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Report

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TSO-DSO-PX Cooperation

Report on the key elements of debate from a workshop of the Future Power Market Platform

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Introduction

Four developments are framing and redefining the role of transmission and distribution networks.

First, the demand for electricity is likely to increase with increasing use of electricity to serve energy demand in transport, industry and heating. Expectations vary, for example a survey of recent studies (excluding industry) suggests a 17% net-increase of electricity demand to serve additional heat and a 10% increase for additional transport demand by 2050.

Second, an increasing share of generation capacity connects to the distribution network (most PV, large shares of wind). At the low capacity factor of wind and solar, this multiplies the generation capacity connected to networks. As furthermore production levels of different wind farms in a region are highly correlated (as is production among solar panels), this increases flow patterns not only on transmission but also on distribution networks (PV is often connected to low, Wind to mid voltage levels).

Third, previously uncorrelated demand patterns from individual households and firms exhibit increasing correlation, including at distribution level, from the charging of electric cars or electric heating. This leads, without other mechanisms, to higher peak demand, peak-to-off-peak ratios and a higher required level of grid capacity for the same amount of energy.

Fourth, demand connected to distribution networks is providing an increasing share of (accessible) flexibility. This flexibility can support network management and balancing at DSO and TSO level. However, both DSOs and TSOs attempt to secure exclusive or priority access to flexibility resources while TSOs are concerned that DSO constraints may preclude their use of distributed flexibility resources.

In some countries, investments in transmission and distribution grid are necessary to address these requirements. However, investments alone (the traditional DSO strategy to invest and forget) would likely be very expensive and difficult to implement.

The workshop therefore focused on regulatory approaches and the market design for a secure and effective use of networks and flexibility options. **What needs to be considered in the market design to coordinate producers, consumers, and flexibility providers, and which aspects of the operational rules governing the cooperation between TSOs and DSOs are relevant?**

So far, congestion at DSO and TSO level remains limited in most European countries. Measured in re-dispatch costs, congestion at TSO level reached no more than 20 Million Euros last year in France, while

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reaching 1 billion Euro in Germany (due to difference in RES levels, grid topology and time-frame of re-dispatch). Nevertheless, it is important to find market design solutions today that are fit for the longer-term needs across the European power market and that provide the incentives to guide investment in infrastructure and design of business models and technologies to serve the evolving needs.

Considerations for market design and future cooperation

Coordination of TSO and DSO request of flexibility

A central challenge is how to allocate the access to flexibility connected to the distribution network, if there are competing interests at the wholesale market, and both the transmission and distribution grid. One example is a longer-term use for congestion management at the DSO level, which precludes the use of these resources for balancing reserves. The current situation is that if a reserve is reserved for a service of one SO (be it DSO or TSO) it cannot be accessed by other SOs and often not even other services by the same SO, thus precluding the effective utilization of resources in the system. Providers of flexibility however want to be able to sell their flexibility to the actor that pays the most in order to maximize its value. Thus, the market design needs to allocate a resource to the purpose and SO where it brings the highest value to the system, while (statistically) fulfilling the reserve requirements for secure system operation.

In many instances, interests of TSO and DSO coincide, e.g. when there is large wind production this may motivate intervention both at DSO and at TSO level. This raises questions like who will mandate wind-spill and incurs costs for compensation or how to avoid parallel (and thus excessive) responses by TSO and DSO.

Locational information on available flexibility

Flexibility Service Companies (FLEXCOs) currently aggregate their flexibility resources at the national level to allocate them to bidding zones. To be of use at times of network constraints at transmission or distribution level, it is necessary to disaggregate this information. For example in France, aggregators inform the TSO about location of the flexibility within the aggregated offer (currently in broad regions defined by the TSO, e.g. Brittany, which is sufficient to resolve congestion), while in California aggregators report behind which connection point (or region) from distribution to the transmission network the flexibility is located. In principle, it is possible to link the locational information to each flexibility bid to ensure balancing actions do not violate grid constraints or flexibility resources can even contribute towards addressing grid constraints.

Providing bids with flexibility resources for specific locations limits the ability of FLEXCOs to pool resources across larger regions within their portfolio to create synthetic products matching today's product definitions of wholesale markets and SOs. It is therefore important that the market functions well and allows for the pooling of resources in the market – both within and across the portfolio of all market participants. This requires the elimination of entry barriers for flexibility resources to the power market and to SO services. They need to be able to offer their full capabilities to these markets. This is possible if the bid format to short-term energy and SO service markets allows energy and flexibility providers to reflect relevant constraints like ramping rates and minimum/maximum operation time. Such capability based bids (also referred to as multi-part bids) avoid the need for pooling within the portfolio

towards synthetic products to sell flexibility on wholesale markets and to SOs. Portfolios retain intrinsic value to reduce transaction costs and for risk-management purposes. A shift towards capability based bid formats at intraday and SO service markets at the same time increases the visibility for SOs on the underlying production and demand patterns, technologies and associated uncertainties and thus enhances security of system operation.

Options to enhance liquidity and reduce local market power

In principle, markets are well suited to create incentives for investment and operation of flexibility resources. They create incentives for the revelation of private information on costs, allow for coordination across multiple actors, and create incentives that align interests of individual actors with the power system.

However, concerns were raised that market-based approaches may be less suitable where only few actors can participate – for example within a smaller part of the distribution network. A set of response strategies exist:

First, integration of different market segments can enhance competition. Joint procurement (or clearing) of system and transmission related services will encourage market participants to price their services competitively to serve system-wide services. If these bids are also infrequently called upon in response to binding grid constraints, then they will (despite local market power at such an instance) be priced at competitive levels.

Second, integration of markets for energy and transmission results in more efficient transmission use and enhances the net-demand elasticity faced by market participants. Market coupling at day-ahead markets has demonstrated these benefits and now needs to be translated to intraday using auction platforms as suggested by ENTSOe.

Third, if competition among existing actors is insufficient, additional competition can be introduced by procuring services in time horizons that allow new actors to invest in new flexibility resources or to pursue grid expansion. Such approaches may however also raise additional concerns, similar to the ones discussed in the later section on “DSO ownership of flexibility resources”.

Explicit measures of market power mitigation

If only few existing assets can contribute towards resolving grid constraints, market design and procurement alone may be insufficient to create a sufficient level of competition. A set of response strategies are then feasible.

First, combining the market based approaches with monitoring of bids or regulating bids to avoid excessive mark-ups or withholding.

Second, simplifying the price formation process with regulatory approaches. Rather than reducing the price at locations with surplus production, the same objective may be implemented with a penalty or rationing of production at times of surplus. Equivalently, demand reduction can be incentivized at times of local constraints, for example with increasing grid connection fees linked to peak demand at times of binding constraints.

Third, inverting the responsibility by granting all parties full access to the grid and mandating the TSO (or DSO) to implement re-dispatch measures to resolve transmission constraints. Remuneration of such re-

dispatch measures has to be oriented at the incurred costs of participants in order to avoid incentives for participants to first contribute to congestion and then benefit from helping to resolve it. While this approach is used with some difficulty for conventional generation and renewable generation assets, it may be significantly more difficult in the context of flexibility options. The variable cost of flexibility options depend on individual preferences, technologies and situations and are thus more difficult to assess with regulatory approaches than the largely fuel related variable costs of generation assets. Furthermore, if flexibility options are only rewarded at variable costs, this does not contribute to incentives for investment towards realizing such potentials.

DSO ownership of flexibility resources

Direct ownership of resources by DSOs is sometimes discussed as a further option to fulfill locational specific flexibility requirements, but for generation and storage assets is precluded in the Clean Energy Package to protect unbundling [3]. Ownership is seen as (one) option to ensure availability of flexibility resources to manage congestion at DSO level. For some grid services, for example reactive power, it is common to procure the power electronics to deliver the service, rather than to procure the service in markets. For the procurement of services, rather than assets, it also needs to be considered that DSOs have lost direct access to markets with unbundling from their generation assets and might therefore have to invest in and maintain the relevant capabilities. Furthermore, the question has not been conclusively answered which services can be procured on markets.

However, ownership of flexibility resources may preclude their use to serve needs at the wholesale level. This implies that additional flexibility resources will be required to serve the system wide needs, increasing total system costs.

Market participants and regulators are also concerned, that ultimately DSO-owned flexibility resources may also serve other market segments [3]. At this point scarcity and price levels in these other markets would drop. DSO ownership of flexibility resources may thus create a regulatory risk for market-based investments in flexibility, generation and storage and thus crowd out other investments.

Perspectives on this choice differ, even within jurisdictions. In California, for example, DSOs own and operate local flexibility resources while in New York the regulation precludes DSOs from doing so.

Centralisation vs Decentralisation

From an economic and engineering perspective, a fully integrated operation of the system would allow for the most efficient use of all resources and would result in the highest level of competition among all actors. However, a fully integrated platform to clear the market for the various energy products and ancillary services while respecting grid constraints across Europe may not be desirable.

First, because the main concern relates to governance as well as aspects of robustness of such an integrated system, for example against cyber-attacks. Second, because this may be computationally too challenging. The computational challenge increases significantly with the representation of distribution networks, because at the distribution level, grid constraints are often caused by reactive power flows. Their representation requires a computationally more challenging non-linear modelling approach (AC representation of network) than the usually applied DC approximation for linear models.

These constraints will be important when determining the future structure for cooperation between TSO-DSO and PX.

- Horizontal decentralization involves cooperation between TSOs or ISOs in different regions rather than a European system operator.
- Vertical decentralization involves local management of distribution systems and interfaces between local and wholesale markets.

More decentralized approaches can contribute to resilience – for example by allowing local or regional systems to operate if necessary independently or when necessary for example because of transformer failure, even in island mode. Local systems and platforms may also be better in engaging with and responding to the needs of local actors – for example at the city level. This does however not imply that local markets, as frequently described, aim to focus on local optimization at the expense of pooling resources at the system level. Instead, we are particularly interested in approaches existing for decentralized schemes and algorithms to solve problems with system wide properties (e.g. bender decomposition).

Concepts for TSO – DSO – PX cooperation

We depict different levels of integration in some prototypical structures for TSO-DSO-PX cooperation. Other approaches of coordination approaches and structuring these approach are presented in a more comprehensive form in [1, Ecofys und Fraunhofer IWES (2017)] and [2, Gerard et. al, 2016].

Full integration – TSO reaching out into DSO networks

In theory, a possible coordination mechanism is for the TSO (or new SO) to run a completely centralized market clearing process, which takes all relevant physical constraints down to the distribution grid into account. This would lead to an efficient market solution, and is in principle possible, however both computationally as well as institutionally and administratively challenging. This is due to the size of the distribution grid topology and the importance of considering further AC characteristics in distribution grids on the computational side, which are usually approximated on the transmission level. Furthermore, keeping control of all bids submitted to a central platform is challenging due to the large number of actors involved. As discussed before this approach is also problematic from a cyber security perspective, as well as from a resilience perspective of the entire system, as it has a single point of failure.

Options for limited integration

Several options exist that offer perspectives of limited integration of decentral resources in the overall system. These, however, fall short of efficiently and dynamically allocating flexibility resources to the highest value purpose. A more comprehensive discussion of these options can be found in [1] and [2].

- Option 1: All flex can offer resources to wholesale level, but the DSO informs the regional platform or power exchange about relevant constraints that need to be considered in clearing. (similar to California approach). Alternatively, the DSO may impose quotas on local market parties, within which they can freely offer their flexibility to the wholesale level [1]
- Option 2: DSO selects priority flexibility options and passes remaining bids to the TSO or wholesale level. This is also called the cascade model [1] or the local market model [2].

- Option 3: DSO clears flexibility options that are passed through to TSO level
- Option 4: Normal single zone energy market platform (e.g. intraday market) with localized information, TSOs and DSOs procure services on that market platform as one of many parties (or by compensating market participants based on bids)

Vertical market coupling

In the vertical market coupling approach, standardized trading platforms provide regional market places, for example at a city level. This allows generation, load, and flexibility to submit bids and offers locally, creating local ownership with the power market, reflected for example in a local web-site depicting supply, demand and clearing prices. The bids will be linked to the location of the assets within the region (e.g. where in DSO network at for DSO relevant regional disaggregation) so that they can participate also in provision of local services.

Building on the flow based market coupling, the local trading platforms are jointly cleared at the national level with an algorithm that also respects transmission constraints. This is done via a decentral, but integrated clearing algorithm, where the larger system wide problem is solved by decomposition into smaller problems, i.e. the local trading platforms, which are checked for consistency with the system-wide problem (e.g. using benders decomposition or similar techniques). This decentral approach may also enable different operation modes to enhance resilience.

This allows both the TSOs to nominate their system requirements at the national and regional level, as well as the DSOs at the local level and results in regional prices and in sub-networks consistent use of demand respond and demand side management.

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