Information about system stability:

The implementation of the block bids solution leverages Benders decomposition and bi-level programming, both of which are mathematically proven and industry-standard optimization methods for solving large-scale Mixed-Integer Linear Problems (MILP) by breaking them into smaller, more manageable sub-problems.
Our system provider has already successfully deployed similar bi-level programming methods in live projects with block bid functionality since 01/10/2025, providing a foundation of operational reliability.

The Block Bids solution introduces additional algorithmic complexity, but this has been carefully managed through:
✓ Proven optimization methods with successful production track record
✓ Robust design safeguards (iteration caps, feasibility cuts, validation layers)
✓ Comprehensive testing strategy covering corner cases and stress scenarios
✓ Strong theoretical foundation guaranteeing convergence and optimality

At this stage, based on the preliminary tests which given promising results, our service provider is confident that the performance will be satisfactory. Further testing is still scheduled for the following months.

Additional clafirication for the example 5 from the "Benders Decomposition Design" document:

The conclusion that the rejection of the 10 MW block bid contradicts welfare maximisation rests on comparing **gross block welfare** (400) with the **realised welfare from single-hour bids** (80). This comparison, however, omits the **opportunity cost of capacity**, which is central to the optimisation logic.

In Example 5, the economic situation can be decomposed as follows:

- In MTUs 1–2, capacity is scarce and valued at 20 €/MWh (as revealed by accepted single-hour bids and the associated shadow prices).
- In MTUs 3–4, capacity is abundant and has a shadow price of zero.

The block bid requires 10 MW in all four MTUs. While its **gross value** is indeed:
10 MW × 10 €/MWh × 4 MTUs = **400**,

accepting the block also forces the system to give up scarce capacity in MTUs 1–2. The opportunity cost of this capacity usage is: 10 MW × 20 €/MWh × 2 MTUs = **400**.

Once this opportunity cost is accounted for, the **net welfare contribution of the block is zero**: 400 (block value) − 400 (opportunity cost) = **0**.

By contrast, rejecting the block allows the acceptance of flexible single-hour bids in MTUs 1–2, yielding a **net welfare of 80**. From a welfare-maximising perspective, 80 > 0, and the rejection of the block is therefore economically optimal.

Two additional points are worth stressing:

- Unused ATC in MTUs 3–4 does not represent lost welfare, because capacity has no intrinsic value when there is no willingness to pay.
- The outcome is driven by the “all-or-nothing” nature of block bids: the block cannot be accepted only in low-value MTUs without also occupying high-value, scarce capacity.

The Benders decomposition explicitly captures this logic through shadow prices and optimality cuts, ensuring that block bids are evaluated on their **net contribution to total system welfare**, not on gross volume or standalone value.

We hope this decomposition clarifies why the outcome in Example 5 is fully consistent with the welfare maximisation objective and does not represent an inefficiency or a flaw in the algorithm.

Please find below the explanation on how it is computed the opportunity cost and so on.

1. Example 5 Data recap

MTU	ATC (MW)	Single-hour bid	Value (€/MWh)	Block bid
1	10	2 MW	20	10 MW @ 10
2	10	2 MW	20	10 MW @ 10
3	10	—	—	10 MW @ 10
4	10	—	—	10 MW @ 10

Block bid:

- Quantity: 10 MW
- Duration: 4 MTUs
- Price: 10 €/MWh
- Gross block value = 10 × 10 × 4 = **400**

2. Baseline scenario: block rejected (y = 0)

MTU	Accepted SH (MW)	Price	Welfare
1	2	20	40
2	2	20	40
3	0	—	0
4	0	—	0

Total welfare (y = 0): W = 80

Shadow prices (opportunity values of capacity)

MTU	Shadow price λ (€/MWh)	Interpretation
1	20	Capacity scarce, high value
2	20	Capacity scarce, high value
3	0	Capacity abundant
4	0	Capacity abundant

These λ values represent **the welfare loss if 1 MW of ATC is removed** in each MTU.

3. Block accepted: gross welfare view

Block gross welfare = 10 * 10 * 4 = 400

This is the gross welfare of the block, but it is **not net welfare**.

4. Opportunity cost of block acceptance

The block consumes **10 MW in every MTU**, including scarce ones.

Opportunity cost calculation

For each MTU:

$$Opportunity\ cost\ = \lambda_t \times\ block\ MW$$

MTU	λ (€/MWh)	Block MW	Opportunity cost
1	20	10	200
2	20	10	200
3	0	10	0
4	0	10	0

Total opportunity cost = 200 + 200 = 400

5. Net welfare contribution of the block

The net welfare contribution of the block is then equal to:

$$Net\ welfare = gross\ welfare - opportunity\ cost = 400 - 400 = 0$$

This means:

> The block **adds no net welfare** once the value of the displaced capacity usage is correctly priced.

6. Total welfare comparison

Outcome	Block value	SH welfare	Opportunity cost	Total net welfare
Block rejected	0	80	0	**80**

Outcome	Block value	SH welfare	Opportunity cost	Total net welfare
Block accepted	400	0	−400	**0**

Hence: 80 > 0

So, the welfare-maximising choice is **to reject the block**.

7. Benders interpretation

The Benders optimality cut derived from λ = (20, 20, 0, 0) encodes exactly:

> “Each MW of this block costs 20 €/MWh in the first two MTUs, so its apparent value is fully offset by opportunity costs.”