Towards smarter grids: Developing TSO and DSO roles and interactions for the benefit of consumers

1. Introduction

Purpose and objective of paper

This is an ENTSO-E position paper on the interface between transmission system operators (TSOs) and distribution system operators (DSOs). It describes the key issues relating to the interaction of TSOs and DSOs – spanning the domains of markets, system operations, network planning, and data handling – and sets out a series of principles and recommendations which can serve as a basis for discussion between electricity network operators and market participants, regulators, and policymakers at the European level.

Background – why TSO-DSO interface?

Europe's energy landscape is experiencing profound change as increasing amounts of renewable energy sources (RES) displace conventional forms of generation. This development has gone hand-in-hand with an expanding share of power production taking place at the distribution level. Simultaneously, consumers have started to become active participants in the market, either by taking on the role of producer-consumer ('prosumer') or by engaging in Demand Side Response (DSR). These trends are expected to continue and will necessitate a revision of the way TSOs and DSOs interact.

Consumers are at the heart of this paradigm shift. TSOs and DSOs should encourage this paradigm shift by enhancing and reforming the way they interact with each other, and how they define their roles and responsibilities. Consumers should be provided with solutions that enable **choice, affordability and reliability**. In order to fulfil these objectives, network operators need to facilitate consumer access to all markets (energy, system services, balancing, etc.) while maintaining the highest standards of supply security.

It is essential to take advantage of the opportunity to harness the valuable and increasing amount of resources at the distribution level (solar panels, wind power, DSR, storage, etc.) for providing **services for the overall benefit of the power system.** Utilising these resources will enable the increasing penetration of RES, and at a lower cost for consumers (by reducing the need to procure services from conventional generation), and maximise the rewards for consumers.

The operational and planning arrangements between TSOs and DSOs need to be revised and developed further in order to **support a market framework that unlocks the abovementioned potential of consumers**. In doing so, network operators will play their part in meeting growing consumer expectations and help the EU achieve its core energy policy objectives of enhancing security of supply, competitiveness and sustainability.

For such reasons the **TSO-DSO interface has garnered increasing attention from policymakers.** ACER's *European Energy Regulation: A Bridge to 2025*, published in April 2014, explicitly calls for 'improved coordination' between TSOs and DSOs and 'more clearly defining their respective roles and responsibilities'.[1] Also, in early 2015 the European Commission plans to publish a Communication on electricity retail markets which should address coordination and boundaries between DSOs and TSOs.

[1] ACER's *European Energy Regulation: A Bridge to 2025*, section *3.36 Improved coordination*: 'The remit of DSOs is perhaps changing faster than any other single actor in the energy sector. Some networks are beginning to require more active management as significant volumes of small-scale generation connect to distribution grids. The TSO-DSO interface therefore requires careful management, as does the need for efficient information exchange, coordinated congestion management and integrated planning (coordination requirements between TSOs and DSOs introduced, for example, by the Demand Connection Code provide a valuable starting point). NRAs and ACER will work with DSOs and TSOs to assist them in

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2. Summary of key points and guiding principles

- **TSOs and DSOs need to provide consumers access to participate in all markets**. All resources (generation, storage and demand) connected to transmission or distribution grids should be able to participate in energy markets and offer services to the system – especially flexibility services. This will require appropriate market frameworks supported by TSOs and DSOs.
- **Resources should be able to value their potential where it is the most efficient for them** (balancing, system services, valuation in the energy market, congestion management, contracts with DSOs or TSOs as an alternative to grid reinforcement, etc.). Creating exclusive, fragmented markets per DSO and per TSO will jeopardize this ability for resources to maximize their economic potential. Furthermore, enabling the market participation of DSR will require removing **all barriers to aggregation.** This means that consumers should be able to aggregate regardless of their connection points and that exclusive markets limited to a particular DSO area would imply an inefficient limitation of the potential of aggregation of consumers.
- **TSOs should work with DSOs and regulators in determining requirements around observability and active power management of distributed generation (DG) and DSR** due to the increasing impact of distributed resources on the overall operation and planning of the system.
- **The utilisation of system services for system purposes should be overseen by the TSO** and implemented directly by the TSO, through the DSO or through an aggregator.
- As DSOs are in need of more tools for the operation of their grids and as the fragmentation of markets should be avoided, **it is preferable to have a single, unique marketplace both for flexibility and balancing**.
- **A clear and consistent governance framework should be designed by Member States for data management** and fulfil the following standard set of criteria: (i) transparency and a clear definition of access rights, (ii) cost-efficiency, (iii) high standards of data privacy, (iv) and a high level of reliability.
- **Many aspects of TSO-DSO interaction will be addressed by the Network Codes**. The implementation, maintenance and amendment of Network Codes is a priority for TSO-DSO collaboration in the coming years.
- **Policymakers will need to acknowledge the strong element of subsidiarity** in the evolution of roles and responsibilities for TSOs and DSOs. Given that there are 41 TSO members of ENTSO-E connected to over 2400 DSOs, the diversity of national arrangements (e.g. voltage levels, roles and responsibilities, capabilities, interests, etc.) will preclude the development of one-size-fits-all solutions.

3. Market framework

Establishing an appropriate market framework is a prerequisite for ensuring consumers maximise the value of their assets and activity in the power system. This has become more pressing as consumers take on the role of 'prosumer', generation decentralises, the need for DSR and system services grows, and technological evolution drives us towards a smarter grid. While TSOs have traditionally not been visible or active in energy retail markets, they will have a growing stake in their development as end-consumers increasingly engage in

more clearly defining their respective roles and responsibilities so that DSOs may manage their evolving networks in a transparent and reliable way, whilst at the same time supplying system services to TSOs.'

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providing system services (frequency response, reactive power, balancing, etc.) and competing on the wholesale energy market. This development will not only provide new tools to TSOs and DSOs to fulfil their missions, but will have a broader socio-economic benefit for society.

Developing a market for system services will require **well-functioning retail markets** where consumers have the ability to switch suppliers easily, have access to clear information, and can make informed choices. In order to successfully engage consumers in providing system services, administrative processes should be made as simple as possible (e.g. single billing through an independent actor should be promoted). Efficient arrangements for data handling are a prerequisite for this.

The **market framework should define the roles and responsibilities of TSOs and DSOs** and the process between them regarding their use of resources. In particular, it should take into account the following key criteria: (1) resources should be used with the purpose of reaching an economic optimization, (2) competition rules need to be followed, (3) rules are transparent, (4) consumer confidentiality is ensured in the collection and use of consumer data (5) cost allocation is assessed fairly and consistently.

Key recommendations

- **Consistency between wholesale market prices and retail contracts must be increased**. Together with smart meters and other smart appliances and technologies, this will allow suppliers to offer supply contracts that incentivize consumers to reduce their consumption when it is economically profitable. New actors, such as independent aggregators or ESCOs, should also be able to offer dedicated DSR contracts to consumers in order to enable them to fully reveal the potential for providing flexibility services.
- **Moreover, to unlock the full potential of consumers in the electricity markets, all resources (incl. distributed connected ones) should be able to participate in all markets. To that extent, network operators should not create exclusive, local and fragmented market frameworks** because this could lead to a lack of economic optimisation, the absence of a systemic view, and could ultimately jeopardize the efficiency of the European energy market and overall effectiveness of system operation. This means resources should be able to sell their services where it is the most profitable for them (e.g. balancing, system services, valuation in the energy market, congestion management, contracts with DSOs or TSOs as an alternative to grid reinforcement, etc.).
- To enable the market uptake of DSR, **all barriers to aggregation should be removed.** This means that consumers should be able to aggregate regardless of their connection points and that exclusive markets per DSO area would reduce the potential of aggregation of consumers.
- As DSOs are in need of more tools (e.g. contracting flexible resources) for the operation of their grids and the fragmentation of markets should be avoided, **a single marketplace for flexibility and balancing will be required**. TSOs should develop in cooperation with the DSOs, regulators, and market players an appropriate market framework with a **unique set of market rules to allow both TSOs and DSOs to efficiently procure flexible resources** in a way that supports prosumers' active participation in wholesale markets and system services at the TSO level. This would allow DSOs *inter alia* to procure the flexible resources connected to their grids to manage local congestion and provide voltage control.
- As per rules applied to TSOs, **DSOs cannot be on both sides of the market as both market facilitator and service provider**. If they are demanding or buying a system service, this service cannot be provided by them as well.
- **The balancing market needs to evolve** in order to take into account: (1) the balancing of the positions of market players, (2) solving operational constraints of TSOs and (3) being able to deal with operational constraints of DSOs (which for example prevent the next resource on the TSO's

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balancing merit order to be utilized, forcing the TSO to get the required response from a different resource in a different DSO's grid).

4. Operational interaction

Given the primacy of the consumer in the energy system of the future, operational arrangements need to be optimised to support the necessary market framework while maximising cost-efficiency and supply security.

As an increasing share of generation connects to DSO grids (in particular, the majority of RES is connected at low and medium voltage levels), one of the central operational challenges for TSOs is maintaining overall system security. As decentralised, non-synchronous forms of power production displace conventional forms of generation, TSOs have been left with a shrinking pool of units available to provide system services (e.g. thermal generation providing frequency response, voltage control and inertia). The growing **scarcity of system services** will become more acute in the future and necessitates new operational arrangements between TSOs and DSOs to unlock the capabilities of DG and DSR to plug the shortfall in these services.

Moreover, **TSOs have overall responsibility for system security while DSOs have responsibility for the secure operation of their distribution networks**. This means TSOs will need to continue to have the leading responsibility for balancing, frequency control and system restoration, whereas DSOs will maintain their responsibility for managing their networks, with an increasing emphasis on distribution congestion and voltage management. Defining the allocation of roles and responsibilities (not just of network operators, but also of new market participants such as aggregators) is a priority area for developing the TSO-DSO interface. This is partly already covered in the Network Codes but requires completion through the concepts described in this paper.

This is particularly important given the **growing need for observability of DG and DSR connected to the distribution network** and the deployment of emerging technologies such as electrical vehicles and storage. Improved observability will not only help network operators maintain security of supply, but will lessen demand forecast errors and limit increases in reserve margins driven by growing uncertainty. This in turn **benefits consumers by increasing the overall cost-efficiency of the system.**

In addition to observability, active power management of DG and DSR is becoming increasingly important for solving congestions in both transmission and distribution grids, for maintaining frequency balance and for managing overall system security. Given its cross-network impacts, the active power management actions of TSOs and DSOs will need to be highly coordinated to avoid jeopardising the security of the distribution and transmission networks.

Key recommendations

- **TSOs should define their needs regarding the requirements around observability for DG and DSR** given the growing impact of DG and DSR on the transmission system and on TSOs' core mission of balancing the system. **DSOs should also define their needs in terms of observability in order to be able to fulfil their missions.** The Network Code framework establishes the basis for achieving this goal. TSO-DSO cooperation is thus needed to ensure the appropriate and timely implementation of these requirements.

- **All active power management actions with an impact on system balancing and/or the transmission system should be overseen by the TSO and implemented either directly by the TSO, through the DSO or aggregator.** Due to the mutual impact of active power management actions, TSOs and DSOs need clear roles and responsibilities in this area – this will provide **consistency for markets**. Any active power management actions taken by the TSO on distribution

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connected resources should be done without prejudice to the DSO's responsibilities to maintain distribution network safety and security. In particular:

- TSOs and DSOs should coordinate in **solving congestions** at the operation planning stage and before real time, and share upfront information about foreseen congestions. National real time operating procedures should be developed to achieve timely and efficient congestion management solutions and system balancing actions.

- TSOs and DSOs should cooperate on the **definition of controllability procedures** on DG and DSR resources and especially to find the solution to allow TSOs to curtail DG or activate DSR, wherever its connection point, in alert and emergency system states. This will require working together to detect when, and in which, active power management situations coordination is needed and what level of coordination is required, identifying which TSO-DSO actions have a mutual impact. For example, this could include *inter alia* defining an efficient operational procedure when: (i) both networks are affected by congestions (i.e. who acts first, who pays, etc.), (ii) TSO balancing actions have an impact on DSOs, and (iii) DSO congestion management actions have the potential to affect the TSO network.

- **TSOs and DSOs should work together to realise the efficient and non-discriminatory utilisation of the capabilities of distribution connected generators and demand resources (wherever its connection point) to provide system services (e.g. voltage, frequency, inertia, etc.).** As a first goal, relevant responsibilities for each system service should be stated. In particular:

  - **TSOs should identify the requirements for system services (especially for frequency control or system restoration) and how these might be delivered by distribution connected service providers.** These requirements should be discussed with the DSOs and implementation issues considered. 'System' and 'local' requirements for services should be balanced taking into account overall system security requirements and efficiencies. Pilot projects should be developed to test the implementation (e.g. co-ordinated voltage control from distribution connected RES to maintain the voltage level at DSO level or if needed to support transmission voltages and frequency response from RES according to TSO requirements).

  - Examples of existing or planned system service schemes that utilise distribution connected resources should be shared between the TSOs and DSOs.

  - TSOs and DSOs should address the issue of legacy distribution standards for generator performance capabilities and distribution protection standards which may restrict the ability of the system to securely accommodate additional DG and DSR. TSOs and DSOs should ensure that protection and regulation settings are coordinated accordingly with Network Codes (e.g. the Network Code on Requirements for Generators) and respect system security principles.

- **In implementing the above-mentioned recommendations TSOs and DSOs should develop system operation agreements[2] to formally set out and agree roles and responsibilities in areas of operational interaction including DG and DSR**. Areas that should be covered include observability and control arrangements, data management and exchange, outage planning, protection/operational settings, performance/compliance management and emergency actions. General principles on operational agreements should be discussed within ENTSO-E to exchange on best practices on TSO-DSO interaction, and possibly facilitate the harmonization of these

[2] Operational agreements would build on the provisions of the Network Codes

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arrangements (using examples such as the TSO-TSO Framework Agreement for HVDC links as a model).

5. Planning interaction

As with operational interaction, network planning processes between TSOs and DSOs need to be optimised and developed in a way that supports a consumer centric market model. This will require **integrated planning approaches** that recognize the growing interdependence of the transmission and distribution networks. Taking account of the **growing potential of 'prosumers' to provide system services, this should be incorporated into the planning stage** (e.g. currently the system may not be planned in a way that enables wind farms connected to the distribution grid to provide wider system services) – providing only a connection is not enough[3]. In this sense, network planning should be based on achieving the widest possible net benefit that takes into account regional and European system needs.

Moreover, regional and local specificities, particularly given the varying physical, commercial and regulatory arrangements at the interface between transmission and distribution across Europe, requires consistency in the planning approach. In particular, DSOs possess considerable knowledge on local and regional trends in demand and generation – harnessing this knowledge into an integrated planning approach is crucial.

Such an approach to planning will necessitate TSOs and DSOs sharing and exchanging information regularly to promote the efficient development of the overall system. Equally important in this respect is ensuring **extensive stakeholder involvement**. TSOs and DSOs will need to work together to ensure that meaningful stakeholder engagement is embedded in their planning processes.

Key recommendations

- **Information exchange between TSOs and DSOs for the purposes of network planning should be based on a structured approach.** This could include regular, formal information exchange of structural data and regular liaison meetings, and sharing information with time horizons that are relevant for the investment decisions in the grid. Examples of structural data include demand forecasts, generation forecasts, dynamic data models, and single line diagrams of planned network conditions pursuant to the requirements in the NCs and other applicable regulations of this type. Meanwhile, informal dialogue can take place in parallel. This can keep up with the pace of change in a way that formal processes would not be able to and could include:
    - discussions on the potential to undertake joint assessments to find the most effective and efficient network solution;
    - exchange of information related to active and reactive power management capability such as DSR, active network management or demand transfers;
    - getting the most out of the available information by sharing forecasts, exchanging models and data, and monitoring performance;
    - management of uncertainties ideally using consistently defined scenarios or sensitivity based approaches;
    - the joint development of further formalised information exchange as it becomes necessary.

[3] A connection that allows steady state active power production or consumption is not always suitable for the provision of more dynamic active power services or reactive power services given the technical characteristic of distribution networks.

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- **The assessment of connection capacity for generation should be coordinated among TSOs and DSOs** in order to contribute to an effective, secure and efficient deployment of generation – particularly RES.

6. Data handling

Establishing the necessary market framework with the concomitant operational and planning arrangements will require a new approach to data handling. More data will not only become available through the entry of new market participants (such as ESCOs or independent aggregators), but will be needed for the enhanced requirements around observability and putting in place the market framework that supports consumer engagement (e.g. enabling consumers to have a single point of contact, facilitating the role of aggregators in harnessing distributed DSR, etc.). Processing the data will be time-critical, especially where balancing or system services rely on DG or DSR responses to control signals. Above all else, **data will need to be managed in an efficient and transparent way, while respecting competition laws, confidentiality laws and the privacy of consumers**.

Defining future data handling procedures is a key challenge facing network operators and market participants and is often cited by regulators and policymakers as the central issue in both revising the TSO-DSO interface and enabling active consumer participation in the energy market. The organisation of, and timely access to, metering and settlement data which will be made available by smart meters is essential for facilitating the uptake of DSR and enabling consumers to take on the role of 'prosumer' in a competitive market setting.

Not only can data be used for different purposes (operation, modelling, short and long term planning, imbalance settlement, etc.) it can be provided for by different stakeholders (TSOs, DSOs, suppliers, aggregators, etc). The question of data handling should be considered from two different perspectives.

From a network operator point of view, TSOs and DSOs should define their needs and anticipate their future needs in terms of exchange of information for the secure operation of the system (for both network planning purposes and real-time operations). Meanwhile developments in the distribution networks have led to **new requirements for operational data which can be difficult or costly to obtain** (e.g. real time information on small-scale RES levels, and DG/DSR observability is not a reality for all TSOs and DSOs). The **Network Codes establish the basic framework of the required data for operating the system**, and jointly TSO-DSO involvement is needed to achieve this goal. However, TSOs and DSOs need to determine what information they require, the quality of the information, who owns it, and how to ensure both confidentiality and transparency.

Given the increased participation of DG and DSR in the markets and that TSOs have a key role in the organization of markets, through managing the imbalance settlements of market players, TSOs will need to acquire data from DSOs and other market participants at the distribution level. Hence, TSOs should also define their data needs to fulfil their tasks on the market.

Data access should also be a tool to allow consumers to be more active in the market (e.g. switch easily between suppliers, have a view of their contracts with their supplier and their aggregator, etc.). Therefore, the management of data for consumers should be considered a public service and the organization of such a service should be defined at Member States' level.

Key recommendations

- The exchange of operational data between TSOs and DSOs has been described in the Operational Security, and Operational Planning and Scheduling Network Codes. Hence, **ENTSO-E is reaffirming the role of the operational codes** and the need both for TSOs and DSOs to comply with their provisions.

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- To that extent, any standardization process concerning data exchange initiated at the EU level should bear in mind that Network Codes will be adopted and hence should not be contradictory to their provisions. **The use of existing standards for data exchange (such as the CIM format) should be preferred.**
- Given TSOs' key role in the organization of markets through the management of imbalance settlements of market players, **TSOs will need to define their data needs in order to fulfil their tasks on the market.**
- **A clear and consistent governance framework should be designed by Member States for data management** and fulfil the following standard set of criteria: (i) transparency and a clear definition of access rights, (ii) cost-efficiency, (iii) high standards of data privacy, (iv) and a high level of reliability.
- **One example of such a governance framework that has been implemented in some countries is a data hub**. Data hubs can be managed by the TSO, DSO, a third party, or be jointly managed by the TSO and DSO.
- To reduce the transaction cost and increase simplicity for customers and market participants, a **central data hub per TSO control area should be considered as preferable**. Because of the high value from the participation of DSR and distributed generation in the TSO's balancing and system services markets, this option can carry significant advantages for society and for consumers.

Notwithstanding the recommendations by the EU authorities, the interaction between the TSOs and DSOs needs to be in line with the applicable EU and national legislative framework. In particular, any interaction needs to be conducted in accordance with the obligations under competition law, the legislation regarding critical infrastructure defined with the Directive 2008/114/EC as well as other public security related rules and the obligations to preserve confidentiality of private and commercially sensitive information, inter alia in the unbundling context.

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