Special Report - Session 4

DISTRIBUTED ENERGY RESOURCES AND ACTIVE DEMAND INTEGRATION

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Session 4 Overview

Session 4 deals with the challenges of adapting distribution networks to facilitate the integration of low carbon, renewable and distributed energy resources (DER). These include distributed generation (DG), energy storage, new loads (e.g. electric heating and electric vehicles), active demand, and aggregation of DER (e.g. Virtual Power Plants).

DER integration challenges feature in some way across all CIRED sessions so Session 4 specifically focuses on new concepts, emerging technologies and solutions, results from research, development or demonstration programmes, with results from network and system integration trials being particularly valued. Various DER integration and solution studies also feature.

Session 4 papers highlight the integration of DER within distribution networks through technical, commercial and regulatory solutions. Papers describe developments in network management, active demand side response, energy storage integration, network monitoring, telecommunications and data analytics and the role of DER in wider DSO business operations.

Session 4 Paper Evaluation and Selection

Session 4 received 279 abstracts and this has produced good quality and diverse contributions to the final conference proceedings where 125 full papers have been accepted and will be presented at CIRED 2017. The review process first selected abstracts on the basis of potential, clarity of contribution, quality and early stage content already in the extended abstract. The full papers were reviewed by CIRED National Committees and then double reviewed by Session 4 members. Full papers were accepted based on value of contributions to Session 4 scope, well-founded on robust research, experimental and demonstration methods, well referenced, highlighted emerging topics and provided interesting ideas and insight to the CIRED community. The most novel research and innovation stage papers have been invited to present in the Research and Innovation Forum (RIF). The overall best quality papers have been selected for Oral presentation in the Main Sessions.

Session 4 Special Report Organisation

This Session 4 Special Report provides summaries of all accepted full papers organized into four blocks as follows:

- Block 1: DER concepts, designs, studies, planning, analysis techniques and tools

- Block 2: DER grid integration enablers and technologies
- Block 3: Technical and commercial DER grid integration methods and solutions
- Block 4: DER integration field trial results, test and standards

This Block allocation follows the logic of a concept to concrete demonstration funnel with Block 1 highlighting new concepts, desktop studies, designs, analysis methods. Block 2 then captures where new technologies and enablers for DER have been developed and tested. Block 3 takes this further still where the ideas have progressed beyond component technologies into formed solutions and methods and Block 4 moves closer to real operational integration and demonstration often in the form of pilot, advanced lab demonstration or roll-out.

Within each of the four Blocks there are sub-headings to aid identification of relevant papers in topical areas. The accepted papers are listed in tables in each Block and Poster, RIF and Oral presentation are noted there.

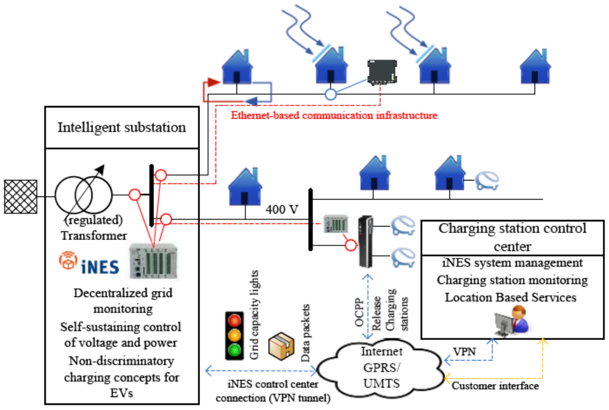
Finally, the Session 4 team would like to thank all the abstract and paper contributors for an excellent array of high quality contributions that have been a pleasure to review and assimilate. We look forward to an excellent CIRED 2017 and have the chance to discuss these papers with authors and audience members.

The Session 4 Chairman and Special Rapporteurs would also like to thank the Session Advisory Group who played a very active and valuable role in abstract and paper review and who will support the Oral, RIF and Poster sessions at CIRED 2017 in June.

Block 1: DER concepts, designs, studies, planning, analysis techniques and tools

Demand Response

Paper 0219 economicaly compares conventional grid enhancement or automated charging management solutions driven by electrification of the mobility sector. It is demonstrated that charging management systems could provide significant economic benefit. The additional benefit of the system is considered too.



Paper 0219 – Concept of smart grid and charging management system

Paper 0267 is focused on the implementation of a thermal energy storage and heat pump control strategy to reduce high transformer loading. The approach considereing different storage sizes is evaluated by a simulation based on real measurements. It shows that thermal energy storage capacity has to be fourfold or 20 times bigger to achieve reduction of transformer loading for 12 hours and over the weekend, respectively.

Paper 0320 explores flexible load management by introducing a methodology for the technoeconomic evaluation of load activation quota in order to prevent grid congestion. The quota represents the maximum share of flexible loads per grid segment for each point in time that can be activated without causing grid congestions. For a region in Southern Germany cost reduction of 24-34% is estimated.

Paper 0447 describes the implementation of a Demand Bidding Programme (DBP) based on 200 hours total annula delivery in summer in mid-day peak periods (11:00-15:00) for large (>100kW) consumers in an Iranian DSO with day ahead notifications. The paper describes an optimisation method to maximise the value of the scheme for customers with fexibe demand and dispatchable generation.

Paper 0567 presents results of task 17 of the IEA/DSM program, which has explored the nature of demand-side flexibility and the stakeholder context. It was found that a portfolio of services and control strategies for coordinating flexibility in an efficient, safe, reliable, and scalable manner can be found. The boundary conditions, valuation and practical implementation are discussed in the paper. Demand response potential on a day-by-day basis is in the order of 5-15 % with peaks up to 30% depending on the user motivation and on the flexible devices. Automation of end-user DR in most cases significantly increases the flexibility potential and makes DR have a lasting impression over time.

Paper 0850 presents a financial-based energy management framework in smart public parking lot, proposing that they act as aggregators of V2G capabilities of EV parked, while assuring that the EV are adequately charged at the departure time. The study is based on parking lot traffic data, electricity price data and on the characteristics of EV (the later based also on assumptions). The authors developed a linear optimization algorithm that optimizes the charging and sischarging schedule according with the priorities of the different players involved.

Paper 0950 discusses how electric heating can act as flexible demand for enhanced network operation. The use of direct or storage electric heating to facilitate demand side management and/or response services address a number of emerging distribution network operation and performance challenges, particularly in relation to increasing distributed generation and system support services.

Flexible Demand Service	DSM		DSR			
			Planned		Unplanned	
	Direct Control	Indirect Control	Direct Control	Indirect Control	Direct Control	Indirect Control
Voltage Controlled	High Potential	High Potential	High Potential	High Potential	High Potential	High Potential
Peak Lopping	High Potential	High Potential	High Potential	High Potential	N/A	N/A
Load Shapping	High Potential	High Potential	High Potential	High Potential	N/A	N/A
Post-Fault Response	N/A	N/A	N/A	N/A	High Potential	Limited Potential
Frequency Response	N/A	N/A	N/A	N/A	High Potential	Limited Potential
STOR	N/A	N/A	N/A	N/A	High Potential	Limited Potential
DG Curtailment Reduction	High Potential	Limited Potential	High Potential	Limited Potential	High Potential	Limited Potential
Dynamic Tariff	N/A	High Potential	N/A	High Potential	N/A	Limited Potential

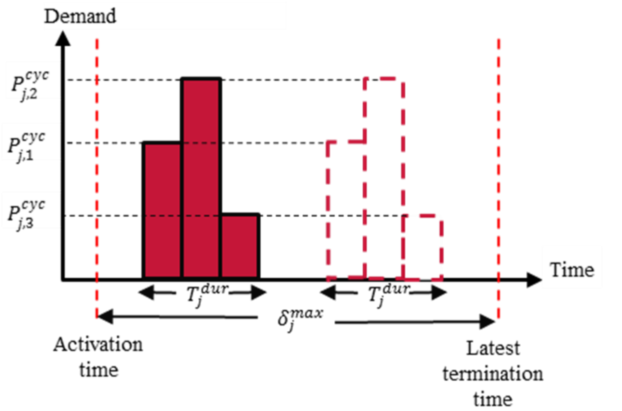
Key: N/A (black), High Potential (green), Limited Potential (red)

Paper 0950 – Electric heating flexibility capabilities

Paper 1023 compares business model for DR aggregators under deregulated markets. The business models are proposed targeting three different power dispatch modes: economic dispatch, energy-saving dispatch and open and impartial dispatch. Based on numerical test results, the paper concludes that the utility is profitable adopting DR under economic dispatch. Under open and impartial dispatch, DR will not affect the power purchasing cost of the utility. DR under energy-saving dispatch can reduce the cost but may possibly lead to higher peak-valley difference. Therefore, DR is profitable in regulated power markets, but its usage depends on the specific market environment.

Paper 1075 presents a SWOT analysis focusing on three transactive energy (TE) advancements, namely PowerMatching, Intelligator and Energy Flexibility Platform and Interface, made in the area of transactive control and coordination mechanism. As a conclusion, applying the proposed methodology carries out effective combinatorial strategy planning for the TE-based coordination mechanism.

Paper 1159 presents a model of distribution network operation and planning integrating this time-shifting flexibility and accounting for the associated customers' inconvenience cost. The paper focuses specifically on wet appliances with time delay functionality, given their significant penetration, energy consumption and time-shifting flexibility. The results demonstrate the value of such flexibility in reducing network operating costs and postponing network reinforcements.

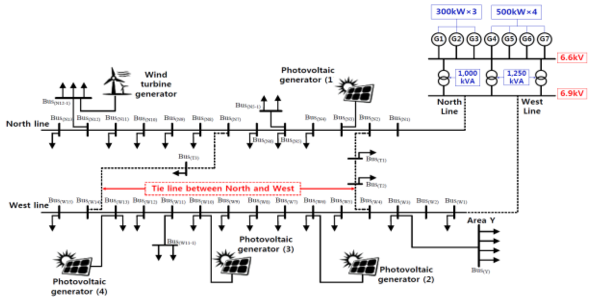


Paper 1159 - Concept of time-shifting flexibility of wet appliances with time delay functionality.

Microgrids

Paper 0128 presents a method, illustrated by case study, for the assessmentt of reliability enhancement of distributions networks based on the probability of successfully forming a microgrid/island where DG and Battery Storage are present. Cases with greater DG and battery storage have a lower Energy Not Supplied (ENS) result.

Paper 0286 presents a study of voltage and frequency response in the South Korean microgrid island of Dukjuk with varying degrees of renewable generation peneration to offset dieseld generation.



Paper 0286 – Dukjuk island microgrid structure.

The results of the study, based on the real system characteristics show a weakening of response with reduced diesel generation and the authors point towards design standards for effective dynamic responses in island operation.

Paper 1188 presents the integration of an energy storage system (ESS) in an microgird. Sein Island is located in the Atlantic Ocean, at 8 km of the continent without any electrical connection to the continental grid. Based on specific simulations, microgrid control algorithms were elaborated and the associated sizing of an energy storage system (ESS) was determined. The command laws of the energy management coupled with the ESS, allowed the completely negation of curtailment of renewable energies for the projected 90 kWc of PV, and the other renewable energy projects coming in 2017. Based on the results the energy suplier decided to install and operate an ESS on Sein Island

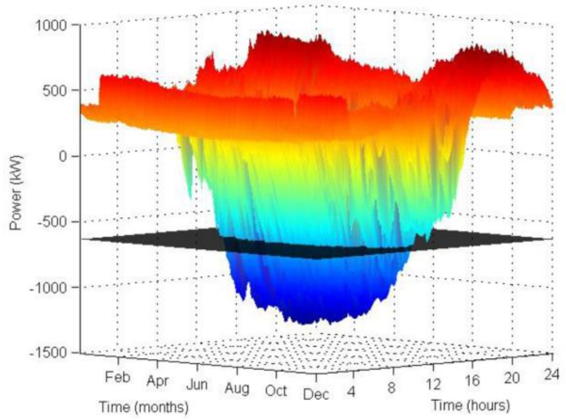
Paper 0288 proposes an energy management system algorithm for stable operation of isolated microgrid to minimise diesel generator operation and allow continous use of battery energy storage systems. The simulation is conducted using practical data of Dukjuk island in Korea. It concludes that the proposed algorithm can control each DG within various DG constraints and state-of-charge limits of battery energy storage systems while keeping frequency more stable.

Paper 1039 presents the three main directions taken by the largest DSO in Romania. These are the large scale smart metering impelementation and development of meter data management system, investment into SCADA and DA systems in order to improve network reliability performance, and constant development in smart grid concept and information technology.

DER Active Network Management

Paper 0104 is comparing five TSO-DSO coordination schemes, including exchange of information for monitoring as well as acquisition of ancillary services (reserve and balancing, voltage regulation, congestion management), both for local needs and for the entire power system. Three related pilot projects in Italy, Spain and Denmark are introduced. In order to enable participation of DERs (via aggregation), in the provision of ancillary services, as well as making real time markets more robust and liquid, the related project is carrying out in-depth analysis of TSO-DSO architectures, design of real time markets and ICT requirements.

Paper 0214 presents a feasibility analysis of the concept of power-to-gas to absorb the excess energy produced by PV modules associates with LV networks, therefore contributing to increase the hosting capacity of those networks and solving the intermittency problem associated with PV production. The results shown include an economic valuation for several different scenarios reflecting combinations of the use of the gas produced and of the characteristics of the power to gas system. It concludes that this technology is still not economically viable, even though it allows to increase the installed capacity associated with PV modules.



Paper 0214 – 3-dimensional plot of a transformer power. For the z axis value, the area below the black plane indicates the excess reverse power flow (associated with PV production)

Paper 0282 presents an algorithm that mitigates voltage issues in distribution networks, by actively managing the active and reactive power of DERs. The paper proposes solving the problem in a fully distributed manner by converting a centralized constraint optimization problem into a fully distributed constraint optimization problem based on dual decomposition, linearized model of the distribution network and peer-to-peer communication protocol. A real low voltage residential semiurban feeder from the region of Flanders (Belgium) has been used as a case study. Simulation results illustrate the ability of the algorithm to mitigate the voltage rise and voltage drop problems using minimum resources.

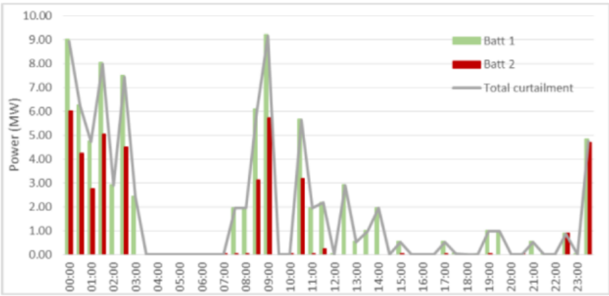
Paper 0402 investigates the impact of consumption tariffs might have on the periods the electric vehicle are charged, with aim of charging it during periods of lower network utilisation and major photovoltaic production. Effect on a grid of proposed customer DSM strategy is shown through a set of case studies. The test results show the successful mitigation of the system overloads and reduction of network losses.

Paper 0491 presents the business case for distributed Energy Storage (ES). The authors quantify the value associated with the provision of several key services through ES (Energy arbitrage, Balancing services, Frequency regulation services, Capacity market, Supporting low-carbon generation and Network support). The value of these services is evaluated for several case-studies to investigate the application of distributed ES for the provision of multiple commercial services under the 2030 UK Gone Green system scenario. The paper argues that the annual gross revenues of ES vary from £46/kW/year to £554/kW/year, depending on the range of services provided simultaneously. The revenues from a single service can not justify the investment cost of ES, being the provision of multiple services the key route for a profitable business case. There is also a considerable added value associated with ES placed near a PV farm when there is an active network constraint.

Paper 0994 describes a mathematical model for aggregation of curtailable generation and sheddable loads. The model determines the quantity and the cost of the flexibility provided by the flexible resources based on their physical and dynamic behaviours. The model also proposes a bidding strategy in order to translate the aggregated behaviour into market bids. Application of the new aggregation algorithms is expected to involve broader groups of flexible loads into market-based trade of resources for the ancillary services, which in turn will contribute to accommodation of renewable energy sources into the power system.

Paper 1044 addresses the challenges implicit in the transition from DNO towards becoming DSO, describing a collaborative industry steering group conclusions. The paper refers the key enabling challenges and commercial changes associated with the transition to a DSO. The author intends to trail two geographic areas as DSO enable network areas within the RIIO ED1 price review - the Dumfries and Galloway network area and the North and Mid Wales network.

Paper 1090 investigates the application of energy storage to reduce curtailment of DG and improve utilisation of distribution networks with Active Netwrok Management (ANM). The results show the impact on DG curtailment reduction for a worst case curtailment day (low demand) in a SP Energy Networks network.



Paper 1090 – DG curtailment mitigation with battery storage.

Paper 1116 presents the results of testing of Active Network Management (ANM) at the National Renewable Energy Laboratory (NREL) in Boulder, Colorado. The testing involved three use cases: Smart Home, Smart Campus and Smart Distribution, while the paper presents the results for the Smart Home (with storage, PV and EV), and Smart Distribution, simulating real time control of a MV feeder with DER and Smart Homes. The authors argue that multiple DER can provide multiple ancillary services to the grid, with further scope for further technological developments, addressing DER control system requirements.

Paper 1234 addresses the conditions for using DSO-connected demand and generation units for balancing (load frequency control) and analyses the effects on the balancing market and on imbalance costs in a case study in the Austrian balancing system. The authors identify several aspects relevant for DSO connected and demand devices (grid tariff, prequalification process, existing monitoring requirements, minimum unit size, minimum bid size, technical requirements and whether it is supplier-independent). Experiences with changed framework have shown an increase in the number of market participants (e.g., aggregators) and the amount of prequalified demand units, contributing to reduce balancing costs. The participation of DSO connected units is possible and expected to grow. The authors argue that tasks and responsibilities of the DSO need to be carefully considered, with eventual measures to avoid negative effects.

DER Integration and Network Planning

Paper 0142 describes a methodology to assess the capacity gains expected by switching from AC to DC, particularly associated with MV cables. This assessment was performed under the scope of the FLINK project, promoted by DNV GL. The paper presents results of the capacity gains associated with the switching from AC to DC for several cable topologies.

Paper 0215 introduces a decision-support tool under development to plan the expansion stages of medium-voltage networks using local flexibilities. The tool currently under test aims to help the DSO to optimally develop the distribution grid in the medium/long term. A case study based on a French medium-voltage network is presented. For each possible expansion path, the first tool release is able to make a probabilistic diagnosis of current/voltage constraints, optimize the existing reactive power controls of MV producers and voltage controls of HV/MV transformers, and find the optimal dates of network adaptations using a traditional planning method.

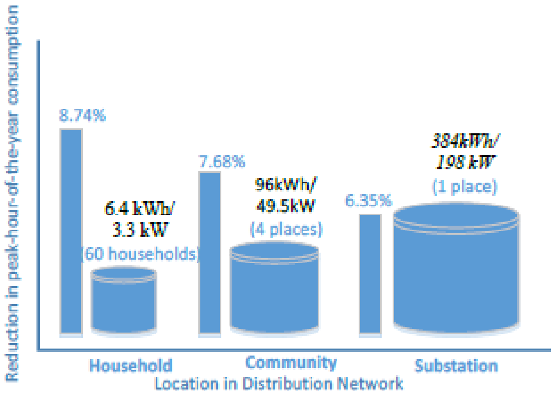
Paper 0558 shows the impact of storage penetration and control on increase of self-consumption of locally generated renewable energy in high penetration of solar panels areas. Benefits of individual and coordinated storage controls are considered. It proposes that the results and the underlying model can be used to predict the effects of increasing renewables penetration in specific areas and design tailor-made local measures to facilitate the integration of renewables.

Paper 0659 presents a DSO perspective on the methods used for analysis of new generator connections to distribution grids in GB, considering the legislative framework and assessing the Harmonics and Transformer Energisation phenomena associated with transformers connected with the network at lower voltage levels. It takes into account the codes associated with generator connections, particularly the ones associated with planning levels for harmonic distortion and planning limits for voltage fluctuations.

Paper 0742 proposes a reliability evaluation method suitable for distribution system with DG. It establishes a probabilistic model of the DG output and ivestigates the island mode of operation. The proposes methodology, an improvement of the minimal path algorithm, is applied on a IEEE RTS 6-Bus test system. The obtained results show that closer DG to the end of the feeder and greater DG capacity the more reliability is improved and traditional DG, compared to renewable DG, could more improve distribution system reliability.

Paper 0755 provides an assessment of the goals associated with the targets set for DER deployment in India until 2022, with further growth expected until 2030, as a consequence of the ratification of the Paris Agreement. Considering that framework, the authors recommend the developing of Information and Communication Technologies, enabling the monitoring and control of variable RES, the deployment of and AMI infrastructure and the development of smart EV charging functionalities associated with smart grids.

Paper 0757 studies the strategic placement of electric storage systems contributing to a deferral of grid investments caused by load growth congestions. An optimization problem solving the dual-purpose deployment of prosumers' level battery storage system has been formulated and is presented. The results of the analysis show that the absolute peak at secondary substation decreases by 8.74% and the average day peak drops by 17% while the total annual energy drawn from the grid reduced by 8.41% with a 100% prosumers scenario. Furthermore, by using household level battery systems for peak shaving of local loads one can achieve a deferral of overloading by 3 years at MV/LV substation.

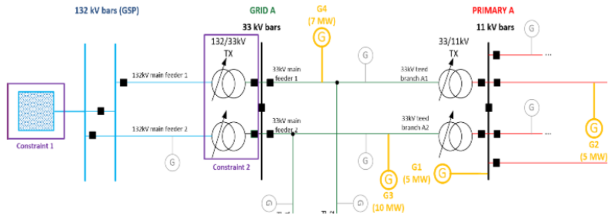


Paper 757 - Comparison among three level placement of battery storage system in distribution network.

Paper 0830 presents an analysis of the contribution of energy storage and demand-side response to security of distribution networks. The authors propose a methodology for computing two capacity credit metrics, Equivalent Firm Capacity (EFC) and Equivalent Load Carrying Capability (ELCC) and explore the suitability of these metrics through the use of case studies, associated with simulations based on data from the Leighton Buzzard primary substation, which has associated a storage system rated at 6 MW with a 10 MWh capacity.

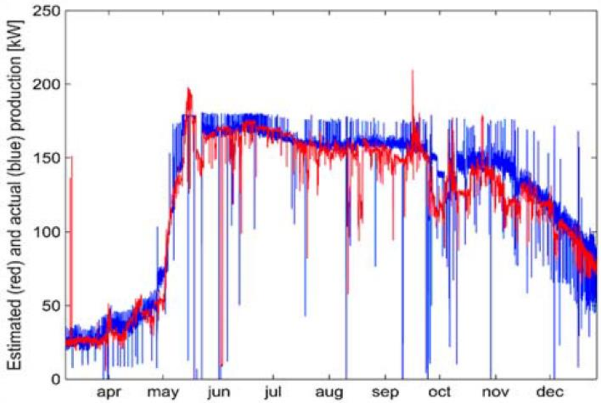
Paper 0935 describes a concept developed for the DSO, Utility Scale Domestic Solar (USCADOS), that allows it to identify optimal PV configurations and assist customers to reach maximum individual profitability when installing self-consumption units. The key elements of the USCADOS concept are network calculation, assessing maximum individual injection and network constraints associated with maximum PV potential, customer profitability assessment for each building and system optimization, providing an optimal design of the inverter giving solar production profiles and network constraints. The optimization also considers the load profile, increasing the self-consumption rate if feed-in tariffs are not available.

Paper 1085 focuses on the operational and technical learining gained in connecting, monitoring and managing of commercial flexible distributed generation schemes in the UK Power Networks' distrbution system. It also shows expirience in optimizing of their active network management schemes.



Paper 1085 – ANM managing multiple constraints.

Paper 1089 presents an estimation methodology to evaluate the energy produced by hydro DG units which are not directly monitored, taking into account weather data, refined with data about generation, load and measurements already available to the DSO. The algorithms were tested within the DEVAL smart grid project.



Paper 1089 Example of power profile (estimated vs actual) for a hydro generator.

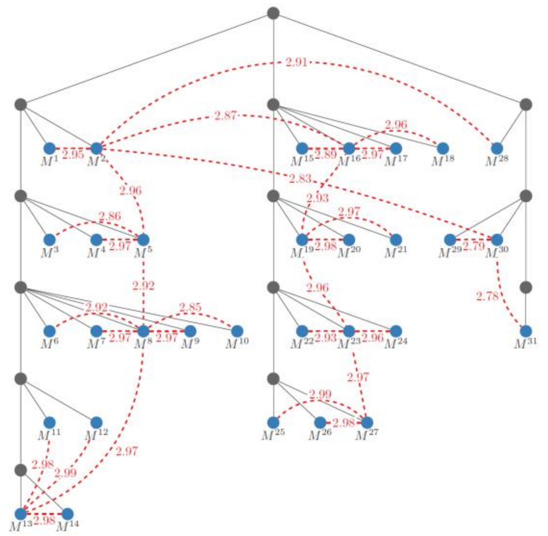
Paper 1155 describes a decentralized off-line strategy for management of PV and batteries, while maximizing the integration of PV systems into the electric grid. The methodology models grid load, for several households sizes, stochastically integrates PV modules and defines the better strategy to manage PV/hybrid systems according with the voltage assessment and including an optimal sizing of the battery.

Smart Metering and AMI

Paper 0500 describes the use of AMI to assess LV and MV network losses, with the goal of assessing technical and non-technical losses in order to foster fraud detection. Three grids were selected for the analysis described (two LV grids and one MV feeder). The deployment of smart meters allowed to improve loss monitoring and yielded benefits in loss reductions due to a decrease in non-technical losses.

Paper 1143 describes a methodology allowing to automatically identify the connection phase of smart meters, based on measurement data. It is based on

PREMASOL project. The model was validated through measurements performed in a sub-urban LV network in Belgium. The developed algorithm relies on graph theory, using the notion of maximum spanning tree (MST) to select the results that maximize the correlation between nodal voltages. It uses a time window for the measurements (for instance, one day), providing insights into the structure of the electrical network.



Paper 1143 – The topology of the electrical network is in grey. The upper node corresponds to the distribution transformer and the nodes that are numbered are measurement points (blue). The maximum spanning tree is in red (dashed) and the weight of the edges is the maximum correlation coefficient.

Paper 1284 presents analysis of AMI data being used to improve DG impact studies in LV distribution networks. The results obtained using AMI data were compared with traditional methods used in distribution for load allocation. The distribution feeder and the AMI information were obtained from the Smart City Búzios project, implemented in Búzios, in the state of Rio de Janeiro, Brazil. The results show that the traditional load allocation techniques could overlook excessive voltage rise. Therefore, AMI could provide important data to perform DG impact studies on LV distribution networks

Photovoltaics Grid Integration and Inverters

Paper 0329 assesses the implementation of the ENTSO-E recommendations "Dispersed Generation impact on Continental Europe region security" concerning the readjustment of frequency protection behaviour (retrofit) of PV plants in the Czech Republic. The paper presents a description of the selected issues of retrofit, and also shows that the choice of the unit output power of PV plants has significant influence on the total number of retrofitted PV plants and their total output power, which will significantly affect the difficulty of the process of retrofitting and the overall associated costs.

Paper 0476 analyses the impact of photovoltaic production variability on transformer tap changer operations in distribution networks. Based on solar energy production with 1 minute resolution, it describes the expected number of tap changes on on-load tap changers associated with MV/LV transformers, for different weather conditions, for different time delay settings.

Paper 0332 presents the results of analysis PV self-consumption based on network model and real production/consumption measurements. Different shares of PV generation with and without battery storage are integrated into the network with and analysis of operation of the distribution network in its present state, with installed PV at the chosen customer sites, and with added battery systems at the chosen clients with PV with resulst showing better voltage regulation and losses performance for comined PV and storage installations (so enhanced self-consumption).

Testing

Paper 0340 shows setup and results of a stress test conducted in a distribution grid supplying residential area by increasing load that led to a short supply interruption and severe unbalance. It concludes that control, bookkeeping and customer incentives are necessary to avoid such outages and to keep a better spread of load across phases.

Paper 0419 describes a methodology to provide short term load forecasting at the level of single buildings, equipped with PV-panels, solar thermal panels, hybrid panels, heat pumps and various thermal and electrical storage facilities. The methodology, based on the K-Nearest Neighbours (KNN) method, is tested at the *Smart City Demo Aspern* (SCDA) project. The KNN forecaster is used to forecast the day-ahead electricity consumption of SCDA buildings for a 5-month period and comparing with real data. The authors claim to achieve a convincing forecast accuracy.

Paper 1051 presents a methodology for collaborative laboratory experiments design with key performance indicators for the testing and validation of novel power system control architectures in multiple laboratory environments. The methodology makes use of the smart grid architecture model (SGAM) and facilitates the integration of individually developed control functions into consolidated laboratory validation and testing to support improved cooperation in smart grid validation and multiple test regimes.

Table 1: Papers of Block 1 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0104**:** SmartNet: A H2020 Project Analysing TSO-DSO Interaction To Enable Ancillary Services Provision From Distribution Networks	X			
0128: Reliability Evaluation of Distribution Network Including Controllable Distributed Generation and Battery Swapping Station				X
0142: Determining Potential Capacity Gains when Repurposing MV AC Cables for DC Power Transportation				X
0214: Techno-economic analysis of Power-to-Gas solutions in the Swiss distribution grid				X
0215: Smart Grid Vendée project: a decision-support tool for the multi-year planning of active distribution networks				X
0219: Profitability Analysis of Grid Supporting EV Charging Management				X
0267: Integration of a Thermal Energy Storage as a Dynamic Load in the Electrical Grid of an Urban Quarter				X
0282: Dual-Decomposition-Based Peer-to-Peer Voltage Control for Distribution Networks				X
0286: Analysis on Voltage and Frequency Responses of Isolated Microgrid According to Minimization of Diesel Generations				X
0288:A Study on Energy Management System for Stable Operation of Isolated Microgrid				X
0320: Techno-Economic Evaluation of Load Activation Quotas as a Concept for Flexible Load Management				X
0329: Impact of ENTSO-E recommendation on retrofitting of PV frequency relays in Czech Republic				X
0332 - Influence of Self-consumption on Distribution Network Operation - the Slovenian Case				X
0340: Charging Electric Vehicles, Baking Pizzas and Melting a Fuse in Lochem				X
0402: Optimization of Low Voltage Distribution Networks in a Strong Embedded Microgeneration and Electric Vehicle Penetration Context				X
0419: Building Power Demand Forecasting Using K-Nearest Neighbors Model - Practical Application in Smart City Demo Aspern Project				X
0447: Peak Demand Reduction by Using Demand Bidding Program in Mashhad				X
0476: Quantification on the Impact of Photovoltaic System on Transformer Tap				X

Changer Operations in Distribution Networks				
0491: Business Case for Distributed Energy Storage	X			
0500: Distribution Loss Reduction in Residential and Commercial Pilots by using AMI system				X
0558: The Case for Coordinated Energy Storage in Future Distribution Grids			X	
0567: Integrating Demand Flexibility with DG-RES at the Residential Household and Commercial Customer level in Electricity grids; Results from IEA/DSM task 17				X
0659: Comparison of Analysis Methods for Generator Connections				X
0742: Reliability Evaluation of Distribution System with Distributed Generation				X
0755: Integration of Multivariate Distributed Energy Resources for Demand Response: Applications in the Indian Scenarios				X
0757: Seasonally variant deployment of electric battery storage systems in active distribution networks			X	
0830: Contribution of Energy Storage and Demand-side Response to Security of Distribution Networks			X	
0850: Designing a Financial-based Energy Management Framework in Smart Public Parking Lot				X
0935: Utility Scale Domestic Solar: The Proactive Transition of Distributed Network Operators in Switzerland				X
0950: Electric Heating As Flexible Demand for Enhanced Network Operation				X
0994: Aggregation Model for Curtailable Generation and Sheddable Loads			X	
1023: Business Models for Demand Response Aggregators under Regulated Power Markets				X
1039: New Functionalities of Smart Grid Enabled Networks				X
1044: SPEN - DSO Vision				X
1051: Laboratory Infrastructure Driven Key Performance Indicator Development using the Smart Grid Architecture Model	X			
1075: A Blueprint for the development of Artificial Intelligence in Market-based Control Technologies by using Energy Flexibility Platform and Interface	X			
1085: UK Power Networks' experience of Managing Flexible Distributed Generation from Planning to Operation	X			
1089: Real-Time Monitoring of Distribution Networks: Experimental Application of Italian Res. 646/2015/R/eel				X
1090: Integration of Energy Storage to Improve Utilisation of Distribution Networks with Active Network Management Schemes				X
1116: Meeting Emerging and Future Requirements for Managing DER in Highly Active Distribution Networks				X
1143: Automatic Phase Identification of smart Meter Measurement Data			X	
1155: Optimal Hybridization and Management of PV/Batteries Hybrid Systems in Residential Distribution Networks				X

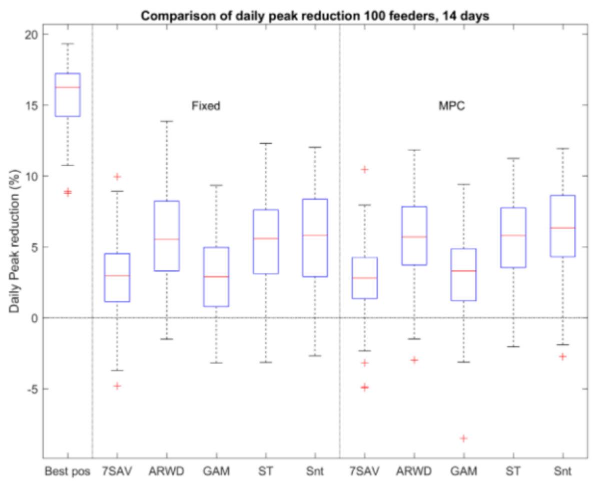
1159: Integrating Time-Shiftable Demand Appliances in Distribution Network Operation and Planning				X
1188: Energy Storage Systems (ESS) and Microgrids in Brittany Islands				X
1234: Balancing with DSO-connected Demand and Generation Units - Case Study Austria				X
1284: DG impact evaluation on LV distribution grids using AMI data: a Brazilian case study				X

Block 2: DER grid integration enablers and technologies

DER Forecasting, Scheduling and Contingency Analysis

Paper 0363 introduces a smart meter (SM) - driven methodology for estimating load composition within forecasted active and reactive load in residential areas. The methodology relies on the assumption that a certain part of the end-users supplied by the same bulk point are monitored with smart meters which have the ability to measure active load of each appliance every minute. The results show, the accuracy of reactive load decomposition has higher dependence on SM coverage than active load. 50% SM coverage brings the optimal accuracy for overall (active and reactive) load decomposition, when compared to the base cases.

Paper 0626 describes a battery storage charge scheduling method for offsetting LV feeder reinforcement based on comparison of five low voltage feeder demand forecast methods and comparing a Model Predictive Control (MPC) approach to a fixed schedule in a test sample of 100 LV circuits. The results show a diversity of performance for forecast methods over certain sizes of feeders, sizes of battery and consequently lead to better performance of the peak reduction algorithms. Both fixed schedule and MPC with simple error achieved better peak reduction for larger feeders. However, MPC with simple error correction have performed better on smaller feeders compared to the fixed schedule.



Paper 0626 - Comparison of the daily peak reduction for each forecasting method and scheduling approach.

Paper 0775 presents a novel back propagation artificial neural network (BP-ANN) method for wind speed forecasting for power system applications. The results of the application of the method actual outcome are shown.

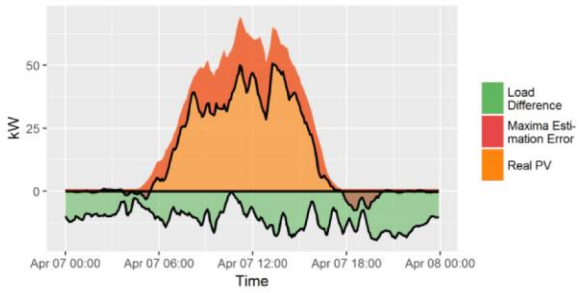
Paper 0902 assess the challenges in model and data associated with the implementation of distribution network contingency analysis for both operational and planning time frames. It is based on a real example of dealing with data exchange, the Kent Active System Management (KASM), and argues for the need of an enhanced TSO/DNO coordination, since the DNO are starting to gain access to a portfolio of responsive demand, storage and controllable generation assets.

Paper 1185 presents a functional model providing net-load forecasts for each LV node (including PV generation and self-consumption) developed for the H2020 UPGRID project. Based on forecasts and available real-time information, an architecture for preventive control of LV grids is built upon chronological analysis capabilities of DPlan.

The net-load forecasting tool generates forecasts for each LV node and was built in order to allow the scalability of the methodology and providing information about forecast uncertainty. It is based on analogues search and kernel density estimation, allowing an enhanced awareness to the LV dispatch operators.

Paper 1185 – Predictive power flow results: red coloured lines identify overloaded feeder sections and red coloured circles identify bus voltages below acceptable levels.

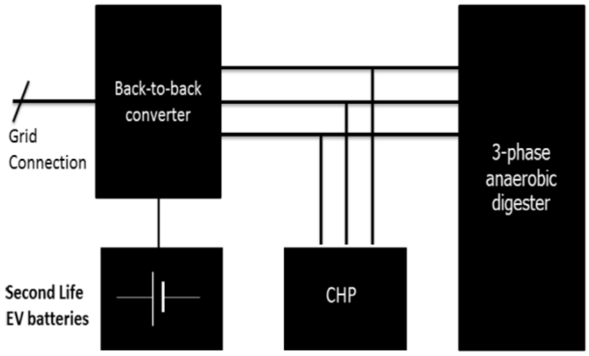
Paper 1333 introduces a load disaggregation method to separate domestic demand from latent PV production behind-the-meter and discuss forecast interval reduction (to 15 minutes) performance improvement.



Paper 1333 - Load and PV disaggregation for one day, exploiting statistical behaviour of minimum and maximum infeed. Results of PV disaggregation is shown in yellow.

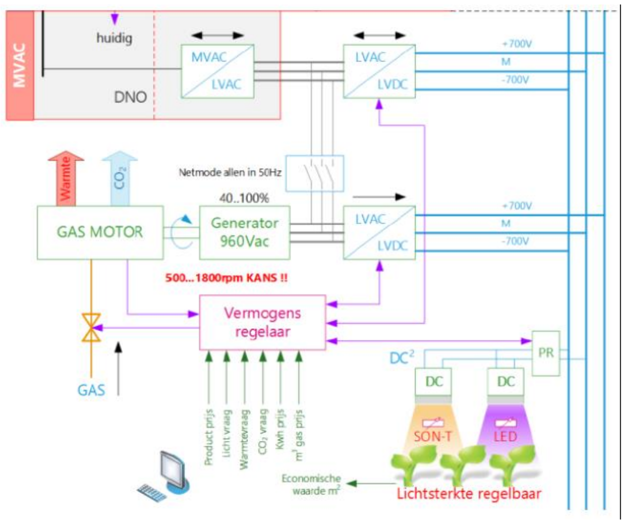
Power Electronics

Paper 0550 describes the use of back to back power electronic converters to provide a stronger 3-phase power supply in weak 1-phase rural grids to enable grid connection of low carbon generation technologies. The overall concept is augmented this with battery storage where charge control is effected by DC link voltage management and coordination between converter control and battery management.



Paper 0550 – Connection schematic for application of converter and battery system to farm application.

Paper 0998 investigates business case for DC distribution grids. Transforming existing AC grids to active DC grids, by, in general, maintaining the installation wiring will solve power quality problems and there will be an overall increased capacity for the meshed grid. It concludes a positive business case for the greenhouse active DC grid, because of the better controllability of the lighting, ventilation and temperature with potential an energy reduction of 30% and the payback time of the investment within a very short time period of 2.5 years. For industrial estates, "last mile" grids, data centers etc., the additional functionality, the natural congestion management and the balancing of multiple sources with multiple storage derives, bring the major advantages of a DC distribution grid.

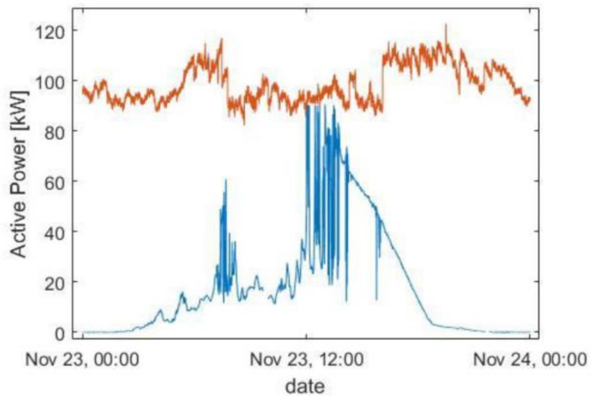


Paper 0998 – The improved active DC grid for the greenhouse.

Paper 1289 presents the evaluation of two power electronics technologies used to connect a super-capacitor stack to a medium voltage grid. It includes an experimental evaluation of a 1.5MJ/25kW energy storage system able to interface directly to a 3.3 kV medium voltage grid.

Hosting Capacity Analysis

Paper 0316 presents a rigorous assessment of five different DG hosting capacity analysis techniques with the results showing a large difference in the obtained hosting capacity result across the methods. The use of measurements in the calculations greatly increases the hosting capacity, compared to when using assumptions based on a "worst case scenario". It was also found that the threshold used (i.e. 100, 99 or 95% of the chosen capacity limit threshold) has a large impact on the calculated hosting capacity.



Paper 0316 - Hosting capacity calculated from time series of voltage (orange) compared to production from a solar installation (blue).

Demand Response

Paper 0059 describes a nonlinear control solution of heat balances, designed to optimize electrical energy costs associated with households equipped with a photovoltaic panel, a battery energy storage and several heating equipment, controlling for the relevant control temperatures of the indoor air, walls, heat storing floors and fireplace, sauna, hot water storage and circulating heating water. The simulations were run for four week periods in four different seasons, helping to optimize the consumption, the storage capacity and the battery sizing.

Paper 1000 presents a method for digital real-time co-simulation (DRTCoS) applied to smart grid integrated with large-scale DR resources. The method presented simulates DR resources decoupled from the rest of the grid, building multi-rate digital simulations. An interface algorithm is designed to exchange information between subsystems. Compared with digital real-time simulation (DRTS) of large-scale DR, the simulations performed uses less computing resources and are more efficient.

DER and Network Management

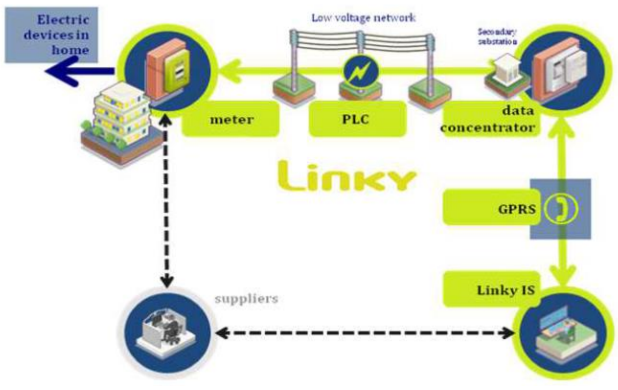
Paper 0131 presents a decentralised power flow solution that facilitates active network management in radial distribution network with a very large numbers of DER. It describes the algorithm and applied approximations. Simulation results show small errors in estimating voltages and power flows due to non-local changes. It increases the network observability without requiring too much data transfer between devices.

Paper 0803 discusses an approach for handling controller conflicts within Multi-Functional Energy Storage Systems (MFESS). MFESS can address several objectives simultaneously. The paper describes use cases associated with controlling voltage and VAr and the PCC, frequency control, voltage and W control at the PCC, minimisation of energy consumed from the network and minimization of electricity cost. These objectives might be conflicting at some occasions, or be outside the control variable capabilities. The paper proposes a methodology to classify conflicts and presents model-driven architecture approach for the identification and handling of them.

Paper 1035 presents the results obtained through Phasor Measurement Units (PMU) associated with a 50 kV ring distribution grid. It provides an analysis of the behaviour and voltages in 50/100.4 kV distribution grid through real time data acquired from the PMU measurements. The results include contingency analysis. The authors argue that the rise in DER increase the need for real-time monitoring, with the PMU data providing a more complete assessment of the grid behaviour during contingencies.

Paper 1049 introduces a UK case study of voltage regulating distribution transformers for LV network voltage control and increased system efficiency. Two options for integrating two CHP units are presented: provide a point to point connection and install a tap changing distribution transformer. The later one is economically viable and several benefits are discussed in the paper.

Paper 1326 shows the associate benefits of the remote transmission of fault detectors and the analysis of voltage values to detect resistive faults based on smart meters. The Linky smart meter system, implemented in Enedis networks, offers technical solutions to modernise network management operations improvement of medium voltage fault management processes, by transmitting fault signals and detecting resistive faults both in a technical and economic efficient way.

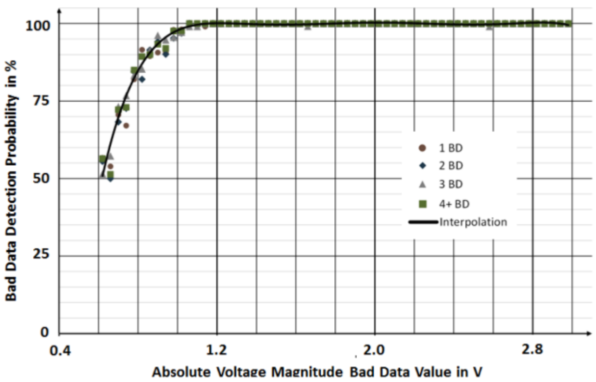


Paper 1326 – Presentation of the Linky smart meter *system.*

Testing

Paper 0071 presents a state-estimation methodology, applied to LV grids, developed with the objectives of detecting single-phase or three-phase violations, providing consistent results in the absence of incomplete smart meter data (which will always be insufficient to achieve network observability, according the authors), while being computationally efficient. The methodology is tested through the comparison between estimated values with real values obtained from a testbed from the projects SmartSCADA and CheapFlex.

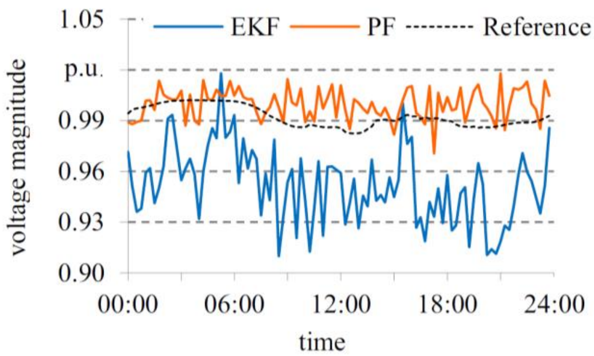
Paper 0327 describes a field test of a linear three-phase LV state-estimation system based on smart meter data. The results were obtained through the SmartSCADA project on a meshed LV network with 120 loads and 24 PV systems. One essential task was the bad data (BD) detection and localization within the input data set. The paper indicates the BD detection probability as a function of the magnitude and percentage of BD. Also, the estimation accuracy of the state-estimation system was assessed, based on the difference between estimated and measured values for voltage and current magnitudes.



Paper 0327 – Detection probability of voltage magnitude BD as a function of BD value and the number of BD.

Paper 0337 describes a test stand for small combined heat and power plants (CHP) with directly coupled synchronous generators. The test stand allows to support transient stability analysis in active distribution networks, exemplifying the transient behaviour during large active and reactive load variations in an islanded network. The test stand is modularly designed, allowing to investigate a large variety of different drives and synchronous generators.

Paper 0984 compares two different approaches for Distribution System State Estimation (DSSE), the Extended Kalman Filter (EKF) and a Particle Filter (PF) approach, for quasi-dynamic state estimation – involving not just a snapshot, but a time-series. The advantages and constraints of each approach, compared with pseudo-measurements (PM) are emphasized. The authors argue that the EKF approach delivers estimation results with high quality as long as the input data is sufficient. A basic variant on the PF approach has been applied, also with acceptable results, although with lower accuracy. However, PF is more robust for uncertain input data. Further efforts should be made to develop the PF approaches.



Paper 0984 – Voltage magnitude at a busbar for generalised extreme value distributed measurement errors.

Table 2: Papers of Block 2 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0059: Nonlinear optimal control of the responses of residential small houses with				X

new energy resources				
0071: Linear three-phase State Estimation for LV grids using Pseudo Measurements based on Approximate Power Distributions				X
0131: Decentralization of Power Flow Solution for Facilitating Active Network Management				X
0316: Using Measurements to Increase the Accuracy of Hosting Capacity Calculations	X			
0327: Field Test of a Linear Three-Phase Low Voltage State Estimation System based on Smart Meter Data	X			
0337: Development of a Modular CHP Test Stand for the Analysis of the Dynamic Behaviour of Small Synchronous Generators			X	
0363: Smart Meter-Driven Estimation of Residential Load Flexibility				X
0550: Charge Control of Second Life EV Batteries on the DC-link of a Back-to-Back Converter				X
0626: Evaluating the Effectiveness of Storage Control in Reducing Forecasted Peak Demand on Low Voltage Feeders			X	
0775: Short-Term Wind Speed Forecasting Using Artificial Neural Network for Scheduling of a Residential Cogeneration Plant				X
0803: An Approach for the Handling of Controller Conflicts within Multi-Functional Energy Storage Systems				X
0902: Challenges in Model and Data Merging for the Implementation of a Distribution Network Contingency Analysis Tool				X
0984: Evaluation of Extended Kalman Filter and Particle Filter Approaches for Quasi-dynamic Distribution System State Estimation				X
0998: Adjustment of available and needed energy and necessary additional functionalities in the distribution grid, caused by the energy transition, can better be solved by DC distribution grids				X
1000: Real-time Digital Co-simulation Method of Smart Grid for Integrating Large-scale Demand Response Resources	X			
1035: PMU-based power system analysis of a MV distribution grid.				X
1049: Voltage Regulating Distribution Transformers for LV Network Voltage Control and System Efficiency				X
1185: Predictive Management of Low Voltage Grids				X
1289: Experimental Round-trip Efficiency Evaluation of an Energy Storage System for Medium Voltage Distribution Grids				X
1326: Linky contributions in management and fault detection				X
1333: Improving Residential Demand Characteristics by Disaggregation of Load and Generation			X	

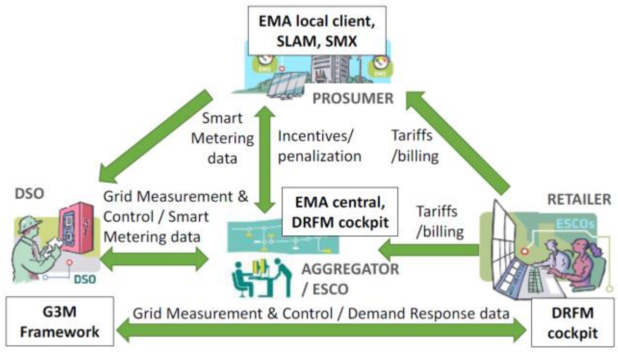
Block 3: Technical and commercial DER grid integration methods and solutions

DER Flexibility Aggregation

Paper 0256 presents an innovative concept to connect prosumers to the grid. The connection is achieved by two galvanically isolated battery storage systems, which are switched over cyclically. The grid-optimized operation is investigated in detail based on a low voltage test grid with different charging strategies for the intelligent prosumer coupling. The concept reveals new options for grid-optimized operation, optimization of self-consumption and energy trades as well as improved utilization of fluctuating generation by renewables in the grid. The results show benefits compared to conventional parallel battery storages for prosumers, system operators, energy traders and integration of RES.

Paper 0307 presents an approach for the interaction between DSO and aggregators in a scenario with existing DER flexibility. It is based on the approaches developed for the IDE4L project, describing possible relations between the Market Operator, the DSO, the TSO, retailers, aggregators and customers, associated with dynamic tariff (DT) formation. The project developed a market agent algorithm, which is tested in the context of a hypothetical MV distribution network. The simulations include unforeseen events, like switching off of a wind turbine. The authors argue that the communication framework associated with DT should not go through the aggregator or be tied to a flexibility market. The market efficiency is improved if several aggregator bids are allowed to be aggregated together, particularly in areas with several small aggregators. DT can solve congestion issues for the DSO and is cheap to implement.

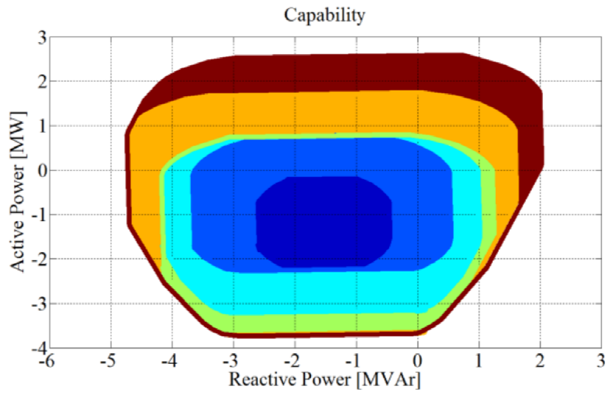
Paper 0561 describes a software driven active customer interface for DER integration. It is based on the Nobel Grid H2020 project, consisting on an IT to integrate and utilize flexibility potentials of demand response and end-customer operated DER. IT associated with smart grids need to seamlessly interface with billing, asset management, SCADA systems and smart homes and building automation, with an adequate cost and complexity.



Paper 0561 – Nobel Grid actor relations

Paper 0661 discusses the benefits of combining Energy Storage Systems (ESS) and Real Time Thermal Rating (RTTR) to solve distribution network problems. It demonstrates that the combination of technologies is a more effective solution to many network problems than either a conventional asset based solution, or using RTTR or ESS alone. Technical and regulatory obstacles which must be overcome to harness the full potential of these, and other, emerging technologies have been identified.

Paper 1273 presents three methods for fast construction of this equivalent aggregated distributed resources capability in distribution networks to aggregate a single capability representing the flexibility limits of the entire network. Flexibility resource pricing is also incorporated into the aggregated P and Q resource capability.

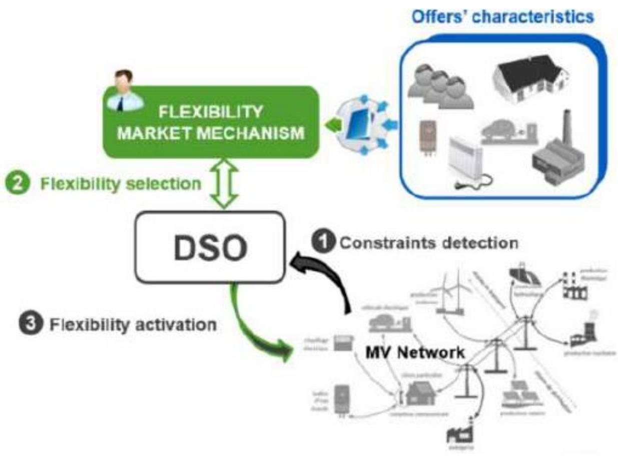


Paper 1273 - Aggregated capability for increasing number of resources according to the marginal cost - higher cost capability towards red) colour areas (computed with the proportional cost method).

PV Integration

Paper 0216 examines the effect of tariff changes in Italy on the economic benefits from PV ownership of domestic consumers. The paper concludes that while there are no additional subsidies for PV there are economic and other advantages in transitioning to an "all-electric" demand solution with PV under the new tariff.

Paper 0411 describes a new market mechanism tool in order to handle the impact of DER and to solve technical constraints (voltage contractual requirements, thermal constraints in lines or transformers) by making flexibility offers available on a flexibility platform. It selects the relevant flexibility offers in order to solve or at least reduce the expected technical constraints while minimizing the overall cost. It will be integrated into Enedis' operational Distribution Management System as a fully automated process.



Paper 0411 – Flexibility offers time process.

Paper 0982 considers use of battery energy storage at customers' level in low voltage networks with high penetration of solar PV. The case study is carried out on a low voltage network supplying 80 customers that is located in the municipality of Évora. It concludes that there is no technological barrier to the implementation of PV and storage capacity from a grid losses perspective as well as current and voltage violations. It was also concluded that the introduction of batteries would lead to an increase of the hosting capacity given that it decreases the grid losses alongside the consumption of the end-users. The only drawback when implementing PV aided by storage capacity is that load curves will have a higher variation during the day. It was that it would be more economically efficient for the electric system to introduce batteries at a client's-level.

Paper 1083 presents detailed analysis of the grid integration of a combined solar PV and energy storage system. The impacts of installing a distributed PV and storage system under various feeder conditions, locations, and control strategies are examined. The results indicate the best locations for the system, how the system should be controlled and that additional services (frequency regulation capacity, solar energy time shifting and voltage support) can be effectively provided to the local feeder and system.

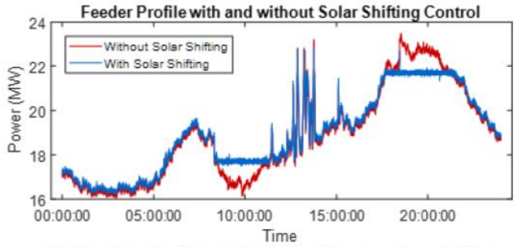


Figure 11 Feeder profile with and without solar shifting on day with no frequency regulation requirement

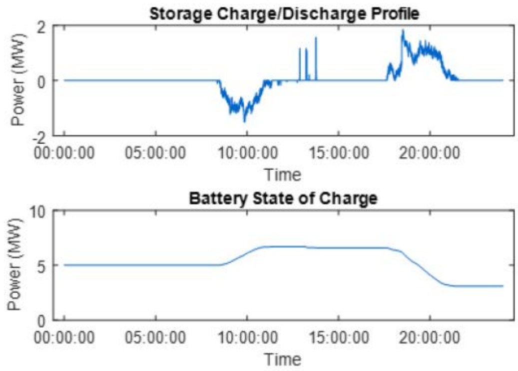


Figure 12 Controlled storage dispatch and state of charge for solar shifting on day with no frequency regulation requirement

Paper 1083 – Solar PV and energy storage system services analysis.

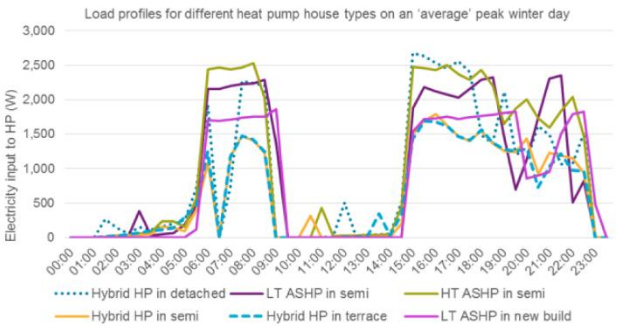
Paper 1227 presents an economical distributed control scheme aimed to keep voltages within the statutory range while increasing the penetration of solar photovoltaic renewable energy in the low voltage network. Battery energy storage system is used during periods of high output from PV, followed by reactive power action if overvoltage persists, and finally PV power curtailment as a last option. Preliminary results on a test network show that in addition to successful overvoltage mitigation, the scheme is economical as it employs use of fewer battery energy storage systems.

Demand Response

Paper 1086 presents a method for the energy management of a set of smart homes in which batteries, thermal storage, and demand response, are considered as flexibilities in order to achieve minimum operation costs. The methodology presented has been developed in the context of the H2020 SENSIBLE project. It evaluates a proposed Home Energy Management System (HEMS) on a case study comprising 40 households, in which a PV plant, a battery, individual demand response and electric water heaters are considered to minimize the operational costs. The results demonstrate that the coordination of thermal and electrochemical storage leads to cost minimization and that results can be extended to real-life testbeds, such as Evora in Portugal.

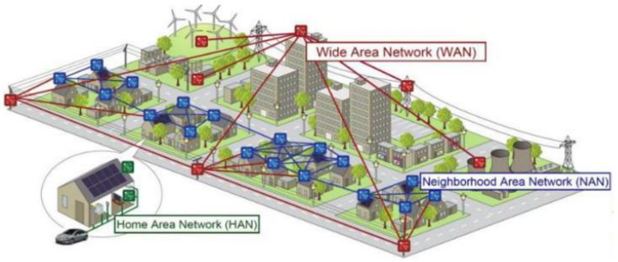
Paper 1101 presents the objectives of the research network, funded by Spanish Government, including integrating technologies and proposing innovative solutions to demand response concerns in modelling and aggregation, automation, application of ICT; implementation in markets; price and consumption forecasts, or monitoring and verification. Different methodologies and tools to develop a model for the effective engagement of customers and aggregators in demand response are presented.

Paper 1123 argues that although heat pump (HP) penetration in the residential sector is low in the UK, it is very likely to increase since they are central to the strategy for decarbonisation by 2050. Therefore, the impact of HP on networks is assessed. For the analysis, the authors gathered data on real life HP operation, built physic models to develop HP load profiles for different house times and diversified those load diagrams for several households, allowing to forecast the uptake of different kinds of HP. Finally, the paper presents an analysis of HP flexibility and modelling of the impact of HP in the network.



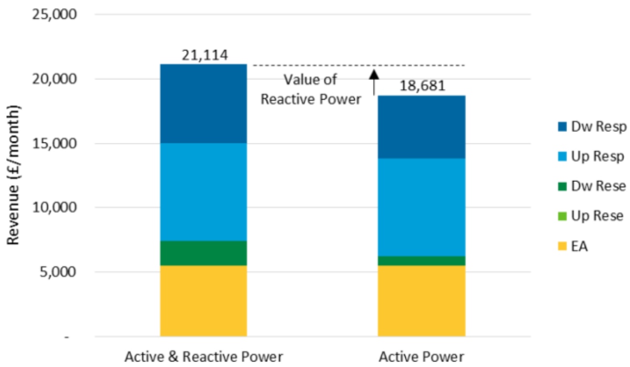
Paper 1123 – Load profiles for 6 different HP – house type combinations on a peak winter day

Paper 1162 presents an analysis of all communications networks that typically participate in the activation of demand side management, and provides an estimate for the overall latency that these networks incur. The most significant sources of delay from each of the components of the communications network are identified which allows the most critical aspects to be determined. It is shown that demand side management can be used to provide primary frequency support services.



Paper 1162 – Urban communication network.

Paper 1274 investigates the business case of coordinating energy storage and proposes model for coordination of active and reactive power outputs from an energy storage plant by optimised operation to deliver maximum benefits by considering its capability. Operation of a real distributed energy storage plant connected to a primary substation in Leighton Buzzard, UK are modelled. Results show that in a multiple service business model, the coordination of active and reactive power may increase total revenue by c. 2,400 £/month, when compared to an active power only operation mode.



Paper 1274 – Monthly average revenues for energy storage coordinated operation of active and reactive power and active power only.

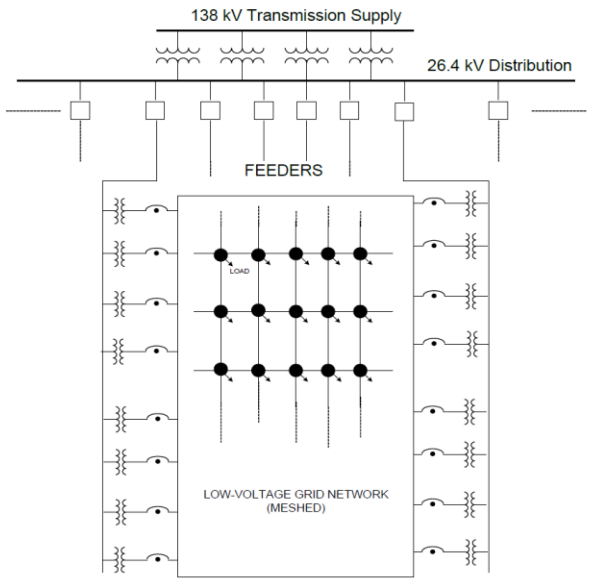
DER Planning and Operations

Paper 0169 presents an optimization model for the interaction between short-term storages (like pumped storage hydroelectricity and battery storages) with long term storages (like seasonal hydro storage and power-to-gas alternatives). Additional seasonal storages (power to gas, P2G) add a further task for the short term storages. During summer months, they balance the generation surplus, so that the P2G systems are operated with a constant (maximal) power. The usage of (decentralized) short term storage is doubled, when adding power-to-gas units to a highly renewable energy system. Therefore power-to-gas systems are no competitor to short term storages. In contrast the usage and demand of short storage rises.

Paper 0233 focuses on how LV producers' reactive power can help to prevent voltage constraints in order to better integrate DG on LV networks. The analysis compares a BaU scenario with a scenario considering constant reactive power absorption from PV units (which has no cost for the PV owners) and a *Q=f(U)* solution. The solutions are compared considering the benefits regarding hosting capacity and LV network losses, with simulations run for 9% of Enedis LV networks (74,000 LV networks).

Paper 0271 presents an analysis associated with the maximization of the integration of crowdfunded PV in a rural distribution grid, simulating solutions based on the operation of inverters with local or centralised control strategies. The results are shown for a smart grid demonstrator (SMAP, SMArt grid in natural Parks) with 8 PV plants totalizing 76 kWp owned by 76 citizen shareholders.

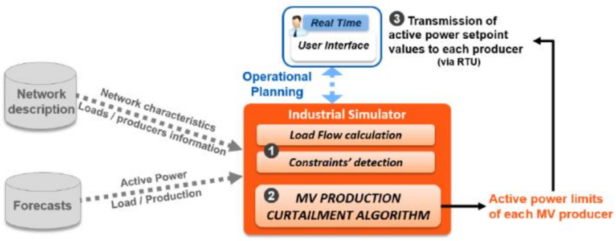
Paper 0403 presents a study, associated with meshed LV networks, on the time and locational value of DER. The study illustrates the complexity and implications of deploying DER in meshed networks to address capacity issues. The effectiveness of DER is highly dependent upon its location relative to the system constraint. Furthermore, the value of DER cannot be determined by applying generalities about feeder characteristics like MW served or any single other performance metric. Comprehensive, objective, and transparent methods are required for consistence and sensible results.



Paper 0403 – Typical Urban Network Distribution System.

Paper 0409 presents an algorithm for MV production active power curtailment, along with the contractual context, set by Enedis and integrated within Enedis' industrial environment for operational planning purposes.

The algorithm is designed to handle several constraints at the same time step, with criteria to rank them and addressed them sequentially, based on the number of producers responsible for each constraint (either associated with equipment's stipulated capacity or voltage constraints). It is used in a fully automated process, from day-ahead constraints prediction until the real time commands sent to producers.



Paper 0409 Global architecture of the active power limitation tool

Paper 0726 describes stochastic algorithm for optimal power flow for the optimised management of storage devices and maximise capability to integrate RE generators. The algorithm implies the integration of a scenario tree to plan the charging and discharging schedule of batteries one day in advance with estimated increases total economic benefit by 3.1% while increasing battery life.

Paper 0733 analyses the cost benefit self-adaptive reactive power control and active power curtailment of DER on MV networks. These two solutions can be implemented to reduce connection costs when constraints are identified on connection studies. Cost-benefit analysis on society at large for these two alternative solutions show a potential reduction of connection costs between 90 k€/MW and 100 k€/MW when these solutions solve constraints and are costeffective compared to network reinforcement.

Paper 0833 considers the effects of distributed energy storages on electricity distribution systems when the storages are used in system services such as frequency containment. The considered energy storage scenario is based on the change of the energy-based electricity distribution pricing model to power-based, which motivates electricity customers to reduce their peak loads, and thus to invest in energy storages. In the LV network the effects of BES used in ancillary services seem to be insignificant, but in the transformer or MV line level a significant proportion of the components may have a considerable load increase.

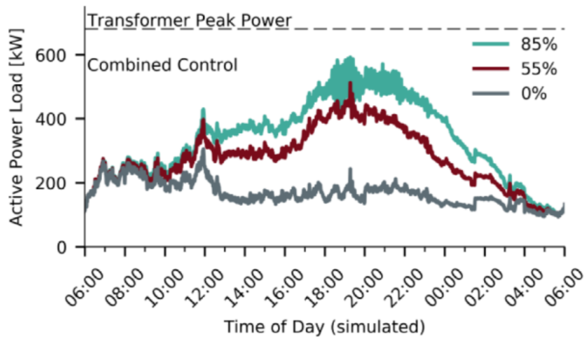
Paper 884 presents autonomous voltage control in LV networks using Q/U and P/U functions of inverters. The influence of Q/U and P/U parameterization on connectable photovoltaic power plants power within the frame of MV/LV transforming station is analyzed on a model of LV network. For the P/U control, an estimation of undelivered energy for one year due to power restriction in the modeled network is calculated. In variants with Q/U control, network losses are calculated for different characteristics.

Paper 0925 discusses how generation curtailment can be utilized to increase the wind power hosting capacity of an existing distribution network. The paper proposes a control algorithm that implements the curtailment and can be easily integrated as a part of the existing network management tools of the distribution system operator. The paper shows that generation curtailment can be an attractive alternative to network reinforcement in cases where the amount of annual curtailed generation is moderate. Additionally a method is presented to evaluate the amount of annual curtailment prior to wind farm construction.

Paper 1120 addresses the planning requirements for DER integration at scale and suggests a full revision of network planning assumptions, techniques and tools. The methodology presented in the paper contributes to robust network planning for active distribution networks. The paper focuses in securing contingency situations: where the network operates with an asset removed for operational reasons (N-1), by proposing a methodology of risk management for Active Network Management (ANM) configuration to match contingency loading thresholds.

Electric Vehicles

Paper 0265 assesses the EV grid integration capacity of different EV charge control approaches based on local voltage measurement, central control from substation loading measurement and a combined approaches. The paper shows that additional capacity can be accommodated but that voltage is a challenge for all methods but that a local control method has good potential.



Paper 0265 – Hybrid control algorithm results on transformer loading for % EV penetration.

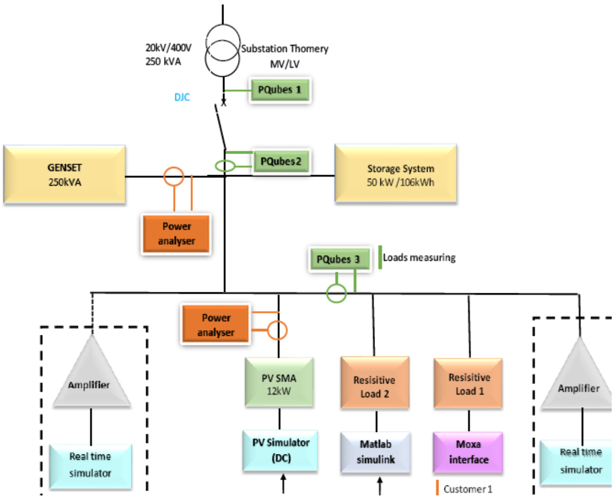
Paper 0377 assesses the reactive power requirements for EV supply equipment with fast charging capability in low voltage distribution circuits to prevent low voltage excursion when charging at high power. The study points towards preliminary guidelines (reported in a matrix) which indicates the amount of reactive power that an individual electric vehicle could be expected to provide when connected to a low voltage feeder without reinforcement.

Paper 0937 describes a virtual energy storage system developed from aggregating smart charging EV, including potential V2G capabilities, in a parking lot. The flexibility that can be reliably called upon from EV in aggregate from a Virtual Energy Storage System (VESS). The paper presents a case study of an EV charging station with 50 spaces and used a Monte Carlo approach to calculate stochastic maximum and minimum aggregate power demand percentiles of the parked EV fleet. It was considered the effect that charging/discharging cycles have on the batteries useful life (battery degradation cost).

Microgrids and VPP

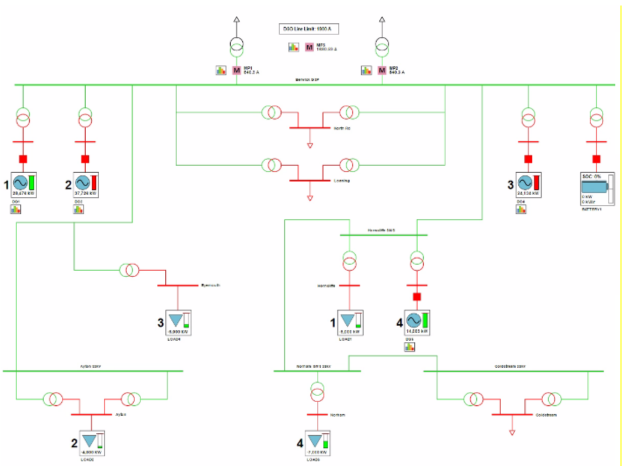
Paper 0740 introduces grid code requirements for DER connected to 'stand-alone energy island' by Korean power company KEPCO and argues for the need for indirect voltage regulation (IVR) control of energy storage provide a practical means for other DER types to contribute to power island voltage and frequency stabilisation where otherwise the ESS would quickly respond to all events. The authors establish the need for IVR and point to field validation as the next stage in development.

Paper 0816 describes the power network flexibility services allowed by IEC 61850 technology by improving interface between DSO and DER. It concludes that IEC 61850 is an adequate solution to provide real time information to the DSO, allowing optimization of the power production of DER and improvement of reaction to the DER unpredictable load. The conclusion of the islanding test is that the eDER, a solution interface between the DER producer and the DSO control center, could successfully communicate with ModBus to address real time set point to the grid.



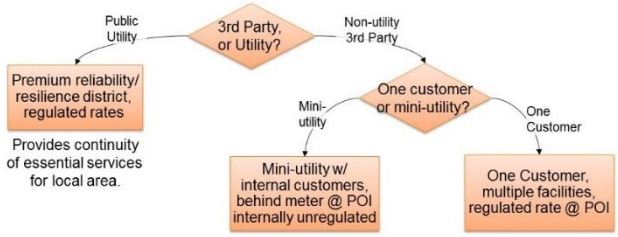
Paper 0816 – Microgrid infrastructure.

Paper 1067 presents a Virtual Private Wire (VPW) solution that can allow generation and demand within the same Active Network Management (ANM) system to be linked in association with specific network constraints. It discusses several approaches that can be used to facilitate sharing of capacity between consumers in a constrained network (bilateral contract, aggregation, local energy supply company or market participation). The authors present the results obtained through a VPW to allow the coordination of DER in an ANM without the need for a private physical wire, facilitating arrangements between load and generators while reducing power flows and avoid curtailment of generators with non-firm connections. The paper presents different possible mechanisms to deliver DER flexibility for the distribution network through the use of VPW and ANM platform.



Paper 1067 – Overview of VPW Demonstration Network.

Paper 1324 presents considerations on how to value the costs and benefits of microgrids. There are factors that complicate the usual benefit-cost assessment as performed by utilities since the microgrid merits can be assessed from the perspective of the electricity end-users and society as a whole. Since the nature and major purpose of the microgrid is to provide its internal customers with enhanced reliability, it is important to ask the questions: “For whom is the microgrid an economical choice?” and “An economical choice compared with what?”.



Paper 1324 - Sample decision tree for determining the structure arrangement of the microgrid

Table 3: Papers of Block 3 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0169: Interaction between Short-term and Seasonal Storages in a predominantly Renewable Power System				X
0216: The effects of the entry into force of the new electric tariff on Italian residential households equipped with a PV plant				X
0233: Using LV Distributed Generation's Reactive Power for Voltage Regulation				X
0256: Intelligent Prosumer Coupling by two galvanically isolated Battery Storage Systems			X	
0265: Evaluation of different Control Algorithms with low level Communication Requirements to increase the maximum Electric Vehicle Penetration				X
0271: SMAP Project or How to Integrate Crowdfunded DER in a Rural Distribution Grid		X		
0307: Optimal approach for the interaction between DSOs and Aggregators to activate DER flexibility in the distribution grid				X
0377: Guidelines for DSOs on Reactive Power Provision by Electric Vehicles Connected in Low Voltage Grids			X	
0403: Studies on the Time and Locational Value of DER		X		
0409: Active Power Curtailment for MV Network Operational Planning in an Industrial Environment				X
0411: Active Demand Management in MV Network Operational Planning: an Industrial Method for the Selection of Flexibility Offers to Solve Technical Constraints			X	
0561: A Software driven Active Customer Interface for DER Integration				X
0661: Combining Energy Storage and Real-Time Thermal Ratings to Solve Distribution Network Problems: Benefits and Challenges				X
0726: A Stochastic Multi-temporal Optimal Power Flow Approach for the Management of Storage and Flexible Demand				X
0733: Cost benefit analysis of MV active power curtailment and reactive power management		X		
0740: Preliminary Regulations of ESS connected to Korean isolated island power system to minimize the capacity of ESS				X
0816: Abstract IEC 61850 to the service of power system flexibility				X
0833: Risk or benefit on the grid: distributed energy storages in system services				X
0884: The impact of Q(U) and P(U) PV plants characteristics and power storage on connectable power in LV distribution networks				X
0925: Generation Curtailment as a Means to Increase the Wind Power Hosting Capacity of a Real Regional Distribution Network				X
0937: Creating Virtual Energy Storage Systems from Aggregated Smart Charging Electric Vehicles		X		

0982: Impact for the DSO of integrating storage systems in a low-voltage grid with distributed energy resources				X
1067: Supporting DER Customer Participation in Active Distribution Networks and Local Markets				X
1083: Integrating photovoltaic and storage systems on distribution feeders		X		
1086: Residential Electrical and Thermal Storage Optimisation in a Market Environment			X	
1101: Methodologies and Proposals to Facilitate the Integration of Small and Medium Consumers in Smart Grids				X
1120: Derivation of ANM Ratings for Complex Abnormal Running Networks				X
1123: Managing The Future Network Impact Of The Electrification Of Heat				X
1162: Impact of a Realistic Communications Model for Fast-Acting Demand Side Management				X
1227: Economical Distributed Voltage Control in Low-Voltage networks with High Penetration of Photovoltaic Units				X
1273: Fast Estimation of Equivalent Capability for Active Distribution Networks				X
1274: Business Case for Reactive Power Services from Distributed Energy Storage			X	
1324: Measuring the Value of Microgrids: An Cost/Benefit framework				X

Block 4: DER integration field trial results, test and standards

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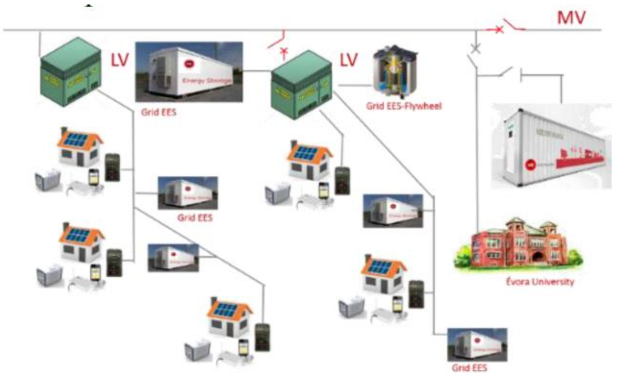
Energy Storage Implementation

Paper 0354 describes the integration of an energy storage system (ESS) which, coordinated with load and generation flexibility, complemented by adequate control coordinated management, enables the islanded operation of LV networks. The analysis described is associated with SENSIBLE project. The ESS includes electrochemical and electromechanical (flywheel) storage. The microgrid demonstrator, validating the possibility to operate the LV network isolated from the MV network, will be implemented in the LV network where the ESS are installed, after extensive laboratory tests.



Paper 0354 – Demonstrator architecture.

Paper 0666 provides a technical analysis of results from three battery storage use cases (backup power, voltage control, peak-shaving) in MV networks. The lithium battery energy storage system provides MV electric supply to a university campus in Portugal and analysis of real operational data enables the validation of the three use cases implemented. This aids building understanding of the technical, economic and strategic implications of using storage technologies for grid management.

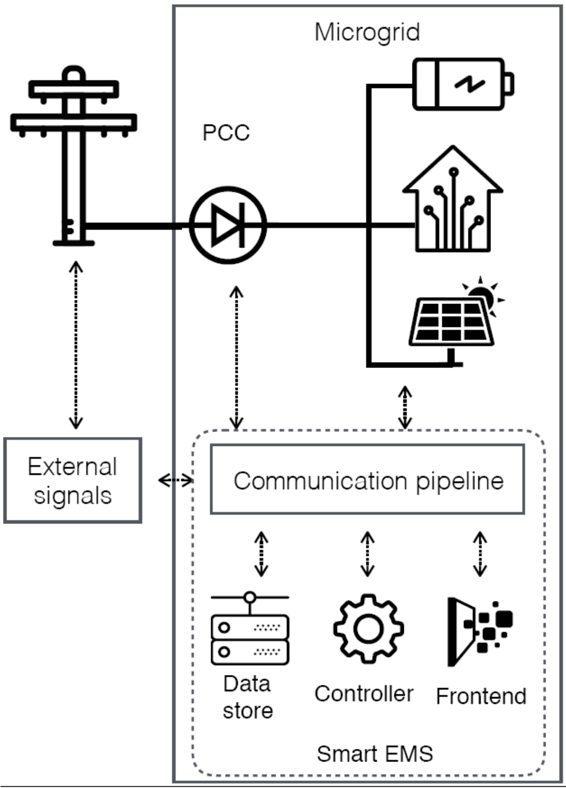
Paper 0810 presents the first performance results of a large (1.2 MW / 600 kWh) battery energy storage system (BESS) connected to a DSO MV substation and used simultaneously by multiple stakeholders. The first test cases starting from August 2016 included simultaneous controls of frequency, reactive power and voltage according to requests from Transmission and Distribution System Operators. The results showed that the first functions were delivered but that there are important control tuning requirements to ensure the BESS is put in to the right State of Charge in response curve deadband periods and that the threshold to start responding to grid conditions is similarly important. The next steps for the 3-year trial period will include PV resource capture and high power EV charging.

Paper 0953 presents the results of the application of large scale (1MW, 3MWh) energy storage to enhance the connection and operation of DG in the Shetland Isles, UK. The results of the trial show that the scheduling of the storage system can provide whole-system load management benefits as well as improvements to system access for DG.

Paper 1110 presents the benefits obtained with large-scale Energy Storage Systems (ESS) in French islands, focused on the PEGASE and “Non-Interconnected Zones Frequency Containment Reserve (FCR) storage” projects. The authors present the benefits associated with the use of 5 MW ESS as FCR in several French islands. The results presented demonstrate the possibility of smoothing renewable energy generation through the use of large-scale ESS. The efficiency is greatly improved if several farms are associated with the same ESS, either from a quality of supply and economic perspective.

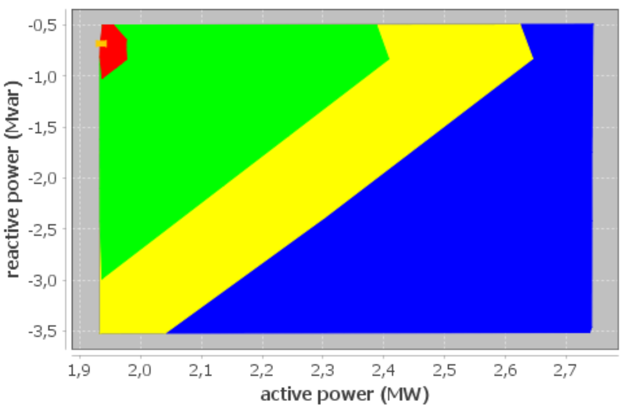
System Flexibility Management

Paper 0211 shows the concepts of the microgrid that is being implemented within the Merygrid project in the Walloon region, Belgium and details how a smart energy management system can be applied. An energy management system that constantly attempts to determine the best options to create some value from the energy and ancillary service markets while at the same time ensuring a robust operation of the microgrid is being developed. It is simulated on a laboratory reproduction of the actual microgrid. Scenario includes a set of motors that have flexibility on the starting time, a fridge that can be switched off as long as the temperature remains acceptable, a set of jobs must be achieved in the oven, and the battery is able to inject energy into the utility grid when the price is relatively high.



Paper 0211 – An overview of the smart energy management system.

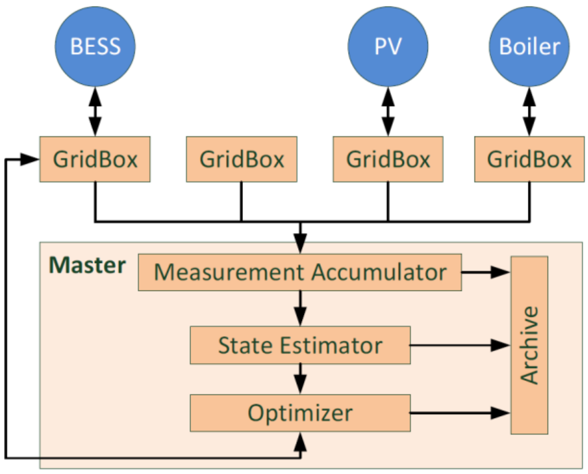
Paper 0410 reports the development and application to T-D boundary flexibility assessment with diverse embedded DER of two novel methods for DSO-TSO cooperation in flexible system management: Interval Constrained Power Flow (ICPF) and Low Voltage State Estimation (LVSE). The results provide a highly useful tool for coordination of flexibility resources between TSO and DSO as illustrated in the figure below.



Paper 0410 - Example of flexibility cost map obtained for a particular configuration of the rural MV network with DSO assets and storage flexibility considered.

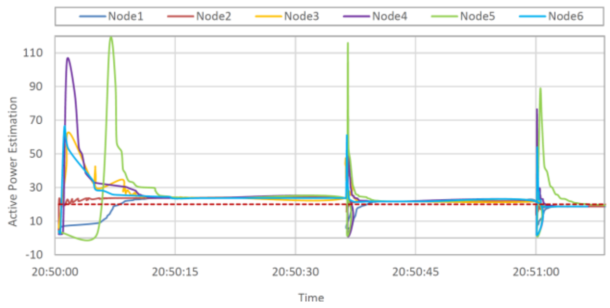
Paper 0829 describes the implementation of a VPP as a means to coordinate the use of distributed resources for different control objectives by TSO and DSO. The concept is demonstrated through the application of the VPP concept on a real 11 kV system, using data from Low Carbon London project. It argues that the VPP concept enables closer integration between TSO and DSO and supports the integration of the whole system in managing synergies and conflicts between distribution network, energy supply, transmission network objectives when allocating DER flexibility.

Paper 0996 presents the findings of a major set of smart network interventions targeted at observability, fault resilience and flexibility in a trial area of the Zurich distribution network. The architecture of the smart solutions is centred around an intelligent node (GridBox) located at MV/LV substations with smart solutions coordinated from there. The results presented include the performance of the communications technologies deployed and the effectiveness of the voltage and loading functions.



Paper 0996 – GridBox architecture.

Paper 1216 presents results from testing of decentralized system operation techniques developed and trialled at the Meltemi community smart grid pilot site in Greece. The use cases are settlement of short term energy imbalances at the distribution level in an intra-day market, mitigation of voltage deviations and congestion management in real-time operations. The results of application of decentralized control implemented on Multi Agent Systems with peer-to-peer interaction is shown to be promising.

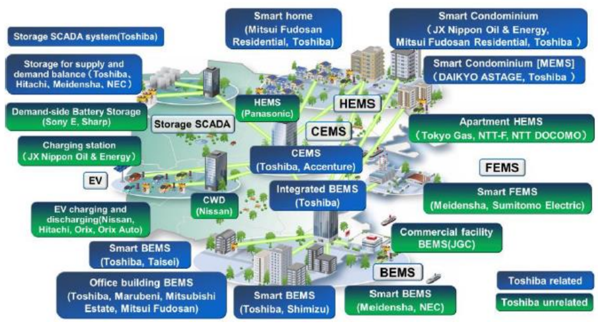


Paper 1216 – active power demand curtailment from P2P ‘gossiping’ reflecting individual ‘node’ flexibility, preferences and ‘negotiated’ response to curtailment requirement.

Demand Response

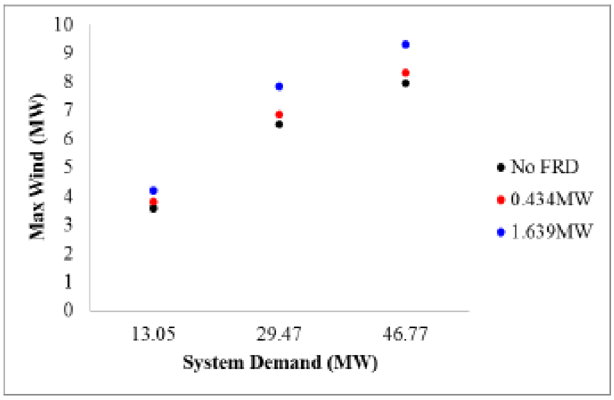
Paper 0044 assesses the potential of demand side management of SMEs to balance wind power. The study finds that the potential is limited due to unwillingness to participate, requirement for custom solutions, difficulty to respond to wind power variability and the need to switch energy usage to potentially more expensive time periods. The paper does note that in specific cases, DSM make sense for SMEs but this requires further attention.

Paper 0789 presents the experience of demand response in the Yokohama demonstration project, one of the largest smart grid initiatives in Japan. The results presented refer to an experiment on the capability of consumers to reduce electrical energy and peak demand and by energy saving and utilization of energy storage facilities. The trial was conducted by several costumers within a community.



Paper 0789 - Overview of the Yokohama Smart City Project

Paper 0804 evaluates the impact of domestic frequency responsive demand (FRD) on the frequency stability of the Shetland Islands network and investigates the potential increase in wind generation that FRD may enable. A number of scenarios derived by varying system demand levels, generator status, and the available FRD are considered. It has been shown that FRD has the potential to support frequency stability and hence allow more wind power penetration. When heating elements (space and water heaters) are fully charging in the 228 homes, the total wind generation that is allowed to be connected increased by 1.36 MW from the case with no FRD.



Paper 0804 - Maximum wind generation for each demand level with different FRD penetration levels.

Paper 1238 presents lessons learned from a DSM approach used within a smartgrid project, based on three steps (load prediction, flexibility planning and online control). The trial encontres two conflicting objectives: the DSO intends to unlock flexibility to avoid peaks and the Customer intends to avoid discomfort and increase energy self-consumption. Furtermore, when a battery is available, the uncertainty associated with PV production prevition might lead to less than optimal use of the charge/discharge cycle.

Impact of DER on Network Operations

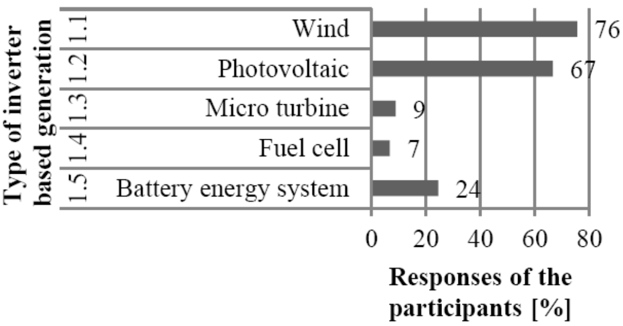
Paper 0731 describes the results of a wind farm measurement campaign, which assessed the contribution of the generators to voltage and system stability. The wind farm is inverter-controlled and it is connected with a MV network with relatively low short circuit power and the measurement parameters included the frequency control and the tan(φ) control.

Paper 1364 describes the challenges associated with the implementation of the Ordinance on System Stability (SysStabV) to decentralized power generation units in Germany. Until 2009, the technical guidelines required an operating range from 49.5 Hz to 50.2 Hz. Since the publication of SysStabV, power generation units are required to operate from 47.5 Hz to 51.5 Hz. Failing to due so requires that they are retrofitted, although there are exemptions from that obligation. According to the authors, retrofitting targets are almost completed and the number of exemptions was much lower than initially expected.

Photovoltaics Grid Integration Inverters

Paper 0180 describes a control strategy of the inverters associated with a 40kW PV system, with different control modes associated with different sunlight patterns, optimizing reactive energy support and investigating the active and reactive power during three-phase faults. The paper concludes that PV systems with appropriate controls (as examined) can achieve effective maximum real power output as well as support distribution systems through the provision of reactive power.

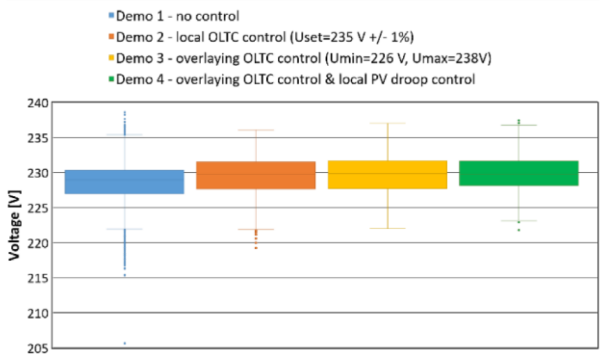
Paper 0898 summarises some of the key findings and observations of a survey with the aim of collecting the present best practices in the industry on modelling of inverter based generation for power system dynamic studies, with the focus on PV systems. In summary, wind and PV generation is very likely to be modelled for power system dynamic studies with 76% and 67%, respectively, and 59% of the utilities and system operators apply individual models instead of aggregated models for power system dynamic studies.



Paper 0898 – Inverter based generation modelling for power system dynamic studies.

Voltage Regulation

Paper 0889 also presents the results of field application of OLTC MV/LV transformers to supply a mixed circuit network with high penetration PV. In addition to OLTC control a local demo SCADA system with WiMAX communications was also installed. The results showed promising results for management of lowest customer voltage (shown in diagram), highest voltage level PV connection point and substation LV busbars. The paper concludes that OLTC alone does not solve network cases with a high difference between maximum and minimum voltage so overlay network wide voltage control plus local PV voltage droop control provide higher effectiveness.



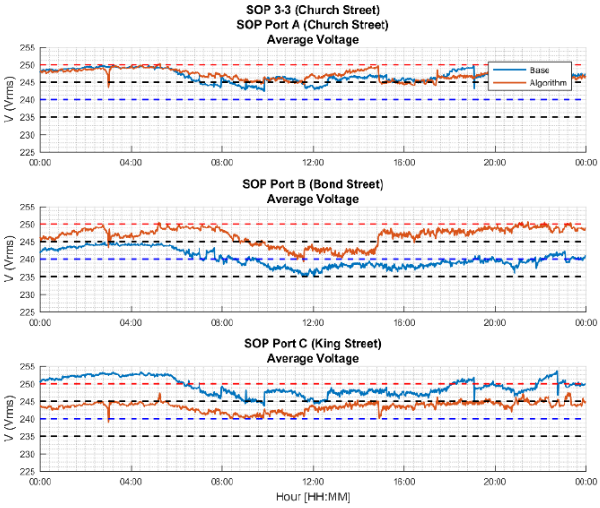
Paper 0889 - Lowest customer voltage level in LV network with different voltage regulation regimes.

Control Systems and Active Networks

Paper 0310 presents a grid code compatible islanding detection schemes for both medium- and low-voltage network connected distributed generation units during both grid-connected and islanded (nested microgrid) operation of Sundom Smart Grid in Finland. Issues, like network status dependency, distributed generation unit type, fault-ride-through capability and fault behavior as well as high-speed wireless 5G communication and routable GOOSE, affecting islanding detection schemes are presented and discussed.

Paper 0420 introduces the implementation of a Distribution State Estimator (DSE) along with dedicated sensors and presents results of a DSE experiment performed on VENTEEA Smart Grid demonstrator. The approach includes an analysis of smart grids operational needs on a priority use case (i.e. Voltage mastering in presence of DER) along with a study of dedicated observability requirements. Reliability and resilience of the telecommunications links are of the utmost importance to guarantee the functioning of the DSE and subsequently of the centralised voltage regulation function.

Paper 0648 describes the use of power electronic solutions in order to create Soft Open Points (SOP) between two or three feeders. The SOP control algorithm was demonstrated by UK Power Networks in the project Flexible Urban Networks Low Voltage (FUN-LV). SOP consist of multiple voltage source inverters sharing a common DC bus. The paper describes the field trial results obtained with the use of SOP to equalise the loads on transformers connected with adjacent feeders and with the use of SOP for voltage support, demonstrating that the operation of the SOP allows to release transformer and feeder capacity and to provide voltage support at the end of the feeder.

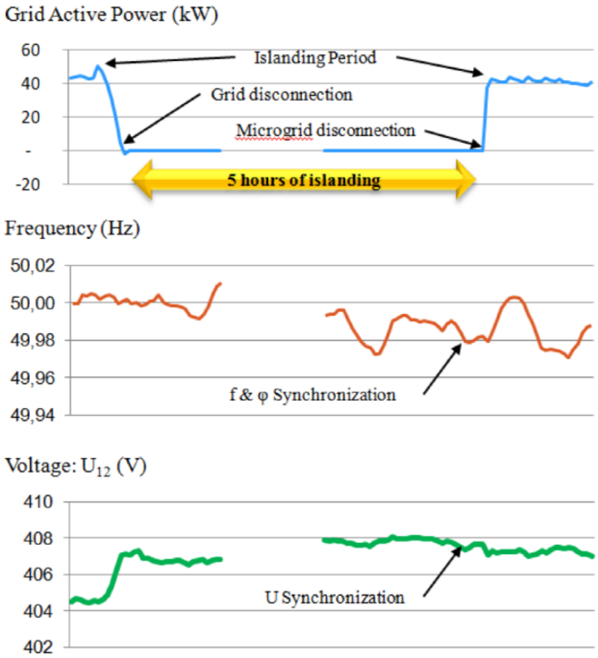


Paper 0648 - The SOP supporting the voltage for a multi-terminal device.

Paper 0930 presents the results of application of fault level monitoring technology to manage MV networks with fault level constraints for DG connection and operation. The authors propose that the successful trial of fault level monitoring, ,along with options to mitigate high fault level enables an Active Network Management (ANM) approach to constrained DG connections and these have now been offered to connecting DG customers.

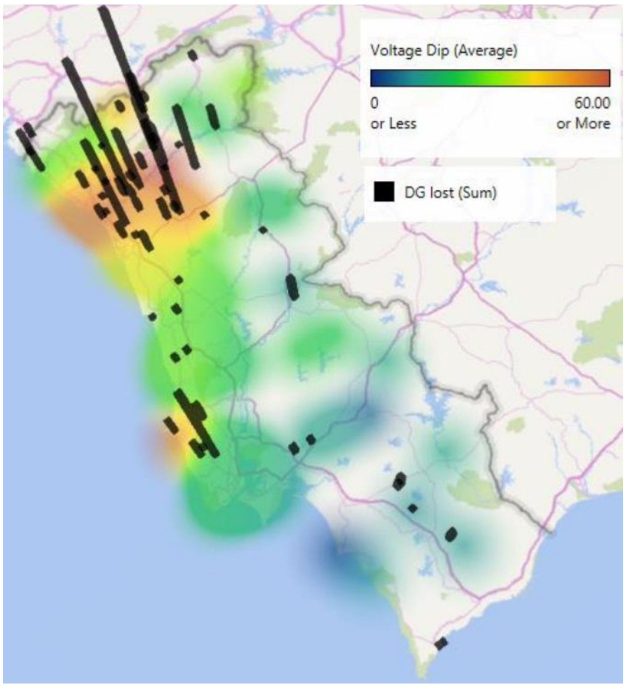
Resiliency and Microgrids

Paper 0786 presents the results of disconnection of a low voltage district in the NICE GRID project for a 5-hour period and its supply only by energy storage and PV generation. This proof of concept demonstration points to a number of key ingredients for small microgrids detailed in the paper and how this demonstration of microgrid solution will be taken further in ongoing work.



Paper 0786 - Grid active power, frequency measured and phase to phase voltage during a scheduled islanding experiment.

Paper 1055 presents a study performed over a Portuguese real case network incident in order to evaluate the distribution side DG resilience to voltage dips caused by a fault in the extra high voltage network. A voltage dip in the network can cause the disconnection of a significant number of DG, which, in turn, can possibly affect the system's stability and security. The countrywide geographical occurrence of voltage dips at the distribution electric system originated from the fault at the transmission system are used. The available real metering data are analysed and DGs that had been partially or totally disconnected from the grid are identified. A good correlation between the location of voltage dips and generation disconnection is observed. The amount of DG lost in the event was relatively small and given that most of the DG were not designed to withstand voltage dips, proves the Portuguese distribution system high resilience to voltage dips.



Paper 1055 – Voltage dip and DG lost at distribution system due to the fault at the transmission system.

Table 4: Papers of Block 4 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0044: The Practical and Theoretical Potential of Demand Side Management in SMEs				X
0180: Control of Active / Reactive Power & LVRT for 40 kW Three-Phase Grid-Connected Single Stage PV System				X
0211: Efficient Management of a Connected Microgrid in Belgium				X
0310: Future-proof Islanding Detection Schemes in Sundom Smart Grid				X
0354: Low Voltage Grid Upgrades Enabling Islanding Operation				X
0410: LV State Estimation and TSO-DSO Cooperation tools: results of the French field tests in the evolvDSO project		X		
0420: Distribution State Estimation: Outcomes from a Field Implementation aimed at tackling MV voltage mastering in the presence of DER				X
0648: A Control Algorithm for Soft-Open-Points in Low Voltage Distribution Networks				X
0666: Key energy storage use cases validation under real operational context.				X
0731: Contribution of a Wind Park to Voltage and System Stability: Results of a Measurement Campaign		X		

0786: Behaviour of PV inverters during islanding of a district				X
0789: Experiences of Demand Response in Yokohama Demonstration Project		X		
0804: Impact of Domestic Responsive Demand on the Shetland Isles' Network Frequency Stability				X
0810: Benefits of Battery Energy Storage for System, Market, and Distribution Network - Case Helsinki		X		
0829: Virtual Power Plant: Managing Synergies and Conflicts between TSO and DSO Control Objectives				X
0889: Voltage Quality Provision in Low Voltage Networks with high Penetration of Renewable Production			X	
0898: Modelling and Dynamic Performance of Inverter Based Generation in Power System Studies: An International Questionnaire Survey				X
0930: Distributed generation connections under a fault level active network management scheme				X
0953: Utilisation of Energy Storage to Improve Distributed Generation Connections and Network Operation on Shetland Islands				X
0996: The Smart Grid Real Lab of ewz: Findings from a large-scale demonstration project		X		
1055: Distributed Generation at Distribution System Level Resilience to Voltage Dips - a Real Case				X
1110: The Benefits of Energy Storage Systems (ESS) in French Islands: PV smoothing and Frequency Regulation				X
1216: Decentralized Distribution System Operation Techniques: Results from the Meltemi Community Smart Grids Pilot Site		X		
1238: Demand Side Management in a Field Test: Lessons Learned		X		
1364: The challenge of retrofitting old decentralized power plants in Germany in terms of Power System Stability				X

SESSION 4 : Distributed energy resources and active demand integration

Block 1 – DER concepts, designs, studies, planning, analysis techniques and tools

Sub-block 1 – Demand response

0219 **Profitability analysis of grid supporting EV charging management**
R Uhlig, S Harnisch, M Stötzel, M Zdrallek, *University of Wuppertal, Germany,* T Armoneit, *Stadtwerke Iserlohn GmbH, Germany*

0267 **Integration of a thermal energy storage as a dynamic load into the electrical grid of an urban quarter**
T Plößer, D Maihöfner, J Hanson, *TU Darmstadt, Germany*

0320 **Techno-economic evaluation of load activation quotas as a concept for flexible load anagement**
N Thie, S Koopmann, A Schnettler, *RWTH Aachen University, Germany,* S Hillenbrand, A Kopp, *Netze BW GmbH, Germany*

0447 **Reduce peak-time energy use by demand bidding program in Iran**
H Delavaripour, A Khazaee, M Ghasempour, H Hooshmandi, *Mashhad Electric Energy Distribution Co, Iran*

0567 **Integrating demand flexibility with DG-RES at the residential household and commercial customer level in electricity grids**
I G Kamphuis, S Galsworthy, *TNO, Netherlands,* M Stifter, T Esterl, S Kaser, *AIT, Austria,* S Widergren, *PNNL, United States,* M Galus, *BFE, Switzerland,* R Targosz, *EIM, Poland,* D Brodén, L Nordström, *KTH, Sweden,* M Renting, *Enexis, Netherlands,* A Rijneveld, *Stedin, Netherlands,* S Doolla, *IIT, India*

0850 **Designing a financial-based energy management framework in smart public parking lot**
A Zare, M Fotuhi-Friuzabad, M Moeini-Aghtaie, *Sharif university of Technology, Iran*

0950 **Electric heating as flexible demand for enhanced network operation**
D Moretti, S Galloway, *University of Strathclyde, United Kingdom*

1023 **Business models for demand response aggregators under regulated power markets**
C Fang, *State Grid Shanghai Municipal Electric Power Company, China,* B Fan, *State Grid Shanghai Chongming Electric Power Supply Company, China,* T Sun, D Feng, J Chen, *Shanghai Jiao Tong University, China*

1075 **A blueprint for the combinatorial strategy in transactive energy based control mechanism by using energy flexibility platform and interface**
M Babar, *TU Eindhoven, Netherlands,* I G Kamphuis, *TU Eindhoven, Netherlands/TNO, Netherlands,* Z Hanzelka, *AGH UST, Poland,* M Bongaerts, *Alliander NV, Netherlands*

1159 **Integrating wet appliances with delay functionality in distribution network operation and planning**
H Karimi, D Papadaskalopoulos, G Strbac, *Imperial College London, United Kingdom*

Sub-block 2 – Microgrids

0128 **Reliability evaluation of distribution network considering controllable distributed generation, battery swapping station and controllable switches**
J Song, J Zhou, *State Grid Shanghai EPRI, China,* C Li, *SAIC MOTOR Corporation Ltd., China,* Y Luo, Y Luo, W Yan, *Chongqing University, China*

0286 **Analysis on voltage and frequency responses of isolated microgrid according to minimization of diesel generations**
D Kim, K W Joung, D H Choi, J I Yoo, J-Wook Park, *Yonsei University, South Korea,* H-J Lee, *KIT, South Korea,* S-M Baek, *Kongju National University, South Korea,* S H Lee, *KERI, South Korea,* H J Lee, J B Shim, *KEPCO, South Korea*

1188 **Energy Storage Systems (ESS) and microgrids in Brittany Islands**
G Lancel, B Deneuville, C Zakhour, E Radvanyi, L Lhermenault, C Ducharme, S Ruiz, *EDF, France*

0288 **A study on energy management system for stable operation of isolated microgrid**
K W Joung, D Kim, D H Choi, J-W Park, *Yonsei University, South Korea,* H-J Lee, *KIT, South Korea,* S-M Baek, *Kongju National University, South Korea,* S H Lee, *KERI, South Korea,* H J Lee, J B Shim, *KEPCO, South Korea*

1039 **New functionalities of smart grid enabled networks**
D C Stancu, D Federenciuc, *Electrica, Romania,* N Golovanov, *Universitatea Politehnica, Romania,* D M Satnescu, *SDEE Transilvania Sud, Romania*

Sub-block 3 – DER active network management

0104 **SmartNet: a H2020 project analysing TSO-DSO interaction to enable ancillary services provision from distribution networks**
G Migliavacca, M Rossi, *RSE, Italy,* D Six, *Energy Ville, Belgium,* M Džamarija, *DTU, Denmark,* S Horsmanheimo, *VTT, Finland,* C Madina, *TECNALIA, Spain,* I Kockar, *University of Strathclyde, United Kingdom,* J M Morales, *University of Malaga, Spain*

0214 **Feasibility analysis of the power-to-gas concept in the future Swiss distribution grid**
C Park, F Bigler, V Knazkins, P Korba, *ZHAW, Switzerland,* F Kienzle, *EWZ, Switzerland*

0282 **Dual-decomposition-based peer-to-peer voltage control for distribution networks**
H Almasalma, J Engels, G Deconinck, *KU Leuven, Belgium*

0402 **Optimization of low voltage distribution networks in a strong embedded microgeneration and electric vehicle penetration context**
M Lagarto, J Ferreira Pinto, *EDP Distribuição, Portugal,* L Ferreira, *Instituto Superior Técnico, Portugal*

0491 **Business case for distributed energy storage**
F Teng, M Aunedi, R Moreira, G Strbac, *Imperial College London, United Kingdom,* P Papadopoulos, A Laguna, *UK Power Networks, United Kingdom*

0994 **Aggregation model for curtailable generation and sheddable loads**
H Marthinsen, A Z Morch, *SINTEF Energy Research, Norway,* M Plecas, I Kockar, *University of Strathclyde, United Kingdom,* M Dzamarija, *DTU, Denmark*

1044 **SPEN - DSO vision**
G Boyd, *SP Energy Networks, United Kingdom*

1090 **Integration of energy storage to improve utilisation of distribution networks with active network management schemes**
M Plecas, H Xu, I Kockar, *University of Strathclyde, United Kingdom*

1116 **Meeting emerging and future requirements for managing DER in highly active distribution networks**
C Gault, F Watson, C Breadon, E Davidson, *SGS, United Kingdom,* C Abbey, *SGS, Canada,* J Miller, *US DOE, United States,* B Currie, *SGS, United States*

1234 **Balancing with DSO-connected demand and generation units - case Study Austria**
S Vögel, *E-Control Austria, Austria,* A Stimmer, *Austrian Power Grid AG, Austria*

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0142 **Determining potential capacity gains when repurposing MV AC cables for DC power transportation**
A Burstein, V Ćuk, *TU/e, Netherlands,* E de Jong, *DNV GL, Netherlands*

0215 **Smart Grid Vendée project: a decision-support tool for the multi-year planning of active distribution networks**
H Dutriexu Baraffe, G Malarange, *EDF R&D, France,* A Bouorakima, M A Lafittau, G. Pelton, *Enedis, France, Enedis, Paris La Défense, France*

0558 **The case for coordinated energy storage in future distribution grids**
N Voulis, M Warnier, F M T Brazier, *Delft University of Technology, Netherlands*

0659 **Comparison of analysis methods for generator connections**
C Foote, C Kungu, *SP Energy Networks, United Kingdom*

0742 **Reliability evaluation of distribution system with distributed generation**
L Gan, Y Liu, G Lu, G Chen, W Mo, T Xiao, *Guangzhou Power Supply Co., Ltd., China,* F Zhang, *Huazhong University of Science and Technology, China*

0755 **Integration of multivariate distributed energy resources for demand response: applications in the Indian scenarios**
R Pillai, A Ahuja, *India Smart Grid Forum, India,* G Ghatikar, *India Smart Grid Forum, India/Electric Power Research Institute, United States*

0757 **Seasonally variant deployment of electric battery storage systems in active distribution networks**
M Z Degefa, H Sæle, *SINTEF Energi AS, Norway,* J A Foosnaes, E Thorshaug, *NTE Net, Norway*

0830 **Contribution of energy storage and demand-side response to security of distribution networks**
I Konstantelos, P Djapic, G Strbac, *Imperial College London, United Kingdom,* P Papadopoulos, A Laguna, *UK Power Networks, United Kingdom*

0935 **Utility scale domestic solar: the proactive transition of distributed network operators in Switzerland**
Y Farhat, M Bolliger, *BKW Energie AG, Switzerland*

1085 **UK Power Networks' experience of managing flexible distributed generation from planning to operation**
A R Ahmadi, T Manandhar, J Barros, M Bernardo, S Georgiopoulos, *UK Power Networks, United Kingdom*

1089 **Real-time monitoring of distribution networks: experimental application of Italian Res. 646/2015/R/eel**
M Delfanti, D Falabretti, M Merlo, *Politecnico di Milano, Italy*

1155 **Optimal hybridization and management of PV/batteries hybrid systems in residential distribution networks**
H Turker, P Favre-Perrod, *University of Applied Sciences of Switzerland, Switzerland*

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0500 **Distribution loss reduction in residential and commercial pilots by using AMI system**
A Khazaee, H H Safa, M Ghasempour, H Delavari, *MEEDC, Iran*

1143 **Automatic phase identification of smart meter measurement data**
F Olivier, D Ernst, R Fonteneau, *University of Liège, Belgium*

1284 **DG impact evaluation on LV distribution grids using AMI data: a Brazilian case study**
R Maciel, M Silva, B Borba, L Fritz, V Ferreira, M Zamboti, *UFF, Brazil,* T Campello, *UFRJ, Brazil,* W Correia, *ENEL, Brazil*

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0329 **Impact of ENTSO-E recommendation on refitting of PV frequency relays in Czech Republic**
F Kysnar, K Prochazka, J Hrouda, *EGC-ČB s.r.o., Czech Republic,* S Vnoucek, *ČEPS, a.s., Czech Republic,* Z Pavlovic, *ČEZ Distribuce, a.s., Czech Republic,* P Cerny, *E.ON Distribuce, a.s., Czech Republic,* J Matous, *PRE Distribuce, as, Czech Republic*

0476 **Impact of the photovoltaic system variability on transformer tap changer operations in distribution networks**
C K Gan, C Y Lau, K A Baharin, *Universiti Teknikal Malaysia Melaka, Malaysia,* D Pudjianto, *Imperial College London, United Kingdom*

0332 **Influence of self-consumption on distribution network operation - the Slovenian case**
B Turnsek, *Elektro Primorska d.d., Slovenia,* I Papič, B Blažič, *University of Ljubljana, Slovenia*

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0340 **Charging electric vehicles, baking pizzas and melting a fuse in Lochem**
G Hoogsteen, A Molderink, J L Hurink, G J M Smit, *University of Twente, Netherlands,* B Kootstra, F Schuring, *Liandon, Netherlands*

0419 **Building power demand forecasting using K-Nearest neighbors model - practical application in smart city demo aspern project**
O Valgaev, F Kupzog, *Austrian Institute of Technology, Austria,* H Schmeck, *Karlsruhe Institute of Technology, Germany*

1051 **Laboratory infrastructure driven key performance indicator development using the smart grid architecture model**
M H Syed, E Guillo, S M Blair, G M Burt, *University of Strathclyde, United Kindgom,* T I Strasser, H Brunner,

Austrian Institute of Technology, Austria, O Gehrke, *DTU, Denmark,* J E Rodriguez-Seco, *Tecnalia, Spain*

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0363 **Smart meter-driven estimation of residential load flexibility**
J Ponocko, J V Milanovic, *University of Manchester, United Kingdom*

0626 **Evaluating the effectiveness of storage control in reducing peak demand on low voltage feeders**
T Yunusov, B Potter, *University of Reading, United Kingdom,* S Haben, T Lee, *University of Oxford, United Kingdom,* F Ziel, *University Duisburg-Essen, Germany,* W Holderbaum, *Manchester Metropolitan University, United Kingdom*

0775 **Wind speed forecasting using back propagation artificial neural networks in North of Iran**
F Jabari, A Masoumi, B Mohammadi-Ivatloo, *University of Tabriz, Iran,* T Nurmohamnadi, *East Azabaijan Electric Distribution Company, Iran*

0902 **Challenges in model and data merging for the implementation of a distribution network contingency analysis tool**
N Huyghues-Beaufond, S Tindemans, G Strbac, *Imperial College London, United Kingdom,* A Jakeman, *UK Power Networks, United Kingdom*

1185 **Predictive management of low voltage grids**
M Reis, A Garcia, R Bessa, L Seca, C Gouveia, *INESC TEC, Portugal,* J Moreira, P Nunes, P G Matos, *EDP Distribuição, Portugal,* F Carvalho, P Carvalho, *AmberTREE, Portugal*

1333 **Comparing and improving residential demand forecast by disaggregation of load and PV generation**
S Kloibhofer, M Stifter, F Leimgruber, B-V Rao, *AIT, Austria*

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0550 **Charge control of second life EV batteries on the DC-link of a back-to-back converter**
M Neaimeh, N Wade, S Blake, P Taylor, *Newcastle University, United Kingdom*

0998 **Adjustment of available and needed energy and necessary additional functionalities in the distribution grid, caused by the energy transition, can better be solved by DC distribution grids**
R Niehoff, F Kuipers, *Eaton Netherlands B.V., Netherlands,* H Stokman, *Direct Current BV, Netherlands*

1289 **Experimental evalutaion of an energy storage system for meduim voltage distribution grids**
C Klumpner, M Rashed, D De, C Patel, G Asher, *University of Nottingham, United Kingdom*

Sub-block 3 – Hosting capacity analysis

0316 **Using measurements to increase the accuracy of hosting capacity calculations**
O Lennerhag, S Ackeby, M H J Bollen, *STRI AB, Sweden,* G Foskolos, T Gafurov, *MälarEnergi, Sweden*

Sub-block 4 – Demand response

0059 **Nonlinear optimal control of the responses of residential small houses with new energy resources**
P Koponen, R Pasonen, A Löf, *VTT, Finland*

1000 **Real-time digital co-simulation method of smart grid for integrating large-scale demand response resources**
J Song, J Zhou, *State Grid Shanghai EPRI, China,* S Jiang, P Zhang, *Shanghai Jiao Tong University, China*

Sub-block 5 – DER and network management

0131 **Decentralisation of power flow solution for facilitating active network management**
T R F Mendonca, M E Collins, T C Green, *Imperial College London, United Kingdom,* M F Pinto, *Universidade Federal de Juiz de For a, Brazil*

0803 **An approach for the handling of controller conflicts within multi-functional energy storage systems**
C Zanabria, F Pröstl Andrén, J Kathan, T Strasser, *Austrian Institute of Technology, Austria*

1035 **PMU-based power systems analysis of a MV distribution grid**
N Save, M Popov, *TU Delft, Netherlands,* A Jongepier, *Enduris, Netherlands,* G Rietveld, *VSL, Netherlands*

1049 **Voltage regulating distribution transformers for LV network voltage control and system efficiency**

M Anzola, D Walker, D Neilson, M Wright, *Scottish Power Energy Networks, United Kingdom*

1326 **Linky Contributions in management and Fault Detection**
P Pelletier, M Chapert, T Bazot, P Lauzevis, S Brun, L De Luca, *Enedis, France*

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0071 **Linear three-phase state estimation for LV grids using pseudo measurements based on approximate power distributions**
R Brandalik, D Waeresch, W H Wellssow, J Tu, *Technical University of Kaiserslautern, Germany*

0327 **Field test of a linear three-phase low voltage state estimation system based on smart meter data**
D Waeresch, R Brandalik, W H Wellssow, *TU Kaiserslautern, Germany,* J Jordan, *IDS GmbH, Germany,* R Bischler, N Schneider, *Stadtwerke Kaiserslautern Versorgungs-AG, Germany*

0337 **Development of a modular CHP test stand for the analysis of the dynamic behaviour of small synchronous generators**
P Erlinghagen, M Knaak, T Wippenbeck, A Schnettler, *Aachen University, Germany*

0984 **Evaluation of extended kalman filter and particle filter approaches for quasi-dynamic distribution system state estimation**
A Brüggemann, K Görner, C Rehtanz, *TU Dortmund University, Germany*

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0256 **Intelligent prosumer coupling by two galvanically isolated battery storage systems**
T Graber, C Romeis, E Perossian, J Jaeger, *FAU Erlangen, Germany*

0307 **Optimal approach for the interaction between DSOs and Aggregators to activate DER flexibility in the distribution grid**
Z Al-Jassim, M Christoffersen, *Danish Energy Association, Denmark,* Q Wu, S Huang, *DTU, Denmark,* G D Rosario, C Corchero, *IREC, Spain,* M Á Moreno, *UC3M, Spain*

0561 **A software driven active customer interface for DER integration**
J Ringelstein, *Fraunhofer IWES, Germany,* M Shalaby, *DERlab e.V., Germany,* M Sanduleac, *Exenir, Romania,* L Alacreu, *ETRA I+D, Spain,* J Martins, V Delgado-Gomes, *CTS-Uninova, Portugal*

0661 **Combining energy storage and real-time thermal ratings to solve distribution network problems: benefits and challenges**
D Greenwood, N Wade, P Davison, P Taylor, *Newcastle University, United Kingdom,* P Papadopoulos, *UK Power Networks, United Kingdom*

1273 **Fast estimation of equivalent capability for active distribution networks**
M Rossi, G Viganó, D Moneta, *RSE, Italy,* M T Vespucci, P Pisciella, *Univirsità degli Studi di Bergamo, Italy*

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0216 **The effects of the entry into force of the new electric tariff on Italian residential households equipped with a PV plant**
S Maggiore, M Gallanti, *R.S.E. S.p.A., Italy*

0411 **Active demand management in MV network operational planning: aniIndustrial method for the selection of flexibility offers to solve technical constraints**
C Paris, M Hasquenoph, S Hourrig, *EDF R&D, France,* O Carré, *Enedis, France*

0982 **Impact for the DSO of integrating storage systems in a low-voltage grid with distributed energy resources**
J Fonseca, *Ernst & Young, Germany,* M I Verdelho, R Prata, *EDP Distribuição, Portugal*

1083 **Integrating photovoltaic and storage systems on distribution feeders**
A O'Connell, A Maitra, J Smith, *Electric Power Research Institute, Ireland/United States,* B Jordan, C Cryer, *CPS Energy, United States*

1227 ***Economical distributed voltage control in low-voltage grids with high penetration of photovoltaic units***
O Unigwe, D Okekunle, A Kiprakis, University of Edinburgh, United Kingdom

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1086 **Residential electrical and thermal storage optimisation in a market environment**
C A Correa-Florez, A Gerossier, A Michiorri, R Girard, G Kariniotakis, *MINES-ParisTech, PSL - Research Universtiy, France*

1101 **Methodologies and proposals to facilitate the integration of small and medium consumers in smart grids**
C Alvarez, *IIE-UPV, Spain,* J I Moreno, G López, *U. Carlos III de Madrid, Spain,* C Carrillo, *U Vigo, Spain,* I J Ramírez, *U. Zaragoza, Spain,* J Matanza, *IIT-ICAI, Spain,* S Valero-Verdu, *UNH, Spain,* A Gabaldón, *ETSII, Spain,* M Ruiz, *UPCT, Spain*

1123 **Manging the future network impact of the electrification of heat**
S Harkin, A Turton, *Delta-EE, United Kingdom*

1162 **Impact of a realistic communications for fast-acting demand side management**
P Dambrauskas, M H Syed, S M Blair, J M Irvine, I F Abdulhadi, G M Burt, *University of Strathclyde, United Kingdom,* D E M Bondy, *DTU, Denmark*

1274 **Business case in support for reactive power services from distributed energy storage**
R Moreira, G Strbac, *Imperial College London, United Kingdom,* P Papadopoulos, A Laguna, *UK Power Networks, United Kingdom*

Sub-block 4 – Planning and operation

0169 **Interaction between short-term and seasonal storages in a predominantly renewable power system**
C Groiß, W Schaffer, *Salzburg Netz GmbH, Austria,* W Gawlik, *TU Wien, Austria*

0233 **Using LV distributed generation's reactive power for voltage regulation**
L Wautier, F Beauné, L Karsenti, *Enedis, France,* J Fournel, *EDF R&D, France*

0271 **SMAP project or how to integrate crowdfunded DER in a rural distribution grid**
M Bernier, *Grenoble INP, France,* A Coutarel, *Atos Worldgrid, France,* J Lavaury Geoffroy, *Enedis, Lyon*

0403 **Studies on the time and locational value of DER**
B Rogers, J Taylor, *EPRI, United States,* T Mimnagh, C Tsay, *Consolidated Edison, United States*

0409 **Active power curtailment for MV network operational planning in an industrial environment**
M Hasquenoph, S Hourrig, *EDF R&D, France,* O Carré, *Enedis, France*

0726 **A stochastic multi-temporal optimal power flow approach for the management of grid connected storage**
E Grover-Silva, *MINES ParisTech, France/ADEME - France,* X G Agoua, R Girard, G Kariniotakis, *MINES ParisTech, France*

0733 **Cost benefit analysis of MV reactive power management and active power curtailment**
L De Alvaro Garcia, F Beauné, M Pitard, L Karsenti, *Enedis, France*

0833 **Risk or benefit on the electricity grid: distributed energy storages in system services**
J Haakana, J Haapaniemi, V Tikka, J Lassila, J Partanen, *Lappeenranta University of Technology, Finland*

0884 **The impact of Q(U) and P(U) PV plants characteristics and power storage on connectable power in LV distribution networks**
J Hrouda, K Prochazka, F Kysnar, F Broz, *EGC CB, s.r.o., Czech Republic*

0925 **Generation curtailment as a means to increase the wind power hosting capacity of a real regional distribution network**
A Kulmala, *VTT, Finland,* S Repo, *Tampere University of Technology, Finland,* J Pylvänäinen, *Elenia Oy, Finland*

1120 **Derivation of ANM ratings for complex abnormal running networks**
S Gough, W Topping, *Western Power Distribution, United Kingdom,* P Almeida, M Collins, R MacDonald, *Smarter Grid Solutions, United Kingdom*

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0265 **Evaluation of different control algorithms with low level communication requirements to increase the maximum electric vehicle penetration**
F Lehfuss, M Nöhrer, *AIT Austrian Institute of Technology GmbH, Austria*

0377 **Guidelines for distribution system operators on reactive power provision by electric vehicles in low**

voltage grids
A Zecchino, M Marinelli, C Træholt, *Technical University of Denmark, Denmark,* M Korpås, *Norwegian University of Science and Technology, Norway*

0937 **Creating virtual energy storage systems from aggregated smart charging electric vehicles**
A M Jenkins, C Patsios, P Taylor, N Wade, P Blythe, *Newcastle University, United Kingdom,* O Olabisi, *Siemens Plc, United Kingdom*

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0740 **Preliminary regulations of ESS connected to Korean isolated island power system to minimize the capacity of ESS**
J B Sim, H J Lee, Y S Lee, I K Song, J Y Ahn, *KEPRI, Korea*

0816 **IEC 61850 to the service of power system flexibility**
Q Morel, T Coste, *EDF, France*

1067 **Supporting DER Customer Participation in Active Distribution Networks and Local Markets**
L Kane, R West, R Taljaard, R MacDonald, G Ault, E Davidson, A Gooding, *Smarter Grid Solutions, United Kingdom*

1324 **Measuring the Value of Microgrids: An Benefit-Cost framework**
J Roark, D Weng, A Maitra, *EPRI, United States*

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0354 **Low voltage grid upgrades enabling islanding operation**
R André, F Guerra, *EDP NEW R.&.D, Portugal,* M Gerlich, M Metzger, *SIEMENS AG, Germany,* S Rodriguez, *GP TECH, Spain,* C Gouveia, C Moreira, J Gouveia, *INESC TEC, Portugal,* J Damásio, *Siemens SA, Portugal,* R Santos, *EDP Distribuição, Portugal*

0666 **Key energy storage use cases validation under real operational context.**
R J Santos, A Neves, G Faria, B Almeida, *EDP Distribuição, Portugal,* J Santana, S Pinto, *INESC ID, Portugal,* José Damásio, Mario Vieira, D Isidoro, *Siemens, Portugal*

0810 **Benefits of battery energy storage system for system, market, and distribution network - case Helsinki**
H-P Hellman, A Pihkala, M Hyvärinen, P Heine, *Helen Electricity Network Ltd, Finland,* J Karppinen, K Siilin, P Lahtinen, *Helen, Finland,* M Laasonen, J Matilainen, *Fingrid, Finland*

1110 **The benefits of large-scale Energy Storage Systems (ESS) in French Islands**
J Callec, P Caumon, L Capely, E Radvanyi, *Electricité de France, France*

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0211 **Efficient management of a connected microgrid in Belgium**
B Cornélusse, D Ernst, *ULg, Belgium,* L Warichet, W Legros, *Nethys, Belgium*

0410 **LV state estimation and TSO-DSO cooperation tools: results of the French field tests in the evolvDSO project**
M Sebastian-Viana, *Enedis, France,* M Caujolle, B Goncer-Maraver, *EDF R&D, France,* J Pereira, *INESC TEC, Portugal/FEP, Portugal,* J Sumaili, P Barbeiro, J Silva, R Bessa, *INESC TEC, Portugal*

0829 **Virtual power plant: managing synergies and conflicts between TSO and DSO control objectives**
D Pudjianto, G Strbac, *Imperial College London, United Kingdom,* D Boyer, *UK Power Networks, United Kingdom*

0996 **The smart grid real lab of ewz: findings from a large-scale demonstration project**
V Poulios, M Mangani, E Kaffe, F Kienzle, B Loepfe, *ewz, Switzerland*

1216 **Decentralized distribution system operation techniques: results from the meltemi community smart grids pilot site**
I Kouveliotis-Lysikatos, D Koukoula, I Vlachos, A Dimeas, *NTUA, Greece,* N Hatziargyriou (2,1), *HEDNO, Greece/NTUA, Greece,* S Makrynikas, *HEDNO, Greece*

Sub-block 3 – Demand response

0044 **The practical and theoretical potential of demand side management in SMEs to balance wind power**
M van Blijderveen, D Joskin, J Garthoff, *Alliander, Netherlands*

0789 **Experiences of demand response in Yokohama Demonstration Project**
K Honda, K Kusakiyo, S Matsuzawa, M Kosakada, Y Miyazaki, *Toshiba Corporation, Japan*

0804 **Impact of domestic frequency responsive demand on the shetland islands network frequency stability**
M Edrah, O Anaya-Lara, I Kockar, G Bell, *University of Strathclyde, United Kingdom,* S Adams, F MacIntyre, *Scottish and Southern Electricity Networks, United Kingdom*

1238 **Demand side management in a field test: lessons learned**
M E T Gerards, J L Hurink, *University of Twente, Netherlands,* R Hübner, *Innogy SE, Germany*

Sub-block 4 – Impact of DER on network operations

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B Heimbach, M Mangani, B Wartmann, M Oeschger, C Kelm, *ewz, Switzerland,* S Krahmer, M Kreutziger, P Schegner, *Technische Universität Dresden, Germany*

1364 **The challenge of retrofitting old decentralized power plants in Germany in terms of Power System Stability**
S Brandt, F Kalverkamp, *FGH GmbH, Germany,* R Heßler, *TransnetBW GmbH, Germany,* S Weber, *Tennet TSO GmbH, Germany*

Sub-block 5 – Photovoltaics grid integration inverters

0180 **Control of active / reactive power & LVRT for 40 kW three-phase grid-connected single stage PV system**
M M Hasaneen, *The Ministry of Electricity and Renewable Energy, Egypt,* M A L Badr, A M Atallah, *Ain Shams University, Egypt*

0898 **Modelling and dynamic performance of inverter based generation in power system studies: an international questionnaire survey**
G Lammert, *University of Kassel, Germany,* K Yamashita, *CRIEPI, Japan,* L D Pabón Ospina, *Fraunhofer IWES, Germany,* H Renner, *Graz University of Technology, Austria,* S Martínez Villanueva, *Red Eléctrica de España, Spain,* P Pourbeik, *PEACE-PLLC, United States,* F E Ciausiu, *Tractebel Engie, Romania,* M Braun, *University of Kassel, Germany/Fraunhofer IWES, Germany*

Sub-block 6 – Voltage regulation

0889 **Voltage quality provision in low voltage networks with high penetration of renewable production**
A Vilman, M Jerele, *Elektro Gorenjska d.d., Slovenia*

Sub-block 7 – Control systems and active networks

0310 **Future-proof islanding detection schemes in Sundom Smart Grid**
H Laaksonen, P Hovila, *ABB Oy, Finland*

0420 **Distribution state estimation: outcomes from a field implementation aimed at tackling MV voltage mastering in the presence of DER**
D Croteau, *EDF R&D, France,* O Carre, *Enedis, France*

0648 **An algorithm for soft open points to solve thermal and voltage constraints in low voltage distribution networks**
N Bottrell, T Green, *Imperial College London, United Kingdom,* P Lang, *UK Power Networks, United Kingdom*

0930 **Distributed generation connections under a fault level active network management scheme**
N Murdoch, A Kazerooni, *WSP | Parsons Brinckerhoff, United Kingdom,* J Berry, *Western Power Distribution, United Kingdom*

Sub-block 8 – Resiliency and microgrids

0786 **Behaviour of PV inverters during islanding of a district**
T Drizard, *Enedis, France,* G Diquerreau, *Socomec, France,* S Vilbois, *EDF R&D, France*

1055 **Distributed generation at distribution system level resilience to voltage dips - a real case**
L Rosa, M Louro, B Almeida, F Gonçalves, A M Rodrigues, J Ferreira Pinto, *EDP Distribuição, Portugal*