GRID OPERATION 2025
DIGITALISATION FOR DISTRIBUTION SYSTEM OPERATORS

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ABSTRACT

In the next decade, the requirements for grid operation will become more and more demanding. The challenges will be multifaceted: a further increase in decentralized infeeds, a constantly changing direction of the load flow, the installation of various smart grid applications and new market players for ancillary services even at lower voltage levels. To face this new demands, grid operators have to take prescient measures and appropriate efforts already at an early stage. One solution is the digitalisation of existing processes, the development of new applications and the installation of interfaces between the various grid operation tools. Therefore, this paper introduces a guideline for digitalisation trends for distribution system operators with a main focus on the security of supply, a fast and efficient fault localization and restoration, new solutions for customer interaction and an emergency management.

INTRODUCTION

In 2017, the Austrian association of electricity companies, “Oesterreichs Energie”, established a working group containing representatives of ten DSO’s, to summarize the prospects regarding the digitalisation in grid operation. The results were compiled in a guideline, which was published in 2018 [1] with a clear focus on the operation of distribution grids considering the expected developments in the coming years. In this guideline already existing and in the near future expected interfaces and system interdependencies are shown. Among other things, the document should serve as a basis for decisions, especially for basic conditions of requirements in terms of ICT-safety and protection technologies. Furthermore, the growing information demand of the customers is addressed and innovation solutions are presented. The document is divided into the following six chapters, which will be presented in this paper:

1. DSO-TSO Interface
2. Digitalisation of the medium-voltage grid operation
3. Digitalisation of the low-voltage grid operation
4. Digitalisation of customer interaction
5. Digital Workforce-Management
6. Emergency management for grid operation

DSO-TSO INTERFACE

The first chapter deals with the interaction between distribution and transmission system operators. With the increasing share of distributed generation, an optimized process coordination as well as an intensified information exchange is essential. Therefore, a clear demarcation of responsibilities and ideas for new process interactions, especially regarding the ancillary services, are presented.

Frequency Control	Voltage Control
Primary control reserve Secondary control reserve Minute reserve supply Automatic power reduction of DRES Interruptible loads Automatic load shedding	Reactive power control Transformer stepping Control of DRES Operation of compensation units Provision of short-circuit capacity
Grid Operation	**Grid Restoration**
Feed-in management Redispatch / congestion management Operational planning / disconnection planning Reserve power plants Use of storage-units Data exchange	Automation and resupply concepts Grid restoration strategies Black-start capability Islanding operation capability Synchronisation concepts

Figure 1: Ancillary services

The ancillary services, as seen in Figure 1, can be divided into system services (frequency control) and grid services (voltage control, grid operation, grid restoration). Frequency control is guaranteed by the control area manager of the individual interconnected control areas and therefore by the TSO. For this purpose, more and more power plants, even at distribution level, are used for the ancillary service frequency control. A possible solution for the online data exchange between TSO and DSOs can be seen in Figure 2. Automatic load adjustments are used as a last stage for frequency regulation and is mainly executed in the distribution grid.

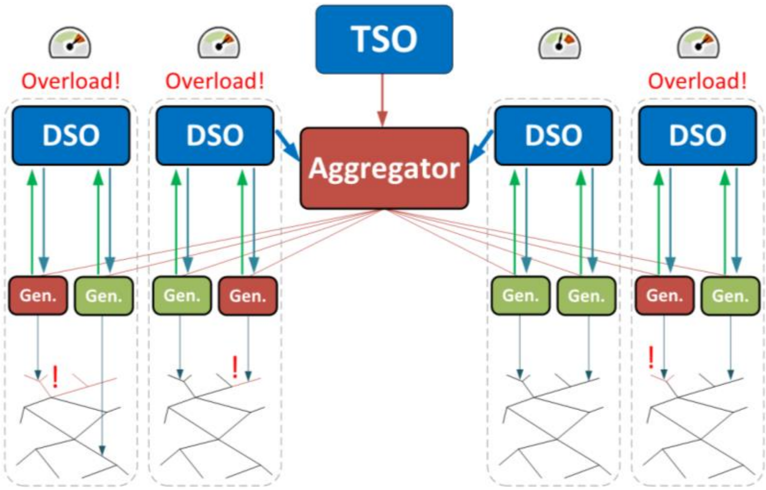

Figure 2: Data exchange between actors [1]

On the other hand, each grid operator - TSO and DSO - is responsible for the grid service voltage control, grid operation and grid restoration in its own grid area, whereby the responsibility for the overall concept for grid restoration lies with the TSO. In Austria, a detailed concept for grid restoration, defining all responsibilities and obligations, is summarized in the new *Austrian Grid Restoration Plan* [5].

The changed framework conditions in grid operation due to the energy turnaround are leading to intensified interdependencies between all actors in the energy sector (DSO and TSO, producers, consumers, prosumers, aggregators and the stock exchange). This increased dependency subsequently leads to an increased, necessarily secure exchange of information in order to be able to ensure a stable grid operation in the future.

Therefore, an even closer cooperation between TSO and DSO is required to guarantee the security of supply, especially regarding the accurate forecasts for operational planning and secure network operation. The extent of the data exchange between the system operators is defined in the *System Operation Guideline* [4]. The data exchange contains online data (switching status and measure values), load and generation forecasts, revision and outage planning, and static system data (transformer data, line and cable data, etc.).

DIGITALISATION OF THE MEDIUM-VOLTAGE GRID OPERATION

In this chapter, the requirements and expectations regarding the digitalisation of the medium voltage level, using particularly central functionalities to further increase the security of supply, are summarized.

In order to be able to make full use of digitalisation for an efficient grid management, the first step is the complete mapping of the medium-voltage grid. This mapping can either take place in the SCADA environment or in other systems such as GIS with interfaces to the leading grid operation system. In addition to the static data, the grid map must also contain dynamic data such as switching states and the load flow situation. The actual switching state could either be tele-transmitted or manual updated for manually operated switching elements. To achieve an overview concerning all voltage levels, these data should be available for higher-level optimization functionalities.

As the medium-voltage grid continues to be equipped with sensors and actuators, the number of available information from the grid is increasing continuously. To handle this ever-growing data stream and to support the grid operator, especially during emergency situations, an intelligent alarm and messaging concept is required.

This can be achieved using an expert system with adaptive filter functionalities. A simple chronological visualization of alarm messages, which is mainly used today, will not fulfil these requirements. An approach would be the implementation of a topological filter functionality combined with an alarm prioritization. In this case, all incoming alarms, messages and even measured values will be prioritised depending to the grid status and automatically analysed according to their topologic dependencies. Due to the regular changing of switching states at this voltage level, new algorithms need to be developed.

Furtheron, applications regarding load flow and security calculations for online as well as for testing planned switching operations including the load and generation forecast, protection issues, detection of islanding, active and reactive power management and the integration of phasor measurement units [6] are addressed. Another support functionality could be the automatic detection of irregularities, e.g. in the protection chain after a fault clearance, or the precise indication of fault locations, e.g. by integrating lightning data into SCADA [7].

DIGITALISATION OF THE LOW-VOLTAGE GRID OPERATION

In particular at the low-voltage level, the chances in the energy system are significant: the integration of a large number of decentralized generators, the installation of decentralized micro grids and the growing number of e-charging stations and decentralized energy storage systems. These developments result in new challenges but also new opportunities for distribution grid operators, which are addressed in this chapter.

The usual grid operation of low-voltage grids is nowadays decentralized, with a very low degree of automation and without any online measurements and update of the load flow or switching status. This kind of grid management will not be sufficient for the oncoming changes in the grid management. The future trends for the low-voltage grid operation can be seen in Figure 3.

For the low-voltage grid, the content of this figure is similar as for the medium-voltage operation approximately 15 to 20 years ago. At that time, a digital grid management of the medium-voltage grid with the visualization of all stations, lines, loads, etc. was not existent. The amount of data to map the low voltage grid is at least 10 to 20 times higher compared to the medium voltage level. Therefore, the visualization of the low-voltage grid will become a major challenge.

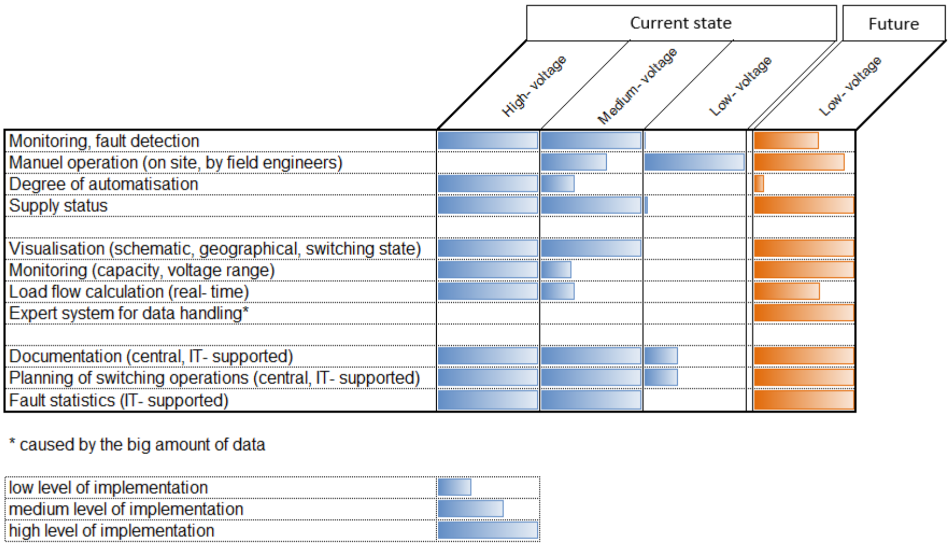

Figure 3: Status quo and future trends for grid operation

A low-voltage grid operation should fulfil the following criteria:

- Display of grid-relevant equipment such as transformers, tap changing position, low-voltage feeders, transformer and feeder fuses, overhead lines, cables, switching options in the grid, loads, generators and storage devices
- Possibility to manually update switches or control tele-controlled switches
- Processing of alarm messages
- Representation of asymmetries, especially with three-phase visualization
- Topological and functional network colouring
- Visualisation of unsupplied customers, e.g. based on smart meter information

Smart meters can not only be used as measuring devices, but also as an additional source of information about the grid condition at the low voltage level [2]. Due to the great amount of data and the complexity for monitoring and information processing, incoming data from smart meters are normally processed in a separate application like the meter data management system. Therefore, in the guideline use cases for implementing smart meter data into the low voltage grid operation are defined.

DIGITALISATION OF THE CUSTOMER INTERACTION

In chapter 4, solutions to improve the interaction between the grid operator and different types of consumers (industry, households, authorities and internal customers) are presented. Furthermore, the trends in the communications technologies as well as the advantages and disadvantages of mobile websites versus mobile apps are described.

In general, there are a few key aspects which cause a high customer satisfaction, such as:

- 24/7 online self-service
- reliable and efficient handling of specific customer requests
- substantial, quick and transparent communication with customers

Austrian grid operators are obligated to notify customers about planned outages and their duration at least five days before execution. In addition to the common channels like letter or E-Mail and to provide a holistic service for customers, the possibilities using communication via modern applications, e.g. Messenger-applications like WhatsApp or social media platforms, are described.

In case of outages, automated telephone systems like an IVR-Manager (Interactive Voice Response), with an interface to a SCADA-System, can support customer service centres. New technologies providing text-tospeech messages can deliver useful and detailed information for specific requests. In the future, the use of chatbots could be conceivable, which would have to be perceived as a personal and individual service for the customer.

Information regarding the duration of planned or unplanned outages can nowadays be visualised using internet applications, as seen in Figure 4. Various grid operators have already implemented such an application, with a direct link to their SCADA system.

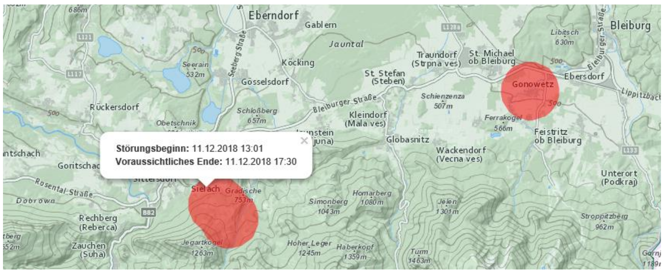

Figure 4: Screenshot of an information platform for customers about outage area, time and duration

To serve all different demands, it could further be useful to run an integrated communications server, which provides incident information for various channels and interfaces. Thus it would be possible to support internal users, external users and platforms in an efficient way.

Regardless of outage information, there are considerations to improve the claims and complaints management process using a platform where customers are able to send their requests digitally. To support the responsible staff of the system operator in replying to these requests, the process could be combined with an automated check summarizing all relevant information.

Furthermore, due to the introduction of the smart meter technology, organizational processes in terms of activation, deactivation and pre-payment issues could be simplified with the implementation of an interface to an electronic payment process.

The main advantage of the described proposals is a fast and reliable information platform for the costumer and a user-friendly support for the responsible staff provided by the new technical possibilities offered by information technology and digitalisation.

DIGITAL WORKFORCE- MANAGEMENT

Chapter 5 covers the digitalisation of the workforce management (WFM) process and the interface between SCADA and WFM. The aim is to fully automatize the data exchange for planned work and during outages between the grid operator and the field engineer using additional data sources like the enterprise resource planning (EPR/SAP) and the geographical information system (GIS).

Due to the requirements about flexibility during daily work and for an efficient time schedule, an integrated workforce management as a part of the operating process is nowadays essential [3]. An advanced system configuration enables a dispatching of all planned and unplanned tasks including specific details, such as complete switching procedures, necessary grounding arrangements, information about the acting supervisor and the crew.

Furtheron, detailed information, especially in case of outages, should be added from an operating system like SCADA, GIS and/or ERP. Using the clustered information of these data sources and having an online interface between SCADA and WFM, the fault localization and the repair work will be more efficient and the downtime will be reduced.

During an outage or even during a planned work, the following costumer information should be automatically forwarded to the field engineer:

- contact details of the affected client and failure description
- address of the consumer
- future grid plans of the affected area
- fault history
- fault location or fault indication

Subsequently, when the work of the field engineer is finished, an automatic transfer of selected WFM-data (type of fault, coordinates of fault location, recovery time, pictures and additional tasks) to SCADA should be executed. This service reduces the subsequent information exchange between the central operator and the field engineer.

Finally, in the end of the whole working procedure a time- and expense report has to be completed automatically, which could be triggered by the collected information in the system. Additional documentation, statistics and analysis can be done in a highly automated and thus less personnel intensive way with the proposed applications.

EMERGENCY MANAGEMENT FOR GRID OPERATION

The continuously increase in digitalisation and the ongoing implementation of interfaces for grid operation systems calls for a clear strategy if parts of these systems fail. Therefore, chapter 6 deals with the emergency management for grid operation covering various breakdown scenarios.

Nowadays, the non-availability of system-relevant tools represents a major threat for the grid operation. This is the reason why it is essential to investigate the most significant potential hazards in grid operations, which cannot be avoided or eliminated by protection relays. Even if the SCADA system fails, information like fire alarms in substations or earth fault information have to be displayed in control centres using redundant or emergency systems.

Therefore, it is expedient to establish minimum standards with regard to local redundancy of relevant systems, independent physical transmission paths, backup systems, summarized alarm messages and selective grid monitoring via additional systems.

The main documents such as grid plans of the various voltage levels, concepts for troubleshooting and workflows for a system recovery have to be available in form of local backups. Furthermore it can be helpful to generate log files to reproduce the original state of the grid after a system breakdown. These additional tools and information should also be available in a redundant control center.

One of the most important installations in a control center is the communication system. In addition to a redundant system of servers, hardware and infrastructure at least one redundant transmission path should be provided (e.g. private mobile radio system), independently of public communication. In this case a regular use or test of these components is essential.

CONCLUSION

In this paper, a guideline for digitalisation trends for distribution system operators is presented. In six chapters, an overview about existing processes and new developments covering various fields of grid operation is given. It is shown, that digitalisation offers various possibilities for further improvements in the area of grid operation. Some of the described applications are already implemented in the grid operation of Austrian DSOs, others are expected in the next couple of years.

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