Special Report - Session 4
DISTRIBUTED GENERATION – MANAGEMENT AND UTILISATION OF ELECTRICITY

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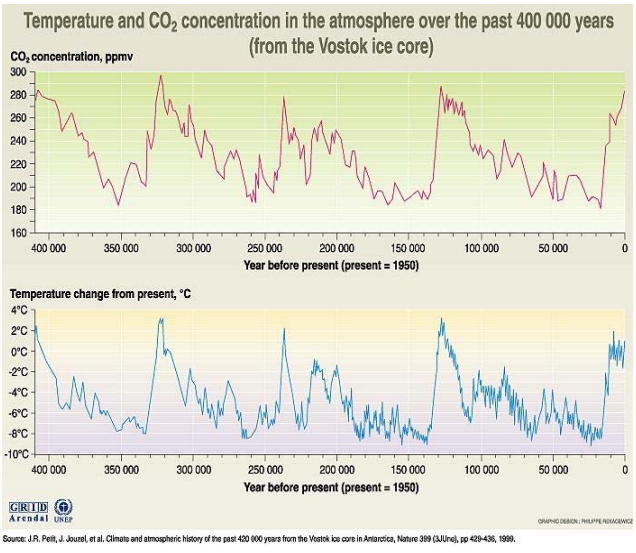
There is now almost universal acknowledgement that global warming is both a real and significant phenomenon. And whilst there is clear scientific evidence of pre-historic cyclic changes in ambient temperature, and a strong correlation with cyclic variations in atmospheric CO_2 levels, it also very clear that man-made emissions of CO_2 and other 'greenhouse' gases have contributed to a position whereby atmospheric concentrations are now at an unprecedented level and continuing to rise.



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

There is now also wide acceptance that unless steps are taken to reduce or at least contain man-made CO_2 emissions, the consequences for the planet could be dire in both economic and human terms. Sir Nicholas Stern in his review on the economics of climate change[1] noted that failing to act to curtail greenhouse gas emission could result in a doubling in the concentration of greenhouse gases in the atmosphere compared with pre-industrial levels by 2035. This would virtually commit us to an increase in global temperature of 2 deg C with a 50% chance of a rise of more than 5 deg C in the longer term. The economic impact of such changes could be equivalent to a loss of global GDP of around 5%, or up to 20% if a wider range of risks and impacts is taken into account.

1 'The Economics of Climate Change' - Sir Nicholas Stern. A report commissioned by the UK Government and published in January 2006.

In response to concerns over global warming (and in addition to commitments already made under the Kyoto Protocol), European Union Member States have now agreed to a binding target of achieving a minimum 20% contribution from renewable sources to total energy production by 2020. Moreover, in order to achieve this target, the required contribution from renewable sources to electricity production could be as high as 34%.

Notwithstanding the potentially devastating consequences of climate change, there are also concerns around the security of long-term sustainable energy sources in the form of (or derived from) fossil fuels.

All of the above gives added weight to the importance of increasing the contribution from renewable forms of electricity generation, and to the more efficient production and use of energy, including the application of efficient CHP and demand-side management. Such measures, effectively executed, could make a significant contribution to containing greenhouse gas emissions. However, the implications for electricity distribution networks are that such networks will need in future to be more actively managed. This will mean embracing a wider range of technologies (including ICT) in order that such networks can continue to be properly controlled and protected, and able to continue to provide customers with a safe, economic and reliable system of electricity distribution.

It follows from the above that learned contributions to CIRED Session 4 have never been more topical or important. It is fortunate therefore that we have been able to accept no less than 97 high quality papers for Session 4.

For the Main Session on Wednesday 23 May, these papers will be divided into 4 Blocks. The 4 Blocks are:

- Block 4.1 - Control and Protection of Active Networks
- Block 4.2 - Network and Energy Efficiency and DSM
- Block 4.3 - Implementation Case Studies, Planning & Support Tools
- Block 4.4 - Analysis, Simulation and Modeling of Active Networks

For the convenience of readers and attendees, each paper has been allocated to one of these 4 Blocks as detailed in Tables 4.1, 4.2, 4.3 and 4.4 below. A selection of these

papers (6 in each Block) has been selected for oral presentation. Each presentation will be limited to approximately 10 minutes in order to allow adequate time for questions and discussion. In addition, each author of an accepted paper has been invited to prepare and present a poster during the 'Poster Session' which will take place for Session 4 on Thursday 24 May.

Round Table Session

In addition to the Main Session, a Session 4 Round Table will take place on Tuesday 22 May. As with the Main Session, the Round Table Session will be divided into 4 Blocks. Oral contributions to the Round Table Session are from an invited panel, and are in addition to the above-mention 97 accepted papers. The Round Table Session is intended to be more interactive. Brief presentations from the panelists will be followed by a longer period of discussion. The format of the Round Table will be as follows:

RT4a Network integration and modelling of large wind turbines

The Round Table will discuss experience in the network integration of large wind turbines and establish the state-of-the-art in modelling such devices. This is a rapidly developing area and it is intended to include discussion of:

- Grid Codes and their application to distribution connected wind turbines
- Voltage and power factor control
- Models of variable speed wind turbines, particularly for fault calculations
- Loss-of-mains protection and its relevance to large wind turbines
- Integration of significant distribution-connected wind generation into transmission systems, and implications for overall system balancing and operation

R/T 4b Ideas for, and experience of, active distribution networks (including commercial and regulatory incentives)

Active distribution networks are now beginning to be developed in a number of countries and this Round Table will review progress. It will discuss the benefits of the schemes and the commercial and regulatory incentives that are necessary to stimulate active operation of distribution networks. The ambition of the Round Table is to gather and disseminate real experience of distribution companies implementing active networks and the support that is necessary from Regulators to stimulate this type of innovation. Invited panellists will cover the following areas:

- An overview of developments in the UK
- Regulatory incentives
- Developing the Large Scale Virtual Power Plant concept (Project FENIX)
- An overview of R&D activities supporting the development of active networks
- An update on the IntelliGrid experience
- A report from a microgen simulation trial

RT 4c EU R&D update

The Commission of the European Union has invested heavily in Research and Development of new approaches to electricity networks though Framework 5 and Framework 6. The results and progress of this research will be reviewed and considered in the context of international initiatives. The 1st round of proposals under Framework 7 is likely to have closed by the time of the Conference but the Round Table will provide an opportunity for discussion of future R&D needs.

RT4d Research & Innovation Forum (RIF)

A number of papers from each of the Main Session Blocks have been selected for the RIF Round Table session (see Tables 4.1, 4.2, 4.3 & 4.4 below). No oral presentations will be given but the authors of these papers will be able to discuss their papers with experienced distribution engineers and technical practitioners. This will allow the important link to be made between 'research' and potential 'development' by discussing the practicality and applicability of the innovative ideas presented. This part of the Round Table session will provide an opportunity to hear about, and discuss, the latest research, innovative ideas and modelling techniques that could help change the future of distribution networks.

Main Session

The remainder of this 'Special Report' will now summarise each of the 97 'Session 4' accepted papers, with each paper discussed under the Block Heading that the paper has been allocated to in the Main Session, starting with the 6 papers in each Block that have been selected for oral presentation.

Block 4.1 - Control and Protection of Active Networks

Undoubtedly the greatest challenge facing network operators in the future will be to ensure that the transition from passive to active network operation is adequately supported by appropriate control and protection systems.

In this respect, control of both voltage and power factor are key priorities. This includes both controls applied to active networks and controls applied directly to DG.

Closely associated with power factor control is the control of load flows in active distribution networks, including the intentional use of DER (including DG and storage) to support the grid.

Stability (including small signal stability) and frequency response are further factors that network operators must understand if active networks are to maintain (or improve) the power quality and reliability that customers will expect

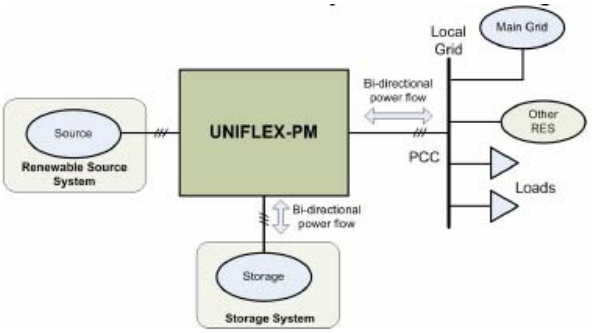
in the digital age. It is also important to understand the impact of DG and inverter connected DG on the quality of the voltage waveform.

Understanding and catering for the fault behaviour characteristics of DG, particularly induction and doubly-fed induction machines, and inverter connected generators, is a further important factor.

All of these issues receive the attention of papers in this Block; each one makes for essential reading for those involved in the management and operation of DG and active networks.

The 6 papers to be presented are as follows:

Paper 217 describes the performance requirements, electrical specifications and control functionality required of power electronic converters in the context of future networks comprising a wide range of renewable energy sources of electricity generation. The UNIFLEX-PM system is described noting that the modular architecture of the power converter leads to high reliability and low cost.



Paper 308 discusses the possibilities surrounding the use of Distributed Generation to provide ancillary services including voltage (power factor) regulation, system stability, black start, and post-fault network restoration. The paper demonstrates potentially significant improvements in terms of voltage regulation and losses reduction.

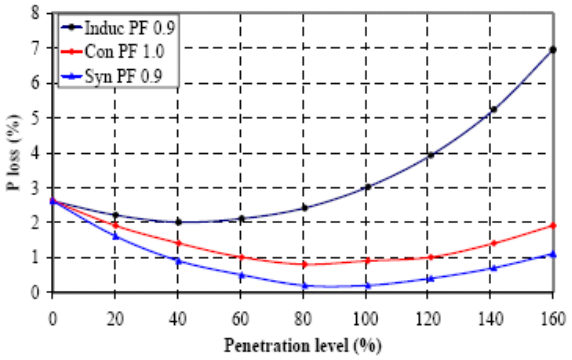


Figure 3: Active power loss with different DG penetration levels

Paper 330 describes the development and demonstration of a centralised Step Voltage Regulator / Static Var compensator based system for controlling line voltage when a large number of Distributed Generators are connected. The results show that a high degree of steady-state voltage stability can be achieved through a combination of centralised and autonomous control.

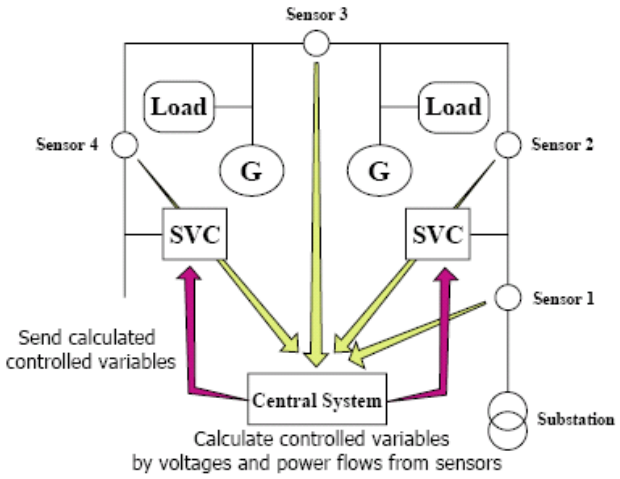


Fig.1 Centralized Control Method

Paper 539 describes the development of a hybrid inverter grid-connected Distributed Generation system comprising a combined Wind / PV / Battery Energy Storage System and describes the possible modes of operation including normal, power averaging and power dispatch. Experimental results from a developed prototype are presented.

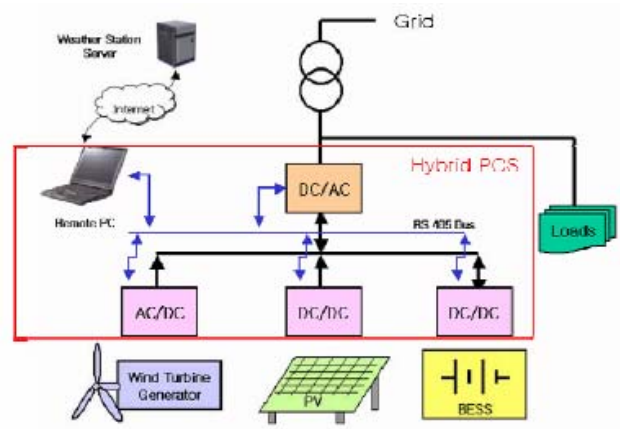


Fig. 1. A configuration of the proposed hybrid generation system

Paper 667 describes a novel Power Flow Control System based on an inverter grid-connected Distributed Static Synchronous Series Compensator-SSSC. Two possible control schemes are presented and the results demonstrate that a smooth control of power flows is possible.

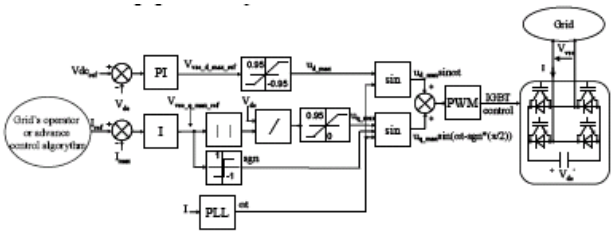


Figure 4 – Single phase control synoptic of the D-SSSC – Parallel control scheme

Paper 727 presents a new approach for voltage / Var control in distribution networks with Distributed Generation. The method proposes the use of a local intelligent and auto-adaptive voltage regulator that is not dependent on measurement and communication signals from the distribution network. The regulator is able to co-ordinate in real-time the control of several Distributed Generators connected to a common HV/MV substation.

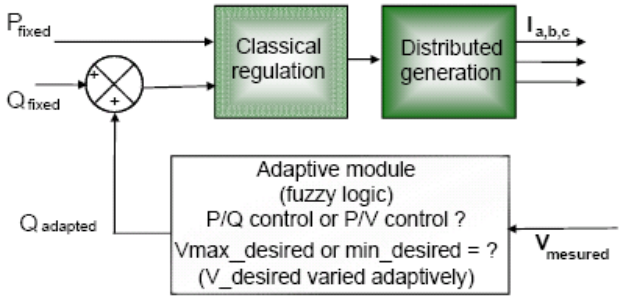


Fig.1b: Functionality of auto-adaptive regulator

The remaining papers allocated to this Block are described below:

Paper 003 describes the design of a computer-based controller for a wind-turbine driven induction generator operating in self-excitation mode using terminal-connected capacitors.

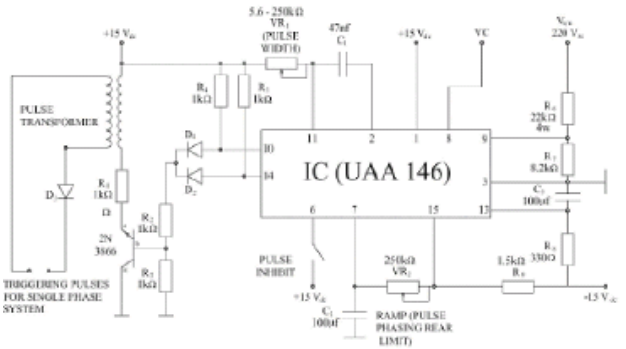


Figure (2): Control circuit for a single-phase of the 3-phase system

Paper 222 meanwhile describes the use of modified converters and Static Var Compensators using a switched capacitor technique to control a 3-phase induction motor improving power factor and energy efficiency.

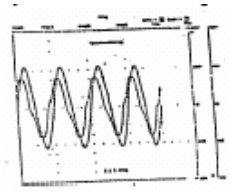


Fig. 14a, Supply voltage and current before compensation

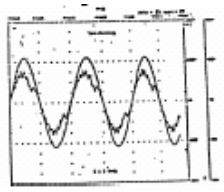


Fig. 14b, Supply voltage and current after compensation

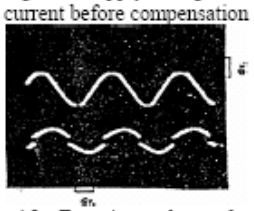


Fig. 15a, Experimental waveforms before compensation

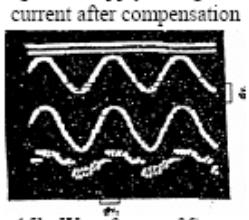


Fig. 15b, Waveforms of S_1, supply voltage, and current after comp.

Paper 031 explores the use of distribution line carrier based detection of unintended islanding and notes favourable comparisons compared with conventional active or passive techniques.

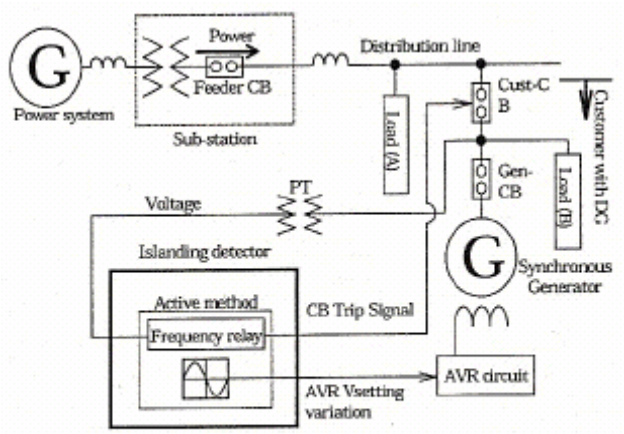


Figure 1. DG System [1]

Paper 548 investigates the fault behaviour of inverter-supplied micro-grids in order to determine alternative approaches to the design of suitable protection schemes. On the basis of the simulations performed, alternative voltage-based protection schemes are suggested.

Paper 655 continues the protection theme by describing an expert computational system approach to the protection of overhead distribution feeders, including feeders with DG. The impact of DG on conventional protection schemes is considered; in particular its effect on voltage profile, short-circuit current levels, system stability and islanding potential.

Paper 066 determines whether a power system stabilizer applied in a small-scale gas fired plant is able to enhance the damping of oscillation modes in a sample power system. The results show that although the effect on local oscillations is negligible, there are benefits in terms of damping inter-area oscillations.

Paper 122 is similar to paper 539 (described above) in that

it describes a hybrid grid-interfaced system comprising a combined Wind / PV / Battery Energy Storage System (BESS) which can individually control the Wind Turbine and PV Arrays using the BESS as an energy buffer. The results show that the system is able to supply flexible and stable power.

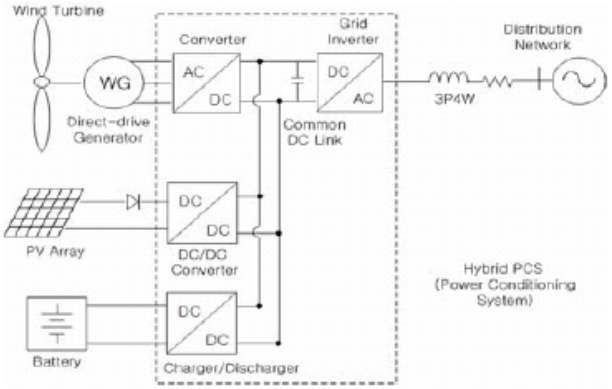


Fig. 1. Proposed grid interactive hybrid system

Paper 148 describes an advanced voltage control relay using state estimation of Distributed Generator output and measurement of local busbar loading as inputs. The results show that the system can optimise network voltage and permit a higher penetration of DG.

Paper 312 presents an alternative approach to Voltage / Var control of distribution networks with Distributed Generation based on a Differential Evolution Algorithm. The results show that the Voltage and power factor at each bus remain within desired limits when the DGs are controlled.

Paper 773 meanwhile proposes an innovative methodology for voltage regulation of MV networks with DG. The method controls steady-state voltage variations by integrating the control of the substation transformer tap changer and the reactive output from the DG via multiple inputs to a control algorithm. Numerical simulation has been achieved using DigSILENT Power Factory.

Paper 467 continues this theme and considers the case for an improved method of optimisation of Distributed Generation voltage from a technical, contractual and regulatory perspective. Examples of simplified voltage control approaches are described.

Paper 572 presents an overview of state-of-art and future wind turbine generation technologies and their compatibility with grid code / regulation requirements for full reactive power management. Constant rotor speed and variable (power electronic converter connected) rotor speed systems are considered, and the paper concludes that whilst the former are not well suited if a wide reactive operating range is required, variable speed systems can fulfill requirements using an appropriate control strategy.

Paper 774 describes the simulation results of a series DG connection module using a voltage source converter (VSC) to control the magnitude and phase angle of the voltage output from a series connected injection / booster transformer. The DG module's power output varies with line loading, providing a load leveling function, and can act as a storage device during light load conditions.

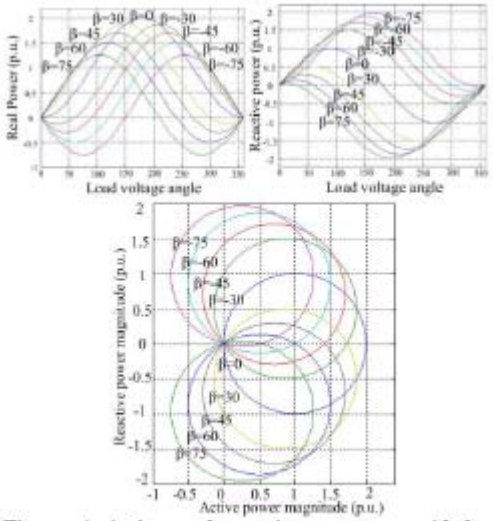


Figure 4 Active and reactive power provided or absorbed by the series interconnection module under different load factor conditions.

Paper 245 assesses the possible improvements in transient and voltage stability of a Distribution Network Cell (DNC) comprising renewable energy sources (RES). Synchronous Generators, Fixed Speed Induction Generators, DFIGs and converter connected generators are considered. Conclusions are drawn from over 500 case studies.

Paper 310 provides an overview and comparison of existing DG interconnection standards and technical guidelines. The paper concludes that there are significant differences across countries and that a common standard is needed as a foundation for international trade and transfer of expertise.

Paper 369 investigates the impact of harmonic distortion as a potential barrier to the wide-scale penetration of Distributed Energy Sources (DER) using a solar power installation. The results show that LF distortion is not a major concern but that resonance may occur above 1 kHz. HF distortion (2–9 kHz) could become a serious problem.

Paper 540 describes the use of simulation studies to explore the resilience of a multi-agent networked distributed micro-grid control system to Information Communication Technology (ICT) faults. Both accidental and malicious faults are considered.

Questions:

1. Network Operators are developing innovative methods for controlling active networks but what is the scope for DG to be fully integrated into the overall control regime?
2. What are the commercial and regulatory barriers that need to be addressed to enable network

operators to use DG to its full potential in balancing distribution system generation and demand?

3. In order to achieve the very high levels of DG penetration that may be required to support CO_2 emissions reduction and renewable energy targets, what new approaches towards network fault detection and protection will we need to develop?

4. To what extent should power quality or even reliability be compromised to permit higher levels of DG to be connected; are some relaxations (for example in terms of short duration voltage excursions) permissible?

Table 1: Papers of Block 4.1 assigned to the Session

Paper No.	Paper Title	Oral	RIF
003	Classical and Modern Control Systems of self-excited induction generator		
031	Comparative Analysis of Islanding Detection Methods in Networks with DG		
066	RTDS/PSCAD study on the operation of a power system stabilizer in a small gas power plant		X
122	Control Design and Performance Analysis of a Grid Interactive Wind/PV/BESS Hybrid System		
148	Advanced Voltage Control for Networks with Distributed Generation		
217	Advanced Power Converter for Universal and Flexible Power Management in Future Electricity Network	X	
222	Energy Development and Control of Electric Motors and Drives in Egypt using Modified Converters and SVC		
245	Improvement of Transient Responses of Distribution Network Cell with Renewable Generation		X
308	Possibility of Using DG for Ancillary Service and Secure Operation of Power System	X	
310	DG Interconnection Standards and Technical Requirements: Comparisons and Gaps		
312	An approach based on Differential Evolution for Volt/Var control at Distribution Network considering Distributed Generators		X
330	A Study of Centralised Voltage Control Method for Distribution System with Distributed Generation	X	
369	Distributed energy resources and waveform distortion		
467	Distributed generation contribution to voltage control		
539	Development of a Grid-Connected Wind/PV/BESS Hybrid Distributed Generation System	X	
540	Resilience of a Distributed Micro-grid Control System to ICT Faults		
548	Fault behaviour in islanded micro-grids		X
572	Low and Medium Voltage Wind Energy Conversion Systems: Generator Overview and Grid Connection Requirements		
655	Expert system for protective device adjustments on distribution systems with DG		
667	Active and Reactive Power Flow Control Based on D-SSSC for Looped or Meshed Distribution Networks	X	
727	Intelligent voltage control in distribution network with distributed generation	X	
773	Innovative Voltage Regulation method for Distribution Networks with Distributed Generation		X
774	A Series Interconnection Scheme for Distributed Generation Applications		X

Block 4.2 - Network and Energy Efficiency and DSM

Leaving aside the environmental benefits of renewable energy sourced generation and good quality CHP schemes, perhaps the greatest scope for reducing CO_2 emissions in the area of electricity generation, transportation and usage lies in improvements in the efficiency of the overall electrical energy supply chain. In this respect, optimisation of network losses (an area which DG can support if properly located and managed) and demand side management of electrical energy are two key areas.

Mitigation of peak demands, both through network and DG solutions, and also through demand side measures, can make an important contribution to reducing network losses and, ultimately, to displacing centralised fossil-fuelled generation.

Commercial, as well as technical, solutions must also be considered, including appropriate market price signaling and the information communications systems that will be necessary to support a closer to real-time pricing regime.

Each of these areas is addressed by papers allocated to this Block. Everyone concerned with the challenge of improving network and/or demand side efficiency should take advantage of the knowledge available from these papers.

The 6 papers to be presented are as follows:

Paper 520 describes energy management through controllable generators and loads using a Bidirectional Energy Management Interface (BEMI). This allows a technically efficient design that does not require fundamental changes to the grid architecture. The concept outlined is that of a decentralised system of decision making based on information from a central control system.

An approach for the management of a pool of DG units using this concept is outlined. This introduces the concept of a new device called 'Pool-BEMI' which will act as a system balancer in place of the conventional central control system. The Pool-BEMI would provide ancillary services enabling effective integration of DG units into the distribution system.

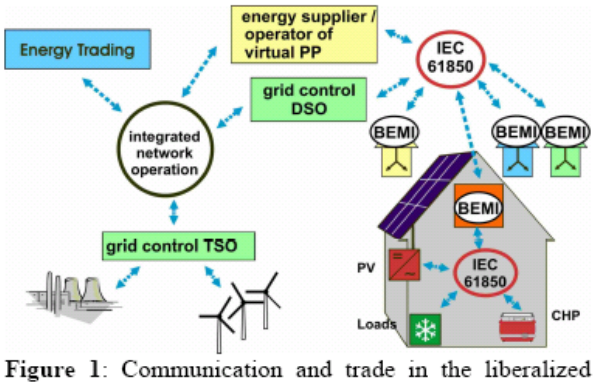


Figure 1: Communication and trade in the liberalized energy market with integration of distributed generation

Paper 530 describes the anticipated transition from 'passive consumer' to 'active participant' where customers will be able to modulate their own load profiles in response to price signaling or a network (emergency) signal. To achieve this will require a multi-functional platform to provide the interface between the distributor / retailer and customer such that the customer's property will become an active node of the network. A test facility has been used to provide a Verification and Validation Environment for the integration of demand side initiatives. The paper describes the method adopted to prove the concept.

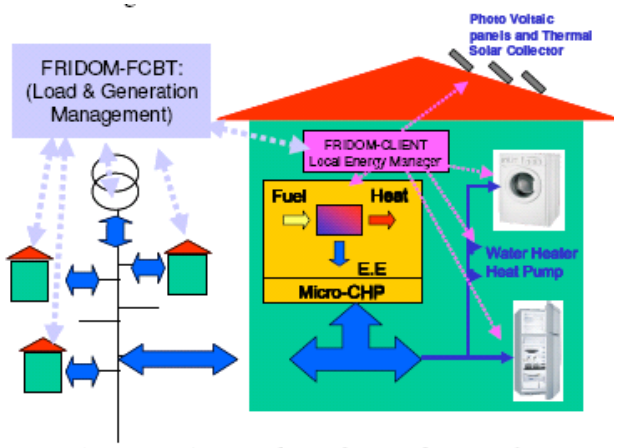


Figure 5. Test facility: *LV dispatching and energy flows' management through MV/LV transformer, LV Customer with the network; Energy management at customer premise (Demand-side Initiative-DSI)*

Paper 532 describes an ICT architecture for delivering market and network signals to final users, and specifies high level requirements for realisation and application of tools to be used by distribution network operators, energy traders and retailers to support the integration of Demand Side initiatives. A test facility has been used to evaluate the integration of experimental systems with a real LV network.

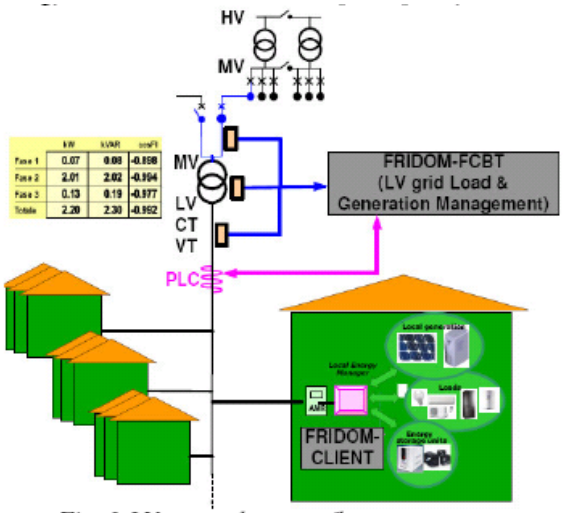


Fig. 3 *LV network power flow management*

Paper 582 discusses the shortcomings of traditional demand response programs in an environment comprising

large amounts of DG. An innovative approach is described in which true Customer Site Integration is obtained by utilising the underlying flexibility of electricity production and consumption devices. The approach is based on distributed control mechanisms and incorporates new market models for distribution and aggregation costs, losses, and network constraints. The paper concludes that distributed solutions such as the 'PowerMatcher' offer a number of advantages over traditional demand response programs.

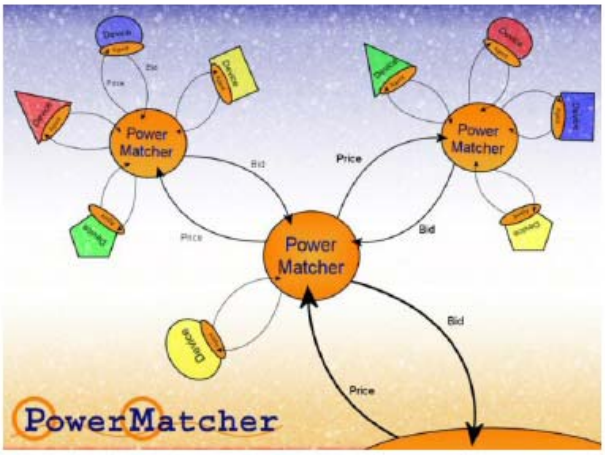


Figure 2 PowerMatcher cell-based control

Paper 725 describes the development of a heating regulator that allows the reduction of peak consumption whilst maintaining a high degree of thermal comfort. The proposed solution can be applied to a group of buildings (virtual consumer) in order to avoid network congestion. An application based on the simulation is presented.

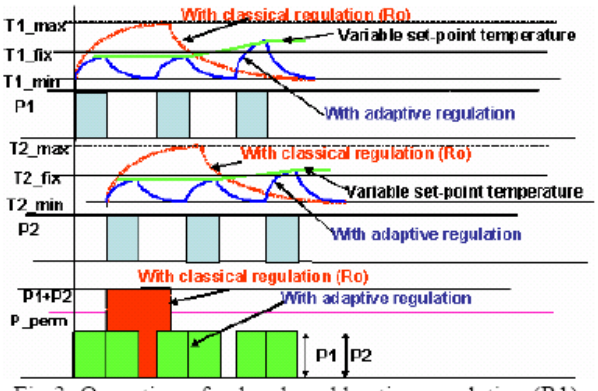


Fig.3: Operation of a developed heating regulation (R1).

Paper 832 describes the potential for balancing of fluctuating regenerative generation using DSM. DG operating in a micro-grid environment can create significant fluctuations in power. The paper suggests that apart from heating load, refrigerators and freezers also present DSM opportunities and that, overall, 20-30% of the load consumed by household appliances could be applicable for DSM without restricting the customer's requirements.

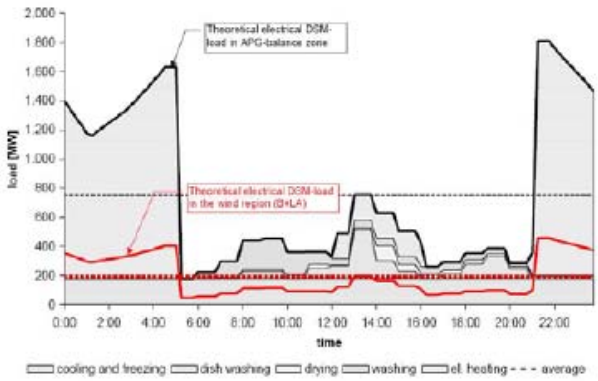


Figure 4: Theoretical DSM-Potential (winter day)

The remaining papers allocated to this Block are described below:

Paper 004 takes an Arabian perspective and deals with the challenge of energy cost optimisation through the implementation of cogeneration and grid interconnection. The paper notes that currently 92% of generation in the Arab World is obtained by burning the equivalent of one billion barrels of crude oil annually. The paper outlines the potential opportunities from cogeneration and power system interconnection between Arab countries.

Paper 024 summarises the approach of the Italian electricity sector to end-use energy efficiency. The paper highlights the Italian energy efficiency target and the White Certificate approach and trading mechanism. The strategic role of Enel is described together with the results following the first year of the mechanism from the perspective of Enel Distribuzione.

Paper 259 describes work to determine the requirements for a planning technique for Highly Distributed Power Systems (HDPS). Multi-attribute analysis is applied to cater for the different technologies, diversity of energy sources and variability of energy profiles associated with HDPS. The results show the adequacy and flexibility of the approach.

Paper 272 also deals with the planning challenge using multi-objective analysis to define qualitative and quantitative parameters applicable to fuzzy logic. The Bellman-Zadeh algorithm is used to determine the optimum positioning of DG on distribution networks in order to minimise losses and maintain adequate reliability and acceptable voltage profiles.

Paper 322 addresses a complementary approach and describes a self-adaptive heuristic search algorithm (Life Cycle Model) to determine the optimum placement of DG. In this model users can switch between generic and 'hill climbing' algorithms when successive iterations do not converge on an improved solution. Simulation shows that a better solution with fewer iterations can be achieved.

Paper 431 discusses the potential for power factor correction to improve energy efficiency and hence reduce

greenhouse gas emissions. Benefits to the network operator include reduced losses and avoided investment. The opportunity requires the optimal use of capacitor banks, communication with end users and increased charges for reactive energy.

Paper 452 proposes the development of a market-orientated service platform for the optimisation of electricity systems using a consistent communication infrastructure to exchange necessary data. The approach known as Integral Resource Optimisation Network (IRON) is based on the concept that unused potential and virtual energy storage can be created through economic signals, and used to remove demand peaks without directly influencing the behaviour of the end user.

Paper 474 follows a similar theme in describing the management of demand and micro-generation using a broadcast of bulk generation efficiency. Demand is moved in time to fill troughs and reduce peaks by using managed demand side appliances (or CHP). Modeling shows that UK peak demand could be reduced by 2GW (approx. 3%).

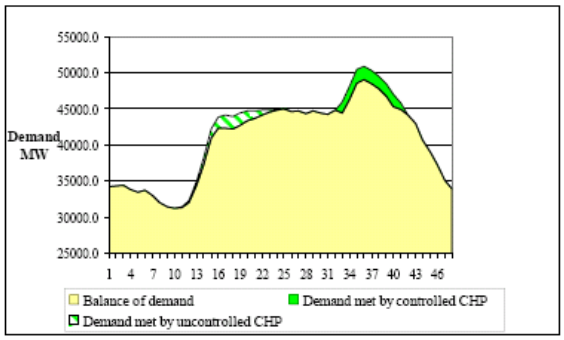


Fig. 6. Response of small and micro CHP to the exergy loss broadcast given in Fig.2

Paper 508 continues this theme and describes actual experiences with the spot-market based price response of residential customers using simulations and field trials. The work identifies that the main barriers to success are electricity market legislation, the high cost of consumption metering compared with the potential savings, and the lack of automated energy management in buildings. Some of these barriers could be mitigated if a large homogenous market could be established.

Paper 581 contributes to this area with an assessment of the possibilities for identifying demand response opportunities within small and medium customer segments. Self-Organising Maps are used to classify customers and their response potential from electrical demand databases with the help of Non-Parametric Estimation and Physical Load Based Modeling as decision support tools. Results show the capability of the approach to improve data management and inform coherent policies.

Paper 713 continues the DSM theme and describes the concept of expandable internet sustained load and demand side management for integration into Virtual Power Plants. The approach described is to synchronise load management in 40 public properties in Hamburg to optimise the load curve and to examine the potential to sell shedable load as reserve capacity back to a Virtual Power Plant or secure a peak-free load profile for all public properties in Hamburg.

Paper 834 examines the potential for energy efficiency in the private sector using a synthetic simulation to evaluate the typical penetration and daily usage of appliances (including appliances left on 'standby') for different types of household.

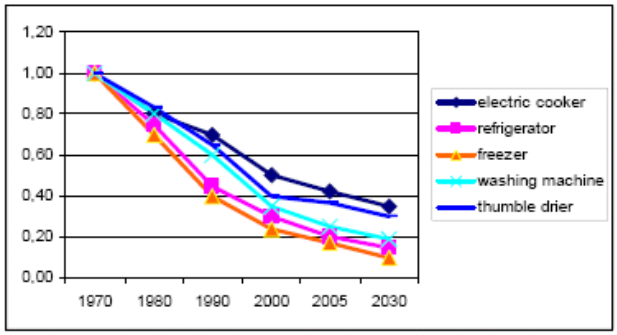


Fig. 3 efficiency improvement of appliances [Electrolux]

Maximum, minimum and conventional appliance penetrations are compared. The study draws a similar conclusion to that of paper 832 described above, i.e. that savings in the order of 20-30% are possible through replacement of old appliances, reductions in number of (surplus) appliances, and the reduced use of 'standby' mode. This is possible without reducing customer convenience or comfort levels.

Paper 914 discusses international perspectives on demand side integration. The paper notes the current convergence of peak demand and generation capacity leading to higher costs and heightened risk of supply shortages across North America, Europe and Australia. Current inconsistencies in demand side terminology burden communication efforts required for regional co-ordination. The objective of the paper is to establish the concept of Demand Side Integration (DSI) as the underlying technical challenge in today's restructured industry.

Paper 624 switches the focus towards DG with a case study used to test the potential development of a methodology to allocate shared costs from generators operating in a micro-grid, applying Cooperative Game Theory. The case study is based on 3 diesel generators supplying 3 buildings and shows how mutual cooperation can realise benefits for customers and generators, including selling surplus power back to the grid.

Paper 702 introduces a different theme and describes the use of photovoltaic applications in railway stations.

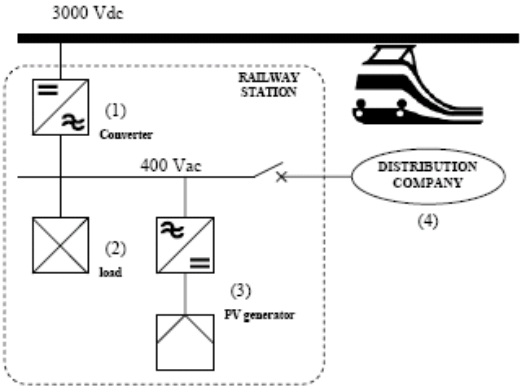


Fig. 1. Modular configuration of the various network analyzed

The study concerns a preliminary technical/economic analysis of the PV panel surface necessary to power different station typologies. The results show the extent to which power is supplied by the PV panels and/or the converter connection to the distribution network for large/medium and small stations.

Questions:

1. What experiences can delegates share in terms of initiatives that have improved network operating efficiencies and/or reduced losses?
2. Is liberalisation and the regulatory separation of 'supply / retail' and 'distribution' businesses a barrier to implementing Demand Side Management and the development of 'smart metering'; what experiences can delegates share?
3. Will the Large Scale Virtual Power Plant concept provide a vehicle for the integrated control of both demand side generation (i.e. microgen and CHP) and demand side load?
4. What are the requirements for ICT to support LSVPP and DMS; what experiences do delegates have of ICT technologies – including distribution line carrier systems?
5. To what extent will domestic customers respond to price signaling; or will it be necessary to develop intelligent appliances that respond automatically? Again, can delegates share experiences?

Table 2: Papers of Block 4.2 assigned to the Session

Paper No.	Paper Title	Oral	RIF
004	Energy cost optimisation through the implementation of cogeneration and grid interconnection		
024	Impact of end-use energy efficiency on the distribution network		
259	Planning the Development of Highly Distributed Power Systems		
272	Analysis of the impact of distributed generation sources on the operational characteristics of the distribution systems for planning studies		
322	A Life cycle Model for Optimal DG placement on Distribution Networks to reduce active losses and investment costs		X
431	Energy efficiency improvement through optimisation of the power factor correction		
452	Market platform for real time efficiency optimisation in energy distribution		
474	Management of demand and micro generators using a radio broadcast of bulk generation efficiency		
508	Experiences from spot-market based price response of residential customers		
520	Bidirectional energy management interface (BEMI) – integration of the low voltage level into grid communication and control	X	
530	Verification & Validation Environment for automation functions supporting Demand-side Initiatives	X	
532	New ICT integrated solutions for flexible management of interactions between LV customers and the network	X	
581	Assessment of possibilities for demand response resources identification in small and medium customer segments		
582	Market integration of flexible demand and DG-RES supply -a new approach for demand response	X	
624	Cost Allocation by cooperation among distributed generators inside a micro grid, using the cooperative game theory		
702	Photovoltaic applications in railway stations		
713	E-island (expandable internet sustained load and demand side management for the integration into virtual power plants)		
725	Peak load reduction by using heating regulators	X	
832	Balancing of fluctuating regenerative generation by DSM	X	
834	Potential for Efficiency Improvement in the Private Sector		
914	International perspectives on demand side integration		

Block 4.3 - Implementation Case Studies, Planning & Support Tools

Of great interest to network operators and prospective Distributed Generators are the actual real-life experiences of practitioners of active networks. This includes experiences with field trials designed specifically to improve our understanding of the impact of DG on distribution networks.

A specific area of interest in the context of active networks is the operation of micro-grids, including grids designed to be capable of operation as islanded networks.

Also of great interest are experiences in the development and application of planning methodologies, planning information systems, and decision support tools to assist both with individual DG connection proposals and also with the development of future (active) network investment strategies.

A wealth of experience in each of the above areas is available simply be referring to the papers allocated to this Block.

The 6 papers to be presented are as follows:

Paper 030 is a UK case study and describes the results of a field trial designed to evaluate the network impact arising from a cluster of 500 domestic properties each equipped with a 1kWe domestic micro-CHP unit. The study involved the monitoring of a single LV feeder serving 69 of the 500 properties. Power Quality monitoring took place at the substation, mid feeder and end of feeder positions. As expected, the results showed a different net load profile to that of a conventional domestic property.

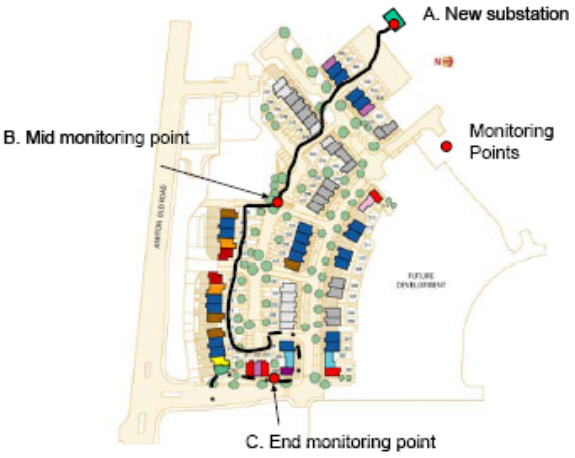


Figure 2. LV Feeder Monitoring points

The main differences are a flatter morning peak demand and higher network voltages during early morning and late evening, with the period between 0600 and 0700 representing the peak voltage with some flicker spikes observed at this time. THD levels remained within limits throughout. Overall, a generally higher net load factor was observed, which must be taken into account in the LV network design.

Paper 083 describes a novel service offering for prospective Distributed Generators. This involves a GIS web-based connection point assessment tool which has the potential to cover the whole of a national electricity network and provide a single point of access for all distribution network information that may be required to provide an initial grid connection assessment for DG or conventional demand applications. The pilot study involving the networks of 3 DNOs has demonstrated that the use of the tool can provide the user with a comprehensive initial connection assessment report (including technical information and indicative costs). The tool has now been fully evaluated and the intention is to extend the geographic coverage to the whole of UK.

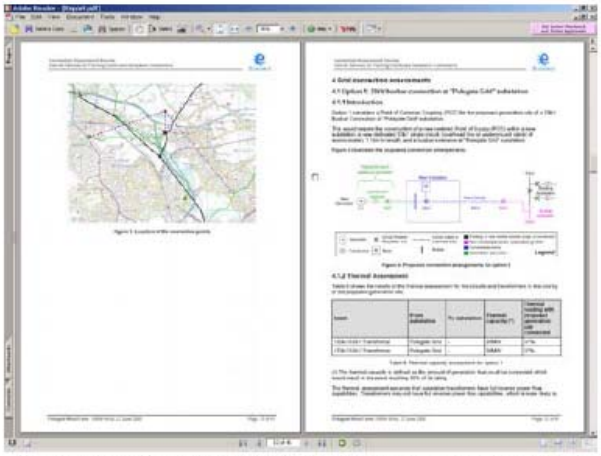


Figure 4: Initial connection assessment report; technical aspects (© Econnect Ventures Ltd and Imass Ltd)

Paper 270 describes the use of planned islanding to improve the reliability of the distribution system.

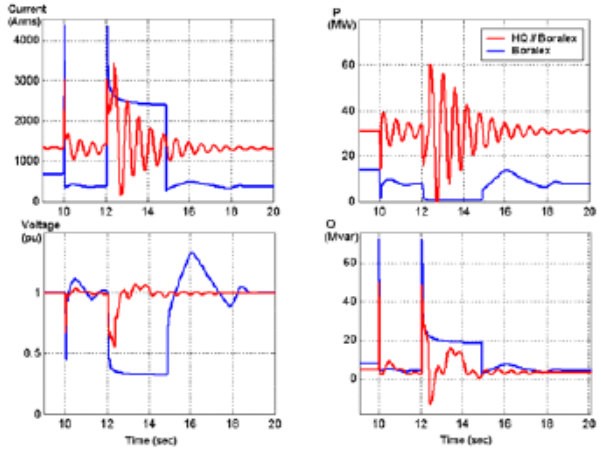


Fig. 2. Simulation results at Boralex busbar for maximal short circuit on distribution system with and without HQ power

Experience is drawn from Canadian utilities. The results show that planned islanding is a potential avenue for innovation in network operation and management,

improving flexibility and performance.

The paper cites an example in October 2005 where the first attempt at islanding a part of Hydro-Quebec's system which included an embedded privately owned thermal power station (Boralex) was successfully maintained for 8 hours with a peak demand of 7MW. Both voltage and frequency remained stabile throughout the period

Paper 502 is a further case study and describes experience in applying a novel approach to voltage control at an HV/MV substation which has 2 small windfarms each connected at the remote end of 2 MV feeders. The equipment known as Gen AVC interacts with the substation conventional AVC to set a target voltage based not only on the substation busbar voltage and net demand, but also on the output from the generators. A combination of direct measurement and state-estimation (based on previously modeled results) is used as an input to the Gen AVC software. Analysis of the results shows that management of the voltage profile is improved to the extent that additional generation could be applied to the substation without the need for constraint.

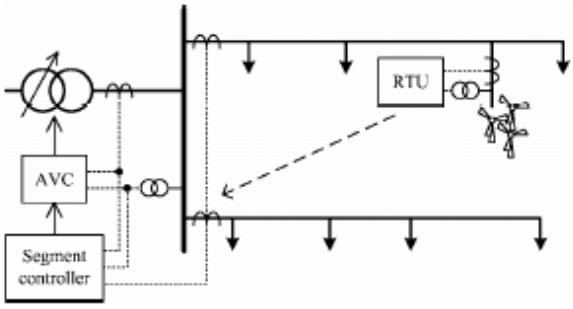


Figure 2 Outline of voltage control system with segment controller

Paper 603 describes an approach to assist with the integration of small scale energy units into the planning and benchmarking of distribution systems incorporating DG.

A robust multi-objective search algorithm is presented based on Monte Carlo simulations nested in an Evolutionary Algorithm. The results are a set of Pareto optimal integration topologies. The approach offers flexibility in decision making and an improved insight into the potential impact of energy storage on profitability and ancillary services.

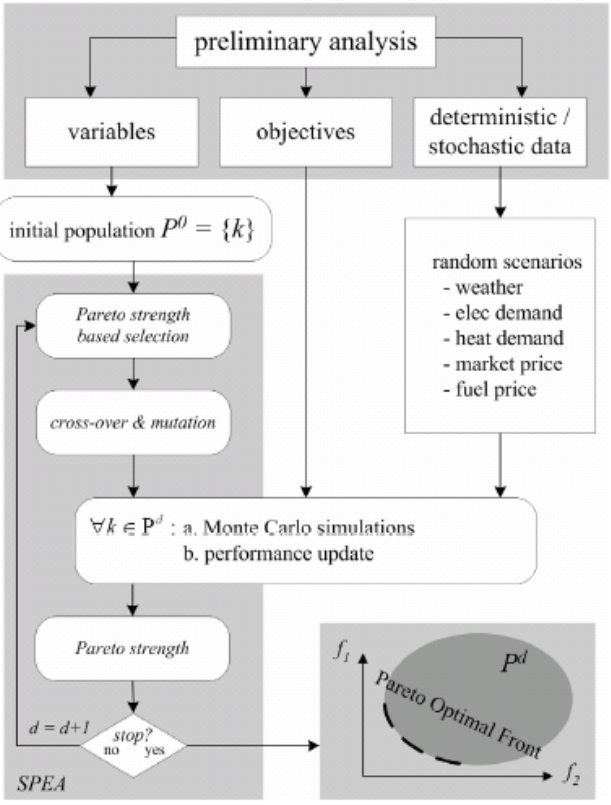


Figure 2: Robust, multi-objective planning method flowchart

Paper 687 explores the potential for strategic investment in networks with high levels of penetration of small-scale distributed energy sources. A software tool evaluates alternative strategies on a large number of statistically similar networks using Fractal Theory.

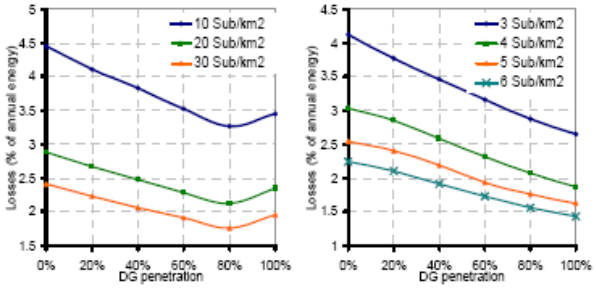


Fig 7 - Value of losses for the urban (left) and rural (right) area for different substations number and DG scenarios

Evaluating the cost of each particular design over these hypothetical networks (each based on realistic parameters) allows statistically significant conclusions to be drawn. The tool also allows the simulation of penetration of micro-generation (CHP / PV / etc.) to determine its effect on the LV system. The overall conclusion is that in most parts of the LV network, reinforcement to accommodate micro-generation will not be required.

The remaining papers allocated to this Block are described below:

Paper 095 describes a methodology for quickly assessing the limits of connection of DG to a sub-transmission (110kV) system as used in practice by a DNO. The paper cites 2 specific examples where voltage regulation and thermal limits proved to be the limiting factors.

Paper 123 describes the publication in Malaysia of an official technical guidebook for the connection of DG which has been developed with the contributions from industry stakeholder experts. The book provides unambiguous guidelines and transparent procedures. It also facilitates exchange of information and promotes standardised prudent utility practice. The guidelines will be subject to continual improvement following practical experience in their use.

Paper 680 follows the same theme as paper 123 in that it describes the publication (in France) of distribution connection rules. The publication describes the connection procedure, requirements for information exchange and the required technical studies. This satisfies the Regulatory obligation to make available to network users, all the documents that constitute the Technical Guidance via a website. There is now a need for a complementary publication covering operation in the event of exceptional voltage, frequency and short-circuit stability.

Paper 158 describes case studies into the evaluation of investment strategies comparing the Real Options method with the traditional simple NPV approach. The conclusion is that the Real Options approach is more flexible and adaptable where a significant level of uncertainty over future scenarios exists, and can lead to a better decision regarding the timing of investment, especially under certain circumstances. It should be noted that RO is a supplement to, and not a replacement for, the traditional NPV methodology.

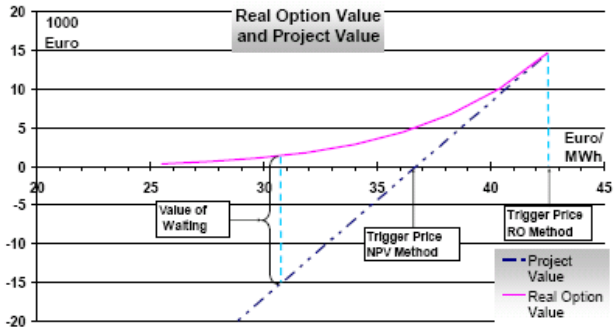


Figure 1. Principles of using the real options method for investment decisions.

Paper 247 proposes a common information language for exchange data based on the Common Information Model (CIM). The IEC 61968 profile CDPSM (and the Transmission equivalent CPSM) are used to demonstrate data interfaces with 2 existing network analysis packages – EUROSTAG and PRAO using bi-directional converters. The conclusion is that software compatibility with CIM based CDPSM and CPSM profiles should facilitate more detailed and extensive analyses to be carried out without the burden of data acquisition for each individual package.

Paper 261 describes the development of an optimisation tool to assess the cost-effectiveness of a wind energy conversion system coupled with a hydrogen storage system. The case study concerns a Sicilian wind farm. Using different forecasting scenarios, the control variables of the storage system have been determined showing good performance of the chosen algorithm.

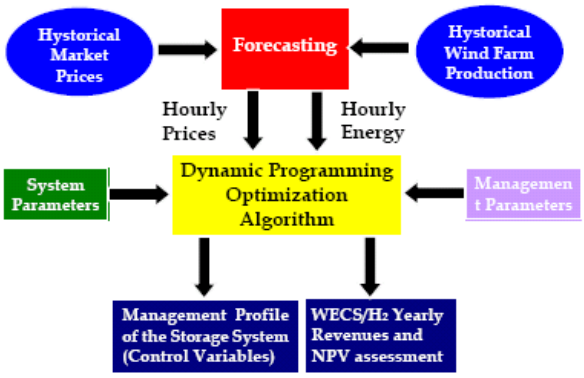


Figure 1. Outline of WECS/H_2 optimization tool

Paper 421 describes the design and field trial of an active power flow management scheme as applied to the Orkney distribution system in Scotland. Real-time and state estimated data is used to determine the set-point control instructions to the wind farm. The on-line response of the wind farm is monitored. The trial will inform the final design of the full active network regime which is expected to be commissioned during 2007.

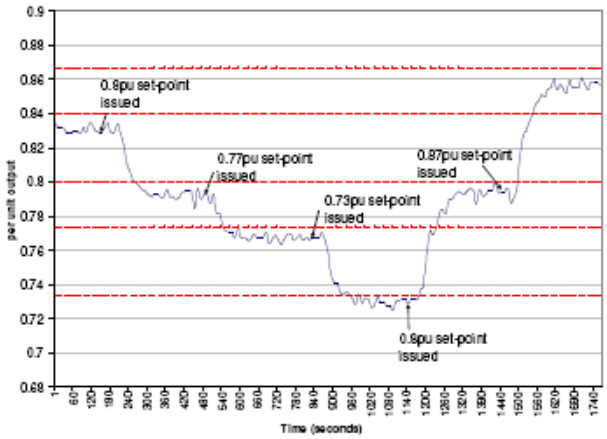


Figure 2. Snapshot of wind farm output during the trial of the Orkney active management scheme.

Paper 438 describes the technical and economic evaluation of the interconnection of the Aegean islands to the mainland grid via HV submarine cables to exploit the excellent wind power potential of the islands. The study shows that

interconnections are both technically feasible and economically viable.

Paper 447 is a case study using field trials and simulations based on PowerMatcher based software agents demonstrating the real-time matching of generation and demand on a very large scale. The field tests demonstrate proof of concept in coordinating a large heterogeneous network of electricity producers and consumers, and demonstrate scalability of the PowerMatcher approach.

Paper 545 discusses intelligent distribution grids and describes experience in integration of network and measurement data provided by 3 DNOs into a simulation environment. Different tools for voltage control are validated by simulation of an existing sample network. Once the remaining technical questions are answered, the economic and organisational aspects will be analysed with a view to implementation of active voltage control of the 3 DNOs who provided data for the simulation.

Paper 641 describes experience in developing a tool to calculate the impact of PV systems connected to an LV grid. A stand-alone MATLAB solution was developed using standard load flow analysis. Harmonic and NPS assessment are under development. The ultimate objective is an easy to apply tool for network operators in assessing prospective PV connections to the grid.

Paper 652 describes field experience in the Czech Republic with connecting dispersed wind power plants to MV power lines. The paper notes that field experience in connecting 850kW and 2MW Vestas machines is very good, with power quality, higher order harmonics, voltage fluctuation and flicker all being in line with calculated levels.

Paper 714 provides an overview of active network management practice in the UK and describes the current methods used by network operators to monitor and control distribution networks in Great Britain. A number of current field trials and implemented applications are described. The paper concludes that existing technologies have sufficient functionality to permit further exploitation, and that further developments in control and communication technologies will permit more sophisticated active management. The need for appropriate commercial and business incentives must however be addressed.

Paper 804 addresses the inherent operational conflicts between conventional protection schemes and DG in MV networks. A new protection methodology is proposed that will address the lack of coordination of overcurrent devices in the presence of DG. The proposed approach will improve service continuity. The approach uses remote signaling of protection operations and fault current directional information to deduce the location of the fault, whereupon automatic isolation occurs, permitting sufficiently rapid restoration (within 180 seconds) for the interruption to be classed as a 'short' interruption.

Questions:

1. Are delegates able to share further examples of field trials of Distributed Generation; if so what issues did they find and what further technological developments might be necessary as a result?
2. Given the expected increase in applications to Network Operators for DG connections, how can we strike a balance between the need to deal quickly with high volumes of connection requests and the need to ensure the continued integrity of the distribution network?
3. Does more need to be done to share network information electronically so that Generators can undertake their own connection assessments; what risks do delegates perceive would be raised by such sharing of information?
4. Are our planning methodologies and decision support tools sufficiently well developed to enable the expected transition from passive to active network management?
5. Is there sufficient regulatory and public support for the high levels of active network investment that might be necessary to fully exploit the potential of DG?

Table 3: Papers of Block 4.3 assigned to the Session

Paper No.	Paper Title	Oral	RIF
030	The Performance of an LV network supplying a cluster of 500 houses each with an installed 1kWe domestic micro-CHP unit	X	
083	Renewable Connections on the Web: Internet Services for Planning Distributed Generation Connections	X	
095	Modelling of networks for assessing the connectibility of a limit power of generating sources into the distribution system		
123	Technical Issues on DG Connection and Guidelines		
158	Case studies of Investment Strategies in Distributed Generation		
247	Interest of a common information language for exchanging data : case study of the impact of DER on Distribution Network		
261	Wind Generation and Hydrogen Storage Management in Liberalised Electricity Market		
270	Planned islanding as a distribution system operation tool for reliability enhancement	X	
421	Design and Trial of an Active Power Flow Management scheme on the North-Scotland Network		
438	Increased Wind Energy Exploitation via Interconnection of Aegean Islands to the Mainland Grid		
447	Massive coordination of dispersed generation using PowerMatcher based software agents		
502	Field Experience with Active Network Management of Distribution Networks with Distributed Generation	X	
545	Intelligent Distribution Grids in respect of a growing share of Distributed Generation		X
603	Long-term planning of small-scale energy storage units	X	
641	Development of a tool for calculating the effects of PV systems connected to a low voltage grid		
652	Field experience with connecting the dispersive supplies to MV systems in the Czech Republic		
680	Decentralised generation Publication of French connection rules		
687	Strategic Investment in Distribution Network with High Penetration of Small-scale Distribution Energy Resources	X	
714	Overview of Active Network Management Developments and Practices in Great Britain		
804	Solution of operation conflicts between protection and distributed generation in MV distribution networks		

Block 4.4 - Analysis, Simulation and Modeling of Active Networks

Due to their as yet generally embryonic nature, experiences with active network planning, design and operation are inevitably limited. Whilst the 3 previously described Session 4 Blocks will provide an invaluable opportunity to share the expertise of those who have managed, designed, and undertaken trials of active network solutions, much still depends on our ability to undertake reliable and effective desk-top analysis, simulation and modeling

Block 4.4 is therefore devoted to papers that describe such studies. It will be noted from Table 4.4 below that a significant number of these papers have also been allocated to the RIF session where authors and participants will have the opportunity to discuss the potential application and development of the techniques described in this Block.

The 6 papers to be presented are as follows:

Paper 116 examines the impact of distributed generation on network losses using a model built to generically represent a UK Grid Supply Point and its associated distribution system comprising voltage levels from 132kV to 400V. 3 representative DG scenarios are considered and a range of annual load profiles determined (domestic, commercial and industrial). Extensive modeling shows that with both urban and mixed networks, overall losses are reduced in the presence of DG. In the case of rural networks, losses are reduced except in the case of the higher DG penetration scenario. In all cases, losses on the MV (11kV) network are increased. The tool developed will enable users to analyse actual interactions.

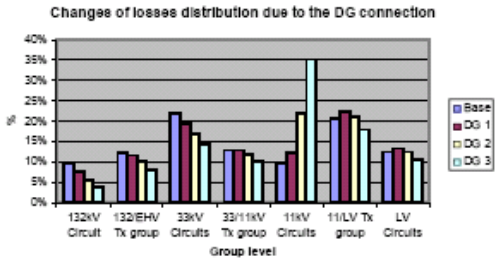


Figure 5. Loss distribution by voltage level for the mixed GSP and applied DG scenarios

Paper 198 describes the use of an optimisation approach to fostering the adoption of DG and energy efficiency actions in an energy planning study. The system is modeled as a network of energy flows from primary sources to the end users.

The procedure aims to maximise the social benefit taking account of emissions and environmental impact, and economic costs and subsidies. The results show that maximum benefits and lowest emissions are achieved through incentives on DG variable costs. Subsidies yield slight variations on social benefit and CO_2 emissions.

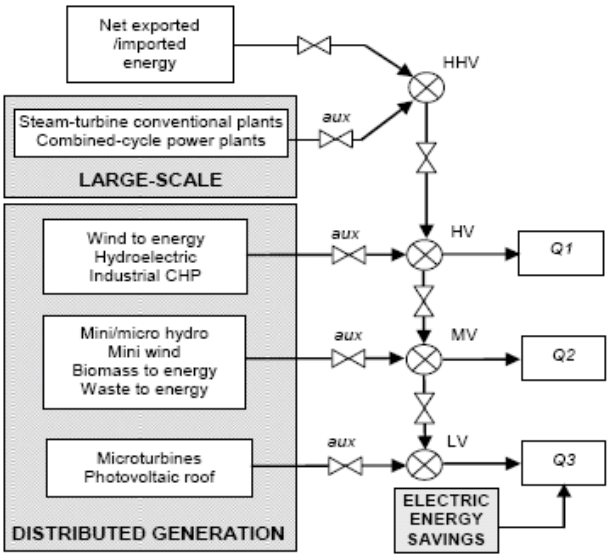


Fig. 1. Electric power grid scheme.

Paper 311 investigates the opportunities for consumers to help ensure production / consumption balance by subscribing to load management programs. 2 kinds of adaptive load consumption algorithms are explained and illustrated on case studies showing how load control can balance intermittent production.

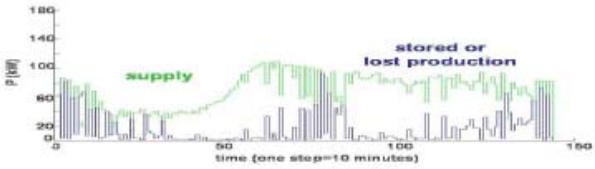


Figure 6:supply and stored or lost production for the basic algorithm

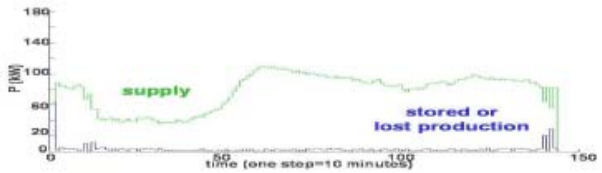


Figure 7:supply and stored or lost production for the improved algorithm

Paper 430 examines the assessment of distribution system performance with high levels of penetration of DG. A novel algorithm to evaluate the reliability of distribution systems with DG is proposed addressing the stochastic nature of DG operation. The proposed algorithm integrates Monte Carlo simulation to estimate the random operating cycles of DG and the ability of the system capacity to meet the total demand.

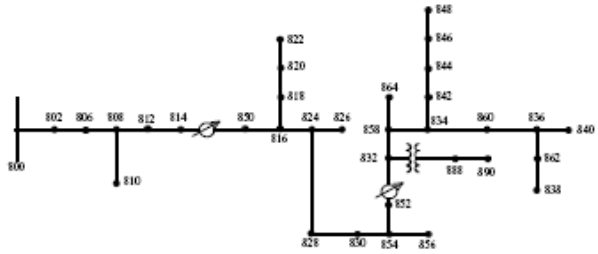


Figure 1: The system under study

A typical case study is presented with DG units operating in parallel and both system margins and unsupplied load are evaluated. A number of conclusions are drawn regarding the location and ratings of DG units.

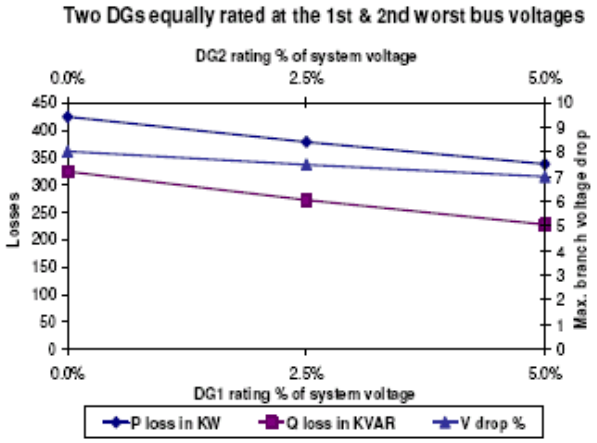


Figure 3: Case II results

Paper 522 describes a test facility for the assessment of local energy management systems. The objective is to explore interaction opportunities between customers and the LV network and to develop and test possible automation functions. The results show that strategies and architectures are ready to be employed in a wider environment.

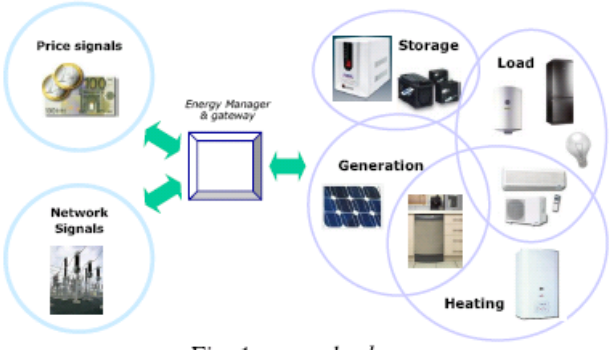


Fig. 1 *general scheme*

Paper 592 addresses the challenge of providing sufficient reactive support under a scenario with high penetration levels of DG connected via power converters which are able to provide real power but only limited reactive support.

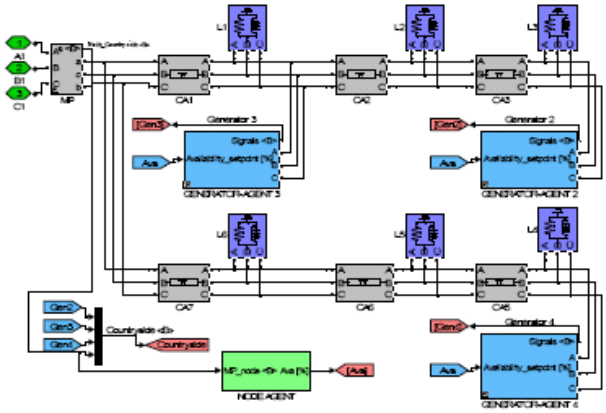


Figure 2 MV (10 kV) grid simulation model

The paper proposes control mechanisms for decentralised DG converters that enable reactive power to be generated by local DG units thereby minimising the reactive power requirement at the feed-in of an MV grid.

The remaining papers allocated to this Block are described below:

Paper 038 describes a power schedule for clustered micro-turbines connected to an LV network using an optimisation approach. A case study is used to describe the technical and economic effects in terms of power losses and operating costs.

Paper 060 examines the factors which affect the economy-wide CO_2 emission changes arising from the application of the Indonesian renewable portfolio standard (RPS) in capacity expansion planning. The paper concludes that there are 4 major components affecting the changes in CO_2 emissions.

Paper 070 investigates opportunities for improving distribution system reliability through DG. Analytical calculations are undertaken to quantify the impact of different types of interface switchgear. The difference between disconnector and switchgear type interfaces are emphasised.

Paper 079 examines the effect of DG on the protection of MV cable and overhead line grids by varying the size and location of the DG unit and evaluating the impact on short-circuit levels. The paper notes that protection blinding is more likely with overhead line grids but is a problem only for weak / long cable grids.

Paper 124 examines an approach to improve probabilistic voltage estimation for the active control of a distribution network. Load modeling and discrete step communication techniques are shown to improve the state estimation accuracy and hence optimise costs of active management.

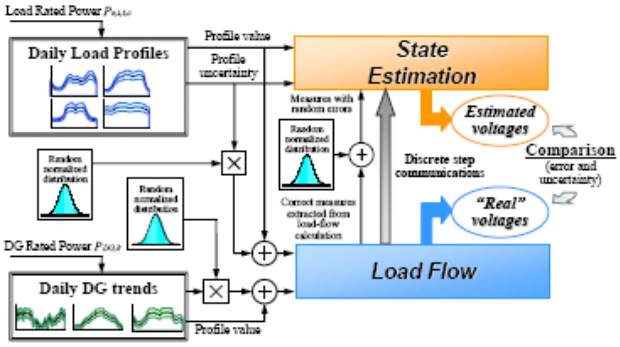


Fig. 5: Basic structure of the daily simulation

Paper 176 examines the impact of extending the penetration of DG and active power flow management on SCADA alarm / indication volumes; in particular, thermal overloads, voltage excursions and tap changer operations. A generic UK distribution network model is used and multiple load flow solutions using half-hourly profiles of DG and demand are applied. The results indicate that a reduction in SCADA alarms compared with the (no DG) base case can be expected.

Paper 313 describes an approach based on the use of an Ant Colony Optimisation Algorithm to determine the optimum reconfiguration of a distribution feeder with DG. The approach should enable the determination of an optimum control regime which minimises cost and improves overall network performance.

Paper 365 examines the small signal stability of a stand-alone power system with DG. The objective is to understand reasons for voltage deviation, investigate key factors influencing small signal stability, and present effective solutions.

Paper 371 addresses sensitivity analysis of frequency and voltage stability in an islanded micro-grid. The objective is to study how changes in system configuration will affect THD and frequency stability.

Paper 454 analyses the parallel operation of self excited single phase induction generators (SEIGs). The approach is to apply no-load and locked rotor tests to the main winding and apply voltage and current equations to the auxiliary winding.

The generalised equation is presented for determining an aggregation model to represent a group of SEIGs connected to the same bus and phase of a distribution system. The model can be used to simulate short-circuit and starting currents for capacitor-starting SEIGs.

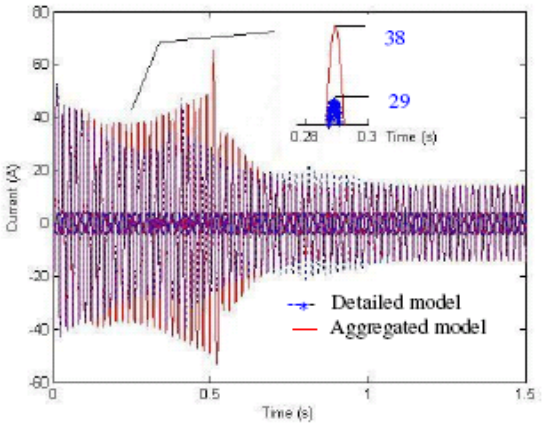


Figure3. Generator starting currents for G_{ag1} model and detailed model

Paper 494 describes the wide-scale integration of dispersed wind generation to the East German network. The paper notes that rapid growth in wind generation has caused difficult loading situations in the power supply system, especially in the distribution networks under strong wind / low load scenarios.

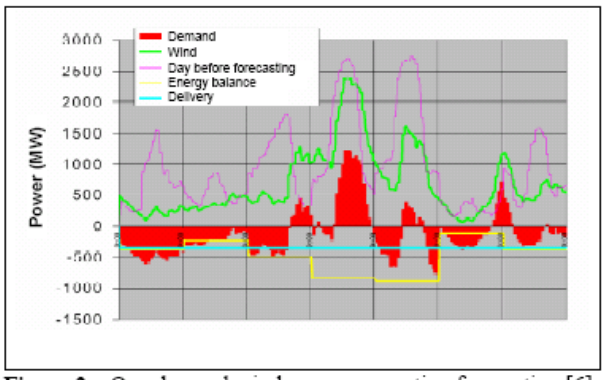


Figure 2 – One day real wind power generation forecasting [6]

Paper 600 describes a simulation study to examine aspects of small-scale hydro-electric power plants to MV distribution networks. The objective is to find solutions to power quality problems due to the starting and operation of the associated asynchronous generators.

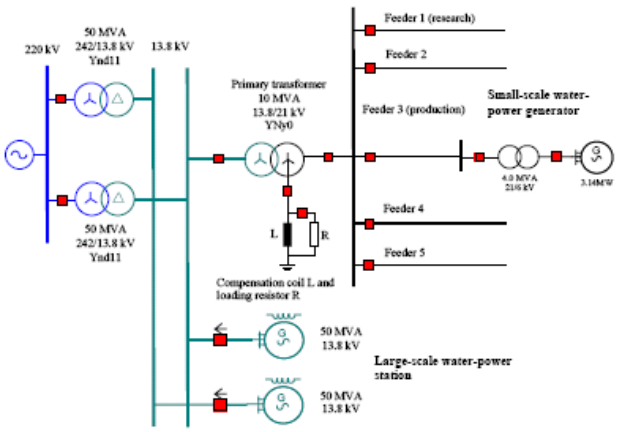


Figure1. Hydroelectric power plants, MV network and electrical transmission system.

Paper 614 describes a study to determine the minimum protection requirements for a system embedded with small sources of DG. The study considers fault level changes, stability, islanding possibilities, and DG connections with and without load transfer. Various results are described.

Paper 636 describes a stochastic optimisation model to estimate the technical and economic effects of DG. Several methods are use to describe load flow, and comparisons are made regarding transmission line loading, voltage magnitudes and line losses. The paper concludes that DC analysis is inadequate, and that whilst AC analysis is adequate except for non-linear optimisation, Fast Decoupled Load Flow analysis in combination with a power system simulator is the most satisfactory approach.

Paper 666 examines the impact of Network Security Management (NSM) on DG. Monte Carlo simulation is used to derive the number, duration and severity of NSM interventions. This enables the effect on each type of DG to be separately calculated. The results of 2 case studies are found to correspond with practical experiences.

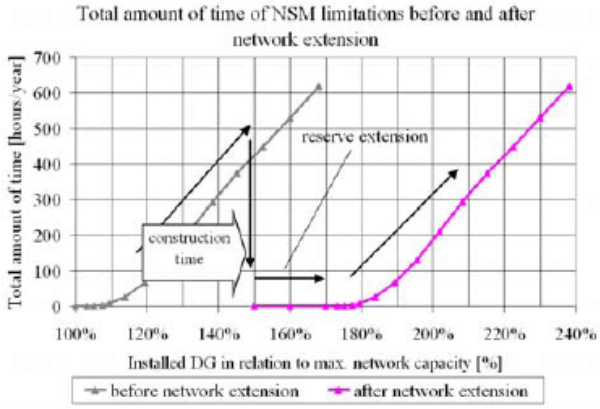


Figure 5 The consequences of a network extension considering the construction time and a reserve extension.

Paper 692 describes a generic model of a virtual power station. The VPS is defined by considering 3 levels of aggregation. A PSCAD library of SSEGs is used to present different SSEG penetration scenarios. The objective is to examine the scope for aggregating and controlling SSEGs to increase their value by behaving as a VPS. The limiting factors at each voltage level are described.

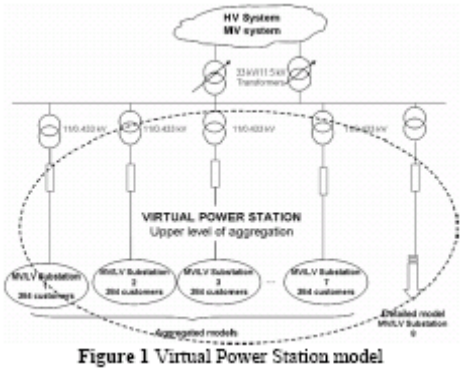


Figure 1 Virtual Power Station model

Paper 697 examines the impact of structure and configuration of a distribution network cell (DNC) on characteristic response. The approach is to consider an 11kV DNC comprising synchronous, fixed speed and doubly fed induction generators, converter connected generators and different types and sizes of loads connected to a 33kV external grid. The results for the various scenarios are described.

Paper 731 considers the impact of very high DG penetration levels in year 2050 with the objective of identifying and developing new planning methods. The results show that with the widespread use of DG, power flows generally reduce and that more demand can generally be added without loss of system security.

Paper 750 describes reliability analysis of a distribution system with connected PV. The approach employed is to develop numerical formulae rather than apply Monte-Carlo simulation techniques to evaluate the impact of different PV scenarios. The case studies compare the analytical approach with the MC approach and show a close correlation.

Paper 766 examines the impact of intentional islanding on the behaviour of synchronous and induction generators with the objective of determining how to control such generators during islanded operation. Both types of generator are found to have a significant impact on the operation of an islanded network.

Paper 775 examines reliability issues of islanded micro-grids with distributed generation and energy storage. The results show that in order to correctly assess the reliability of islanded micro-grids, a wide range of timescales have to be modeled stochastically.

Paper 780 also examines the operation of an islanded distribution network. The approach is to use a simulation to examine the impact on system stability, voltage and frequency of inserting a disturbance and check that the system remains stable.

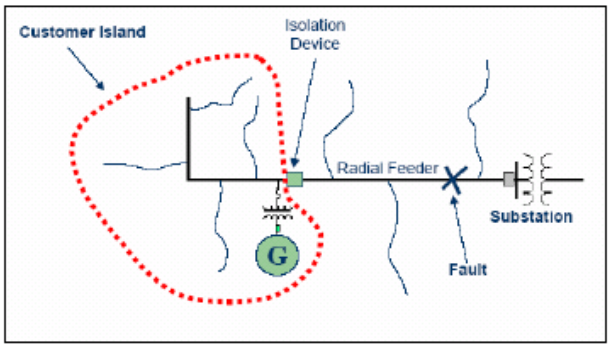


Fig.1 Intentional Island

Paper 810 examines forecasting methods for wind power management in a liberalised electricity market. A combination of simple exponential smoothing and the Markov Chain approach has been applied to historical data from a Sicilian wind farm. The results show good forecasting with the Simple Exponential Smoothing (SES) approach but even better forecasting using the combined SES/Markov approach.

Paper 852 describes a common modeling interface for utility simulation tools and active distribution networks. The benefit of the proposed structure is that it allows the same model to be used in a range of simulation platforms. This will facilitate the capability of DNO planners to adequately model the changing behaviour of their networks. Results are shown for a transient stability implementation using 2 widely used commercially available programs.

Paper 863 describes an approach to examine the maximum accommodation of distributed wind power generation. A multi-objective program based on the Non-dominated Sorting Genetic Algorithm (NSGA) is used to determine a set of optimal connection points for a UK medium voltage network.

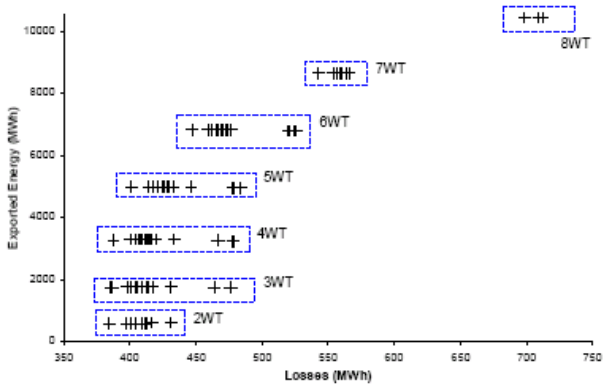


Fig. 8. Pareto-optimal solutions – maximization of export, minimization of losses and short-circuit levels for *Vref*=1.00p.u.

Paper 872 describes a novel algorithm to evaluate the reliability of distribution systems with DG. The results show that, if well managed, DG can improve reliability and reduce energy not supplied (due to faults).

Paper 887 examines the impact of DG on distribution network planning using Evolutionary Programming as an optimisation technique. 2 scenarios are considered, one with load supplied only by the substation, and one with DG contribution. The algorithm is evaluated, and demonstrates that the DG scenario provided a considerable reduction in total costs.

Questions:

1. Accurate analysis and modeling are essential to our understanding of the impact of DG connections. How representative of real networks are our current models and what more needs to be done to improve their usefulness?
2. Simulation can provide an essential intermediary step between network modeling and field trials. Are delegates able to share further examples; if so how good was the correlation between the modeling predictions and the results of the

simulation trials?

3. How representative are our current analyses of the largely stochastic nature of LV connected DG (and DSM) behaviour in a liberalized market; can we be sure that we have a good understanding of the overall impact on net load profiles?

4. Does more need to be done to monitor the impact of DG and DSM so that our analysis methodologies and models can be updated; if so how could we ensure that post-implementation appraisals are properly captured and the key learning points incorporated?

Table 4: Papers of Block 4.4 assigned to the Session

Paper No.	Paper Title	Oral	RIF
038	Power schedule of distributed generation in clustered low voltage network		
060	Implications of Considering Renewable Portfolio Standard (RPS) in Power Sector Development: an input-output approach		
070	Improving distribution system reliability by means of distributed generation		X
079	Effect of Distributed Generation on Protection of Medium Voltage Cable Grids		
116	The Impact of Distributed Generation upon Network Losses	X	
124	Probabilistic voltage estimation for active control of distribution networks		X
176	Assessing the impact of Active Power Flow Management on SCADA alarm volume		X
198	Fostering the adoption of distributed generation and energy-efficiency actions in an energy planning study	X	
311	Load Control to balance limited or intermittent production	X	
313	An Approach Based on Ant Colony Optimisation for Distribution Feeder Reconfiguration Considering Distributed Generators		X
365	Small Signal Stability Analysis of Stand Alone Power System with Distributed Generation		X
371	Sensitivity Analysis of Frequency and Voltage Stability in Islanded Micro-grid		X
430	Assessment of Distribution System Performance with Considerable Distributed Generation Penetration	X	
454	Aggregated the wind turbine self-excited single-phase induction generators models in distribution System simulation		
494	Integration of Dispersed Wind Generation to the East German Network		
522	Test facility for the assessment of local energy management systems	X	
592	Local reactive power support for grids with a large share of decentralised generation capacity	X	
600	Aspects of connecting small-scale hydroelectric power plant in MV distribution network – a simulation study		
614	Determination of a minimum protective system for distribution systems embedded with small sources of distributed generation		
636	Improved consideration of the grid in stochastic electricity market models dealing with distributed generation		
666	Calculation of Network Security Management (NSM) Intensity in the Distribution System		X
692	A Generic Model of a Virtual Power Station Consisting of Small Scale Energy Zones		X
697	Characteristic Responses of Distribution Network Cell: The Effects of Cell Structure and Configuration		X
731	Impacts and Management Arrangement for High Penetration Distributed Generation		X
750	Analytical Reliability Evaluation of Distribution System Connected Photovoltaic Generation		X
766	Impact Study of Intentional Islanding Operation of Synchronous and Induction Generator		
775	Issues for Reliability Analysis of Islanded Micro-Grids with Distributed Generation and Energy Storage		X
780	Intentional Islanding of PEA's Distribution Network		
810	Forecasting Methods for Wind Power Management in Liberalised Electricity Market		X
852	Common Modeling Interface for Utility Simulation Tools and Active Distribution Networks		
863	Maximising the Accommodation of Distributed Wind Power Generation		X
872	A Novel Algorithm for the Adequacy Assessment of Distribution Systems With Distributed Generation		X
887	Impact of embedded generation on distribution network planning using evolutionary programming		X