MARI: Algorithm Design Principles

CLARIFYING QUESTIONS

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1 Clarifying questions – Core presentation

Q1 To understand the importance of transparency of results, can you clarify the link between transparency of algorithm results and balancing market pricing signal achieved by allowing counteractivations, with the market participants offered prices and the marginal pricing scheme in terms of achieved competition?

As an introduction, we would like to position all our answers in a “only divisible bids environment”. This is because treatment of indivisibilities is a separate problem which also relates to transparency and unforeseeable/paradoxical results, and which is therefore preferably addressed separately.

Given this, the key difference in terms of transparency between preventing CA or not is that preventing counter-activation makes it impossible to guarantee that solutions have a single balancing price and (no un)foreseeable rejection of (divisible) bids. Indeed, for a given price, one of the two price compatible bids which are not matched because of the “CA prevention constraint” will necessarily be unforeseeably rejected in case a single price for upward and downward activations are required[1].

It is the presence of URBs which primarily drove our view that preventing counter-activations is detrimental in terms of transparency. This relates to the notion of “price equilibrium”: the classical way to interpret a price is that all “in the money bids” (i.e. bids which are compatible with the published price) must be fully accepted and all “out of the money” bids must be fully rejected (while “at the money” bids can be fractional, by definition set the price, and are neutral to be accepted or not because they don’t generate any surplus/welfare).

Such a traditional pricing scheme fosters the price signal of a market in the sense that acceptance/rejection of bids is solely driven by the compatibility with the clearing price. In other words, everyone can assess – solely based on the published price - if its (divisible) bids are accepted or not, i.e. there are no unforeseeable results. This appears as a very transparent price signal. On the contrary, the fact that such a rule is not always true if counter-activations are prevented makes – at least in our view – the pricing scheme less transparent (i.e. less foreseeable).

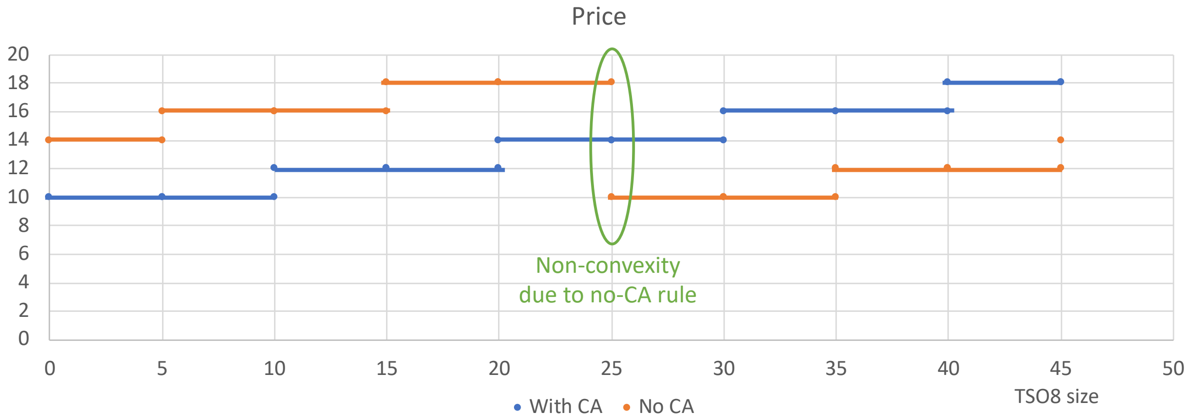
A second observation related to transparency, competition and interpretability/understandability of results relates to the “non-convex” aspect of the CA prevention rule. Let us illustrate this with an example:

BSP1_UP:	10MW @ 10€
BSP2_UP:	10MW @ 12€
BSP3_UP:	5MW @ 14€
BSP4_DOWN:	-10MW @ 18€
BSP5_DOWN:	-10MW @ 16€
BSP6_DOWN:	-5MW @ 14€
TSO7_NEED_DOWN:	25MW inelastic
TSO8_NEED_UP:	-1MW inelastic

For such a scenario, the TSO7 downward need shall be satisfied at a price of 14€ (i.e. the price of BSP6) if CA are not allowed, and 10€ (i.e. the price BSP1 at intersection of the curves) if CA are allowed.

[1] Note there might exist an alternative model where upward and downward activations have different prices. However, further investigation would be required to assess the market properties of this alternative model (Cf. Q3)

Let us now compare these balancing energy prices when the volume of TSO8 (upward need = demand for power) increases:



As one can observe, allowing CA has a more "natural" (i.e. transparent) behaviour: as demand for power increases, the balancing price increases monotonously. This is to be opposed to the CA prevention scheme, where – precisely when the size of the UP need becomes larger than the size of the DOWN need – the price "changes of curve" and suddenly drops. Such a "non-monotonous pricing" can be seen as detrimental for the price signal, and the consequences on the bidding strategies (e.g. pricing, volumes) would need to be further assessed. (Note also there are always URBs on the "not active curve" in case of CA prevention.)

Importantly, it remains unknown to us what is the frequency at which such counter-activations would occur in practice: if they are frequent, the difference in design will definitively be of larger impact.

Q2 To understand the interactions between the blocking of the counter-activations and the other requirements (since we cannot have it all as illustrated on slide 4):
a. Assume that you have only divisible bids, no linked bids (nor parent-child, nor exclusive), no elasticity, no UAB/URB constraints (obviously since there is no indivisible bids)
b. The question is: is it possible to avoid all counter-activations throughout Europe (in the sense of blocking also "discussable" counter-activations such as illustrated on slide 27, in order to keep as many bids as possible available for direct activation) while still making sure to satisfy TSO needs in all cases?

Firstly, as explained in answer 1, it is not so obvious that "no UAB/URB constraints" can be avoided even in presence of only standard regular divisible bids for the case where CA are not allowed.

Secondly, the question is understood with the implicit complement that – in order to guarantee that TSO needs are satisfied in all cases – there is adequate availability of relevant BSP bids (i.e. with not enough BSP bids, TSO needs cannot always be satisfied – irrespective of the counter-activation discussion).

That being said, **in presence of only inelastic TSO needs**, it is possible to define various alternative requirements to block counter-activations[2]. As an example, let us consider the following requirement:

[2] As opposed to bluntly preventing any activation of bids in both directions throughout Europe, which will most likely not be a satisfactory requirement.

Maximize welfare, subject to:
1. BSP bids can only be activated to satisfy TSO needs (global constraint)
2. TSO needs can only be satisfied by BSP bids in case they cannot be satisfied by (price-compatible) TSO needs in the opposite direction (global constraint)
3. Adapted pricing rules (to account for the impacts of constraints #1 & #2)
4. Volume constraints (balance, CZC, ...)

There exist exact algorithms for such requirements, such as a 2-steps approach where:
- STEP1: computes the "nettable TSO needs volume" (for example by performing a welfare optimization with only TSO inelastic needs).
- STEP2: runs a welfare maximization optimization comprising all data, subject to constraints #3 & #4 and complemented with two following constraints:
  - Sum of executed upward BSP bids = Sum of executed upward TSO needs minus "nettable TSO needs volume"
  - Sum of executed downward BSP bids = Sum of executed downward TSO needs minus "nettable TSO needs volume"

These later constraints impose that BSP bid in one direction are only activated to satisfy TSO demands in this direction. At the same time, STEP1's component ensures that BSP bids are only activated in case the TSO need cannot be netted[3].

Such an algorithm would however provide unexpected results in presence of elastic TSO needs (because such TSO needs are no longer always at the beginning of the merit order). Let us illustrate this by an example:

BSP1_UP:	10MW @ 10€
BSP2_UP:	10MW @ 12€
BSP3_UP:	10MW @ 14€
BSP4_DOWN:	-10MW @ 20€
BSP5_DOWN:	-10MW @ 18€
BSP6_DOWN:	-10MW @ 16€
TSO7_NEED_DOWN:	25MW @ 15,5€
TSO8_NEED_UP:	-25MW @ 14,5 €

With such an orderbook, STEP1 will not identify any netting possibility, because the 2 TSO needs are price incompatible. The volume/primal problem of STEP2 will however identify profitable deals in both directions, as both UP and DOWN needs have profitable BSP counter-parts.

It therefore remains to be specified what the pricing/dual constraints of STEP2 should be, and what would be the expected solution for this example (there cannot be a single price without unforeseeable acceptance of TSO needs, as the price should be simultaneously above 15,5 and below 14,5). Importantly, any pricing model (i.e. dual formulation) which would reject the solution found by the primal/volume optimization will turn out to have a detrimental algorithmic impact, though the severity of this impact can hardly be evaluated without the exact requirement.

This is why we expressed in slide 4 that some requirements are incompatible with each other: in the above example, we discuss why elastic TSO demands are somehow incompatible with a stricter restriction of "counter-activations" (i.e. "block any discussable counter-activation") basically because

[3] Note that only running step 2 (hence setting the "nettable TSO needs volume" to zero) provides an alternative CA restriction (similar to Scenario 3 in our study) where CA are authorized up to the volume of TSO needs' satisfaction.

it is hard to determine which satisfaction of elastic TSO demands leads to a "discussable counter-activation" (while satisfaction of inelastic needs is seen as mandatory)

Q3 Would the removal of algorithm requirements open the path to more feasible solutions to avoiding counter activation?
a. If yes, the removal of which requests would open up which potential solution path (please roughly elaborate).

While our answer to Q2 discusses the compatible combinations of requirements in general, we understand this question as more specific to the specific algorithmic technicalities.

The main algorithm specificities which can be relaxed are the following:

- **Acceptable run time**: low expected benefits
  - In the experiments that were presented in Oslo, all runs for scenarios 2 – 4 were allowed to iterate between the primal problem and the pricing problem until they exceeded a 3-minute run limit. For those instances where the algorithm was not able to terminate within one minute, the algorithm was not able to terminate within 3 minutes either. It therefore seems that relaxing the run time from 1 minute to 3 minutes doesn't make much difference in terms of finding the optimal solution to the problem.

- **Relaxed guarantee for optimality**: low expected benefits
  - The simulations performed in the study were all based on exact algorithmic methods (i.e. branch and bound). There might however exist other methods such as heuristics. The key functional difference between these two classes of algorithms is that heuristics do not naturally output quality indicators in terms of optimality. Please also refer to our answer to Q6.

    For example, one could test solutions that are very conservative in terms of counter-activations (e.g. no counter-activations over the entire system), but likely to be very poor in terms of welfare, and discover that there exist prices that can support these solutions. But such a trial solution would likely be very far from optimal, and it would not be clear what one would have to do if a consistent price could not be found for such a solution.

- **Relaxed consistency of prices:** high expected algorithmic benefits, market impact to be assessed (likely to be high impact, though unknown if acceptable/preferable)
  - The consistency of prices is probably the most difficult aspect of the MARI problem. Therefore, the choice of the pricing rules strongly affects the difficulty of the problem, and also the run time of the algorithm. At the outset of the project, we proposed a pricing rule that would deviate minimally from the day-ahead market pricing rule, by simply allowing divisible URBs in case counteractivations are prevented. This was accepted as being a reasonable proposition.
  - An alternative pricing rule which could be considered is based on the concept of side payments (e.g. with the so called "convex hull pricing" scheme). This approach could be applied to all four scenarios, however as we have not investigated this possibility, we cannot comment on its algorithmic behavior or market impacts. We do, however, point it out as an interesting option for future investigation.

- Another option that has been proposed is the possibility of pricing differently in the upward and downward direction. Assuming that the price of upward (resp. downward) activations equals the marginal value of the marginal TSO or BSP order in that direction, it may be that - under certain definitions of counter-activations[4] - the problem is computed within reasonable time. Further investigations are however in any case required to precisely analyze the market consequences of such pricing rules. For example, if buyers of power would pay a different price than the price that is being paid to sellers, there can be cases where extra money is left over after the market clearing. Another possible consequence of such a dual pricing scheme relates to the coherence of prices across zones, which may be less easy to justify and potentially lead to other transparency and intuitiveness concerns.
- The key question is therefore if such alternative pricing requirements which facilitates the algorithmic aspects have acceptable/desirable market consequences.

Q4 Would the re-definition of the objective function open the path to other feasible solutions? E.g.: a. Cost minimization?

Firstly, defining an objective of "cost minimization" is not straightforward in the MARI context, given that (1) for downward TSO needs the objective of TSOs is rather to maximize revenues and (2) the presence of elastic TSO needs should also be taken into account. An alternative objective function taking these two aspects into account could for example be to "maximize the TSO surplus" (i.e. maximize the sum of the absolute value of differences between the clearing price and the limit prices of satisfied TSO needs).

In general, changing the objective function implies that the day-ahead-style pricing rules would need to be enforced explicitly as additional constraints, that have a challenging mathematical nature. In particular, we would need to rewrite the problem with the newly proposed objective of cost minimization, but as an optimization over both primal variables (activation of offers and flows) as well as price variables. That in itself is not so problematic. The problematic aspect is that the consistency between prices and activations would have to be captured through non-convex constraints. The introduction of these constraints would immediately disqualify extremely powerful solvers such as CPLEX and GUROBI from solving the market clearing problem, because these solvers can only handle problems with convex constraints, whereas the constraints now would become non-convex. No commercial solvers are known that can handle these bilinear non-convex constraints efficiently for the target run times and scales of problems that we are interested to tackle in MARI.

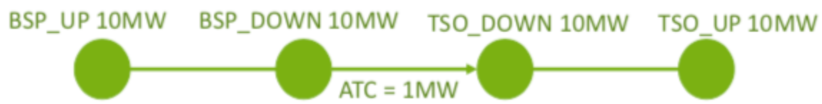
b. Separate optimization per activation-direction?

A separate optimization per direction could be interpreted as follows: match upward TSO demands with upward BSP offers, and then match downward TSO demands with downward BSP offers. If one proceeds with such a separate optimization per direction, it is not clear how the "no counter-activation" requirements would be enforced, since there is no explicit consideration of the BSP upward offers when deciding what to do with BSP downward offers, and there is no explicit consideration of the BSP downward offers when deciding what to do with upward BSP offers. If the "no counter-activation" would be satisfied, it would be so by chance.

[4] As explained in the answer to Q7, multiple definitions have been discussed for the prevention of counteractivations.

Further, TSO netting will not be straightforwardly identified and it would also not be possible to set a single market clearing price for both directions.

In addition, cross-border usage may become suboptimal under such a two-step approach, as the sequence in which the directions will be treated will have an impact on the results. This is illustrated the example below: as one can see, treating the UP direction first will not allow the TSO with Upward need at extreme right to access the upward offer of the BSP at the extreme left because of the ATC constraint. However, treating the Down direction first would free up such a capacity. In contrast, treating both directions together would allow TSO netting, which is in our understanding the preferred solution for inelastic TSO needs, irrespective of the counter-activation discussion.



Q5 On slide 26, it is indicated that infeasibilities arise when trying to prevent counteractivations on European level. Can it be clarified whether it is still possible to limit counteractivations in this situation to those strictly necessary to meet TSO demand due to congestions?

Our understanding of this question is very similar to question Q2. Therefore, we refer to the answer of question Q2.

Q6 Can it be clarified how a different type of algorithm (for example, iterative) could influence the difference between options in terms of complexity?

Generally speaking, complexity is seen as intrinsic to a problem, and different classes of algorithm can cope with different classes of problems with their respective complexity.

For this analysis, we have performed simulations using state-of-the-art solvers based on branch-and-bound algorithms. These are very advanced mathematical techniques to resolved mixed integer linear problems and which have the very valuable property to be "exact", in the sense that either they output optimal solutions, or – in case they cannot output optimal solutions within a given time boundary – output the best solution obtained so far, together with a precise quantitative indicator measuring the largest possible distance between the output solution and the optimal one. Thus, it is always possible to closely assess the quality of the output solutions.

There indeed exist multiple other approaches to resolve complex problems (for example, iterative heuristics). Some can prove to be very efficient on specific problems. However, while none of them provides such a precise quality indicator (i.e. distance to optimality), the fact that there exist efficient alternative heuristics that can be applied to a problem does not reduce the fundamental complexity of the problem at stake.

Moreover, in general, there exists a wide body of academic literature and empirical evidence that shows that heuristics are non-deterministic (in the sense that different runs on the same data produce different solutions), provide no guarantees on the quality of the solution, require the manual tuning of a large number of parameters, and are not robust to problem data or scale. Such meta-heuristic algorithms were therefore not considered for this study.

Our assessment is that the prevention of counter-activations is in any case an additional layer of complexity. Though, compared to the alternative model which allows counter-activations, another difference is that this latter has already been exhaustively studied, both in the academia and in the industry, and that therefore efficient resolution methods are already (nearly) readily available.

Q7 Which requirements used in the analyzed scenarios such as divisible bids should not be rejected, flexible TSO needs, only one price should be provided, etc) would need to be dropped/abandoned such that:

a. There would be no counter activations of BSP bids at uncongested area level, and

b. Computational time and robustness of the solution would be graded the same/similar.

As explained during the meeting, strictly restricting counter-activations at uncongested area level is very challenging from an algorithmic perspective, due to the fact that the definition of "uncongested areas" cannot be known ex-ante (it is an output of the calculation, not an input). In other words, the problem of preventing counter-activations at uncongested area level is genuinely difficult to resolve, irrespective of the algorithmic technique. Any further complication (e.g. any additional sophisticated requirement) just adds on this complexity.

We also explained that restricting counter-activations at the whole perimeter is probably undesirable (e.g. if there is an upward need in one area, a downward need in another area, and no capacity between these areas, then our understanding of the TSO requirement is that both needs should be satisfied – which would however strictly read as a counter-activation since there are BSP bids activated in both directions).

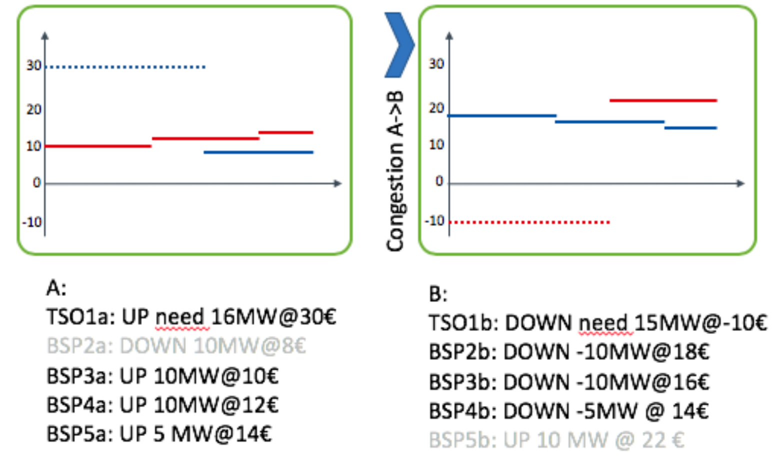
Notably based on the questions above, we note a possible alternative TSO requirement where BSP bids activations should occur "only if strictly necessary to satisfy TSO demands". For cases where all TSO demands are inelastic, this is likely to be achievable by an exact and efficient algorithm (i.e. it can for example be modelled by a two-steps linear optimization problem, as long as there are no special orders. See answer of Q2/5), provided that the pricing rules are consistent with the problem definition.

In presence of elastic TSO demands, the main problem relates to the definition of "strictly necessary to satisfy TSO demands" Please refer to the example in questions 2/5 to illustrate our point: Would a counter-activation be deemed as strictly necessary if it is to satisfy two price incompatible TSO demands?

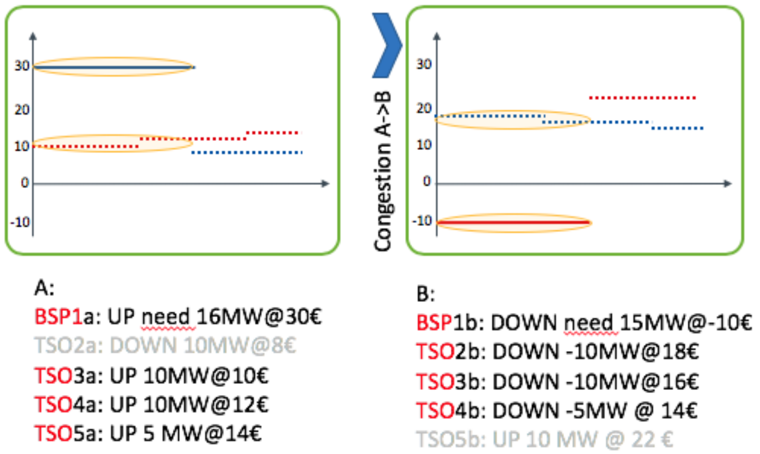
- If so, it can be impossible to find a single price with no unforeseeable acceptance of divisible bids or TSO needs;
- If not, what would be the criteria to distinguish "strictly necessary" and "not strictly necessary" counter-activations?

Another example to illustrate the difficulty to define a counter-activation prevention rule in presence of elastic TSO needs derives from the one expressed in slide 27, and which is repeated below. In this example, our current understanding of the TSO requirement to "only activate what is strictly needed" would lead to a TSO netting of 15 MW complemented with a 1MW upward activation in A at 10 € (with a common price in A & B of 10 €).

Importantly, the welfare maximization solution of the "no counter-activation per uncongested area problem" would be to accept 16 MW of BSP bids in A and 15 MW of BSP bids in B. This solution would increase the welfare by executing price compatible BSP bids and keep the congestion between A & B (hence the requirement of no counter-activation within an uncongested area is satisfied: there is a counter-activation but between congested areas). Such a solution is however seen as undesirable because activation of BSP bids in both directions could be avoided.



Let us now consider a very similar example, where we have inverted the BSP bids with TSO needs, and vice-versa. The welfare maximization solution under the "no counter-activation per uncongested area" would remain the same (in such a setup, the algorithm does not distinguish between BSP & TSO bids whatsoever). However, treating the alternative "only activate what is strictly needed to satisfy TSO needs" requirement is trickier. At this stage, it is unknown to us what would be the solution desired by TSOs in this case (or more precisely: how would the requirement be formulated to adequately treat both examples). In the absence of a clear requirement, it is difficult to assess whether an efficient algorithm exist. Our intuition is however that it may be challenging.



Q8 I understood that there is no tool available for Scenario 2 and that algorithm which would prevent counter activation at uncongested area level needs to be developed. According to your expertise, how much resources both in term of time and money would be required? Can you provide any estimates?

Preventing counteractivations at uncongested area level is very challenging, and it may not even be possible to find good solutions within the allocated run time. Moreover, there remain some open questions related to the definition of this requirement (cf. question Q7 or slide 27 of our presentation). It is therefore not possible at this stage to provide any meaningful estimates in terms of budget and resources.

Q9 TSO described the problem (objective function) as maximization of the social welfare. According to my understanding there is natural property of provided problem definition that the BSP bids could compete also among themselves, e.g. BSP down offer is competing against BSP up offer, and not only against TSO demands? Prevention of counter activations is solved with the definition of constraints only. Is my understanding correct?

In a welfare maximizing scheme where counteractivations are not prevented, a BSP down offer can indeed be matched with a BSP up offer if this trade increases the welfare. Elastic TSO demands will compete with BSP offers in the opposite direction (i.e. a BSP up bid and a TSO down need are both meant to inject in the grid), and only the most economically efficient trades will be executed.

Prevention of counteractivations requires the introduction of additional constraints in the mathematical model, or alternatively a penalty term in the objective function. This latter option is actually similar to defining a constraint with an associated penalty factor when it becomes violated.

Please also refer to Q4a for another discussion on possible alternative objective functions.

Q10 Can we define the objective function differently the what was proposed so far and at the same time satisfy the needs of TSOs?

The use of any other objective function except for welfare complicates matters, because – due to fundamental properties of optimization and economic theory – the welfare objective specifically ensures coherence between the volume-related variables (i.e. primal) and the price-related variables (i.e. dual). In the absence of a well-developed theory for expressing the profit-maximizing reactions of agents in a problem where we are maximizing welfare in a linear way, we would have to solve for our desired objective function with a set of difficult non-convex constraints which describe how agents react to prices. For example, if a BSP wishes to provide upward activation at a certain marginal cost and we broadcast a price that is greater than that marginal cost, then the agent will react by producing its full bid quantity, because this is the action that maximizes the profit of the agent.

If we change the objective of the platform, we need to develop a new theory (if one even exists) to formulate the problem with linearized constraints, which is a serious and risky research effort in its own right. Otherwise, we can directly insert constraints to a problem which solves for prices and primal variables (activations and flows), while also imposing relevant constraints on limiting counter-activations.

As explained in the answer to question Q4a, introducing these constraints explicitly to our problem rules out very powerful commercial solvers, and limits us to large run times on problems that are prohibitively small in size, compared to the expectations that have been expressed in the MARI project.

Q11 Would minimization of all balancing energy costs be an option to be used as an objective function? If yes, would the issue of counter activations still remain in this case?

The answer to question Q10 and to question Q4a explains why the minimization of balancing energy costs would not lift the challenges of imposing constraints on counter-activations.

Q12 In Executive summary, on slide 2, similarly on slide 23, 41 is mentioned:

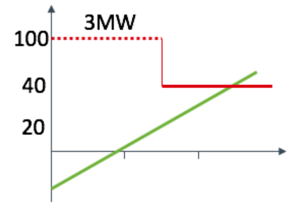
- **Allowing CA is the best choice regarding algorithm properties, transparency of results, welfare and liquidity**
- **However, it may lead to higher TSO activation costs and fewer bids available for DA (at least in the short term)**

I would like to have more explanation on this from N-Side. (I can imagine that CA would use some DA bids and thus any DA bid activated after "scheduling" would increase the price of DA. In my understanding, it is not a short-term problem/threat)

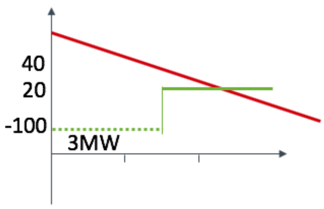
There are three interrelated effects at stake.

1. Firstly, as counter-activations "consume" BSP bids, it is logical that those BSP bids that are counter-activated during Scheduled Activations and that are marked as "direct activatable" become unavailable for direct activation;
2. Secondly, because these direct activatable bids are no longer available for DA, other bids further down in the merit order must be activated (hence a decrease of the TSO economic surplus, which is the proxy we used to define the balancing energy cost in a context of TSO needs in both directions).
3. Thirdly, the TSO economic surplus of the scheduled activation is also reduced in case of counter-activations.

Our understanding of the question refers only to the two first effects. This third effect is also a logical consequence of allowing competition between TSO demands and BSP bids in case counter-activations are allowed. The pictures below illustrate this effect based on a very simple example. Conform with our convention in the slides, dashed lines always represent TSO needs and plain lines represent BSP bids.



Scenario 1:
TSO eco surplus= 180€
➔ 60€/MW (not quite sure about the units here)
Scenario 2: (most favorable for TSOs)
TSO eco surplus = 240€
➔ 80€/MWh



Scenario 1:
TSO eco surplus= 360€
➔ 120€/MW (not quite sure about the units here)
Scenario 2: (most favorable for TSOs)
TSO eco surplus = 420 €
➔ 140€/MWh

As one can see in these examples, the fact to prevent counter-activations is equivalent to "cutting" the plain lines in one of the two curves. As there are only TSO needs in one direction for these examples, the choice on which curve to cut is trivial. Clearly, these cuts reduce the total generated surplus (i.e. the total surface between the two curves). Though, such cuts also influence the execution price, and thereby increase the TSO portion of this total generated surplus (NB: last accepted bid always sets the price).

The views expressed in our presentation that "preventing CA increases the TSO economic surplus" is thus correct given fixed orderbooks (as in the examples above). The open question – which we tried to express on slide 23 – is whether such an effect pertains in the longer term. A valid line of thoughts is indeed that if the BSP generated surplus is reduced (as a consequence of preventing counter-activations), the attractivity of the venue may reduce and bidder may seek for other platforms to execute their spare capacities[5]. In other words, despite a clear short-term effect, the long-term effects are less foreseeable.

Q13 Another question on N-Side: Is the algorithm still running, even though the demand is 0?

In case counteractivations are prevented (if it is possible, depending on the requirement definition), it probably does not make much sense to run the algorithm when there are no TSO demands, as nothing would be matched anyway.

If the market design allows counteractions on the other hand, some BSP offers could be activated even if there is no TSO demand. Running the algorithm is then needed to be in line with the market expectations. It is always possible to detect that there is no TSO demand, and avoid running the algorithm in that case, but it would in our opinion not be a good idea as it would not be coherent with the market definition.

[5] Note that this assumes that BSPs are free to choose the platform on which they offer their spare flexibility. This assumption is though debatable for pre-contracted/reserved mFRR capacity.

2 Clarifying questions – Guaranteed volume

Regarding the GV, could you please clarify the expected impact of option 2.B (activation of GV through the platform; 2.A is thought as a fallback solution) on:

- **the Algorithm in terms of a) implementation effort and b) compliancy with the other design requirements (in particular available time for the algorithms to converge: 1 minute for SA and 20 seconds for DA).**
- **Cross Border Marginal Price formation**

Based on the two alternative working assumptions:

i. GV bids are accessible to the TSO only when this TSO places a demand that exceeds the non-GV volume it made available to the platform (and thus in the absence of imports, it would cover its demand by its GV volume) EXAMPLE: TSO A submits 100 MW of DA bids and defines a GV of 70 MW. If TSO A does not place demand into the platform, only the 30 MW are accessible by the other TSOs. When TSO A's demand exceeds 30 MW (i.e. the volume made freely available to all TSOs in the Platform), for example 50MW, then the 20 MW will be accessible by all TSOs at that activation. The rest of the 50 MW GV is not accessible.

Our understanding of the model (i) is that, for this example, if TSO A submits a need of 50 MW, then the best available BSP bids will be executed to satisfy his need (hence not necessarily the GV bids, it depends on their respective price attractivity).

Our understanding is also that the paragraph would better read "20 MW will be accessible by all TSOs <u>for the next activations</u>" instead of "20 MW will be accessible by all TSOs at that activation".

There are two reasons for this suggested difference:

- Firstly, our understanding is that TSO demands for direct activations are typically unique per AOF run. This means that the change of "Guaranteed Volume accessible to other TSOs" can typically be adapted in-between two AOF runs as a data handling process (i.e. after the concerned TSO has requested "more than the non-GV volume", then this additionally requested volume is removed from the GV volume and becomes available to the other TSOs in case they submit further needs in this period).
- Secondly, even if there are multiple TSO demands during one AOF run (presumably TSO demands are exclusively inelastic and in the same direction[6]), two cases can be distinguished:
    - Either there is sufficient liquidity to satisfy the concurrent TSO needs. In this case, the first bids in CMOL will be selected. If there are GV bids selected, then they can always be "attributed" to its submitting local TSO without any negative impact for the other TSOs (i.e. this doesn't use CZC, so does not restrict other executions).
    - Or not all the TSO needs can be satisfied altogether, in which case our expectation of the requirement is that the TSO who has GV would have priority (i.e. it remains "guaranteed for him").
- Hence, our understanding is that in all cases
    - the AOF must be completed with a constraint that only allows a specific TSO to access its specific GV volume.
    - Any change of GV volumes under this requirement can be processed in between AOF runs.
- Consequently, if during a given AOF run some GV bids are not accessible, they may become unforeseeably rejected (i.e. in case they would be accepted without the GV constraint). They

[6] Our remark on slide 49 about queuing was referring to a potential alternative design where TSO needs in both directions can be present in a single AOF run – quite a second order detail for this discussion

may however become accepted during following AOF executions. This implies that the DA prices output by the AOF for successive calculations can change in either direction (while in absence of GV and indivisible bids, successive DA UP – respectively DOWN – AOF calculations would necessarily increase – resp. decrease – the execution prices). Besides this specific observation, the XBMP principle apply.

- The direct algorithm impact for such a requirement is not expected to be of major importance. Rather, most of the technicalities will be handled via the MARI IT application (i.e. envelope of the AOF).

ii. GV bids are accessible to the TSO that has defined this GV only when this TSO places a demand that exceeds the non-GV volume it made available to the Platform. EXAMPLE: TSO A submits 100 MW of DA bids and defines a GV of 70 MW. As soon as TSO A's demand exceeds 30 MW (i.e. the non-GV volume made to all TSOs in the CMOL), this TSO will see the activation of its GV bids. In other words if TSO A asks for a DA of 50MW, the first 30 MW will be activated from CMOL (regardless where these bids come from) but the remaining 20 MW will be activated from its GV (i.e. from the 70 MW local bids in TSO A's area).

Here again, let us first clarify our understanding of variant ii: in this example, the 20 MW would necessarily be activated from the GV, i.e. even if there exist DA bids with better prices in the CMOL. This is the fundamental difference with variant i.

With this understanding, the approach appears from a process perspective as fully identical to the option 2A: a TSO request might be split into two parts: a "regular request" and a "GV request". The GV request then triggers activations "outside CMOL & AOF", although technically still be the MARI system (e.g. a separate module).

PRICING ISSUE: this feature could potentially increase XBMP for all TSOs since GV contains by definition is composed by the most expensive bids from a TSO. In order to avoid this risk a possible settlement principle could be the following: if TSO A requests more than 30 MW bids (i.e. the non-GV bids) and the final XBMP is higher than the price of the last activated GV bid of TSO A, then the XBMP can apply to all in the uncongested area; otherwise if the XBMP is lower than the price of the last activated GV bid of TSO A than TSO A's GV bids will be paid by TSO A pay-as-bid. By this, GV bids will get at least their bid price and on the other hand TSOs not requiring for the GV will not be penalized by the higher XBMP.

On the one hand, the price of the last activated bid (be it GV or not) is by definition the XBMP for each AOF run. The price of the last activated bid can therefore not be higher or lower than the XBMP.
On the other hand, our interpretation of the question relates to the fact that, under variant ii, there might be attractive BSP bids which are not selected because the TSO is by design forced to execute its GV bids (even if there are more attractive bids available), which in turn may increase the DA price affecting other TSOs (and thereby also create URBs for non-GV bids). If this is the concern, a logical solution would be to fully prevent that the GV activation under variant ii affects the XBMP. In other words, only the "regular requests" have an impact on XBMP, while the "GV requests" are settled separately(e.g. paid-as-bid).
Here again, the logic appears from a design perspective as fully identical to option 2A where GV is treated locally. A pragmatic approach is indeed that "regular DA bids" and "GV bids" are treated in parallel (fully distinct processes and algorithm runs, which is possible since the two sets of bids have no influence over each other). Compared to option 2A, the difference is therefore solely technical, and varies solely on the technical location of GV handling (here within the MARI architecture, while locally under option 2A).

3 References

[1] M. Madani, Mehdi and M. Van Vyve, “Computationally efficient MIP formulation and algorithms for European day-ahead electricity market auctions”. European Journal of Operational Research vol. 242, no. 2, pp. 580-593, 2015.