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Research Report

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Auctions for Intraday-Trading

Impacts on efficient power markets and secure system operation

Report on the key elements of debate from a workshop of the Future Power Market Platform,
 RTE, Paris, 4th October 2016
 Karsten Neuhoff, Jörn Richstein, Nils May

The power system in Europe is rapidly transforming. This is bringing about new determining factors for the design of electricity markets, in particular for short-term markets.

- Variable renewable energy sources (VRES) will make up a larger share of generation. This leads to higher activity in intraday markets due to uncertainties until shortly before real-time. To efficiently use system resources, adjustments to dispatch and consumption need to be made in short-term markets.
- Countries could rely more on their neighbors to ensure adequacy and reliability. This requires however efficient and predictable allocation rules for transmission capacity plus stronger coordination of operational rules for SOs.
- Fewer conventional power plants operating at the same time make it more difficult to replace power plant outages within individual portfolios: response by all market participants in the system is needed.

However, a set of challenges is increasingly apparent (which were discussed in FPM on [“A Blue Print for European Power Market Design”](#), June 2016, Brussels)

- Inconsistencies between intraday market clearing and real-time markets for balancing energy create risks of gaming.
- Misaligned products in intraday markets limit access and provision of flexibility in particular by the demand side and small market players.
- Disputes over gate-closure time lines illustrate inconsistencies between the pure commodity-based trading (bilateral or PX-based) and TSO-centered short term arrangements for operational security.
- Lack of reliable generation forecast results in unannounced loop-flows and puts secure system operation at risk.
- Market based and flow-based allocation of transmission capacity between bidding zones cannot be realized with continuous trading.

In the discussion we found overall support for the broader use of intraday auctions within and between member states based on multiple benefits they can offer with respect to eight criteria discussed in the reminder of this workshop report. The two design elements discussed most extensively are the frequency and the bid format for intraday auctions and no universal consensus was reached on this topic. For a coherent discussion and since they impact several of the criteria we assume in the following – unless explicitly stated otherwise:

- Frequency: It became apparent that auctions merely at the beginning and ending of the intraday period are insufficient to realize most benefits of auctions. To simplify the further presentation we therefore assume that every two hours an intraday auction is executed at which all 15 minute intervals that are remaining in the intraday period are cleared. We discuss alternative options with criteria 5.

- Bid format¹: In day ahead auctions a variety of bid formats have been established in EU member states. The failure to subsequently harmonize these bid formats as part of Euphemia points to the importance of early harmonization. We therefore assume capability based bids (also referred to as multi-part or unit based bidding) as reference but also allow for simple energy bids including to arbitrage prices between auctions. We discuss implications of alternatives with criteria 3, 4 and 8.

1. Improving market liquidity

Intraday auctions increase the volume of bids and offers that are available at any point – the **market depth**. This is because market participants can offer all available capacity at its marginal costs, as all accepted bids will be remunerated based on the marginal price. The clearing platform can facilitate standing orders – thus all participants can easily bid their capacity into the market and the offer can remain valid in all consecutive auctions without the need for active trading for 24 hours.

While in marginal clearing auctions market participants can bid their marginal cost, in continuous trading market participants need to mark up their bids in order to recover opportunity costs, as each bid is cleared at the offer price (pay as bid). The appropriate mark-up depends on the demand and supply balance and therefore needs to be continuously updated to maximize revenue. Consequently market participants only submit limited orders for a fraction of their available capacity retaining a part of their flexibility for a later change in the supply-demand balance. As a result, power plant outages are more frequently resolved on a bilateral basis, than over the continuous market. In the German case, the additional auction increased market depth from about 1.5 GW to more than 4 GW.²

To avoid the need for marking up of bids virtual bids³ are required, – e.g. players need to be able to submit energy bids in auctions to arbitrage expected price differences between day-ahead, intraday and balancing markets. Typically few arbitrage trades suffice for prices in earlier time periods to reflect the expected price closer to real time and in balancing markets. Virtual bids are in principle already possible in today's power market. Where virtual bids are not allowed, market participants mimic virtual bids by adjusting bids for anticipated production or demand to pursue such arbitrage. Such adjustments are also likely in continuous intraday markets as part of inter-temporal arbitrage. Such implicit arbitrage however reduces the reliability of flow forecasts based on schedules submitted to TSOs.

Trading volume is sometimes also used as proxy for market participation and therefore efficiency. For example with the introduction of an auction at the beginning of the continuous intraday trading in Germany, trading of the least-liquid 15 minute products doubled while also trading volumes for other products increased.⁴ Auction based intraday markets in Spain and Italy exhibit the highest trading volumes in the whole of Europe⁵.

¹ See <http://www.europex.org/external-consultations/all-nemos-consultation/> where NEMOs have recently published a consultation package listing ID products as well

² Karsten Neuhoff, Nolan Ritter, Aymen Salah-Abou-El-Enien, Philippe Vassilopoulos (2016): Intraday Markets for Power: Discretizing the Continuous Trading? DIW / Cambridge discussion paper

³ On virtual bidding see: https://www.hks.harvard.edu/fs/whogan/Hogan_Virtual_Bidding_052516.pdf

⁴ ibid

⁵ http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/NATIONAL_REPORTS/National_Reporting_2016/NR_En

It is also important to note that sufficient trading frequency is necessary for price discovery in continuous trading. In contrast, in auctions, robust price discovery occurs even without active bidding if a significant share of market participants submits standing orders.

2. Facilitating contracting for flexibility

Longer-term financial products are usually referenced to the day-ahead auction result, which depends on the expected demand-supply balance, not the finally realized one. It therefore only reflects an average of potential outcomes and smooths the volatility of (close to) real-time demand-supply balance. In order to represent the full value of peaking capacity and flexibility products in longer-term products, a reference price in real time or close to real time is necessary.

To achieve this under continuous trading, power exchanges calculate volume-weighted average prices of, for example, the last three hours before gate closure. These are then used as basis for price-index based hedges. However, in a continuous trading arrangement, an asset offering or requiring flexibility in the short-term cannot sell this power at the average index price but in a specific transaction, which may be priced differently (in 5% of cases more than 86 Euro/MWh basis risk⁶). The hedge to stabilize revenues and costs is therefore incomplete. While some of the basis risk may be averaged out for larger players with many transactions, all participants (including the bigger players) would benefit from auction results close to real time that allow for hedging without such basis risk.

3. Allow effective participation of players of all scale and technologies (including flexibility)

Continuous trading is largely focused on 15 min energy bids. However, for example a gas or coal plant can only produce for multiple consecutive 15 minute intervals, and can therefore not offer independent (energy only) bids for 15 minute intervals without risking open positions that they cannot physically cover. Thus in continuous trading arrangements market participants often resort to telephone calls to agree on a schedule for several hours if they need to acquire energy to compensate for example for the failure of a power plant. This is however limited to potential partners within the bidding zones unless sufficient free transmission capacity exists for the respective period.

To overcome the limitations of 15-min energy bids, additional bid formats have been established for auction based trading to reflect the interdependencies across 15 minute intervals. Initially block-bids were introduced for all intervals within the peak period. With increasing shares of wind and solar generation, conventional assets are no longer requested to produce either peak or base load, but to match residual load. Therefore additional types of block-bids have been introduced based on requests of market participants in the different countries. Different types of complex or linked block bids emerged in member states reflecting both different generation technologies and market structures. Due to path dependency and vested interests, it was to date not possible to standardize these bid formats with the introduction of a joint auction clearing algorithm at the day ahead stage (Euphemia)⁷.

To avoid such lock-in for intraday auctions, an early standardization for intraday auctions seems warranted. Capability based bids are the natural candidate, as they can reflect the full physical capability of different unit

⁶ Karsten Neuhoff, Nolan Ritter, Aymen Salah-Abou-El-Enien, Philippe Vassilopoulos (2016): Intraday Markets for Power: Discretizing the Continuous Trading? DIW / Cambridge discussion paper

⁷ On the contrary, the draft guidelines on electricity balancing design a balancing market limited to the hour ahead, with no interest in optimizing physical assets over a longer time frame (e.g. 24 or 48 hours).

types and are thus suitable for all power systems. They are well established for clearing of intraday or balancing/ancillary services platforms in Ireland, Poland, Spain and Italy. With capability bids, plant operators submit capability-based bids of their units. These capabilities include technical parameters like minimum run and ramping rates and start-up times, as well as economic parameters like variable and start-up costs. Additional information on existing commitments for the provision of ancillary services or re-dispatch actions ensures feasible outcomes. The market participants could alternatively choose to submit (portfolio-based) energy bids for 15 minute intervals. The submission of capability bids (instead of energy bids for 15-min intervals) can be voluntary and thus allow for a smooth transition in countries focused on trading energy for 15-min intervals. Ultimately one may expect most participants to submit capability based bids, as they can thus offer the maximum flexibility while ensuring only production that is profitable, thus delivering the maximum operational profit in a competitive market.

Capability bids allow for full participation of all flexibility options, be it supply or demand, large or small players on a level playing field. Smaller players do not need to maintain a costly 24 hour trading desk, and still participate directly in the market by submitting standing orders (also known as sleeping bids, which can be subsequently updated). While capability bids do in principle allow for individual participation of all market participants, there are opportunities to save on transaction costs and realize economies of scale by allowing for aggregation for example of demand side flexibility.

This raises questions on the precise nature of bids to best meet the needs of different demand and storage options – including those located in distribution networks. It is also discussed on what geographical scale demand can be aggregated into single bids? In principle it needs to be differentiated – like in the case of generators – between physical aggregation and financial pooling. Portfolios of assets retain a value even without physical aggregation, because firms owning multiple plants do continue to pool the financial responsibility for imbalances of individual plants.

4. Ensure technical feasibility

In continuous markets, algorithmic trading is on the rise. As a result for example the German market sees about 100,000 orders per day. The speed of trading determines who can capture the margins between a bid and an offer – triggering an arms race on algorithms and IT capacity with no specific benefits for the system. For the market place the increasing volume of orders risks back-logs and ultimately system security. This problem would be exacerbated with cross-zonal trade and by block bids: There are very many matching possibilities, increasing non-linearly with cross-zonal trade. This is not a topic for auction based trading – as all bids and offers are remunerated at the clearing price.

For auctions two questions remain. First, the discrete nature of combinatorial (block-bids) and unit commitment (capability based bids) can inhibit a simple auction clearing. There may be no clearing price and quantity at which all accepted bids recover their requested bid price and none of the rejected bids would like to be accepted. Two approaches are common to resolve this question. First, in Europe the day-ahead market can involve rejection of bids that would be profitable at the clearing price. Second, in North America minimum uplift payments are granted both to units accepted in the clearing if this is necessary to recover full variable cost otherwise not remunerated by the clearing price. An uplift payment may also be granted to units not accepted by the clearing to compensate for foregone profits. While in practice the overall volume of such payments is small, it resolves an inherent problem of markets with non-convexities and enhances acceptance by all parties. Details for implementation that require further discussion are the alignment with CACM code

(e.g. Article 38) and allocation of potential costs. In the US the concept so far has been applied in the context of day-ahead and real-time market clearing, hence further analysis of implications of application to repeated intraday auctions is necessary.

Second, as soon as bids are accepted that comprise inter-temporal linkages (all block bids and capability bids), then sufficient computational capacity is required to clear the auction. This is of particular concern for block-type bids, because the auction clearing algorithm needs to resolve a large combinatorial problem that causes significant delays in the clearing of the day ahead auction algorithm Euphemia. Capability type bids also imply some combinatorial questions (unit-commitment choices), which need to be further investigated. Experience from the US shows, however, that capability bids are in combination with the use of, for example, minimum up-lift payments a (efficiently) solvable problem.

5. Compatibility with current (continuous) trading arrangements

Auctions can be introduced in complementarity into markets with continuous trading, which would be halted for the duration of the auction following similar procedures in financial markets (and is in accordance to CACM regulation, cf. Article 63 of CACM code). The key question is the frequency of auctions. While an opening auction might be suitable for the initial allocation of transmission capacity, closing auctions raise questions on how transmission capacity is priced that is allocated prior to the closing auctions.

Overall, several arguments speak for more regular auctions: they enable easier integration of national designs, which might have different gate closures. They could also provide a clearly anticipated space for making new transmission capacity (based on updated TSO calculation) available to the market. Furthermore intraday auctions provide early opportunities to adjust for changes in wind forecast or generation outages using the entire flexibility available across bidding zones. The main concern about higher frequency relates to the amount of interruption of the continuous trade. Figure 1 illustrates the time-line of intraday auctions executed every 2 hours. Along the x-axis the timing of day-ahead auction and intraday auction and continuous trading is depicted, while the y-axis characterizes selected 15min intervals that are being traded.

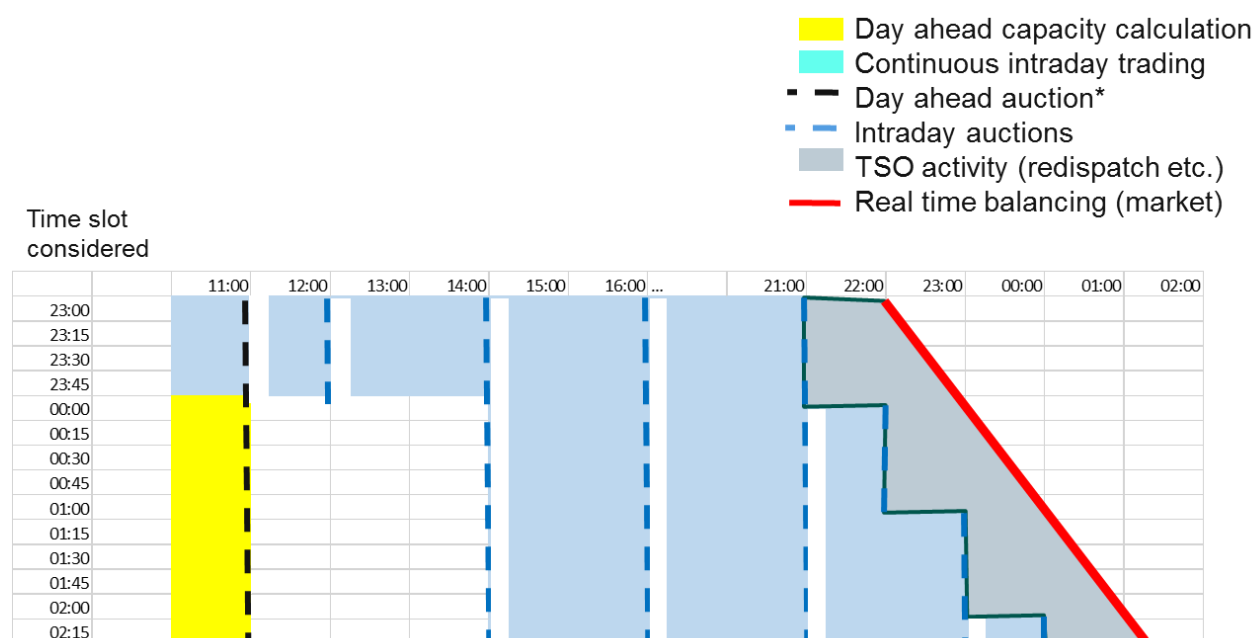


Figure 1: Two-hourly intraday auctions with continuous trading

Relatively frequent intraday auctions do require standing orders that limit the required effort for participants and thus ensure broad participation and market depth. Capability based bids offer a suitable basis for this: The capabilities of a unit and therefore its bid will usually not adjust over time and can therefore be submitted as a standing order. The bids can obviously still be updated during intraday, reflecting outages, changes in wind power output or demand and the option value of power plants.

What might change from the perspective of an actor bidding its units during the sequence of intraday auctions is the committed energy production or reserve provision. This pre-commitment needs to be nominated for the first intraday auction as it determines the reference point against which intraday auctions clear. The subsequent intraday auctions can then be directly based on the commitment resulting from the previous intraday auction and only requires updating if this results from transactions in continuous markets or within the portfolio. Each intraday auction only clears the differences to the contract position resulting from the previous auction. Such intraday auctions could then in the longer-term also offer the basis for the better integration of energy and reserve markets.

6. Ensure consistency between intraday and balancing

Flexible resources can be offered not only to intraday markets, but also to auctions for balancing reserve and in an increasing number of countries directly to real-time (balancing) markets. If the same product can be offered at different platforms this can (i) create competition for liquidity and (ii) opportunities to arbitrage/game inconsistent market rules.

Balancing markets are increasingly opened for participation of all flexibility options even where not contracted for balancing services (real time balancing markets). This allows for increasingly efficient- allocation of energy and reserve provision. Balancing markets are also increasingly cleared based on a single marginal imbalance price. Both trends are supported by the balancing guidelines. This is attractive for smaller and less informed players. Thus the increasing volume of demand side flexibility and small scale storage may shift trading activity to real-time (balancing) markets. They can avoid the effort, risk and inherent bias against small players of calculating mark-ups for intraday bids cleared as pay as bid. All players can offer their full flexibility in intraday markets, if capability based bidding offers simple processes and intraday auctions apply a marginal clearing price. Thus a more efficient and more secure outcome results due to the increased and early provision of flexibility to the market place.

A further concern about combining intraday continuous trading (pay as bid) with real-time (balancing) markets, relates to implied last minute generation adjustments that can undermine reliable system operation. As generation units will mark-up their bids during intraday to reflect opportunity costs, the market outcome may not reflect an efficient (least cost) generation schedule. In a subsequent real-time (balancing) auction with marginal clearing, competitive generation units will submit bids reflecting their marginal cost and the auction clearing results in a least cost generation schedule. This might imply significant adjustments to output of individual power stations and thus also flow patterns very close to real time but has to date not been modelled. This can be avoided, if intraday market clearing is also based on marginal clearing rather than pay-as-bid continuous trading.

For energy prices to remunerate the full value of flexibility and therefore for generation adequacy it is important that contracted balancing reserves are appropriately priced when used for balancing. An operational response

demand curve can for example reflect the opportunity cost of reducing reserve levels in real time (balancing) price when reserves are being called upon. To ensure that this price signal can propagate to earlier market segments, virtual bids can allow for arbitrage of intraday and balancing markets.

7. Allow for pricing and efficient use transmission capacity between bidding zones

In day ahead markets, market based allocation of transmission capacity is well established in implicit auctions that jointly clear energy and transmission allocation. Thus scarcity rents can be captured and returned to grid users as reduced grid fees. Furthermore flow based allocation can allow for the most effective use of scarce transmission capacity in the interconnected system to serve the needs in the regions with highest prices (and most scarcity). This will be of particular importance for smaller countries or bidding zones.

In contrast, in continuous trading, it is not trivial to price transmission capacity. If the transmission price is set ex-ante, it will, first, inhibit efficient trades if it is set too high, and, second, transfer rents to traders if it is set too low. Moreover, traders risk losses on transactions, if the price is set ex-post and the charge for transmission exceeds the trading margin. However, the CACM code envisages as the standard case the continuous intraday trading while also asking that reliable pricing of transmission capacity should be introduced. However, in practice of most countries and in the currently developed joint order book (X-Bid) transmission capacity is allocated free of charge on a first-come first-serve basis. The first mover to reserve the capacity explicitly or by best offer on the exchange screen receives the potential scarcity value of transmission capacity. This allocation favors quick trades, rather than efficient ones.

Fortunately the CACM code also allows for the use of complementary regional auctions (Art. 63 CACM). In the workshop it was argued by some that more clarity about the scope granted for such auctions by the code was requested, for example with respect to Art 63.4a (“regional auctions shall not have an adverse impact on the liquidity of the single intraday coupling”) or Art 63.4b (“all cross-zonal capacity shall be allocated through the capacity management module”). This has now been granted with the explicit mentioning of intraday auctions in the Winter Package (30.11.2016, [COM\(2016\) 861 final](#)). The intraday auction between Italy and Slovenia offers a first example of successful cross-border implicit auctions. It provides coherence between the day-ahead and the intraday timeframes, enables the pricing of capacity and gives liquidity where needed.

Allocation of transmission capacity via implicit auctions offers a further advantage. They allow TSOs not only to increase the available allocation during the day, but can also be used to reduce the capacity made available by buying transmission capacity back from a deep and liquid market. This additional flexibility allows for a less conservative provision of commercial transmission capacity.

When operating intraday auctions and continuous trade in parallel, the question arises how to allocate transmission capacity between the two trading formats. Since implicit allocation of transmission capacity is more efficient, there is a strong argument for allocating more or all of the available transmission capacity via auctions. This is of particular relevance where additional transmission capacity is made available to the market. This suggests the alignment of time frames of auction and recalculations of available transmission capacity. On the other hand it was argued that capacity which remains free after an auction could then be made available for free in continuous trading. This does however raise questions on (i) gaming by bigger players that may restrain their participation in intraday auctions to retain private information and access transmission capacity for free in continuous trading (ii) why quicker players should benefit from accessing transmission capacity (for free) and thus capture scarcity rents that would otherwise be used to reduce grid fees.

8. Reduce unannounced loop flows

One challenge for flow forecast and system operation can be the reliability of generation schedules from participating units provided during intraday periods. Without reliably updated schedules during intraday, TSOs cannot make and share reliable flow forecasts to support secure system operation. While in countries with one dominant player as well as in countries with unit based bidding intraday updates to generation schedules are considered reliable, this is a concern for some of the other countries and their neighbors.

Intraday auctions with capability bids result in early and reliable generation schedules that are consistent with balancing and real-time markets. They thus provide a basis for improved flow forecasts by TSOs also in countries with diverse actors, as also large players are incentivized to bid their individual units directly into the market using capability bids. This reduces unanticipated flow patterns.

Outlook

The discussion pointed to the benefits of multiple intraday auctions based on capability bids in terms of the following eight criteria:

- Improving market liquidity
- Facilitating contracting for flexibility
- Allow effective participation of players of all scale and technologies (including flexibility)
- Ensure technical feasibility
- Compatibility with current (continuous) trading arrangements
- Ensure consistency between intraday and balancing
- Allow for pricing and efficient use transmission capacity between bidding zones
- Reduce unannounced loop flows

Thus intraday auctions could constitute an important step to enhance efficiency thus reducing cost of operation of European power systems, to accommodate increasing shares of wind and solar energy, and to enhance security of system operation.

The recent experience with regional initiatives for power market design however also points to potential challenges. So far regional initiatives have concentrated on pet-projects of a subset of countries and often failed to reflect needs of other countries and may thus have limited prospect for Europe-wide diffusion. Hence an organic growth concept proposes to first agree on common frameworks across all member states. Implementation may then start at regional level, but will be consistent and can subsequently be integrated with other regions. This points to the importance to also provide early European guidance on aspects like bid-format for cross-border auctions.

We also discussed different institutional options for hosting such intraday auctions. While they could be in principle hosted by existing power exchanges, their effective operation will require increasing coordination with system operation aspects. It was discussed whether a closer integration of system operation and market platform could ultimately result in more regional ISO type structures. Experience from North America points to the importance of appropriate governance structures to avoid lock-in with inefficient design choices. This would be an argument for further exploration of different institutional arrangements not least to retain competition between actors for their future role as an incentive for constructive development of the approach.