Special Report – Technical Theme 3

OPERATION, PROTECTION AND NETWORK CONTROL

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INTRODUCTION

Some 41 papers – out of more than 70 proposals, coming from more than 20 different countries, were selected for the following 4 main groups:

- Fault management and outage reduction
- Maintenance and refurbishment
- Protection and control
- Distribution automation and distribution management systems

Following the first keynote address about "Network Operation with a tailor-made offer for customer needs" the first 2 main groups will be presented by some 3 + 3 papers as representative cross-section of the most relevant topics, to be followed by a discussion together with the authors of the remaining 8 + 5 papers, which provides the opportunity for the auditorium to address themselves directly to the authors of the panel in form of an open discussion.

The afternoon session will begin with another keynote address about "Integrated Protection and Control Benefits in the Distribution Network" with the remaining two main groups. This will again include some 3 + 5 papers on the most relevant topics, to be followed by an open discussion again together with the authors of the remaining 4 + 9 papers.

The session will be completed by a tutorial on "Best Practice in Distribution System Protection" on Thursday morning and a Round Table discussion about "Network Operation in the Competitive Market" besides the facilities for a poster session on the third day.

MORNING SESSION

The session will start with the invited speakers keynote address.

Part A: **Fault management and outage reduction**

11 papers will contribute to this part with 3 papers nominated for a condensed representation in order to outline the main scope.

The starting will be prepared by Mr. Lehtonen 3_9-SF with an overview of automatic fault management in distribution networks indicating the two main competing lines of software supported assistance for proposing corrective actions to the operator versus complete automation supported by predefined switching sequences up to complete restoration after checking technical constraints. A similar procedure for an Asian metropolitan area is described by another paper 3_7-D for a neutral grounded network. The topic of earth-fault detection in compensated networks, without using voltage measurements and corresponding cost savings is subject of paper 3_4-F, where implementation is planned, by introducing an artificial neuronal network (ANN) based protection principle with comparison of zero-sequence and phase currents.

Fault distance location practical experience for rural MV-networks with cable and overhead line mixed circuits and of compensation is reported in paper 3_6-D, giving figures of the accuracy's achieved for different models and fault types, sufficient for rural networks and very helpful for faster fault location and associated supply restoration. A genetic based fault location algorithm for transmission lines is presented in paper 3_3-K.

The second paper to be presented 3_5-D covers actual earth-fault measurements in compensated 110 kV system comparing indirect parameter evaluation methods by resonance curves and damped oscillations on fault records to direct fault tests as only means to also include the harmonic components.

The results of the measurements lead to new proposals for optimizing the tuning, as well as increasing the maximum size of the network considerably, due to the discovered reductions of damping factors.

Statistics for self extinguishing faults and consequently interruption reductions for several pilot installations of Petersen coils in Italian networks can be found in paper 3_11-I, where also guidelines for ENEL solutions adopted as a function of transient interruptions, earth fault currents and earth resistivity are indicated with regard to the quality of service needs.

As third paper to be presented the proactive management of underground LV networks in London will be described 3_1-UK, where measures to detect incipient faults are used. Furthermore application of innovative performance indices for worst served customers are proposed. Several additional tasks for future developments are named as new opportunities to be exploited.

Improving customer information following severe weather conditions with a multitude of simultaneous faults, including the whole fault management process is the topic of another paper 3_2-UK, where the complete business process was the background for developing a decision support tool.

Also in this group is a paper for remote switch control by radio 3_10-RO as economic means for reclosers and switch-disconnectors. A similar topic where the architecture of communication is discussed and the advantages of decentralized intelligence based on performance indices are evaluated for switch and recloser application is treated in 3_8-US.

Some open questions to discuss for group A:

- Is compensation by Petersen coil recommendable for mainly cable networks in view of danger for intermittent faults by insulation damages?
- Which strategy is applied to disconnect faulted section in compensated network?
- Are there experiences with evolving faults in compensated networks?
- Would fault management process be simpler in case of resistance grounded neutral?
- Would French method of current comparison also be applicable for meshed networks?
- How do London performance figures compare to other metropolitan systems and what cost/benefit ratios can be indicated in relation to quality improvements?
- To what proportion would probability for cross country faults increase for larger network sizes in compensated networks?
- Has fully automatic fault management been applied at other utilities and which experiences can be reported? Also for compensated networks?

Part B: **Maintenance and refurbishment**

Two Dutch papers are dealing with underground cable asset management. The first one to be presented in this group 3_19-NL is concerned with increasing the capacity or cable rating by collecting experience with temperature measurements incorporating glass fibers and developing better thermal models, also using the history and emergency rating. Additional moisture sensors and mechanical stress sensors can be incorporated and life cycle cost analysis has proven favorable cost/benefits ratios.

The second paper3_18-NL deals with diagnostics for realizing responsible maintenance programs using voltage tests, dielectric and partial discharge measurements as a basis for condition based maintenance with overview tables for maintenance frequency and applicability.

Several other papers describe the different maintenance methods having evolved from corrective to time based and condition based maintenance with the reliability centered maintenance as latest step 3_15-D and illustrate the consult concept and the development of strategies for the assessment supported by corresponding software tools.

Different models, such as Markov are analyzed 3_12-UK, looking for the best cost-benefit ratios, and further reduction in maintenance costs are expected by setting correct MTBF targets in combination with continuous monitoring of circuit breaker performance 3_13-UK.

The second paper to be presented 3_17-N deals with the risk management in Norway, where compensation for energy not supplied have to be taken into account for the optimization process using condition-based maintenance and consequently a reliability component is introduced in favor of industrial loads with 12 times higher value per energy unit as compared to household loads.

Therefore risk-based maintenance is considered as a further improvement, insurance considerations are mentioned and need of more complex tools using Monte Carlo simulation model is proposed.

The third paper to be presented in this group 3_14-D describes the refurbishment process for a major utility infeeding HV/MV substation, where the switchgear configuration had to be analyzed by the aid of reliability studies, optimizing efficiency. In the example shown the overall structures of the associated network parts were restructured and the reliability calculations for interruption frequency and energy not supplied indicate that simpler and less costly single busbar including high speed transfer switching would be almost equal to double busbar arrangements without essential restrictions for operation.

Another economic comparison, illustrated in paper 3_16-CZ, deals with the replacement of older circuit breakers with high maintenance costs by newer ones with less maintenance need. Even though repair costs and outage costs are included, the example indicates that the high costs of an early replacement can not be justified under the assumptions taken.

Some open questions to discuss for group B:

- How are network development and load increase considered in maintenance strategy optimization?
- What is percentage of monitoring costs with regard to investment costs for various equipment?
- What values for compensation for energy not served are applied in other countries.
- What are ratios of energy costs of industrial to household loads or for different industries?

- Are other examples for reliability centered maintenance in distribution networks available and what cost savings have been achieved?
- Are comparative figures for outsourced maintenance available?

AFTERNOON SESSION

Part C: **Protection and substation control**

Besides the second keynote address about the benefits of integrated protection and control 7 papers are dealing with this topic.

The first paper to be presented 3_23-D will describe more about the impact of accommodation of diverse disciplines, such as protection, control and metering, into one single intelligent electronic device (IED) on present practices and reliability of each of the implemented functions. Also included will be the German working group efforts to define scope of core functions and communication interoperability among IED's of different makes.

Another look at other innovations is given in paper 3_21-F using distributed and modular architecture, facilitating of stepwise evolution, and using novel sensors for low power, together with other features.

The standards and policy of an utility company are the subject of paper 3_20-B, indicating the rules for setting with the architecture of the network as most important parameter for the protection and the remotely controlled elements.

The second paper to be presented 3_25-CH is dealing with the new strategies and trends towards intelligent substations where also condition supervision and outage management will be integrated in a substation oriented decentralized automated concept.

Also paper 3_22-F is concerned with the maintenance aspects looking at the whole life cycle for substation computers including their software and obsolete components.

Another important aspect newly introduced by the deregulation process is subject of the third paper to be presented 3_24-N, where compensation costs for energy not supplied focused special interest on the reliability of protection and control. 10-year period fault statistics were used to find out that technical as well as human errors, testing or incorrect setting of the protection and control equipment contribute as second largest portions to the Energy not supplied at the voltage levels 33 – 420 kV, where unwanted and missing operation of relays appear as major cause.

Last but not least a paper from South Africa 3_26-RSA is presenting the experience with various types of circuit breakers for a reliable protection in low voltage network.

The following questions emerge from the papers of group C:

- What are the consequences of the integration of diverse disciplines into one common IED on:
  a) Dependability and security of protection, control and metering?
  b) Traditional utility organizations?
  c) Handling of one single IED by various authorized persons?
  d) Fault and service analyses of various engineers with data derived from one common data base?

- To what extent have deregulation and technical innovation changed:
  a) The utilities technical organization?
  b) The protection and control management, e.g. setting procedure, engineering, commissioning, maintenance, fault analysis etc.?
  c) To what extent is remote excess to relays and bay controllers applied?

- Considering the huge amount of installed traditional instrument transformers in service what will happen to novel sensors:
  a) When is a fair share of this technology out in the field expected?
  b) Are there any obstacles for wide-spread implementation of low energy sensors
  c) Will they be in the long run replaced by optical sensors?
  d) Has the field bus for a communication of all bay related sensors and actuators as being discussed in transmission a future in distribution substations?

There are numerous proprietary and standard protocols today in service. With the advent of the new world-wide standard IEC61850 along with UCA 2, how do users and manufacturers cope with retrofitting of new protocols into existing plants?

Part D: **Distribution automation and distribution system management**

This most comprehensive group includes 15 papers from many different countries and therefore 5 papers have been selected for presentation covering major parts of the different aspects limited, however by outside constraints.

The first paper for presentation 3_41-CH will give an overview of the new business processes for distribution companies, answering the question how control centers can be built in order to deal with this rapidly changing process and protect the short and medium term investments in data, application programs and other resources.

The overall system techniques, such as architecture and interfaces, as well as optimization of new business processes are described. Implementation experiences of a workflow automation tool for a control room operator in an integrated network management and geographical information system are indicated.

Another paper from overseas 3_37-US discusses also business process automation perspectives and enterprise application integration and the role of standardization efforts.
The main design aspects of the information system for a distribution automation (DA) system, resulting from a completed feasibility study for one of the largest metropolitan areas in the world is the second paper for presentation 3_34-US/MEX. This will include 8 distribution network operation centers for an area serving around 5 million customers and consist of basically two different types of system architecture using partly existing and new platforms for the reliable, safe and efficient operation of the 23/13.2/6 kV distribution network.

The benefits achieved by network automation in such a metropolitan urban centers in Europe are described in paper 3_27-UK from London as one of the frontrunners in the deregulation process with impressive progress in improvements of supply quality over the last 5-year period indicated. The key drivers, lessons learned and benefits delivered together with an outline of future developments, challenges and expectations are summarized.

As an example for a newly realized distribution management project (DMS) in South America the next presentation deals with one of the most integrated DMS systems, put in service two years ago 3_33-KOL/D for the city of Medellin with some 42.000 distribution transformers. For the DMS the main applications together with the experience implementing the geographical information system (GIS) interface are described, as well as the integration experience of several makes with different communication protocols. Special criteria for selection of the feeders to be automated were applied and data acquisition strategies as well functionality's are described, together with resulting improvement of performance indices.

Other projects in North-America are described in paper 3_35-US where the different stages of implementation for advanced DA in US utilities are indicated and main characteristics of distribution operation model, as well as fault location, isolation and service restoration functions and voltage and reactive power control with the resulting improvements are shown.

Returning to Europe again we find various other examples, such as in 3_36-F from Metz, resp. 3_40-I from Milano and 3_29-UK from Northern Ireland, ranging from remote control systems for the whole range of 225 kV to low voltage in France with network calculation and quality management to trouble management system in Belfast.

Another modern DMS for a large regional company with 132/33/11 kV for 2 million customers is described in paper 3_28-UK, where the logical architecture, functional components for the different business functions are described and extensive use of common object request broker architecture (CORBA) is made.

The fourth presentation will be made for paper 3_30-P from Portugal where component based architecture is used and more CORBA user experience will be outlined for a new generation of distribution control center for some 5 million customers. Besides software architecture overview main software concepts of the distributed event bus, the stepwise approach with a configuration overview and the future implementation program are described.

Different experiences from other foreign countries, such as Malaysia, where interfacing work between substations is considered in paper 3_31-MAL, resp. a novel micro-SCADA system has been developed locally for middle Egypt in paper 3_39-EG, or the organization of distribution dispatching in developing countries is described for the Teheran area in paper 3_32-IR, serve for completing the multi-facetted picture around the world with a glimpse to some near and far eastern countries.

The last presentation 3_38-YU will come from another south-eastern country, where power applications, an integrated system of 25 different software modules, is considered as very essential basic component for DMS besides the data base and SCADA parts. Besides preparatory and analysis applications there are basic and composite ones and 4 different main modes are identified covering operation management, operation planning, development planning, and finally the group of analysis, simulation and training. Besides 2 development centers, 7 Serbian utilities using parts of these applications, as well as Italian and Brazilian customers are indicated and experiences and benefits expressed in absolute and relative amount and monetary values as far as possible.

The following questions emerge from the papers of group D:

- Are there figures about the cost/benefit relation regarding DMS installations available?
- To which extend will network management system be used for low voltage systems?
- How can workflow automation tools be adjusted to changing maintenance policies?
- Where will be in future the border line between energy management and distribution management?
- How can loss optimization be performed in deregulated surrounding?