Special Report - Session 5
PLANNING AND SYSTEM DEVELOPMENT

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Introduction

The Electric Power Distribution business is going to face dramatic challenges as the integration of Distributed Energy Resource is now a reality and the development of electric mobility will necessarily claim for smarter planning and operation techniques. Furthermore, the economy of many developing countries is increasing with very high rates and massive investments in the distribution system are necessary to support such development. Finally, there is increasing interest in strategies designed to face the rapidly changing level of demand in both rural and urban areas, the extension of electrification in rural areas requiring a high quality of supply, and development strategies intended to mitigate against low probability high risks extreme events.

Session 5 deals with the short and long term development of distribution systems, spanning from theory to the application of asset management, planning and load forecast techniques bearing in mind economics, market, regulation, power quality and security of supply.

The main topics are related to:
- Demand needs and forecast
- Performance requirements, results and benchmarking
- Network schemes, design criteria and practice
- Investment strategies
- Active Networks and Advanced Network Management.

The S5 papers will be discussed in three events:

- Main Session (Thursday, June 9, 9:00-12:30 and 14:00-17:30),
- Poster Session (Tuesday, June 7, 9:00-12:30 and 14:00-17:30),
- Research & Innovation Forum (Wednesday, June 8, 16:00-17:30).

A Round Table will be organized (Wednesday, June 8, 11:00-12:30):

- RT 5b - Planning the distribution system development with a proper coordination of TSO and DSO

Two joint RTs will be also co - organised with S1 and S4:

- RT 1a/5a - Distribution networks for large cities: new components and system development issues (Wednesday, June 8, 09:00-10:30)
- RT 4a/5c - Integration of Plug-in-Vehicles in Distribution Networks. Contributions from 2 major EU FP7 projects: MERGE and G4V (Grid for Vehicles) (Wednesday, June 8, 14:00-15:30)

The aim of this special report is:
1) to present a synthesis of the items treated in the papers,
2) to call for prepared contributions at the plenary session,
3) to stimulate the free discussion at the plenary session.

The 2011 plenary session will be divided into four blocks. Each block will be divided in two main parts:
1) oral presentations based on papers that cover general items or can stimulate the discussion (12 minutes presentation in both the Main Session and RIF),
2) discussion (prepared contributions and free discussion).

Block 1: Asset Management, Maintenance Strategies

Sub Block 1: Theoretical Models

Sub Block 1 deals with the analytical part of the problem of Asset Management. In this section methodologies are proposed to assess the issues of aging equipment and the decisions related to renewal Vs maintenance of existing assets as well as risk assessments and investment optimization process.

Paper 0010 proposes a methodology considering both network reliability and equipment economy. It consists of two parts: equipment-replacing necessity decision-making, which is used for all electrical equipment to select annual replacement needs with equipment-replacing probability index; and equipment-replacing option decision-making, which is used for each equipment to find out the best replacing option among three alternatives with equipment-replacing B/C ratio index, considering its performance improvement. The proposed method has been applied to Shanghai Siping Community for its annual replacement plan of electrical equipment in distribution network.

Paper 0152 addresses the problem of measuring network risk, both present and anticipated, in a part of the network where multiple factors are involved. A composite methodology has been developed to evaluate the impact on network risk of several factors, and in particular to assess the interaction of these factors. This methodology is illustrated with a case study based on an actual part of the UK network. It is used to evaluate the growing level of risk in each year before transformer replacement can be justified, and thereby determine the optimal year for such replacement under a number of different possible scenarios.

The conclusion is that, in a portfolio of possible capital investment projects, many of which have more than one driver, some can be postponed for a number of years with little increase in network risk, while postponement of others would result in an excessive increase in network risk. The methodology presented in this paper enables such projects to be ranked and scheduled in a way which minimizes total network risk for a fixed capital expenditure profile.

Paper 0314 is organized in two parts: the first part of the paper deals with the assessment of multiple-fault frequency in networks exposed to progressed component aging. The concept is based on conditional probability for occurrence of a second or third fault location as a consequence of an initial fault. In the second part of the paper algorithms for simulation of efficient post fault restoration procedures in cable- and overhead-line networks are presented for cases in which fault-clearing personnel has to expect occurrence of more than one fault location per failure-event.

As a conclusion, a method for the evaluation of component multiple-outage frequency is presented. Outage frequency is modelled as a function of component age and of failure effects accumulating during component lifetime. This concept is implemented into computer software for evaluating reliability indices of medium voltage networks. Special attention focuses on realistic simulation of supply restoration activities for cases in which fault-clearing personnel has to deal with more than one fault location per failure-event. Different restoration strategies were tested for a typical medium-voltage network consisting of a mix of overhead-lines and cables. Taking solely first-order-failure events into consideration, supply restoration procedures without limitation of not successful switching actions result in the lowest total energy not supplied. However, these strategies impose a large burden on system with the consequence of significant component lifetime reductions.

Paper 0367 deals with Asset management and the problem of Replacement Vs Refurbishment of assets. Within the asset management it is crucial to monitor the performance of the assets and search for potential cost increase of maintenance and the risk exposure, in order to assess the best intervention in economic terms: (1) Replace with new equivalent, (2) Adapt, (3) Rehabilitate and (4) Repair. To achieve the referred objective the MAD MODEL has been developed in EDP Distribution.

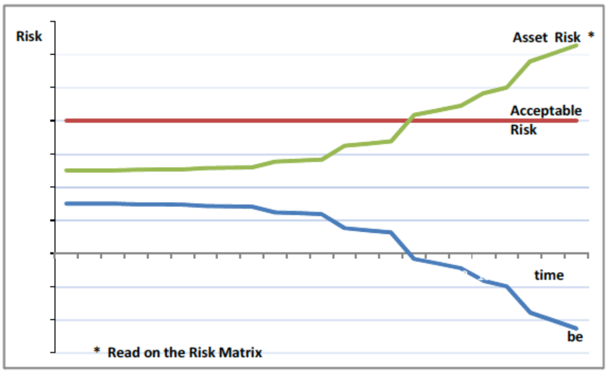

Fig. 1: Risk as a function of time in Paper 0367

Paper 0429 assesses the asset management process analyzing strategies for long term investments to ensure the required functionality and quality of the complete system. A more sophisticated approach includes the actual condition distribution of the asset group into the simulation method. The final result is the evaluation of the total investments and operational expenditures as well as the comparison of different investment and maintenance strategies.

The substantial advantage of a dynamic asset simulation is, besides from the knowledge of the financial requirements under consideration of the current maintenance and renewal strategy, to evaluate the influence of different strategies on the final result, e.g. the shift of a renewal measure or extension of a maintenance activity, which can be beneficial e.g. in case of the discussion with the appropriate national authorities regarding the investment strategy and the related financial expenditures.

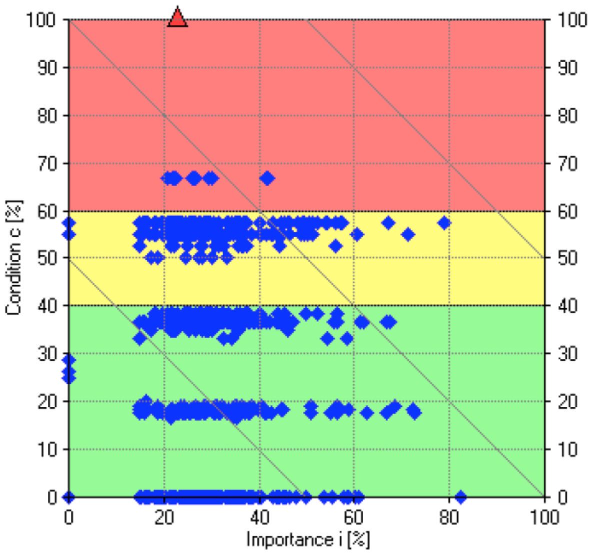

Fig. 2: Condition and importance asset of power transformers, as in Paper 0429

Paper 0443 aims at calculating the yearly costs of high voltage equipment to obtain long-term information about balance values and cash flow values. This is done because, due to incentive regulation, one of the main asset manager challenges are long-term cost analyses in order to optimize the yearly expenditures. The results of the cost analyses show the importance of stable and positive cash flow values. Therefore, it is reasonable to optimize the ageing model and the cost analyses by introducing an investment limit which ensures positive cash flows and avoids too high investment peaks, which is also desirable. The investments can be shifted to the following years and lead to more evenly distributed costs.

Paper 0648 shows how the Distribution System profitability is at risk from decreasing network fees. To meet financial targets, distribution system operators are thus obliged to curtail their re-investment, operation and maintenance budgets.

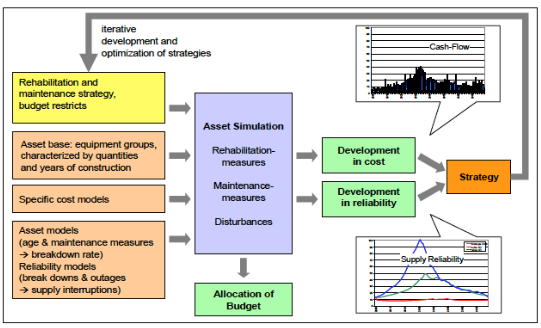

Fig. 3: Schematic asset simulation model as in Paper 0648

The paper describes each step in detail, as well as the models developed, especially asset simulation and reliability-centred maintenance planning, and is complemented by a case study. This strategy is applicable to gas, water, district heating and electricity networks. The experience gained to date underlines the great economic potential offered by this approach. In future, the impact of smart grid technology in particular will be integrated into the models.

Paper 0756 shows the study done by Shanghai Municipal Electric Power Company about the operation and maintenance of their assets. During the Grid Asset life cycle, Operation and Maintenance (O&M) period covers more than 95% of the life cycle. In China, the proportion of Grid Asset O&M period costs in the Life Cycle Cost (LCC) is much greater than the international average standard. Therefore, how to control the asset operation cost effectively becomes a significant issue.

Asset operation period cost consists of Operation cost and Repair cost. After publishing the Equipment Repair Cost Fixed Quota, the Company steps further to develop a research on O&M cost fixed quota system. Because of dispersion of equipment and multiple-activities, O&M cost has been the weak part of the cost control for a long time, which makes the O&M budget cannot match with the asset base. The Company conducted a comprehensive research on O&M activities of substation equipment, transmission lines (overhead and cable) and various assistant facilities, which made all activities be linked to certain assets.

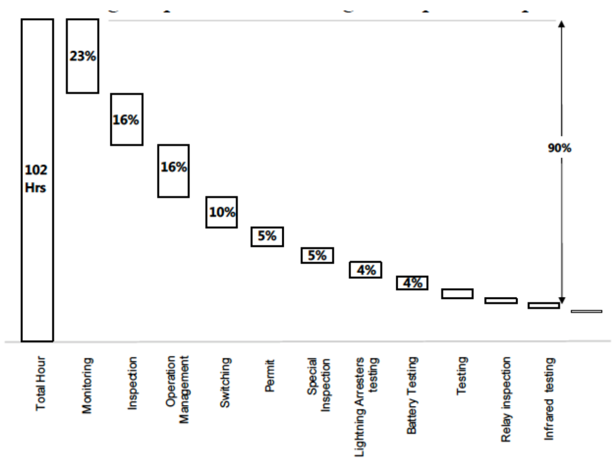

Fig. 4: Portion of labour working hour occupied by different activities as in Paper 0756

Paper 0805 describes how indicators to monitor and manage distribution system vulnerability can be identified and established. The process is based on the bow-tie framework for vulnerability analysis, structuring threats, unwanted events, consequences and barriers. Relevant vulnerability indicators are those able to provide adequate information about vulnerability prior to events and the development of vulnerability. As a conclusion, Indicators like technical condition of components and system should be combined with weather forecast and other indicators like emergency preparedness to create an overall picture of the vulnerability towards a certain threat or hazard.

Paper 0825 finds similarities and differences in the strategic asset simulation for electricity and gas distribution grids. Asset simulation and automated asset optimization as well as the methods described in this paper are absolutely independent from the sector and can be used for electricity and gas as well, as long as the individual parameters, targets and dependencies are represented in an appropriate way.

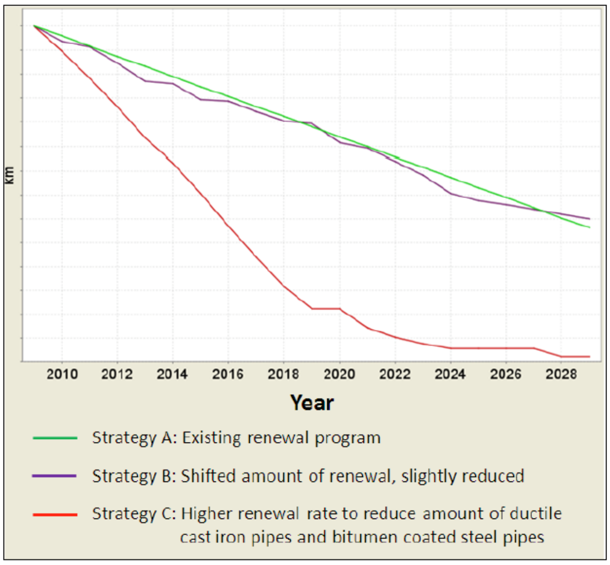

Fig. 5: Improvement of the existing strategy by adjusting renewal amounts as in Paper 0825

The approach of strategy benchmark can be easily adapted to the needs of an electricity distribution grid provider and may be enhanced with other required key figures. With this combination of tools and methodologies asset managers will be enabled to focus on their core competences while regarding a wider range of requirements.

Paper 1002 studies life cycle costing and risk approaches to asset investment and planning. Understanding the lifetime costs for power distribution and transmission assets is of critical importance to maintaining and reinforcing existing networks and developing new ones, including those anticipated in future networks such as Smart Grids.

An integrated life cycle cost (LCC) and risk assessment methodology, which addresses whole life costs from original planning, to construction, operation and eventually the management of end-of-life of assets, has been developed. The approach can support asset investment and policy to enable optimum solutions to be identified, taking into account economic, environmental, health and safety and social costs, with explicit account of hazard.

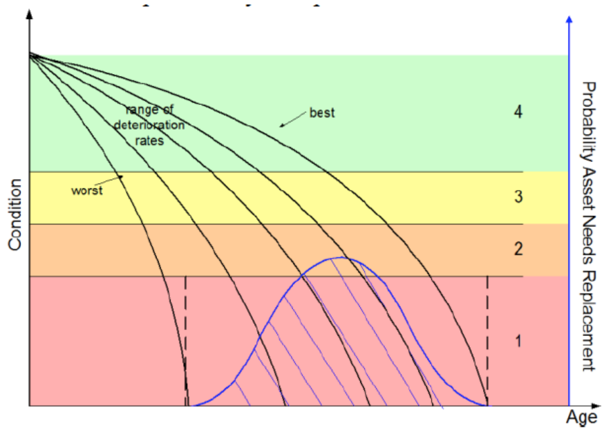

Fig. 6: Asset deterioration rates as in Paper 1002

Paper 1013 describes the underlying methodology used in Condition-Based Risk Management (CBRM) to determine asset criticality. This methodology has been designed to be highly practical, enabling network operators to rapidly determine the criticality of many tens of thousands of assets, particularly when the available data is limited or incomplete. The presented methodology explains how the severity of the consequences associated with an event or failure can be estimated by taking into account known factors such as the physical location of the asset, the function performed by the asset, the accessibility of the asset for repair and the cost of replacement. The methodology also enables relevant subjective data from other sources to be included. Once established, these factors can be derived from the asset population in an efficient and consistent manner, enabling the rapid calculation of individual asset criticality.

It is hoped that the applicability of this approach to a wide range of asset types within a common risk framework will enable and encourage further development in this area.

Paper 1202 tracts the experience of the Distribution System Operators (DSO) of Berlin and Hamburg have applied the method of Risk Based Asset Management (RBAM) for about a year for decision support as well as for the comparison of alternative solutions. The present paper will describe this approach and the concrete procedure using the example of a cable type only sporadically employed (internal gas-pressure cable) with high failure risk and very long corrective maintenance time. Due to the use of the same reference unit (Euro), the efficiencies of different projects can be easily compared with each other, and the best possible variant identified. Through the reference to the commercial variable EURO, all those involved obtain a very plastic impression of the extent of possibly existing risks in the handling of the supply task.

The RBAM method thereby helps in developing very systematically creative solutions and producing transparency for the communication processes necessary prior to the relevant project implementation.

Paper 1307 deals with the Evaluation of Economical Profitability of Assets. The electricity distribution system in Brazil is regulated by a PRICE CAP model, in which cap prices are imposed to the utilities every four years during the periodic tariff review process, and the prices suffer a tariff readjustment on an annual basis using price indexes. This kind of regulation establishes on each periodic review the revenue considered adequate to both provide electricity services and fairly compensate for the investments done, based on O&M costs modelled for a reference firm and invested capital analyses. This article intends to present a methodology for the distributors to select investments to expand and/or improve their networks, considering in an aggregated way both technical benefits and regulatory compensations.

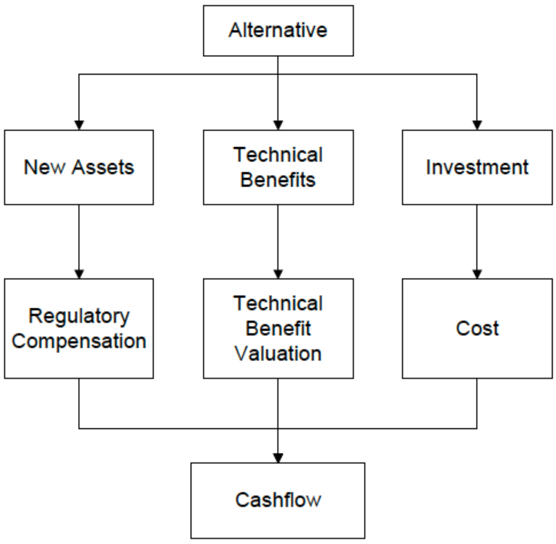

Fig. 7: Fluxogram for evaluating alternatives according to Paper 1307

The tool and the methods developed proved to be efficient and consistent with the electricity distributors' needs.

Sub Block 2: Reliability assessment

Sub Block 2 refers specifically to investment related to reliability and continuity of service. In this section, which again deals with mathematical models, the main interest resides in translating reliability issues into quantitative factor to be assessed in a decision-making process.

Paper 0444 proposes a framework to understand and manage reliability in distribution networks, based on the analytical breakdown of popular indexes, such as SAIDI and TIEPI. The aim is to isolate and quantify the key determinants of reliability, providing a tool that decision makers can use to understand the past and make decisions for the future.

Network reliability, as measured by popular indexes such as SAIFI, SAIDI or TIEPI, reflects the combined impact of very different drivers, such as equipment failure rates, network topology, effectiveness of outage handling processes, performance of protection schemes and environmental factors. Applied to specific cases, the framework proposed in this paper enables a quantitative understanding of the factors that have driven past reliability results.

Paper 0714 presents the analysis of reliability value fluctuations during the day using three years data set taken out from the real power network, with the aim to help improving reliability indices and final customer satisfaction. The beginning moment of unplanned (forced) interruption occurs stochastically. Also, reliability has dynamic (fluctuating) nature during daily hours.

After observing the three years data set it became obvious that probability of interruption with more difficult consequences is higher within heavily loaded network than during light load regimes. Also, the interruptions that happen during off-peak hours usually have longer duration, particularly during the nights.

Paper 0837 shows a method to determine the distribution of the widely spread reliability indices for electrical networks.

Since 2009 the German Federal Regulation Authority has applied incentive regulation for electrical networks with a monetary evaluation of reliability indices.

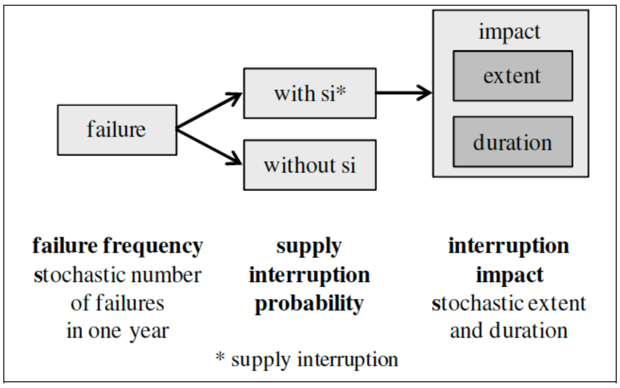

Fig. 8: Areas with different stochastic influences as in Paper 0837

This paper presents an approach to determine the distribution of reliability indices for a single network operator by using existing comprehensive statistical data of supply interruptions from a large variety of network operators for Monte Carlo simulation.

Based on the existing statistical data containing all stochastic influences on supply interruptions and the determination of the systematic differences, the distribution for an individual network operator can be calculated based on a set of scribing parameters. The presented method also allows evaluating the effect of a longer period of consideration on the stochastic spreading of the reliability indices. Initial evaluations show a considerable reduction of the spreading up to a period of three years before the reducing effect decreases.

Paper 0970 proposes a quantitative reliability method applied to invest planning of power distribution system. The method consists of well-established reliability indices such as SAIDI and life cycle cost calculations (LCC) including e.g. maintenance cost for the entire economical left time. The novelty of the method is to use tariff regulation as economical input combined with quantitative reliability indices.

Results from the example show that is possible to receive clear and stable data that could be used by a DSO for an investment decision with several relevant alternatives. Hopefully this will inspire other DSOs to introduce more advanced planning methods enabling higher degree of cost efficiency. That will be increasingly important for the worldwide tendency of performance based tariff regulations and increased demand for reliable electricity supply in the future.

Sub Block 3: Applications and Experiences

Sub Block 3 deals with on-going operation of Asset Management systems. It should be noticed that, notwithstanding the huge interest that in next 5-10 years has surrounded the topic, very few practical applications are reported.

Paper 0178 presents the implementation of an asset management program on distribution transformer operation and maintenance with the objective to decrease the rate of distribution transformer failures. The activities include capturing and collecting data on distribution substations and transformers, diagnosing of the latest equipments conditions, enhancing of proper maintenance methodologies, and implementing of integrated conditional based maintenance program (CBM). The methodologies and procedures are also applied in technical system, management infrastructure and mindset capabilities and leadership. Implementing the asset management needed the step by step action which was guided by a good strategy.

All these activities should be supported by computerized applications with up to date database and the human resource connected to the asset. The improvement of asset management could be pursued by introducing the Operation Performance Improvement (OPI) program which handles three main aspects. Since the launching of OPI program in Gambir, the number of transformer failure declined, and the healthiness of transformer can be enhanced.

Paper 0690 illustrates, with some value event examples, the importance of the use of Recording Devices as an effective tool for predictive and condition-based maintenance. These cases include actual records at Medium Voltage Distribution Network that helped, after analysis, to determine the need for equipment maintenance. Examples of these cases are:

- Breaker restricting,
- Intermittent fault and
- Fault location

On-line condition monitoring is also among existing useful tools in the area of asset management. When used as part of a well developed strategy, on-line condition monitoring can be powerful for utilities to use in order to achieve its intended business benefits. Data analysis and diagnostics from records obtained from Fault Recorders lead to amazing conclusions that support the predictive maintenance operation in any world-wide electricity utility.

Paper 1224 presents the main aspects related to the risk assessment of performance-based maintenance of medium voltage distribution systems for offshore wind farms. This assessment encompasses reliability/availability calculations using input data such as failure rates and average repair times which, during system operations, are closely correlated with maintenance processes and performance.

Authors also developed risk assessment considerations and accordingly delivered KPIs associated with the maintenance of medium voltage distribution systems of wind farms.

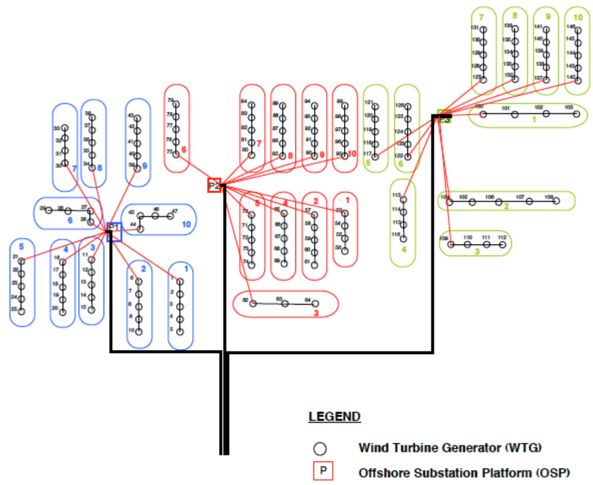

Fig. 9: Wind Farm Distribution System as exposed in Paper 1224

For an assessment of the operational risks associated with the failure of the T&D system to transfer the power generated by all available WTGs it is important to calculate the network availability during the design phase and measure its performance periodically at an agreed production period

Potential scope of discussion - Block 1

In the evaluation of Risk, many approaches and tools are available to DSOs for Asset Management and Maintenance Strategy development such as: Asset Simulation, Reliability-Centred Maintenance (RCM), Target Network planning, Net Present Value (NPV), Aging Distribution Networks, Risk Based Asset Management (RBAM), Conditional Based Maintenance program (CBM) and others. Each Company uses also many analysis tools to take decisions, in addition to many possible scenarios. But, considering technical and economical issues could be better select one technique, make a mix, or searching for new ones?

A lot of literature has been produced in last ten years about Asset Management and related topics; tools and methods have been proposed and developed. However it seems interest on the topic ends once the AM system comes into operation; a very few contributions refer to AM systems as everyday decision-making tools informing Company's overall behaviour, notwithstanding this kind of investment decisions should be the more frequent and relevant in terms of impact on the investment plans.

Table 1: Papers of Block 1 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0010: Annual Replacement Decision-Marking of Electrical Equipments in Distribution Network				X
0152: A composite methodology for evaluating network risk				X
0178: Asset Management Improvement in Distribution Substation				X
0314: Medium voltage network reliability evaluation: Simulation of practically applied supply restoration strategies for double-failure events	4			
0367: Asset Management - Replace or Refurbish Assets				X
0429: Investment strategies based upon asset simulation				X
0443: Optimization of long-term cash flow calculations for high voltage equipment				X
0444: An analytical framework to understand and manage reliability in distribution networks				X
0648: Sustainable investment strategies for aging distribution networks	3			
0690: Examples of Condition Based Maintenance in Distribution Systems	5			
0714: Daily Fluctuation of Electric Reliability Indices				X
0756: With transmission grid asset operation and maintenance fixed quota to support Life Cycle Cost absorption and analysis				X
0805: Indicators to monitor and manage electricity distribution system vulnerability				X
0825: Similarities and differences in the strategic asset simulation for electricity and gas distribution grids	1			
0837: Distribution of reliability indices in electrical networks				X
0970: An authentic example of investment planning of power distribution using quantitative reliability and cost analyses				X
1002: New Life Cycle Costing and Risk Approaches to Asset Investment and Planning				X
1013: Determination of asset criticality: a practical method for use in risk-based investment planning				X
1202: Risk Based Asset Management - Decision Support and Comparison of Solution Alternatives	2			
1224: Assessing the Risk of Performance-Based Maintenance of Off-shore Wind Farm Distribution Systems				X
1307: Economic evaluation of assets profitability				X

Block 2: Network Development

Sub Block 1: Innovative Power Distribution

The Distribution sector has recently become perhaps the most innovative among electrical industries. This is surely due to the evolution of communication, control and automation devices and systems, which has made available advanced functionalities at an affordable cost, but also to the increased demand for a reliable and flexible energy infrastructure, required by more sophisticated customers' needs, and to the fast development of emerging technologies.

Sub Block 1 deals with innovation related to all issues except active networks, which include advanced system functionalities related - among others - to demand side management, quality of service, voltage regulation and load management including innovative loads such as Electric Vehicles (EV) charge facilities.

Paper 0126 analyze the impact of EV on LV networks, with practical reference to rural areas in which grid reinforcement are more likely to be needed in order to accommodate future charging facilities according to traditional "fit & forget" paradigm. Two different load management approaches are described and simulated; the results of the simulation are compared in terms of transformer loading and min-max voltage. The results show that typical German LV rural network probably still have excess capacity that may support future EV needs, but implementation of load management systems can contribute reducing under- and over-voltages, helping avoiding unnecessary network reinforcements.

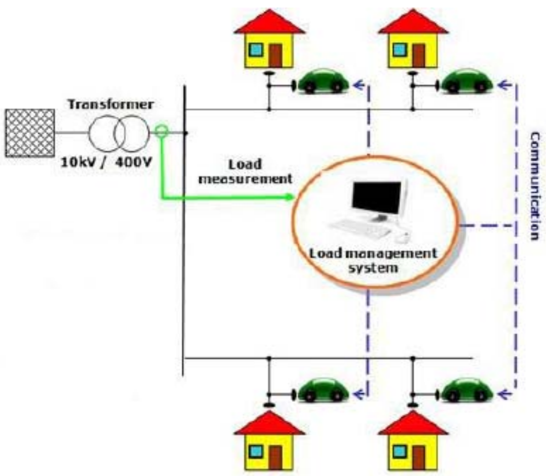

Fig. 10: Concept of a Load Management System as in paper 0126

Paper 0294 also investigates impact of EV, deepening the "idyllic" vision which refers to EV charging infrastructure as an additional load *per se* contributing to the flattening of load diagram. The paper addresses, starting from consumption data gathered from a Smart Metering system, two different network conditions (a low-consumption suburban area and a high-consumption one), finding out that a positive impact of EV in flattening load diagrams can be expected allowing not only the postponing of investments but also a more efficient infrastructure usage. However, experienced relationship between tariff systems and consumption habits shows a communication effort must be carried on - towards final customers - in order to get those potential benefits; Smart Metering systems are essential in the process of increasing customers' awareness.

Paper 0498 outlines a 2020 scenario for EV diffusion in France, in terms of number of vehicles, type and number of charging facilities, consumption and load profile of each one of them. Simulations' results indicate that private recharge devices, due to the expected daily load profile, should be preferred and promoted, leaving to public charging station a role of "last chance" or leaving them as a "niche" supply. Price mechanisms combined with advanced load management and Smart Metering functionalities are required to ensure future networks fully support the process.

Innovative distribution network need simple, robust and secure communication infrastructures. **Paper 0094** deals with characterization of indoor cables as PLC vectors. Standard indoor cables are modelled and transfer functions are calculated using MATLAB in the case of different loading conditions, cable lengths and number of bridge taps. Results show that uncertainties and diversity of behaviour can be expected, and performances decrease accordingly, as the complexity of the system grows.

Paper 0400 refers to the results of a project, carried out in Belgium, in which a transmission system with PLC filtering and multiple gateways for each LV feeder has been adopted. The higher performance that can be achieved with this technique might enable advanced functionalities for Smart Metering systems and Load Management applications.

Demand Side Management (DSM) is the starting point of **Paper 0098**, in which results of two research projects on the economical and social aspects of DSM are summarized, with reference to a pilot project with over 300 residences where DSM functionalities are going to be tested. According to authors, attention must be paid to ensure that objectives are to be interpreted in desired behaviour and desired behaviour should be translated into adequate DSM instruments. Four fields of attention were identified and analyzed as relevant for instrument development: technology, incentives, interaction and communication.

Storage facilities are key elements in any Smart Grid concept. **Paper 1129** offers a comprehensive, state-of-the-art presentation of possible storage functionalities and of today's available technologies: transmission and distribution system will benefit from storage, in terms of transmission congestion relief, transmission and distribution upgrade deferral, peak shaving, time of use energy cost management, voltage support, variable renewables grid integration, variable renewables capacity firming, reserve capacity, power quality and reliability improvement.

A systematic review of storage technologies and application by voltage level is presented in **Paper 0569**, where a segmentation of contributions possibly offered by storage to power system is performed. In the case of HV grid, high capacity pump-storage is mostly seen as related to curtailing peak-valley energy differences; in MV networks, storage use is meant in combination with DG; at LV level, battery equipment as well as UPS or EV can reduce load variations and voltage drops on the network as well as acting as an emergency supply.

Emergency issues are also introduced by **Paper 0981**, which summarizes planning criteria based on resilience to extreme disaster situations. The paper proposes an emergency planning method of urban distribution networks based on microgrids, including DG facilities, which must be able to self-recover in case of lack of external supply. First of all, emergency scenario classification and load classification methods are proposed; then an emergency planning model of urban distribution networks based on microgrid is set up.

Tab.1 Scenario Classification

Categories	The situation of power damage	Time of power outages（h）
Normal	None	0
	Transformer or line “N-1”	(0,3]
Sub-extreme	Transformer “N-1-1”	(4,24]
	Transformer “N-2”	(4,24]
	Single 110kV transformer	(8,72]
	Several 110kV transformers damage caused by 220kV lines damage	(8,72]
Extreme	Lose all or most of the external power supply	>=24

Fig. 11: Classification of emergency scenarios according to Paper 0981

Significant system parameters are then computed and compared between a conventional planning approach and the proposed one; it is reported that the proposed planning method can be preferred when emergency scenarios need to be considered.

Paper 0447, based on the results of a project funded by the German Federal Ministry of Economics and Technology, describes the general architecture as well as some key components of innovative MV and LV networks. Direct voltage regulators, wide area controllers and electronic sectionalizers are introduced, and Smart Grid concepts such as ICT-based network control, storage facilities, enhanced voltage regulation and others are recalled within a sound and consistent conceptual framework. Theoretical comparison between different network development concepts is then carried in order to envisage the most promising approaches in economical terms. Experimentations on a real network will be then performed.

Paper 0377 argues that advanced control and protection functionalities at MV level could be achieved down-scaling the fully-blown Substation Control and Protection system within a Ring Main Unit (RMU) architecture. A simplified architecture can be imagined, with a limited number of interface signals, but maintaining remote control and protection functions typical of transmission level. Reference architecture is proposed, then characteristics of main components and some applications are outlined accordingly. Authors believe that the substantial reduction of customer interruptions / minutes lost and the extended lifetime of the assets should allow for the investment.

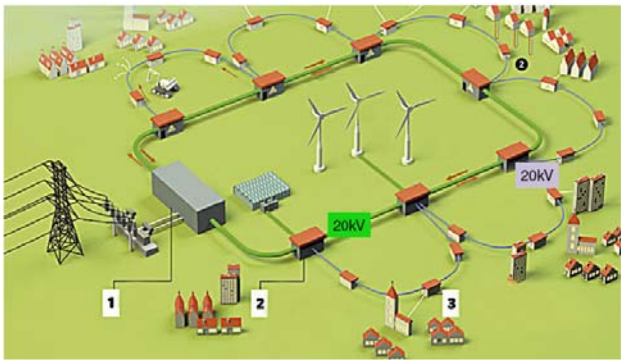

Fig. 12: Intelligent Network Capacity Upgrade (Paper 0377)

RMUs are among the core components of an advanced MV network, according to **Paper 0545**. The authors describe the preparation and the pilot phase of a large-scale distribution automation project, which can be considered as a part, or form of a smart grid. Starting from the design of automation functionalities, the paper outlines the requirements for power components (namely switchgears), data acquisition devices and communication infrastructure supporting advanced control and automation; lessons learned and suggestions follow.

Paper 1199 also refers to components and functionalities which are proper of a Smart Grid concept. The paper outlines the main features of a distributed sub-system able to monitor and re-configure the network at a local level. Self-healing functionalities related to the adoption of “intelligent” switching devices are described, intentionally recalling telecommunication re-routing techniques. According to the paradigm expressed, this will result in enhanced operation through improved sensing, computation and communications.

Paper 0305 deals with the representation of electric networks through general structures, representing a standard description, or better an expected self-description, of every single component; IEC 61850 and CIM models are recalled.

The paper claims that IEC 61850, usually referred to as a communication standard, is in perspective able to support the whole engineering process, whose degree of automation can grow together with the standardization of its conceptual foundations.

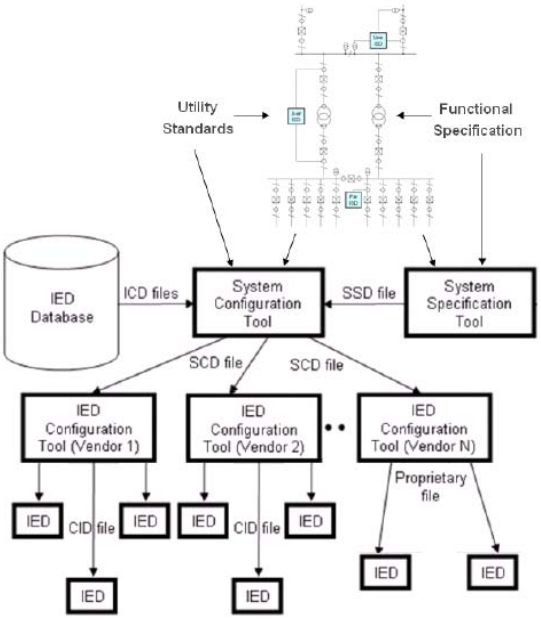

Fig. 13: Simplified UML diagram of the SCL model according to paper 0305

Paper 1279 describes a new topology for underground distribution in Sao Paulo city, based on normally closed primary loop and automated switches, which is currently being built for testing. Protection, automation and monitoring schemes for underground applications have been specifically proposed to take into account fault clearing and loading changes in a closed loop configuration.

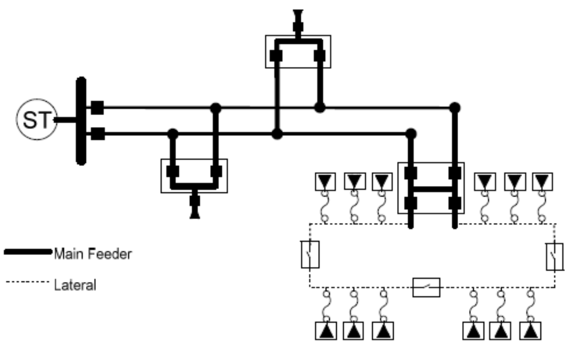

Fig. 14: Parallel loop architecture with lateral loop supplying smaller loads as described in paper 1279

The experimentation related to this innovative project will take place in the Sao Paulo 21 kV MV network.

Paper 1037 describes a project, funded by the Italian Ministry of Economical Development, based on a Smart Grid architecture in which the already available network devices and systems have been specialised for closed-ring operation. The paper synthetically describes the key innovative components (sensors, MV circuit breakers, protection equipment, communication infrastructure) and the main features of an innovative closed-loop operation in a MV neutral-compensated real network.

Paper 0426 summarizes more than four years of ENARD, the IEA Implementing Agreement on Electricity Networks Analysis, Research and Development. ENARD's vision is to facilitate the uptake of new operating procedures, architectures, methodologies and technologies in electricity T&D networks, such as to enhance their overall performance in relation to the developing challenges of the "3Rs" of electrical power systems development, namely network Renewal, Renewables integration and network Resilience.

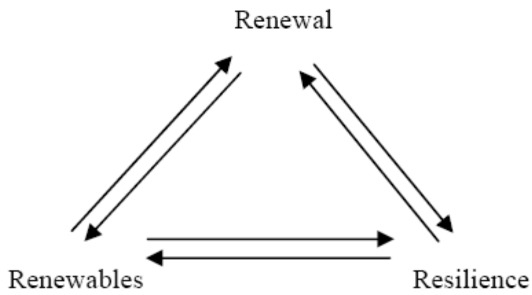

Fig. 15: The 3Rs of Electrical Power Systems Development, according to Paper 0426

Paper 0991, finally, describes the state of the art of Smart Grid technologies and application with reference to present day situation in China. In details, authors point at some key technologies for an information-support system of a smart distribution network, including smart dispatching based on the real-time and global information, distribution management system (DMS) based on Geographic Information System GIS, the data platform based on the real-time database and data-mining of distribution networks.

Sub Block 2: Active networks

Distribution networks have been built as passive elements connecting the transmission system to final customers; planning methods, operation criteria and protection algorithms have been designed according to this paradigm, allowing simple schemes, devices and systems.

The increasing amount of distributed generation (DG) connected to distribution networks is gradually challenging conventional network planning and operation criteria; an increasing amount of network awareness (according to the "Smart Grid" paradigm) is required in order to manage bi-directional power flows related to an active grid.

Sub Block 0002 deals with the developments related to the on-going transformation of the distribution grid from a neutral, passive element to an active, possibly self-sufficient, entity.

Vision is one of the key elements for the development of Smart Grids, and many papers bring vision to the topic.

Paper 0311, coming out from CIGRE C6.11 WG, summarizes on-going Active Distribution Network initiatives. State of the art is represented accurately and extensively, and a classification is offered of the project listed according to the type of application and the improvements over present situation. WG recommendations follow in the areas of Grid Operation, System Operation, Regulatory Environment, and Awareness Building.

Paper 0073 presents Hydro-Québec Distribution's smart distribution vision and roadmap, in which all strategic projects related to grid innovation are framed.

The figure below shows in particular HQD's Smart Grid Roadmap, which is centred on the four pillars of System Performance, Transmission Capacity, Active Customer Participation and Asset Management, and whose plans are detailed according to (0-5 years time-frame) and (5-15 years time-frame).

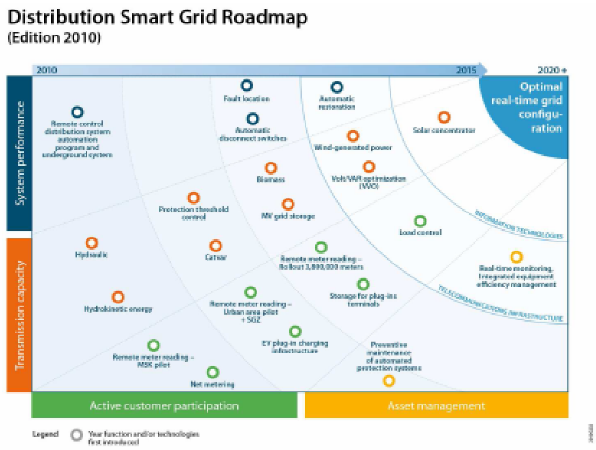

Fig. 16: Hydro-Québec Distribution Smart Grid Roadmap, exposed in Paper 0073

Specific initiatives are then described according to their contribution to the vision and roadmap.

Planning technological transition from present day distribution systems to Smart Grid, according to **Paper 0364**, means addressing the "Trilema" of investment/operation costs, quality of supply, and the prize of electricity to end customers.

To reconcile the Trilema elements, the authors examine extensively several objectives which can lead network development and the related owners and benefits.

According to the authors, the attempt to solve issues in grid structure with the "Smart Metering", or other IT solutions only, will fail: a long term development strategy of distribution systems should combine grid optimization techniques, network planning and the most important key technologies including IT and automation.

Objective	Investor	Beneficiary	Concept and Technology
Securement of supply reliability	Grid operator	Power consumer Grid operator (in case of quality regulation)	• Distribution grid automation • New grid concepts • Equipment monitoring
Improvement of voltage quality	Grid operator	Power consumer Grid operator (in case of quality regulation)	• Participation of distributed generators in voltage control • DSM (based on smart metering) • LV-transformers with on-load tap changers (OLTC) • Reactive power control by power electronics at grid side • New grid concepts
Reduction of / equal low grid loading	Grid operator Metering service provider	Grid operator	• Distribution grid automation • DSM (based on smart metering) • Storage
Loss reduction - technical - non technical	Grid operator Metering service provider	Grid operator Power consumer (reduced bill)	• New grid concepts • Participation of distributed generators in voltage control • DSM (smart metering)
Simplified grid operation	Grid operator	Grid operator	• Distribution grid automation • New grid concepts
Active power balancing	Metering service provider Energy supplier	Energy trader Energy supplier Balancing responsible party	• Participation of distributed generators in active power balancing • DSM (based on smart metering) • Virtual power plants • Storage

Fig. 17: Objectives of Distribution System Development, as exposed in Paper 0364

Paper 0387 sets a framework for transition towards active distribution networks (ADNs) taking into account opportunities offered by technological advancement as well as challenges coming from increased performance expectations. A planning model for ADNs planning is proposed considering the planning goals, the technical and economical constraints and the starting point in terms of existing infrastructures.

Accommodation of DER coming from primary sources such as wind, solar or from storage systems and EV batteries requires the incorporation of advanced automation and control strategies to the existing distribution grid. **Paper 0578** provides an investigation of smart distribution grid concepts and outlines some of the characteristics of an advanced distribution management system (ADMS) which will perform advanced distribution automation (ADA) benefitting from information data flows based on existing (or future) Automatic Meter Infrastructures (AMI).

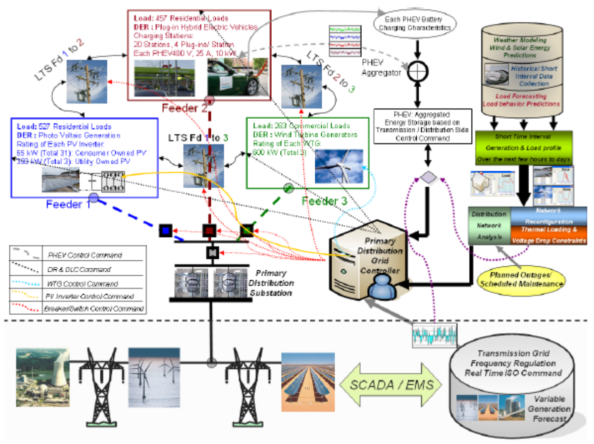

Fig. 18: Conceptual Diagram of AMI/MDMS Information Flow to ADMS, according to Paper 0578

A Microgrid can be seen as a cluster of loads and microsources operating as a single controllable system. **Paper 0722** points at Microgrids as a new paradigm for defining the operation of distributed generation. To the smart grid the microgrid can be thought of as a controlled cell of the power system, which can respond in seconds to meet the needs of the transmission system; to the grid users the microgrid can be designed to meet specific needs, such as enhance local reliability, reduce feeder losses, support local voltages, provide stable or uninterruptible power supply, and so on.

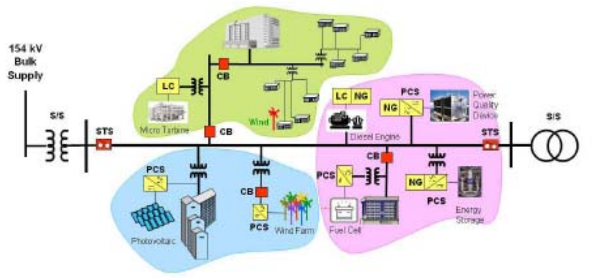

Fig. 19: Microgrid representation as described in Paper 0722

The paper presents analytical functions to evaluate microgrid construction as an optimization problem with constraints as well as control functionalities for management of DG.

Paper 1329 starts considering “green energy” scenario, where renewable energy sources showing an intermittent character and a low energy density will soon be transforming today’s consumption driven generation into a generation driven consumption. In order to reconcile in time and space the load-generation equivalence distribution network will have to be flexible and reactive.

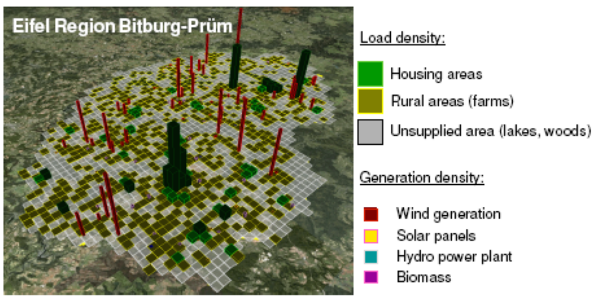

Fig. 20: Dispersed Load and Generation density (Paper 1329)

Authors examine technical (operational), market and regulatory issues related to this new approach to distribution and describe ongoing projects in which advanced management functionalities, mostly based on Smart Metering systems, are being tested.

The impact of DG on system reliability in MV networks is examined in **Paper 0404**. Authors focus on how to enhance the positive effects of DG in terms of loss reduction, voltage support and, in particular, backup and emergency supply which can be ensured by DG. A methodology for reliability assessment, based on a Bayesian model of the network, is exposed and applied to a sample distribution feeder. The DG impacts on reliability indices and interruption cost are calculated for different DG sizes. The results show that for the given sample, the larger DG size, the better the reliability and the lower interruption cost for the system.

Paper 0850 introduces a “Smart Grid Communication Simulator” which has been designed and deployed within GAD project in Spain. The system, which has been connected to Transmission, Distribution and Supplier application, is capable to represent the behaviour of an entire Province (100.000 synthetic customers) simulating the users’ reaction when a critical order is sent from the TSO, the DSO needs to carry out a technical order or a new pricing policy is sent from the Power Marketer.

The paper describes the elements of the Simulator and the functionalities which have been deployed and tested.

Sub Block 3: Case Studies

Smart Grids represent by definition the innovation in distribution networks, and single innovative experiences are therefore related to Smart Grid projects. However, this being such a general concept, even applications of the same name may differ considerably.

Paper 1054 outlines the characteristics of a Smart Metering System according to a model based on the role of an independent metering operator. Within this framework, authors define potential customers to serve and market relations needed. IT-System design fundamentals are then exposed, together with the description of the interfaces and integration issues which are inevitably going to affect all market players’ applications.

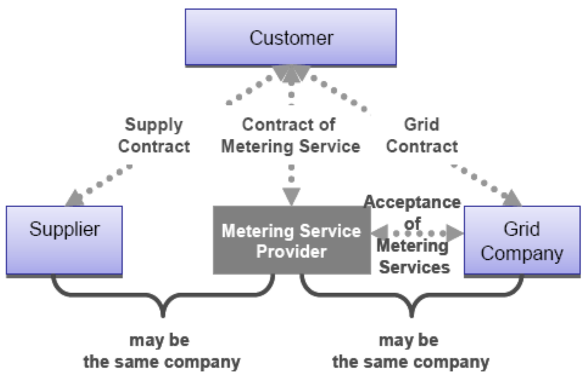

Fig. 21: Market rules and contract relations according to the model in Paper 1054

Paper 1106 presents the characteristics of a model representing energy storage systems. By simulating performance required and related system costs, taking into account technical constraints, the model allows evaluation of planning alternatives in terms of battery technology, storage capacity, grid connection power and control strategy to support a certain objective. Different objectives can be envisioned: e.g. integrating renewables, avoiding grid reinforcement or increasing the security of supply. According to the authors, the proposed simulation model, however, shows what can be accomplished with storage, but does not tell how.

MV Cabling can be just as innovative and fascinating as Smart Grids. **Paper 0924** exposes Vattenfall Finland strategy for systematic use of MV cables in rural areas, setting a particular focus on the research and development of cables more cost efficient and of highly reliable cable networks. Some examples are given in the paper, such as research of new techniques for cabling in rocky soil and condition monitoring of cable network.

Paper 0977 goes deep in the Reserve Grid concept which can be linked to the presence of a secondary grid which has been already experienced in Zurich urban MV network. The paper compares different topologies for secondary grids in terms of structure, cost and system reliability. By equipping reserve grids with DG a further step in the convergence towards Smart Grids can be expected.

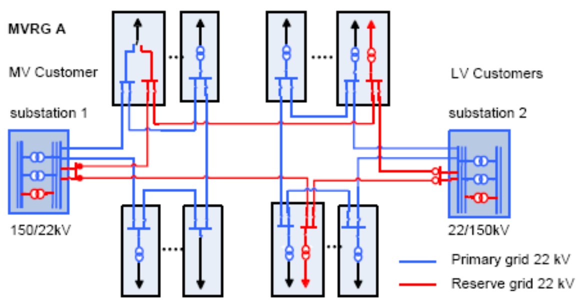

Fig. 22: Topology of the primary distribution grid on the medium voltage level including a reserve grid (Paper 0977)

Paper 1069 and **Paper 1076**, from the same authors, carry on a complete analysis of the transition from a 'fuel based' generation system to a distributed and 'renewables based' one in a closed distribution system located in the Island of Pantelleria. Behaviours of electrical network, generation facilities and load have been simulated and quality of supply, reliability and losses have been calculated and compared with those related to a traditional scenario. Results from simulations, presented in **Paper 1069**, point out there can be benefits due to the evolution of the present electrical system in an active one both in terms of losses reduction and of quality of the energy supply. A detailed economical assessment of cost and benefits is then carried on in **Paper 1076** .

Paper 1071 presents modelling approaches and results relevant to smart distribution system development with DG in European grids. The studies, based on real data and DG/consumption scenarios of distribution networks from different European countries, compare expected network reinforcement needs and reverse power flows according to different network management strategies.

Results show that:

- benefits from DG arise at a low penetration level but higher quantities of DG may result in increased losses due to counter-flows;
- accommodation of DG can be easier in stronger network structures, while benefits in terms of operational may be small. On the other side, weaker networks may significantly benefit from insertion of DG, but may suffer for that in terms of voltage profiles;
- active management of distribution network allows reinforcement investment reduction or postponement, at the expense of higher operational costs (due to increased energy losses), while maintaining traditional (passive) management requires high volumes of investments but results in a significant reduction operational costs.

Paper 1171 refers to a EU-funded project (named "ADDRESS") aimed at delivering a comprehensive commercial and technical framework for the development of "Active Demand" (AD) in the smart grids of the future. The project is about enabling the active participation of domestic and small commercial consumers in power system markets and in the provision of services to different power system players. This paper describes the system architecture and functional specifications of Distribution System Operator (DSO) and Transmission System Operator (TSO) control systems needed for the management of active grids exploiting distributed generation, storage and load/storage flexibilities and AD on distribution networks (MV and LV).

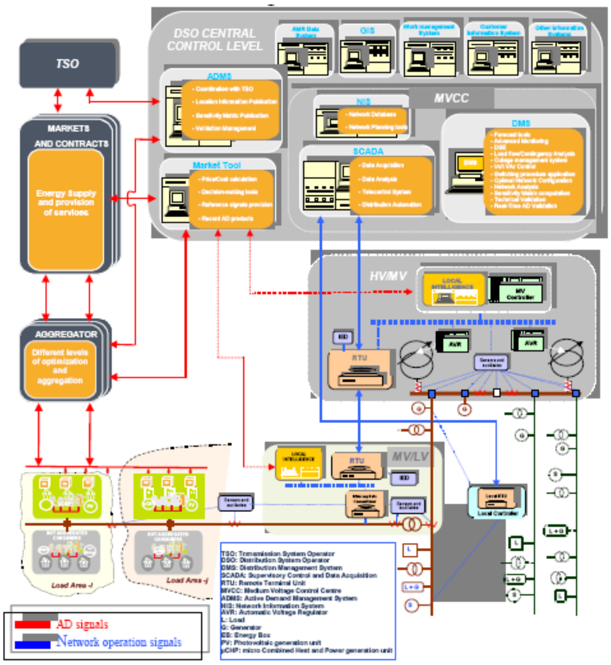

Fig. 23: DSO control system functional architecture as in Paper 1171

The paper concludes that to both enable and exploit the flexibilities and services provided by massive demand side participation, distribution network management has to be substantially enhanced by introducing new functions at the DSO Control Centre level as well as by decentralizing intelligence.

ADRES project, as in **Paper 0694**, aims at developing robust energy system for island-grid with applications in rural electrification. At this stage of the project, authors focus on load-generation balancing issues according to the "load-follow-generation" concept; simulation have been performed to evaluate available RES generation in three Regions of Austria. Once generation plants had been sized, forecast model for household loads have been developed and customers' reasonably flexible behaviours have been verified in order to assess the stability of the system in relationship to the fluctuation of supply from the generation side.

Potential scope of discussion – Block 2

Active grid and (in general) Smart Grid appear to represent in any possible scenario the inevitable evolution of distribution networks both at the MV and LV level. Projects and demonstration have been carried on and it seems that most of the technology needed is already available to build a Smart infrastructure in each possible site. However, being possible in each given site doesn't necessarily mean being economically feasible in all places at a whole. Not all technologies available for Smart Grids are in the same stage in terms of maturity, cost effectiveness, and so on. Opinion sharing about that could be interesting.

Table 2: Papers of Block 2 – Network Development

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
73: Hydro-Québec's SmartGrid Roadmap Update and Smart Grid Zone				X
94: Investigation of Indoor Low-Voltage Cables as Data Communication Channels				X
98: User Centric design of smart grids; a social and economical approach				X
126: Impacts of electric mobility on distribution grids and possible solution through load management				X
294: Optimizing the EV electrical demand impact		5		
305: Engineering the Distribution Systems of the Future				X
311: Development and operation of Active Distribution Networks. Results of CIGRE C6.11 Working Group.		1		
364: A Structured Approach for Smart Grid Implementation		3		
377: Challenges in smart distribution grids				X
387: A planning approach for Active Distribution Networks				X
400: Technological Breakthrough for Real Time Smart Metering via Power Line Communication (PLC)				X
404: An Approach for Reliability Assessment of Distribution Network with DG				X
426: ENARD: Results from the First 5 year Term of International Collaboration in Electricity Networks				X
447: Innovative Concepts for Efficient Electrical Distribution Grids		4		
498: Distribution network adaptations and recommendations for 2020 EV infrastructure charge development in France				X
545: Introducing smart grids - Practical experience of a DSO				X
569: The energy storage application strategy in different voltage levels of distribution system		8		
578: Migrating Towards a Smart Distribution Grid: State of the Art		2		
694: ADRES@World				X
722: Optimal Planning and Control of Microgrids with Distributed Energy Resources on Smart Grid				X
850: Smart Grid Communications Emulator (100.000 synthetic users).		9		
924: Cabling of Rural Networks - from Vision to Practice				X
977: The Topology of Self-Sustaining Grids regarding Reliability and Cost : From Reserve to Smart Grid				X
981: Emergency Planning Method of Urban Distribution Networks Based on Microgrid				X
991: Research and Practice on Technologies of Smart Distribution Networks				X
1037: Advanced Management of a Closed Ring Operated MV Network: Enel Distribuzione's P4 Project		7		
1054: Utilizing a single transitional platform for traditional and Smart meters. Opportunities & challenges.				X
1069: From fuel based generation to smart renewable generation: preliminary design for an islanded system. Part I: technical issues and future scenarios				X
1071: Distributed Generation and Smart Grid Development: Case Studies in Different European Countries				X
1076: From fuel based generation to smart renewable generation: preliminary design for an islanded system. Part II: selection of future scenario and economical issues				X
1106: Techno-economical and life expectancy modelling of battery energy storage systems				X
1129: Storage devices impact on electricity distribution networks				X
1171: Architecture and functional specifications of distribution and transmission control systems to enable and exploit active demand		10		
1199: Distributed Intelligence Provides Self-Healing for the Grid		6		
1279: Automated closed loop underground distribution for supplying sensitive loads				X
1329: Design and operation of smart grids - Technical system and market model				X

Block 3: Distribution Planning

Sub Block 1: General Planning

The papers of **Sub Block 1** refer to general planning algorithms that are proposed to solve classical distribution planning problems as the optimal feeder or the location and design of substations. The optimization is led by economic reasons or by the need of improving both reliability and power quality. The challenge imposed by the integration of DER and the Smart Grid paradigm stay "behind the scene" in many of these papers because the authors are conscious that some of the proposal should be deeply revised due to the future distribution systems.

Some papers are mainly focused on planning algorithms for expansion planning in the medium and long term. Some propose well-known techniques adapted to a particular case study, some others develop novel implementations or adaptations of techniques.

Paper 009 deals with the distribution network planning with the evaluation hierarchy establishment. The application to a 10 kV network in China proved the engineering practicability.

In **Paper 0028** the optimal feeder routing problem is solved with an application of a branch exchange algorithm. The main novelty in this case is represented by a basic integration with the municipal map of the urban areas. Also **Paper 1252** deals with the distribution planning aided by geographic information systems. The presented real world case study shows the capabilities of the really advanced tool CADDIN that makes use of load spatial analysis for the long term planning. **Paper 0728** is also related to geographic information and spatial analysis of the load forecast in the area served by a distribution companies. The strategic planning system gives information on the areas where there is the need of upgrades or new installations as well as demand side actions. The impact of load profile on planning is also dealt with in **Paper 0082** that shows that with a clear understanding of electricity usage pattern by consumers substantial savings may be achieved.

A significant group of papers is devoted to algorithms for distribution planning. **Paper 0065** presents an original application of game theory to planning to find compromise solutions for compensation among different stakeholders and reducing the time for the negotiation process. **Paper 0112** proposes a fuzzy comprehensive evaluation method to find the optimal connection modes for the Shanghai network. The dramatic development of Shanghai economy is really a challenge for the distribution system. **Paper 0122** also deals with planning in Shanghai with reference to two practical engineering applications in the reformation of MV distribution network. **Paper 0363** proposes a hybrid metheuristic procedure for expansion planning of distribution networks based on the simulated annealing technique and mixed integer linear programming algorithm. Even though the idea is not completely new, the hybridization seems to be quite effective and capable to reduce the computing time in real size applications. **Paper 0328** solves the long term strategic planning of substations with a nice use of dynamic programming. **Paper 0539** also deals with a similar planning problem and applies the total supply capability index.

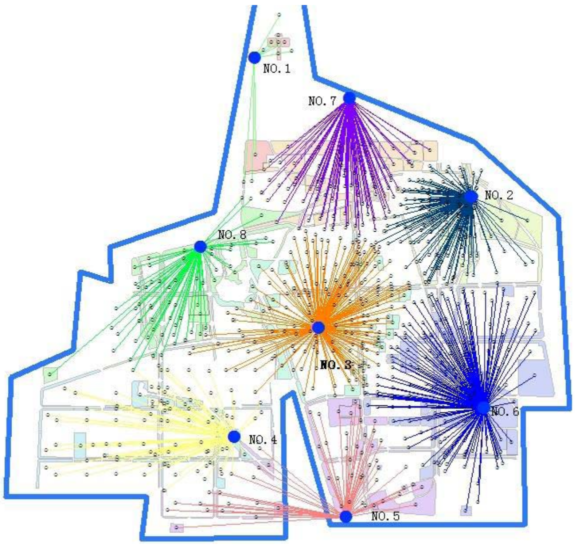

Fig. 24: Optimal size and location of substations as found by the algorithm proposed by Paper 0328

The problem of optimal feeder routing is solved with Genetic Algorithms or Branch Exchange algorithms in **Paper 0639** and **Paper 0606**, which is mainly interested to improve reliability. The particle swarm optimization algorithm is successfully used in **Paper 0688.** The algorithm can be adapted and implemented to the modern distribution network with a reasonable effort. **Paper 1331** also uses the Genetic Algorithm for grid reconfiguration to reducing energy losses. The Genetic algorithm implemented is a part of a complex network, energy and data management system used in a Poland distribution company.

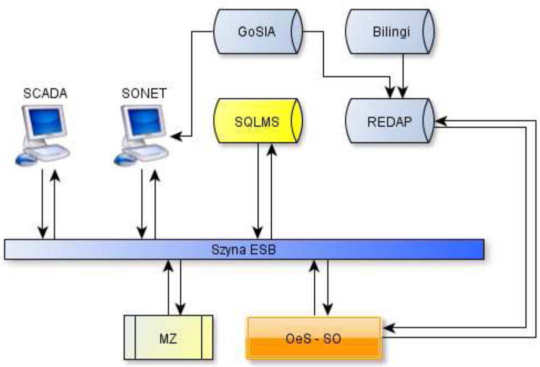

Fig. 25: Architecture of the system for network, energy and data management in Paper 1331

Paper 0883 outlines and illustrates the latest version of an automatic network routing algorithm with particular reference to the treatment of existing MV network, which should prove invaluable in aiding the development of least cost investment plans. **Paper 0095** deals with the interaction of master plan with day by day planning in a fast developing city of Turkey with high diversity in the area under consideration. It describes the expected development of the electrical infrastructure for the next 20 years and acts as a guideline for the short term planning which is necessary to remove the bottlenecks in the network and to get approval for high investments from the regulator.

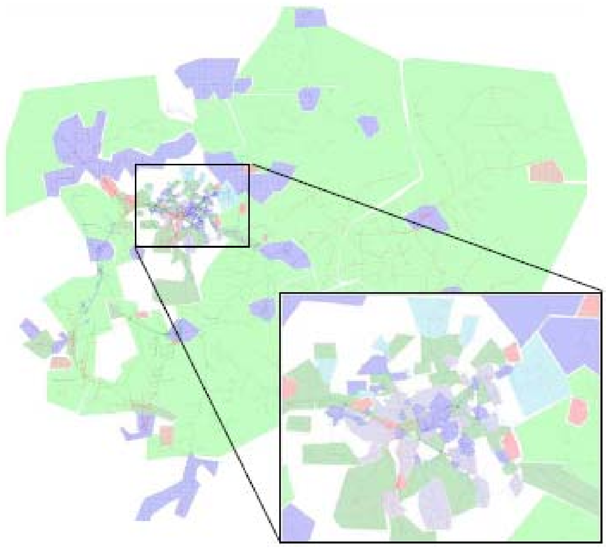

Fig. 26: Load growth in the area studied in Paper 0095

Reliability and risks of operation in planning process are dealt with in **Papers 0147** and **0824**. **Paper 0783** describes the status of MV networks in China considering 31 large and medium cities in China. The objective configurations of MV distribution for the development of economic society and DG integration are proposed by applying system theory and reliability-based distribution planning method.

Paper 0876 aims at improving the design process of LV networks to meet voltage magnitude requirements of low voltage feeders, by using the measurement assessment incorporated in quality of supply standards. The adoption of a novel probabilistic approach makes the paper really useful and the results are more cost effective than those achievable with the worst case deterministic approach.

Paper 0412 deals with the introduction of electric vehicles and electric heat pumps in new residential areas, which can have a high impact on low voltage networks. Investments for LV network upgrade are convenient only if the changes in load profiles are going to happen within 10 years, otherwise it would be better to postpone them.

Fig. 27: Comparison between different strategies for LV investments (Paper 0412)

Paper 0267 deals with Smart Grid and customer friendly networks. The maximum entropy principle and fuzzy analysis method and the compatibility between system disturbance and equipment are studied also.

Two papers deal with active management, Smart Grid and planning. **Paper 0635** finds that the phases of planning process of passive and active networks are similar. As most DER, controllable loads, storage devices and electric vehicles are invisible to the DNOs, forecasting the generation growth for coming years can be offered by the Virtual Power Plant operator. The introduction of load and congestion management in active distribution network will reduce the number of bottlenecks. Further reduction can be offered by the VPP through active control on the contribution of DER and other newcomers. The combination of active networks and VPP systems, which leads to smart grids operation, provides a wide range for load and congestion management.

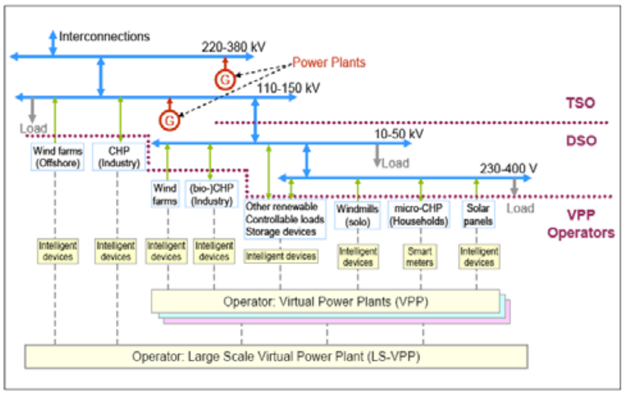

Fig. 28: Operators of network and VPP (Paper 0635)

Paper 0999 deals with the simulation of advanced active distribution networks and highlights the relationship between the regulatory environment and the level of active management implementation. Different scenarios have been assumed and the behaviour of the system stakeholders has been simulated with multi-objective algorithm. The main relevant conclusion is that the active operation of the system is fundamental to reduce investments for the network upgrading in the medium term.

The interesting **Paper 0954** deals with MCDM (Multi-Criteria Decision Making) that is fundamental to achieve coherent and more appropriate choices oriented to a certain areas' energy sustainable development. AHP (Analytic Hierarchy Process) is one of the most widely used multi-criteria decision-making methods in the field of energy planning. The paper develops an innovative framework to be used for an AHP to assist the decision making in sustainable electrical power systems planning. The methodology has been tested on a real and complex case concerning the planning of a electrical power system to supply end users of an island in the Indian Ocean.

Sub Block 2: Automation and Reactive Compensation Planning

Sub Block 2 refers to planning techniques and methods related, but not limited, to the development of automation and voltage regulation system. Most authors approach optimization problems dealing with continuity or quality of service, solved by varying the positioning of devices such as remote-controlled switches or circuit breakers, shunt capacitors, etc..

In **Paper 0858** automation criteria for remote-controllable secondary substations in Helsinki are presented. Optimal placement of RMUs and automation strategies are defined according to topological evaluations and cost-benefit analyses based on reliability indexes fixed by new national requirements.

Paper 1028 presents a methodology for defining optimal network reconfiguration in presence of outages, in order to choose the reconfiguration that presents the lower power losses. The methodology is based on statistical failure and repair data of the distribution power system components and uses fuzzy-probabilistic modelling for system component outage parameters; all possible reconfigurations are then evaluated by load flow calculations, excluding those who lead to undesired network conditions, and the feasible reconfiguration with lower power losses is selected. A case study on a real distribution network follows.

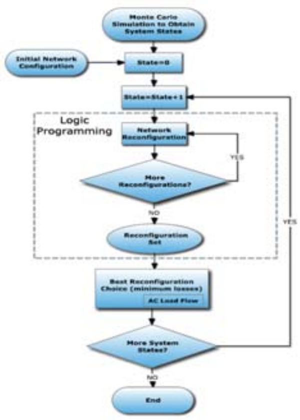

Fig. 29: Reconfiguration Flowchart as described in paper 1028

Paper 0298 deals with the optimal placement and sizing of fixed capacitor banks in MV in order to achieve reactive power compensation, improved voltage regulation, power factor correction, power/energy loss reduction, as well as power quality improvement. A methodology based on a modified simulated annealing technique is proposed and applied to two case studies, in which linear and nonlinear loads as well as wind turbine generators are modelled and the object function is represented by the annual savings emerging from the reduction of both the peak power demand, due to power loss reduction, and the energy losses, deducting the cost of the installation of capacitors. Results show that benefits are very much case-depending, thus justifying the need for evaluation algorithms.

Paper 0496 presents a Micro-Genetic Algorithm for optimal placement and sizing of shunt capacitors and voltage series regulators. The problem is formulated as a mixed integer, non-linear, constrained optimization problem in which an objective function (e.g., the total cost including the losses cost) has to be minimized while meeting a number of equality constraints (e.g., power flow equations) and inequality constraints (e.g., admissible ranges of the bus voltages and limits on line currents). Two alternative methodologies, Linearization Method (LM) and Point Estimate Method (PEM) are applied to the IEEE 34-node test system and compared; results show that both methods provide good solutions in the examined cases, LM requiring computational efforts significantly lower than those of the PEM.

Sub Block 3: DG/EV Accommodation Planning

While automation and voltage regulation are internally-driven issues and can drive investment decision related to compliance to performance requirements, DG and EV accommodation points directly to the adequacy of the network to external challenges. Furthermore, future behaviours of DG investors and penetration of EV charging facilities are not easily forecasted; this adds uncertainties and requires planning algorithms that may differ from conventional ones.

Paper 0093 investigates penetration of DG in a HV distribution network, proposing a methodology, based on Particle Swarm Optimization algorithm, for defining maximal active power can be injected into pre-defined buses of grid considering the possibility of multiple accesses of generating units. The methodology is based on an economic dispatch study, considering objectives as minimal losses, minimal risk of operational violations, and maximal individual penetration. A 14 bus IEEE network is tested accordingly.

Paper 0920 presents a model for evaluating investment decision in DG within an active distribution network environment. An objective function is defined to determine the optimal time, place, and size of DGs with different technologies to be installed in the distribution system in such a way that the net profit during the planning period is maximized; the multistage DG expansion planning problem is approached through a Genetic Algorithm. The model has been applied to a case study; results show that, under the assumptions of a deregulated environment, network operator behaviour (as the aggregator of DG units) may significantly favour higher penetration of DG if playing the role of an active market player (that bids into the energy and ancillary services markets).

Optimal planning of active networks is also approached by **Paper 1025**. This paper presents an updated mathematical model aimed at defining a least-cost network investment strategy, taking into account traditional network reinforcement as well as the deployment of active network management schemes as investment decisions. The problem is initially modelled as a complete mixed-integer program, then Benders decomposition is applied to divide the original problem into a binary investment problem and two operational sub-problems. Stochastic programming techniques are used to incorporate the uncertain nature of intermittent generation and demand when calculating operational costs over the planning period. Authors report that in practise, when applied to distribution networks, results from simplified algorithms such as DC load flows may not be as accurate as needed but complete AC load flows being required result in an increase of computational complexity.

Future diffusion of EV will surely affect distribution networks; trying to evaluate the nature and extent of this influence is the scope of a series of papers.

Paper 1158 approaches the problem through a stochastic method to assess the impact from EV charging on a LV residential network trying to take into account uncertainties inherent with EV usage, such as location, EV type, energy usage and connection time using predefined probability distribution functions. Simulations are carried on assuming EV penetration from 10% to 50% on a given network; results show that violations are not going to be likely in the case of study, but could be significant in other networks according to the possible contemporaneity of peak loads of EV charging system and residential loads.

A Monte-Carlo simulation technique is adopted in **Paper 1225** to estimate the impact of EV on LV grid. The author approaches an EV "residential" model in which vehicles and recharge facilities are represented as household appliances. The simulation is carried on in a typical LV network taking into account different possible scenarios, randomly generated, differing in terms of EV penetration, time of use, load profile, charging and pricing strategy. Load profiles are then generated for each scenario and overload probability is evaluated. Further activities are foreseen in order to validate base data with real sampled data at individual households.

Paper 1247 aims at evaluating the ecological impact of EV and PHEV as well as the technical and economical effects on the network. The methodology is applied to an existing suburban network area within a scenario in which 50% of the residential customers own an EV. Network reinforcements and new network structures needs are calculated in order to accommodate the whole EV load. An estimation of the ecological consequences related to the selected scenario is also provided in terms of emissions' reduction and traffic noise reduction.

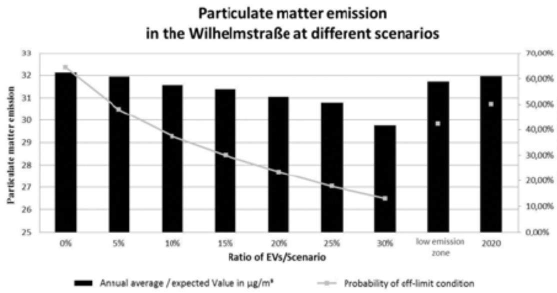

Fig. 30: Impact on EV penetration on particulate matter emissions (Paper 1247)

Paper 1110 evaluates the Milan distribution network according to its capability of supporting a massive diffusion of EV without network reinforcement. Maximum power and maximum additional energy are calculated in case of complete usage of existing infrastructures, and the number of vehicles who can be supplied is determined in case both of slow and fast charging. Finally a theoretical maximum is determined, assuming maximum additional energy is completely usable by means of smart charging techniques.

Analyzing the usage of EV as a responsive demand and dispatchable storage is the scope of **Paper 0434**. Authors investigate the effect that the inclusion of EV will have on the distribution network, assuming that control of charging facilities can be performed; possible benefits of charging control functionalities are examined and several techniques are exposed and compared in terms of accuracy, computational complexity, and so on.

Paper 0742 deals with the impact on the network of mass application of EV, provided EV users are able to join grid operation within a framework which allows management of both charge and discharge phase. The paper examines main EV charge/discharge characteristics, defines a model for dual interaction between grid and vehicles and, after setting an objective function based on minimum mean square deviation of regional load curve varying the charge/discharge hour profile, finds optimal charge/recharge strategy maximizing the utilization of the grid using a Particle Swarm Optimization (PSO) algorithm.

Paper 0718 proposes a statistical framework for modelling the impacts of PEVs in order to make extensive network analyses such as congestion studies feasible and reliable. Several methods are proposed in order to capture EV uncertainties in terms of type, location and load profile. The above methods may be used in the case of congestion studies in active networks for either long-term planning or shorter look-ahead time horizons. Identification of critical lines can be achieved by means of a multivariate modelling of all possible scenarios and then performing load flow calculations to the most optimally reduced database, followed by a correlation analysis of the results.

Paper 0750 refers to impact of plug-in hybrid electric vehicles (PHEV) connections to the grid. Authors examine extensively advantages and drawbacks of employing PHEVs and then set scenarios related to different network management criteria and PHEV-network interface. Then the optimization problem is defined based on objective functions such as minimizing fuel cost of the power plants, minimizing start-up cost of the power plants, minimizing line losses of the grid, etc., expecting as results a sizing of the EV fleet which is likely to be accepted by the grid, as well as the characteristics of the energy management system.

Sub Block 4: Case Studies

Planning is an everyday activity and planning examples do not necessarily deserve a specific evidence. Each one of the examined cases is for some reason peculiar, referring to a non-standard planning condition: some start from scratch or near-scratch conditions, some refer to niche application whose experience may be fruitfully shared, and, finally, some are pilot applications of specific interest.

In **Paper 0335** the project for the renewal of an urban 150 kV cable in Zurich is performed in relationship with strict national prescriptions about long-term exposition to magnetic fields. Several technical alternatives are examined and compared in terms of compliance with permission requirements, investment costs, reliability and losses. Results show that optimal decision-making process strongly depends on the relative importance and hierarchy of the evaluation factors.

Cross-bonding practices are quite common in HV cable lines. **Paper 0438** proposes a cross-bonding technique in a MV underground line. A study has been carried on to assess theoretically the costs and benefits related to introducing cross-bonding. A pilot test has been conducted in order to validate the analytical results: field measurements show that benefits may arise in terms of loss reduction and increase of cables capacity.

A specific network revamping and developing project carried out in the city of Pointe Noire, Congo, is exposed in **Paper 0475**. The authors describe the process of planning and building a new HV/MV substation, six MV/MV substations, MV feeders and a control system based on fiber optic communication. The whole construction has been made using standardized Enel Distribuzione components and unified contract schemes, resulting in a simpler design, interchangeability of components and, finally, in savings related to scale economies in tender and spare parts management.

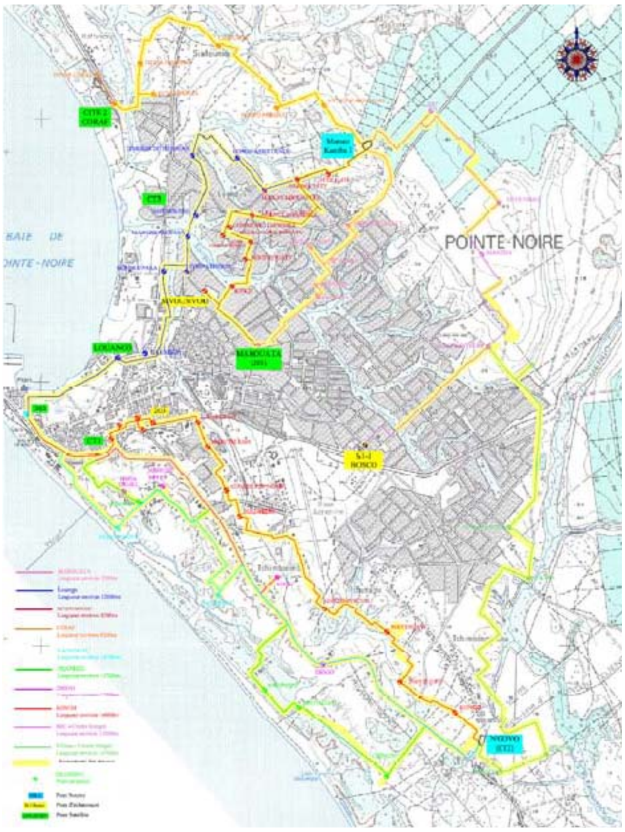

Fig. 31: Pointe Noire network at the date of January 6th 2011, according to Paper 0475

Paper 1309 describes the results of a survey, conducted in the city of Sao Paulo, about underground cable acceptance related to aesthetics perception and customers' willingness-to-pay (WTP) for it. The survey employed the Contingent Valuation Method to quantify the environmental benefits of residential customers related to the conversion of overhead lines into underground ones: results show that the aggregated WTP in the neighbourhood could account for about 30% the projected investment.

Paper 0785 reports the results from a study that investigated the load pattern from EVs. The analysis was performed monitoring the operation of 15 outlets (charging stations) in a strong urban grid. Power and energy measurements were carried out to establish load characteristics; power quality measurements were also performed. Available results include aggregate load profiles, utilization time statistics and power quality analyses. As a matter of fact, power quality performance was well within the limits given in the Norwegian Power Quality (PQ) Code.

Paper 0474 describes the characteristics of a distribution automation system designed to ensure self-healing functionalities in a 10 kV MV network. The key element of the system is DTU (Distribution Terminal Unit) which can perform data acquisition and fault location for the different fault modes. Restoring of supply according to information available from network measurement points can also be performed.

Potential scope of discussion – Block 3

State-of-the-art medium-to-long term planning techniques should be able to take into account all significant events related to network planning in the chosen time frame. However, due to the increasing complexity of the system involved, optimal planning should be able to forecast the evolution, among others, of EV penetration, RES development and Active Demand diffusion. It may possibly be that the uncertainties in the scenarios' forecast exceed the differences between alternative network development solutions. To face this paradox, alternative strategies can be selected:

- refine the scenario forecast model more than the network planning optimization tools;
- perform scenario sensitivity analyses, trying to evaluate how optimal planning (according to a specific planning objective) differs in case of different scenarios;
- adopt flexible network technologies, building a network which can be easily re-configured, looking for the capability of adapting more than the accuracy or reliability of forecast;
- stick to conventional analytical planning, which in most cases represent the safest alternative in terms of network sizing.

Table 3: Papers of Block 3 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
9: An Effective and Applied Method on Evaluation of Distribution Network Planning				X
28: Optimum Planning of Primary-Secondary Distribution Networks According to Real Municipal Maps				X
65: Game Analysis of Interest Groups in Policy-processing of Power Grid Construction and Research on Compensation Mechanisms			X	
82: End User Load Profile Analysis For Distribution System Planning				X
93: Maximizing Penetration of Active Power by Distributed Generation on Real System.	10			
95: Network Planning in Highly Diversified Areas				X
112: A Fuzzy Comprehensive Evaluation Method for Connection Modes of Urban HV/MV Distribution Network				X
122: Planning and Optimization Strategies of MV Distribution Network in Shanghai				X
147: Scheduled interruptions in an urban network and their risk for substantial customer costs in a follow-up outage: A contribution to mitigate economic losses.				X
267: The Programming Method of Customer Friendly Distribution Systems Considering the Uncertainty of Short Time Power Quality Disturbances			X	
298: Optimal Size and Location of Capacitor Banks in Distorted Distribution Networks with Distributed Wind Generation				X
328: A New Distribution Substation Multi-stage Planning Algorithm Based on Dynamic Programming				X
335: Design of an urban 150 kV cable connection with regards to regulatory requirements for magnetic fields				X
363: Expansion planning of distribution networks using simulated annealing technique				X
412: Investment strategy for low voltage networks regarding new technologies	7			
434: Multi-objective network planning tool for the optimal integration of electric vehicles as responsive demand and dispatchable storage			X	
438: Cross-bonding in middle voltage distribution grids, as a method of energy efficiency improvement				X
474: Research on Automatic Backup Power based on DUT				X
475: Revamping and developing of the Distribution Network in Pointe Noire, Republic of Congo - an Eni Congo and Enel project				X
496: A probabilistic approach for Voltage Regulators and Capacitor Placement in three-phase unbalanced distribution systems				X
539: Sensitivity Analysis on Total Supply Capability for Distribution Systems				X
606: Distribution System Optimal Planning for Reliability based on Genetic Algorithm				X
635: Planning and Design of Smart Grids with Virtual Power Plants				X
639: Enhanced Design of Distribution Networks, Using BE & GA Methods				X
688: Improved Hybrid TS/PSO Algorithm for Multistage Distribution Network Expansion Planning				X
718: Using a multivariate DOE method for congestion study in distribution systems under impacts of plug-in electric vehicles			X	
723: Status quo and Prospects of Urban MV Distribution Network Structure in China				X
728: Long Term Planning based on the Prediction and Analysis of Spatial Load			X	
742: V2G Charge-Discharge Strategy with EV Mass Application			X	
750: Analytical Assessment of mutual Impacts between PHEVs and Power Grid				X
785: Integration of electric vehicles to the distribution grid	12			
824: Failure Risk Associated with Different Substation and HV Network Configurations				X
858: Customer damage evaluation and network automation strategies for different urban zones	8			
876: Design parameters for LV feeders to meet regulatory limits of voltage magnitude				X
883: Optimizing MV network development and enhancement using a routing algorithm and cable re-rating				X
920: Distributed generation expansion planning in active distribution network				X
954: A novel AHP framework for Decision Making in Power Systems sustainable development				X
999: Multi-Objective analysis of Regulatory frameworks for Active Distribution Networks			X	
1025: An Optimization Model to Integrate Active Network Management into the Distribution Network Investment Planning Task	9			
1028: Hybrid Fuzzy Monte Carlo and Logic Programming Model for Distribution Network Reconfiguration in the Presence of Outages				X
1110: Electric Vehicles' impact on the planning of the Milan distribution network				X
1158: Stochastic Analysis of the Impact of Electric Vehicles on Distribution Networks				X
1225: Modelling Electric Vehicles at Residential Low Voltage Grid by Monte Carlo Simulation	11			
1247: Technical and ecological impacts of the network integration of electric vehicles in a distribution network of a major city in Germany				X
1252: Planning of the distribution network Ogulin using optimization tool CADDiN				X
1309: Economical evaluation of the aesthetic aspect of putting cables underground				X
1331: Optimization of MV grid based on genetic algorithm implemented in OeS calculation system.				X

Block 4: Methods and Tools

Planning activities work by methods and use tools; that said, the papers which have been inserted in Block 4 explicitly deal with specific network calculations of large diffusion and general use in planning activities, and in particular:

- Load forecast;
- Load flow calculations and State estimation;
- Energy Losses Minimization.

Sub Block 1: Load Forecast

Paper 0034 deals with long term load forecasting and presents a comparison between two models when applied to the Egyptian unified network; these models are Artificial Neural Network (ANN) model and regression model. Data pre-processing techniques have been applied to improve forecasting accuracy of the model. Forecasting capability of each approach is evaluated by calculating two separate statistical evaluations of the Mean Absolute Percentage Error (MAPE) and the Average Absolute Percentage Error (AAVE).

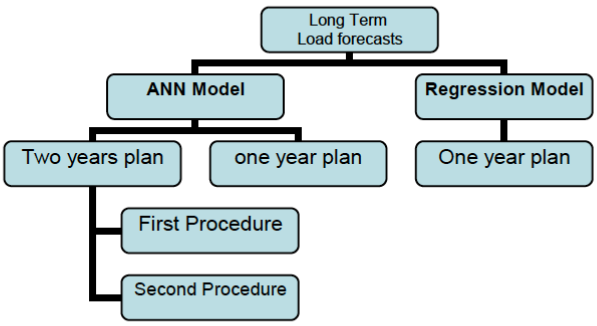

Fig. 32: Models Proposed in Paper 0034

The proposed method was utilized to predict peak load and energy sales for Egyptian unified network. It is obvious that the new methodology of combining one or two variables to get a new training variable reduces significantly the forecasting error.

Paper 0277 presents different possibilities for utilizing Automatic Meter Reading (AMR) data on customer classification and load profiling. The customer classification and load profiling can be made separately or they can be combined by using clustering algorithms. Individual load profiles can also be formulated from the AMR measurements.

The availability of AMR data also enables new and more accurate methods of modelling distribution network loads. Accurate load profiles are needed in daily used distribution network calculation, for example in load flow calculation, state estimation, planning calculation and tariff planning.

Paper 0306 studies several practical Short-Term Load Forecasting (STLF) models, such as time series, least mean squares, gray model and similar day. Integrated optimum model is studied for better utilization of each model, and it is more suitable in STLF.

A whole STLF system based on dispatching automation system for a certain district in Shanghai is successfully developed according to the practical demands of electric power company, with the advantages such as real-time, economy and practicality. Client/Server(C/S) mode is used in the system. Oracle 9i is employed as supporting database platform.

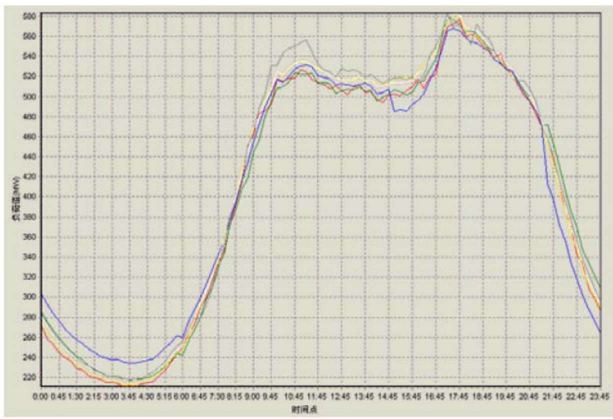

Fig. 33: Forecasting and real curves of Nov 8, 2010 (Paper 0306)

The forecasting system introduced in this paper is now used in the power supply companies in Shanghai Electric Power Company. It is developed based on SCADA system and is mainly designed for power dispatching department for short -term load forecasting, with the merits such as friendly man-machine interfaces, high work efficiency and good forecasting precision.

Paper 0416 presents a model for forecasting peak power demands on distribution networks, using two forecasting components. The baseline component is based on a top down approach and combines energy, load factor and historic peak forecasts, integrated into a single forecast using an interactive procedure.

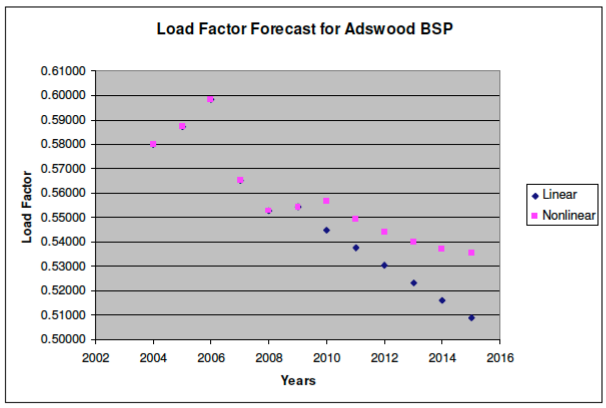

Fig. 34: Compared Forecasts of load factor by two methods exposed in Paper 0416

The incremental component is a bottom-up approach that adjusts the baseline using information supplied by local planning authorities. The proposed methodology is being developed to forecast peak demand at all bulk supply substations within the Electricity North West area. Possible improvements include replacing annual historic peak forecast with weekly historic peaks to reflect seasonal and annual trends.

Paper 0717 deals with the prediction of loads on MV and LV network explaining the criteria underlying the forecasts and the algorithms adopted by Enel Distribuzione. The reference scenario shows increasing complexity, given by the number of network owners, the introduction of the free energy market, more and more important by the presence of distributed generation, and finally by the continuing legislative and regulatory developments. In this context, the methodologies developed by Enel and described in the article are based on the considerable opportunities offered by technological developments, with particular reference to instruments used by Enel Distribuzione for measuring energy and power.

These ones have made possible to refine the software "PRECAR" for the calculation of load forecasts, developed in collaboration with CESI. Finally, the increasing of distributed generation on the electricity distribution network has required further implementations on the software that would enable greater efficiency and reliability.

Paper 0799 describes the use of data from smart meters at LV customers to obtain knowledge of load behaviour, load profiles and coincidence factors. These data can be used to improve load models of LV customers, which are used for calculation tools regarding planning and analysis of LV networks. The data obtained during the winter of 2010 from 200 smart meters was analyzed. Several conclusions can be drawn. The various loads during the peak don't show a normal distribution. About 20% of the connections contribute for about 50% to the peak load of a transformer and a feeder. In order to obtain proper result of LV-calculations the parameters used for expected load and coincidence factors must be adjusted.

These results show that new elements, such as the increase of home entertainment appliances, the penetration of in-house DG, new heavy loads like heat pumps and electric vehicles, may have impact on the performance of the LV network and have to be taken into account by calculations performed for planning and other analysis of LV networks.

Paper 0808 proposes a method for the balancing of LV feeders. LV networks often operate in an unbalanced way, especially in the case of rural networks where there are few connected consumers. Indeed, as the connected phase of existing consumers is not identified in the Geographic Information System (GIS), it may not be possible to choose the best phase to connect a new customer. Due to this randomly based connecting scheme, important voltage drops and additional losses can occur.

The AMM infrastructure currently deployed by ERDF in the LINKY Project will provide the utility knowledge of real phase connection and individual load curves, opening opportunities to identify unbalanced LV networks and to consider the possibility of large scale balancing plans; the study showed that a stochastic method such as a genetic algorithm could be adapted to address this issue, paving the way for optimal balancing.

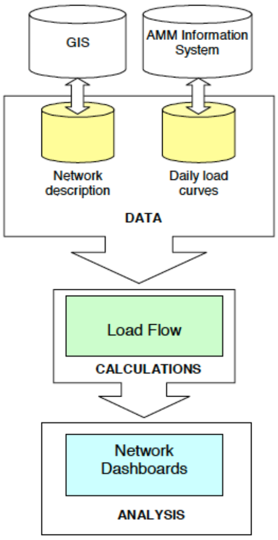

Fig. 35: AMM Data Processing as exposed in Paper 0808

Paper 1016 presents a Monte Carlo simulation method for generating stochastic load profiles for models of low voltage (LV) electricity grids to support middle- and long-term strategic asset planning processes. Models that calculate aggregated loads in a deterministic way using a coincidence coefficient (simultaneity factor) do not give insight in the probability of an overload and eventual asset failure.

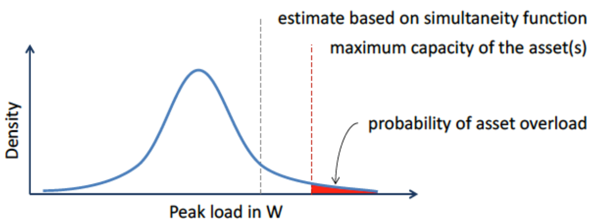

Fig. 36: Probability distribution Vs deterministic estimate of aggregated peak loads (Paper 1016)

Analysis of minute-to-minute load data obtained with Monte Carlo simulation, based on the characteristics and behaviour patterns of different household types, can provide more accurate probabilities of peak loads, especially for subordinate grids where individual consumption behaviours have relatively high impacts.

A limitation of the presented method is that the analysis only considers loads; voltage drops are ignored, whereas in rural or suburban LV networks with rather long strings, the critical voltage limits are generally reached before the critical loading. This limitation can be overcome by performing follow-up analyses on a representative sample of grids using more sophisticated grid analysis software.

In **Paper 1018**, long term load forecasting is presented, focusing on external factors. Factors having impact on the load are categorized into three groups, namely: governance factors, social factors and urban planning factors. Subordinates of each factor are identified and quantified. Then, a data-driven model is constructed, having the external factors as inputs and peak loads and energy consumptions as outputs. Subsequently, the outputs of the model are utilized to calculate load factors.

In **Paper 1330**, LEM-Software presents a database-supported software solution for bottom-up energy forecasts on various time scales. Handling the daily business regarding forecasts is a time-consuming challenge. Dealing with thousands of recorded load curves and hundreds of thousands of load profiles, software is needed that can do as many of the necessary processes automatically.

Sub Block 2: Load Flow Calculations and State Estimation

Paper 0224 presents the design of real-time data-base for Smart Distribution Management System (SDMS). The design of real time database is important for stable operation of the management system which performs the analysis of large scale power system, because the efficiency of system resource and stable operation should be considered. In SDMS there are some applications for monitoring and operating the power distribution system, and these applications should be continuously and stably conducted. For this reason, the real time database is designed for considering the performance.

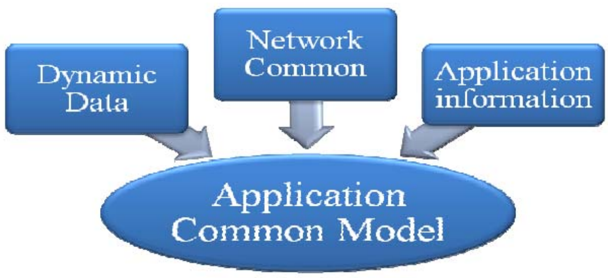

Fig. 37: Conceptual Structure of ACM Concept as exposed in Paper 0224

The Application Common Model (ACM) is designed to extract common model depending on the computing characteristic on each application, and the most of the common models are designed according to equipment model and topological structure.

The ACM presented in this paper has been applied directly in the application software for the analysis, and designed to consider the fast computing speed and the stable operation of the application.

Paper 0454 presents a distribution system state estimation (SE) algorithm for application to radial distribution networks. This method exploits the radial nature of the network and uses forward and backward propagation scheme to estimate the line flows, node voltage and loads at each node, based on the measured quantities.

The benefits of this proposed method are the computational efficiency by using the branch currents as the system state and using the historical load data as measurement, allowing the WLS approach for distribution systems and make it very suitable for practical applications. Using the methodology proposed is possible to evaluate the real technical and non-technical losses, and then, identify the regions with discrepancy, helping on the execution of a fraud combat plan.

Paper 1112 explores the potential to apply an artificial intelligence planning approach to a distribution network so as to manage voltage with much less dependency on human intervention which is usually required to set control targets for controllers. This is achieved by the integration between a load flow simulator and a planner.

There are many ways to control voltages in an electricity network, which can be briefly summarized as below:

- Reactive power compensation by SVCs and mechanically switched capacitors (MSC)
- On-load tap changing transformers (OLTC)
- Generator terminal voltage control
- Line reactance compensators e.g. series capacitors.

A voltage planning methodology within a distribution network has been introduced with the aim of finding a sequence of control settings that allow voltage limits across a network to be respected while minimizing the number of individual control actions.

Paper 1177 describes basic and logic concepts used by the new calculation model, developed through a collaboration with CESI, which supports all calculations needed to verify LV network condition taking into account the presence of DG as well, performing all criticality analyses related to voltage profile and voltage variations, loading of components, short-circuit behaviour and the risk of undesirable islanding. Since last decade, Enel Distribuzione has developed and operated a Geographic Information System (GIS), named SiGraf, for the purpose of mapping MV and LV network characteristics and the geographical and electrical position of every single MV and LV customer. More than being a mere cartographic tool, during last ten years SiGraf has been gradually integrated with many of the other Company IT systems, allowing systematic data sharing and updating with Smart Metering and Commercial applications, among others.

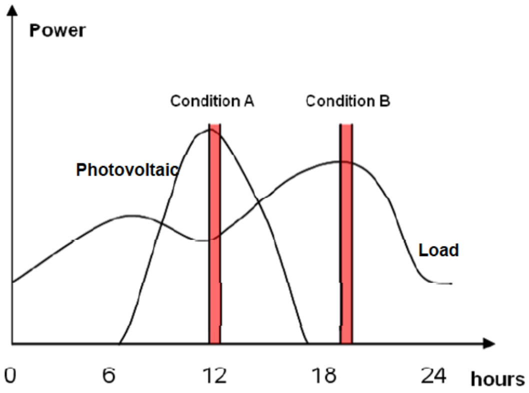

Fig. 38: Typical daily load and PV generation as exposed in Paper 1177

SIGRAF application was developed by ENEL Distribuzione to verify user connection to the BT network. It is based on a statistical approach: the power values at the nodes of the network are no longer being treated in a deterministic way, i.e. as time-depending, but rather in terms of statistical variables. The results (power flow and voltage), are statistical variables having a certain probability (based on a risk coefficient "α") not to be exceeded.

It's important to emphasize that the results obtained by the statistical method may not satisfy Kirchoff's laws. On the other hand, using a deterministic method would produce results that respect Kirchoff's laws on the network but it would have the disadvantage, certainly not acceptable, of repeating the calculation for time intervals in which it is assumed loads/generators remain constant, and then repeat the calculation, for example, at intervals of 15 minutes.

Paper 1211 presents the evaluation of the uncertainty level introduced by the distribution state estimation in the Distribution Management System (DMS) operating. Examples derived by a representative distribution network are presented.

Distribution State Estimation (DSE) is fundamental for the active management of the distribution networks because it gives the Distribution Management System the essential information for the real time scheduling of generation and responsive loads and the network reconfiguration. The DSE represents a source of uncertainty in the operating of the DMS and the more accurate the quality of the estimates the more suitable the decisions made by the DMS can be.

In **Paper 1191**, a new Total Transfer Capability (TTC) based on the Static Voltage Stability Region (SVSR) method is developed and incorporates a new transmission probabilistic nodal loading model (PNLM).

In this paper, the quantitative component-level description is used at the distribution-level to investigate the status of individual residential appliances which switch on and off according to appropriate responses to changes in the outdoor environment, thermostatic set-points, and human behaviour induced effects.

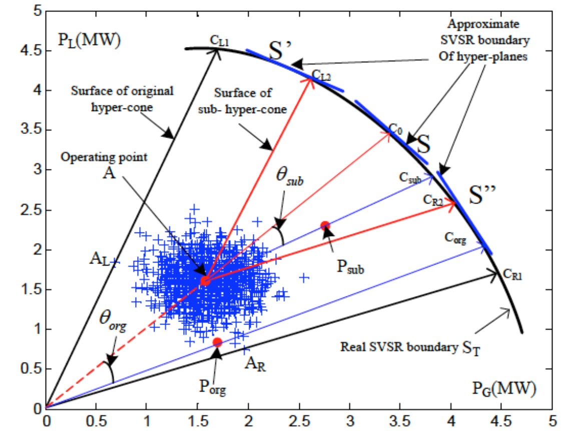

Fig. 39: Hyper-cone-like probabilistic loading model in power injections space (Paper 1191)

Sub Block 3: Energy Losses Minimization

Paper 0064 presents an Optimal Reconfiguration of Radial Distribution System which can be obtained by closing switches (tie-switch normal open) and opening closed switches (sectionalizing switch–normal close) to satisfy Radial Distribution System for getting improvement system voltage, and power losses.

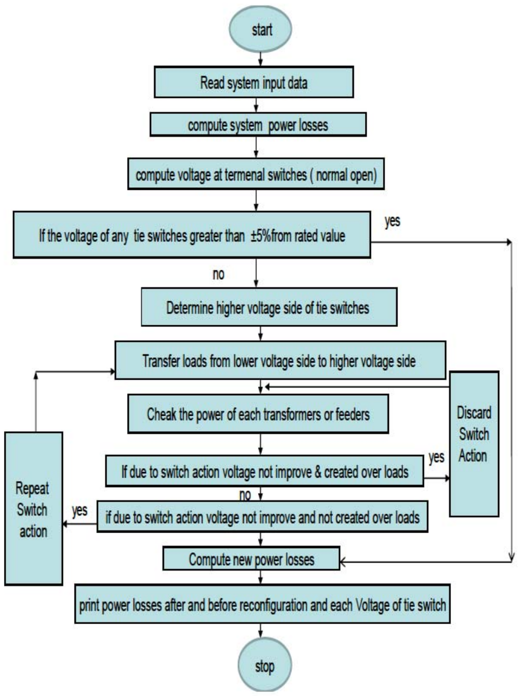

Fig. 40: Flow Chart proposed for Network Reconfiguration (Paper 0064)

In the reconfiguration strategy described here it is assumed that the distribution system is radial. So, each load is served through only one source.

Paper 0101 presents a two-stage methodology for the optimal capacitor placement problem in distribution systems using fuzzy and Selective Particle Swarm Optimization (SPSO) to reduce the power losses and to improve the voltage profile. The proposed algorithm applied to a real distribution system in Canal Company for Electricity Distribution (CCED) to select the nodes to be compensated, as well as the optimal capacitor size to be placed at these nodes. The simulation results investigate the effectiveness of the proposed algorithm in reducing the power losses and improving the voltage profile.

In **Paper 0177** a planning management method for MV (medium voltage) distribution networks is formulated. This proposed method takes into consideration combined effect of voltage drop, overloads and a technical power loss based on the worst network conditions, and propose the main constraints of mathematical calculation of the presented case studies.

In **Paper 1313**, energy losses in active distribution networks are estimated by a straightforward technique. This technique, after its first adjustment to a network, does not require any extensive computations such as scenario-based load flow calculations. Active distribution networks are characterized by accommodating more stochastic energy flows due to the proliferation of electric vehicles as well as renewable resources. To take successful steps toward planning and configuring active distribution networks, utilities need to take a predictive look at how the new active system's components would affect the traditional efficiency indexes such as the energy loss.

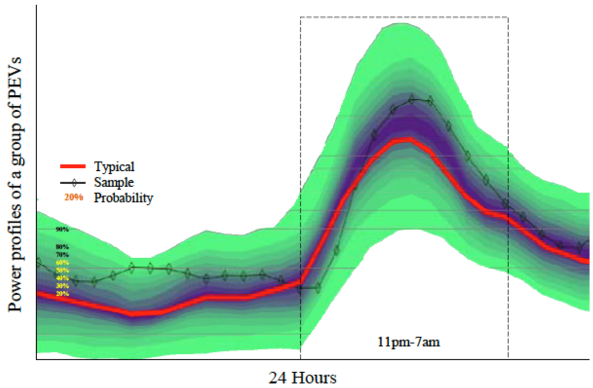

Fig. 41: An illustration of scenario-based approximation of typical PEV loads uncontrolled behaviour (Paper 1313)

Potential scope of discussion - Block 4

Distribution System Operators (DSOs) will be facing problems in Voltage Management and regulation also due to the increased penetration of new energy sources in the form of Distributed Generation (DG). These problems could be approached with techniques such as Demand Side Management (DSM) or advanced control by DSOs. The potential to apply artificial intelligence to manage voltage with less dependency from human intervention could be discussed, focusing on the quality and reliability of this kind of control under a pseudo-random energy generation from DG.

Table 4: Papers of Block 4 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0043: Long Term Load Forecasting for The Egyptian Network Using ANN and Regression models				X
0064: Distribution network reconfiguration to improve system performance and reduce power losses				X
0101: Towards Power Losses Minimization and Voltage profile improvement in CCED, Practical Case Study				X
0177: Configuration Management of Electric Distribution Network				X
0224: Design of Application Common Model for Network Analysis in Smart Distribution Management System				X
0227: Customer Classification and Load Profiling Based on AMR Measurements				X
0306: A Comprehensive System for Short-term Forecasting applied in Shanghai				X
0416: A Composite Model for Long-Term Forecasting of Distribution Peak Demands				X
0454: Intelligent state estimator system for distribution systems				X
0717: Benefits of the modern energy metering systems for the distribution network planning and development processes with the diffusion of distributed generation.				X
0799: The use of smart meters to improve customer load models				X
0808: Large Scale Phase Balancing of LV Networks using the AMM Infrastructure				X
1016: Mote Carlo Simulation of Load Profiles for Low-Voltage Electricity Distribution Grid Asset Planning				X
1018: Modelling the impacts of governance, social and urban factors on long term Load Forecasting				X
1112: Voltage Control of Distribution Network Using an Artificial Intelligence Planning Method	6			
1177: A GIS-Based LV network calculation engine supporting the integration of distributed generation: A new statistical algorithm for ENEL- Distribuziones's Sigraf.				X
1191: Probabilistic Total Transfer Capability based on Static Voltage Stability Region Analysis and Uncertainties of Aggregated Feeder-level Load Data				X
1211: Impact of Distribution State Estimation in DMS operation				X
1313: Energy loss forecasting in active distribution networks				X
1330: Bottom-up forecasts for load demand and the grid infeed of renewable energy sources				X