The Role of TSO-DSO Coordination in Flexibility Asset Prequalification

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***Abstract*—As market-based ancillary services (e.g., for congestion management) are introduced and developed for the various grid levels of the European power systems, it becomes a necessity to coordinate the actions of power system operators (TSOs, DSOs) in defining and implementing the processes needed for functioning of these evolving markets. Prequalification is one of the key processes, where TSO-DSO coordination has a significant role. However, it can be implemented with various degrees of complexity. This paper analyses the sequence of actions necessary to carry out prequalification and the actors and functionalities involved.**

***Index Terms*--Aggregation, Balancing, Congestion management, Demand response, Flexibility**

INTRODUCTION

Flexibility is an increasingly attractive means for solving electricity grid issues without relying on the conventional solution—grid reinforcement. Both generation-side and demand-side flexibility (i.e., demand response) are useful for this. In some parts of Europe, transmission system operators (TSOs) are already procuring aggregated demand response for power system balancing [1]. Furthermore, the recast Electricity Directive [2] calls for incentivizing flexibility procurement also on the distribution system operator (DSO) level, e.g., for congestion management services. Although flexibility markets as such are not precisely defined in academic literature and can take many forms [3], a common characteristic is that they allow system operators to procure services from resources connected to the distribution grid via their energy service providers [4] or through new actors called flexibility service providers (FSPs).

Some pioneering flexibility market projects have already emerged in Europe (Piclo Flex, Enera, GOPACS, NODES). In ref. [5], these projects are analyzed and compared. One of the subjects of comparison is the approach to TSO-DSO cooperation in the operation of these markets. It is found that coordination between operators can increase liquidity and potentially aid in synergetic activations of flexibility resources. However, it is also acknowledged that implementing such coordination costs time. Nevertheless, as confirmed in [6], TSO-DSO coordination mechanisms substantially increase the system welfare.

TSO-DSO coordination issues have attracted notable academic and practical interest lately. For instance, in [7] the market and grid operation coordination for congestion management within different system states is discussed. In ref. [8], a game-theoretic framework for operator interactions within three coordination schemes is proposed. The Horizon 2020 project SmartNet proposed five different market coordination schemes [9]. The recently initiated project INTERRFACE also tackles coordination issues. In a stakeholder survey [10] it was found that among other issues, prequalification processes is a subject where operator coordination when procuring flexibility is an important requirement.

Prequalification processes must be in place to ensure that a particular FSP is actually capable of delivering a particular product. This concerns the abilities related to both, the FSP and the flexibility resources contracted to it, on the one hand, and the grid where the resources are connected to, where the flexibility service is to be delivered to and any intermediate grids, on the other hand [11].

Prequalification fits in the overall process of congestion management (Figure 1). Particularly, it is an important part of the preparatory phase. However, prequalification also has significance in the market phase. During the former, resource grid and product prequalification takes place, whereas, during the latter, bid qualification can be implemented. This paper analyses the sequence of actions necessary to carry out these processes and the actors and functionalities involved. The results derive from the initial stages of the INTERRFACE project [11].

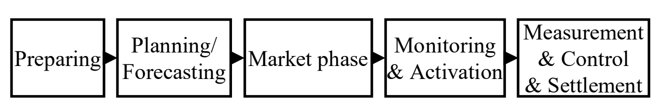

Figure 1. Congestion management overall process

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I. Resource Grid Prequalification

Grid prequalification is a crucial process for proper and effective functioning of emerging markets, e.g., congestion management, because it ensures that the flexibility offered by a particular FSP can actually be delivered without causing an undesirable situation in either of the involved grids. The Active System Management (ASM) report published by ENTSO-E and European DSO associations [12] proposed two not mutually exclusive ways of carrying out this process:

- Dynamic grid prequalification, where the possibility of grid access for flexibility resources is re-examined at regular intervals;
- Conditional grid prequalification, which grants improved grid access for flexibility resources based on clearly specified criteria determined in advance.

Furthermore, the ASM report additionally recommends that “the prequalification process should be user friendly striving to minimize the different steps and standardize them when possible”, and that “the prequalification could take place on an aggregated/portfolio level if technically acceptable”.

The prequalification processes described in this paper are aligned with these recommendations and strive to expand on them. However, they are nevertheless described in a generally high-level to serve as a common basis for conceivably diverse implementations.

Resource grid prequalification can be performed as an initial process the main outcome of which is, primarily, an affirmation from the concerned system operators that the particular resources in the particular locations can, in general, be used as flexibility in the intended direction, time and foreseen maximum amount. Secondly, a flag can be issued during the prequalification process, marking if the initially qualified resources must be subjected to the bid qualification process during the market phase. This is similar to the traffic light concept [12], but from a different angle—a green light received in the resource grid prequalification would signal that the resources can always be used for, e.g., congestion management markets, without a need to be subjected to the bid qualification, whereas a yellow light indicates a need for the more elaborate process during the market phase after bid collection.

A feasible general sequence of the resource grid prequalification process is illustrated in Figure 2. It is envisioned that this process should benefit from the utilization of two new entities – a Flexibility Register (FR) and a TSO/DSO coordination platform (or more generally, an SO coordination platform – SOCP).

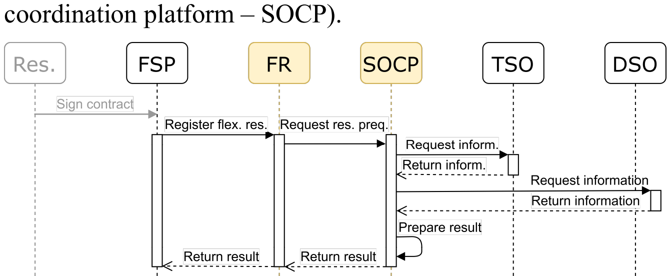

Figure 2. Resource grid prequalification

Coordination between system operators in carrying out the prequalification process is beneficial, firstly, to avoid one system operator potentially causing issues to other operators, and, secondly, to also simplify and streamline the processes from the flexibility provider’s point of view. With more thorough coordination between operators, the prequalification processes should become more efficient also in terms of speed and accuracy.

In regard to the resource grid prequalification (Figure 2), the actual implementation of it can vary based on a number of circumstances. Nevertheless, the most important steps in a common general description are as follows:

1. After an FSP registers new flexibility resources to the Flexibility Register, the FR issues a request for resource grid prequalification to the TSO/DSO coordination platform. This request can utilize information stored in the FR (or fetched from a Datahub if applicable): resource ID, metering point ID, voltage level, locational information, connected SO ID, type of resource (PV generation, CHP, heating load etc.), resource nominal capacity, flexibility direction (load/generation reduction/increase, both), temporal availability, maximum duration, recovery time, maximum downward and upward flexibility, rebound effect characteristics (if applicable: temporal characteristics, maximum rebound, energy recovered, etc.)

2. In the simplest case, the need for exhaustive calculations for each new resource grid prequalification request can be avoided if the SO has already determined in which areas flexibility (in a certain direction) can always be allowed (i.e., akin to conditional grid prequalification wherein the condition is the expected congestion status of the grid area where the flexibility resources are connected in). Thus, the resource grid prequalification result in such cases can be returned after a simple check of the flexibility resource grid location.

3. However, in the cases where the flexibility resource is not located in such a grid area where flexibility (in certain direction) can be accepted without more detailed analysis, it is necessary to carry out an actual assessment of impact on the SOs grids. The methodology of this assessment depends on the information the SOs have shared with the TSO/DSO coordination platform.

For instance, the SOs can with certain periodicity (or whenever notable topology changes occur) send their network data to SOCP. This data can either contain the full information on network topology, line parameters, congestion limits, forecasts from the operators (if the grid model calculations are to be performed within the SOCP) or less information, such as power transfer distribution factor (PTDF) matrices, node capacities etc. The contents of the information exchange between the operators and the coordination platform depend on the division of duties between them, e.g., where the grid models are calculated, what information the individual operators are willing to share etc. Alternatively, the prequalification process can entirely be carried out by an SO itself, in which case the SOCP only serves as a data exchange facilitator.

4. The TSO/DSO coordination platform returns the prequalification result to the party issuing the request (i.e., the FR). In case of successful qualification, the result contains an either yellow or green flag. A green status enables an FSP to avoid being subjected to a bid qualification process later during market phase.

5. The FR stores this result and notifies the concerned FSP.

II. Product Prequalification

Once the FSP has received the resource grid prequalification, it can issue product prequalification (sometimes also called unit prequalification [12]) requests to the markets where it is interested in participating. Conceivably, it can be done directly. However, this can also be delegated to a single interface (e.g., the FR or the SOCP), which would notably simplify the process for the FSPs. The main general steps of the product prequalification process are outlined in Figure 3. It is assumed that the FR serves as an intermediary in the product prequalification process. However, this role could as well be assumed by the SOCP or the two entities could both be involved in the process.

The FSP needs to meet technical requirements set out by the market operator (MO) for a particular product, such as the maximum timespan from sending the activation signal to a full activation, the accuracy of the activation (i.e., the activated amount must be within certain margins from the requested amount) and potentially other parameters depending on the particular service and its related product. The compliance of the flexibility service provider to the technical requirements can be established firstly by comparing the information about the flexibility resources against the product requirements and, secondly, by performing a prequalification test, whereby an activation signal is sent to the flexibility service provider's assets during normal operating conditions.

However, additionally to product technical prequalification for participation in a particular marketplace, the FSP also must have established contractual relations with the MO, including posting collateral, if necessary. These procedures ought to be streamlined from the MO's side to ensure easier FSP access, including but not limited to by minimizing the number of actions necessary to be taken from the FSP's side.

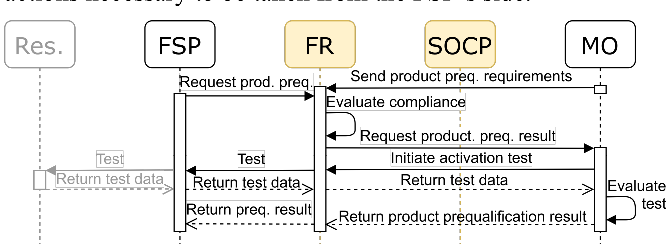

Figure 3. Product prequalification

The general steps of the product prequalification process (Figure 3) are as follows:

1. The MOs define and publish the technical requirements for participation in a particular market for satisfying SO needs (including data exchange requirements, activation procedure, product specifications). These requirements should be available to the FR (or SOCP) for more effective product prequalification, especially if an FSP wishes to prequalify for several markets at once.

2. On the other hand, the FSP requests product prequalification for one or more MO products.

3. The FR (or SOCP) evaluates the available information (also requesting it from a Datahub if necessary). If the available information is sufficient to establish that the FSP cannot provide the particular product, a denied product prequalification can already be issued.

4. Otherwise, a data exchange and activation test may be organized to ensure that in case of need (and favorable market clearing) the flexibility resources can actually be activated, and the relevant data exchanged in sufficient quality.

5. Depending on the outcome of the test, the prequalification results can be issued to the FSP and stored in the Flexibility Register. If the product prequalification process was initialized for participation in several different markets, the returned result should contain prequalification decision for each of them.

It should be noted that if product prequalification for several MOs is carried out by a single interface, it can notably simplify the product prequalification process for FSPs who are willing to participate in multiple distinct markets. In such case, this interface would issue product prequalification requests to each of the markets on behalf of the FSP. Furthermore, depending on the product requirements, it can also strive to minimize the prequalification tests that need to be carried out, when the FSP can be prequalified for several products at once.

The product prequalification tests can be repeated at regular intervals (e.g. at least each five years), when the technical characteristics of the flexibility assets utilized by the FSP notably change or when the technical requirements change. Additionally, if during normal market operation the FSP has failed to correctly deliver the activated volumes either a certain number of times or exceeding a specified margin of error, this can also be grounds to annul the issued product qualification to the FSP and require new tests to regain it.

In terms of flexibility service provision, currently the most untapped potential of flexibility resources lies in small units which require aggregation to access markets. The prequalification test in such cases can conceivably be done in both ways – by testing the aggregated resources as a whole or each individually. The distinction between these two methods can clearly be seen in Figure 4.

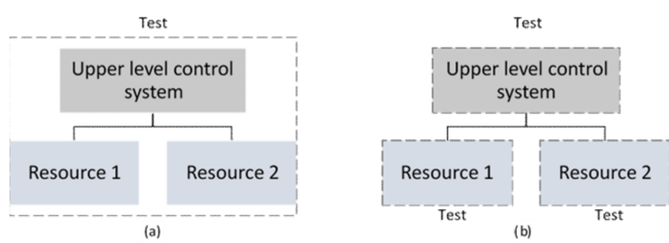

Figure 4. Testing of aggregated Reserve Unit (a) as a whole and (b) testing of individual resources [13]

Testing the aggregated resources as a whole has some clear advantages over testing them individually. Firstly, such an approach ensures the process is less burdensome to the FSP, as a mandatory requirement to test every individual resource could be seen as an entry barrier, especially for FSPs utilizing a large number of small consumers (e.g., on the residential scale). Secondly, the first option is simpler and more streamlined also from the SO point of view. Moreover, it is more realistic in terms of communication testing as it can reveal communication bottlenecks when all resources are activated at once. Ultimately, the SOs intending to procure aggregated flexibility resources should have the discretion to apply a more thorough testing procedure if, for technical reasons, they deem it necessary.

The Guideline on System Operation (SO GL) [14] lays out principles for the prequalification process for specific reserves, namely, FCR (article 155), FFR (Article 159) and RR (Article 162). Additionally, it sets out the minimum technical requirements for each type of reserves. Furthermore, Article 182 more explicitly deals with prequalification for balancing resources connected to the distribution level as summarized in the EU Electricity Network Codes [15]. However, SO GL does not deal with congestion management services, although, similar principles can be envisioned, whereby the system operator who intends to procure flexibility for congestion management defines technical specifications and requirements the flexibility service provider needs to comply with to participate in the congestion management market. The testing procedure to be used also should be devised by the procuring system operator. The role of an MO can conceivably be assumed by the SOs themselves or by third-parties [11].

III. Bid Qualification

Finally, after product prequalification is obtained, the FSP can use its flexibility resources to bid in the markets it is qualified for. A dynamic grid prequalification process is envisioned in this paper to be initiated on the SOCP after bid collection (for any single ancillary services market) for the purposes of increased liquidity and more accurate avoidance of potentially negative effects caused by flexibility activations. The possibility to assess bid impact on the grids dynamically (e.g., before each market clearing) would aid in increasing the overall liquidity by allowing the initial resource grid prequalification criteria to be laxer and thus less flexibility resources being outright rejected.

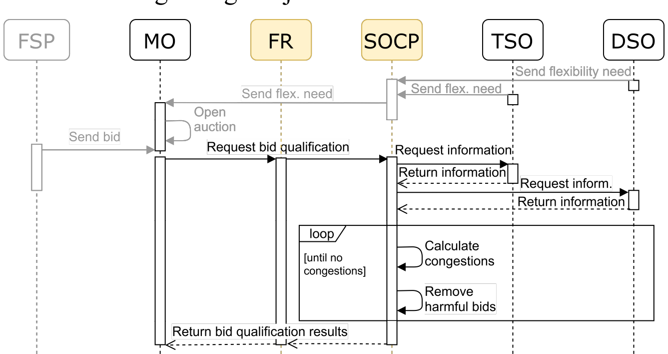

Figure 5. Bid qualification

In Figure 5, the steps regarding the bid qualification are as follows:

1. Prior to initiating bid qualification, the MO of a balancing or congestion management market (or more generally, a flexibility market) collects bids responding to needs issued by SOs.

2. Once the bids are collected, the MO issues a bid qualification request through the FR, which forwards information of the bidding resources to the TSO/DSO coordination platform (not shown in Figure 5 is an option for the FR to request necessary information also from a Datahub). However, bid qualification is not required for those FSPs who have received green status during the resource grid prequalification (where it is already established they would not cause grid issues).

3. The SOCP requests/receives updated network information from the system operators. The full extent of this information depends on the division of duties and relevant data/network model sharing between the coordination platform and the individual SOs. However, compared to the resource grid prequalification in the preparatory phase, in this phase the permissible calculation times might be significantly smaller due to the temporal nature of some of the types of ancillary services markets.

4. The coordination platform aggregates the bids to their respective nodes and an assessment is made on whether activation of all the aggregated bids could cause issues to the grid of the SO where the flexibility resources are located, or to other involved grids. The coordination platform could calculate this with significant precision by estimating the post-activation state of the networks if it has data on the network topology, line parameters, load forecasts etc., however, there are two significant drawbacks to such an approach: (1) it is potentially too time consuming, (2) the SOs might be unwilling to share overly detailed network information.

Alternatively thus, the SOs could calculate the pre-activation operating states in-house prior to the closing of the concerned flexibility markets, do load flow analysis, identify the available capacities in each node, forward available capacity information to the TSO/DSO coordination platform which would then only have to do simple comparisons to find if congestions could be caused by flexibility activations. Moreover, the bid qualification process can also entirely be delegated to an SO if it has suitable technical capabilities for that (e.g., advanced SCADA systems), in which case the SOCP's purpose is to collect, combine and forward the bid qualification results.

Nevertheless, a number of configurations between these two extremes is also possible. For instance, the SOs could share PTDF matrices, initial line flows, node voltages and congestion limits with the TSO/DSO coordination platform, which could then utilize the PTDF matrices to calculate network states in cases when all flexibility bids are activated. This approach does still have the issue of being an approximation (a linear model), but at the same time it is significantly less computationally expensive than full load flow analysis.

Ultimately, the bid qualification process implementation can in either of these cases benefit from the TSO/DSO coordination platform (the processes as depicted in Figure 5 allow for any of these implementations). However, ultimately the separation of the functionalities between SOs and the coordination platform, and the exact methodology for bid impact analysis is a trade-off of the level of confidential information sharing, computational time and accuracy of the prequalification process.

5. Regardless of the approach selected for the congestion analysis, if it concludes with identified congestion issues caused by the flexibility bids, the most harmful (and/or expensive) bid should be removed from the aggregated bid list. At this point, stages 4-5 can be repeated (if necessary), removing bids one-by-one (or in blocks) until the remaining bids no longer cause issues to the grid. If technically feasible and allowed by the FSP and MO, an FSP bid of aggregated resources can be qualified/disqualified also partially.

6. Once the condition for the iterative process to end is met (no more congestions), the prequalification results are sent to the MO, which can disqualify the bids which were denied during the iterative qualification process, and combine the remaining bids into a Merit Order List (or forward them to a party which forms a common MOL) for market clearing.

IV. Implications of the rebound effect

It should also be pointed out that even if the flexibility bids do not cause any negative issues to the grids during the activation time, it is possible that due to the characteristics of the rebound effect of particular resources, congestions in the grids could be expected once the activation time is over. For instance, if load reduction because of flexibility activation for congestion management at one time point causes increased electricity consumption in subsequent time points.

There are generally three solutions to this issue: (1) permitted rebound characteristics could be part of the product specification for congestion management, thereby allowing the SOs to limit participation by resources with excessive rebound effect, however, this approach would harm the overall market liquidity; (2) the rebound effect could also be taken into account during bid qualification during the market phase, thereby disqualifying those bids which at those particular times could cause congestions; (3) alternatively, the rebound effect can be taken into account in the congestion forecast, thereby enabling the affected SO to purchase congestion management services as necessary in the respective time to alleviate the rebound [11].

However, the latter would obviously not be an effective way to conduct congestion management from the SO's point of view. Thereby, the best option seems to be to consider potential issues caused by the rebound effect during the bid qualification process. Either way, this signifies the necessity for the Flexibility Register, as if it were to store information about the flexibility resources, including their rebound characteristics, this would allow for increased market liquidity by not outright disqualifying rebounding assets, instead utilizing this information to evaluate their permissibility on a case by case basis after bid collection.

Conclusions

Prequalification processes have an important role in the functioning of any ancillary services markets. While they are somewhat sufficiently defined for the existing, mature balancing markets, the emerging congestion management markets are more diverse, and no standardized approaches have been developed yet. Moreover, if distributed flexibility resources are to be used, the necessity for adequate prequalification procedures is even more pronounced to avoid SOs inadvertently causing issues to one another.

To avoid it, coordination between SOs is required. In general, coordination is beneficial in all the phases of ancillary services provision, particularly in the market phase, especially if through coordination the needs of several operators could be solved with the same flexibility activation. However, coordination is beneficial also earlier in the preparatory phase.

In terms of prequalification, the processes can be subdivided in three components – resource grid and product prequalification before an FSP can participate in flexibility markets; and bid qualification in the market phase after bid collection. This enables both more liquidity and more opportunities to benefit from SO coordination. However, the actual technical implementation of coordination can vary greatly from very close to nearly symbolic, whereby it is a tradeoff between speed, accuracy and information sharing.

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