Special Report - Session 4
DISTRIBUTED ENERGY RESOURCES AND EFFICIENT UTILISATION OF ELECTRICITY

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Introduction

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 368 abstracts and this has produced good quality and diverse contributions to the final conference proceedings where 140 full papers have been accepted and will be presented at CIRED 2019. 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 at least two 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: "Co-ordination, Flexibility and Services"

- Sub block 1: Commercial Solutions
- Sub block 2: Technical Solutions

Block 2: "Planning for and understanding the impact of DER"

- Sub block 1: Forecasting and Modelling
- Sub block 2: Impact on Policy, Protection and Power Quality

Block 3: "Optimising DER"

- Sub block 1: Battery Energy Storage Systems

- Sub block 2: Distributed Generation, Electrified Transport and other DER

This Block allocation follows the logic of a concept to concrete demonstration funnel with Block 1 highlighting commercial and technical solutions for DER co-ordination, flexibility and services . Block 2 then captures techniques for planning and assesing the impact of DER, and Block 3 examines the optimisation of the various DER technologies.

Each of the three Blocks have been sub-divided 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 2019 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 2019 in June.

Block 1: "Co-ordination, Flexibility and Services"

Sub block 1: Commercial Solutions

TSO – DSO Interaction

Paper 666 introduces a flexibility hub enabling a multi service framework for the coordination of decentralized flexibilities. It is a platform of tools managed by the DSO to facilitate market-based flexibility provision to the TSO using resources connected to the distribution system. It includes services like services active and reactive power flexibility as well as grid dynamic information (by means of the equivalent dynamic). The solution will be implemented and tested in a Portuguese demonstration.

Paper 1158 describes a simulator, which precisely estimates the impact of TSO-DSO coordination schemes from the bidding and market clearing perspective, taking into account the consequent effects on the network physics at both transmission and distribution level. The paper compares two distinct coordination schemes: One were the DSO is not participating to the market and one in which the DSO manages it together with the TSO. The analysis demonstrates how the access of the DSO to distribution flexibility can improve the activation of existing reserves, limiting the residual imbalance and the procurement of additional automatic frequency restoration reserve.

Paper 1632 presents the outcome of the cost-benefit analysis (CBA) for different alternatives of the coordination between TSOs and DSOs. The CBA within the SmartNet project compares five coordination schemes in three countries (Italy, Denmark and Spain) on the basis of several economic indicators. The main results for the Italian and the Spanish cases are presented.

Paper 1662 discusses the challenges and opportunities for the DSO, focusing in particular on the coordination with the TSO and to the possible new approaches in network planning and operation. A hypothesis is to use the existing tools and/or use centralized platforms that collect all data acquired from the plants and then make it available for all the subjects authorized to receive them: TSO, DSO and aggregators.

Market and grid service provision by distributed energy resources

Paper 870 proposes a software framework to facilitate the integration of operational flexibility from distributed energy resources (DER) into balancing services for the electricity system. The framework allows electricity end-users to write their own short-term demand response contracts and submit them to the aggregator's digital platform. It allows the delegation of contract specification to DER owners.

Paper 1058 introduces a real-time monitoring and control system for low voltage grids built with Smart State Technology's LV-Sensors together with an energy management methodology. A live test of the proposed control algorithm shows that the system runs stable and adapts the control setpoints adequately to prevent peaks in the power usage. Next step is to enhance the software with multi-threading capabilities.

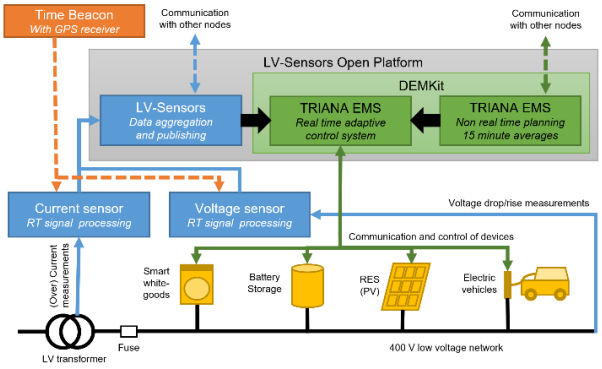


Fig. 1: Open Real Time Development Platform for Smart Grids (Paper 1058)

Paper 1208 describes a French demonstration project, aiming to coordinate the operation of a portfolio of distributed resources for multi-services provision. The services include frequency support, flexibility solutions (like peak shaving) and reactive power services. The supervisory control layers as well as the communication infrastructure of the aggregator is presented.

Paper 1295 presents a methodology for the provision of flexibility services delivered as market services to mitigate congestion problems at the distribution level through energy communities. Peaks shaving, backup power and power ramp rate reduction are formulated as services in this study. The paper illustrates with a test case that energy communities are able to provide grid services, as well as leading to a considerable enhancement of community welfare and commitment.

Paper 1506 assesses the energetic self-sufficiency of a residential district under consideration of an "energy cells approach". The paper shows how by means of the combined installation of energy generators, converters and storages and considering building renovation and increasing e-mobility, it is possible to achieve electrical self-sufficiency from up to 67 % and energetic self-sufficiency from up to 31,7 % in the investigated district.

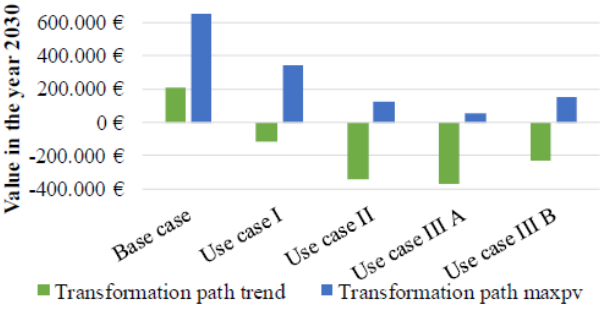


Fig. 2: Value of the use cases in the year 2030 (Paper 1506)

Paper 1891 illustrates the results achieved by the European ELECTRA project and the detailed analysis on market implications related to the deployment of the novel decentralized control architecture, namely the Web-of-Cells. Particular emphasis was given to the analysis of market mechanisms that must be implemented to perform the needed trading for the balancing and voltage control services. In particular, the "power exchange", where balancing and voltage control products are traded between the Balance Service Providers and the Cell System Operators is analyzed.

Paper 1900 introduces a simulation framework to test agent based energy management systems during the development state. The target is to match electrical demand and supply within a given energy community. A pricing mechanism provides an economic incentive for agents to shift the controllable load to favourable times. The agent consists of a communication module, a Blockchain based billing module, a flexibility forecast tool, a decision making module, and a control unit. To test the performance of multiple agents, a bottom-up load and flexibility generator is used. The functionality of the whole framework is explained with special emphasis on the modules using the load and flexibility generator.

Paper 1992 presents the capabilities of distributed small-scale Energy Storage Systems (ESS) to enable grid and market services. Five use cases were tested to demonstrate storage for grid operation and end-customer applications. This paper presents the final results of the real environment tests focusing on the technical, economical and societal conclusions of the Évora (Portugal) demonstrator. It was possible to improve market participation results as well as to support the DSO on distribution grid operation in case of any technical constraints. On the grid side, it was proven that storage can influence both quality of services as well as outage time minimization.

Paper 2037 introduces a regional coordination control for an active distribution network based on bidding mechanism. The simulation analysis of the example shows that this method has good control performance and effect on the power fluctuations of the active distribution network.

In paper 2144, the energy procurement of large industrial consumers with the minimum cost of alternative energy sources including the micro-turbines, bilateral contracts, power market and renewable energy sources, namely wind turbines and photovoltaic systems and storage is investigated. The effects of real-time pricing demand response program (RTP-DRP) and the time-of-use demand response program (TOU-DRP) on the load curve of the large industrial consumer have been studied. A comparison of the results shows that the cost of purchasing industrial consumer's energy is reduced by 12.33% and 6.23% due to the use of RTP-DRP and TOU-DRP, respectively; and also indicates the efficiency of the proposed RTP-DRP in comparison to the traditional TOU-DRP.

Paper 2325, shows that by sharing only the net individual scheduled loads to the other users of the network, a solution characterized by a Nash Equilibrium can be reached. The overall cost, reflecting both the real commodity and network costs, is optimum, and the consumers benefit from it in a fair manner without jeopardizing the other actors. Besides, the communication and computation can be conducted by Smart Meters, hence requiring no additional device or party. This DSM scenario, by involving each user in the objective through their cost impact, naturally leads to the adoption of more reasonable habits and the long-term promotion of cheaper and more renewable energy resources while considering the liberalized context adopted by many parts of the world.

Regulatory and policy aspects

Paper 879 analyses different categories of distribution system charges for electricity producers, including prosumers, currently in place across Europe, as well as their structure, level and relation of these charges to the respective DSOs' cost structures. In this context several policy recommendations are presented in the paper.

Paper 1044 presents a tool allowing network planners to study network expansion plans robustness' under future incentive scheme designs changes. It can screen HV/MV substation service areas for investment needs under various adoption scenarios and two incentive design schemes. In the presented case the policy maker's choice of incentive design schemes can potentially reduce network upgrade costs, by 2.5 million Euro.

Paper 1215 presents the recent developments of small-scale distributed generation in Brazil and its regulatory framework evolution. Motivations for the second general review of the regulatory framework and an overview of its main aspects are also highlighted. As a result, the study opted for combining scenarios in diverse approaches for local and remote systems. The proposal will be submitted to a public hearing and the review is intended to be finished by 2019.

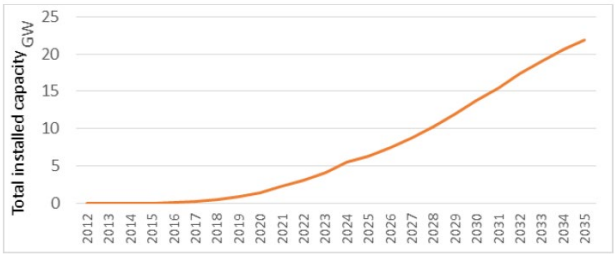


Fig. 3: Paper 1215 projections for total installed capacity in Brazil according to the scheme review proposal.

Table 1a: Papers of Block 1, Sub Block 1, assigned to the Session

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
666	Flexibility Hub – Multi service framework for coordination of decentralised flexibilities				x
870	A Smart Contracting Framework for Aggregators of Demand-Side Response	x			
879	Charges for Producers connected to Distribution Systems				x
1044	Assessing the Impact of Distributed Energy Resources' Incentive Designs on Network Expansion Using a Spatial Technology Diffusion Model				x
1158	Testing TSO-DSO Interaction Schemes for the Participation of Distribution Energy Resources in the Balancing Market: the SmartNet Simulator				x
1208	The EU-SysFlex French industrial-scale demonstrator: coordinating distributed resources for multi-services provision				x
1215	Net Metering in Brazil: Setting the Scene for the Regulatory Framework Review				x
1295	Provision of flexibility services through energy communities	x			
1506	Assessing the energetic self-sufficiency of a residential district				x
1632	Cost-Benefit Analysis of TSO-DSO coordination to operate flexibility markets				x
1662	Coordination and data exchange between DSO and TSO as key factors for optimizing DER management in the future energy system.				x
1891	A Transparent Market Design for Balancing and Voltage Control Products				x
1900	Stochastic bottom-up framework for load and flexibility for agent based controls of energy communities				x
1948	The role of market facilitator: how DSO-owned Energy Storage Systems can support private DERs in ancillary services market				x
1992	Storage and Energy Management enabling Grid and Market Services: SENSIBLE's Portuguese real demonstration results	x			
2037	Regional Coordination Control of Active Distribution Network Based on Bidding Mechanism				x
2144	Energy Procurement of Large Industrial Consumers: Real-time Pricing against Time-of-Use Pricing				x
2325	A Collaborative Demand-Side Management Scenario for Liberalized Smart Grids				x
	Totals	**3**	**0**		**15**

Sub block 2: Technical Solutions

Battery Energy Storage Systems and Microgrids

Paper 1164 describes the transformation of a microgrid into a grid-support asset, providing services for the electric retail market. In the framework of a Spanish demo site, an existing microgrid composed of photovoltaic and wind generators, lead acid batteries and consumption points is being converted into a system that works in a coordinated and optimized way that provides flexibility services to the electric grid operator. A remote system has been developed, which monitors the entire system via SCADA and operates components based on optimization algorithms, minimizing energy costs and offering auxiliary services to the DSO.

Paper 1186 proposes an adaptive energy resource management solution. It is a combined energy storage and microgrid management system aiming to provide a flexible and straightforward way of scaling out microgrid based solutions in existing electrical power systems, as a mean of effectively tackling challenges while enabling the efficient and safe increase of networks capacity to host new DER.

Paper 1394 investigates a real community integrated energy system in China that includes multiple energy devices, multiple energy demands and multiple energy conversion links. A day-head scheduling strategy is established to schedule the operation of different devices in the system, with considering the flexibility of storage devices and the impact on distribution network. The results show the proposed strategy can realize an economic and reliable operation by coordinating various energy devices. The tie-line power is well smoothing with a lower ratio of the peak-valley values.

Paper 1416 introduces a blockchain based self-consumption optimization in local energy communicates. A simulation model is created representing a local energy community. Several scenarios are created, for instance extending the cluster with a community electricity storage and a community photovoltaic power plant. Aim is the self-organization as a virtual power plant offering flexibility services and following a given load-profile by utilizing all system components in an optimal way. A comparison between the different scenarios is presented and possible implementations of the blockchain technology are evaluated.

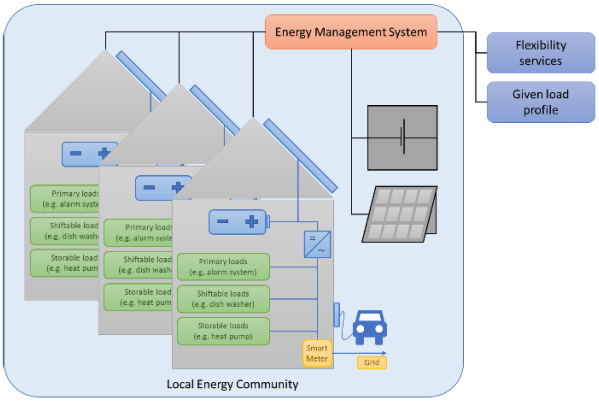


Fig. 4: Model of a local energy community (Paper 1416)

Paper 1936 presents an overview of the assets, technologies and control tools that will enable new grid support functions from small-scale storage. The Évora demonstrator in Portugal, clearly demonstrates the various technical possibilities and benefits arising from using distributed storage to support distribution grids. However, these technical results were achieved by an experimental infrastructure, using tailor made control tools that are hard to adapt and customize to a different demonstrator site. Furthermore, the integration of these control tools in existing Distribution Management Systems is extremely complex and typically faces resistance due to the high importance of these systems to daily grid operations.

In paper 2320 a model for simulating provision of multiple services via Battery Energy Storage System (BESS) is presented. The paper investigates the possibility to deploy a storage facility in the Primary Substation and to control it in order to fix imbalances of distributed PV resources. Moreover, in order to improve BESS economic viability, a multi-service control has been investigated. In particular, since BESS has limited energy reservoir, power intensive services are supposed to be more profitable than energy intensive, consequently frequency control has been coupled with PV support. Numerical simulations on real life data showed technical and economical profitability of the approach proposed;

Grid integration, network management and related technologies

Paper 199 describes the evolution of active network management at SP Energy Networks (SPEN) in UK. Between 2013 and 2016 SPEN ran an £8.4M innovation programme called Accelerating Renewable Connections that explored innovative ways of connecting DER. The paper describes that project and the technical and commercial learning it generated. In conclusion, flexible connections is the direction and pathway that will enable future connecting customers to both access the network and enable them to participate in the wider operation of the energy system for the benefit of all market actors and stakeholders.

Paper 684 proposes a coordinated volt/var control (VVC),

where the control scheme leads to energy losses and also voltage profile improvement. Also, the proposed VVC allows the coordinated control of traditional equipment (voltage regulators and capacitors bank) and power electronic devices (inverters, transformers with electronic commutation and distributed resource). Both in simulation test network and real network application, the algorithm reached the expected and promising results.

In the context of increasing distributed generation, paper 1137 investigates alternative solutions to reduce integration costs. In addition to self-adaptive reactive power management and active power curtailment for feeder constraints, the largest French DSO is studying active power management to alleviate HV/MV substations constraints. Cost-benefit analysis show a potential reduction of connection costs up to 40% with the ratio of wind to solar power connected to each substation being one of the key factor.

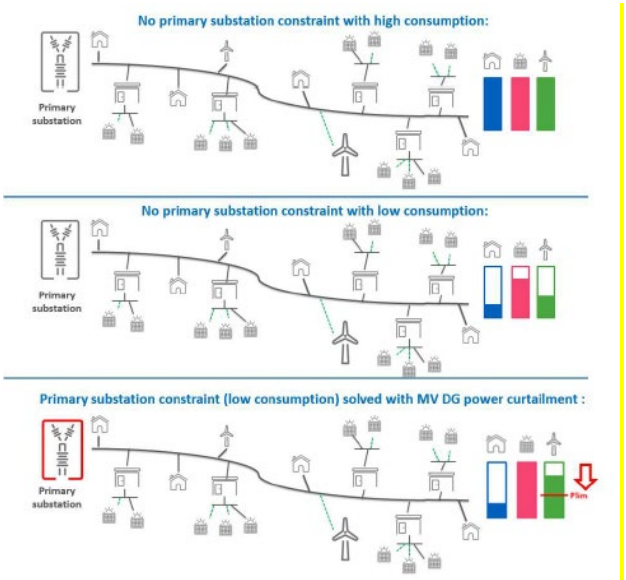


Fig. 5: Active power curtailment principle (Paper 1137)

Paper 1502 presents a tool for an aggregator of thermostatically controlled loads (TCLs) to optimally combine their flexibilities into a few representative bids to be submitted to a real-time flexibility market designed for the activation of balancing and congestion management services. Results of the simulated case study have shown the feasibility of the developed algorithm for generating flexibility bids, thus allowing the participation of a portfolio of domestic TCLs in real-time capacity markets.

Paper 1652 analysis different alternatives for TSO – DSO cooperation, both in long-term simulations and in real-life demonstration projects. Despite some practical difficulties found during the implementation phase, the pilot demonstrated that the unused available capacity back-up from radio base stations, if properly aggregated, can be very useful for the DSO for congestion management and for supporting the TSO under the "Shared balancing responsibility" coordination scheme. Eventually, it can also avoid the costly ignition of thermal power plants.

In paper 1688 a symmetric voltage regulation approach is tested with the aim of coordinating technologies on the LV side. It demonstrates that the coordinated control of smart transformer with OLTC and PV inverters, offers new possibilities to increase the hosting capacity whilst fulfilling statutory limits. Based on the outcome of this research, a hierarchy of coordinating technologies with the aim of enhancing the renewable hosting capacity of the LV distribution grid and reducing losses is suggested.

Paper 1721 describes a technical framework for the coordination and control of transmission and distribution networks in UK during real-time operation. Aim is to improve the interaction between National Grid, UK Power Networks and energy resources connected to the distribution system, through a technical and commercial solution. Simulation results obtained from testing the functionality of the Distributed Energy Resources Management System (DERMS) when providing real and reactive power services to National Grid are presented. The proliferation of DERMS on distribution network where all the network data, schedules and information are available, provides the infrastructure to effectively manage/optimise the distribution system constraints and offer TSO services to National Grid.

Paper 1731 presents two solutions proposed to enhance transmission and distribution system coordination and control; simple constraint headroom assessed approach (managed by National Electricity Transmission System ~Operator (NETSO)) and Distribution System Operator (DSO) load flow assessed approach (managed by DSO). The intact network generates small seasonal sensitivity variation for DERs with respect to constraints and therefore the implementation of the NETSO managed approach with few signals would be adequate for simple radial distribution networks.

Paper 1806 presents an overview of the results obtained during the first year of the INTERPLAN project, which aims to develop an integrated network operation planning tool. Integrated means in terms of voltage levels, going from high voltage down to low voltage levels, and in terms of forming a bridge between static, long-term planning, as well as considering operational issues through the introduction of controllers in the operation planning. Different use cases for the tool are presented.

Paper 1847 studies three types of hydrogen infrastructures connected to the electricity distribution grid, by taking into account the expected business models of water electrolysis and the cost of providing flexibility services to the distribution system operator. The contractual framework is divided into a multi-year commitment contract and a day-ahead activation contract. The calculations of the average costs for the flexibility provision to the DSO reflect these two parts.

Paper 2055 describes the results of studies carried out as part of the on-going Power Potential project which is investigating the use of DER to support voltage control on transmission network. In order to enable the use of DER for transmission services, a sequential two-stage reactive market approach and security constrained optimal power flows based reactive power allocation have been developed. A set of studies was carried out on the South East part of the GB transmission system to demonstrate the feasibility and effectiveness of the proposed methodology; the key findings from the analysis are presented and discussed in the paper.

Potential scope of discussion

This block has wide raging scope for discussion, including as it does technical and commercial solutions for the operation of the future decentralised power system. Coordination and provision of services between system owners and users is a key area of discussion, including the boundary between TSOs and DSOs. Design and trial of network management techniques is also of note.

Table 1b: Papers of Block 1, Sub Block 2, assigned to the Session

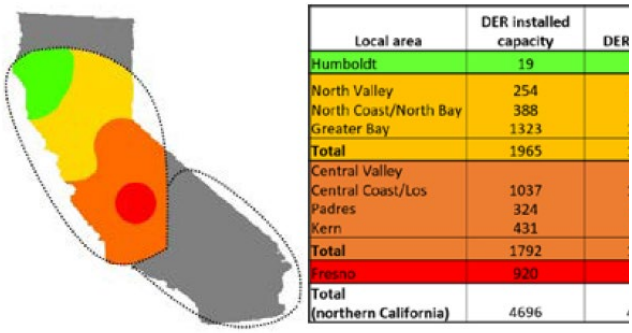
Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
199	From Flexible Connections to Enabling Flexibility: The Evolution of Active Network Management at SP Energy Networks				x
684	Coordinated Volt/Var Control for Smart Distribution Grids				x
1137	A smart grid alternative to network reinforcement for HV/MV substations constraints : Active power curtailment	x			
1164	Transformation of a microgrid in a distribution grid support asset				x
1186	Adaptive Energy Resource Management System – scaling out microgrid based solutions in electrical power systems				x
1394	Optimal Operation of a Community Integrated Energy System Considering Tie-line Smoothing				x
1416	Blockchain-based self-consumption optimization in local energy communities			x	
1502	Aggregation of thermostatically controlled loads for flexibility markets				x
1652	Use of radio base stations to provide ancillary services to the DSO through local flexibility markets				x
1688	Holistic coordination of smart technologies for efficient LV operation, increasing hosting capacity and reducing grid losses				x
1721	UK Power Networks Providing Power Services from Distributed Energy Resources to Transmission System Operator via a Centralised DERMS platform				x
1732	Enhanced Transmission and Distribution System Coordination and Control Utilising Distribution Network Capacity and Avoiding Conflicts of Service Offered to Transmission System Operator	x			
1806	INNOVATIVE ELECTRICITY NETWORK OPERATION PLANNING TOOL FOR TSOs AND DSOs			x	
1847	Valuation of harnessing flexibility from decentralized water electrolysis systems for the DSO				x
1936	Project SENSIBLE's results from MV/LV coordinated island operation in a distribution grid				x
2055	Integration of distributed reactive power sources through Virtual Power Plant to provide voltage control to transmission network	x			
2320	BESS located in Primary Substation for RES integration and ancillary services provision				x
	Totals	**3**	**0**	**2**	**12**

Block 2: "Planning for and understanding the impact of DER"

Sub block 1: Forecasting and Modelling

Paper 0184 addresses the issue of missing data on datasets used for AI-based load time series forecasting. The authors propose an architecture combining a denoising autoencoder (DAE) for imputation with a predictive recurrent neural network (RNN). The proposed model was used associated with the Interflex micro grid demo, in Sweden. The authors conclude that the DAE succeeded in recovering mean imputed values by learning the data distribution for small fractions of missing entries, even if this effect vanishes with an increase in the percentage of missing data. The combined AE-RNN models achieved a better accuracy than the RNN's prediction with an incomplete mean dataset. Furthermore, DAE is an option suitable for automatic data pre-processing.

Paper 0308 provides an account of distributed energy resource modelling practices in North America. Describes the efforts focused on improved and consistent steady-state and dynamic DER modelling and includes DER system impact studies in California based on the described modelling framework (shown in **Fig.6**). It discusses DER ride-through settings that allow DER to remain on-line through load tripping disturbances.



Local area	DER installed capacity	DER
Humboldt	19	
North Valley	254	
North Coast/North Bay	388	
Greater Bay	1323	
Total	1965	
Central Valley		
Central Coast/Los	1037	
Padres	324	
Kern	431	
Total	1792	
Fresno	920	
Total (northern California)	4696	

Fig. 6: Study Area and Amount of Modelled DER (Paper 0308).

Paper 0413 describes three algorithms that disaggregate the net load on electricity grids into solar PV generation and household consumption, based on the rescaling of nearby reference PV systems. The paper evaluates the accuracy of the algorithms on a test case, through the mean absolute error of the results (as compared with PV installed capacity), total generated energy and total installed capacity and for several generation to consumption ratios (assessing both the accuracy of the algorithms and its robustness across a wide range of PV installed capacity to consumption values.

Paper 0427 describes a model of lithium-ion battery, allowing to simulate a power system containing batteries of that technology. The model can fit the external characteristics of the energy storage system in a grid containing loads with constant impedance, constant current and constant power (ZIP) and induction motors, in the presence of large voltage disturbances. The model was built with a simple structure, few parameters and intending to be able to be applied to a wide range of real networks. Nevertheless, it was able to effectively simulate the behaviour of the battery, internalizing the associated output simulation in the presence of different load levels under a 20% voltage disturbance.

Paper 0549 assesses the flexibility of an energy system that will include devices with high simultaneity factor, such as PV plants, heat pumps and electric vehicles, which might cause local grid congestion. The paper determines available flexibility provided by distributed energy systems considering load and feed-in uncertainty in a Monte-Carlo simulation. The results obtained shown that the available flexibility of storage systems is high during winter seasons, when those systems will be able to buffer a high simultaneity of heat pump demand. During the summer, storage units will tend to buffer both PV and demand peaks. Furthermore, considering the uncertainty of the profiles, it would be reasonable to consider flexibility provision for given areas.

Paper 0598 presents the results of a state estimator developed for MV networks, combining sensor-based measurements and pseudo-measurements to determine the network state at any time, allowing the OLTC dynamic management. The state estimator addresses the issue of bad data, either caused by sensor misuse or failure. The benefits of using the state estimator were operationally proven through a smart grid demonstrator, as long as there are more "healthy" data than erroneous ones. It also allows to detect defective sensors, enabling the DSO to perform maintenance interventions on those sensors.

Paper 0726 shows the use of real-time data associated with AMI to improve distribution planning. An analytical investigation is provided for agricultural and industrial loads. Some modifications are presented to improve demand side management to curtail peak demand. The results obtained show the effectiveness of the use of AMI system for peak-shaving and planning of distribution networks.

Paper 1020 provides a methodical approach to describe the stationary and dynamic behaviour in typical German regions. Several factors are considered, including the properties of individual load types and seasonal fluctuation in their usage. The resulting load model enables the dynamic simulation of changes in active load and reactive power demand caused by variations in load and frequency. The load model is parametrized for simulating the behaviour during midday, evening and night time on monthly basis for households, industry and "intermediate" loads.

Paper 1134 assesses the reliability of scheduling and flexibility forecasts from distribution network operators, in

order to use the capabilities associated with ICT and smart grid applications to optimize the power balance of a network and for flexibility services provisions. The results presented show that the reliability of the schedule and flexibility forecast is very high.

Paper 1419 proposes a model, based on publicly available statistics, to estimate the time-series of electricity demand for a year in an arbitrary distribution network, and examines the usefulness of the model in supporting asset management activities. The paper evaluates the accuracy of the model by comparing the estimated demand with observed demand. As an example of application of the model, the residential load characteristics in the case of high penetration of photovoltaic power generation and increased electrification ratio for energy demand is evaluated for several distribution networks in Chubu, Japan. Some results and real data are presented in **Fig. 7**.

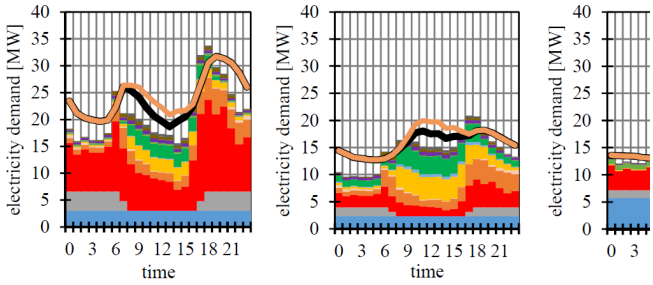


Fig. 7: Monthly average of estimated electricity demand on weekday in January (Paper 1419).

Paper 1438 presents a computationally light method to generate a set of graphical formats that enable an intuitive understanding of variability in future electricity systems with a high share of variable renewables. It considers both typical and extreme weather condition, as well as domestic and cross-border potential. These visualizations facilitate an initial assessment of quantities and characteristics of the complementary flexibility and dispatchable resources required, particularly in systems with a high share of variable renewable energy generation.

Paper 1531 proposes a method enabling automated detection of EV from smart meter data, providing insights for DSO about spatiotemporal EV charging patterns. Since the challenge is to identify EV based on smart meter data with hourly resolution, the method uses machine learning methods to detect EV signatures, with models trained and evaluated on labelled data before being tested on unlabelled real data. Tuned models to maximise either precision (be certain about detections) or recall (find as many EV as possible) can detect 90% of EV with 10% false positives. When using models to detect EV on unlabelled Norwegian smart meter data, detections are coherent with the EV share according with national registries and accounting for expected spatiotemporal patterns. However, models may be confused by baseline consumption patterns, requiring the collection and inclusion of a labelled dataset of consumption data.

Paper 1569 describes a method to estimate flexibilities in terms of real and reactive power available at the distribution level. It is based on an interactive calculation of flexibility area across a distribution grid. The method was tested on a 152 bus radial distribution grid that included 28 nodes with devices providing flexibility to the network. The method was able to provide a representation of available flexibility at a specific point considering the flexibilities available at associated nodes, which would be useful for a hierarchical control approach.

Paper 1669 analyses the impact of the correct modelling of low voltage grids with high PV share on the voltage and reactive power behaviour of the superordinate voltage levels. Results show that a more realistic modelling of the network is necessary to correctly reflect the reactive power behaviour of low voltage grids. The reactive power consumption of low voltage grids increase with the bus bar voltage on the secondary side of the distribution transformer, changing the reactive power behaviour of low voltage grids, with a significant impact on voltage levels in the high and medium voltage networks.

Paper 1713 presents a model-based predictive control strategy for current control of double-fed induction generators (DFIG), using Euler's derivation rule. Furthermore, an equation is developed, which can be used in all operational conditions. In addition to simulation studies, the proposed algorithm is verified using a laboratory setup.

Paper 1738 develops a three-phase four-wire state estimator (SE) algorithm. To analyse the performance of this algorithm, a LV test network was considered. The SE algorithm for LV networks had to be deeply modified from algorithms dedicated to HV and MV networks, to account for the characteristics of those networks. The SE prosed in the paper was based on weight least squares approach, and is not dependant of measurement errors.

Paper 1818 introduces a method to model the influence of distributed energy resources, considering regional differences of the infeed, and load distribution, and regional topology. Assuming that a detailed large-scale model containing all voltage levels is impractical due to the enormous number of nodes, the paper describes a method to aggregate regionalized distribution networks for dynamic simulations in the transmission grid (example in **Fig. 8**). Distribution networks were shown to drastically influence the stationary as well as the dynamic behaviour of a transmission grid. Thus, modelling distribution networks is important to increase the quality of simulations of the transmission system with a high share of DER.

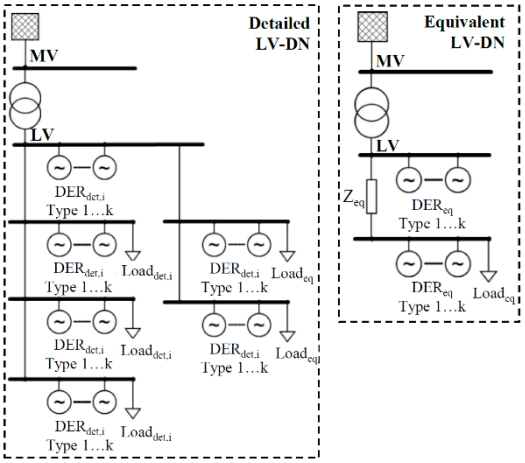


Fig. 8: Schematic detailed and equivalent grid (Paper 1818).

Paper 1861 describes a methodology for evaluating energy losses and their allocation to the correct voltage levels, in large distribution systems, considering the presence of distributed generation. The results are presented for the supply areas of four large German DSO, while also discussing the impact of DG on grid losses and of loss reduction measures. The paper argues that proper grid reinforcement is an effective measure to reduce losses. However, the solely emphasis on grid losses may lead to an overinvestment in grid assets. Therefore, a holistic and coordinated cost-benefit optimization to improve the overall efficiency of distribution systems should be preferred. **Fig. 9** illustrates the losses in relation to aggregate power.

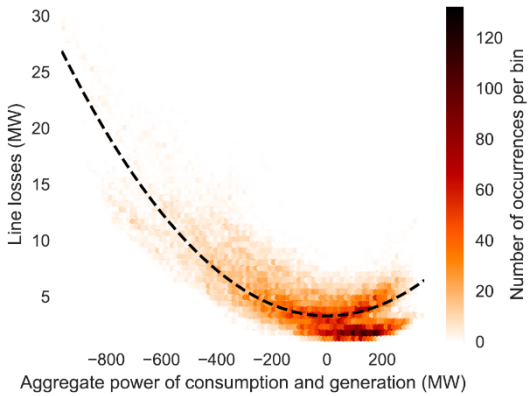


Fig. 9: Line losses in relation to aggregated power of a HV grid (Paper 1861).

Paper 1983 focuses on behaviour of inverter-based power sources in loss-of-mains situation in low-voltage networks. The transition to island operation might be one of the basic features of future smart grids. Focus of this paper is aimed on evaluation of P(f), Q(P,U) and P(U) control modes performance in island operation. A model created in PSCAD as a tool to simulate variable scenarios, including the stability analysis of the system.

Paper 2016 explores the effect of forecast on model-based methods for control of energy storage. The described model predictive control (MPC), an optimization-based technique, requires demand, renewable generation and electricity prices forecast. The paper explores the performance of MPC using different forecast techniques, with varying levels of error. Furthermore, it analyses the deterioration of system performance when forecast errors increases, for a customer with storage, under different settings.

Paper 2062 estimates optimal PV panel orientations for each month of the year, so that the solar power output fluctuations are attenuated without reducing energy production below 10%, based on the assessment of output power for 513 different orientations for each month of the year, with the output measured with 1 Hz resolution. Solar power smoothing potential associated with panel orientation reduces the occurrence of control events, associated with power fluctuations, was estimated to be reduced by 30.7% for a whole year, for defined optimum orientation, as compared with conventional orientation setup.

Paper 2251 demonstrates a method for demand side management by optimally scheduling the energy consumption of individual dwellings, maximizing individual reward subject to utility-imposed and user preferences constraints. The paper categorizes load resources in terms of their flexibility in energy consumption and operating time and uses a particle swarm optimization algorithm to solve the problem. It concludes that the demand response request is able to depress the peak load by 10% under the maximum comfort scenario. Thus, even with modest time-of-use pricing, it is comfort, not critical peak pricing, that constraints demand response.

Table 2a: Papers of Block 2, Sub Block 1, assigned to the Session

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
184	Filling missing values for AI-based (load) forecasts within the InterFlex micro grid demo in Simris, Sweden				x
308	Recommended Distributed Energy Resource Modeling Practices in North America	x			
413	Disaggregating Grid Load into Consumption and Solar Generation				x
427	Generalized Synthesis Load Model Considering Lithium-ion Battery				x
549	Flexibility Determination of Distributed Energy Resources, Storage Systems and Heating Units considering Load and Feed-In Uncertainty				x
598	Voltage management in the presence of Distributed Energy Resources - Field implementation of a robust Distribution State Estimator with errors in sensor data				x
726	Optimization of network planning based on hourly classification of consumed energy				x
1020	Modelling of Stationary and Dynamic Demand Behavior considering Sectoral and Regional Characteristics				x
1134	Assessment of the Reliability of Power Balance and Flexibility Forecasts from Distribution Networks				x
1419	Development of Electricity Demand Estimation Modelin Distribution Network Based on Grid-Square Statistics				x
1438	Visual Display of Variability and Adequacy Requirements for VRE-Dominated Electricity Systems				x
1531	Automated Detection of Electric Vehicles in Hourly Smart Meter Data				x
1569	Recursive estimation of flexibilities in a radial distribution network				x
1669	Impact of the correct modeling of low voltage grid with high DG share on the medium voltage grid calculations				x
1713	Mathematical modelling and evaluation of a control algorithm for speed control of DFIGs using model-based predictive control				x
1738	A Three-phase Four-wire State Estimator Algorithm for Low Voltage Network Management				x
1818	Regionalized Aggregation of Distributed Energy Resources and Distribution Networks for Large-scale Dynamic Simulations	x			
1861	A comprehensive study for evaluation of the energy losses in distribution systems with high penetration of distributed generations				x
1983	Dynamic Modelling Approach to Assess Control Strategies of Distributed Energy Resources				x
2016	Impact of forecast on control methods for customer-sited battery storage				x
2062	Computational Diagnostics of Photovoltaic Smoothing Potential for Composite Orientations				x
2251	Multi-dimensional energy consumption scheduling for an event-based demand response.				x
	Totals	**2**	**0**	**0**	**20**

Sub block 2: Impact on Policy, Protection and Power Quality

Paper 0390 presents a study about the hosting capacity of low-voltage networks concerning the appearance of microgeneration, within the context of amendment #167 Directive of European Parliament and of the Council on the promotion of the use of energy from renewable sources. It concludes that LV networks in the Czech Republic are suitable for general application of a fit and inform strategy for 50 kW generation units.

Paper 0421 proposes a scheme for under frequency load shedding for a microgrid that includes renewable energy sources, with the goal of stabilizing the system frequency. The proposed scheme aims to minimize the amount of required load shedding, while keeping the minimum frequency value within the acceptable limit during severe disturbances. It is developed through a genetic algorithm, with multi scenarios performed on the system to train an artificial neural network.

Paper 0425 describes the effects of three-phase grid fault on the performance of a wind-driven single machine-brushless double fed induction generator, including the behaviour of the static synchronous compensator (STATCOM), which includes a DC source, during fault ride-through. The performance of the stator and rotor currents, stator and rotor voltages, electric torque, active power, reactive power, harmonic distortion, battery pack voltage and current are presented. The paper concludes that the presence of the STATCOM decreases the effect of ground faults on the transient of the stator and rotor voltages and currents and maintained the battery charging process.

Paper 0524 focused on isolated power operation in a domestic household, equipped with photovoltaic panels or fuel cell, and a battery energy storage system, during a blackout. The paper analysis the alternatives of connecting the storage system through independent power conditioner systems (PCS) or through a common PCS, which allows to charge the battery without considerations regarding the capacity of the PCS (**Fig. 10**). Demonstration tests were conducted in a smart house to examine the effectiveness of the operation of the systems. The results confirmed that in comparison with a conventional system, isolated operation using the DC link system could direct more power from the PV panels to the battery.

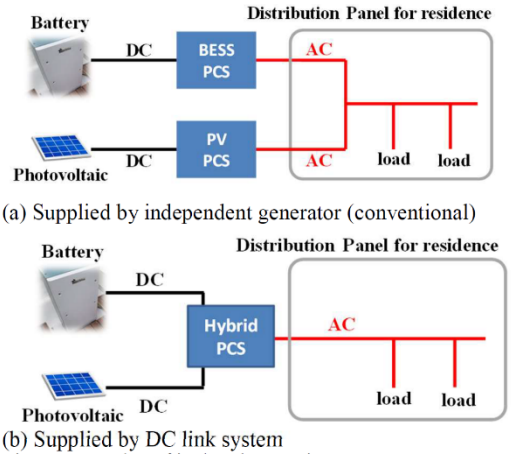


Fig. 10: Examples of isolated operation (Paper 0524).

Paper 0624 presents the voltage stability limit of a 6.6 kV network with photovoltaic generators, testing voltage stability limit caused by a large amount of generation located on a long distribution network. It confirms that the connection point voltage rapidly decreases along the P-V curve when the voltage stability limit is reached by the reverse power flow from the inverters. The distance from the substation has an inverse relation with the amount of PV than can be connected. Also, power losses increase substantially when the network is near the stability limit. The PV connection capacity decreases when PV is generating with a lead power factor, or when the wires have a larger diameter. Therefore, making the wires larger is not a countermeasure to prevent voltage stability issues.

Paper 0671 discusses the influence of voltage-controlled transformers on photovoltaic power plant inverters, by analysing the permissible current carrying capacity of the semiconductor modules and the required AC input voltage range of the central inverter at a certain grid node setting the limit for the transferable power of the inverter unit. The adaption of the AC voltage has a positive influence on the efficiency and power delivered through the inverters.

Paper 0702 describes the issues associated with the increase in distributed generation in Korea, namely on instability of power quality, increase of safety risk due to islanding and protection coordination. A distributed energy resources management system (DERMS) was introduced to address the voltage problem, showing the results obtained through demonstrators.

Paper 0729 examines, from a costumer perspective, how higher voltages due to residential PV affects demand, and how conservation voltage reduction (CVR) can bring benefits in this scenario, based on a realistic MV-LV network and for two CVR schemes to actively keep customer voltages low. Results show that, without CVR, higher voltages due to PV systems increase the energy consumption of appliances which, in turn, mostly affects customers without PV as they solely rely on grid imports. With CVR, on the other hand, customers that largely rely

on the grid with or without small PV systems) reduce energy imports the most, making the presence of PV combined with CVR beneficial for everyone.

Paper 0982 develops a risk-based framework for maximization of distribution companies' profit, considering the implementation of incentive reliability regulations. Various investment alternatives are considered, including the installation of distributed generation units and network reinforcement, compared with the help of an optimization genetic algorithm. The solution is tested on a distribution network, in order to evaluate the obtained results.

Paper 1058 presents a real-time monitoring and control system for low voltage grids. The energy management platform described in the uses synchronized real-time measurement data from several locations in the grid, combined with a control system to resolve deviations in power consumption from a given planning. Hence, grid overloading is avoided and quality of service is improved. Initial integration tests show that the solution is stable and resolves prediction errors to ensure quality of service. A schematic overview of a possible setup is presented in **Fig. 11**.

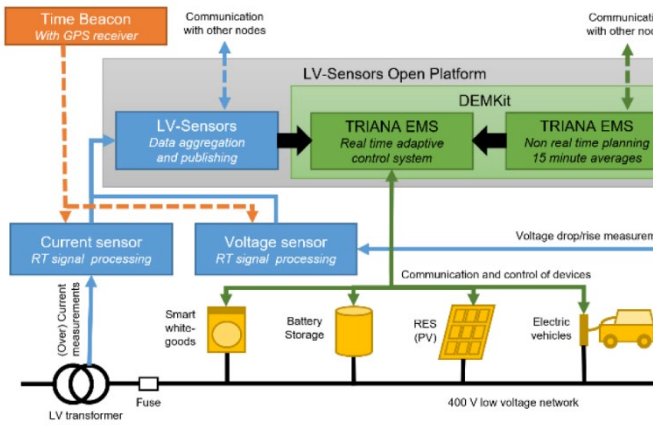


Fig. 11: Overview of the proposed system for an open real time development platform for smart grids (ORTEP) (Paper 1058).

Paper 1319 describes the conditions for increasing DER anti-islanding protection frequency range, within the context of Commission Regulation (EU) nº 2016/631. It is based on an extensive study on islanding formation both on real and simulated scenarios, considering two grid sections connected with different generator technologies. It was found that unwanted islanding may occur even without active frequency control generation. The paper also presents the strategy envisioned for the Portuguese grid aiming to contribute to a European synchronous system resilience using additional communication-based anti-islanding detection methods.

Paper 1330 presents a real case islanding detection on the distribution network by using micro phasor measurement units (µPMU), addressing the issue of anti-islanding detection when the load demand is very similar to the generation. Discusses new approaches for that detection, including the phase angle difference between the main grid and the DG side, based on a trial with a system that includes a storage system. Therefore, the paper shows anti-islanding detection situations with this methodology, while also presenting some difficulties found during the installation and operation of µPMU. **Fig. 12** presents the frequency measurements at two µPMU implemented to detect the difference between phasor angles.

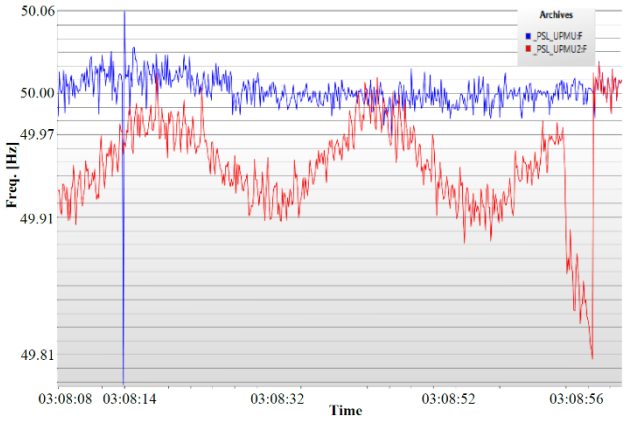


Fig. 12: Frequency of µPMU1 and µPMU2 during the 1st outage observed (Paper 1330).

Paper 1588 uses a data driven approach to complement and enhance the robustness of a decentralized local primary frequency control. The methodology and implementation of the proposed approach is demonstrated through a case study on a reduced (five area) dynamic model of Great Britain power system and its performance verified by means of real-time simulations. Four classifier models have been evaluated for true frequency location identification, proving the feasibility of the approach in real-time simulations.

Paper 1978 proposes a scalable approach for validation of distributed control schemes for smart grids by emulating the communication in a decentralised manner, utilising the open platform communications unified architecture in a controller-hardware-in-the-loop environment. As a proof-of-concept, the paper describes the effect of communication delay through denial-of-service attacks to a converter-dominated communication-heavy and consensus-based microgrid control algorithm, elaborating how scalable power systems communications emulation can help selecting appropriate mitigation strategies for telecommunication-based stress conditions.

Paper 1994 discusses the coordination between on-load tap changers (OLTC) and energy storage systems (ESS) to regulate distribution systems voltage levels. An ESS is equipped with power electronics interfaces, which are capable of supporting the voltage control in different network points while delivering ancillary services.

Therefore, the paper proposes an alternative scheme of voltage control which uses reactive power from an ESS, optimising the utilisation and extending the life of OLTC. The proposed scheme was tested in a trial in a network connected with an HV/MV substation in the UK, showing that grid scale ESS is effective in providing voltage support across a full load cycle (24 hours).

Paper 2210 presents a method to size a battery energy storage system (BESS) to minimize underfrequency loading shedding in island power systems. The proposed method was applied to two Spanish isolated power systems and confirmed through dynamic network simulations. The paper argues that BESS with a capacity around 6% to 9% of the installed generation capacity are needed to avoid load shedding.

Paper 2237 studies the effects of partial shading in PV solar panels. Under those conditions, the shaded modules behave as loads. In order to connect a PV system into the grid, an inverter is required. This inverter will inject harmonics. The paper presents a model of a solar PV array connected with the grid through inverters, both in normal conditions and in case of partial shading, while also studying the effect of the harmonics in the system.

Paper 2271 addresses system security and stability associated the transition from a system with coal power plants into a system with variable renewable energy sources. The paper discusses the effect of an increase in PV generation on a decrease in system inertia and investigates the performance of battery energy storage services (BESS) to provide fast frequency response. Finally, it develops a model for the state of Queensland (Australia) to simulate renewable energy penetration scenarios while imposing contingency events. Concludes that BESS improves frequency control substantially. Nevertheless, the effect of an aggressive renewable energy target justifies further research concerning the system stability.

Potential scope of discussion

Block 2 incorporates several papers describing methods to use the data acquired by smart meters to better model distribution networks, including a better understanding of the effects of growing distributed energy resources (renewable generations, energy storage systems and demand management) on distribution networks and electrical energy systems. The concern about data quality and availability is addressed, with models described to estimate missing or bad data. Often, the models presented benefit from the use artificial intelligent or machine learning algorithms, which are increasingly being used to address the increasing complexity of managing distribution systems.

Regarding the energy policy topics, this block presents several studies on the stability limits of LV and MV networks with large quantities of photovoltaic generation associated, and how to manage the hosting capacity on those networks (for instance, through energy storage deployment or demand management initiatives). It also discusses the expected conditions of network operations within the context of the Commission Regulation 2016/631 and of the amendment #167 to the Directive of European Parliament and of the Council on the promotion of the use of energy from renewable sources.

Table 2b: Papers of Block 2, Sub Block 2, assigned to the Session

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
390	Reasonability of “Fit and inform” for sources up to 50 kW within LV networks	x			
421	A novel scheme of under frequency load shedding for a microgrid integrated with renewable energy resources				x
425	Mitigation of Faults in Grid-Connected Single Machine Brushless Double-Fed Induction Generator				x
524	Experimental Study of the Isolated Operation of a Home DC Link System				x
624	Study on Voltage Stability Limit of 6.6 kV Distribution System by Reverse Power Flow from a Group of Photovoltaic Generators				x
671	The influence of voltage-controlled transformers on PV-Park Inverters.				x
702	The Introduction of Voltage Stabilization System according to the Increased DERs in KOREA				x
729	CVR in PV-Rich Distribution Networks: A Customer Perspective				x
982	A risk-based framework to optimize distributed generation investment plans considering incentive reliability regulations				x
1058	Combining distributed synchronized high frequency measurements with a control system for smart low voltage grids			x	

1319	Conditions for increasing DER anti-islanding protection frequency range	x			
1330	Real case islanding detection on the Distribution network by using microPMU units				x
1588	Data Driven Approach to Decentralized Control: A Primary Frequency Control Study				x
1978	Scalable Power System Communications Emulation with OPC UA				x
1994	Coordinated operation of a grid scale energy storage system with tap changer for voltage control on primary substations	x			
2210	Sizing of a battery energy storage system to minimize underfrequency load shedding in island power systems	x			
2237	Design and Analysis of an MPPT Technique for Solar PV Arrays Connected to harmonic-polluted Grids Under Partial Shading Conditions				x
2271	Battery Energy Storage for Frequency Control in an Electricity Market with High Penetration of Renewable Energy				x
	Totals	**4**	**0**	**1**	**13**

Block 3: "Optimising DER"

Sub block 1: Battery Energy Storage Systems

Paper 0020 presents a methodology to determine the optimal location of BESS for continuity of supply improvement and for facilitating the integration of renewable energy and distributed energy resources. The methodology is applied to a real network case in order to compare the optimal location of BESS in the transmission grid or in the distribution grid. The results show that batteries located in the distribution network provide a better solution to reduce the energy not supplied in case of faults in the network.

Paper 0069 describes the potential of the Hybrid Battery Storage System, implemented in the research project 'Hybrid-Optimal', to operate in a grid-friendly manner is determined by simulations. After a description of the used algorithm and the input data, results for a prevention of over voltages, reduction of the peak power demand and self-sufficiency in times of power outages are presented. The potential of battery systems to behave grid-friendly is high as seen in the results, and these will be validated as far as possible through real measurements in the project

Paper 0081 explores the potential for aggregator-controlled behind-the-meter BESS to address these issues by limiting reverse power flows and providing peak-shaving capability. 40 BESS have been installed in 36 homes as part of a 2-year long trial that assesses the impact they have on the network. preliminary data analysis has shown that forcing the batteries to charge/discharge at their maximum rate during peak generation and demand is more beneficial than a threshold charging scheme and can lead up to 50% reduction in peak export and up to 70% reduction in peak demand.

Paper 0091 assesses the use of stationary energy storages operated by intelligent software to find optimal operation modes and to adapt it to the changing load conditions in low voltage networks. During the project it has been shown that the proposed algorithm performs under computer simulated circumstances as expected. In addition, hardware experiments by using a 30 kW/100 kWh vanadium redox flow battery and an adjusted low voltage grid shows the capability of the control software under realistic conditions

Paper 0196 presents two novel charge scheduling algorithms for EVs that distribute EV power demand pro-actively in order to prevent network congestion and voltage limit violations. Simulations and tests performed with real hardware confirmed the correct execution of the algorithms' control architecture and its potential to mitigate asset overloading. The results obtained regarding the integration of a VRFB indicate that a BESS can increase the hosting capacity of a LV network considering uncontrolled charging of EVs.

A model of solar CCHP system considering energy storage is proposed paper 0430. Three evaluation indexes of energy, environment and economy are set up by taking the split supply system as the reference object and using judgment matrix method to establish a comprehensive evaluation index. A two-level optimization strategy is used to optimize the capacity design and operation strategy of the system, and the outer layer adopts swarm search algorithm to optimize the capacity of the equipment.

The project described in paper 0644 aims to solve congestion problems in the network efficiently while maintaining the voltage quality within the Dutch standard boundary limits. This is achieved through the purchase of the required flexibility from the local flexibility market based on price. In addition to that, the variable connection capacity mechanism is also introduced that allows the DSO to manage the network's congestion efficiently. In this paper, the importance of smart battery storage for testing the proposed concepts is discussed.

Paper 0936 proposes a practical adaptive decentralized controller that, constantly adapts the charging and discharging power rate of the BES system throughout the day, so that reverse power flows are significantly reduced whilst still reducing customer grid imports. Its performance is assessed on a real Australian medium voltage feeder with realistically modelled low voltage networks and smart meter data. Results highlight that the proposed AD controller overcomes the limitations of the OTS by mitigating technical issues while still bringing similar reductions in electricity imports.

In Paper 1065 the authors present knowledge acquired from 2 years of experience operating a MV Storage unit in the Portuguese grid. During this time, the ESS system went into islanding mode several times due to unplanned grid outages. These real cases of successful and unsuccessful islanding operation are the focus of the paper.

Paper 1413 demonstrates the modelling and analysis of ES as a non-wires alternative in stacked-services and the associated distribution system impact and value on a real high-DER penetration utility feeder located in Southern California, USA. The modelling and analysis of stacked reverse power flow limiting, voltage regulation support, and bulk/market services are presented. The research shows that wholesale market participation can constitute of notable portion of the ES revenues and thus, can determine whether a storage investment is cost-beneficial. However, detailed and accurate feeder models and data are required for assessing ES stacked-services on high-DER penetration feeders.

Paper 1481 presents results and findings from deployment and operation of a large-scale battery storage unit connected directly into a MV distribution grid in the Czech Republic. Furthermore, it offers an input for discussions about the approach of Distribution System Operators (DSO) towards this type of grid element.

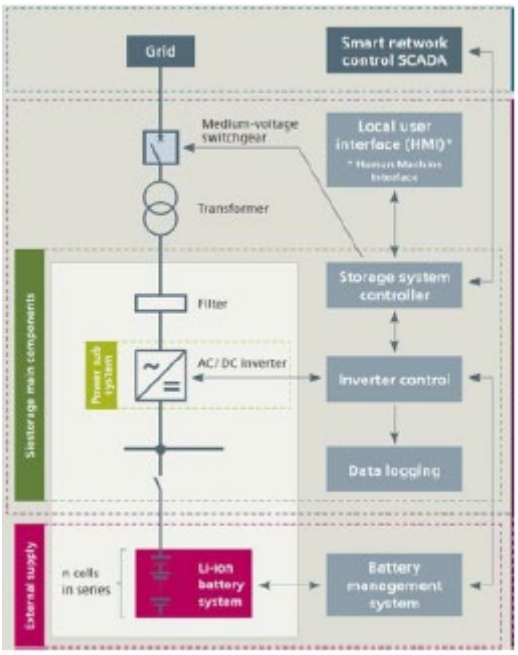


Fig. 13: Simplified diagram of BESS (Paper 1481).

Paper 1577 presents the impact of residential batteries and their charging strategies on an LV network simulated using the Smart Operation tool. Additionally, this paper presents the impact of forecasting errors on the battery control strategies.

Paper 1599 analyses the value of coupled PV-plus-ES systems for a project in northern California. A critical ES breakeven cost is proposed as an indicator of the feasibility of PV-plus-ES. Degradation is shown to be a key driver of PV-plus-ES system capacities when maximising a system's net present value (NPV).

Paper 1745 presents results to show that LV ANM can be used as a short or long-term alternative to network reinforcement by demonstrating the automated control of the power output of battery storage systems in domestic properties, in response to the power flows monitored at the distribution transformer. The solution presented acts as a platform for the control of aggregated distributed energy resources (DERs) and this has been demonstrated in live operation.

Paper 1763 presents an optimal management system for a Battery Energy Storage System (BESS) providing demand peak reduction to its local electricity distribution network. This optimal energy management system (EMS) is based on a Material properties Model (MPM) of the BESS, enabling the EMS to take advantage of continuously updated information describing the BESS's parameters. The EMS schedules the charging/discharging of the BESS in such a way that it minimizes the battery degradation and the operational cost, and maximizes the BESS's efficiency. The EMS is tested using real-world data and uses information about local Distribution Use of System (DUoS) charges when creating the operational schedules for the BESS; the impact of these charges, and their variation in different regions, on the operation and profitability of the system are investigated.

Paper 1764 presents experiences and findings from the NINES project regarding BESS's operation, utilisation and efficiency (energy losses). The main project objective was to reduce peak demands to be met by conventional generation and also to increase the demand at off-peak times, providing additional headroom for non-firm distributed generation, i.e. ANM Controlled Generation (ACG) through the use of a 1MW, 3MWh Battery Energy Storage System (BESS). The constraint rules that limit the ACG export are discussed alongside practical issues around charging the BESS in response to the ACG curtailment.

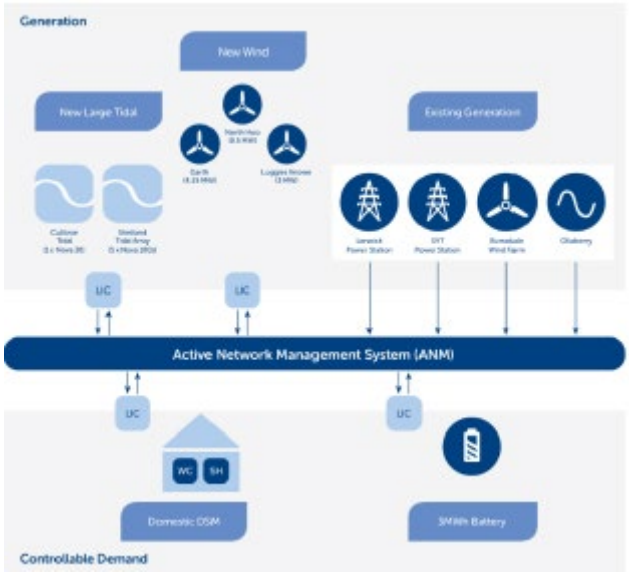


Fig. 14: NINES Active Network Management System (Paper 1764).

Paper 1769 presents project results showing that energy storage applications are a key tool to enable the flexibility required for the energy transition and can provide benefits to the grid as well as the end user. The project aimed to demonstrate that the 2030 EU energy policy targets are achievable, and that distributed energy storage has a crucial role enabling such ambitious targets. The conclusions, which are underpinned by KPI results, prove the impact of energy storage on the energy system of the future.

Paper 1816 introduces a new local voltage control scheme that uses both active and reactive powers so as to address the problem of voltage regulation in distribution networks with a high penetration of renewable energy sources. This scheme uses information regarding the R/X ratio of the lines to enhance the effectiveness of traditional droops in case of lines with non-negligible resistance. The proposed method emphasizes preventing unnecessary active power exchange with the grid during admissible voltage ranges whilst also achieving the best results for more severe voltage deviations. The proposed method is tested on LV and MV benchmark networks and a comparative analysis to existing local methods is performed.

Paper 2069 analyses the impact of batteries in the hosting capacity of a low voltage grid with prosumers with photovoltaic generation installed under different scenarios. Storage location in the grid has been selected with the criterion of reducing congestion. Two scenarios have been considered: the first with current demand of consumers in the grid and the second by increasing their demand profile proportionally, whilst maintaining the daily load curve shape, until a congestion situation is reached. Simulation of increasing PV generation and storage capacity is performed until a congestion is given, resulting for the first scenario an increase of 140% of PV production is achieved with 100kWh of storage. In the second scenario 230 kWp of maximum hosting capacity can be achieved with 400kWh of storage.

Paper 2135 develops a linear optimization model to solve the multi-domain allocation and positioning problem for different energy storage and conversion technologies in an existing urban energy system, considering households and industrial prosumers. The results show, how an urban energy system with a high share of renewable generation can relieve the higher-level electrical grid by ensuring a more decentralized generation-load balance. The optimal allocation of multi-domain distributed storage and conversion technologies is investigated for different stakeholder viewpoints and show benefits regarding the energy import/export balance and CO2 emissions.

Table 3a: Papers of Block 3, Sub Block 1, assigned to the Session

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
20	Analysis of the optimum allocation of BESS for contingency support				x
69	Grid-friendly Operation of a Hybrid Battery Storage System		x		
81	Distributed Storage and Solar Study				x
91	Autonomous and cost-efficient operation of a stationary battery energy storage in low voltage networks				x
196	Scheduled charging of electric vehicles and the increase of hosting capacity by a stationary energy storage				x
430	Optimal Capacity Design for Solar-assisted CCHP System Integrated with Energy Storage				x
644	Integrating Smart Storage and Aggregators for Network Congestion Management & Voltage Support in a Pilot Project in Eindhoven		x		
936	Residential Battery Controller For Solar PV Impact Mitigation: A Practical and Customer-friendly Approach		x		
1065	Two Years of Battery Energy Storage System performance in automatic islanding in the Portuguese MV network				x
1413	Impact and Value of Energy Storage on a High-DER Penetration Distribution Feeder in Southern California		x		
1481	Experience from Deployment of Battery Storage in Czech Distribution Grid				x
1577	Case study for understanding impact of residential batteries on LV grids				x
1599	Combined Solar Photovoltaic and Energy Storage Sizing in Constrained Distribution Networks		x		
1745	Demonstrating the Control of Aggregated Domestic Battery Energy Storage Systems for LV Network Efficiency				x
1763	Incorporating Ageing parameters into Optimal Energy Management of Distribution Connected Energy Storage				x
1764	Utilisation of Energy Storage to Improve Distributed Generation Connections and Network Operation on Shetland Islands				x

1769	Energy Storage and Energy Management in Distribution Grids, Communities and Buildings: Results from SENSIBLE, a Flagship Project				x
1816	Local Voltage Control Strategies for Storage Systems in Distribution Networks with a High Penetration of Inverter-Based Generation				x
2069	Impact of batteries in the hosting capacity of a grid with photovoltaic generation				x
2135	Optimal allocation of energy storage and conversion technologies in an urban distributed energy system		x		
	Totals	**0**	**6**	**0**	**14**

Sub block 2: Distributed Generation, Electrified Transport and other DER

Paper 0021 discusses the results of a thorough statistical analysis of a real PEV fleet data to identify their commuting and charging patterns, the number of connections by charging level and the charging frequency per week as main parameters to understand how they will influence the network. In that regard, a methodology based on the Poisson process and the Monte Carlo method to generate a random series of aggregated charging profiles in case of unavailability of real data that can be used to perform network studies is proposed. Finally, the methodology is validated through a series of simulations and the outcomes are discussed.

Paper 0075 presents results of PSCAD simulations of a multi-objective ANM scheme during grid-connected operation of Sundom Smart Grid. Conclusions are stated related to preventing unwanted MV and LV network reactive power / voltage control interactions and potential mutual effects between voltage, frequency, and control functions of DER units which are actively participating in the ANM scheme.

Paper 0104 presents a new strategy to improve the economic, technical and environmental aspects of distribution systems (DSs). This strategy depends on using both different types of the distributed generation (DG) units and capacitor banks together to accomplish the best level of improvement with reasonable cost. The problem is formulated through a multi-objective function, where the DG dynamic output and load variations are considered. Different constraints are considered including the number of units, the total DGs capacity, the total capacity of capacitor banks, voltage limits at all buses, and operating hours of diesel units. The genetic algorithm (GA) optimization technique is used for identifying the optimal allocation of units. The proposed framework is evaluated using IEEE 33-bus typical system. The results indicate better performance of the system with the use of the combination of DG types and capacitor banks.

Paper 0334 describes the largest innovative multifluid microgrid pilot in South East Asia and the associated use cases enabling safe control and optimal operation of DER.

Paper 0480 develops an optimal load control strategy considering end-user comfort with a focus on air conditioning, electric water heater and lighting load. The paper presents an equivalent thermal parameter model of temperature-controlled load by taking into account diversified load types. A temperature-controlled load polymerization model is then developed based on Monte-Carlo method. Finally, an optimal load control strategy is modelled by a multi-objective optimisation problem, which takes into account end-user comfort and the errors in load adjustment. The effectiveness of the proposed optimal control strategy is tested by case studies.

Paper 0518 introduces the active and reactive power technique for power management using a single-phase inverter connected with the utility grid and maximum power point tracking (MPPT) for renewable energy sources, such as Wind-Turbine (WT) and Photovoltaic (PV) panels. The dead-beat control algorithm is utilized to control the active and reactive power injected into the grid. The dead-beat control algorithm is based on discretized equations in (α-β) stationary reference frame transformation. Resistive and inductive loads are connected with the micro-grid system, and illustrated their influence on the performance of the inverter. The maximum power point tracking algorithm is introduced to insure the most utilization of the available powers to feed the required loads and the grid power, as a part of the proposed management system.

Paper 0539 introduces a decision-making process enabling network operators to unlock the necessary flexibility for congestion management in an operational environment. This model relates the cost of an over-loading and the financial risk of a blackout to the price a distribution system operator is willing to pay for flexibility.

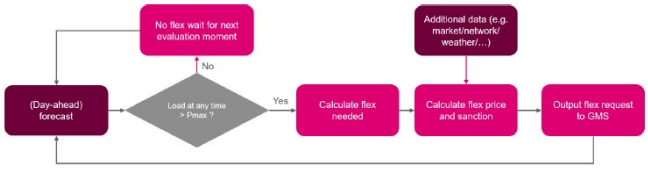


Fig. 15: Decision making process from Paper 0539.

Paper 0566 focuses on the holistic economic optimization of the operation of a sector-coupled system. Initially, the load flows of all sectors are calculated independently of each other and then combined into a composite. Subsequently needed actions are evaluated and unused reserves identified, followed by economic optimization.

Paper 0627 investigates the effect of repairing fault periods (RFP) on the DG optimization process. Comparisons between optimal DG allocations on low voltage (LV) distribution network based on normal operation period (NOP) only and considering both NOP and RFP are comprehensively introduced. Also, the paper presents a choice preference between inserting DG units near the distribution transformers or at the consumer locations regarding RFPs during the optimization process. A two-part objective function is developed based on energy losses reduction and voltage improvement.

Paper 0993 discusses electric vehicle (EV) charging control in apartment buildings in cases of high EV penetration. The introduced control method for EV charging utilizes real-time measurements and memorized peak power consumptions to determine a suitable charging

power. The aim of the control method is to avoid an unnecessary increase to the peak powers of the whole property, while still allowing EVs to be charged sufficiently. This kind of control method could lead to cost savings if the power-based distribution tariff of distribution system operators (DSO) included a price component based on monthly peak power.

Paper 1120 proposes an application of multi agent system to drawing coordinated behaviour from many controllable customers' appliances in order to support primary control and secondary control by modulating the consumption power of customers' appliances. A problem caused by the load control system is unfairness in use of customers' appliances if the assigned ranges of frequency deviation are fixed to specified customers' appliances. In order to solve the problem, an application of average consensus algorithm (ACA), which is a method for multi agent system, to the load control system is proposed.

Paper 1150 identifies the key technical and economic aspects for the proactive integration of EVs into electricity grids as providers of flexibility services through a review of the technical aspects addressed in literature, analysing EV impacts and smart charging strategies at various levels of the power systems.

Paper 1156 focuses on Web of Things (WoT) concept as a possible enabler of uniform machine type access to DERs. The results of the paper provide a blueprint of WoT adoption patterns in smart grid domain through the example of microgrid management system (MGMS). The paper delivers work-in-progress implementation of the metadata registry that facilitates the automated service-oriented discovery of MGMSs by aggregator management systems for purposes of market and grid.

Paper 1217 proposes a secondary substation centred control approach which deals with the effective coordination of multiple Distributed Energy Resources (DER) connected along the LV grid. The presented tool manages and schedules the flexibilities (i.e. active and reactive power injection or absorption) provided by DER in order to address over voltages or voltage sags, while minimizing operational costs. The methodology is based on a three-phase multiperiod optimal power flow.

Paper 1334 reports on the Innovate UK funded Smart Hubs project which is addressing the inefficiency and missed opportunities that result from uncoordinated installation of DER. A description of the system structure centred on a central DC-bus and the connected subsystems is given. The emulation of subsystems for testing purposes is described along with interfacing and safety considerations. A rationale for energy management strategies is presented. Modelling of the energy flows in the Smart Hub is used to illustrate possible operational scenarios.

Paper 1365 presents a multi-objective ESS capacity configuration model under the application mode of peak shaving to optimize the equivalent load, by analysing the fast charging load and intermittent photovoltaic (PV) output connected to a combination PV and EV charging station.

Paper 1496 describes proposed, implemented, tested and verified technical solutions supporting distributed energy resources (DER) integration in the distribution grids. New approaches for PV inverters control are introduced in a way that DER integration is less limited by voltage constraints or other grid issues. Different approaches for LV and MV grids are explained. Smart solutions including autonomous functions of PV inverters, remote control or energy storage are presented to show the future potential for successful DER grid integration.

Paper 1505 addresses the practical integration of renewable energy systems in power supply as well as alternative drives in the transport sector. Two methodical approaches for evaluating the grid reserve capacity are introduced.

Paper 1517 presents a case study of three different approaches to mitigate localized voltage issues – smart PV inverters with Volt-VAr functionality, on-load tap changers and battery systems. An actual 11 kV distribution feeder of a utility in Delhi, India is modelled, incorporating the low-voltage 415 V network, to present realistic voltage estimates. Load growth and solar PV capacity growth scenarios are included to understand the expected operational challenges of rising solar PV penetration levels. A practical estimate of the cost associated with each mitigation technique against the expected benefits has is reported.

Paper 1526 presents, an Automated Demand Response System (ADRS) project's results and lessons learnt from the first year of operation, while briefly introducing the system's architecture. The results show the adequacy of the system to reduce the variability of the demand and to promote better standards of energy efficiency. In addition, the system is effective on helping grid operator tackling contingency situations in the network.

Paper 1542 develops a close-to-real-time energy management system for a smart multi-family residential building with PV production and energy storage systems. The model aims to control the operation of controllable residential appliances to minimize the total energy procurement cost while ensuring the users' satisfaction. A mixed integer linear programming model is developed to solve the optimization problem in a rolling time window.

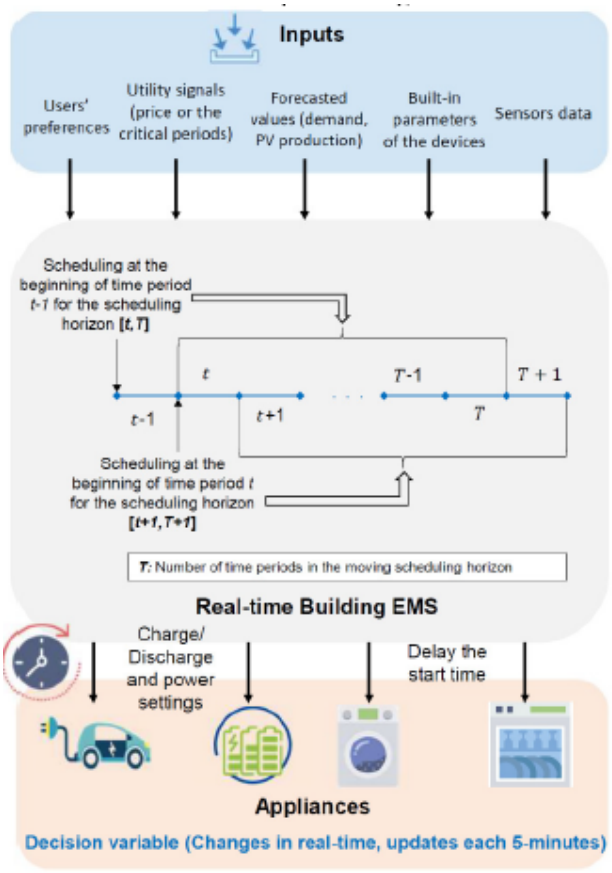


Fig. 16: Model used in Paper 1542.

Paper 1571 describes the results of the implementation project "eTaxi in Vienna". In this project the effects of switching from conventional taxis to electric taxis in an urban area are investigated. Analysed of whether there are differences in driving distances and driving times of electric taxis compared to conventional taxis. It is found that the operation of a taxi fleet with electric vehicles is already possible under today's conditions. The biggest challenges at the moment, however, are not technical barriers, rather a multitude of organisational, regulatory and economic problems.

Paper 1607 highlights the opportunity for combined implementation of advanced Energy Management, DER management systems (DERMS) and DSR in behind the meter C&I situations. The paper draws out the results of development and implementation of real time and historic energy dashboards, two DSR service opportunities available in the UK market and an analysis tool for annualized value of DSR and DER implementation. The paper concludes that emerging IT and DERMS technological solutions are a good fit for the C&I market; that configurability and extensibility for DER, DSR and Dashboards is particularly valuable given the ongoing changes in the energy sector; that integration of energy/DER/DSR with factory production scheduling; and that modest but clear financial benefits area available from the demonstrated use cases and several other use cases.

Paper 1615 describes the Grid Flexibility 4 Chile project, a lighthouse project focused on improving power system flexibility through Demand Response, which provides a mechanism to modify power demand in response to grid signals using OpenADR communication protocol.

Paper 1647 presents a study to determine if the electrical railway network could be successfully integrated and used to charge electric vehicle (EV) batteries at station park-and-ride facilities. The results through modelling and simulation showed that a compromise is possible but the charging uptake has to be limited to allow trains to be properly powered. The AC railway voltage levels were maintained above the lowest permanent voltage value in most cases but it was observed that in scenarios of high train numbers incorporated with extended EV numbers, a limitation in the system will be highlighted in terms of voltage drop.

Paper 1687 investigates the voltage violation problem that might arise from the integration of a large-scale PV system into a distribution network in Noordwolde, the Netherlands. Subsequently, a sequential control scheme is proposed that coordinates reactive power absorption and active power curtailment of PV inverter to mitigate such problem. The proposed control is locally performed at the inverters and does not require an extensive communication system. Its performance is compared with the control scheme employing only reactive power absorption or active power curtailment.

Paper 1716 gives an overview of the MW-level microgrid case in Marjamäki in which all the production units and battery energy storage are connected to grid through an inverter. The focus on the paper is on modelling and simulation of transient dynamics at the time of islanding while there are no rotating AC machines for frequency nor voltage references. The industrial-type microgrid operates on medium voltage level. Based on the results, it is evident that with the chosen control method the energy storage is capable of supplying the needed active and reactive power while adjusting only its output voltage magnitude and thus, makes islanding possible. With the adopted method in this paper, the master and all the slave units can operate independently just monitoring their output values so that communication between the units is not needed.

Paper 1740 proposes the system dynamics and stability as a criterion for choosing a microgrid control strategy. This is explored into the microgrid composed of photovoltaic and battery energy sources, as well as constant impedance load. The influence of inner current control loop parameters on microgrid dynamics, for both droop control and hybrid V-f and PQ control, is achieved through Small-signal stability analysis. The obtained results determine the

proper control strategy from stability limits of two control methods established in the left half complex plane.

Paper 1751 describes the development of the Aggregation Platform for Flexibility (APF: a software solution that empowers aggregators to create a powerful Virtual Power Plant (VPP) that is able to quantify the current and future flexible capacity of a cluster of DERs. The APF enables the aggregator to optimize the trading of flexibility of DERs, such as electric cars, batteries and solar panels, to be utilized in both energy markets as well as ancillary service markets. With the APF the value of flexibility can be maximized by performing value stacking of flexibility, which improves the business case of the aggregator.

Paper 1766 gives a concise literature review of inverter controller optimization with respect to stability and power sharing in microgrids. Then controller parameters are optimized for an existing rural low voltage grid with several battery storage systems utilizing a genetic algorithm. The new feature is that not only controller parameters are optimized, but also the choice of the controller type, such as grid-forming and grid-supporting droop control. The results underline that using different inverter controller types in one microgrid improves the stability and power sharing.

Paper 1830 presents a methodology in the context of Peer-2-Peer exchange in microgrids. The obtained results showed that the implementation can enhance the system resilience without compromising the economic benefits and the carbon emissions reduction.

Paper 1853 presents a Model Predictive Control (MPC) tool for a DC microgrid that allows to perform multiple control objectives, like voltage regulation, power sharing and energy storage management, at the same time. The proposed tool is based on optimization and its performance has been tested with good results both in simulation and on a real low-voltage DC microgrid.

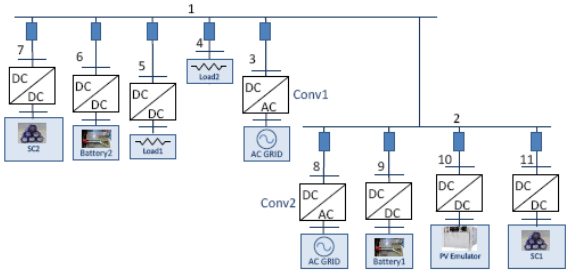


Fig. 17: LV DC microgrid used in Paper 1853.

Paper 1854 describes the transactive demand-response project called The Grid Edge Active Transactional Demand Response (The GREAT-DR. This project gives Prosumer participants at the edge of the grid better control of their electric usage while helping optimise and secure the grid. The impacts of new technologies installed at the grid edge, a description of the general architecture, the results of phase 1 to date and introduction to the new concepts being added in phase 2 are described.

Paper 1855 presents a technical-economic evaluation of the allocation of EV charging stations in a Brazilian University. This study is carried out initially aiming to evaluate the allocation charging points in strategic places of the campus and to analyze the economic viability of the project for the university and the feasibility of the differentiated tariff of the university for the drivers. Thus, the net present value (NPV), the internal rate of return (IRR) and payback period were considered as metrics to evaluate the investment. The results show that in the university under study both level II and fast charging stations can be considered economically feasible, but with better performance of level II type.

Paper 1916 presents the assumptions necessary for the proposed method and describes a state-of-charge (SOC) management plan and a concept of critical SOC for EV charging requests. In addition, a V2G operation scheme for frequency regulation is defined and classified according to the charging requests. Finally, the simulation results using PSCAD/EMTDC and analyses are presented to verifying the effectiveness of the proposed methods.

Paper 1946 summarizes experience from many demand response field trials. It gives an overview of several field trials for modelling and control of both aggregated electric loads and individual sites. It also considers district heating in order to complete the energy balance. The tests comprise different residential houses and large industry. The paper also discusses field trial design, implementation and lessons learned.

Paper 1956 presents a project, which aims to improve the efficiency and the hosting capacity of distribution networks in a context of highly distributed renewable generation by introducing flexibility (storage management) and control in the low voltage (LV) grid. The analysis methodology - which follows the Smart Grid Architecture Model (SGAM) framework paradigm- is presented, along with the identified use cases and actors.The proposed initial architecture is also presented, as derived from the use case analysis process together with a cybersecurity analysis of integration and interoperability issues.

Paper 2043 continues previous studies into islanded grid operation, considering areas as potential microgrids operated by a DSO at MV level and needing SCADA observability for operation.

Paper 2067 provides an overview on the most common connection arrangement, or Principle of Access (PoA), in the UK as well as present a simplified method to connect and manage devices based on voltage sensitivity estimation, which is computationally viable with

considerable improvement on curtailment efficiency when compared with other PoA. In the proposed strategy, the computation burden is shared among the Active Network Management (ANM) software and participating controllable devices, enabling the solution to be applied to a more realistic distribution network automation scheme.

Paper 2080 introduces two methods that underpin a UK project – Network Optimise and Primary Connect – and presents use-cases for their application. It also gives an overview of the site selection methodology for the four project trials and outcomes of the site selection process.

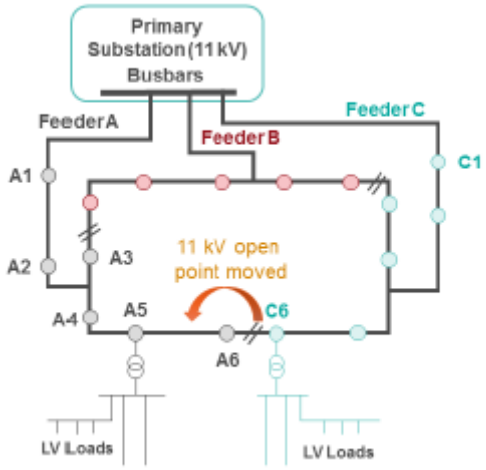


Fig. 18: Network Optimise Principals (Paper 2080).

Paper 2238 introduces a design for several modified interconnected nanogrids via a dc-link within a multilevel direct current (DC) system that called an open energy distributed system (OEDS). Each nanogrid includes a SBI with a contribution towards improving its performance by offering a new model-reference closed-loop control technique for its dc-link voltage. It also includes a controller technique for the proposed interconnected nanogrids to achieve the optimum power flow with high reliability.

Paper 2274 focuses on quantifying the impact that various active power management control schemes have on PV production and curtailment. Active power management and the systems that support it could be considered "non-wires" alternatives to traditional "wires" upgrades. The full suite of wires and non-wires solutions provide utilities and PV developers with flexible interconnection options.

Paper 2285 describes the outputs from a working group that developed reference control methods for mapping DER group-level to device-level functions. This includes a reference set of functions to enable modelling and the technical analysis needed to study the business case / value proposition of DERMS. It also provides a baseline set of functional requirements for DERMS products and its specification that enables consistency in DERMS request for procurement (RFP) across the industry. Finally, as different reference control methods are documented through this initiative, it identifies gaps in the relevant communication standards upstream and downstream of DERMS by evaluating their sufficiency to support reference control strategies.

Paper 2286 presents the results of a modelling study that assesses the potential of using distributed energy resource management systems (DERMS) to control the reactive power of distributed energy resources (DER) to improve hosting capacity. The baseline for comparison is fixed power factor control. This paper considers the ability of DERMS to apply locational and time-varying reactive power settings and quantifies the resulting distribution hosting capacity benefits.

Paper 2309 describes the smart grid architecture and main functionalities put in place in the Italian pilot of San Severino Marche. A major focus regards the strategies implemented to optimize the medium voltage grid configuration: a genetic algorithm, a Monte Carlo method and a heuristic approach are used and benchmarked against an exhaustive research.

Potential scope of discussion

Block 3 discusses various forms of DER and techniques to optimise their utilisation, through placement or operational principals. Discussion around this block on Optimisation and processing of data are key, and will be further explored in the Round Tables.

Table 3b: Papers of Block 3, Sub Block 2, assigned to the Session

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
21	Stochastic Generation of Aggregated Charging Profiles of PEVs for the Operation Analysis of Low Voltage Networks				x
75	Multi-objective Active Network Management Scheme Studied in Sundom Smart Grid with MV and LV Network Connected DER Units				x
104	TECHNICAL PERFORMANCE ENHANCEMENT OF DISTRIBUTION SYSTEMS VIA OPTIMAL DG DEPLOYMENT				x

334	SPORE multifluid microgrid tests and results in the tropics		x		
480	Optimal Power Load Control Strategy Considering End-user Comfort				x
518	MPPT and Dead-Beat Control for Power Management of Hybrid Micro-Grid Applications				x
539	Flexibility for congestion management: An operational decision making process				x
566	Optimized economical and technical sector coupling under consideration of defined incentives				x
627	Optimal DG allocation in LV distribution networks considering repairing fault periods				x
993	Control of EV charging to reduce peak powers in domestic real estate				x
1120	A Proposal of Average-Consensus-Based Load Control Reducing Unfairness in Use of Customers' Loads				x
1150	Electric Vehicles as flexibility providers for distribution systems. A techno-economic review.		x		
1156	Uniform Web of Things based Access to Distributed Energy Resources via Metadata Registry			x	
1217	A centralized control for the operation of low voltage distribution networks with multiple Distributed Energy Resources				x
1334	Smart hubs – DC interconnection and management of PV, EV and ESS			x	
1365	Energy storage capacity configuration of electric vehicle charging station with PV under peak shaving mode				x
1496	Technical Solutions for Increasing DER Hosting Capacity in Distribution Grids in the Czech Republic in Terms of European Project InterFlex		x		
1505	Potential Analysis for the Integration of Renewables and EV Charging Stations within a Novel LVDC Smart-Trolleybus Grid				x
1517	Voltage Control in Distribution Feeders with High Solar PV Penetration: Case Study for Different Approaches.				x
1526	LISCOOL – A Demonstration Project of an Automated Fast Demand Response Management System: Main Outcomes				x
1542	A rolling horizon approach for the optimal real-time dispatch of energy sources in smart residential buildings				x
1571	Results from the project "eTaxi for Vienna" concerning the integration of EVs in the distribution grid		x		
1607	Integrating DER Management Systems into Industrial Energy Management - Deployment Results		x		
1615	Grid Flexibility 4 Chile				x
1647	INTEGRATION OF ELECTRIC VEHICLES AND RAILTHROUGH PARK-AND-RIDE INFRASTRUCTURE				x
1687	MITIGATING IMPACT OF LARGE-SCALE PV INTEGRATION ON MV DISTRIBUTION NETWORK WITH SEQUENTIAL CONTROL FUNCTIONS: A CASE STUDY IN NOORDWOLDE GRID, THE NETHERLANDS				x
1716	Case study on commercial sized MW-level microgrid				x
1740	Inner current control loop influence on islanded microgrid dynamic behavior				x
1751	Maximizing the utilization of DERs with the Interflex Aggregation Platform for Flexibility				x
1766	Small-Signal Stability Optimization of LV microgrids with Grid-forming and Grid-supporting Inverters				x
1830	Resilience improvement from P2P EMS in microgrids considering faults, carbon emissions and economic benefits				x

1853	Model Predictive Control for the Management of DC Microgrids				x
1854	Transactive Demand Response—Hydro Ottawa Experience				x
1855	Economic Feasibility Study of the Implementation of PEVs Charging Stations at a Brazilian University				x
1916	Vehicle-To-Grid Based Frequency Regulation Method In An Isolated Microgrid Considering Charging Requests Of Electric Vehicles				x
1946	Demand response field trial experiences				x
1956	RESOLVD - Renewable penetration levered by efficient Low Voltage Distribution grids. Specifications and use case analysis.				x
2043	MV microgrids –case study				x
2067	SIMPLIFIED VOLTAGE SENSITIVITY BASED CURTAILMENT FOR ACTIVE NETWORK MANAGEMENT IN DISTRIBUTION NETWORKS				x
2080	Active Response to Distribution Network Constraints			x	
2238	DC-Based Interconnected-Modified Nanogrids within an Open Energy Distributed System (OEDS)				x
2274	DER Flexible Interconnection Framework and Case Study				x
2285	DERMS Reference Control Methods for DER Group Management		x		
2286	Evaluating the Value of DERMS: Methods and Mitigation to Increase Feeder Hosting Capacity				x
2309	Optimization of distribution network configuration: an experimental testbed in the InteGRIDy project framework				x
	Totals	**0**	**6**	**3**	**36**

Best Young Academic Paper nominees

38 Papers were received in session 4 that qualify for the BYAP award. 19 of these papers received an average grade of 4 or above. The paper selected from Session 4 is:

Paper No.	Title	Submitter Name	1st Author Name	Country
936	Residential Battery Controller For Solar PV Impact Mitigation: A Practical and Customer-friendly Approach	Kyriacos Petrou	Kyriacos Petrou	Australia