Special Report - Session 3
OPERATION, CONTROL AND PROTECTION

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Introduction

The number of 193 abstracts received for Session 3 of Cired 2007 underlines impressively the still growing interest in Cired and especially in the matters covered by Session 3. Compared to former Cired-Conferences the trend of receiving about 10-15 % more abstracts every two years is still continuing. Due to the extreme high number of abstracts received for Session 3 Chairman and Rapporteur had to be quite strict in rejecting papers in order to keep quality and a manageable number of papers during the conference.

Out of these abstracts 116 were accepted by National Committees and Technical Committee (TC) and the authors were called to submit a full paper. Finally 104 full papers have been accepted for Session 3. An overview of the review process gives Figure 1.

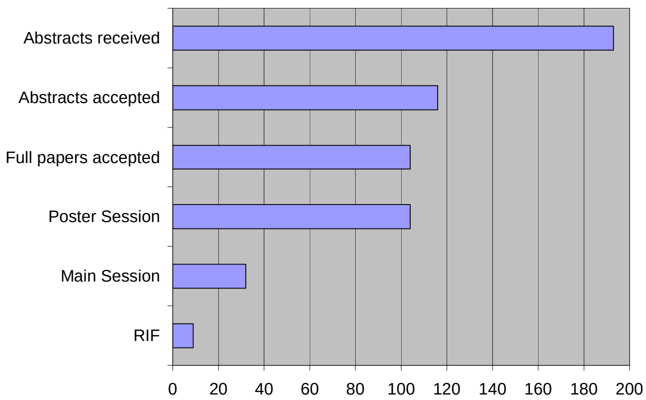


Fig. 1: Review process

The authors of all finally accepted papers are asked for a poster presentation, 32 of them will be additionally presented in the Main Session and nine more academic papers are allocated to the Research and Innovation Forum (RIF).

The subject of the session is structured in three blocks which are subdivided by topics originated from the main focus of the papers presented.

Block 1 Operation

- Distribution Management
- Maintenance/Workforcemanagement

Block 2 Control

- SCADA/Applications
- Distribution Automation
- Communication/ IEC 61850
- Data Management/Safety

Block 3 Protection

- Earth Fault/Neutral Earthing
- Settings/Application
- Distributed Generation

The tasks covered by the papers have changed slightly compared to former Cireds. While there are still a lot of papers dealing with “classic” Session 3 maters like how to find high impedance earth faults or how to build up more efficient SCADA-systems, several new aspects are getting more and more into focus driven by novel technical developments or regulatory impacts.

As an example for changing tasks the number papers dealing with the operation, control and protection of grids with a lot of distributed generation is constantly growing. Nearly all papers in this sub block deal with the problem how to establish protection schemes which are able to handle the new requirements of generation feeding directly into distribution grids.

Another trend is the rising number of grid operators optimizing the efficiency of their workforce due to workforce-management systems. Five papers and an additional round table cover this important task.

All papers dealing with communication present applications of the new standard IEC 61850. While at Cired 2005 there was only one “pioneer”-paper dealing with IEC 61850 the high number of Cired 2007 papers and the round table show impressively how the standard is proceeding to be established in Europe and worldwide.

Completely new in Session 3 is the sub block data management. The papers of this sub block deal with the integration problem of various IT-systems and keeping consistent data bases for the different operational aspects.

An overview of the number of papers related to the different blocks and sub blocks is given in Figure 2.

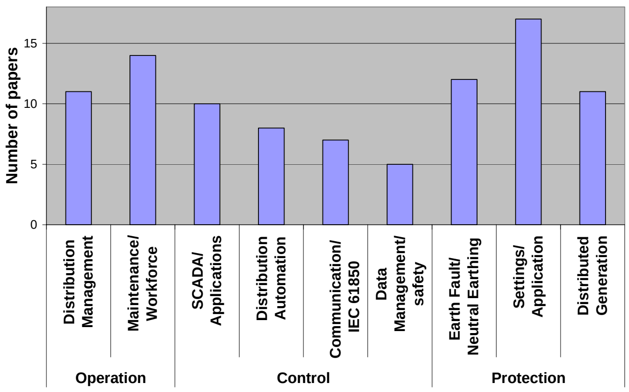


Fig. 2: Overview of the accepted papers

The majority of papers is prepared by groups of authors. In some cases these groups are composed of authors from different countries and even continents.

The papers are reflecting

- the experience of large and small grid operating companies,
- new products and strategies of manufactures,
- applications of scientific developments to practical grid operation business and
- new scientific research results presented by universities and research associations.

Block 1: OPERATION

Distribution Management

The first block contains eleven papers which deal with several quite different aspects of distribution system management. A wide field of tasks from data collection to loss reduction is covered by these papers.

It starts with two large collections of reliability data getting more and more important in a liberalized market.

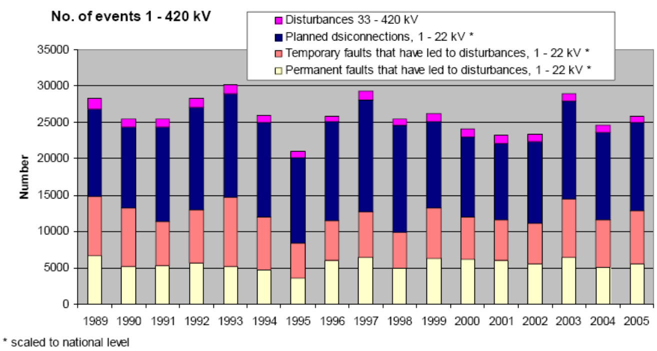


Fig. 3: Number of events 1 kV-420 kV, Norway

Paper 22 presents a useful collection of incident data in the Saudi Arabian transmission system in order to define and prevent potential causes of supply interruptions. A large data base collected in Norway for the last 15 years to observe the quality of supply in a liberalized market is shown in paper 801. The main result gathered from this impressive data collection is, that the number of incidents and the number of supply interruptions did not change significantly during the last years (compare Figure 3), while the energy not supplied (ENS) is decreasing (Figure 4) since the mean interruption duration decreased during this period of time.

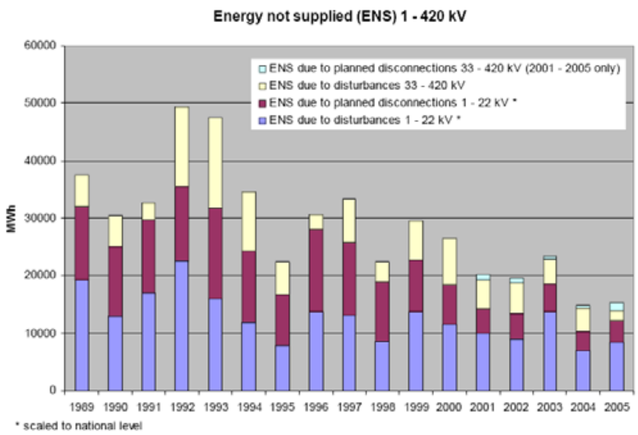


Fig. 4: Energy not supplied 1 kV-420 kV, Norway

Paper 44 presents the special situation of parts of Eastern Germany with lots of wind power feeding directly into the Medium Voltage (MV)-grids. A security management approach is given to reduce the distributed wind power injection in case of expected overload or imbalance of the grid.

The next paper 112 deals with rapidly growing grids to solve the enormous increase of power demand in China. Such rapid development needs management systems which combine special kind of load forecasting, grid structure dynamic analysis as well as reliability calculations.

Paper 151 is a joint paper from the Netherlands, U.K. and Canada which presents the effects of manifold local interpretations of several operational safety aspects (e.g. interlocks) and their influence on the design of MV substation equipment.

Paper 451 from the U.S. reports on the validation of a high-fidelity transient model of an existing wind farm with directly connected fixed-speed induction generators implemented on a real time digital simulator. As an example in Figure 5 the power and the reactive power calculated by the model are compared to the real values. For most calculations the simulation and the reality meet quite well.

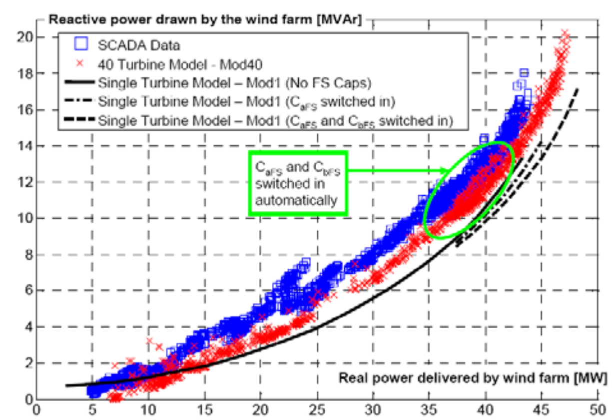


Fig. 5: Comparison of simulation results and SCADA data

In paper 625 a Swedish approach to develop and validate a business process model for outage management is presented.

Paper 719 (Germany) describes how system losses can be reduced by optimising the circuit states in typical 110-kV urban distribution grids under different load and generation configurations. Depending on the configuration up to 20% of the losses can be saved without reducing reliability of supply and within the allowed short circuit limits. Figure 6 gives the chronological sequence of system losses for different circuit states.

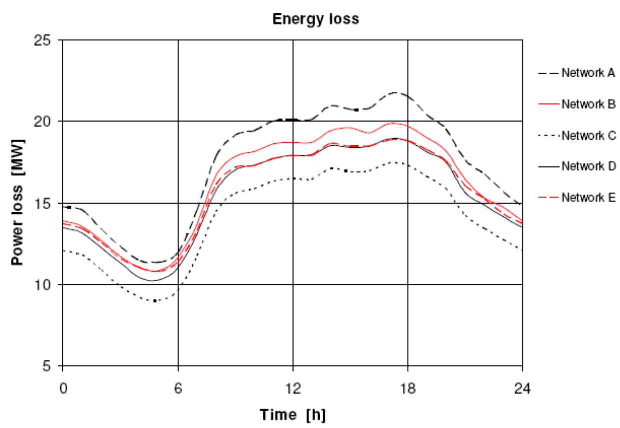


Fig. 6: Chronological sequence of system losses for different configurations

Paper 840 gives the experience of a Brazilian grid operator with serial compensation in 23-kV distribution grids.

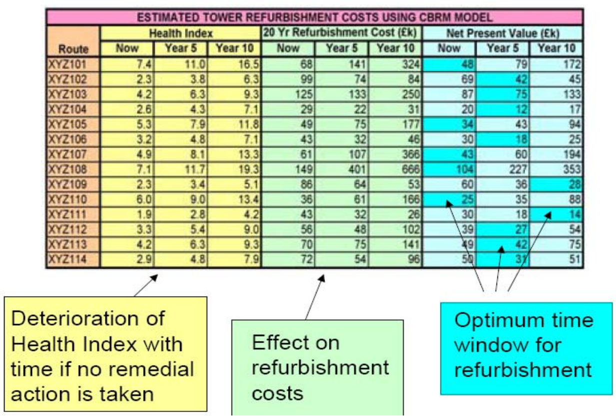
In paper 899 from Italy an approach for thermal protection of overhead lines is shown. It combines the prediction from a thermal model with an adaptive correction algorithm, which is continuously adjusted by field data acquired through fibre optic sensors.

Finally paper 909 presents an analytical evaluation of a 110 kV overhead line in Austria. Footing resistance, shielding angel and lightning activity are investigated to improve the power supply performance. As a result the rearrangement of the overhead line systems led to a significant decrease of outages caused by lightning strikes.

Maintenance/Workforcemanagement

The first part of this block deals with different types and variations of maintenance strategies. Most network operators do not carry out time based maintenance anymore, but have changed their strategies to condition based maintenance (CBM) or even more advanced to reliability centred maintenance (RCM) or risk based strategies.

Starting with CBM paper 510 presents a special approach of CBM for insulators. Test systems which measure the leaking current of several insulators and concluding from the results on the pollution of the insulator have been installed in areas of Italy which have heavy air pollution. Based on the pollution measurement of the insulators maintenance action (cleaning) in the affected region is carried out sooner or later. Paper 658 (Italy) gives an overview of the CBM approach and the maintenance management system used at Enel Distribuzione to reduce the overall maintenance costs and to improve the quality of supply. Paper 209 presents a method of an Egyptian network operator which uses data collected from the SCADA-system to optimize the maintenance of MV circuit breakers and cables. Paper 243 from the U.K. follows a paper presented at Cired 2005 about how to collect condition data of High Voltage (HV) towers effectively by helicopters and calculate a health index as well as an optimum time for refurbishment (Figure 7). The new paper shows practical experiences from a large case study where the method described before was used and its influence on the health index model.


ESTIMATED TOWER REFURBISHMENT COSTS USING CBRM MODEL

Route	Health Index			20 Yr Refurbishment Cost (£k)			Net Present Value (£k)		
	Now	Year 5	Year 10	Now	Year 5	Year 10	Now	Year 5	Year 10
XYZ101	7.4	11.0	16.5	68	141	324	48	79	172
XYZ102	2.3	3.8	6.3	99	74	84	69	42	45
XYZ103	4.2	6.3	9.3	125	133	250	87	75	133
XYZ104	2.6	4.3	7.1	29	22	31	20	12	17
XYZ105	5.3	7.9	11.8	49	75	177	34	43	94
XYZ106	3.2	4.8	7.1	43	32	46	30	18	25
XYZ107	4.9	8.1	13.3	61	107	366	43	60	194
XYZ108	7.1	11.7	19.3	149	401	666	104	227	353
XYZ109	2.3	3.4	5.1	86	64	53	60	36	28
XYZ110	6.0	9.0	13.4	36	61	166	25	35	88
XYZ111	1.9	2.8	4.2	43	32	26	30	18	14
XYZ112	3.3	5.4	9.0	56	48	102	39	27	54
XYZ113	4.2	6.3	9.3	70	75	141	49	42	75
XYZ114	2.9	4.8	7.9	72	54	96	50	31	51

Fig. 7: Condition assessment of HV towers

The CBM strategy of HV and Extra High Voltage (EHV) grids presented in paper 538 (Austria) uses online SCADA-system information as well as additional fault data. Both data pools are combined to estimate components condition which gives the maintenance priority (see Figure 8)

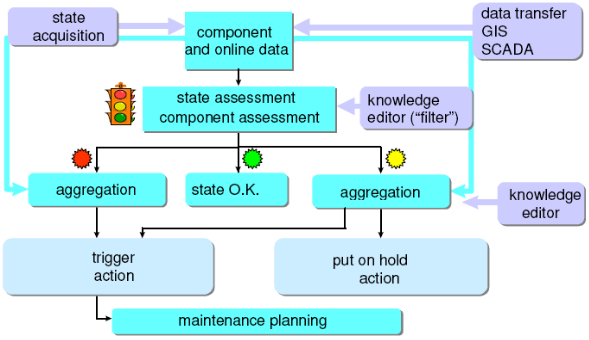


Fig. 8: Decision making process for CBM

As special aspect of CBM the vegetation management, that is how often and in which way trees in the surrounding of an overhead line have to be cut in order to prevent short circuits, is discussed in paper 422 (France), which gives a method used in the New York area, and in paper 598 from Argentine. Finally in paper 867 (Brazil) monitoring techniques for HV equipments that include fixed series compensation are used to support CBM of these components.

Paper 119 from Serbia presets a special kind of RCM. The components with the lowest reliability are identified based on the common reliability indices gathered from statistics and measurements of modern diagnostic devices. The maintenance activities are focused on these low-performing components. Paper 492 from Norway defines a risk based maintenance strategy as a further development of the RCM approach. Four goal categories -economy, safety, quality of supply and reputation- are covered by the risk matrix.

In the second part of this block four papers deal with different practical applications of workforcemanagement (WFM) systems.

Paper 34 from Italy states that workforce management systems are the key driver of optimization and performance improvement for grid operating companies. Several aspects and implementation problems of the WFM system designed by ENEL for about 8,000 field engineers are discussed. Paper 286 (Finland) presents a method to make grid inspections more efficient by collecting data with mobile devices. No paper collection is needed anymore since the data is transferred automatically to a central data base after connecting the mobile device. Paper 645 from Sweden presents a WFM project of Vattenfall grid operator. It shows several lessons learned from the implementation of mobile processes and techniques. Paper 789 from Brazil shows details on how Personal Digital Assistants (PDA) are used to access and exchange information from remote places.

Finally paper 67 (Italy) describes the successful implementation of an efficient fault and emergency management system –a special type of WFM-system- as well as its integration into the IT environment. Five million customer calls per year using a free phone number are handled and dispatched by 28 operational centres all over Italy. All incoming supply interruption calls are displayed in a real time report of unsupplied substations which gives an overview of Italy's supply situation (see Figure 5) at all times especially in case of large black outs due to adverse weather conditions.

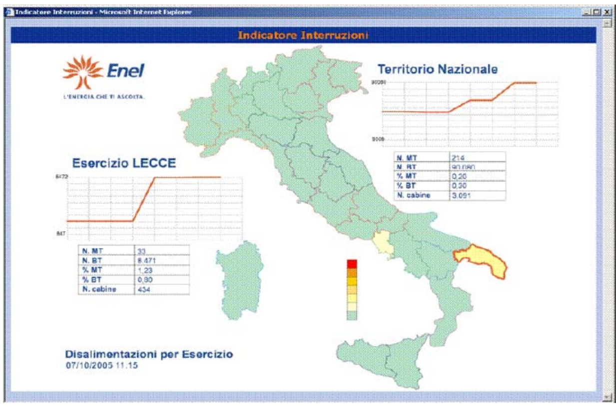


Fig. 9: Overview of Italy's supply situation

Questions Block Operation (1)

1. Is there a general relationship between investment or maintenance strategy and customers' quality of supply? How can this relationship be described?
2. How about the cost-benefit relationship of advanced maintenance strategies? Is there a payback for the high afford of data collection ?
3. Can the cost-benefit relationship for network operators for the implementation of workforce management system be determined in general? What dimension can the savings reach?
4. How will the implementation of workforce management systems change the common operating processes in network operating companies?
5. Which degree of mobile network operation can be reached and which degree is useful?

Table 1: Papers of Block Operation assigned to the Session

Paper No.		Title	MS a.m.	PS
No.	22	TRACKING TRANSMISSION SYSTEM PERFORMANCE WITHIN SAUDI ELECTRICITY COMPANY (SEC) NETWORK		X
No.	34	Enel Work Force Management System		X
No.	44	Solutions to integration of wind power in distribution networks		X
No.	67	EMERGENCY MANAGEMENT: AN ADVANCED TROUBLE CALL SYSTEM		X
No.	112	Management Practice On A Speedily Developed Distribution Network in Shanghai	X	X
No.	119	One new approach to maintenance of electrical power equipment in 110/x kV substations		X
No.	151	Effects of local interpretations of operational safety in Europe and North America on design of IEC Medium Voltage Switchgear		X
No.	209	Optimizing maintenance and improving operation of distribution network based on SCADA Application Program		X
No.	243	Strategic Asset Management Of Electricity Distribution Lines Using Advanced Helicopter Inspection Techniques	X	X
No.	286	An XML-based mobile application for distribution network maintenance inspection		X
No.	422	Approaches to Vegetation Management		X
No.	451	Model Validation and Voltage Deviation Analysis of an Existing Wind Farm Using High Fidelity Real Time Digital Simulation		X
No.	492	Establishing maintenance standards following a risk based maintenance strategy	X	X
No.	510	Evaluation of the insulator surface pollution as a trigger for cleaning operation	X	X
No.	538	Involvement of SCADA event and fault data into the condition based maintenance system for EHV- and HV-network of Wien Energie Wienstrom	X	X
No.	598	Mitigation of level of incidence and frequencies for Short cuts		X
No.	625	A Standard Based Approach to Power Operation and Control Process Evaluation		X
No.	645	Mobile workforce Vattenfall		X
No.	658	Maintenance management system for electric installations in Enel Distribuzione	X	X
No.	719	Loss Reduction in an High Voltage Urban Distribution System	X	X
No	789	Operation information management using mobile network		X
No.	801	Trends in quality of supply in a liberalized electricity market	X	X
No.	840	AES Sul’s Experiences Using Series Compensation on Distribution System		X
No.	867	High Voltage Equipment Monitoring: a tool for fixed series compensation preventive maintenance in power systems		X
No.	899	Integration of Satellite technologies and Learning techniques for Wide Area thermal Protection Systems		X
No.	909	Possibilities and remedial measures to reduce lightning caused outages in a distirbution network	X	X

Block 2: CONTROL

SCADA/Applications

Six papers of this block give practical applications of grid operators replacing their old fashioned SCADA-systems by modern ones and all the problems related to these changes.

Paper 32 from Italy shows how Enel is performing the transition from its stand alone SCADA-system to an enhanced Distribution Management System (DMS), capable of optimizing and integrating all current processes and able to meet regulatory and operational requirements. Enels 28 control centres spread all over Italy (Figure 10) can handle an extreme complex grid, managing not only traditional grid operation, but also extended applications like collecting quality data, dispatching crews in the field, supporting maintenance strategies and cooperating with other grid operators in emergency situations.

Fig. 10: Distribution of Enels control centres

Paper 131 presents the experience of an eastern Romanian grid operating company in the development of its SCADA-system. Especially local SCADA solutions are compared to an integrated system for the whole supply area. Paper 470 deals with the experiences of a recent project in Andorra, where two legacy systems are replaced by a new combined SCADA/DMS-system. The principal configuration of the system is shown in Figure 11.

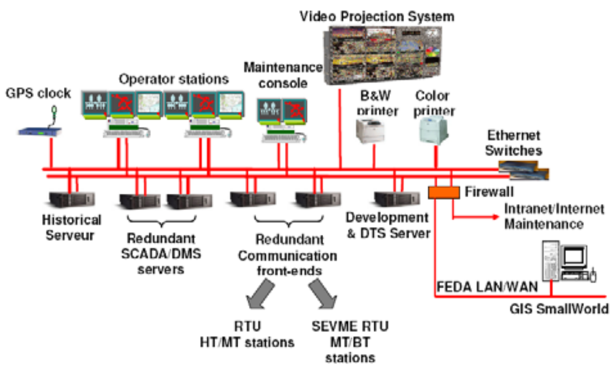


Fig. 11: Hardware configuration of Andorra's SCADA/DMS-system

Paper 628 presents a replacement and enlargement project of the SCADA-system of Crotias' four biggest control centres. The problem was how to transfer all existing communication from the old to the new system without loosing control over the system. The solution was a new, specially developed communication interface. During major disturbances, dispatcher staff in control centres is overloaded by alarm messages produced when automatic controls operate to clear faults. Paper 338 from France presents an intelligent alarm processor based on an innovative method which provides a fast and deterministic analysis of events. The method has been installed in several control centres worldwide; in the paper the implementation of the framework in the distribution control centre of Qatar is shown. Paper 381 (Belgium) describes the replacing of old despatching system solutions by modern ones in several large chemical plants all over Europe. The overall concepts, the forecast and load-management applications as well as the innovations in the control centres are explained.

Paper 90 from China presents an application which uses on-line information from the SCADA-system to enhance the accuracy of theoretical line loss calculations and therewith to reduce the workload of control centres' staff.

In paper 199 (Spain) an intelligent system to automate the deployment of capacitor banks and transformer taps is shown. It is part of a larger system to improve grid operation by foreseeing future network states and provide appropriate control actions.

Paper 619 from Germany presents the method of self-describing power grids to develop automated network management systems. The information of design and state of the considered system is not held in a centralized database, but each component has its own intelligence and is able to register in the grid autonomously and publish information about its position, services and data (Figure 12) Web technology is used to link the autonomous components together.

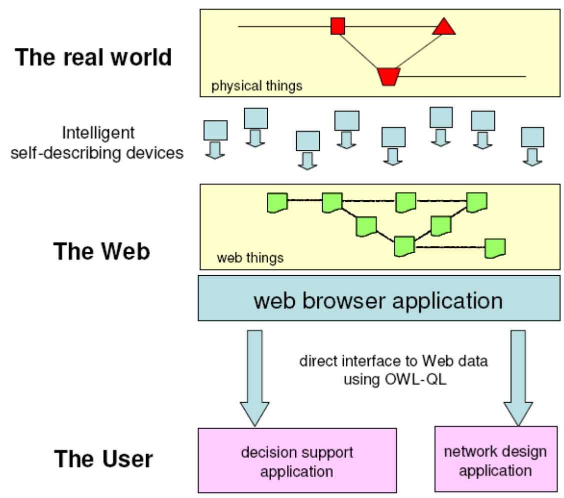


Fig. 12: Self-describing power grids

Paper 622 (Brazil) discusses security risks of Control centres due to the connection of SCADA-systems and corporate networks or even the Internet and draws some conclusions how to overcome these risks.

Distribution Automation

Most papers allocated to this block deal with the struggle of grid operators to improve their reliable of supply and especially to reduce customers' durations of supply interruptions by automating MV- and even LV-grids

Paper 17 presents the Portuguese LAIT-project to improve customers' quality of supply and especially the interruption duration by automation of the MV-grid. The aim until 2006 was to restore supply in case of an MV-failure in about 25% of the MV-feeders in less than 3 Minutes at least in the very dense urban areas of Lisbon. Paper 29 from Italy states that the contribution of Low Voltage (LV)-grid to the total customer supply interruption duration it's constantly growing. Therefore remote control of LV-grids is getting more and more interesting. First operational experience of four pilot grids automated with motor driven LV circuit breakers is given. In paper 49 a new fault isolation and restoration technique for looped MV circuits employing local Ethernet network is presented. The authors promise to isolate all short circuit faults within 200 ms and restore the supply of the healthy section in less than 2 seconds. Paper 144 (Malaysia) highlights the experience in the implementation of a MV feeder automation system which brings drastic improvement of the restoration time in case of MV failures. The average interruption duration index (SAIDI) for MV grids was reduced from more than 4 hours to about 15 minutes. Finally paper 278 from Egypt suggests a combination of automatic line reclosers, sectionalisers an limit fuses to reduce restoration time in MV-grids significantly.

The objective of paper 426 (Korea) is to monitor power quality problems using distribution automation systems. The authors developed several kinds of remote terminal units (RTUs) to monitor power quality aspects in the substations and transmit them on-line to the SCADA-system.

The quite visionary Paper 565 (France) describes the possible roadmap in terms of distribution automation and new tools and equipment that will be needed in the control centre, in the substation and at the distributed generation facilities within 5, 10, and 20-25 year time frames. On the long term a more local treatment of distribution control functions and a more integrated optimisation of load and generation flexibilities at the local level are expected

Paper 584 from Nigeria presents an algorithm and a device to choose the most steady one out of three possible LV-phases.

Communication/ IEC 61850

The new communication standard for substations IEC 61850 strongly forced by the manufacturers is getting more and more established in grid operating companies. So nearly all papers of this block deal with opportunities, problems and practical applications of the new standard.

Paper 6 from the Netherlands shows conformance tests for IEC 61850 standard communication. It focuses on the purpose and value of conformance tests and describes contents and objectives of a testing program. In paper 77 (Slovenia) IEC 61850 is used to dislocate several components of the protection and control system of a distribution grid substation in order to save redundant components (Figure 13).

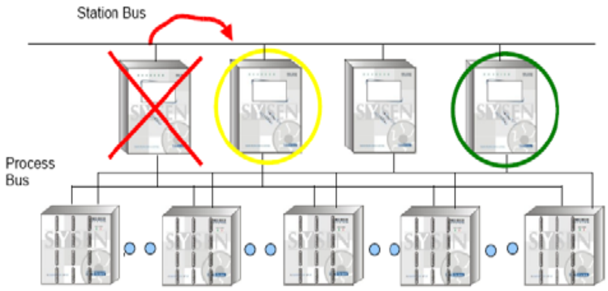


Fig. 13: Clustering of redundant components

Paper 147 from Spain makes a proposal on how to design teleprotection devices according to IEC 61850 standard, while paper 602 (China) uses the new standard to realize interlocking in substation automation systems. In paper 839 an Austrian network operator presets his 'lessons learned' from a remarkable number of substations implementations (see Figure 14) according to the new standard IEC 61850. The main lesson is that it is still a long way to reach the standards' goal 'interoperability'.

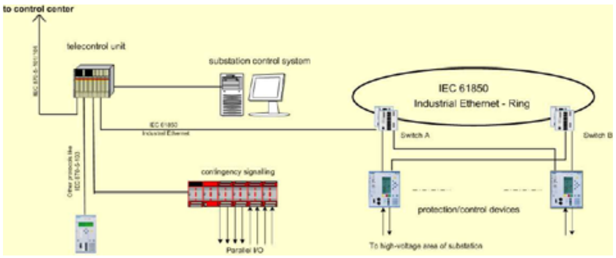


Fig. 14: TIWAG-Netz IEC 61850-Implementation standard

Paper 875 (Austria/U.S.) analyzes the IEC 61850 object models of multifunctional distribution protection relays. The functional hierarchy, protection and non-protection functions are described. A single logical device and multiple logical device models are presented.

Paper 384 from China discusses advantages and disadvantages of existing communication techniques based on several practical applications.

Data Management/Safety

The integration and consistency of several data bases and IT-applications for different purposes like grid planning, control, operation or workforcemanagement is getting more and more complicated for grid operating companies since their number and extend is constantly growing. Most papers in this new block accommodate this issue.

Paper 130 (Belgium) presents the experiences gathered from redesign of different IT-applications at Siblga, which is the network operator of the Brussels region. The goal was to link the different systems (DMS, SCADA, GIS etc.) and data pools together to achieve a unified data base.

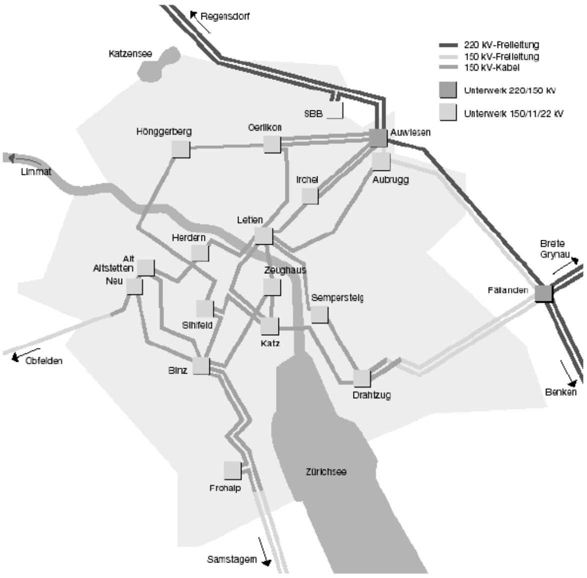


Fig. 15: Overview of Zurich's 150-kV grid

Paper 202 from Switzerland illustrates the experiences gathered from the implementation of a distribution management system (DMS) to the 150-kV grid of the city of Zurich (Figure 15). The main challenge was to integrate all different data sources and applications in the DMS. Figure 16 gives and overview of the whole IT-infrastructure linking together all sources and applications.

In paper 297 from the Netherlands a way is shown how online grid information derived from the SCADA system can be prepared easily for asset management decisions. Once again the important point is to link all available data together getting a full picture of the grid to take the right decisions. Paper 635 from Croatian deals with the primary problem in power system data management and exchange that is the wide variety of platforms, protocols and security technologies that need to be integrated. The goal is to define common modelling elements that can be mapped on a variety of technologies as needed. The paper provides some details of the technology proposed for implementation of standards for enterprise application integration within grid operating companies. It also deals with a real project of application integration in Croatian.

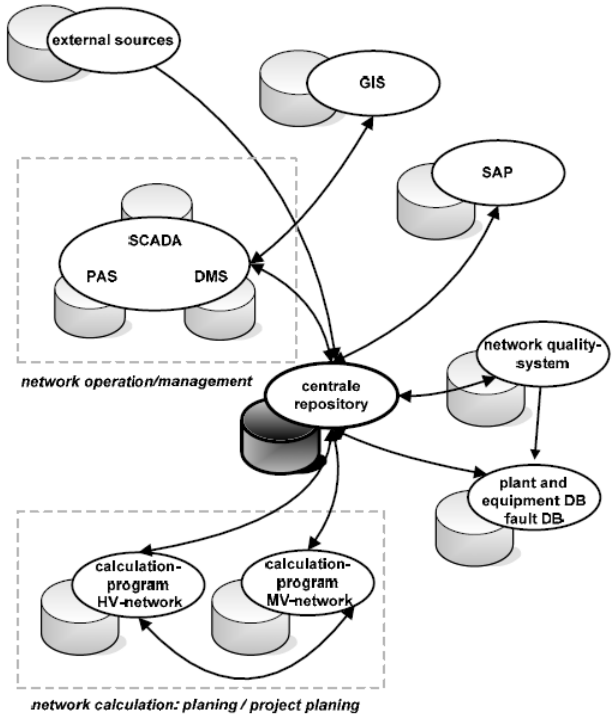


Fig. 16: IT-systems and data bases

Paper 262 from Italy presets a case study on different scenarios of critical aspects related to the role of information technology (IT) in the management of distribution grids. In detail the security of remote teleoperation and control functions, the interaction between grid operators in emergency conditions as well as the integration between process control and corporate activities are investigated.

Questions Block Control (2)

1. What is the cost-benefit relation for automation of MV-networks in developed countries? Is there a cost-optimal automation-level and is it close to the regulators point of few?
2. How can the relationship of networks' automation degree and customers' quality and reliability of supply be described?
3. Can an optimal number and size of network control centers be determined?
4. First experiences with IEC 61850. Is it worth the trouble?
5. How can the integration and consistency of several data bases and IT-applications be reached?

Table 2: Papers of Block Control assigned to the Session

Paper No.		Title	MS a.m.	PS
No.	6	IEC 61850: Role of conformance testing in successful integration		X
No.	17	Creating value for Clients and Shareholders guaranteeing a high level Service Quality (Project LAIT)	X	X
No.	29	Reduction of Supply Interruptions Duration by means of Low Voltage Network Remote Control: An Enel Distribuzione Experimentation		X
No.	32	Evolutions in the ENEL SCADA system	X	X
No.	49	Fast Fault Isolation and Restoration of Looped Distribution Network		X
No.	77	Dislocating I/O-s and CPU-s on the LAN enables new features of the substation protection and control system		X
No.	90	Develop and Application of Network Real Time Theoretical Line Loss Calculation and Analysis System		X
No.	130	DMS,Scada and GIS interactions redesigned while renewing the GIS legacy system.	X	X
No.	131	An east-European utility company’s approach in the SCADA/DMS systems development		X
No.	144	Experience In The Implementation Of A Feeder Automation System Using Wireless Dial-Up	X	X
No.	147	Using IEC 61850 for Teleprotection		X
No.	199	ICONO - Intelligent COntrol Network Operation		X
No.	202	Key issues while implementing a DMS Return of experience from a large municipal utility	X	X
No.	262	Emerging Information Technology scenarios for the control and management of the distribution grid		X
No.	278	Improving Distribution System Reliability Using Distribution Automation based on Coordination between Auto-Recloser , Sectionaliser and limit Fuses		X
No.	297	Bringing grid information into the office		X
No.	338	Intelligent Alarm Processor for DMS based on “chronicle” concept		X
No.	381	Innovative Dispatching System based on TCIP for Industrial and Utility Application		X
No.	384	New Communication Mode for Distribution Substation Monitoring		X
No.	426	Power quality monitoring of distribution networks using distribution automation system		X
No.	470	A new Distribution Management System for Andorra’s grid	X	X
No.	565	Roadmap for New Requirements for French Distribution Control and Automation	X	X
No.	584	A model of an Automatic Phase Switch		X
No.	602	A Multi-Agent Based Logical Interlocking in substation automation systems		X
No.	619	Intelligent Self-describing Power Grids		X
No.	622	Security Aspects of Information Exchange in IT/AT Networks Interconnections of Electrical Transmission and Distribution Facilities		X
No.	628	New Distribution Control Centres in Croatia	X	X
No.	635	Architecture for Integration of Power System Applications	X	X
No.	839	Risks and benefits for the implementation of IEC61850		X
No.	875	IEC 61850 Object Models of Multifunctional Distribution Protection IEDs		X

Block 3: PROTECTION

Earth Fault/Neutral Earthing

The first two papers of this block deal with the control of Peterson coils in compensated grids. The control method by injection of two different frequencies was already presented at the last Cired. Paper 89 gives an update of the work on this method and presents two real applications. A similar method presented in paper 120 (Austria) determines resonance point, zero sequence grid parameters and earth fault current in compensated grids. Therefore a Dirac-like pulse is injected into the zero-sequence system to calculate the earth admittance spectrum and the zero sequence parameters. Based on the spectrum the maximum of an earth fault current can be predicted.

Paper 129 from France describes the zero-sequence protection scheme of EDFs MV distribution grids and gives a feedback from the field on its effectiveness. Furthermore the paper analyses the impact of discontinuity of cable screen earth connections on unexpected tripping of zero sequences watt metric relays and gives some recommendations on how to identify and localize cable faults.

Three papers discuss the best neutral treatment for different types of MV-grids. The objective of paper 289 (China) is to find the most suitable neutral grounding method for the system according to the present situation of Henan power grid. The authors suggest a combination of neutral arc-suppression coil and resistance grounding method to be the most suitable. This combination does not only overcome the well known limitations of the resonant grounding method and the resistance grounding method, but also has inherited their superiorities. Paper 683 from Germany discusses several neutral treatment options for a 25 kV power supply system of a huge open cast lignite mine. Due to the ongoing mining the structure of the 25 kV grid changes quite often (e.g. portable transformers are used, Figure 17) and short circuits have to be cleared fast and reliable. The final decision was a current limiting neutral earthing.

Fig. 17: Portable 25-kV-transformer

In paper 699 (Austria) a new approach for innovative neutral point treatment in compensated grids is presented. The innovative principle consists in the combined use of additional neutral point resistors and special distance protection relays. The resistors are activated for a certain limited time in order to achieve low touch voltages at the earth fault point. Results from field tests in MV- and HV-grids prove the suggested solution.

Paper 345 from Portugal determines settings for the earth fault relays regarding the human safety aspect. Several situations that can endanger human safety being close to electric distribution equipment are analysed and a correlation between fault currents and fibrillation thresholds for persons are derived. The authors' result was that earth fault relaying should consist in a 2 step protection with a first step set to clear faults with low currents with no special constraints on time and a second step set up for higher currents in less than 0,2s. This is considering the human safety aspect.

Three papers cover the problem of detecting and locating earth faults in MV-grids. The objectives of paper 373 (Finland) are to show the key factors decreasing the earth-fault location accuracy of the traditional distance relay type of algorithms and to introduce a new algorithm as a solution for the problem. Computer simulations are used to illustrate the behaviour of the grid models and the new algorithm. Field test recordings from a real grid (configurations shown in Figure 18) are used to validate the simulation results.

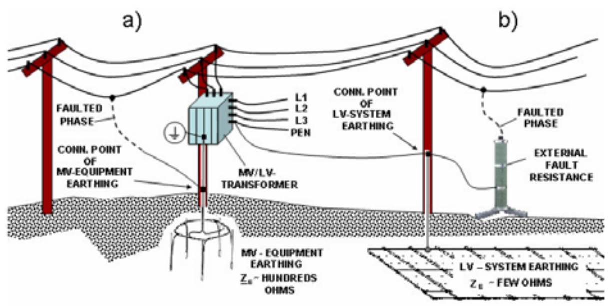


Fig. 18: Schematic presentation of fault impedance configurations

Paper 398 (Poland) deals with the problem of undetectable faults occurring in MV grids with substation's protection, especially with open phase or open phase with simultaneous phase-to-ground in overhead line wires. These faults can be detected in MV/LV-transformers at the LV-side and localized by a distributed measurement system. Finally in paper 591 from the Czech Republic artificial neural networks are used for earth fault localisation in MV-grids.

Paper 696 from the U.K. deals with on-line fault location in LV-grids. The goal is to reduce the inconvenience and costs of intermittent LV cable faults by providing a practical and easy to handle application for use by non-specialist field workforce. A high success rate has been achieved at Scottish Power with the on-line fault locator application.

Paper 876 from the U.S. presents a high impedance fault detection system that is integrated in a standard feeder protection relay. The input signals are filtered and processed by special detection algorithms for high impedance faults. The new technology seems to work, since it is proven by many successful field tests.

Settings/Application

This block starts with three papers investigating the detection of downed or broken conductors. In paper 23 from Portugal the effectiveness of different current methods for detecting broken conductors is evaluated. The authors conclude that negative sequence current based relaying is less effective than the traditional zero sequence currents based approach to detect these faults. Only for broken lines not touching soil and carrying significant load currents negative sequence based protection provides some improvement. Paper 571 from Norway aims to verify detection of all types of downed and broken conductor faults of MV overhead lines, including broken loop, back-fed fault and blown MV fuse. The method is based on voltage imbalance at the LV-side of the MV/LV-transformer as shown in Figure 19.

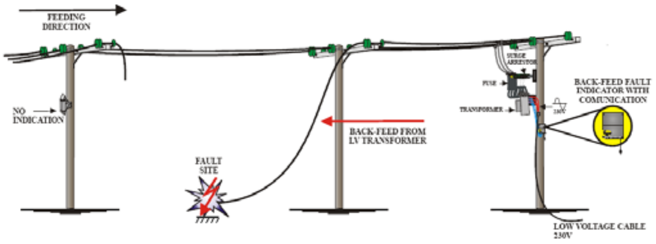


Fig. 19: Back-fed earth fault not detected by the feeder protection

Emphasis must be put on communication to ensure fast and reliable detection and location via the SCADA system. In paper 623 from Greece current unbalance protection, which can be easily incorporated in standard earth fault overcurrent protection schemes, is used successfully to detect broken and downed MV-conductors.

Paper 46 (U.K.) analyses fifteen years of experience in numerical relays, particularly lessons learnt on their commissioning, operation, maintenance and de-commissioning. Advantages and possible errors, which can be entered into a power system with implementation of numerical relays, are discussed.

Paper 56 from the U.S. presents advanced differential protection schemes for power transformers, generators and busbars using Rogowski coil current sensors and multifunction relays. As illustrated in Figure 20 Rogowski coils are linear (do not saturated) and therefore can be applied at any fault current levels.

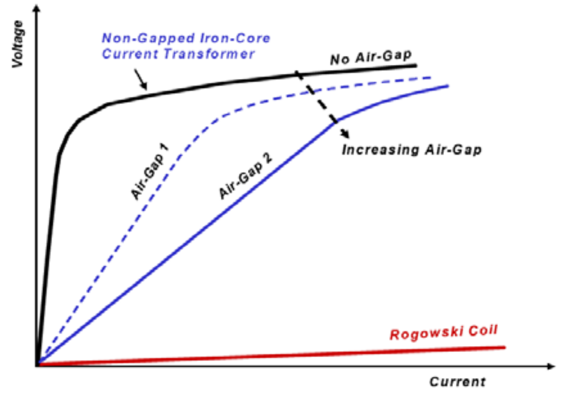


Fig. 20: Characteristics of conventional Current Transformers and Rogowski Coils

The next four papers deal with centralized protection devices which cover several protection functions of one substation or even a larger part of the grid. First paper 172 (U.K.) reports on the development of integrated protection for power systems in which a centralized protection system (or relay) provides the protection of multiple power plants or substations (compare Figure 21). A novel integrated protection scheme for distribution system based on overcurrent protection technique is described. Studies show that the new scheme does not only offer the new protection features for individual power lines, but also provides the characteristics of integrated protection.

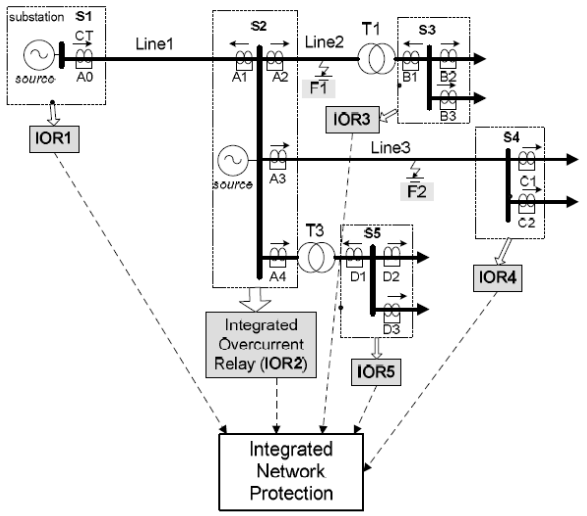


Fig. 21: Integrated protection scheme

Paper 346 from Spain shows in detail how distributed bay protection units can act as an integrated protection system for a substation including busbar differential protection. Paper 252 from the Netherlands presents Nuons' philosophy of 'sense and simplicity' to improve the quality of MV grids. The idea is that components which are not there can not fail and so improve the reliability of the system. One example for the philosophy is the implementation of the SASensor system that consists of two redundant computers which covers all control and protection functionalities in one substation. Finally paper 651 from Italy describes a new integrated system that provides all the functions to protect up to ten MV-feeders and to control a variable Petersen coil connected to the same MV-busbar using a single compact device. System features, performances, direct and indirect savings and first prototype applications are included

In paper 179 from the Netherlands a new evaluation method has been developed for the investigation of failure behaviour of electromechanical protection relays. It is a qualitative method based on failure mode effect and criticality analysis. Electromagnetic protection relays are ageing since they are no longer serviced to an “as new” condition.

Paper 288 from South Africa highlights the application limits of distance protection, whereby these relays fail to operate instantaneously for faults in zone 1 on short HV lines. With the use of known theory and operational patterns of distance relays, its limits are examined closely. In addition to that a case study is used to complement the theory.

Paper 350 (Brazil) presents a computational tool developed with the objective of automatically determining the adjustments of all protection devices in a distribution grid so as to obtain the best technical application, optimizing its performance and expediting the making of protection studies. Two extensive practical protection studies in Brazil have been carried through using the developed tool.

The purpose of paper 463 (Brazil) is to asses the influence of current harmonic components (mainly third-order components) on the operation of a three-phase distribution system at 34.5-kV, which employs as predominant load single-wire earth return systems.

Paper 615 (Canada) presents the results of a Voltage Drop-based Fault Location (VDFL) technique using remote power-quality measurement devices. So far, it has shown a very good potential for permanent and temporary-fault location on an overhead radial distribution system (see Figure 22).

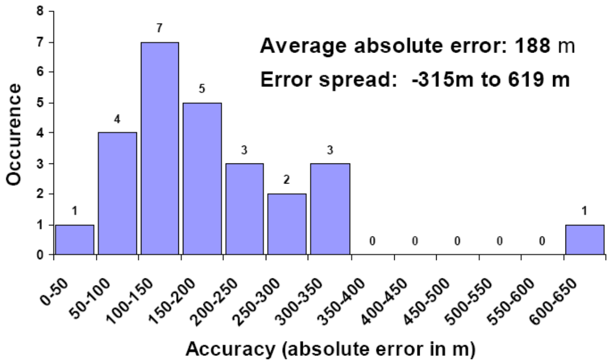


Fig. 22: Statistics on fault location accuracy

Paper 729 presents a real time performance analysis of numeric distance protection used in two 500-kV transmission lines of CEMIG (Brazilian Utility). Several types of faults and various conditions of the power system have been simulated.

Paper 739 from the U.S. describes how the existing infrastructure to monitor substations and power quality can be used to identify fault locations automatically and gives practical examples for that.

Paper 749 from the U.S. analyzes refurbishment strategies for the protection of distribution systems based on functional requirements, available devices, communication protocol selection and future technology trends. The impact of IEC 61850 and how legacy devices can be integrated in distribution protection systems based on the new standard are discussed.

Paper 757 (U.S.) analyzes the requirements and methods for load-shedding in distribution systems and discusses frequency and voltage based functions in protection relays. Centralized and distributed load-shedding schemes are described. The impact of IEC 61850 on load-shedding is considered as well. Special attention is given to the load-shedding during the Western Europe blackout in November 2006 (Figure 23).

In paper 908 (Austria) a case study of a rotor angle instability in a distribution grid is presented. Rotor angle instability can have a significant effect on the selective operation of protection relays due to rotating voltage and current phasors. Taking the case study simulation results into account the protection scheme can be extended to avoid non-selective tripping.

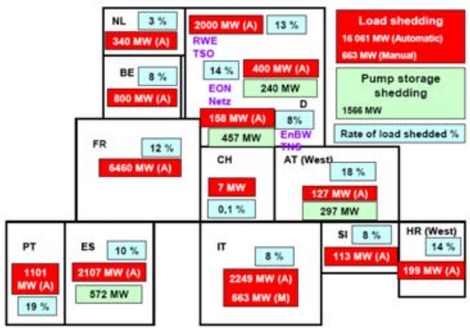


Fig. 23: Load-shedding during the Western Europe blackout in November 2006

Distributed Generation

This block consists of several papers which cover various aspects of the impact of more and more distributed generation feeding directly into the MV- or LV-grids on their operation and protection.

Paper 45 (U.K.) proposes the use of series braking resistors that are switched into circuit at the generator terminals as a means of improving transient stability, and thus avoid or at least defer major upgrades to distribution system protection.

Paper 75 from Belgium shows that significant margins exist for the penetration of distributed generation to prevent malfunctions of the protection system in today’s MV-grids. Figure 24 gives the main possibilities, mal-trip and fail-to-trip, of protection malfunction caused by distributed generation.

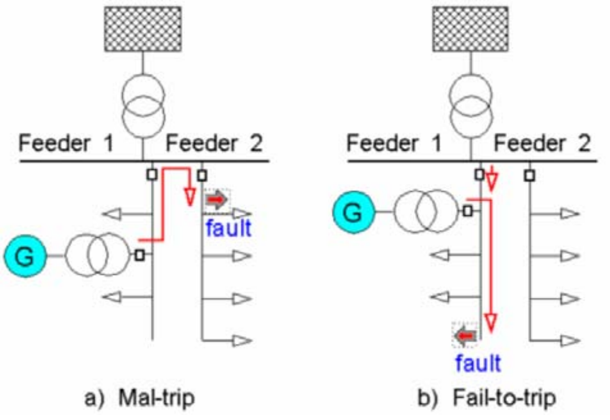


Fig. 24: Feeder mal-tripping

Paper 107 (Finland) analyses suitable solutions for earth fault protection with a lot of distributed generation in grids operated with isolated neutral which is typical for the Nordic countries.

Two papers deal with the complexity of fault location in grids with distributed generation. The goal of Paper 372 from Finland is to study fault type and location detection in microgrids with different control method based converters. An example of such a LV-microgrid is given in Figure 25.

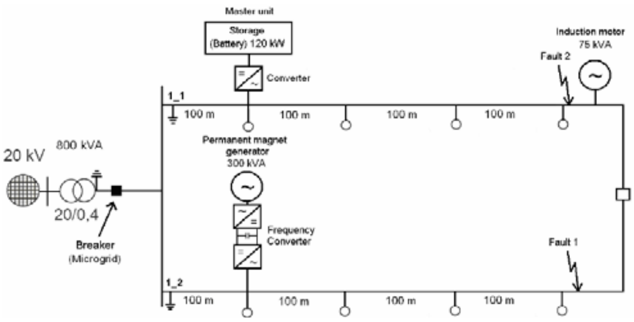


Fig. 25: Urban LV-microgrid

The authors conclude that fault location can be done, if all converters have the same control principle, so there is urgent need to implement standards or other regulations. Paper 723 (U.K.) describes a new relay that uses disturbances in the three phase voltages to provide reliable and fast detection of different types of faults within micro-grids.

Paper 461 presents the results of the European project FENIX to develop general concepts of virtual power plants. It focuses on the consequences for the distribution system operators and their need for active power system management.

Paper 527 gives a systematic overview of the various impacts on protection, control and operation when more and more distributed generation feeds into MV- and LV-netwoks.

Paper 535 from the U.K. deals with the penetration of distributed generation becoming widespread, a myriad of issues with an increasingly grid-wide scope arise, and have led to proposals for numerous techniques and devices to improve the management and operation of the grid. The paper introduces and describes an actual grid demonstrator, which will offer an environment to make distribution grid operators able to test and adopt the new techniques.

Paper 568 from Finland summarises the most important consequences to power system protection that have to be taken into account when more and more distributed generators feed directly into MV- or LV-grids. Especially the still unsolved 'Loss-of-Mains'-problem and its solution are discussed.

In paper 746 from China a theoretical method based on fuzzy judgement is presented to control voltage and reactive power in distribution grids with lots of distributed generation.

Paper 836 (Ireland) states that constraining distributed generation from contributing to voltage control means to ignore the possible benefits available from its participation. The results of a test system show, that distributed generation must not automatically cause voltage control problems, but can improve the voltage control in some situations if it is permitted to do so.

Questions Block Protection (3)

1. Each of the different neutral earthing methods offers benefits for the operation. Which method is the most suitable for mixed overhead line and cable networks?
2. Are their different neutral earthing philosophies best fitting for a specific overhead line/cable ratio?
3. Is there a general trend in Europe to change the MV-neutral policy towards more compensated network operation? How is the state of the art in different European countries?
4. What is the benefit of the presented new fault location algorithms compared with conventional algorithms?

Table 3: Papers of Block Protection assigned to the Session

Paper No.		Title	MS p.m.	PS
No.	23	Evaluation of protection approaches to detect broken conductors in Distribution Networks		X
No.	45	Applying Series Braking Resistors to Improve the Transient Stability of Low Inertia Synchronous Distributed Generators		X
No.	46	Numerical Relays - Where Are We Now	X	X
No.	56	Novel Differential Protection Systems for Improved Network Operation Reliability		X
No.	75	Effective Impact of DER on Distribution System Protection	X	X
No.	89	Operational Experiences with the New Method to Control Petersen Coils by Injection of Two Frequencies		X
No.	107	Impacts of distributed generation on earth fault protection in distribution systems with isolated neutral		X
No.	120	A new procedure for determining resonant point for arc-suppression coil tuning, network parameter and ground fault current in neutral point compensated power systems.		X
No.	129	EDF return on experience concerning zero-sequence protection scheme for MV networks		X
No.	172	An Integrated Protection Scheme for Distribution Systems Based on Overcurrent Relay Principle	X	X
No.	179	Evaluation of Failure behaviour of Service Aged Electromagnetic Protective Relays		X
No.	252	The power of simplicity	X	X
No.	288	Short Feeder Distance Protection and its Application Limits		X
No.	289	Appraisal And Research On the Combination Use of Neutral Grounding Measures for Distribution Networks		X
No.	345	Speed vs. Sensitivity in Earth Fault Protection regarding Human Safety in aerial MV Networks	X	X
No	346	Distributed bus differential relay becomes the complete integrated protection system for the substation		X
No.	350	Coordination and Automatic Selectivity of Devices Protection in Distribution Networks		X
No.	372	Fault Type and Location Detection in Islanded Microgrid with Different Control Methods Based Converters		X
No.	373	Advancements in fundamental frequency impedance based earth fault localization in unearthed distribution networks		X
No.	398	Identification and Location Open Phase Fault in the MV Network with Wireless Data Acquisition		X
No.	461	Innovative Operations with Aggregated Distributed Generation	X	X
No.	463	Analysis and Field Tests of the Influence of Harmonic Components for Protection Relay Currents on Single-Wire Earth Return Systems	X	X
No.	527	Changing Network Conditions due to Distributed Generation - Systematic Review and Analysis of their Impacts on Protection, Control and Communication Systems		X
No.	535	A Network Demonstrator for Active Management Devices and Techniques	X	X
No.	568	Loss-of-Mains Protection - Still an Issue with Distributed Generation		X
No.	571	Secure Detection of Downed and Broken Conductors		X
No.	591	Using of the Artificial Neural Networks to the Localization of the Earth Faults in Radial Networks		X
No.	615	Accurate fault location technique based on distributed power quality measurements	X	X
No.	623	High impedance fault detection on MV feeders using current unbalance protection		X
No.	651	A new integrated protection system for the MV section of primary substations	X	X
No.	683	Adequate neutral treatment for 25kV power supply systems of a new huge open cast lignite mine	X	X
No.	696	Experience with on-line low voltage cable fault location techniques in Scottish Power		X
No.	699	Innovative Neutral Point Treatment in Compensated Networks	X	X
No.	723	A New Voltage based Relay Scheme to Protect Micro-Grids dominated by Embedded Generation using Solid State Converters.		X
No.	729	Distance Protection Performance Analysis in Short and Long Transmission Lines using Real Time Digital Simulation		X
No	739	Using PQ monitoring infrastructure for automatic fault location		X
No.	746	Voltage and reactive power optimal control in distribution networks with distributed generation		X
No.	749	Refurbishment Strategies for the Protection of Distribution Systems		X

No.	757	Advanced Load-Shedding Functions in Distribution Protection Relays	X	X
No.	836	Taking Advantage of Distributed Generation for Voltage Control		X
No.	876	System for detection of high impedance fault	X	X
No.	908	Influence of Rotor Angle Instability on Protection systems in Distribution Networks		X

Research and Innovation Forum (RIF)

The Research and Innovation Forum (RIF) focuses more on scientific and academic contributions than the Main Session does. So in this block several research activities mostly from universities or other research associations - often as joint work with manufacturers or grid operating companies- are presented.

Paper 87 from China deals with the problem that the capacitance to ground is difficult to measure or calculate correctly. The difficulties are analysed and on this basis a more effective calculation method is introduced.

The objective of paper 174 (Finland) is to uses discrete wavelet transformation (DWT) to detect high impedance faults in 20-kV compensated grids.

Paper 317 (China) proposes a new communication protocol to adopt the group-to-point communication as a backup to the point-to-point communication in case of loss of physical connection between agents or faulty coding.

The goal of paper 329 from China is to find the exact reason for the inefficiency of the ground fault protection relay technique based on the analyse of the 5th harmonics component. Due to the weakness of the signal itself it cannot have a high accuracy for the selection of the faulty feeder.

Paper 646 (Czech Republic) deals with new techniques of testing protection relays by the help of digital testing equipments enabling automated procedures for dynamic tests.

In paper 656 from Spain an application for automated fault location in distribution grids starting from measurements at one substation is designed.

Paper 726 describes a Brazilian approach using an Ant Colony Optimization (ACO) metaheuristic to solve the problem of optimal supply restoration by means of switching operations.

In paper 828 from Colombia a hybrid system is presented that combines a fault location algorithm and a technique based on artificial intelligence to improve the power supply continuity indices.

Paper 897 uses Monte Carlo simulation combined with load flow analyses to estimate depth and duration of voltage dips in distribution grids. The behaviour of circuit breakers as well as fuses in terms of the simulated voltage dips characteristics is investigated and compared.

Table 4: Papers of RIF

Paper No.		Title	RIF	PS
No.	87	Online Monitoring of Capacitance to Ground in Neutral Ungrounded Network and Precision Measurement of Capacitance to Ground in Neutral Compensating Network	X	X
No.	174	DWT-Based Detection of High Impedance Fault Due to a Leaning Tree in a Compensated MV Network	X	X
No.	317	An Error-tolerant Communication Protocol of Multi-agent Systems for Power System On-line Voltage Control	X	X
No.	329	The Grounding Protection Based On the 5th Harmonics' Component Facing A Severe Challenge	X	X
No.	646	New approaches to the testing and operation tests of electric protections	X	X
No.	656	Fault location in distribution systems by means of a toolbox based on N-ARY TREE Data Structures	X	X
No.	726	Minimum number of switching operations via Ant Colony Optimization	X	X
No.	828	Hybrid system to improvement of the power supply continuity indexes	X	X
No.	897	Voltage dips analysis by Monte Carlo approach	X	X