FUTURE CHALLENGES FOR DISTRIBUTION SYSTEM OPERATORS

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Abstract

The Distribution System Operators, as the central hub between generation and consumption, play a key role in the energy transition. The new European regulatory framework and the implementation of new market players (e.g. flexibilities) result in major changes especially within DSOs grid operation. In this paper, the ongoing developments in DSO's grid operation from an Austrian point of view are highlighted.

1 Introduction

The energy transition is taking place at an ever-increasing speed. On the one hand, centralized and mainly conventional power stations are being shut down and on the other hand, the number of decentralized, renewable and therefore volatile generation units is growing rapidly. Due to this increasing number of distributed generation units, electrical grids are reaching and exceeding their technical limits. With the transfer of generation capacity from the transmission into the distribution system the delivery of ancillary services and therefore the interaction between Distributions System Operators (DSOs), Transmission System Operators (TSOs) and Significant Grid Users (SGUs) is getting more and more important. This transformation will have fundamental and extensive consequences for the entire energy system and especially for the grid operation of the DSOs.

The Austrian energy and climate strategy, summarized in the document *#mission2030* [1], was published by the Austrian federal government in 2018. In this document a future energy system is described that should be safe, sustainable, innovative and competitive at the same time. Based on the analyses in the *#mission2030-Impact-Study* [2] the estimation amounts to 12 GW of installed photovoltaic capacity by 2030, especially in the low- and medium-voltage grids, and approximately 9 GW of connected wind power capacity in the 110-kV distribution grids.

2 Regulatory framework

In the last couple of years, several European network codes and supporting documents were established to facilitate the harmonisation, integration and efficiency of the European electricity market. Each network code is an integral part of the drive towards completion of the internal energy market, and achieving the European Union's energy objectives. Figure 1 gives an overview of these codes.

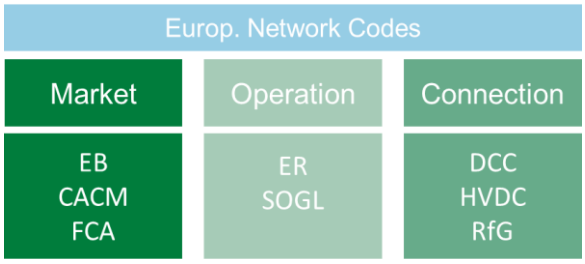

Figure 1: European Network Codes [3]

EB	Electricity Balancing
CACM	Capacity Allocation & Congestion Management
FCA	Forward Capacity Allocation
ER	Emergency and Restoration
SOGL	System Operation Guideline
DCC	Demand Connection Code
HVDC	High Voltage Direct Current Connections
RfG	Requirements for Generators

Further European specifications, with a significant impact on the prospective grid operation, are summarized in the following documents:

GLDPM: All TSOs' proposal for a **G**eneration and **L**oad **D**ata **P**rovision **M**ethodology in accordance with Article 17 of Commission Regulation (EU) 2016/1719 of 26 September 2016 establishing a guideline on forward capacity allocation

CGMM: All TSOs' proposal for a **C**ommon **G**rid **M**odel **M**ethodology in accordance with Article 17 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management

KORRR: All TSOs' proposal for the **K**ey **O**rganisational **R**equirements, **R**oles and **R**esponsibilities relating to Data Exchange in accordance with Article 40(6) of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a Guideline on Transmission System Operation

The network codes as well as the approved TSOs' proposals define minimum standards for all EU member states with a focus on the transmission level. The number and scope of these documents, the overlap in the individual requirements and the possibility of national design make implementation in the individual member states more difficult. However, the increasing importance of distribution grids has hardly found its way into these European documents and a number of other documents can be expected. In the meantime, necessary clarifications need to be addressed in national specifications.

3 Changes in Grid Operation

Throughout Europe, grid operators are already facing the challenges of the paradigm shift in energy supply. The classic infeed and control structure of the generating plants is fundamentally changing with far-reaching consequences for the overall system. In Austria, a large proportion of the total generation capacity is already connected to the distribution grids. Therefore, the following considerations are based on a development that is already in full swing.

The provision of the ancillary services by the grid operators is of essential importance for system security and stability. Due to the ongoing changes, the high standards for the ancillary services can only be maintained by an intensified effort and cooperation between the TSOs and DSOs. The ancillary services can be divided into system services (frequency control) and grid services (voltage control, grid operation, grid restoration).

The TSOs are responsible for the system services "frequency control". Due to the increasing amount of decentralized energy resources, the generation units at DSO-level will have to make a much stronger contribution to this ancillary service in the future.

Therefore, the effort for the TSO will increase significantly in order to maintain the necessary overview and system security for its central task of frequency control. The decentralized generation, mainly through photovoltaic and wind in various voltage levels, is becoming increasingly important. "Aggregators" organize the generated energy at these voltage levels and enter the market. In particular, they will also participate in the balancing energy market with aggregated flexibilities. For the TSO, this results in an increasing need for information for the assignment of control tasks and therefore demands new rules concerning the interaction with the DSOs, where the vast amount of generation infeed is connected.

Regarding the grid services "voltage control" and "grid operation", each TSO and DSO is responsible in its own grid area. Coordinated measures between TSO and DSO, especially of voltage control and grid management, can contribute to an optimization of grid operation. The ancillary service "grid restoration" is a joint effort, whereby the TSO is responsible for the overall concept for grid restoration.

For the DSO, the great challenge is to maintain a secure grid operation despite the rapidly growing number of highly volatile prosumers, but also consumers, which repeatedly push the grids to their technical limits. In the event of a revision, congestion management is already being used at an increased level.

To meet these challenges, DSOs are relying on the digitalization of medium-voltage as well as low-voltage networks to observe and possibly even to control the connected generators and loads. This will enable continuity across all voltage levels and grid customers, e.g. to be able to use flexibility options efficiently. To achieve this grid observability, DSOs are continuously deploying sensors at different voltage levels and even investigating using information from Smart Meter devices [4].

This digitalisation will increase the capability to interact with the demand of the TSO and market platforms as well as to integrate flexibility in the system. On the other hand, it increases the complexity of network operation substantially.

Currently, in Austria redispatch interventions are mainly available to transmission system operators to remove bottlenecks in their grids. Due to the planned opening of the redispatch market, new rules will be necessary to avoid grid-critical situations in the distribution grids, through redispatch and flexibility measures. Furthermore, new system applications for the determination of free grid capacities in the distribution grids, based on generation and load flow forecasts, have to be implemented.

Therefore, the future flexibility of the electricity system will require long-, medium- and short-term forecast models to ensure the necessary generation capacities for load coverage. Increasing complexity in the forecast models and processes is expected due to market-oriented generation and load behaviour as well as the possibility of redispatch and control power interventions.

With these preconditions, an intensive cooperation between transmission and distribution system operators with clearly defined responsibilities and structured tasks for mastering the system complexity is a key element to maintain a secure and stable grid operation in the future. The flexibilization of the system will require high demands on grid operators in terms of operational planning and forecasting. Furthermore, the development of market mechanism, standardized processes and a common platform supporting the role of the DSO as a hub between producers, aggregators and customers will be necessary.

4 The Distribution Grid: the Hub between Generation and Consumption

The intended opening of the redispatch and balancing energy markets to smaller units as well as the use of redispatch measures to remove bottlenecks in distribution grids will decisively change the load and generation behaviour of these new market participants. Therefore, new generation of distribution management tools are required in order to incorporate flexibility and resilience in network operation and planning tools. DSOs will need to improve their short-term operation planning, being able to effectively control its grid assets and at the same time mobilize new flexibility services for grid support to finally enable a more efficient and effective grid operation for its own grid as well as demands from the TSO.

To support these arising changes and simultaneously guarantee the security of supply, DSOs have to address the following topics:

- Increase in the degree of digitalization and observability in the medium- and especially low-voltage level
- Further development of a load- and generation-, and consequently, a load-flow-forecast model, at least at the “day-ahead”-level for grid security analyses
- Development and improvement of SCADA-applications, e.g. for grid security analysis or congestion management
- Extension of the data exchange between DSO, TSO and SGUs
- Development of regulations for TSO-indicated redispatch/congestion management in distribution grids depending on the available grid capacity
- Establishment of new rules between DSOs und TSOs based on the cascade principle
- Ensuring and checking the short-circuit power required for the correct function of protection relays

The future challenges and the concrete measures for DSO’s are summarized in Figure 2. To handle these new tasks operationally, DSOs have to build-up specialised personnel for a 24/7 operational planning in their grid control centers.

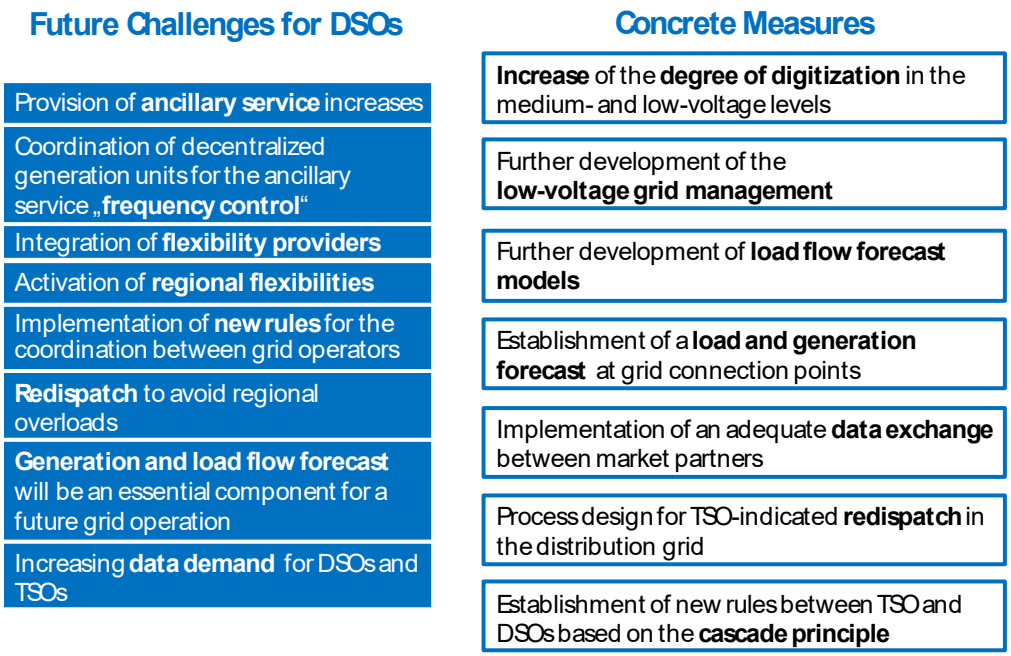

Figure 2: Future challenges and concrete measures for DSOs

5 Data Exchange

The pre-condition for new processes and the cooperation with new markets is an intensive knowledge of the own grid with its connected generation and consumption. Additionally, an extended data exchange with other grid operators, which are connected upstream and downstream to the own grid, is required.

The data exchange with other grid operators as well as service providers has to be clearly defined, task-oriented, fast, secure and efficient and is of essential importance. Figure 3 visualizes the data exchange between DSO and TSO including data from SGUs and grid partners. This exchange contains basic/static data, online-data, schedules, unavailabilities and load/generation forecasts. Furthermore, TSO and DSO can exchange their results of their grid security analysis.

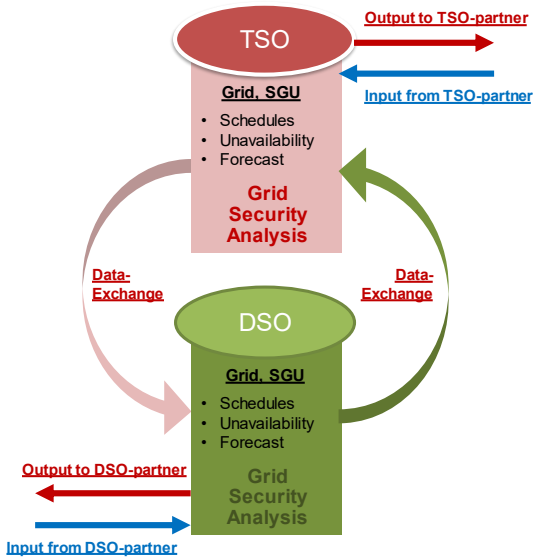

Figure 3: Data exchange between DSO-TSO-SGUs

To establish this extended data exchange three steps have to be taken. Step one is the definition of the required data, including the degree of aggregation for each partner. Step two is the definition of the associated processes and step three is the implementation of secure data highways and new applications to exchange, store and process these data.

6 Grid management based on the cascade principle

The main objective for each grid operator is the security of supply as well as the stability of its system, at TSO-level as well as DSO-level. Therefore, grid operators are responsible for all customers and generation units connected to their own grid. If this secure grid operation is endangered, the responsible grid operator must take all measures available to maintain a stable grid operation. This can be achieved with

- grid-related measures (e.g. topology measures)
- market-related measures (e.g. congestion management)
- emergency measures (e.g. load-shedding)

Primarily, these measures should be taken in the own area of responsibility without or with minor impacts for the grid operation of other areas. If necessary, measures can be requested from other grid areas – upstream or downstream – as part of an operational cascade. This demand has to be forwarded to the responsible grid partners, who evaluate the demand in their security analysis.

Direct state-changing access by third parties of generation units, e.g. for frequency containment or frequency restoration reserve is therefore only permitted in close coordination with the responsible grid operator. A poor coordination can lead to severe problems in the affected grid area.

With this cascade, prospective problems in the own grid area, such as bottlenecks and critical grid situations, are solved in cooperation with other grid operators. However, it is important that each grid operator is initially responsible for the stability and security in his own grid. Based on the load and flexibility forecasts of the DSO, the provision of ancillary services, especially for the transmission grid, can be evaluated and activated.

The safe and reliable functioning of this cascade is the basic requirement for maintaining reliable and secure grid operation in the future. Due to the ongoing changes as well as the implementation of new market players new rules between grid operators and market partners are required.

7 Conclusion

The transfer of generation capacity from the transmission into the distribution system and the implementation of new market players will especially change the grid operation of the DSOs. The increased mutual dependency between DSOs and the TSO subsequently leads to a higher data exchange in order to be able to guarantee stable grid operation at all voltage levels. In the future, this coordination process - based on a cascade principle - will be crucial for a safe and reliable grid operation.

To fulfil these demands, in the next years DSOs will further increase the degree of digitalization and observability in the medium- and low-voltage level, extend their load-flow-forecast models and grid security calculation, install new SCADA-applications and establish new rules based on the cascade principle. These new tasks will require additional financial and especially human resources for operational planning on a 24/7 schedule.

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