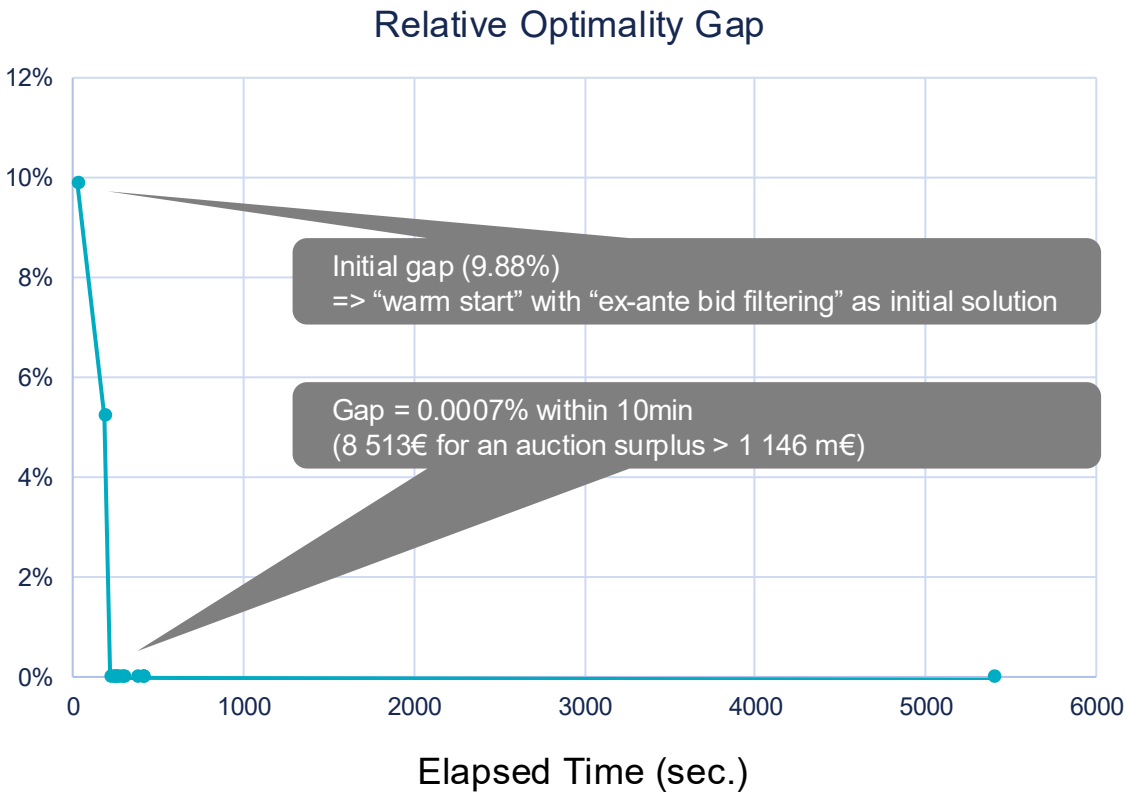


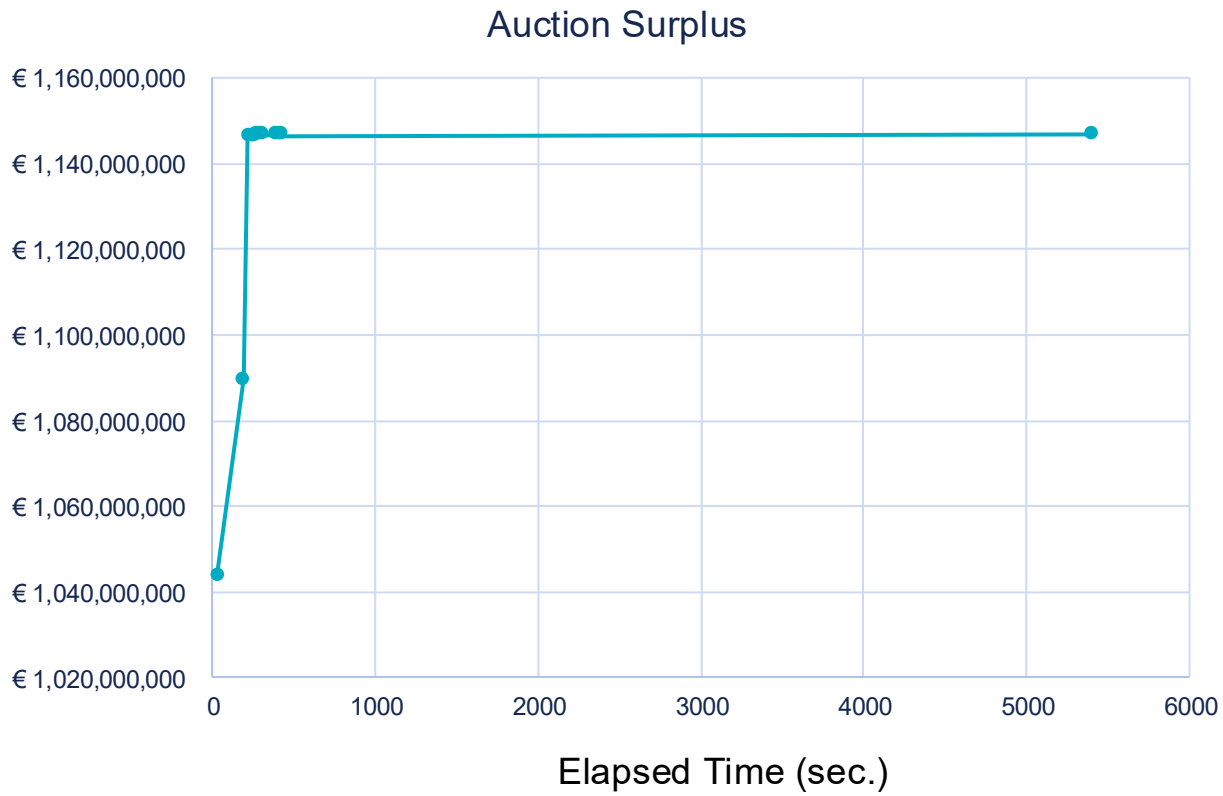
Net Effect = Total Variation of the Traded Volume (slide Main KPIs)

N.B. In this scenario, credit limits are not exceeded under price caps + ex-ante bid filtering.

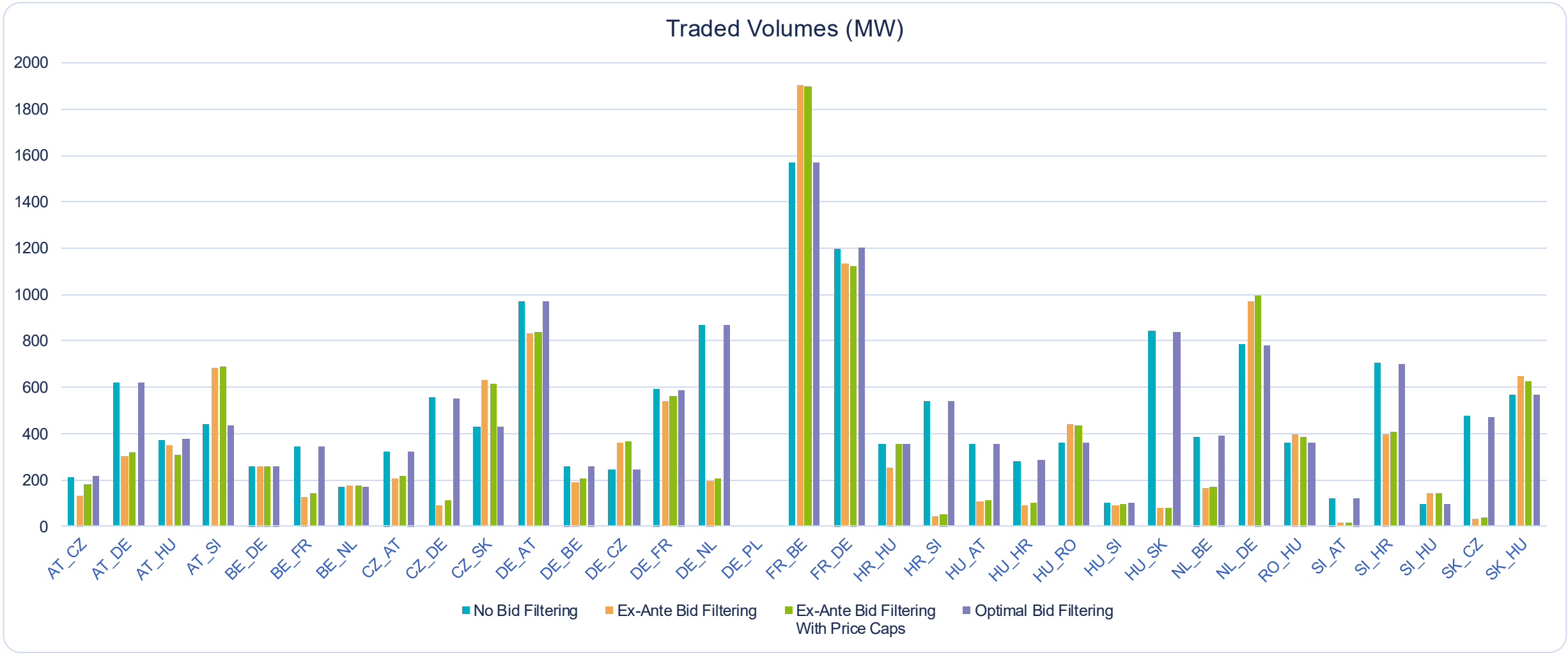
Optimal Bid Filtering PoC Performances
→ Near-optimality Often Reached Within 10min

Simulations run on a Apple M4 Pro (24 GB)
Using CPLEX 22.1.1.0 (via the Python API DOcplex)

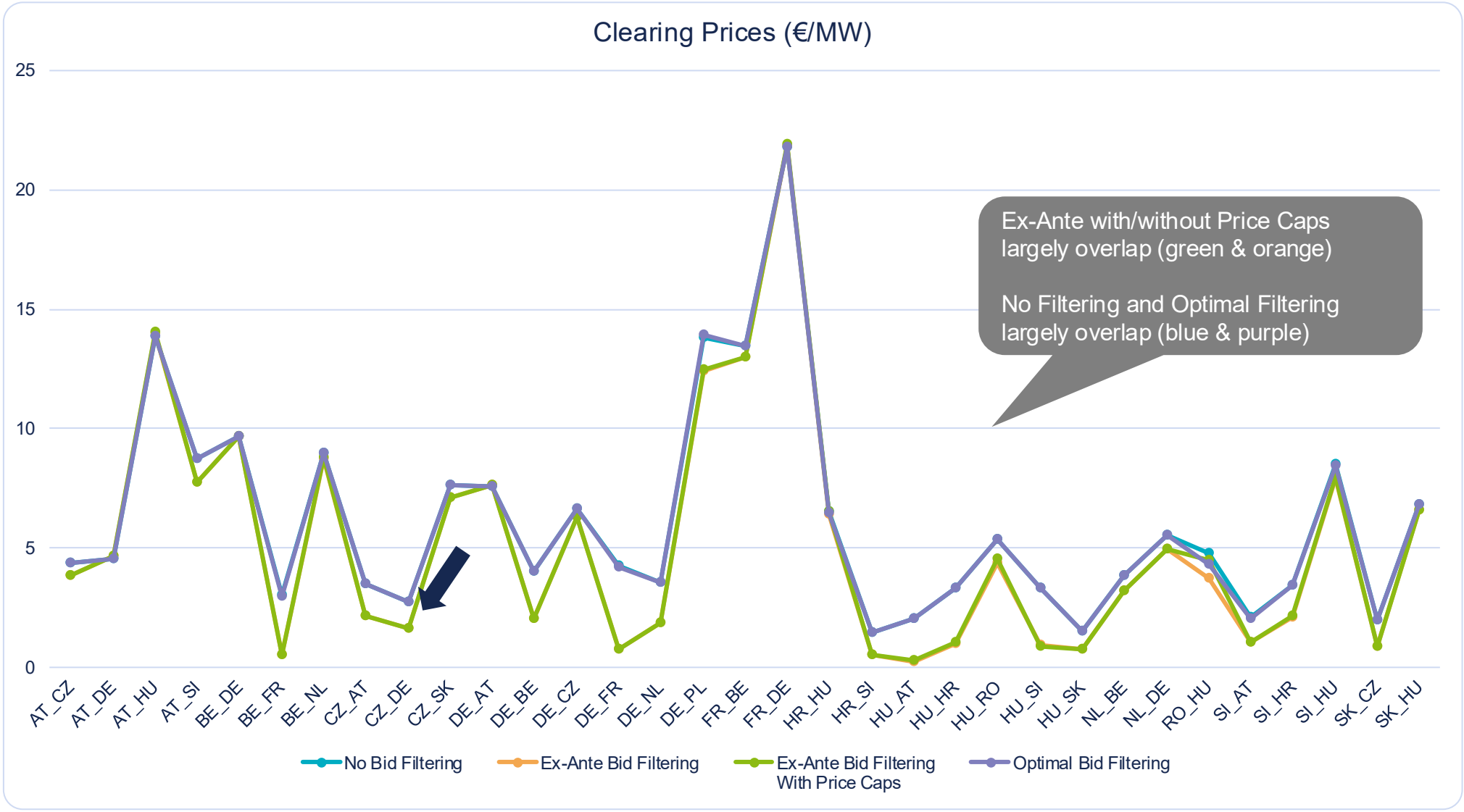




Traded Volumes Per Border → Less Impacted with Optimal Bid Filtering

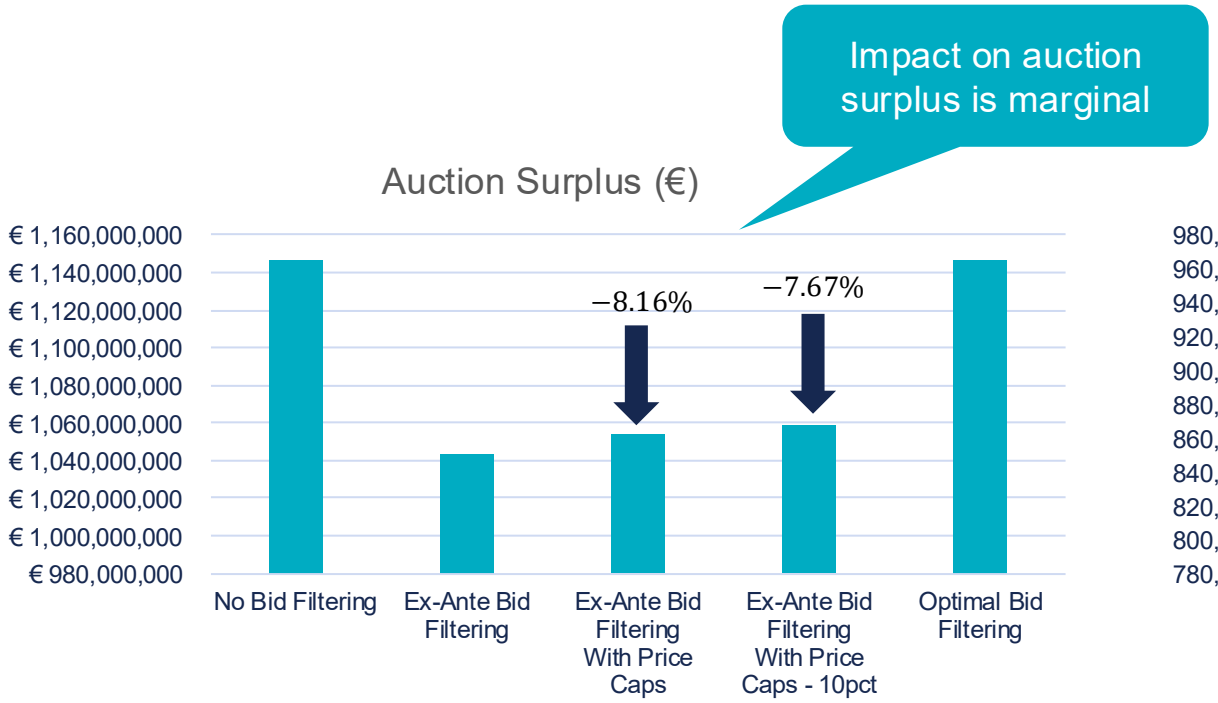


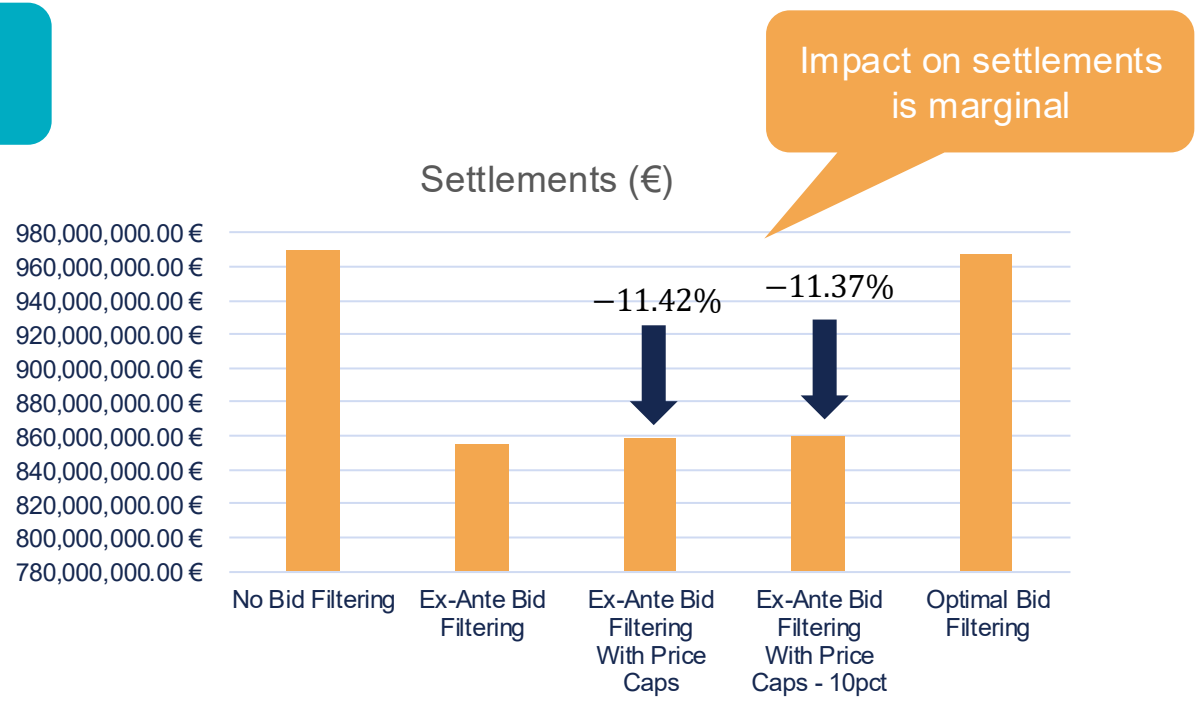
MCP Per Border → Less Impacted with Optimal Bid Filtering



Further Lowering Price Caps Has Only a Modest Impact

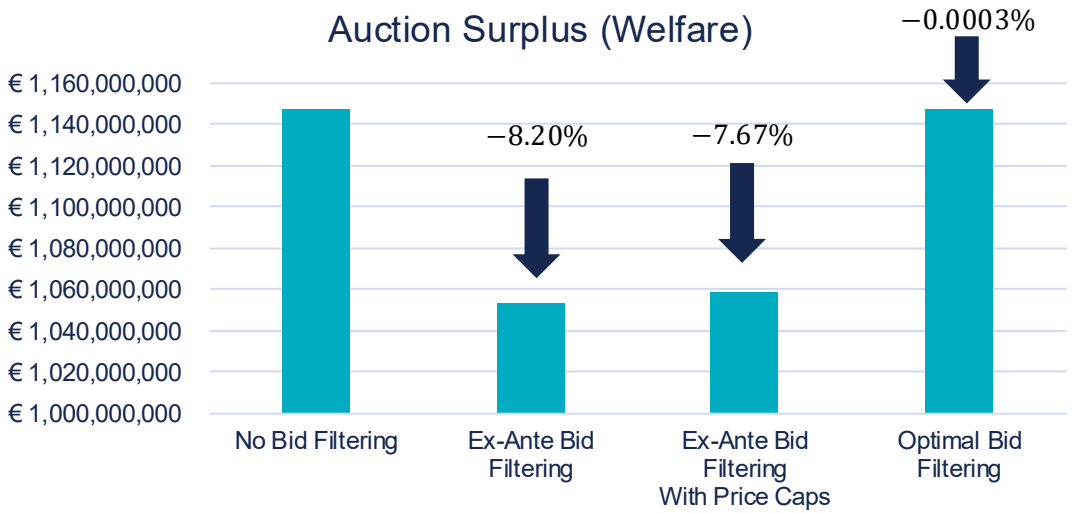
→ Expected, in view of the discussion on MPO above

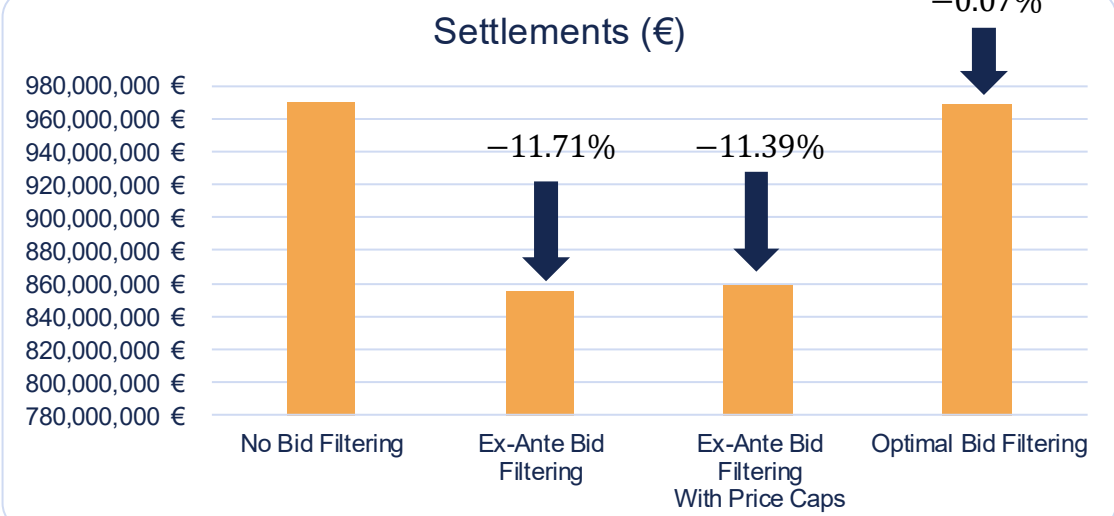


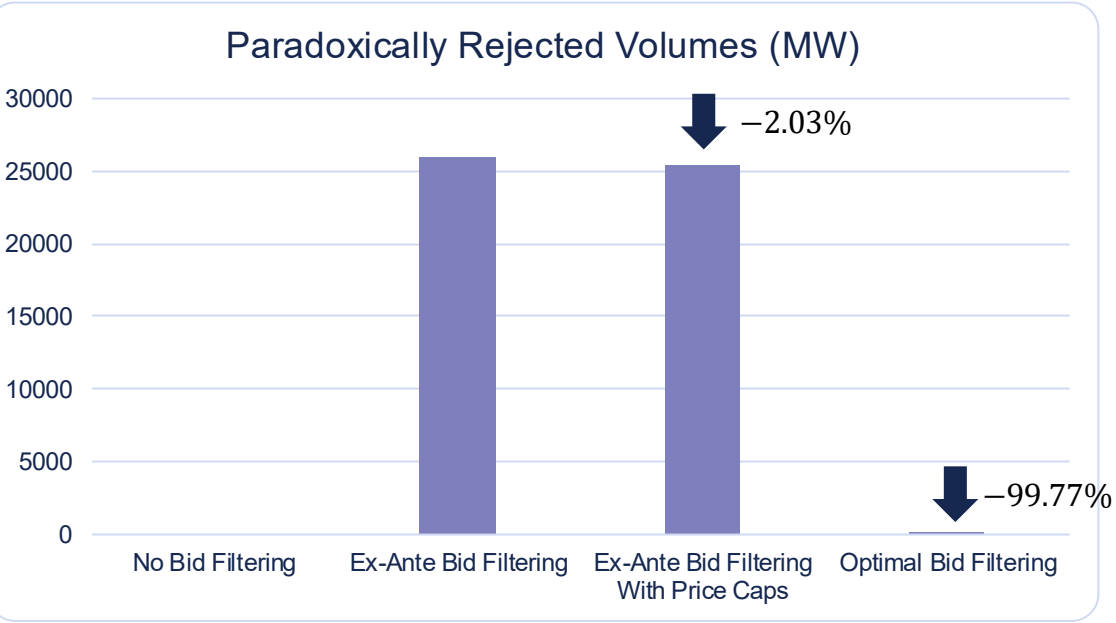


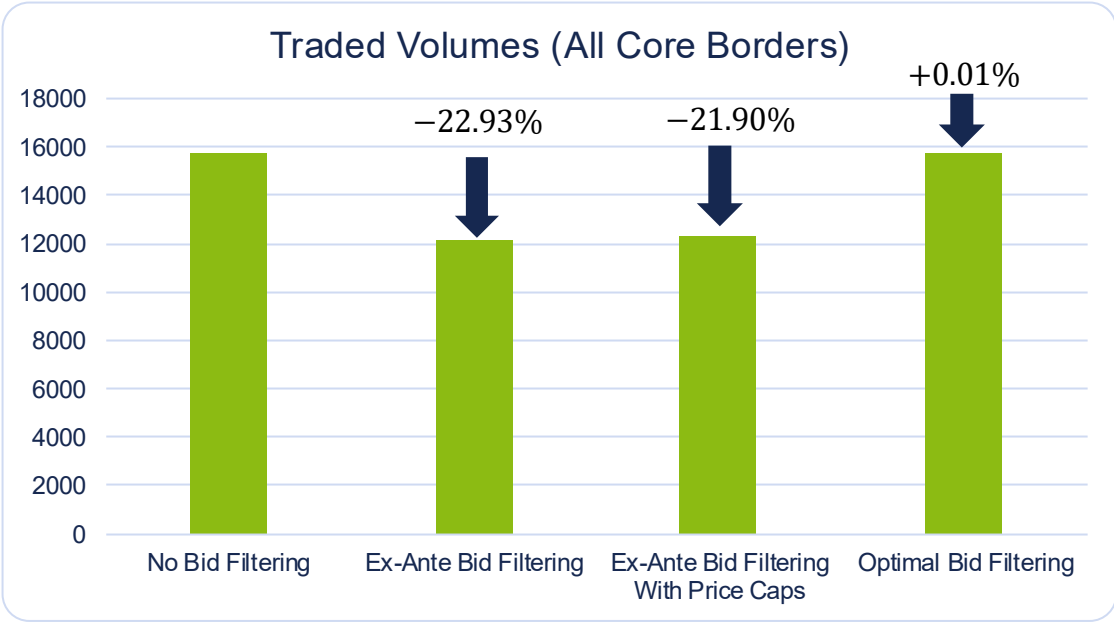
Lowering Price Caps increases the risk of a “situation that the MP does not have enough collateral to cover their actual liabilities” (ENTSO-E, **5th Workshop on the long-term flow-based allocation**, slide 6 reproduced in annex.)

Main KPIs Are Improved with the Optimal Bid Filtering

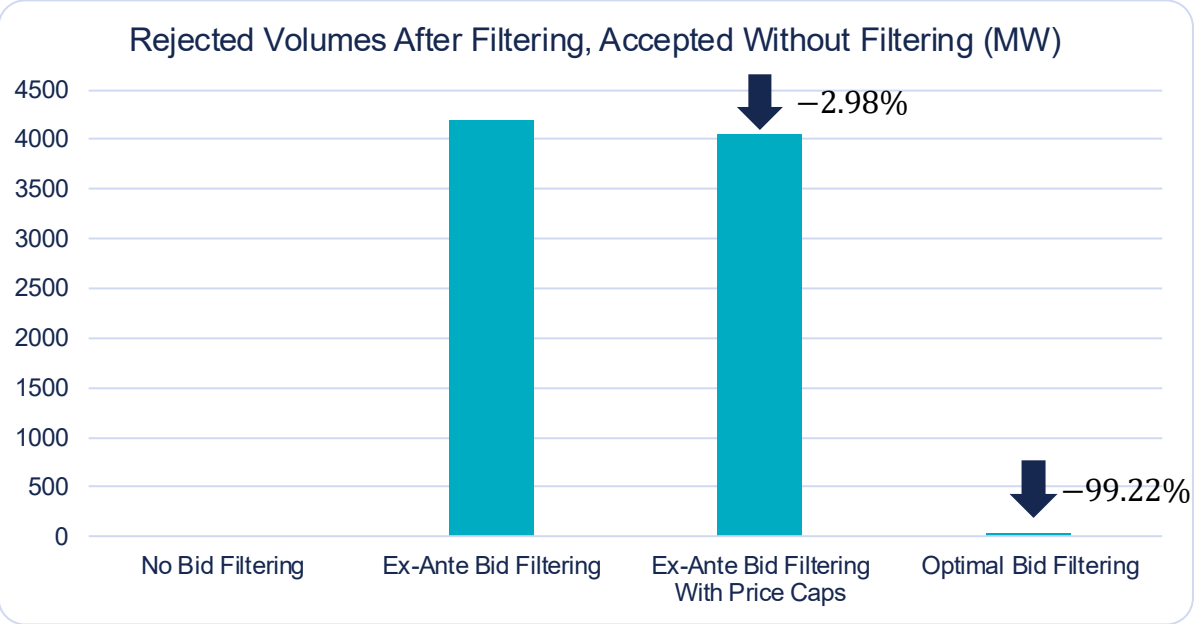


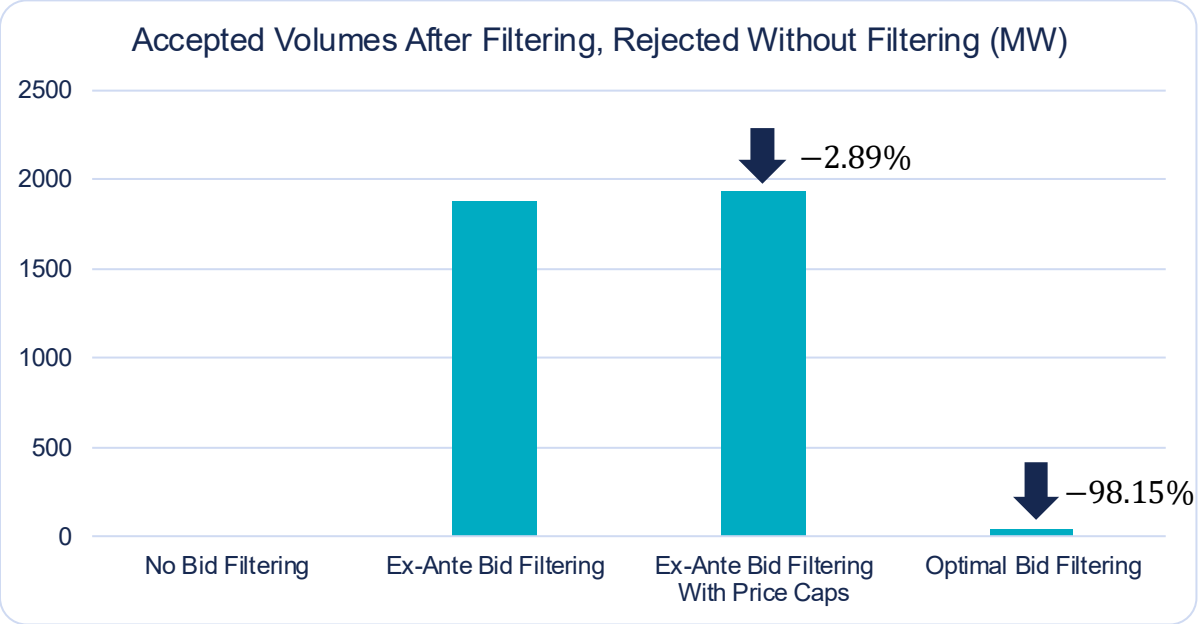






Filtered Volumes are Also Improved



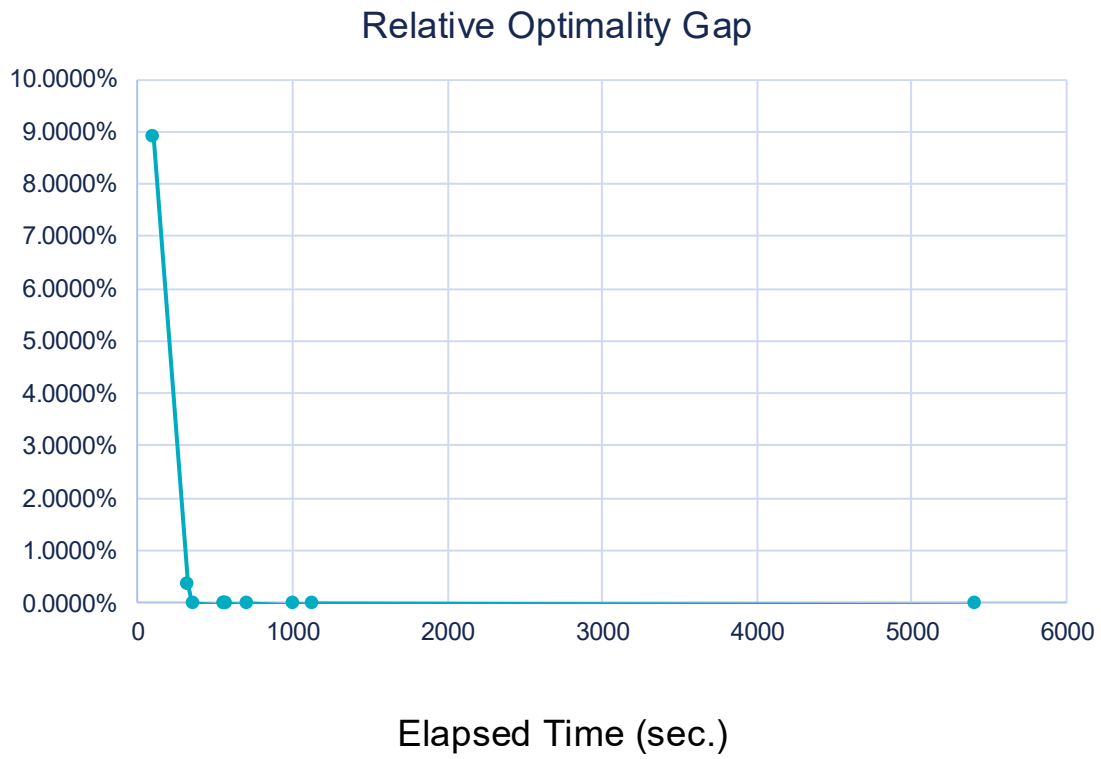


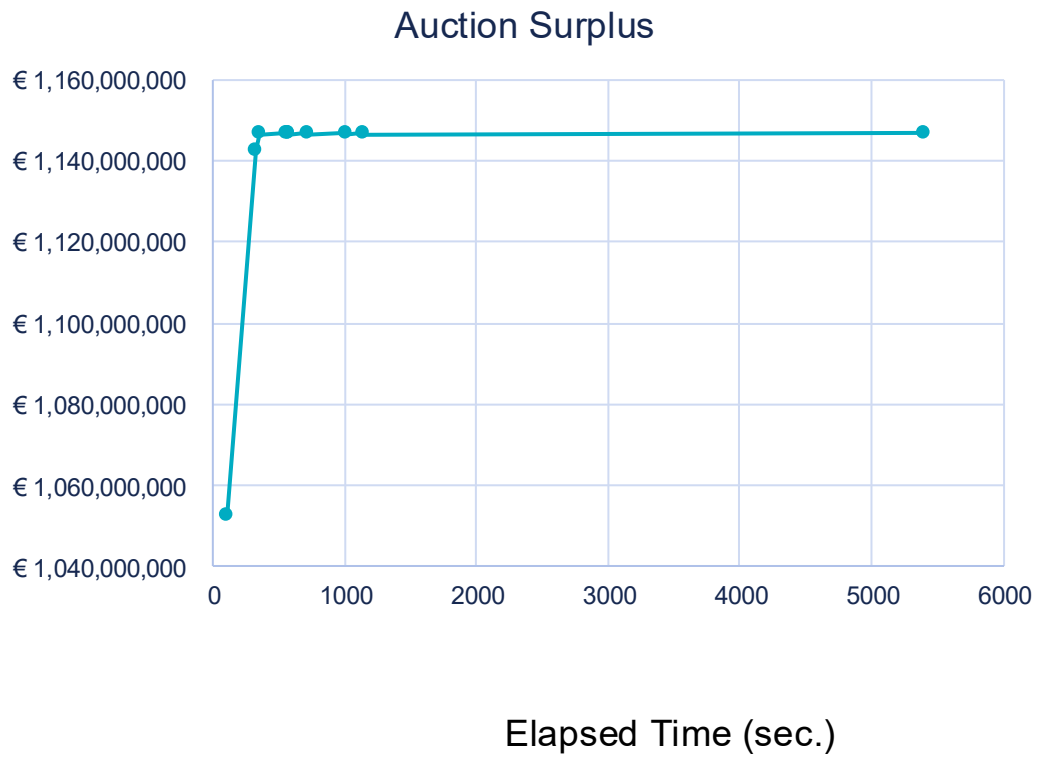
Net Effect = Total Variation of the Traded Volume (slide Main KPIs)

N.B. In this scenario, credit limits are not exceeded under price caps + ex-ante bid filtering.

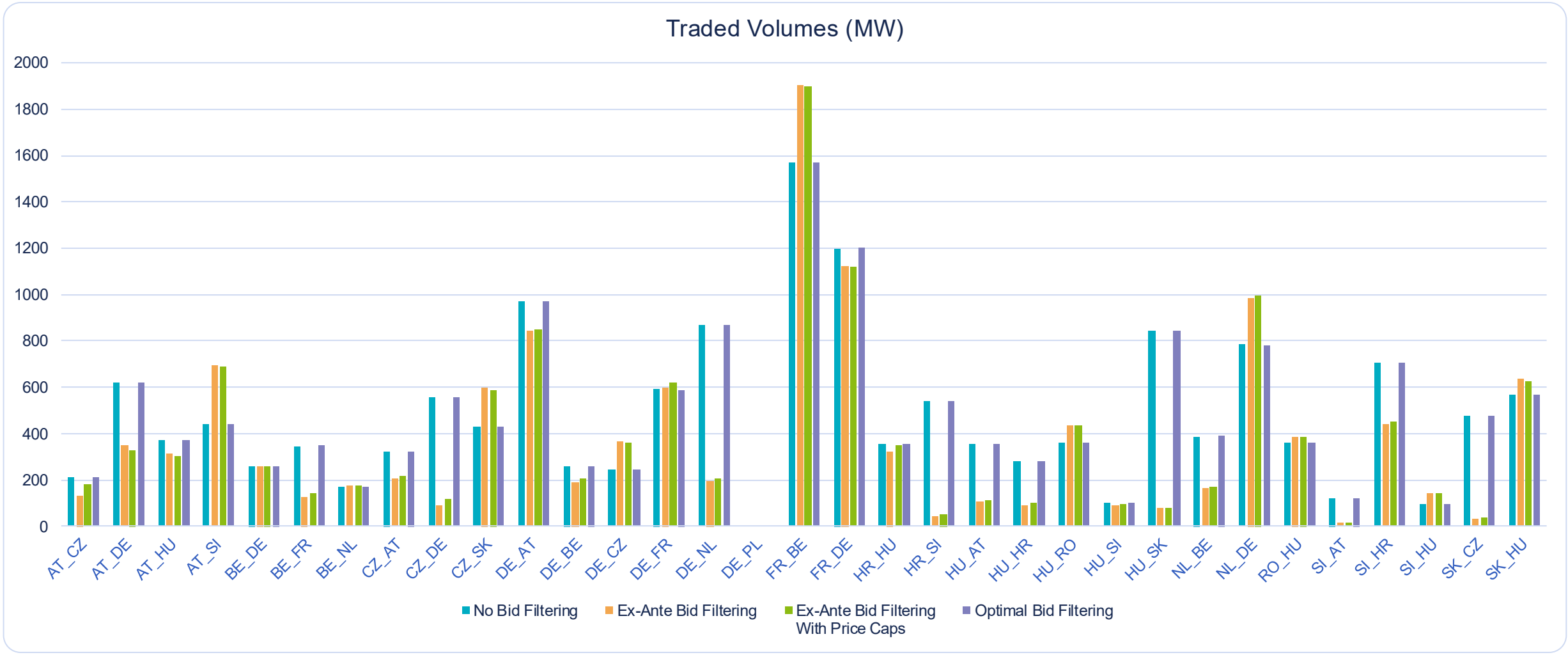
Optimal Bid Filtering PoC Performances
→ Near-optimality Often Reached Within 10min

Simulations run on a Apple M4 Pro (24 GB)
Using CPLEX 22.1.1.0 (via the Python API DOcplex)

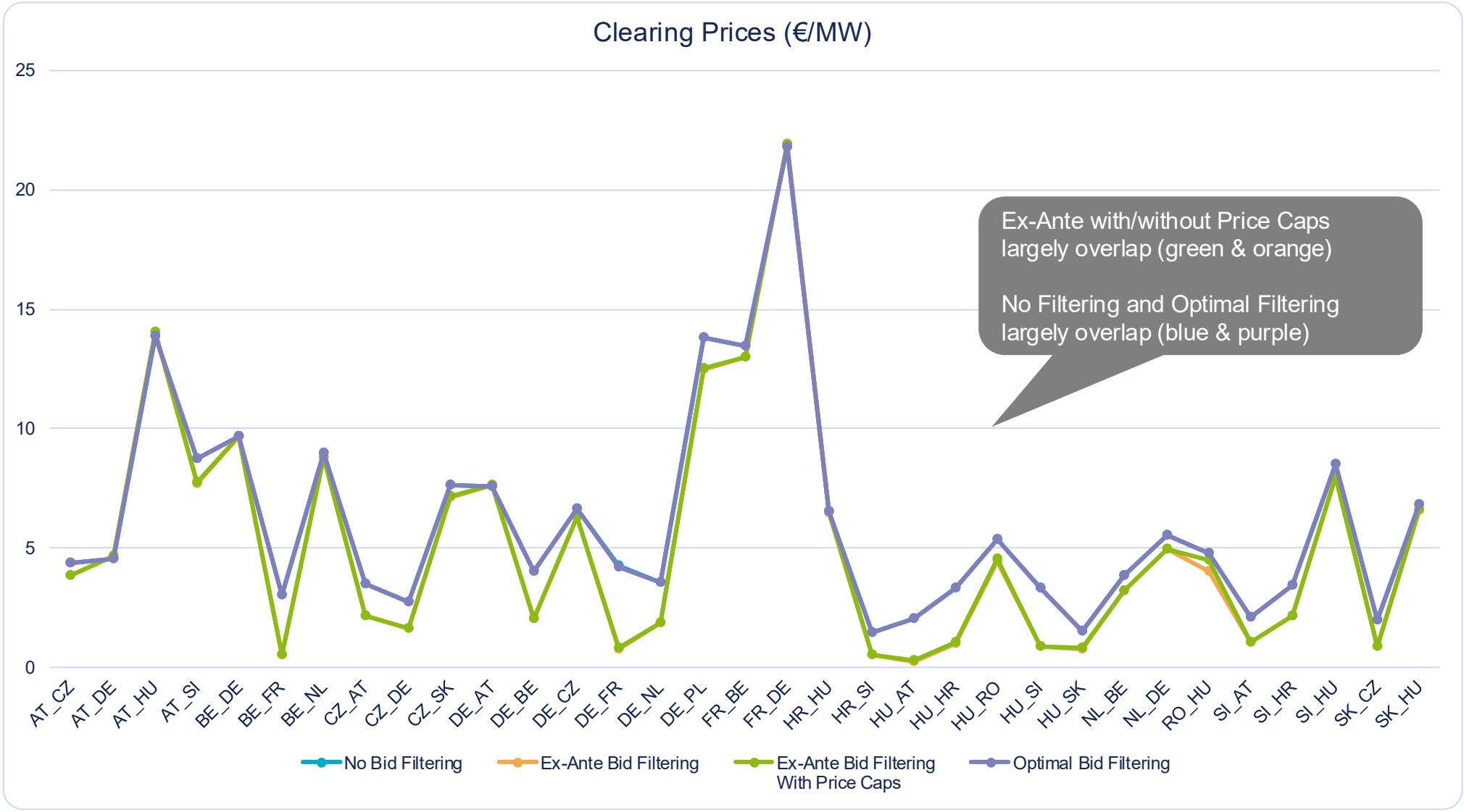




Traded Volumes Per Border → Less Impacted with Optimal Bid Filtering



MCP Per Border → Less Impacted with Optimal Bid Filtering



N-SIDE

Conclusions & Next Steps

Public data

Conclusions

Optimal bid filtering based on auction clearing prices (i.e. Final Payment Obligations):

- is **technically feasible** and can realistically be embedded in the auction clearing process,
- **fully secures TSOs against any settlement risk**, without overestimating collateral needs.

N-SIDE simulations *(collateral budgets set to 75 % of MPO for all participants)* show that optimal bid filtering:

- has **negligible impacts on auction surplus** compared to no bid filtering,
- delivers **significantly better outcomes for market participants** and TSOs than ex-ante bid filtering,
- results in **substantially fewer filtered-out bids**.

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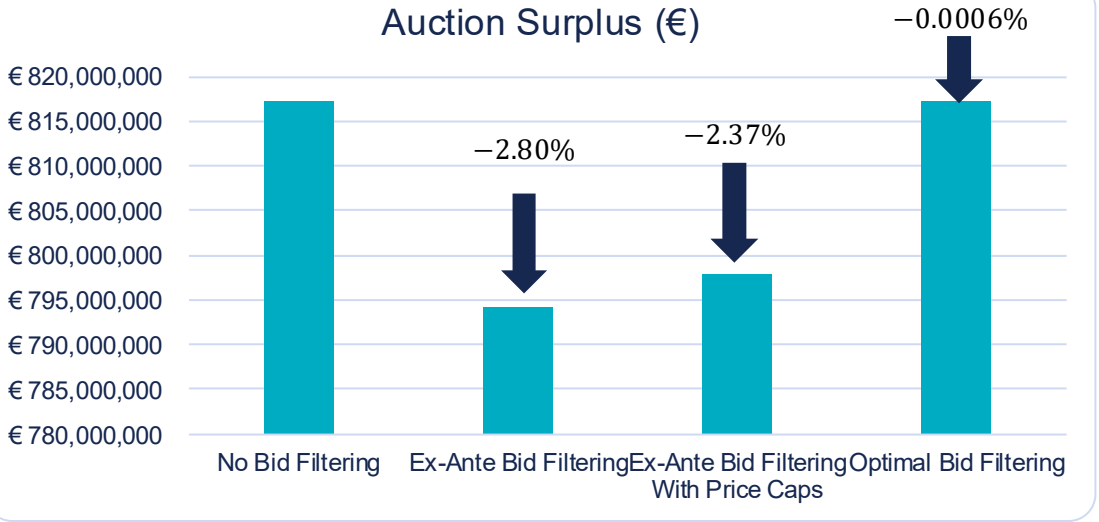
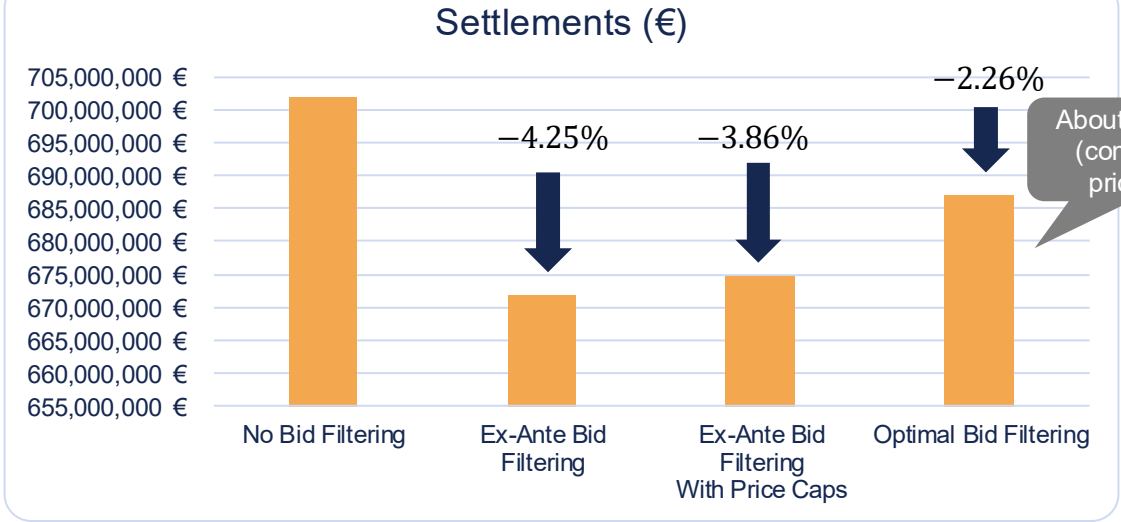
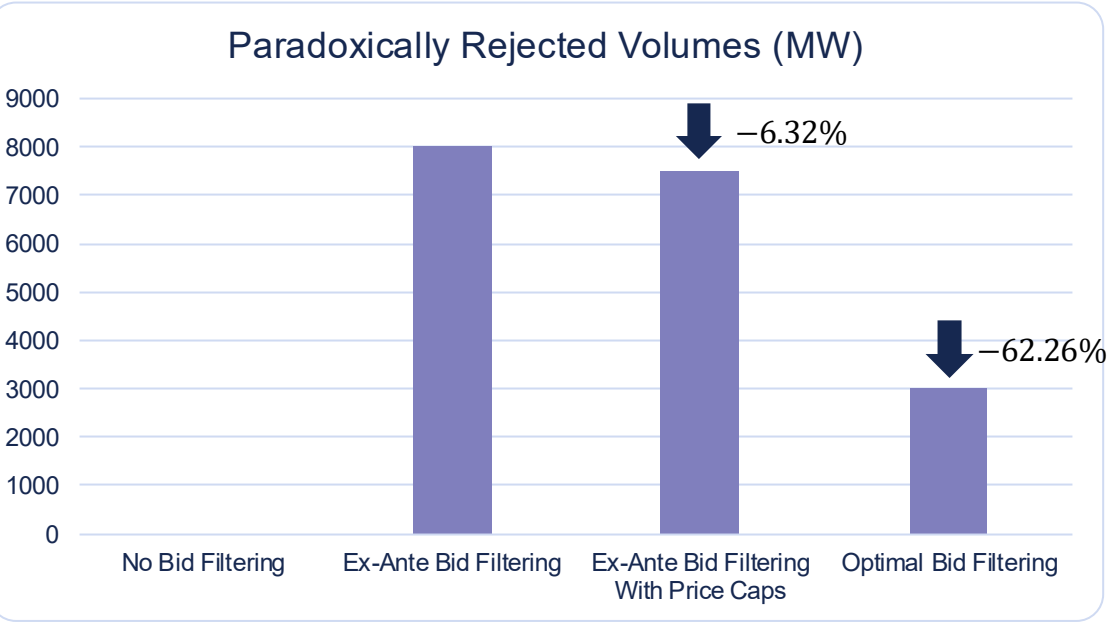
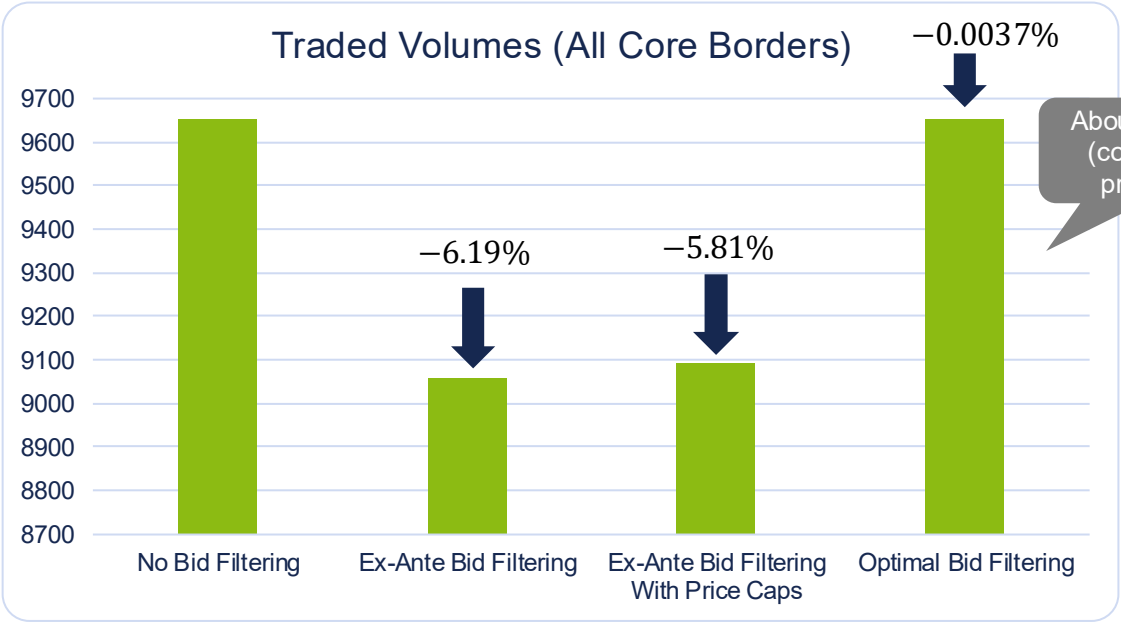
Main KPIs Are Improved with the Optimal Bid Filtering

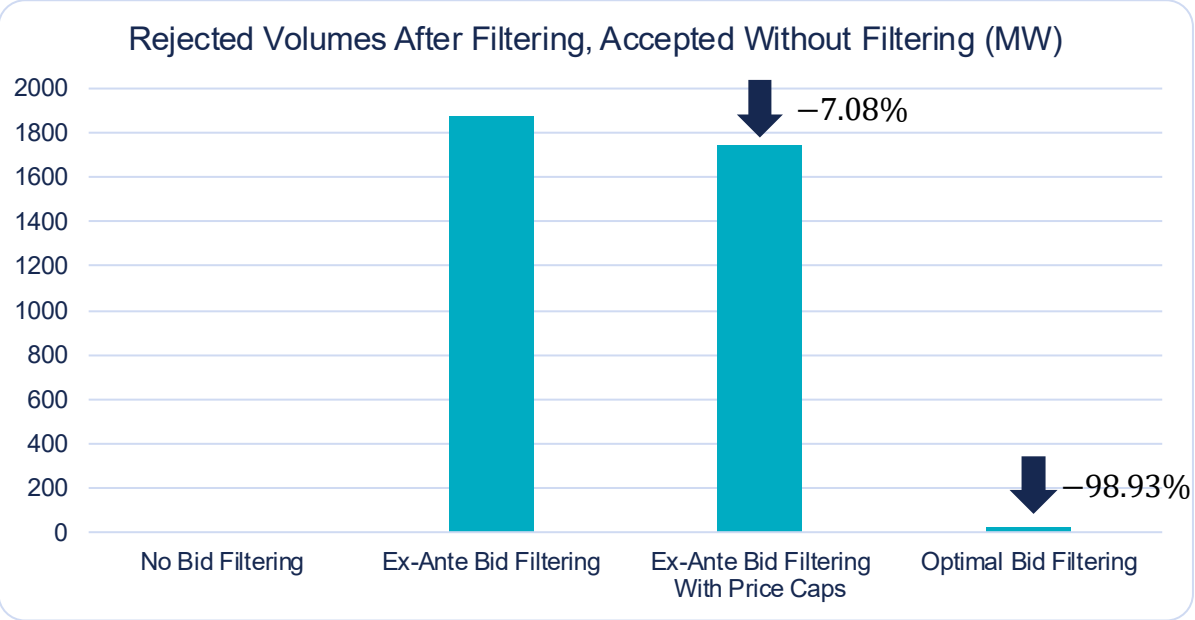


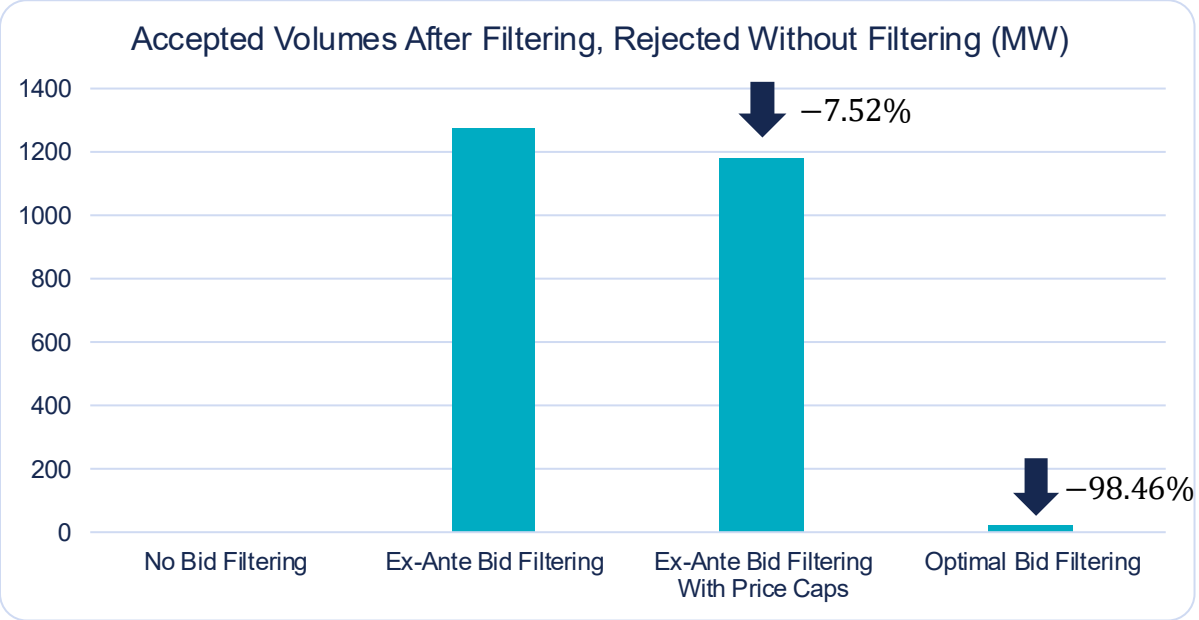






Filtered Volumes are Also Improved





Net Effect = Total Variation of the Traded Volume (slide Main KPIs)

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Optimal Bid Filtering PoC Performances
→ Near-optimality Often Reached Within 10min

Simulations run on a Apple M4 Pro (24 GB)
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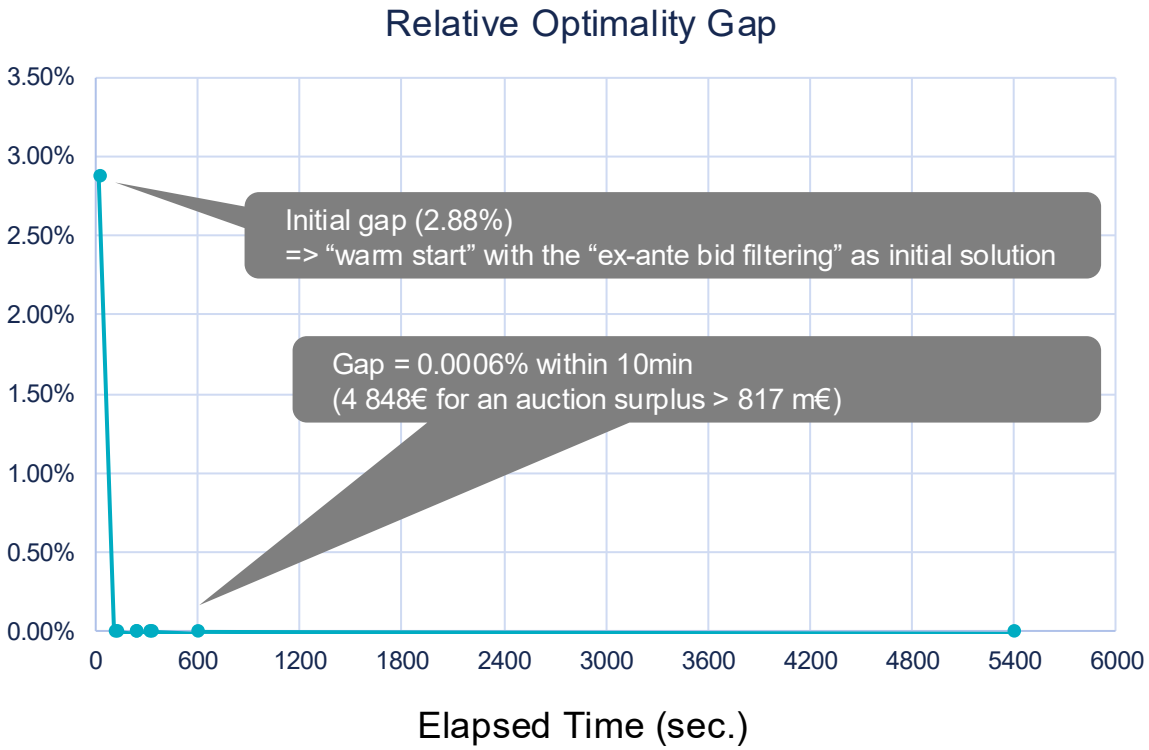
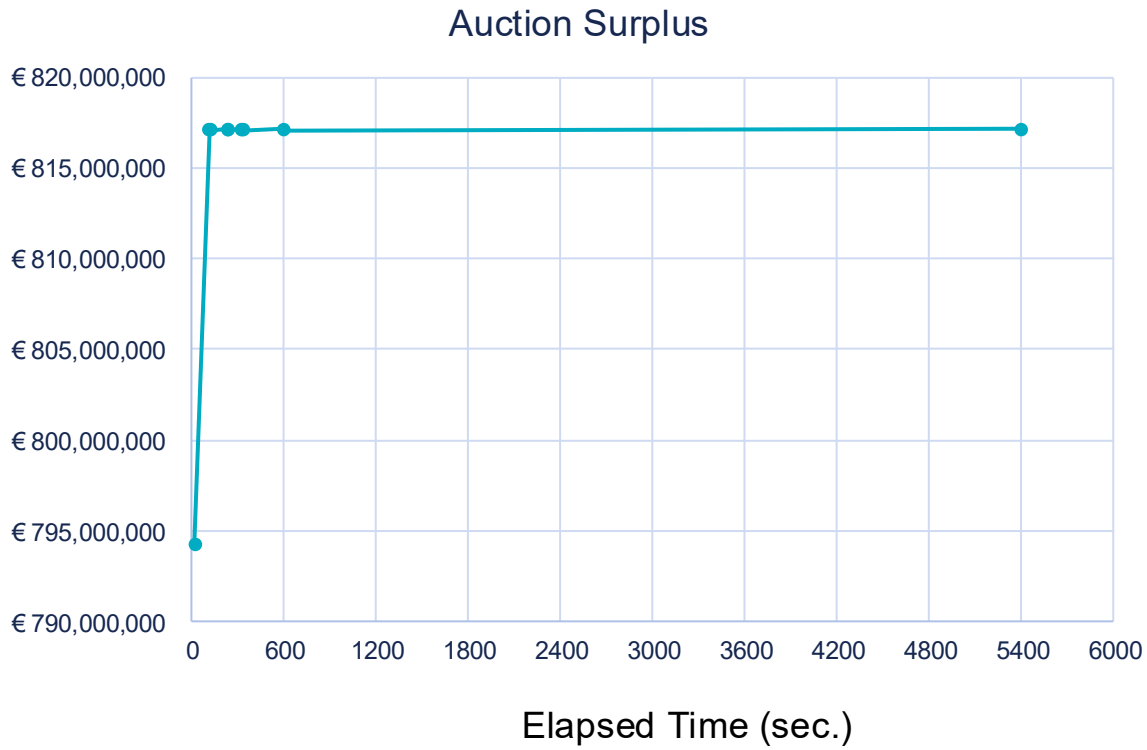
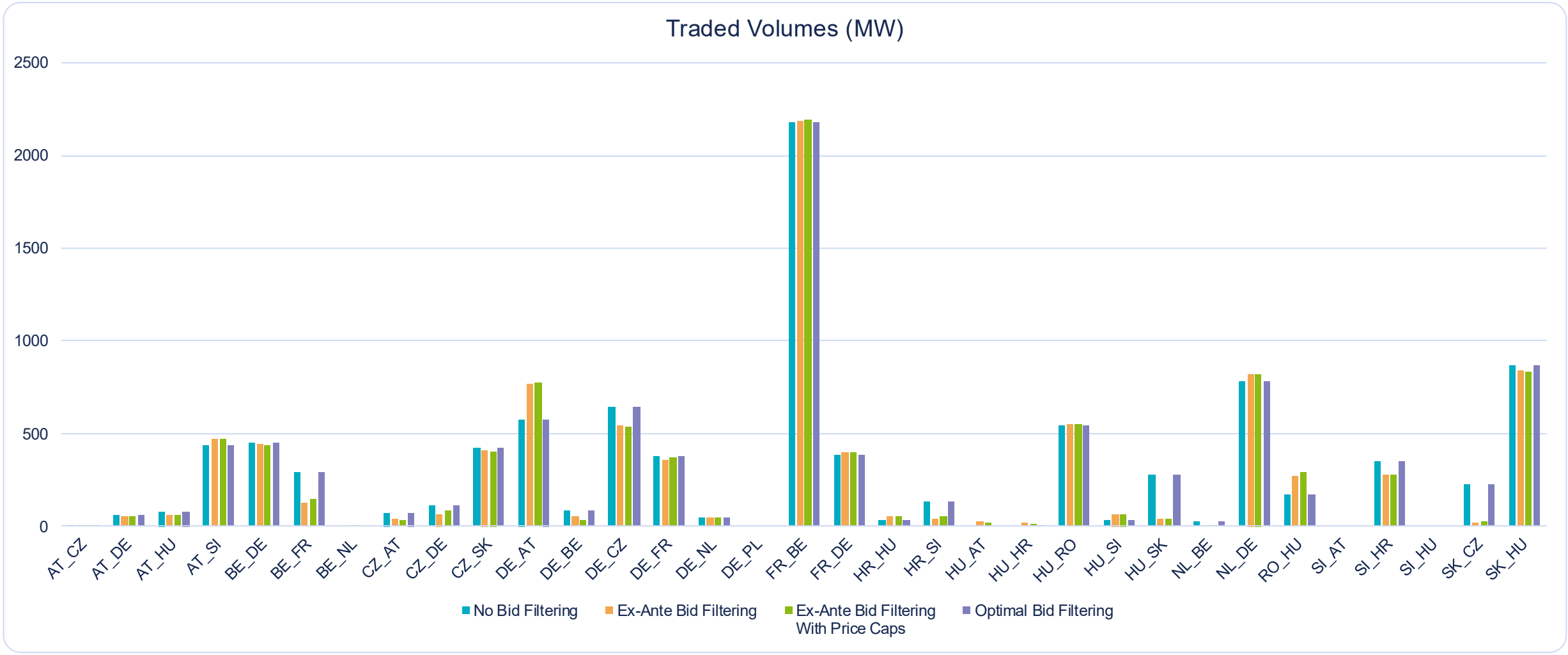


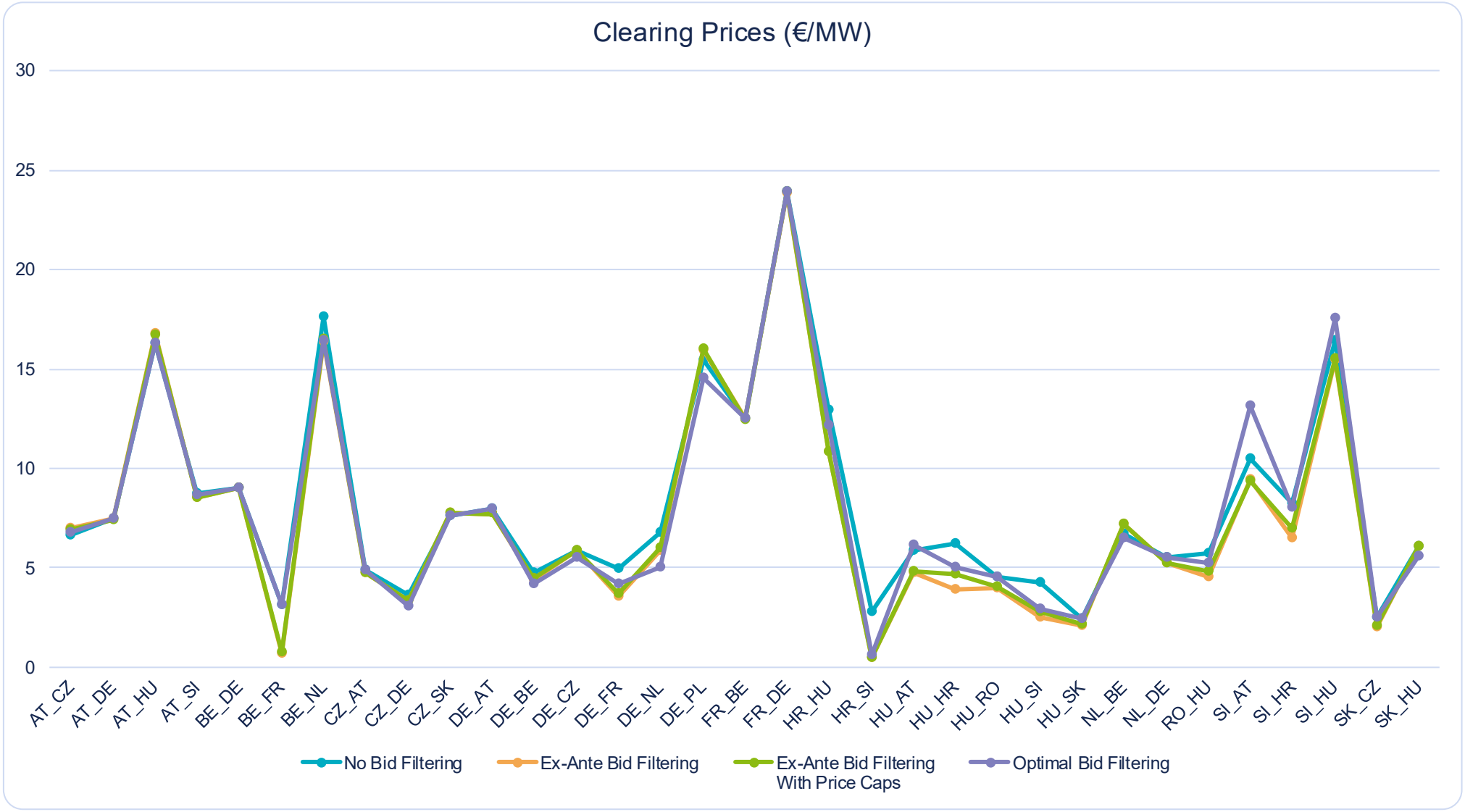


N-SIDE

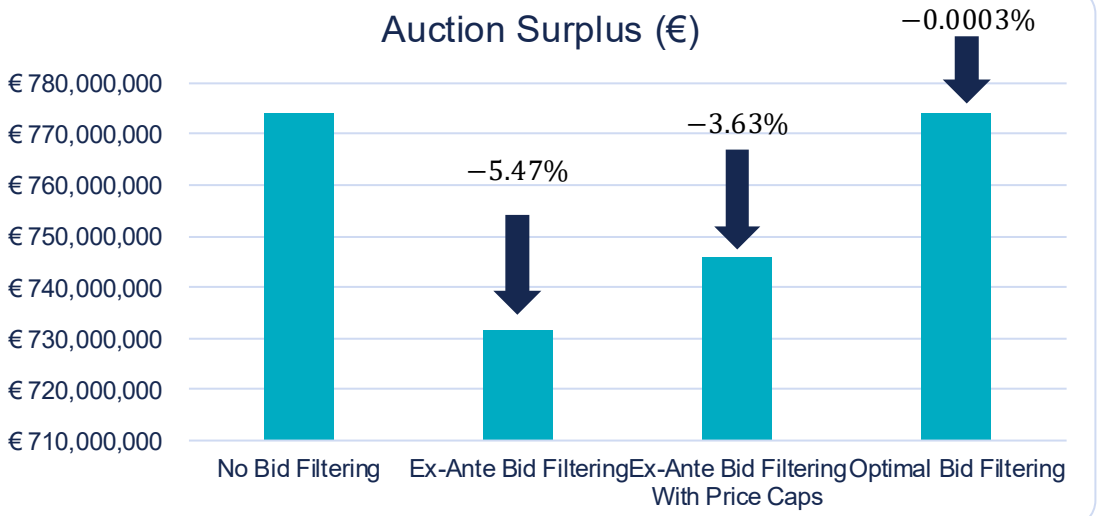
Traded Volumes Per Border → Less Impacted with Optimal Bid Filtering

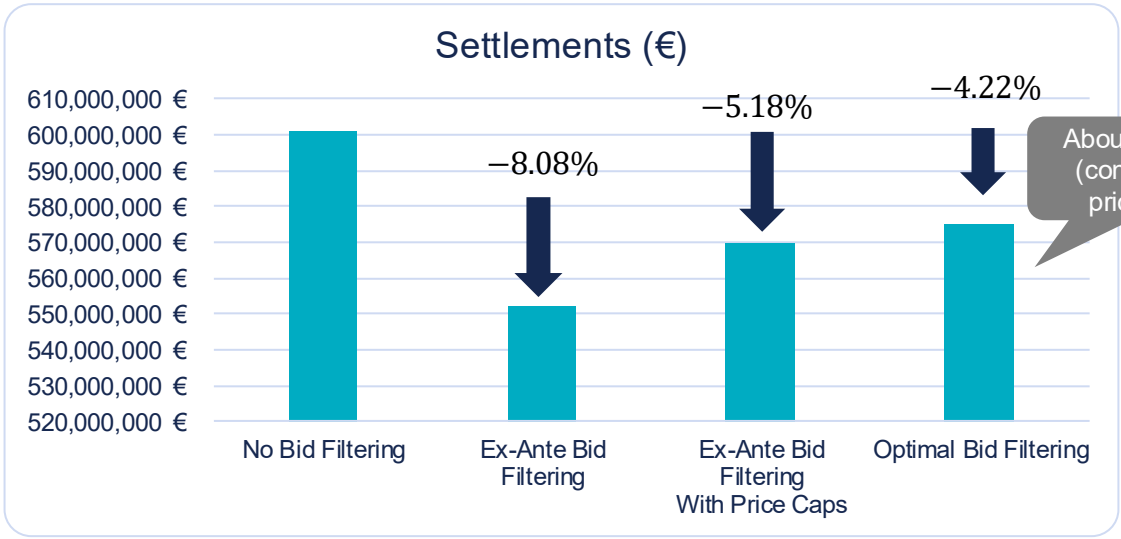


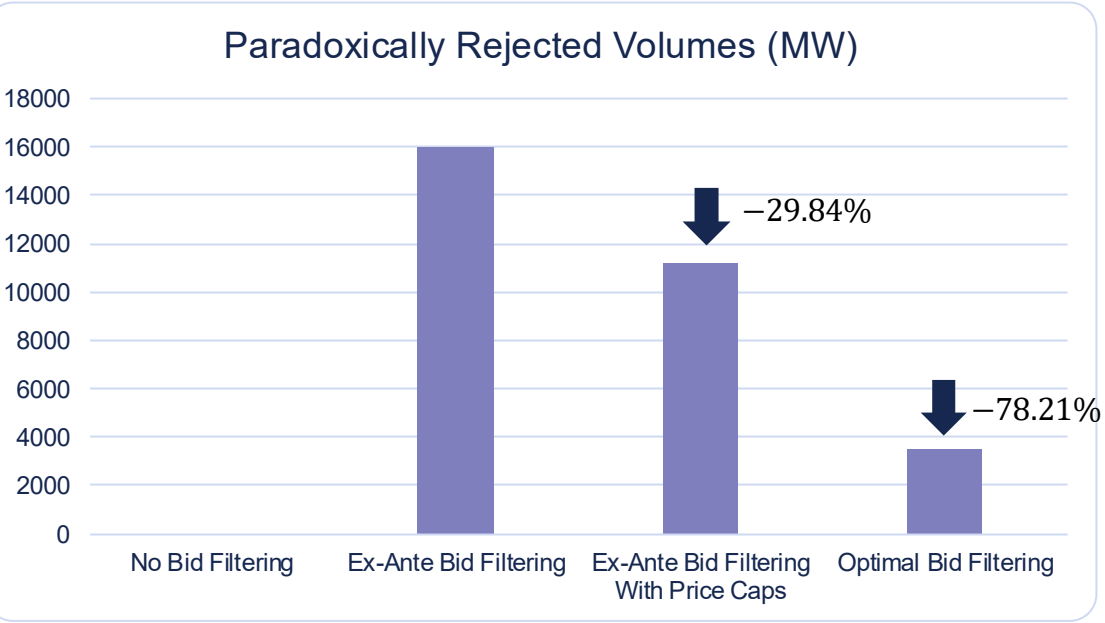
MCP Per Border → Less Impacted with Optimal Bid Filtering

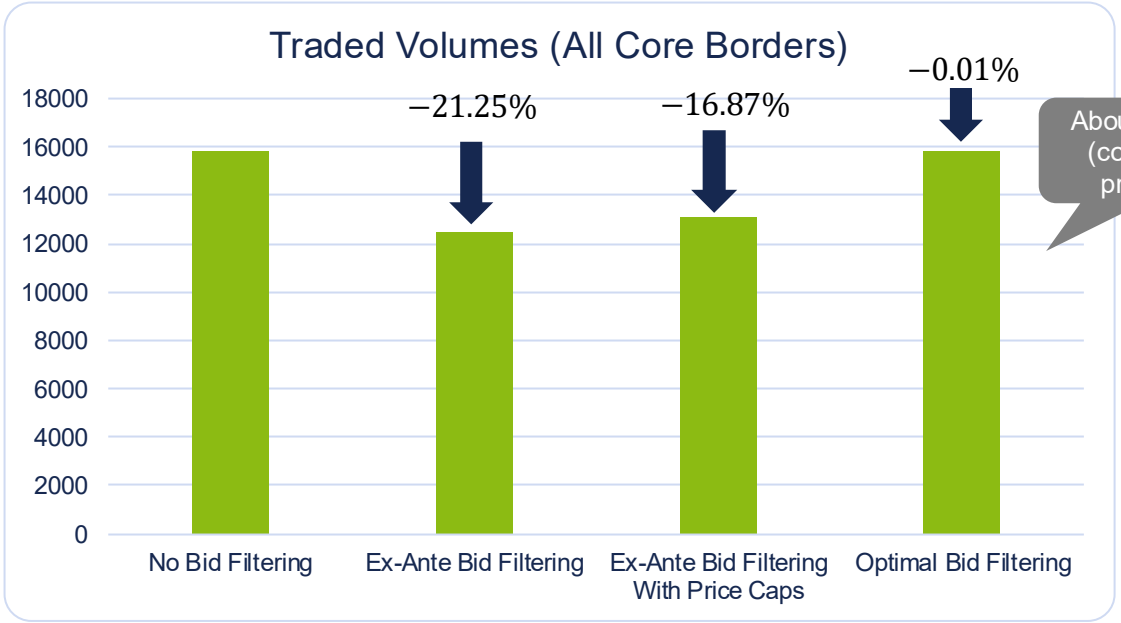


Main KPIs Are Improved with the Optimal Bid Filtering

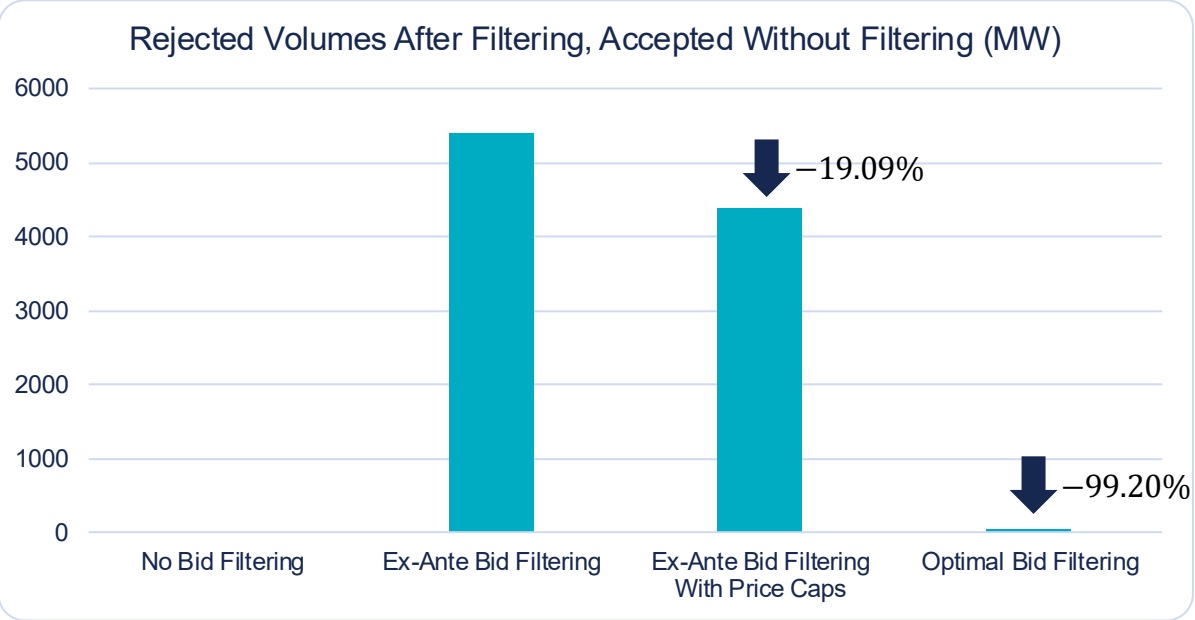


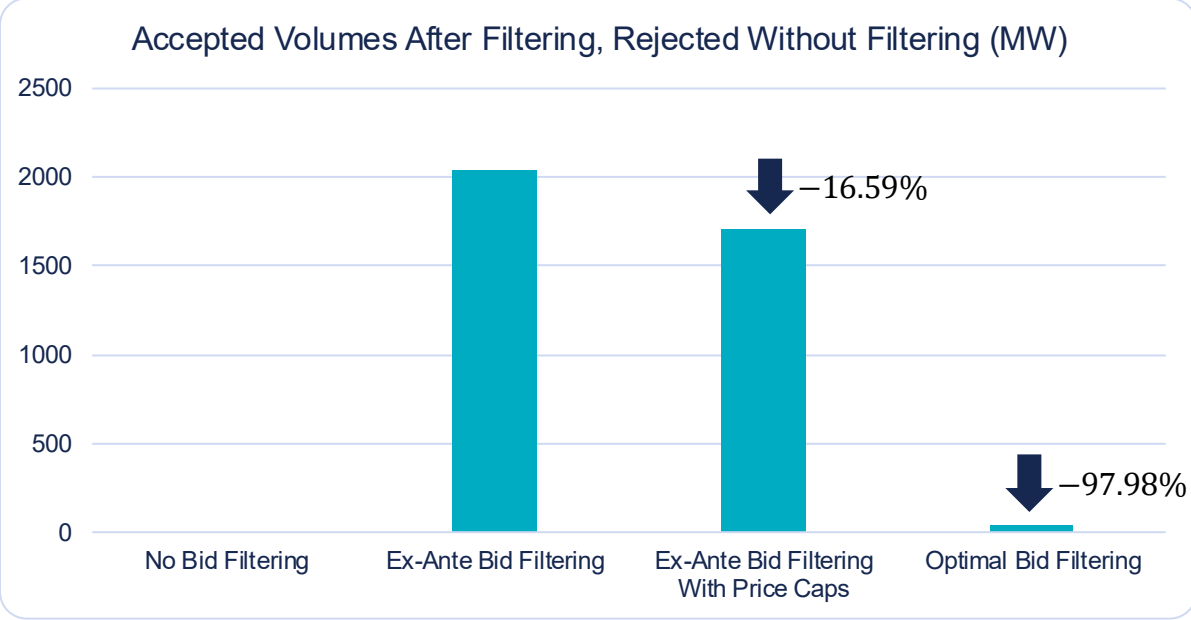






Filtered Volumes are Also Improved





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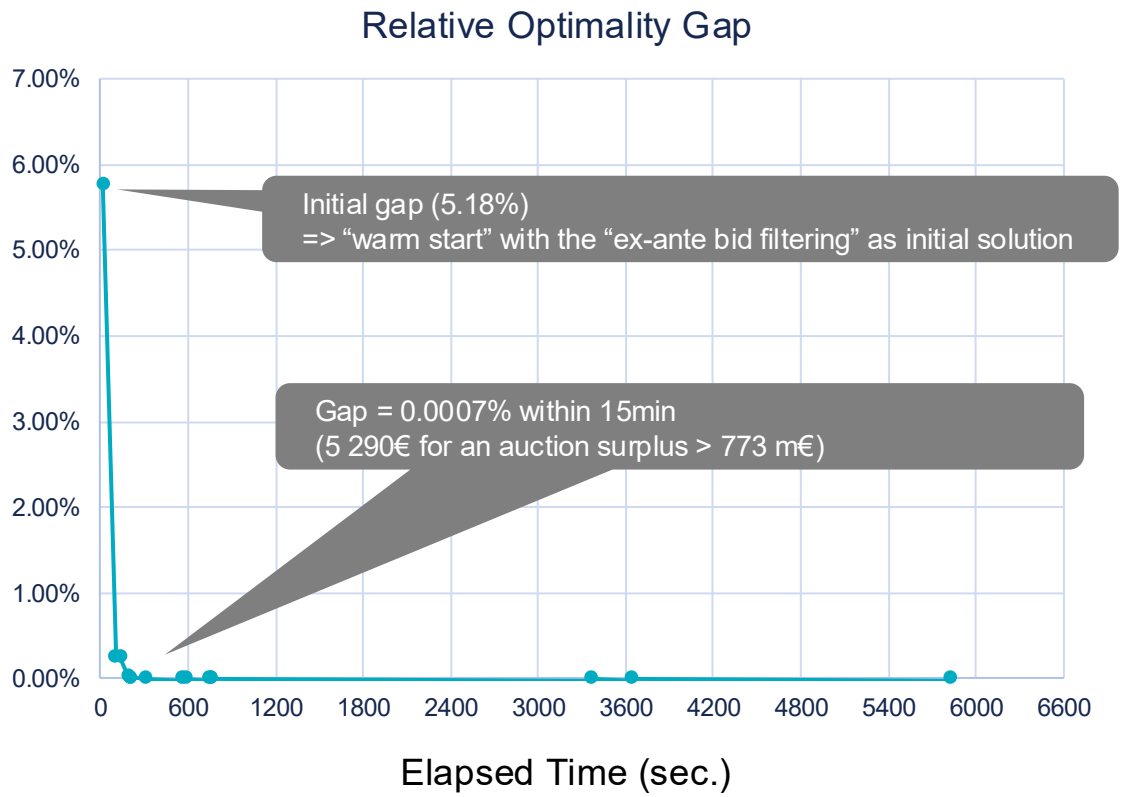
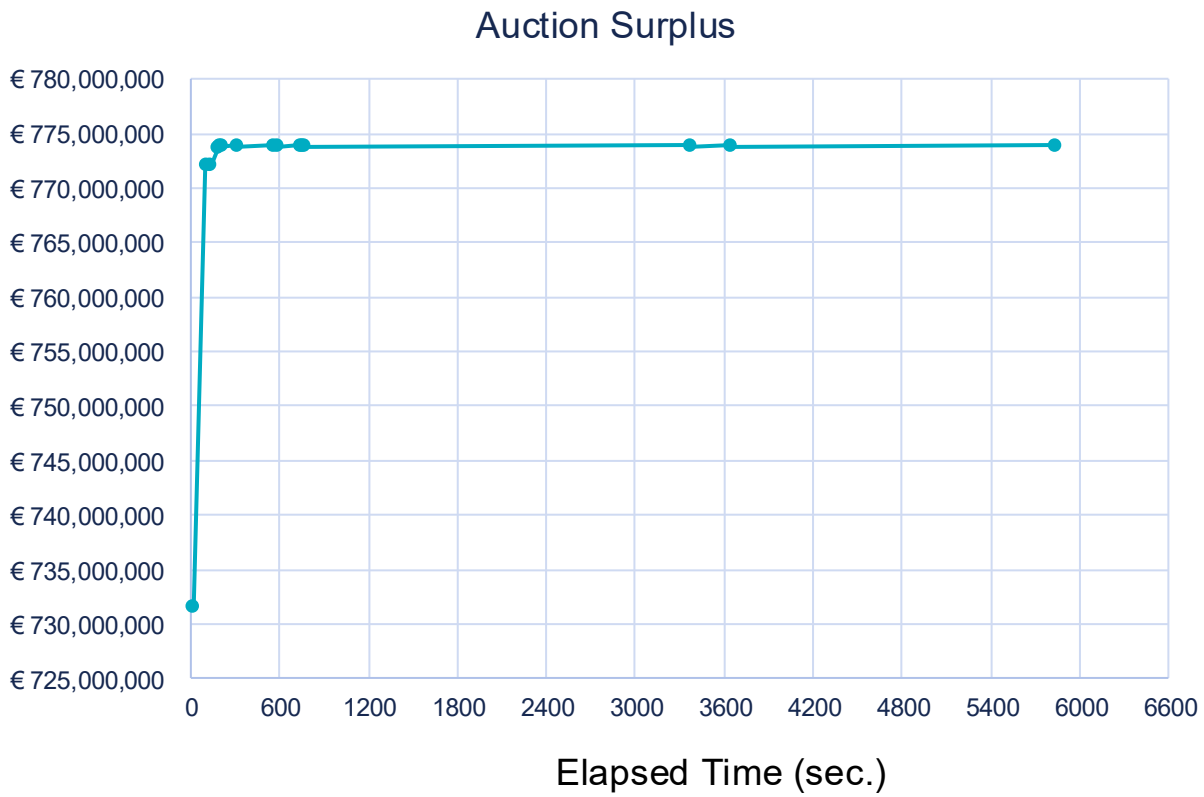
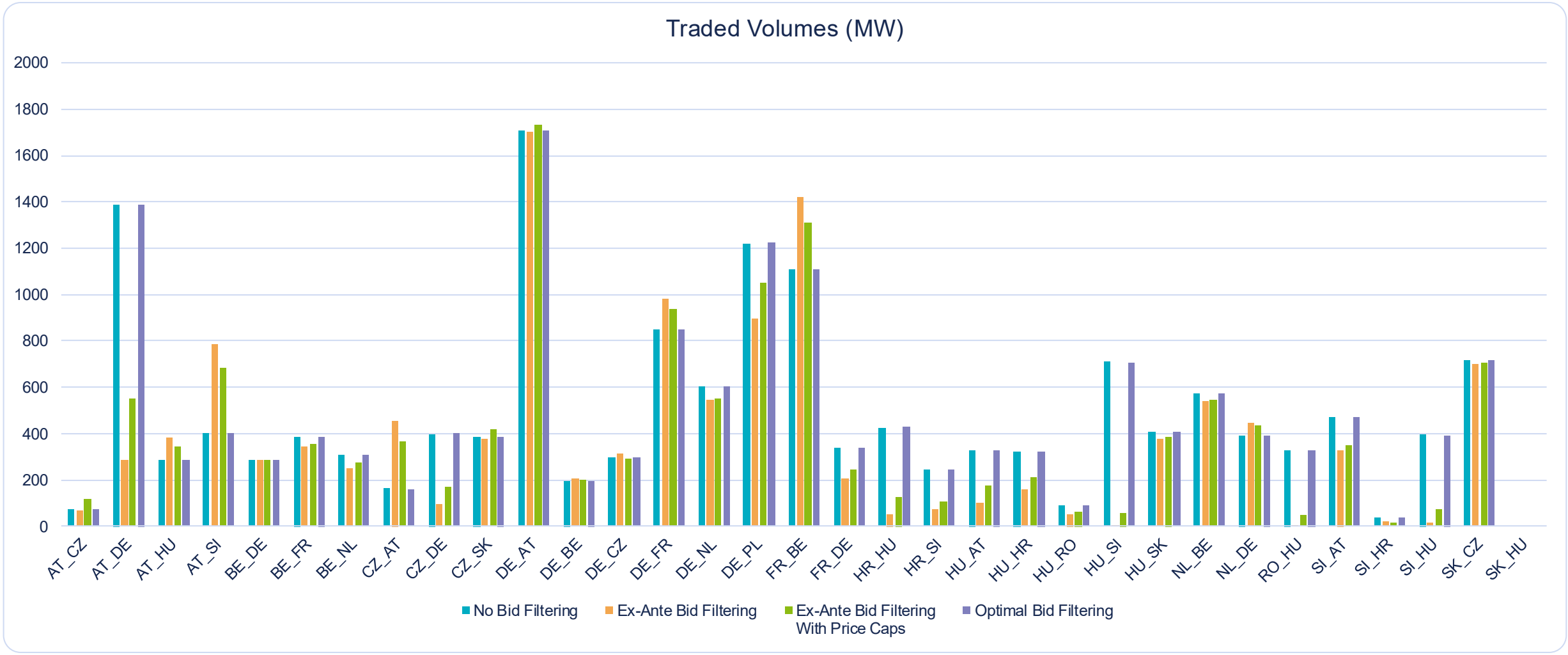


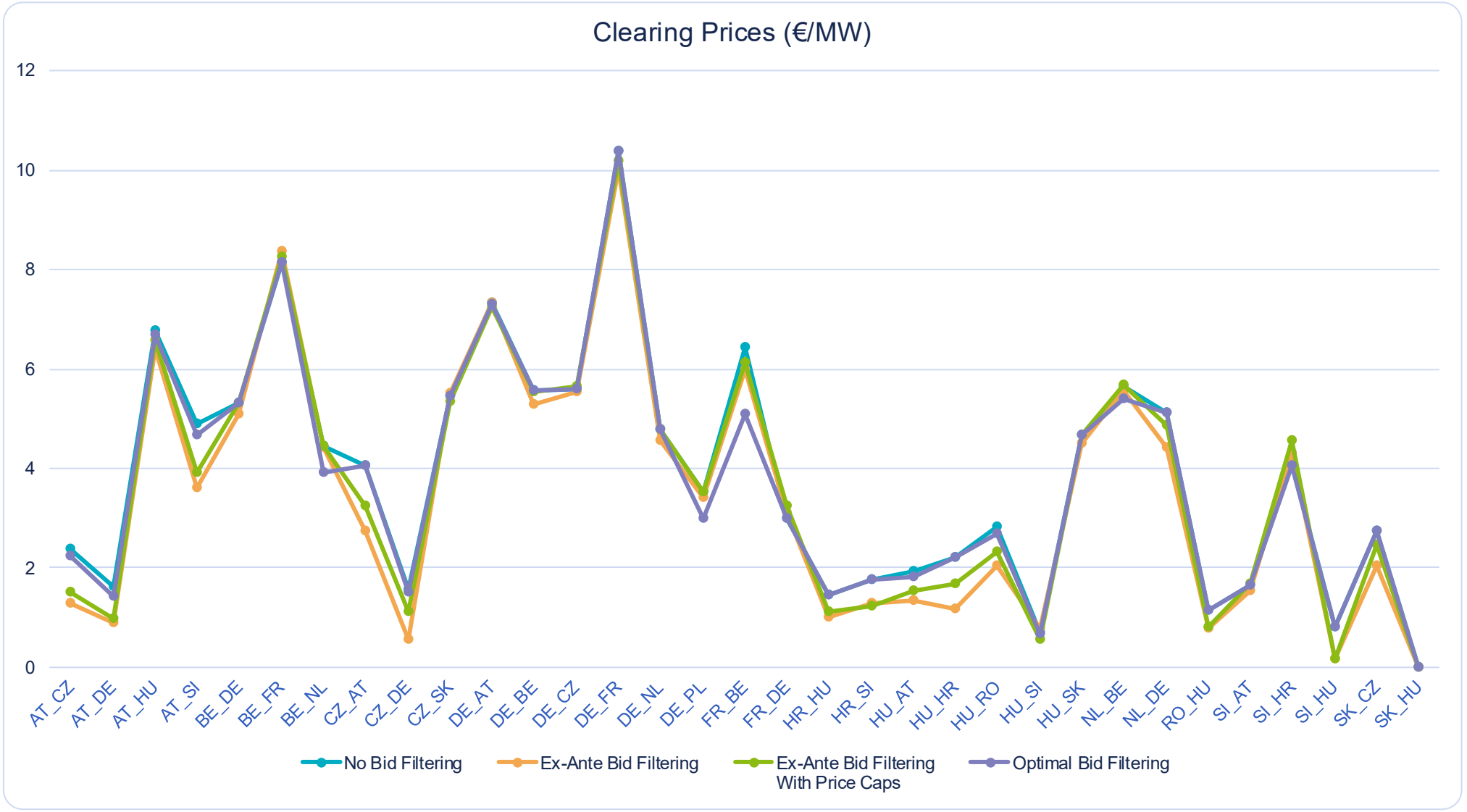


N-SIDE

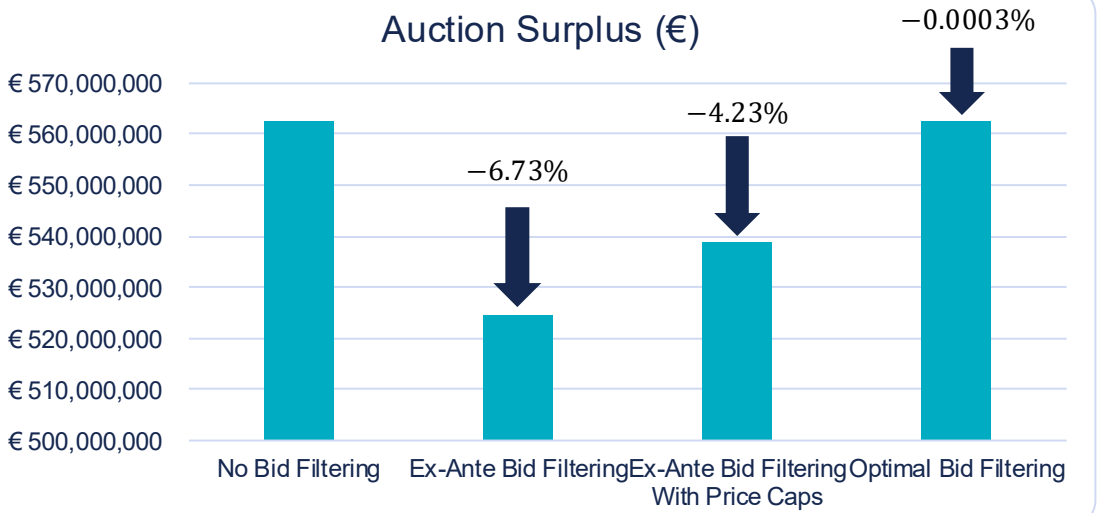
Traded Volumes Per Border → Less Impacted with Optimal Bid Filtering

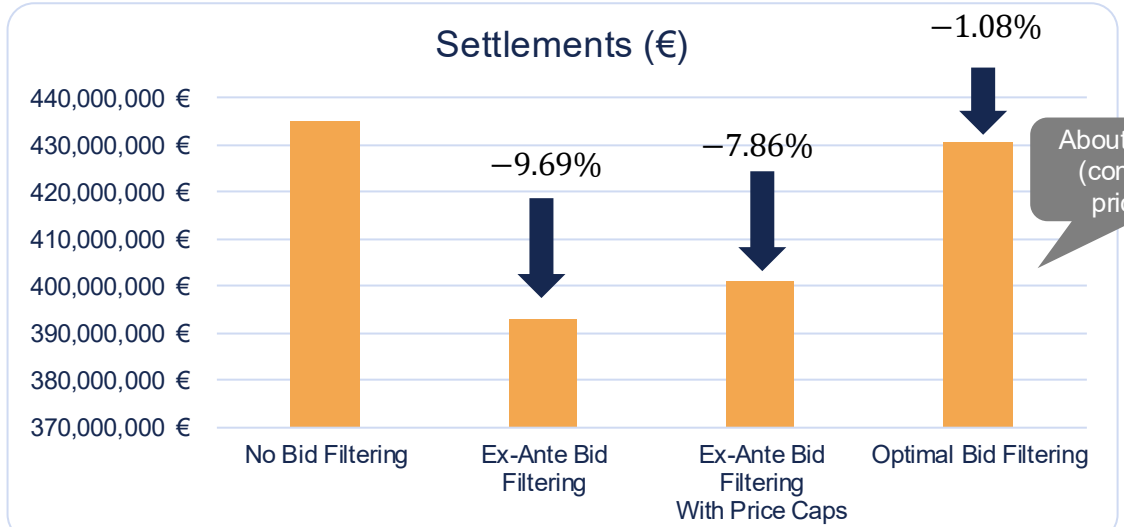


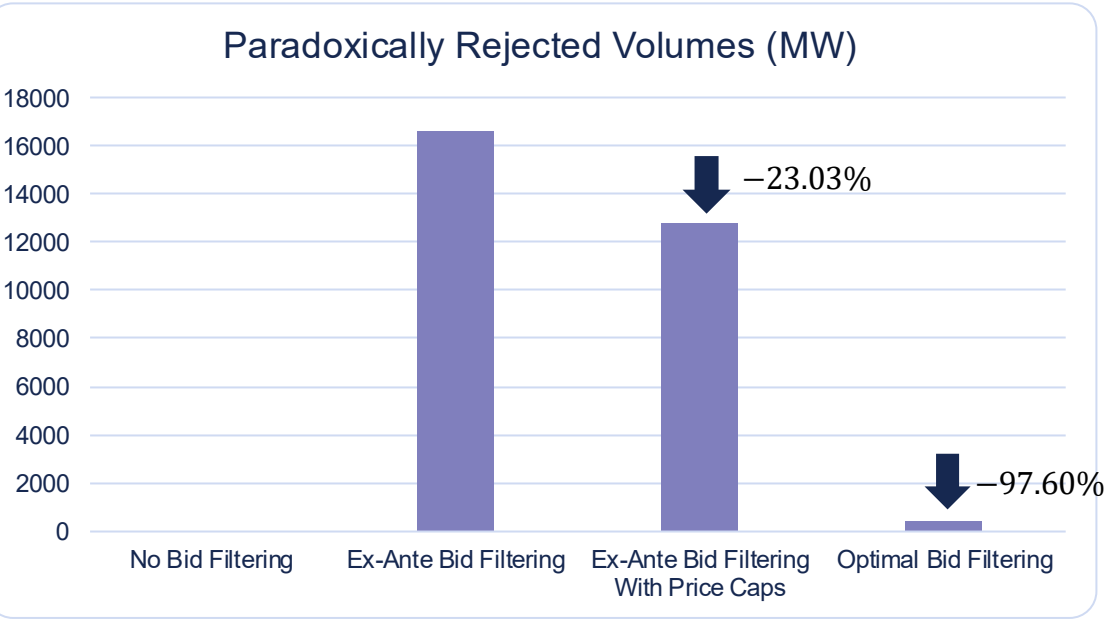
MCP Per Border → Less Impacted with Optimal Bid Filtering

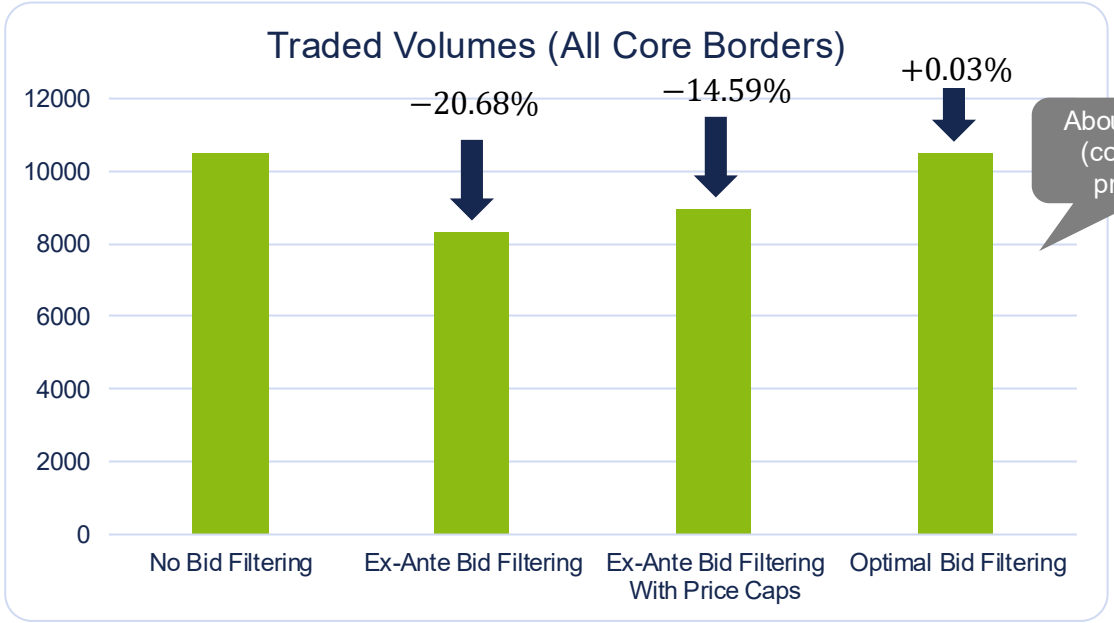


Main KPIs Are Improved with the Optimal Bid Filtering

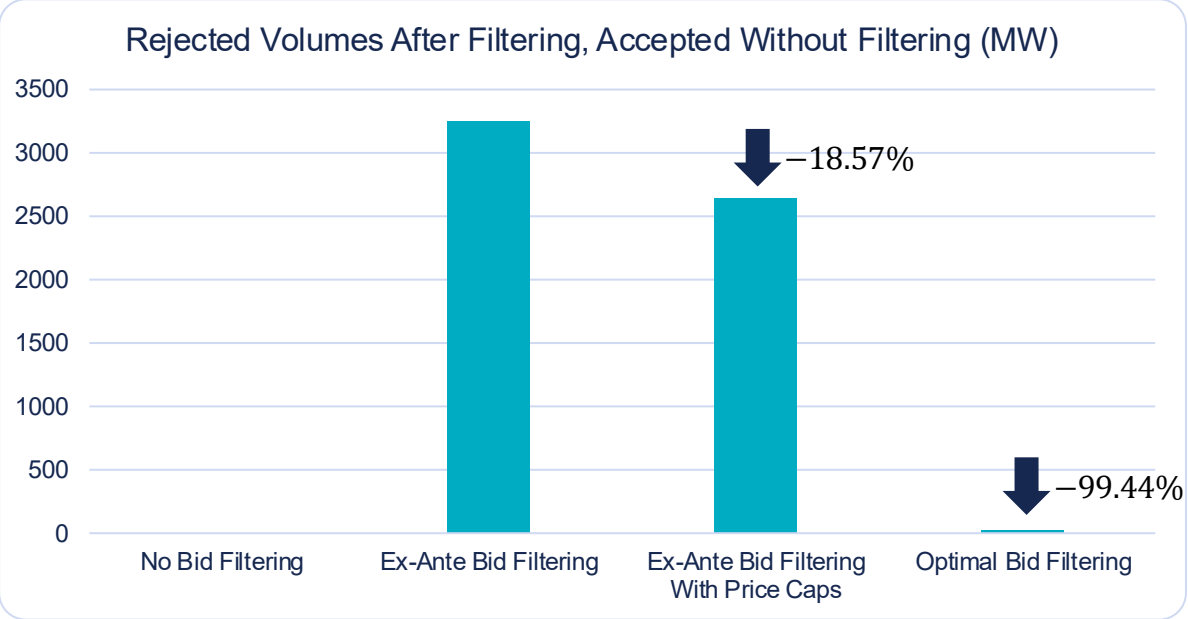


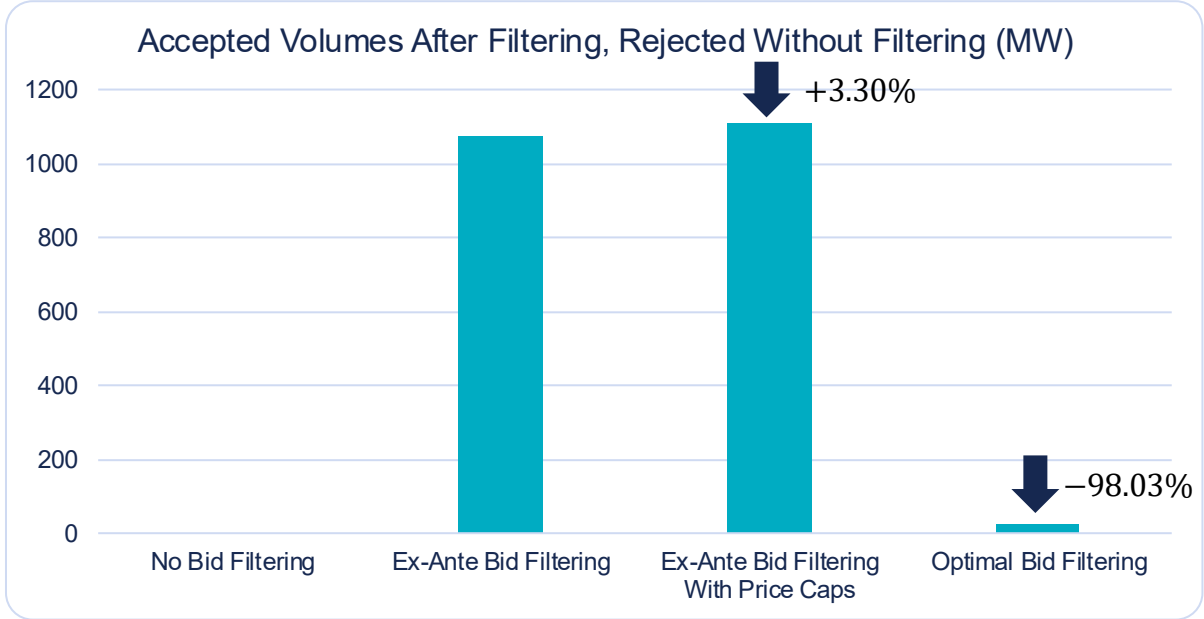






Filtered Volumes are Also Improved





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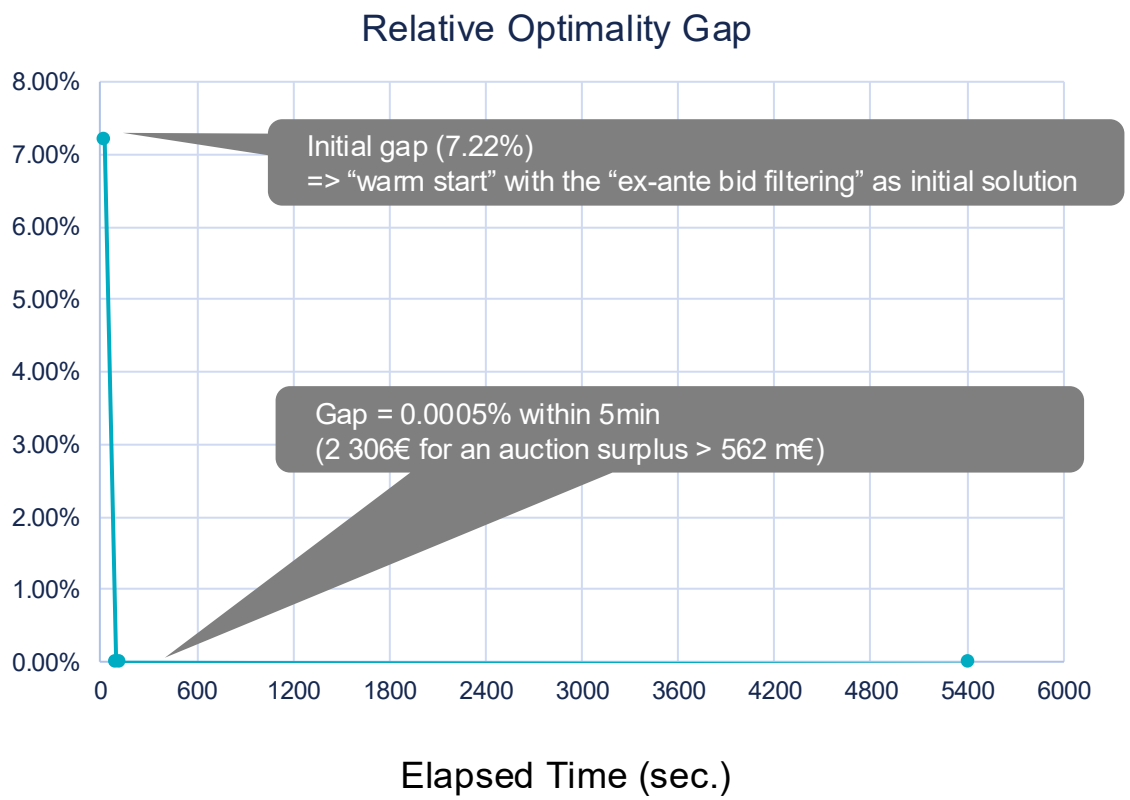
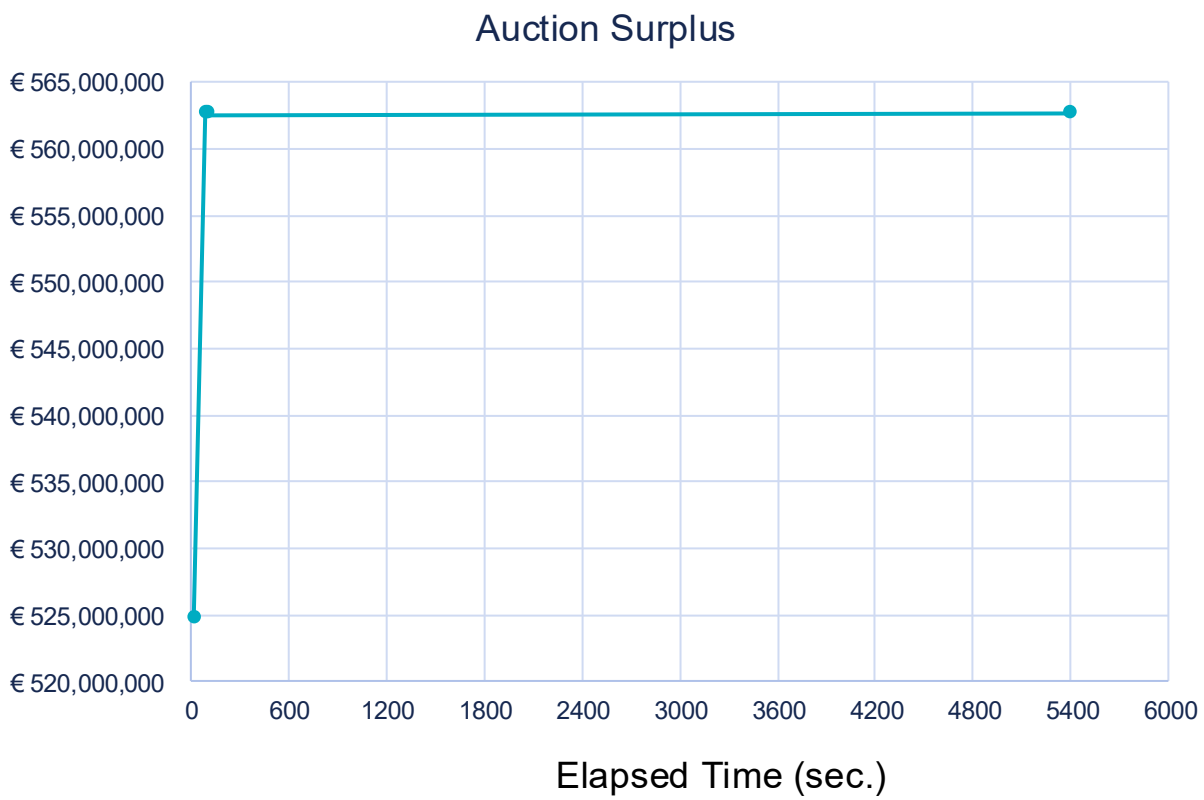
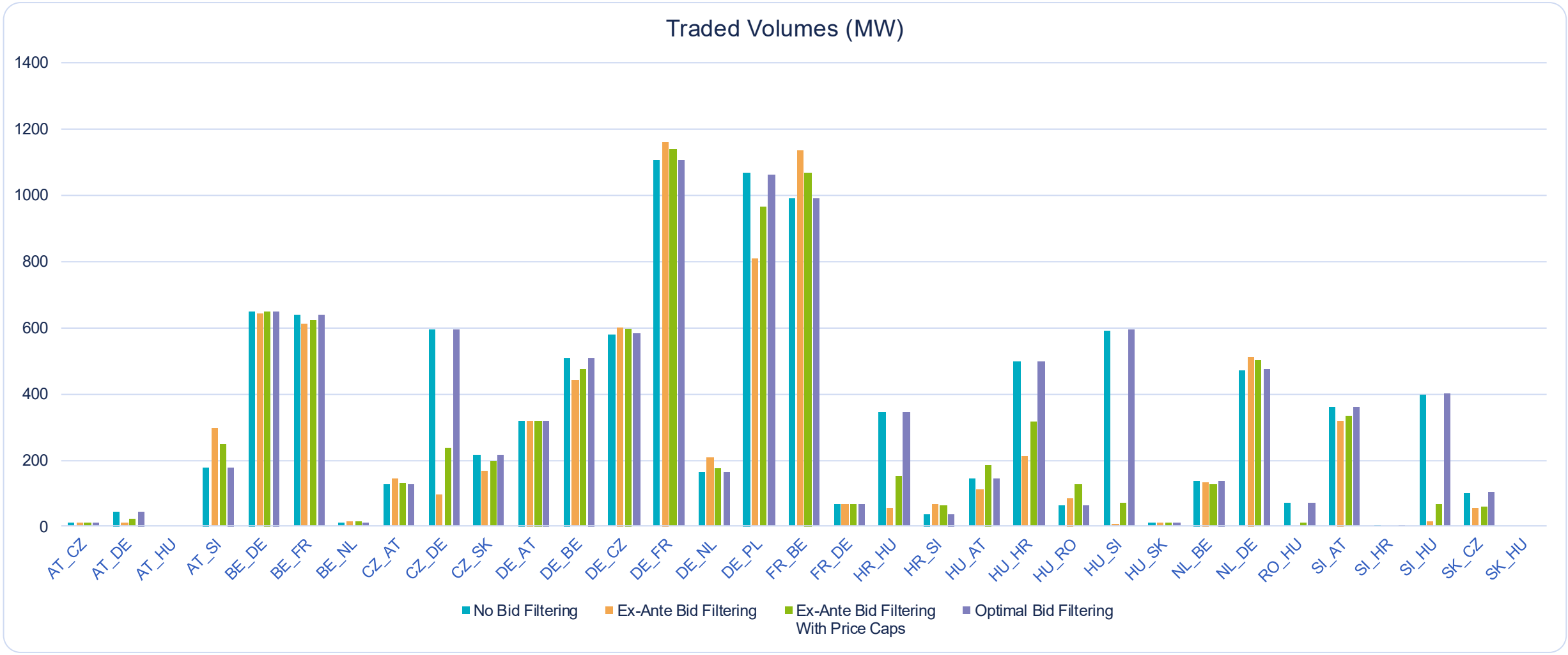
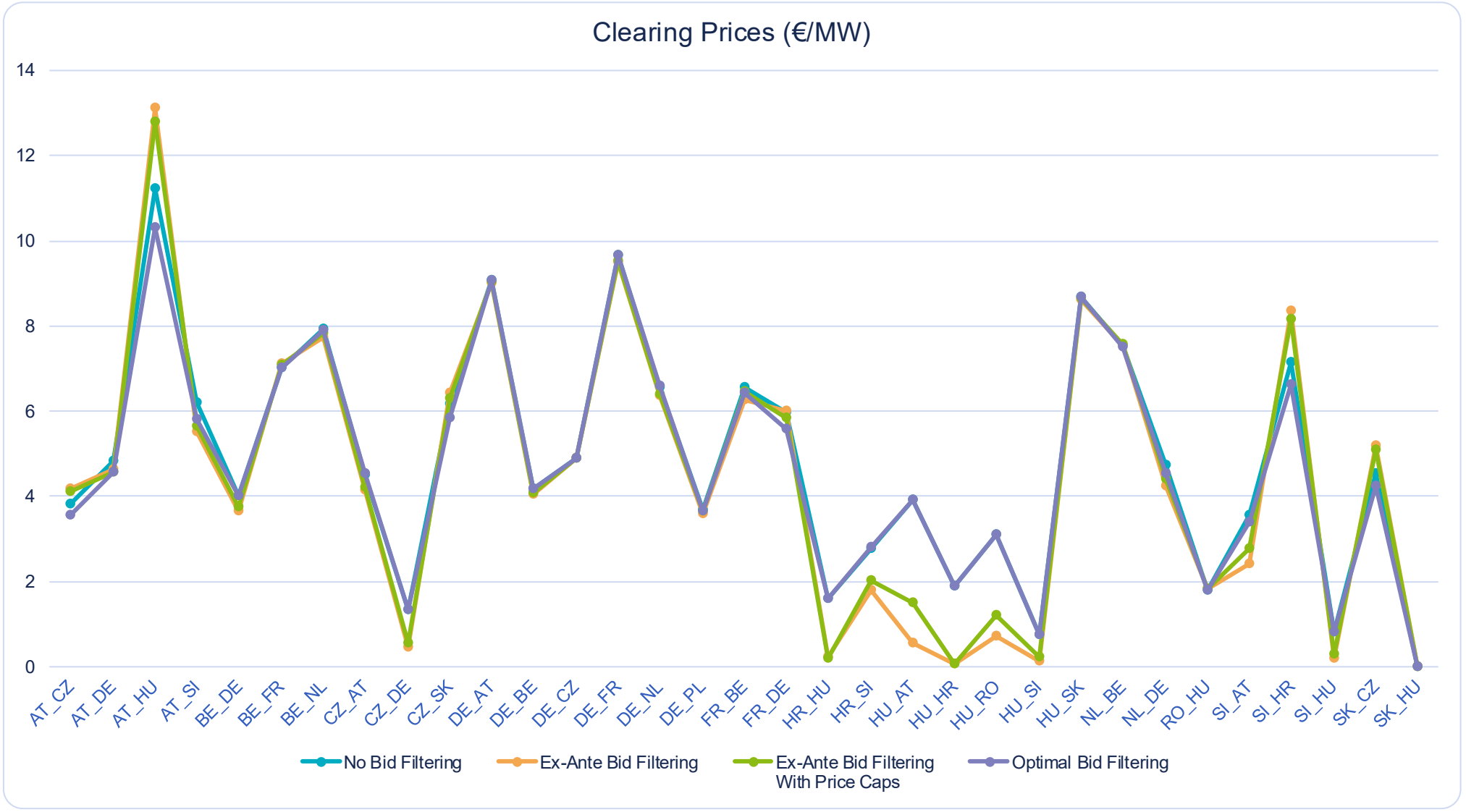




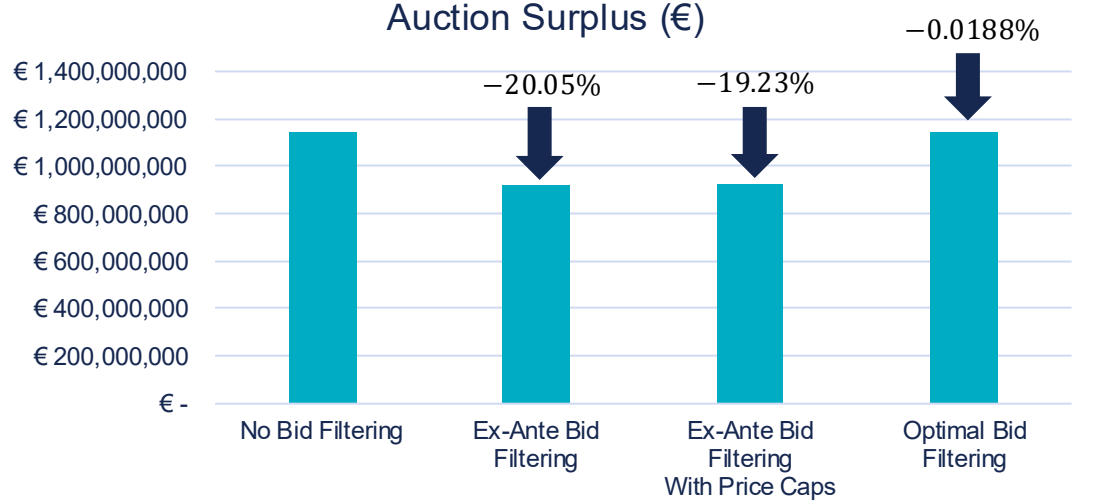
Traded Volumes Per Border → Less Impacted with Optimal Bid Filtering

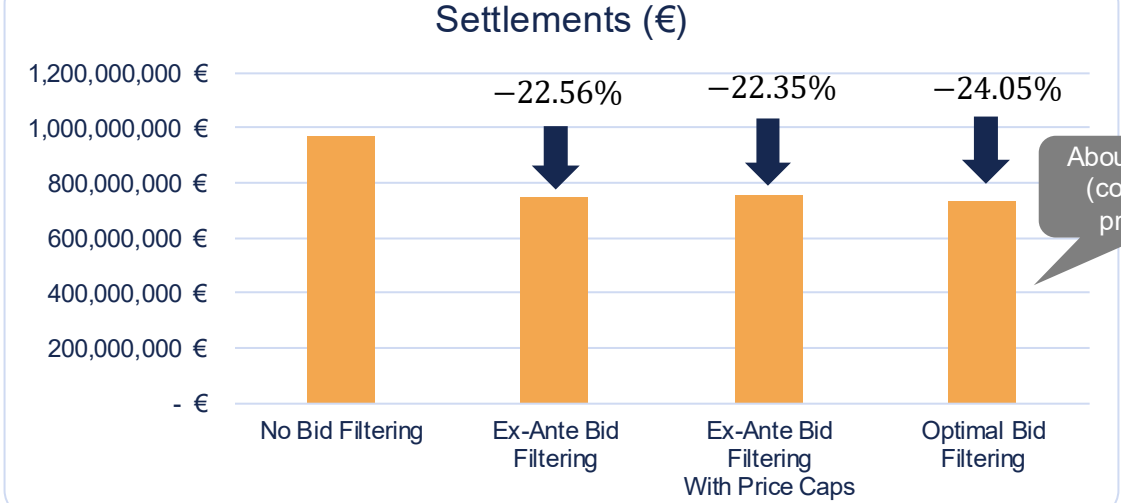


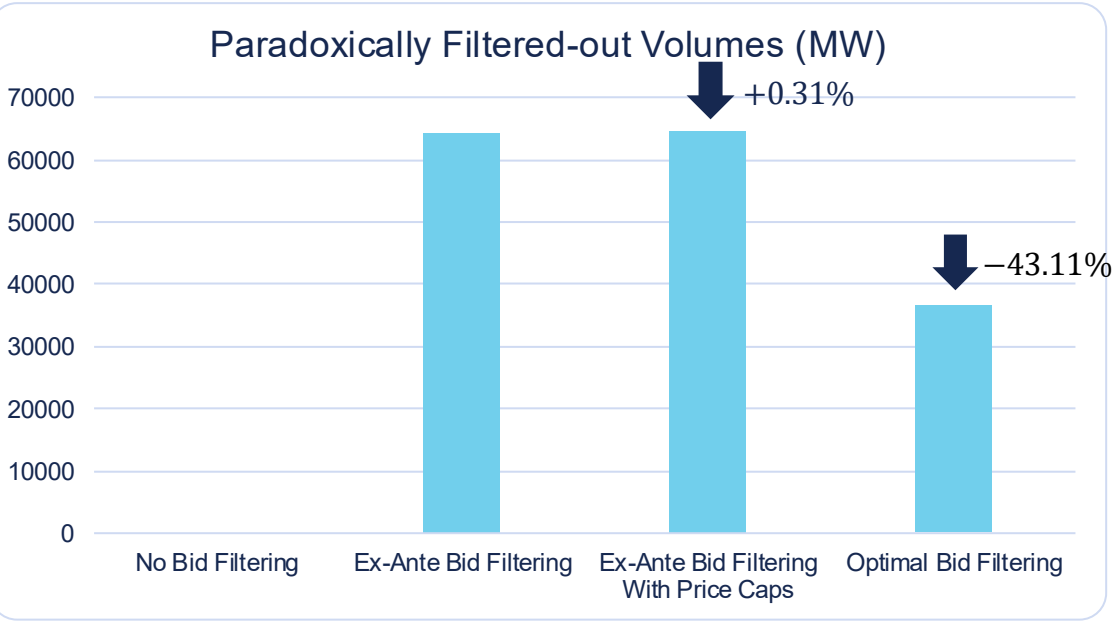
MCP Per Border → Less Impacted with Optimal Bid Filtering

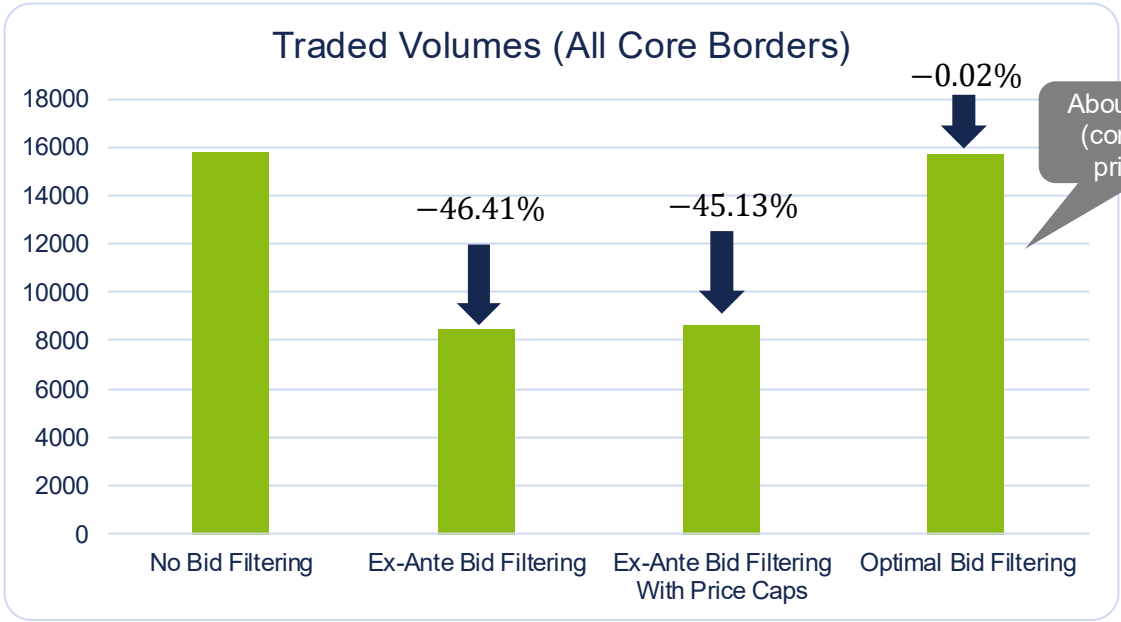


Main KPIs

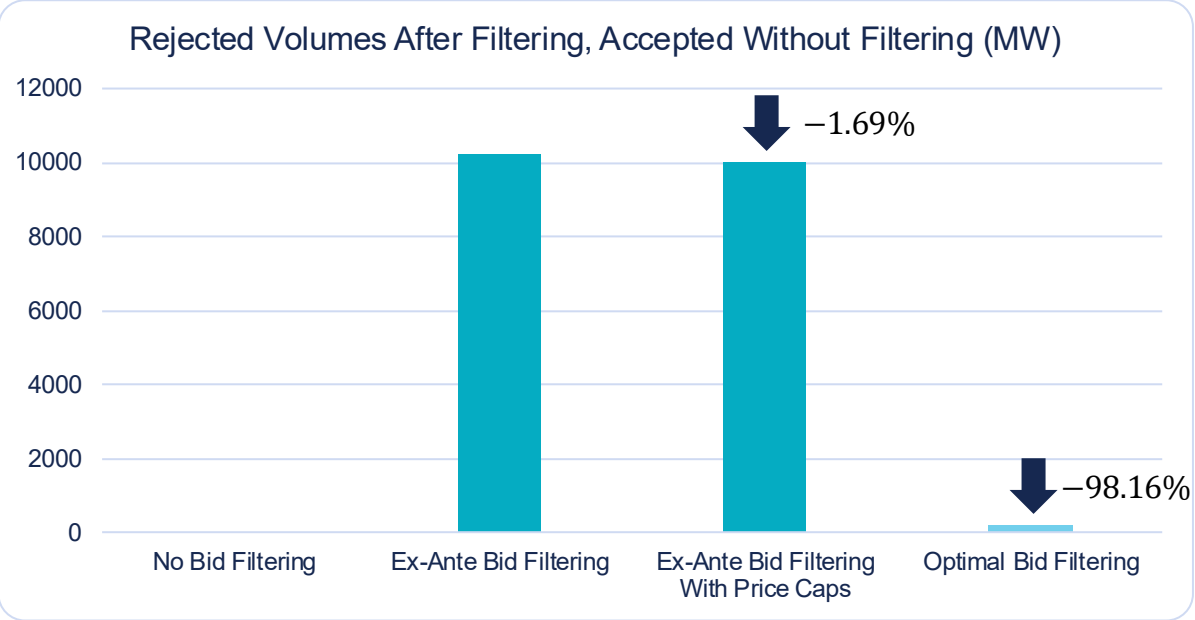

Auction Surplus (€)
€ 1,400,000,000
€ 1,200,000,000
€ 1,000,000,000
€ 800,000,000
€ 600,000,000
€ 400,000,000
€ 200,000,000
€ -
−20.05%
−19.23%
−0.0188%
No Bid Filtering
Ex-Ante Bid Filtering
Ex-Ante Bid Filtering With Price Caps
Optimal Bid Filtering

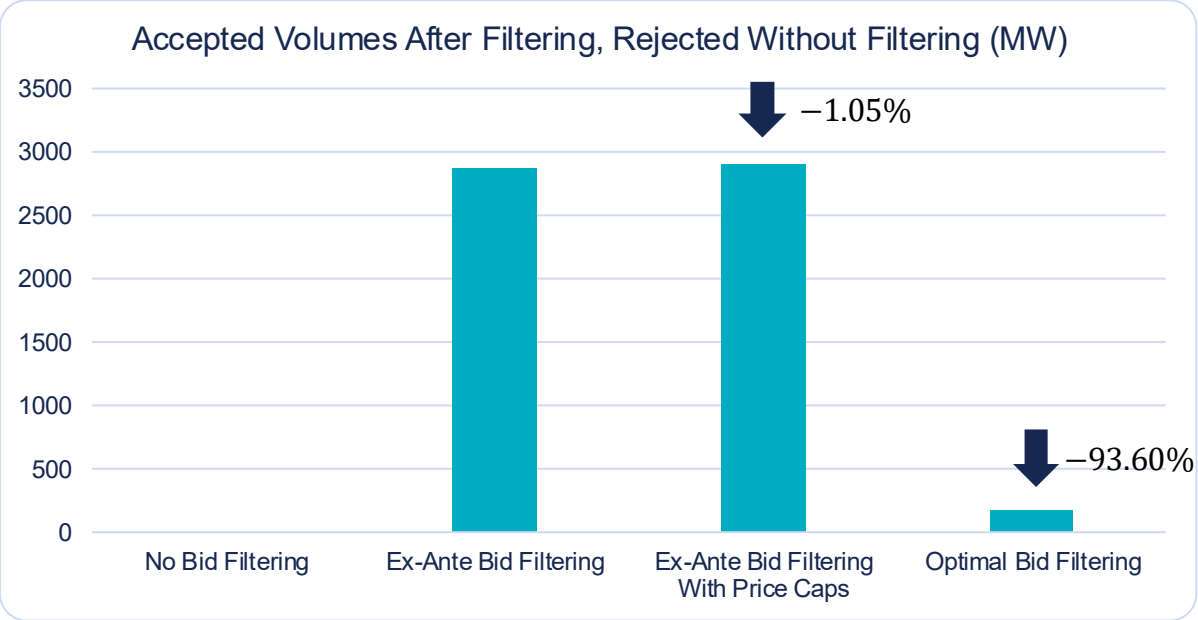

Settlements (€)
1,200,000,000 €
1,000,000,000 €
800,000,000 €
600,000,000 €
400,000,000 €
200,000,000 €
- €
−22.56%
−22.35%
−24.05%
About – 16,5 m€ (compared to price caps)
No Bid Filtering
Ex-Ante Bid Filtering
Ex-Ante Bid Filtering With Price Caps
Optimal Bid Filtering


Paradoxically Filtered-out Volumes (MW)
70000
60000
50000
40000
30000
20000
10000
0
+0.31%
−43.11%
No Bid Filtering
Ex-Ante Bid Filtering
Ex-Ante Bid Filtering With Price Caps
Optimal Bid Filtering


Traded Volumes (All Core Borders)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−46.41%
−45.13%
−0.02%
About +7,1 GW (compared to price caps)
No Bid Filtering
Ex-Ante Bid Filtering
Ex-Ante Bid Filtering With Price Caps
Optimal Bid Filtering

Filtered Volumes





Net Effect = Total Variation of the Traded Volume (slide Main KPIs)

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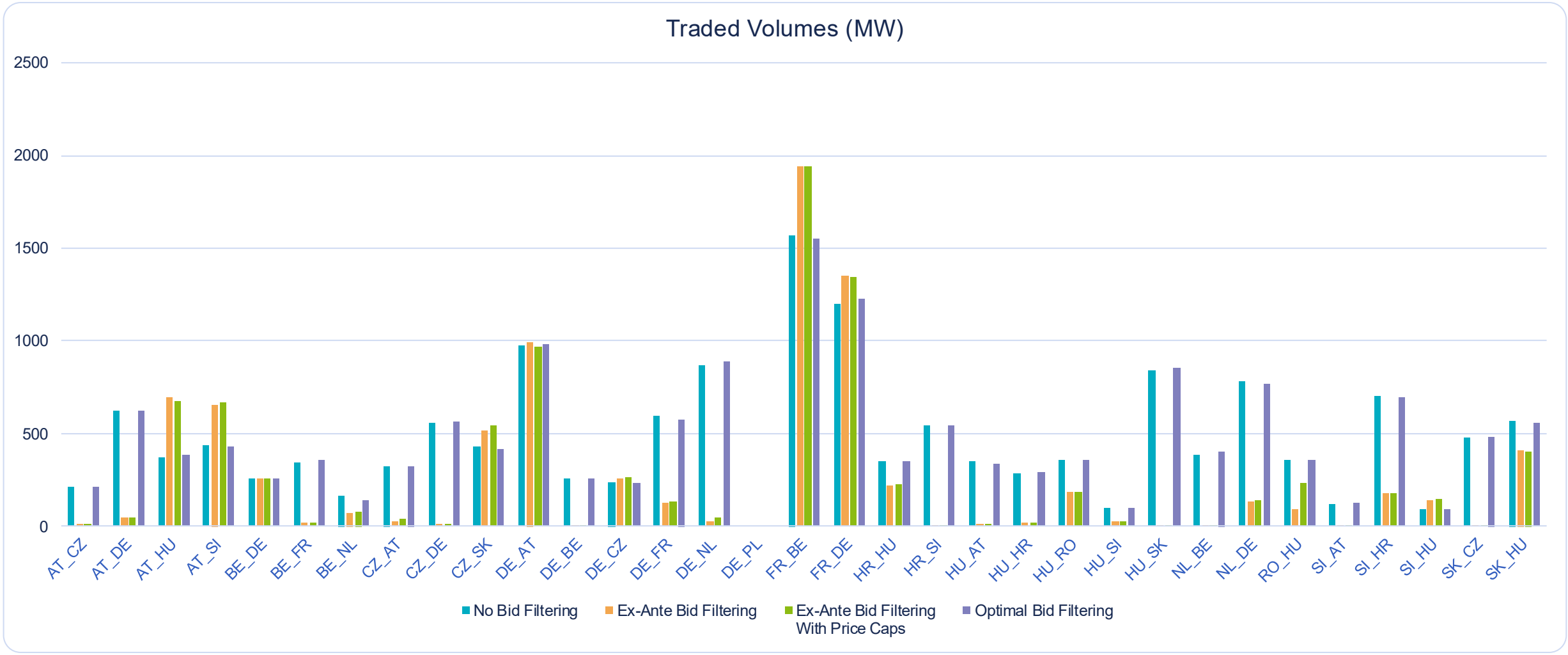
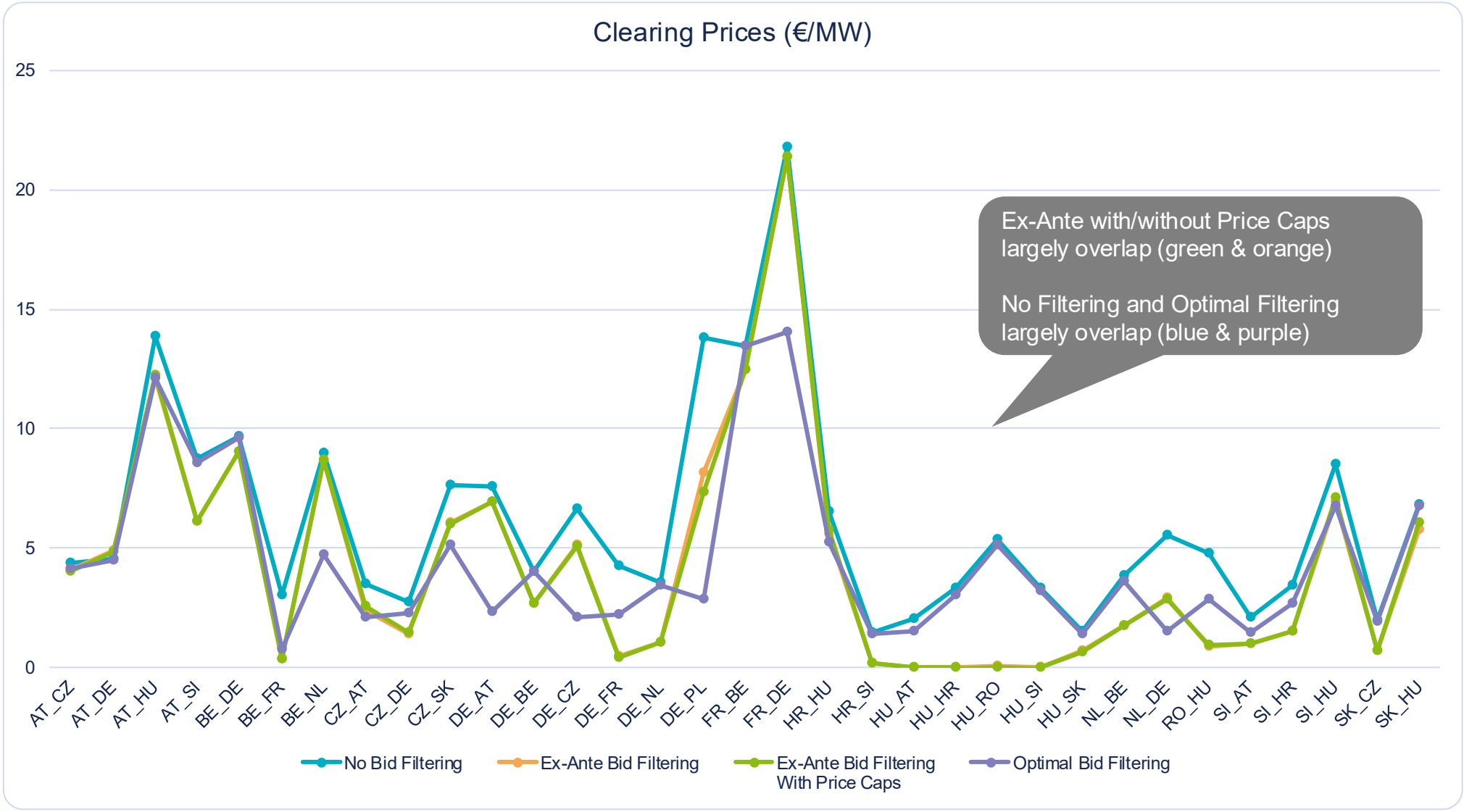
Traded Volumes Per Border → Less Impacted with Optimal Bid Filtering



MCP Per Border



Optimal Bid Filtering PoC Performances → Near-optimality Within 20min

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