# INTEGRATED DISTRIBUTION GRID MANAGEMENT SYSTEM

Robert SCHMARANZ
KNG-Kärnten Netz GmbH
robert.schmaranz@kaerntennetz.at

Reinhard ISKRA
KNG-Kärnten Netz GmbH
reinhard.iskra@kaerntennetz.at

Jürgen PASKER
KNG-Kärnten Netz GmbH
juergen.pasker@kaerntennetz.at

Thomas DIETRICHSTEINER
KNG-Kärnten Netz GmbH
thomas.dietrichsteiner@kaerntennetz.at

## *ABSTRACT*

*This paper introduces an Integrated Grid Management System using a SCADA-approach including the high-, medium- and low-voltage level to further optimize the workflow for distribution grid operation. It deals with the new challenges and possibilities of a fully centralized grid operation system using digital data from various sources such as SAP, Workforce Management, Geographical Information Systems, Meter Data Management and customer applications. The already installed and in the future planned applications as well as the interfaces between these platforms will be presented and described.*

## INTRODUCTION

In the last decade, centralisation and digitalisation were the main drivers in the area of grid operation. In parallel, DSO's developed and installed various other applications, e.g. workforce management systems, customer platforms or very recently smart meter applications. The next step towards an Integrated Digital Grid Management System is the process-orientated data-exchange between these systems.

The KNG-Kärnten Netz GmbH is an Austrian DSO with a peak load of 751 MW and a distribution volume of 4 TWh. The KNG operates a high-, medium- and low-voltage grid of approximately 18.000 kilometres in length. 46 substations at a 110-kV voltage level and 7.300 MV/LV transformer stations and provides energy for more than 300.000 customer installations.

Within the KNG, a major step towards centralisation and optimization of the grid operation was taken in 2007 [1, 2]. The key task was to establish system interfaces between SCADA/DMS, the geographical information system (GIS) [3] and the enterprise resource planning (ERP/SAP). In the last years, new digital applications were established like a workforce management system (WFM), an interactive voice response system (IVR), an availability and failure statistics (in Austria: INTERASS), customer applications or meter data management systems (MDM).

Step by step, the system integration was taken on a next level, towards a fully Integrated Grid Management System. Starting from the work planning and outages respectively, the digital data flow runs through the Backoffice, the Control Center, the field crew applications and is simultaneously used for customer information platforms. For each event, a data set is generated and is successively extended by adding new information in each step of the workflow.

## SYSTEM CONFIGURATION

For an integrated grid operation, it is necessary to interconnect a number of different OT/IT-systems. The core component of all these systems is the SCADA/DMS system with integrated functionalities for Outage Management and Trouble Call Management. GIS is the leading system for geographical and electrical data of the medium and low voltage (LV) grid. The main system for customer information (e.g. customer number, name, address, connection point) is the ERP system (SAP/IS-U).

Both systems have file-based interfaces to SCADA. The import of data from GIS and SAP to SCADA runs on a weekly basis. For reasons of availability and performance, there is no online interface implemented. For the same reasons, all necessary information are held in the database of the SCADA system.

All other systems shown in Figure 1 have online interfaces to SCADA based on web services or database links. The interaction between these online connected systems like

- work force management
- web based service portal
- interactive voice response
- lightning detection
- web application for visualization of disturbances
- availability and failure statistics

as part of the integrated grid operation will be described in the next chapter.

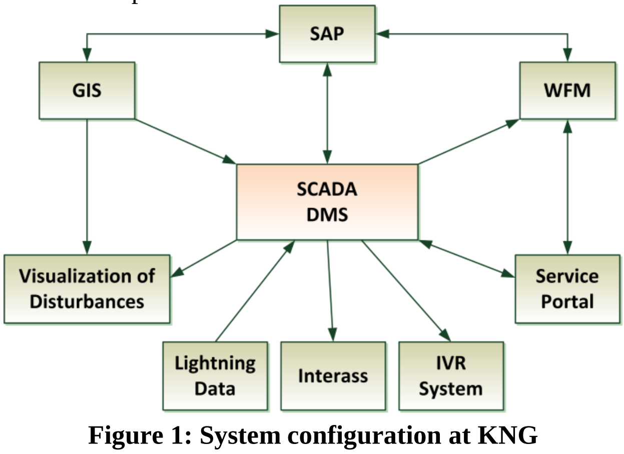


**Figure 1: System configuration at KNG**

## INEGRATED GRID MANAGEMENT SYSTEM

Key element for the introduced Integrated Grid Management System [6] is the interaction between the Backoffice - where planned work orders are processed - the Control Center - where these work orders or the outage management due to faults are carried out - the field crew and the customers, as shown in Figure 2.

Basically, an outage can be distinguished between two cases. The first case is a planned outage which is generated when assets like overhead lines, cables, switches, isolators, transformers, etc. get maintained. For planned outages, the responsible maintenance crew creates a request via a web based service portal. In the next step, the staff of the Backoffice checks and evaluates this request and prepare the most effective switching procedure within the SCADA outage management system. With the acceptance of the request, an assignment in WFM is created which includes all requisite information for the field crew.

with a time stamp for further use in other applications, like the availability and failure statistic.

An important aspect in the work flow is the customer information. Due to legal requirements in Austria, customers have to be informed about planned outages at least five days in advance. For this purpose, KNG-customers have the possibility to register online to get the outage information as soon as the work assignment gets accepted by the Backoffice staff. The way of communication could either be fax, e-mail, and/or text messages depending on the customer request.

The second case of an outage is a disturbance due to a fault. These disturbances can be registered directly with SCADA alarms or indirectly via trouble calls from customers. In case of a circuit breaker trip, a SCADA outage record gets generated automatically. Customers calling the disturbance hotline are being connected to the Backoffice. The Backoffice employee creates a Trouble Call Ticket

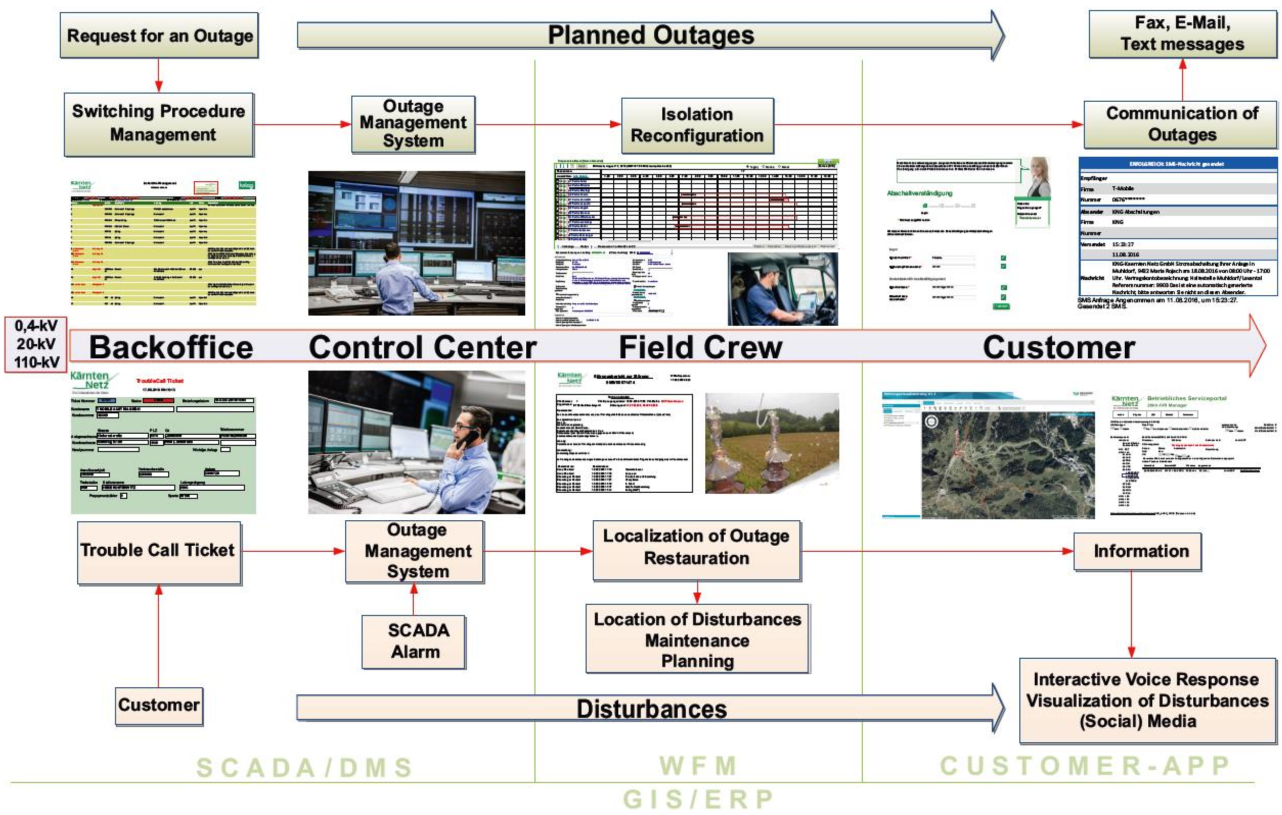


**Figure 2: Integrated Grid Management System**

During the planning process of the switching procedure it is ensured that the five safety rules are applied and no load flow or voltage violation will occur. When the planned task is carried out, the operator in the Control Center instructs the field crew about the safety measures and switching instructions as documented in the switching procedure record. The field crew has the same record on their WFM device and double checks every step. All executed steps are recorded in the SCADA outage record

with the information given from the customer. Due to the data interconnection, as described in Figure 1, the connection point of the customer as well as the allocation to any planned outage or to a known disturbance is indicated automatically. If the identified problem is unknown to the system and lies within the responsibility of the KNG, the Backoffice employee creates an outage record in SCADA and all corresponding Trouble Call Tickets are allocated automatically to this record.

After assigning a field crew, the information from this SCADA record such as

- customer information (address, telephone number, connection point, etc.)
- affected area including grid plan
- (possible) fault location
- fault history

is forwarded to the mobile device of the workforce management system.

At the moment, the information of the grid connection of customers in SCADA, which is the main system for grid operation, ends at the low-voltage feeder. Additional and more detailed information about the low voltage grid are available in GIS. The next steps towards an extended low voltage visualisation and monitoring is described in the next chapter.

The prime objective during a disturbance is to find and isolate the fault location. There are several ways to detect the defective area. The SCADA system can automatically identify possible fault locations with the fault impedance from protection relays and/or information from other telecommunicated grid elements like short circuit indicators, phasor measurement units or advances earth fault detection relays. These locations are displayed in the geographic and schematic grid maps. In the geographic grid map, various overlays like satellite images, lightning data [7] and locations of trouble calls from customers can be superimposed for a faster fault localization.

The operators in the Control Center assign the outage record to a field crew and send the crew to the prior determined or assumed fault location. With the assignment of the field crew, a WFM record gets generated with all information from the SCADA outage record and associated Trouble Call Tickets.

Customers calling the service-hotline are informed about the known disturbance areas and the ongoing repair work via an interactive voice response system. The IVR-Manager receives the information of circuit breaker trips from SCADA and activates the pre-recorded announcements instantly. Additionally, every customer can view his specific outage details in a web based self-service portal. Further, a geographical visualization of all outages can be found on the KNG homepage.

## LOW VOLTAGE GRID OPERATION

In the past, the DSO's centralized grid operation was mainly focused on the high- and medium-voltage level. Operation centers and their hardware infrastructure were designed to deal with the amount of data coming from these voltage levels. Due to the increased decentralization of power generation with renewables and the arising challenges due to storage systems, electric vehicles and micro grids, more detailed information about the low voltage level for grid operation and planning will be essential in the future.

Therefore, the information for the DSO's grid operation need to be extended from the high- and medium voltage levels to the low voltage system. The roll-out of smart meter devices and the continuously increasing number of additional sensors in combination with various smart grid applications at the low voltage level facilitate the access to this information. The advancements in hard- and software design in the last years enable the integration of this new data amount into SCADA.

The first step for this task is the visualisation of the low voltage grid to prepare the incoming information for the operators. Depending on the already existing systems and the grid operation strategy for the low voltage grid operation, there are different operating systems available: SCADA, GIS or an independent platform with an interface to both systems mentioned above. For the LV-modelling, four different levels are feasible, starting from the simplest to the most complex solution [4]:

1. LV information on medium voltage display
2. modeling of LV busbar and LV feeder head
3. reduced LV model
4. full LV model

If there is a need to display system unbalances, a 3-phase-visualization is recommended.

In general, there are two types of grid-views available: a geographic or a schematic view. If a schematic scheme of the low voltage power grid is requested, an Automatic Display Builder can be used. With this feature, every selected feeder will be schematically drawn by a special algorithm. The advantage of this method is the efficient creation of a schematic view in comparison with the customization of a hand-drawn map. The disadvantage are the variations in the layout caused by changings in the switching state and the limited view on the grid.

The actual monitoring of the low-voltage grid mainly depends on the speed of the data transmission of the low voltage sensors. In case of using data coming from smart meter, it varies with the communication technology and the availability of the communication platform used. Irrespective of the system architecture, the following advantages and acquirements are feasible:

- localization of outages and failures
- monitoring of voltage thresholds
- detection and avoidance of bottlenecks
- detection of asymmetric loads

For updating the actual switching states, two methods are available. In a centralized operational management, this task will be carried out by the operators of the operation centre. The advantage is a centralized overview, the disadvantage the additional work load for the grid operators. In a decentralized solution, the switching procedures can be documented using a mobile unit, which is synchronised with the central application for the grid monitoring. The documentation of the switching procedures is therefore carried out by the field crew.

Within the KNG, the next step will be the extension of the Integrated Grid Management System with the missing low voltage information downstream of the feeder. The advantage of the SCADA approach will be the combination of all voltage levels within one platform using all existing system interactions.

## SMART METER IN GRID OPERATION

One of the most promising application using the data exchange between the operating system and the Advanced Metering Infrastructures (AMI) is the LV fault localization and fault isolation [2, 5], as shown in Figure 3. In this workflow, three use cases can be distinguished.

The first case, which can be found in the upper half of the figure, is an additional service for Trouble Call Management due to customer calls. During a trouble call, a request to the customer's smart meter will be sent. With the response from the smart meter devices it could be distinguished if the problem exists inside or outside the grid operator's responsibility or if a larger area is affected. The requirement for this service is a smart meter response within the duration of the trouble call and therefore within approximately one minute.

An essential requirement for using these data in operation centers is an intelligent data processing.

A current non-accessibility of smart meters doesn't always result from an outage in the grid. There could be an intended disconnection of a smart meter from the owner or an electrician or the communication from or to the smart meter could be disturbed. On the other side, a disturbance in the medium voltage level could result in a data flood from smart meters, depending on the way of communication and the integrated smart meter functionalities.

In the third case an outage gets detected and processed with a known fault location in SCADA, as described in the penultimate chapter. Additional information of all disconnected smart meters in the outage area could be provided by MDM, but wouldn't be useful for the grid operator. However, after the repair of the outage by the field crew a request to the MDM could be started. The MDM confirms either the successful resupply of all involved smart meters or shows remaining problems in the outage area. If the area response confirms that there are still unsupplied customers, the grid operator can send the field crew to these identified households.

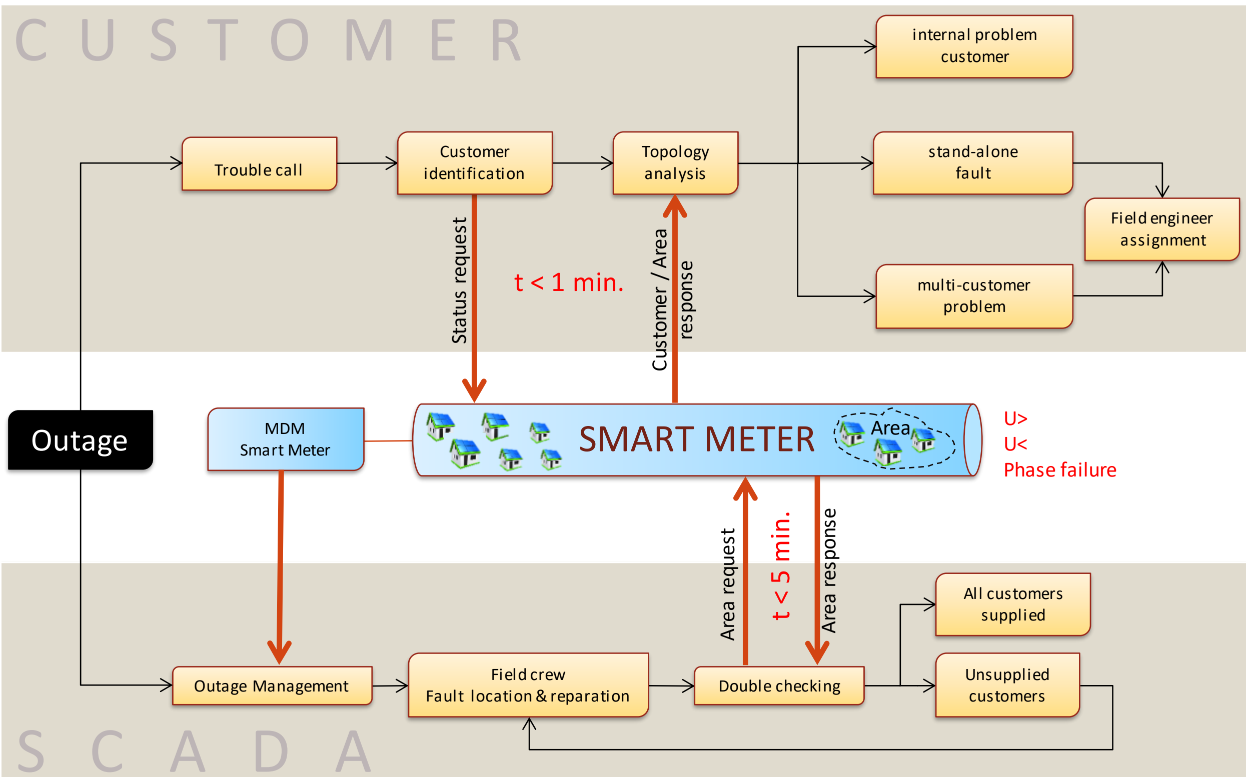


**Figure 3: Fault localisation and isolation using smart meter information**

For the second case, shown in the lower half of the figure, a disturbance gets registered by smart meter devices and will be transmitted to MDM. This information could be automatically transferred to SCADA outage management to show the grid operators present problems in the grid.

The response time of this smart meter request should be within five minutes. If the request would take much longer, the benefit of this service wouldn't be fulfilled because the field crew probably will not be on the outage spot anymore.

## CONCLUSIONS

In this paper, an Integrated Grid Management System using data from various sources is introduced. The main aim was the process-orientated data-exchange between the different digital platforms within the utility to optimize the distribution grid operation. The generated data sets for an outage or every planned maintenance work will be extended during every step in the process and can be used for various applications throughout the working process.

Furthermore, the next steps concerning a fully integration of the low voltage network is discussed and solutions are presented. The utilization of data provided by the Meter Data Management System and therefore by the smart meter devices is the key element for a digital operation of the low voltage grid. The introduced approach provides the foundation for a holistic workflow concerning all voltage levels for the grid operation of a DSO.

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