KEY ISSUES WHILE IMPLEMENTING A DISTRIBUTION MANAGEMENT SYSTEM RETURN OF EXPERIENCE FROM A MUNICIPAL UTILITY

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ABSTRACT

The implementation of a ***D****istribution* ***M****anagement* ***S****ystem (DMS) - which complements an (existing) SCADA-system in supporting the management of distribution networks - including the network parts not under remote control - requires great attention with respect to the integration in the existing IT-infrastructure. Similarly data administration should not be underestimated as initial efforts during data acquisition or lifelong efforts for data maintenance. This is the price for additional benefits in supporting Network operation with tools like the Power Flow and the Short Circuit calculation.*

INTRODUCTION

To supply the city of Zurich with electrical energy, **ewz** (Elektrizitätswerk der Stadt Zürich) operates a distribution network, consisting of 19 subsubstations (Figure 1), 833 transformer stations and about 4300 km HV- and MV/LV-cables.

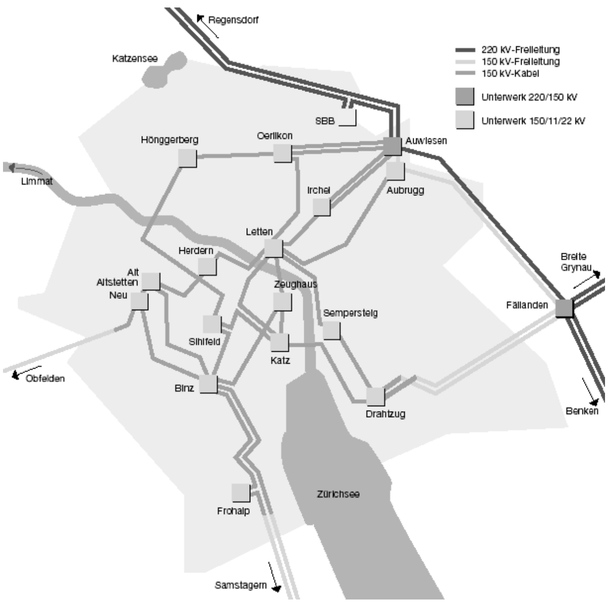

Figure 1 150 kV Sub-Transmission Network with 15 HV to MV Substations and 2 EHV to HV Feeding Substations

During the last hundred years, **ewz** has built up a transmission network to connect their hydro power plants in the alpine region of the Grisons with the distribution area of Zurich (Figure 2).

Along with the technological development, the operation of the network became more and more centralised. Whereas manual switching is still common practice in the MV and LV distribution networks, HV substations and generation units were first controlled and monitored by SCADA-Systems from several control centres. Now, the area of Zurich is operated by one single control centre. In case of unavailability of the latter, network operation and control are ascertained from a decentralised emergency control centre.

The last innovation was the implementation of a **D**istribution **M**anagement **S**ystem (DMS) allowing the visualisation and operation of all HV and MV distribution networks, as extension to the SCADA-System and with complementary functionality.

The added functions - consisting mainly in real-time operation and analysis tools for the distribution – require extending the SCADA data model and additional data management. This is not a one-time effort to be done during the implementation of the solution: the data management in IT-systems and tools is a continuous task.

Consequently, further IT-projects at **ewz** have to coordinate and optimise data management among the numerous utility’s IT systems.

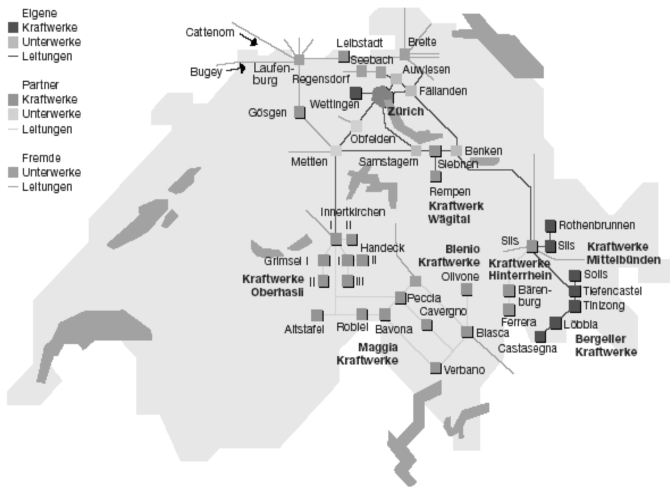

Figure 2 EHV Transmission network connecting the generation in the alpine region with the distribution area of Zurich

NETWORK MANAGEMENT

The concentration of the HV/MV/LV Network Management tasks in one organisational unit some years ago laid the fundament for the next step. To get a centralised view (and control) from HV network, as well as from MV (11kV and 22kV) ring-main network, a DMS application was evaluated.
The requirements for a DMS had also to consider the current organisation for network operation, as well as the existing and complex IT-infrastructure.
The main tasks of the distribution network operation are:

- Monitoring HV and MV networks
- Planning switching operations and preparing switching orders
- Coordinating and implementing switching orders
- Remote control of automated devices
- Fault management
- Reporting

Previously, to support these tasks, several IT tools were in service (for example, logging and registration of planned or hazardous events were done by an especially developed database-application). Prior to approval of switching operation, voltages and currents have to be calculated and confirmed as within the limits. For historical reasons, distinct calculation programs were used for the HV and the MV networks. The diversity of tools had to be reduced and the operational sequences (workflows) simplified. Therefore one important requirement was the seamless integration of calculation features (power flow and short-circuit) into the DMS to simplify the preparation and implementation of switching operations. Also the switching documents have to satisfy on one side the needs for manual switching in the MV distribution network, on the other side, the regulations (legal obligations) concerning documentation of operations.
The most important requirements for a DMS are the following:

- Visualisation of the network topology with the actual switching and supply statuses
- Easy detection and localisation of network faults
- Management of switching orders (creation, simulation, detection of conflicting orders, execution and administration)
- Validation of switching orders (with power flow calculations)

The significant advantages for performing power flow calculation (PF) in a SCADA-DMS environment are:

1) The calculation triggering is automatic based on operator's activity (seamless integration in the operational workflow)
2) Consideration of the prevailing (real-time) topology of the network, i.e. also if abnormal or dictated by unplanned situations
3) Automatic adaptation of the PF load model according to (remote metered) real-time measurements
4) Calculation results and potential alarming are reflected directly in the operator's working environment

In contrast, in the past, the off-line power flows were used in the back-office and performed their calculation only against the normal topology or the anticipated topology (with a state of the network as it should result from the planned switching)
A further advantage in encompassing in a single PF calculation the HV network and the MV network is that the results will reflect the mutual influences of the two networks.
Fulfilling these requirements with a DMS simplifies evidently the network operation processes. But DMS will influence the work of the operators and one should pay great attention that this new tool will be accepted by them. A good solution chosen by **ewz** was to involve the operation manager as well as some operators throughout the analysis and implementation phases of the project.
Finally, the DMS shall provide the users with safer operation capabilities, enabling operators to perform switching under critical situations (where in the past they would take suboptimal alternatives) and allowing operation of the network closer to its limits. But this implies that, under all circumstances, DMS will constantly provide reliable information.

DATA MANAGEMENT

DMS functions require a suitable and accurate data model of the distribution network. The quality of services provided by DMS is fully dependant upon the quality of these data:

- The static data model: the network components, their connectivity, their schematic representations, their electro-technical characteristics, their possible relations to remote terminal units, operational rules, etc.
- The dynamic data model: the devices' state, measurements, operations, operational permissions and restrictions, etc.

Data management is a short term issue: finding necessary and reliable data within the organisation, capturing these huge quantities of data into DMS, validating and commissioning them. For a network of the size of **ewz**, the number of parameters (for lines, transformers, devices, busbars, etc.) to consider in the DMS account in hundreds of thousands.
Data management is also a long term issue: maintaining data models all along the lifespan of the system, updating them in concert with network operational events and structural changes.
Furthermore, the life-cycle of the data (almost equal to the network components' life-cycle; i.e. 30 to 50 years) being much longer than the life-cycle of the IT system, one has to consider the capability of recovering all these data at the end of the life from SCADA-DMS system.
Considering long term data management issues and the multiple interactions DMS has with other utility's

organizations (or systems), it is paramount to store this information into a standardized model. Therefore, **ewz** has selected a DMS that complies with the standard IEC61970 [1].

SYSTEMS MANAGEMENT

At **ewz**, the multitude of data related to network management are stored into various systems (see Table 1 for an overview).

System	Type of Info	Data
SAP	Business information	Customer information Network components (type and costs) Maintenance information Costs and material Measurements data
GIS	Geographic information	Distribution network incl. location of equipment (all voltage levels) • Cadastral plans and constructive information (trace) • Geo-schematics of the networks
SCADA -DMS (incl. PAS)	Topological and operation information Equipment characteristics	• Networks schematics: transmission (380/220kV), sub-transmission (150kV) and distribution (11/22kV), substations diagrams. • Lines: Length and characteristics • Devices' state • Measurements (metering) and load flow profiles • Network components: type, characteristics
CAD-tool	Constructive information	Building designs and networks layout drawings of substations and transformer-stations, . schematic plans of networks
Fault, plant and equipm. databases	Fault statistics Equipment-data	Inventory-data, reliability- and fault information, etc.

Table 1: IT-systems and their main information with respect to network management

It is important to build links between various data repositories in order to avoid efforts for multiple data captures, and the inherent risks of data inconsistencies,.
Also, one has to define updating procedures to ensure the quality of the data.
On the long-term each system has to be maintained, updated, adapting the program interfaces to new versions and building up a data administration to ascertain data quality and actuality.
Integrating DMS into the already complex IT-environment from **ewz**, while fulfilling the above requirements, was a challenge. Integration problems were minimised thanks the open and object-oriented architecture of DMS that generally correspond to the standard IEC61968 recommendations [2].

PROSPECTIVE IT-ENVIRONMENT

Network management is performed on the base of numerous information that are available and maintained in different information systems (Table 1). Information is often redundant in those systems. This is particularly true of network components' electro-technical characteristics and other general information. Redundant data management and thus the necessary additional effort for data administration are well-known problems, for which each utility has to deal with. An important approach to mitigate these difficulties at **ewz** will be to manage the redundant information in a central data base (repository).
The experiences made during the commissioning of the DMS have highlighted the urgency for **ewz** of such centrally managed administration of network components and especially of their electro-technical information. In particular the different network calculation programs would have a collective platform for the exchange of data. The solution (see Figure 3) shall be implemented during the next years.

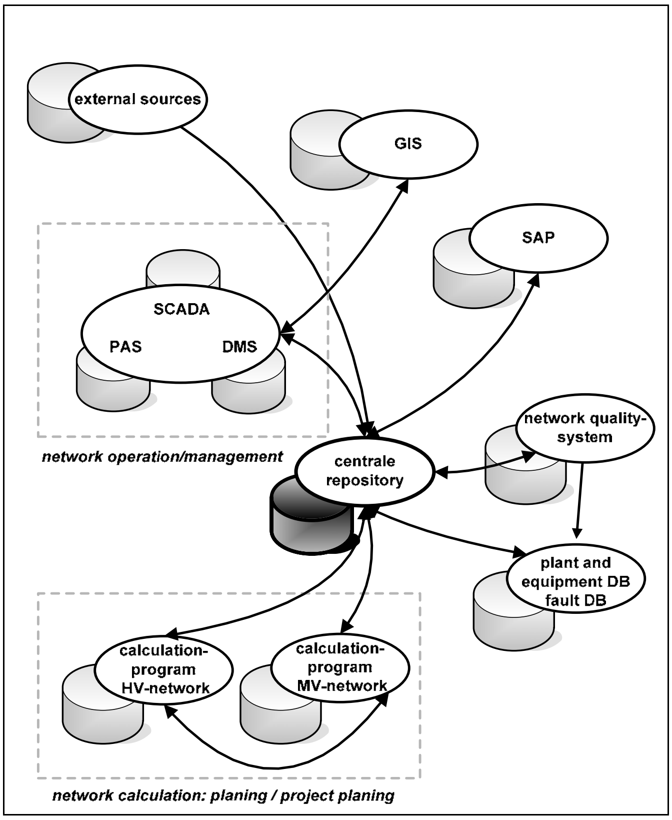

Figure3 IT-infrastructure with central storage of important information related to the network management like electro-technical characteristics for load flow calculation

FIRST EXPERIENCES WITH THE DMS

The DMS project started in May 2002, was commissioned during the year 2004 and put finally in operation in January 2005.
Due to the extensive presentation requirements, the network schematics were newly captured with DMS tools including the network topology. In contrast, the characteristics of the network, available in other systems, have been imported automatically into the DMS database.
Data import was more time-consuming than originally expected. One main reason is the difference in the modelling granularity in each of the systems. To solve this, additional software tools were required to adapt and transform the data. Such tools will be useful also after the initial data import, i.e. during the system life-long management of the data. It became apparent that for this last matter, additional measures are necessary. Hence, a clear organisational structure with the corresponding responsibilities for data administration is necessary to minimize the effort and the risks of mistakes. In this respect a considerable support could be provided by a central data base system.
Another unexpected burden was faced during commissioning of the real-time power flow. Setting-up a consistent data model among the object instances, their topology, their characteristics and the related SCADA measurements resulted in a longsome iterative process for data debugging and model correction, requiring a lot of expertise and feeling. Half way trough this iterative process, it was decided to activate in the SCADA-DMS environment, temporarily, a Distribution State Estimator [1] to facilitate the data debugging. This has proven to be so efficient, greatly accelerating data commissioning, that **ewz** is now considering purchasing this function to support permanently the data management. But the greatest benefits from a Distribution SE shall be in the operation environment where the application will leverage the quality and reliability of the network state information for the operators.

SUMMARY

The introduction of a DMS network management system for the HV and MV distribution of the City of Zurich is an important step for **ewz** towards centralised and more efficient network operation of all voltage levels of the urban distribution.
The experience gained in the implementation phase shows that data management in general represents the biggest issue in such project: this encompasses data modelling, data gathering, importing from other systems, validation and data maintenance along the system's life. Significant findings:

- use of a Distribution State Estimator provides significant support in debugging the data
- data administration must be supported by a suitable organisation within the utility
- IT infrastructure needed to be adapted accordingly

ewz is seeking for a solution to minimise the efforts and the risks of errors; i.e. the most important information will be managed in a central data base

REFERENCES

[1] International Electrotechnical Commission *IEC 61970: Energy Management System Application Program Interface (EMSAPI)* - Part 301: Common Information Model (CIM)

[2] International Electrotechnical Commission *IEC 61968: System Interfaces For Distribution Management* - Part 1: Interface Architecture and General Requirements

[1] The Distribution SE is a variation of the classical SE. It is capable in making use of excessive process measurements (e.g. with a redundancy factor of ~2) to determinate state variables in the "observable" parts of the sub-transmission and distribution networks. Then (in a second phase that starts from the resulting state variables at the border of "observable" network parts), it uses the sparsely available measurements of the distribution network, together with other parameters (e.g. load profiles), for making a best estimate of the state variables in the "non-observable" network parts