Special Report - Session 3
OPERATION

Carsten BÖSE
Chair - Germany
carsten.boese@estw.de

Andreas ABART
Rapporteur - Austria
andreas.abart@netzooe.atm

Helfried BRUNNER
Rapporteur – Austria
helfried.brunner@ait.ac.at

Marie-Cécile ALVAREZ-HERAULT
Rapporteur - France
marie-cecile.alvarez@g2elab.grenoble-inp.fr

Introduction

Since many years session 3 was the session for the topic operation, control and protection. Year by year the number of abstracts increased and at the end 2/3 of the abstracts had to be rejected due to the large number of received proposals. On the other side the integration of renewable and dispersed generation became daily business and was mainly covered by session 4. Aspects of renewable integration had also been discussed in many other sessions. This was an opportunity to distribute the papers about integration of dispersed generation completely into the other sessions and to get a free slot to divide former session 3 into the two new sessions. We know that lots of participants are interested in operation and control, the main sessions of the two new sessions 3 and 4 will not be in parallel and it gives the opportunity to participate in both main sessions.

The split of the session 3 lead also to two new rapporteurs in our session. Helfried Brunner from AIT in Austria was already rapporteur of session 4 and he is now rapporteur of the new session 3. Marie-Cécile Alvarez-Herault from University of Grenoble in France is a new member of the CIRED technical committee. The technical committee of sessions 3 is completed by Andreas Abart from Austria and Carsten Boese from Germany.

Session 3 received 248 abstracts. 41 had been reallocated to other sessions, 43 had been rejected and 164 had been accepted. Finally, we received 147 papers from main authors out of 33 countries and all 5 continents.

The new session about operation of electrical grids has been divided into four blocks (figure 1):

- Strategies and Maintenance
- Operation Center
- Operation in the Field
- New Use Cases & Special Applications

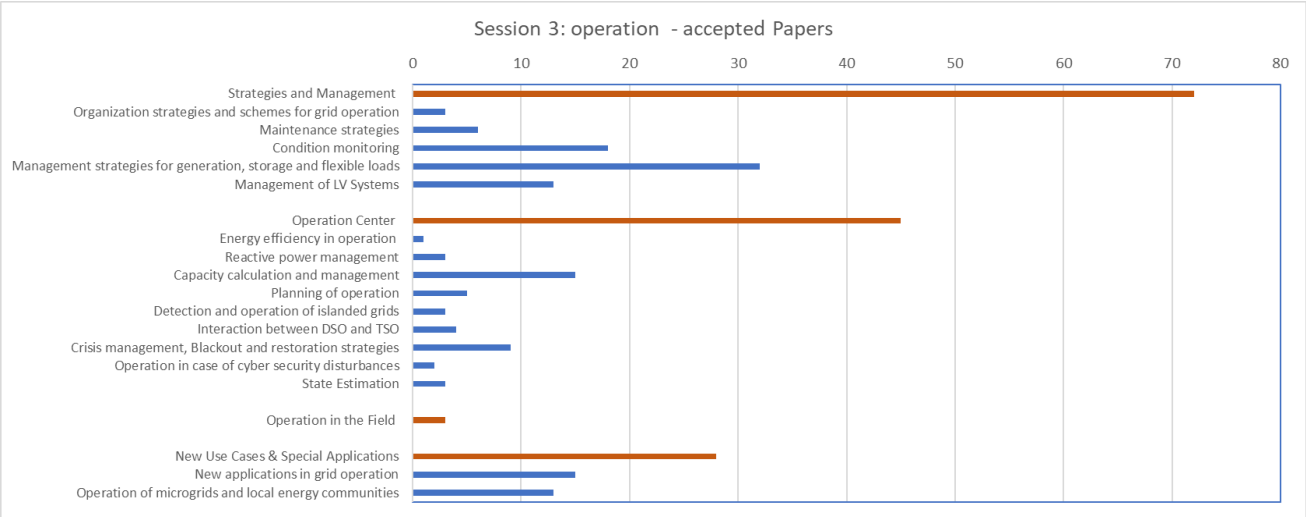


Figure 1: Papers accepted allocated to blocks and subblocks

Nearly 50% of the papers discussing the strategy and management in the field of operation. As expected, the main focus is on the integration of generation, storage and new loads. 43 papers cover the operation center with one focus on capacity calculation. 30 papers show new use cases and only 3 cover the operation in the field.

The review process of papers had been done during one weekend together with the colleagues of session 4 in Graz. The result of lots of interesting discussions was the selection of papers for main session and research and innovation forum.

In the main session the first two blocks cover the strategies and management papers. The third block is about operation center issues and the finally the main session 3 will end with presentations about new use cases.

In the research and innovation forum 12 papers will be presented. In the first part the topics strategies and management as well as the operation center will be shown. The second part will only focus on new use cases.

Additionally, lots of very good papers will only be presented during the poster session.

Block 1 Strategies and Managements

- Sub block 1: Operational strategies and schemes for grid operation
- Sub block 2: Maintenance strategies
- Sub block 3: Condition monitoring
- Sub block 4: Management strategies for generation, storage and flexible loads
- Sub block 5: Management of low voltage systems

Block 2 Operation Center

- Sub block 1: Energy efficiency in operation
- Sub block 2: Reactive power management
- Sub block 3: Capacity calculation and management
- Sub block 4: Planning of operation
- Sub block 5: Detection and operation of islanded grids
- Sub block 6: Interaction between DSO and TSO
- Sub block 7: Crisis management, Blackout and restoration strategies
- Sub block 8: Operation in case of cyber security disturbances
- Sub block 9: State Estimation

Block 3 Operation in the field

Block 4 New Use Cases & Special Applications

- Sub block 1: New applications in grid operation
- Sub block 2: Operation of microgrids and local energy communities

Block 1: Strategies and Management

Sub block 1: Operational strategies and schemes for grid operation

Actually the most challenging issue for DSO's resulting from Energy transition is the voltage rise from DERs. Paper 11073 from Australia provides a method to derive a simplified Operating Envelop with limited monitoring effort, called asset Capacity and delta voltage OE for LV-grids. Voltages are estimated by sensitivity curves. Based on optimized Power flow in paper 11232 from Germany demonstrates a case study for MV-Grids with minimum voltage levels and balance of reactive power at high infeed.

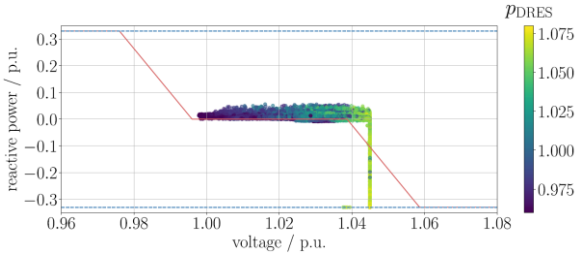


Figure 2: Exemplary DRES: OQF (dots) ad optimized powerflow, regressed $q(v)$ (line)- Paper 11232

Congestions occurring from DER and upcoming loads where reinforcement of the grid is lagging to requirements can cause overloading of lines and transformers. For cables and transformers, a degradation will result in aging and related costs. Paper 11455 from Denmark presents calculation and results for these costs to support the strategies on use of thermal rating.

Sub Block 2: Maintenance strategies

Inspection is one of the major tasks of maintenance to identify, damages or irregularities. Paper 11371 from Brazil reports about ongoing development of an innovative inspection tool with AI using photos and results from high frequency test signals. In Indonesia the gathering of asset's failure history is used for prediction of future performance of components in the network (paper 11060). An overview on maintenance roadmap in Iran is given in paper 11253. To increase the quality of supply paper 10148 presents the Indonesian way of condition and time based maintenance and the use of mobile substation to avoid planned outages during work.

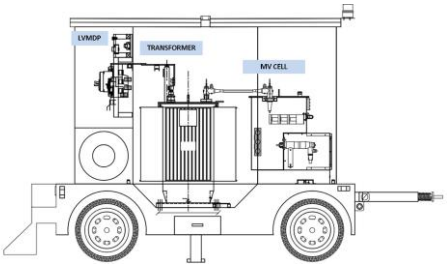


Figure 3: Exemplary DRES: OQF (dots) ad optimized powerflow, regressed $q(v)$ (line)- Paper 11232

Analytics4Vegetation is the strategy for vegetation

management in Portugal including Analysis of pictures from helicopter and drones combined growth models to optimize the scheduling of pruning. Also in France, as paper 10983 reports, every 3 years helicopter flights with advanced Laser techniques LIDAR (Laser Imaging Detection And Ranging) are used to identify the need of pruning efficiently.

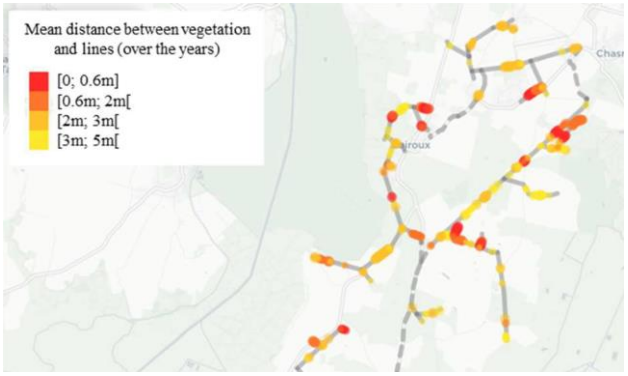


Figure 4: Heatmap of distances between vegetation and lines (in grey), paper 10983

Sub block 3: Condition monitoring

From Germany in paper 10135 a DSO reports about digitizing inspection of 110-kV-lines in respect to vegetation using satellite images combined with drones to detect damages at wires and poles. Authors conclude that relevant parts of manual inspection can be replaced and supported to increase the efficiency.

Figure 5: satellite image for vegetation management and use of drones for inspection of lines and poles, paper 10135.

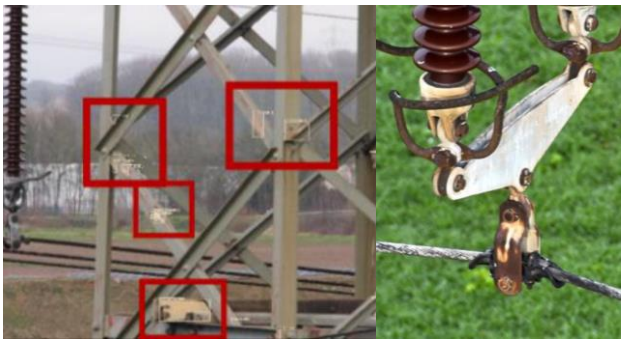


Figure 6: pictures from damages gathered with drones, paper 10135.

Paper 11442 from Portugal also reports about digitized inspection on vegetation based on LIDAR and component's condition with drones. The authors from DSO observed a total saving of inspection costs of 20%. In Malaysia the clearance from Ground is checked with single point LIDAR from drones (paper 10853). Paper 10757 presents a robot like a cable car used on the wires of overhead lines. Authors state, that the solution is just a proto-type to be further developed.

Figure 7: inspection robot on wires, paper 10757.

At a German DSO infrared sensors where installed at a 24-kV-switch gear over two months for monitoring. Results presented in paper 10448 demonstrate load-currents between 30 and 110 A resulting in temperatures between 24 and almost 35 °C. Authors suggest further investigations regarding more details.

For data from monitoring e.g. in substations paper 10456 from German manufacturer and university suggests a digital twin model to easily access the results. Paper 11176 reports about partial Discharge measurements in substations in voltages but also with a camera locating results from acoustic detection. For high voltage disconnectors paper 11118 from Spain reports about an IoT based multi sensor equipment for monitoring to save opex for inspection and maintenance. A vibroacoustic monitoring detecting degradation by deviations from former characteristics gathered by self-learning is presented in paper 10390 from Germany. Another advanced monitoring application is discussed in paper 11460 from France. Pulses from partial discharge in MV voltage branches are used for diagnosis and location resulting into predictive maintenance by condition monitoring.

In paper 10884, from Poland a "Health Index" for cables, joints and termination gathered from partial discharge and tan delta measurements is demonstrated. This index is used for aged equipment to decide about replacement, depending on the condition. Therefrom lifecycles can be maximized. For prediction of faults at joints a wireless solution, empowered by a component harvesting energy from the cable, monitoring temperature and transmitting data in real time is presented in paper 10797.

Figure 8: underground installation for monitoring of joints, paper 10797.

Paper 11065 from Portugal demonstrates a Platform for Real time monitoring to detect broken conductors from voltage and current measurements. Algorithms where even tested as robust against impact from very high penetration of PV-Systems. Also realtime conditions are monitored with the solution presented in paper 10359 from Belgium using orientation and acceleration of sensors for detecting events weather events like wind, icing etc. Also at a DSO in Korea a tilt sensor and an acceleration sensor are used for real time detection of any impact on the equipment (paper 10599).

Figure 9: damages on poles detected in real time with tilt- and acceleration sensors, paper 10599.

Paper 10134, from Germany reports about the successful installation of fully automated inspection of fault location with a drone taking off from primary substation to destination fault, located by travelling wave analysis. This solution saves expenses and mainly time in case of faults.

Sub Block 4: Management strategies for generation, storage, and flexible loads:

Management of distributed energy resources (DER)

Paper 10375 describes the development of innovative functional modules, based on optimal power flow calculations and grid forecasting, dedicated to the predictive management of the distribution grid considering DER flexibility, which are integrated into a commercial SCADA/DMS solution.

Paper 10420 presents a joint energy, reserve capacity and flexibility capability scheduling framework for optimal coordination DERs. A technical virtual power plant (TVPP) supervises and coordinates the DERs to participate in day-ahead wholesale market while meeting the distribution network's reserve and flexibility requirements.

Paper 10471 presents a novel and scalable tool for ancillary services procurement by DSOs. The developed tool takes into consideration the inter-temporal and variable nature of DER in an uncertainty-aware approach.

Paper 10771 proposes an optimization model to manage the flexibility in the LV network to both solving local network problems and aggregating the available flexibility for use at higher levels while satisfying LV network constraints. The model is a tool for the LV DSOs to optimally manage the flexibilities and its features

Paper 10992 compares and analyses the energy system benefits and implications of distributed flexibility operated under three operational coordination strategies: (i) whole-system, (ii) DSO centric, and (iii) non-DSO centric approaches. The study uses the future Great Britain net-zero energy systems as test cases and two heat decarbonisation pathways: hydrogen heating and electrification.

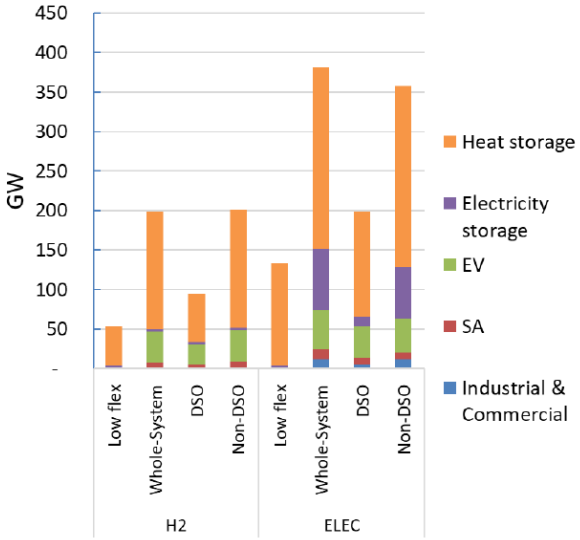


Figure 10: Impact of operational coordination strategies on distribution flexibility requirements - Paper 10992

Paper 11260 presents a co-simulation environment which allows for an investigation of active grid operation. As operation tasks a state estimation and flexibility coordination are implemented, which can be executed independently or in interaction with each other. In addition, the regulatory requirements for the flexibility units of the coordination can be varied.

There has been a lot of research on how to run the grid more efficiently by interconnecting the various energy management systems of the different actors like network operators, energy producers and energy consumers. Paper 11224 presents a snapshot of the related data and communications standards landscape and how it is expected to develop in the future.

Virtual Power Plants (VPPs)

The design of a management algorithm for a virtual energy storage system (VESS) is presented in paper 10427. The algorithm aims to coordinate the operation of VESS components to mitigate the error in the forecasting of renewable generation on Gökçeada Turkish Island (see . Simulation results show that the control actions led to the mitigation of the forecasting error of renewable generation.

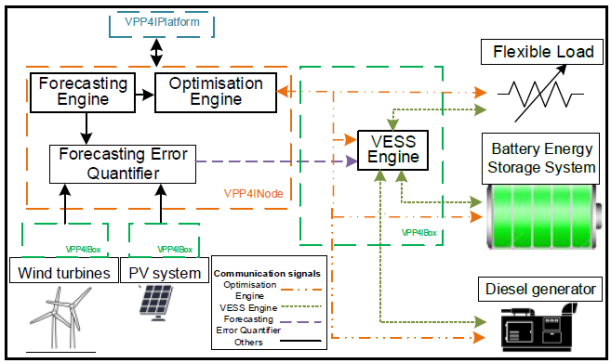


Figure 11: Proposed tools for a VP management algorithm - Paper10427

In paper 10460, a method for evaluating the effect on a grid connected with various VPP resources is proposed. The VPP effect evaluation index (VEEI) for each bus is derived using fuzzy logic. The feasibility of the proposed method is verified through various case studies.

Paper 10818 illustrates two different VPP structures with the purpose of providing flexibility services to the distribution grid. Within the first structure, excess generation is curtailed when the hosting capacity is exceeded. The second structure, as battery energy storage systems, stores and releases energy depending on the market prices.

Paper 11344 investigates in detail the possible provision of aggregated flexibility (VPP) by different technologies but thorough a lens of different business models. Thus, presented work relies on the real use cases. The focus of this work is on the overall architecture (hardware and software) of the demonstrator plant in East Kilbride Scotland and the integration of assets.

Paper 11451 presents the simulation of the operation of EV Charging stations equipped with a photovoltaic solar generation system. The EV charging stations load power curves are compared with PV generation curves. The results are validated taking as reference the electrical data and climatic parameters associated with a microgrid equipped with a solar generation system, EV Chargers and a Battery Energy Storage System.

Paper 11463 tries to solve the optimal power flow using an improved Genetic Algorithm. The optimal flow formulation is oriented to the efficiency of the network, under the boundary restrictions of limited curtailment of the output of distributed generators based on renewables and non-discriminatory behaviour.

Photovoltaic (PV) and loads

Paper 10109 introduces a risk-based approach to improve the hosting capacity of low voltage grids with high penetration of PV. It considers simultaneously the cost of PV's curtailment, cost of voltage violations, and the unfairness of PV's curtailment to obtain a set of different hosting capacity improvement plans. It evaluates the solution minimizing the risk of financial losses (costs) and unfairness of PV's curtailment.

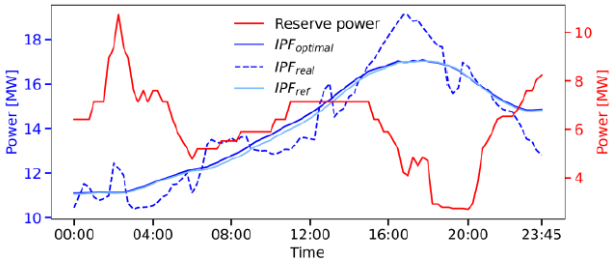


Figure 122: Interconnection power flow (IPF) and reserve power profiles - Paper 11109

In paper 11109 an optimal cross-voltage operation strategy of active distribution networks, considering industrial loads flexibility is proposed to enable the future distribution grid operators to manage the resources optimally to share system balancing responsibility.

Paper 10511 developed and field tested two algorithms for reducing energy exchange and power peaks between the low- and medium-voltage grids caused by photovoltaic generation. It is a reactive rule-based controller and a proactive schedule-based controller. Both controllers require only a limited amount of input data and can achieve their goals of reducing energy exchange and power peaks.

Paper 11348 proposes an energy management system model according to ISO 50001 standards that offers a management solution in the building sector to remotely monitor and analyse home appliances' utility consumption based on energy efficiency and cost reduction to improve the energy performance.

Paper 10168 highlights step voltage regulator (SVR) reallocation to handle load growth in critically operated distribution networks. The benefit-to-cost ratio of optimally reallocating SVR is evaluated compared to other techniques. To guarantee the optimum selection of SVR location in between far distant nodes, modification of a power-flow algorithm is presented in the paper.

In paper 11148 introduces a new type of SVR with a new control method that could address the voltage drop phenomenon. A demonstration test is conducted, using a commercial distribution system selected from various distribution systems.

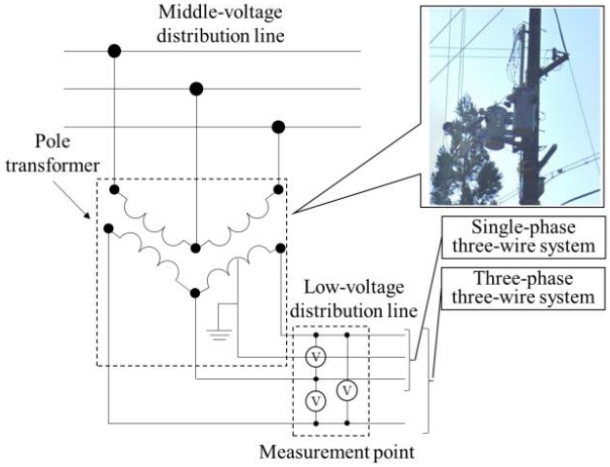


Figure 13: Construction of measuring three-phase voltage though plo transformer - Paper 11148

Battery energy storage systems (BESS)

Paper 10358 proposes an aging model for Li-ion NMC batteries that considers both calendar aging and cyclic aging. In addition, a method to integrate ageing into the control of a bi-service battery introduced. The results presented are based on a real load profile of an industrial test case with a local PV production of 2 MWp.

Paper 10461 presents a study addressing the assessment of the impact of distributed generation and BESS in medium voltage distribution networks and mainly in the operational planning process. The results presented show that some issues must be properly tackled and that better coordination and information exchange between system operators and flexibility operators are needed.

Paper 11342 discusses, how different stakeholders can unlock the potential of BESS. It is achieved by stacking multiple applications in multi-use operational strategies. First different single-use applications are evaluated and requirements when stacking them are discussed. Second, the deployment of investigation scenarios in a close-to-reality co-simulation environment is shown. The focus is on testing and benchmarking developed operational strategies and designed control algorithms.

Paper 11423 outlines technical & commercial challenges associated with integrating BESS with active network management (ANM) systems on a distribution network. It presents examples from SP Energy Networks serving 3.5 million customers in Scotland, England, and Wales.

Electric vehicles (EV)

Paper 10330 discusses the vehicle-to-home (V2H) control strategies to be implemented in a demonstrator in the Azores, Portugal. It includes the design, development and validation of versatile self-consumption control strategies using a rule-based algorithm to coordinate generation and consumption.

Paper 10598 investigates the flexibility potential of EVs regarding home charging operations in a real LV-distribution grid in Germany. For grid service, the charging behaviour is determined by two different approaches with a linear optimization problem to avoid peak loads. To analyse the flexibility potential for further system services, the feasible operating region of the EVs is defined and summarized for the grid using an aggregation method based on the resulting charging behaviour.

To EV power system integration, paper 10489 introduces a cluster-based procedure and control principle, which allows an interpretation of the holistic grid load by monetary incentives based on aging models of main grid assets. An intelligent charging control enables the usage of these incentives to reduce the charging power in a grid serving way.

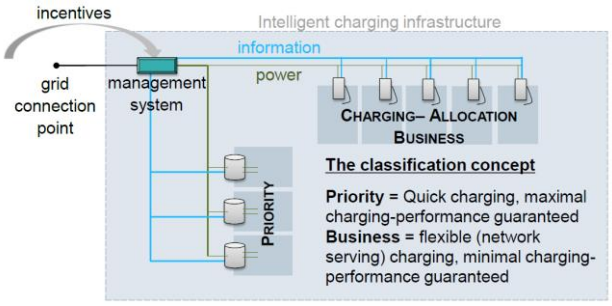


Figure 14: Structure of a class-based charging infrastructure modell - Paper 10489

Paper 10731 discusses the utilization of local RES embedded with public charging stations in addition to the distribution grid to fulfill the daily operational load demand of autonomous EVs. A novel model predictive control (MPC) strategy with mixed integer linear programming (MILP) is developed to address optimal charge scheduling such that charging costs for the fleet are minimized and grid constraints are satisfied.

Paper 10878 investigates a concept that can support the management and control of a set of electric snowmobiles for V2G services in the Arctic. To provide peak shaving assistance for a grid, the project has investigated different foresight methods and has addressed the practicality of the approach developed for a use-case set in a part of Northern Finland.

This paper 11179 presents a performance analysis in the use of EVs fleet in real conditions of operation and maintenance of power distribution networks in emergency activities and technical-commercial services and measured the main impacts on operational needs.

Pape r 11292 introduces an approach for decentralised, semi-autonomous monitoring and management of individual grid cells as well as a prototype of a suitable test and validation system. It is a controller-hardware-in-the-loop environment (C-HIL) for the parameter optimization of grid friendly EV charging control.

Paper 11520 developed a transactive-based algorithm for the collaboration of the EV units in mitigating the network congestion caused by overpower generation/consumption of local resources. The system operator updates the energy price at each EV station considering its connecting point to the network to induce the EVs participation in mitigating the network congestion. Moreover, EV charging stations update their power request considering the received updated energy price from the operator.

Paper 11177 introduces an integrated operation algorithm of the transportation network and power grid, which determines the amount of Demand Response (DR) through power flow results at the upper level and resolves traffic congestion by setting the optimal route for EVs at the lower level

Sub-Block 5: Management of low voltage systems

Paper 10353 presents different clustering algorithms, and their performance of topology detection of low voltage grids is compared. Furthermore, the influence of measurement uncertainties is investigated in the form of a sensitivity analysis.

Paper 10741 investigates the validation of real LV feeder models by using smart meter data. Exploiting the availability of smart meter data, this paper presents a three-step, data-driven methodology to validate electrical models

Paper 10366 paper shows the purpose of phase identification and how it can be implemented in the overall modelling of a distribution network.

Paper 11035 describes the experience with the operation of a smart distribution transformer in a Spanish pilot. The correlation between voltage violations at the transformer substation and unbalanced load consumption peaks has been identified, along with benefits of balancing feeder loads by a correct deployment planning of new loads and distributed generation.

Paper 10458 tackles the solution allowing efficient exchange of sensitive information between the local assets and centralized powerful analysis of the state of the assets. It is shown how to apply Federated Learning distributed technique, including platform and local predictive models which are used in learning the state of the whole grid centrally without sharing sensitive data in huge amounts.

Paper 11049 presents a novel solution integrated into a platform for real-time voltage and active power estimation in low voltage grids. The tool utilizes smart grid infrastructure data, including historical data, real-time measurements from a subset of meters, and exogenous information such as weather forecasts and dynamic price signals.

In Paper 11127, the authors compare the performance and accuracy of the same state estimation algorithm for four wire low-voltage distribution networks using the latencies provided by two very different technologies, namely power line communication and 5G technology.

Paper 11398 formulates a state estimation algorithm for power distribution system, using apparent power, voltage angle and voltage magnitude measurements from smart meters at low voltage residential customers.

Paper 11268 presents an approach for simulating the integration of new flexibilities and DER in a low voltage grid. It is aiming in a better operational management of LV networks.

Paper 10968 includes a technical study on a large sample of LV networks to choose the most appropriate reactive power control for increasing the hosting capacity. It includes details on the choice made by Enedis and the large-scale implementation conditions of the solution.

Paper 11261proposes the use of a load depending voltage regulation on the primary (HV/MV) substation to counteract voltage variation in the low-voltage (LV) grid resulting from PV injection.

Paper 11184 presents the approach, main conclusions, and the benefits of proactively developing an algorithm to identify LV circuits with potential latent neutral losses and defines the criteria for replacing bimetallic terminals before failures occur.

Figure 15: Screw terminals with torque limiter - Paper 11184

Paper 11336 describes the implementation of a demand response system deployed to protect the fuses. It relies on the remote modification of the subscribed powers of smart meters that were installed.

Table 1: Papers of Block 1 assigned to the Session 3

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10109.: Hosting Capacity Improvement in Low Voltage Distribution Networks: A Risk-based Approach				x
10134.: An Automated System for Overhead Line Inspection with Traveling Wave Measurement and Unmanned Aerial Vehicles	x			
10135.: Digitizing Grid And Vegetation Inspection With Remote Sensing And Artificial Intelligence	x			
10148.: On-line Medium Voltage Panel & Transformer Maintenance				x
10168.: Reallocation of Step Voltage Regulators in Distribution Networks to Overcome the Effects of Load Growth				x
10330.: V2X Integration in Self-Consumption Energy Management System				x
10353.: Determination of the Topology of Low-Voltage Distribution Grids using Cluster Methods				
10358.: Integration Of Battery Aging Model In Ancillary Services And Self-consumption Combined Strategies.				x
10359.: DETECTION OF WEATHER INDUCED EVENTS ON THE OVERHEAD POWER LINES	x			
10366.: Phase Identification of Single-phase Users in a Distribution Network				x
10375.: The Next Generation of ADMS Functions for Predictive Management of DER				x
10390.: The Use Of Digital Data For A New Innovative Quality Level Of Asset Management For Transformer				x
10420.: Joint Energy, Reserve, and Flexibility Scheduling of DERs in Power Distribution Networks				x
10427.: A Virtual Energy Storage System to Compensate for the Uncertainty in Distributed Renewable Generation				x
10448.: Thermal Monitoring of Medium Voltage Switchgears: Testing in Operation Environment				x
10456.: A Digital Twin for MV Switchgear Condition Monitoring Data				x
10458.: LV Grid state estimation using local flexible assets: A Federated Learning approach				x
10460.: A Novel Evaluation Method of Virtual Power Plant Effect on Distribution Networks Using Fuzzy Logic				x
10461.: Assessment of the impact of Hybrid Distributed Generation / Batteries Energy Storage Systems on DSO Operational Planning			x	
10471.: Scalable Uncertainty Aware Ancillary Services Procurement Tool For Active Distribution Systems	x			
10489.: Grid Serving Charging Control of Electric Vehicles				x
10511.: Balancing PV Generation In Low Voltage Grids With Limited Data				x
10598.: Investigation of Grid-Serving Flexibility Provision by Electric Vehicles in a Distribution Grid				x
10599.: FEEDER REMOTE TERMINAL UNIT OF DISTRIBUTION AUTOMATION SYSTEM FOR DETECTING IMPACT AND TILT CHANGE APPLIED TO DISTRIBUTION EQUIPMENT	x			
10731.: Model Predictive Control for Smart Grid Charging of Autonomous Electric Vehicle Fleet using Local Renewable Energy Generation				x
10741.: Validating Real LV Feeder Models Using Smart Meter Data: A Practical Experience From Project EDGE			x	

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10757.: Development of a Robotic System for Inspecting Overhead Power Distribution Lines				x
10771.: Optimal Management of Flexibility Services at LV Distribution Grid Level				x
10797.: WIRELESS SELF-POWERED MONITORING SYSTEM FOR UNDERGROUND CABLE JOINTS: A REAL USE-CASE				x
10818.: Flexibility Coordination Mechanism Between A Distribution System Operator And A Virtual Power Plant Involving Wind Parks And A Battery Energy Storage System				x
10853.: Single Point Lidar Technology For Ground Clearance Measurement In Medium Voltage Overhead Lines With The Deployment Of Unmanned Aerial System (UAS) In TNB Distribution Network Division				x
10878.: Using Light Electric Vehicles For V2G services in the Arctic				x
10884.: The New Condition-Based Maintenance of MV Cable Lines Supported by Diagnostic Data				x
10968.: Techno-economic Comparison Of Reactive Power Control Modes For Distributed Generators For Voltage Regulation In LV Grids				x
10983.: Data Analytics For Pruning Optimization Around Power Lines	x			
10992.: Operational Strategies for Maximising the Value of Customer Flexibility	x			
11035.: Distribution Smart Transformer Pilot Experience for LV Grid Real Time Operation				x
11046.: An Impact of Electrical Distribution Networks on the Operation of AC 25 kV Railway System				x
11049.: DeepGrid: Bringing the Operational Awareness to the LV Grid				x
11060.: The Implementation of Linear Asset Management As A Framework Solution In Distribution Electricity Network in Indonesia				x
11065.: A Platform For Real-time Monitoring And Detection Of Conductor Integrity Related Health Hazards In Distribution Networks	x			
11073.: Assessing the Pros and Cons of Different Operating Envelope Implementations Across Australia	x			
11109.: Optimal Cross-Voltage Operation of Active Distribution Networks Considering Flexibility and Production Schedule of an Industrial Customer with Various Business Models				x
11118.: IoT enabled System for High Voltage Disconnector Advanced Asset Management				x
11127.: Performance Analysis of a State Estimator for Low Voltage Unbalanced Grids Using Different Advance Metering Infrastructure Technologies	x			
11148.: Demonstration for New Type SVR Using Commercial Distribution System with DERs				x
11176.: Partial Discharge Diagnostics on Medium-Voltage Switchgears - Measurement Methods and Benefits			x	
11177.: Optimal Scheduling of EVs Route Considering Integrated Power and Transportation System				x
11179.: Performance Evaluation and Operational Logistics in Energy Distribution Utility Fleet Electrification				x
11184.: E-REDES Adopt New Monometallic Technology and Predictive Algorithm to Minimize and Predict LV Neutral Loss Failures Detection				x
11224.: Vision For Smart Grid Interoperability: Standards Based Integration Of E-Mobility, Prosumer, And Grid				x
11232.: Determination of Q(P)- And Q(U)-Characteristics By Means Of Time-Series Based Optimal Power Flow Calculations To Optimize Distribution Grid Operation	x			
11253.: Mapping Maintenance Road on Iran Power Distribution Network				x

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
11260.: Modeling Active Grid Operation In A Testbed For Cyber-Physical Systems				x
11261.: Use of Voltage Regulation on HV/MV Substations to Increase Hosting Capacity in the LV Grid				x
11268.: Simulating Integration Of New Flexibilities And DER In A Low-Voltage Grid				x
11292.: C-HIL Environment for Parameter Optimization of Grid Friendly Charging Control	x			
11336.: Demand Response Using Remote Modification Of Smart-Meters' Subscribed Power To Protect Low-Voltage Feeders In Ouagadougou, Burkina Faso				x
11342.: Investigation of Stacked Applications for Battery Energy Storage Systems				x
11344.: Enhanced Virtual Power Plant Design And Implementation Lessons				x
11348.: An Integrated Approach for Energy Management Optimizations in Customer Premises				x
11357.: How To Control The Vegetation In Overhead Lines? – Analytics4Vegetation				x
11371.: Platform for Traceability and Inspection Management Through the Use of Artificial Intelligence Techniques				x
11398.: Linear State Estimation in Distribution System Using Smart Meter Data				x
11423.: Challenge of Integration BESS on Distribution Active Network Management Scheme				x
11442.: GridDrone: Use of Drones to Perform Thermographic, Distance Measurement and Visual Inspection of the HV and MV Aerial Network				x
11451.: Operation of Electrical Vehicle Recharging Station with a Photovoltaic System to Reduce the Impact on the Distribution Network				x
11455.: A Methodology for the Evaluation of Congestion Induced Costs in Distribution Grid Operation				x
11460.: Optimized Deployment of Online Partial Discharge Monitoring Solutions for Branched MV Networks				x
11463.: An Improved GA-based Approach for Reduced Non-discriminatory Renewable Energy Curtailment				x
11520.: Transactive-based Control of Electric Vehicle Charging Stations Considering Network Congestion				x

Block 2: "Operation Center"

Sub block 1: Energy efficiency in Operation

As the electricity price was rising right before the preparation of this conference and the cost for losses in many countries were affected at the beginning of this year the topic energy efficiency in electricity grids will become an upcoming issue. Actually, only on paper (11089) from Portugal deals with losses depending on the configuration and optimization of configuration to reduce these. The DSO intends to change topology twice a year, following the change of characteristic load flows caused by DERs.

Sub block 2: Reactive Power management

Reactive power management in respect to balancing, increasing the hosting capacity of a grid by voltage control Q=f(U) and control of load flow in transmission grids has been an issue providing a couple of papers at each conference.

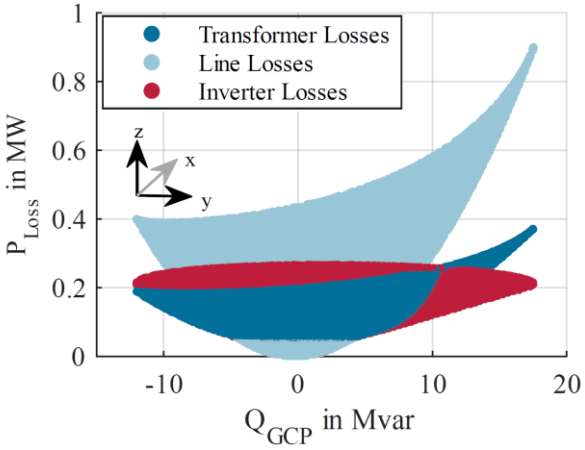


Figure 36: allocated losses in Windfarm (9x1,5 MVA) caused by reactive power supply- Paper 10732

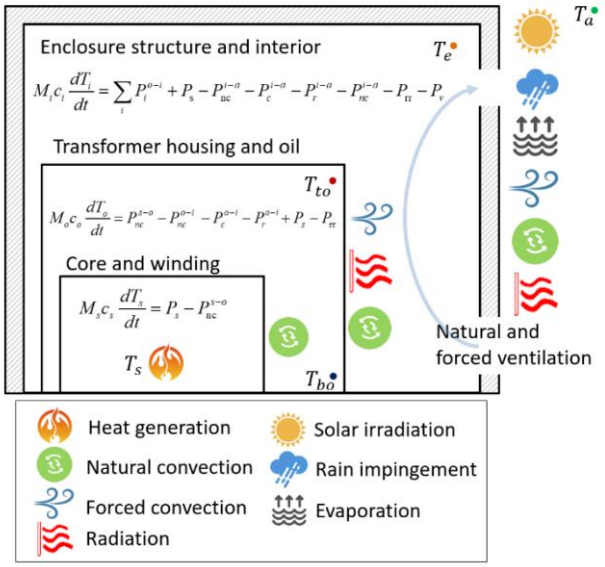
Paper 10732 from Germany regards the losses in Wind farms including an approach to reduce them, followed by paper 10394 from France dealing with the optimization of reactive power in operational planning of MV grid by the setpoints of Q = f(U). Paper 10216 from Belgium reports about a Machine Learning Algorithm for prognosis of reactive power flow at the TSO-DSO interface.

Sub block 3: Capacity calculation and management

The basis for capacity management is prognosis for load and generation. Paper 10349 from Austrian DSO focuses on prognosis at primary substation level (110 kV/MV) to be used for day ahead prognosis. Authors conclude that for Loads the Gaussian regression gives most accurate results (3…8%) and for generation linear regression (1…5%).

Circulating currents, resulting from phase angle differences are major affecting the capacity of lines and transformers or can even cause failures. Paper 10405 from Belgium reports about successfully applied real-time-simulations before switching.

Operating the grids close to the limits rises the question of temporal operation above the limits – thermal rating. Quite deep investigations about secondary substations, applying a multi physics thermal model and demonstration results are presented in paper 10986 from Slovenia. Depending on weather conditions a capacity gain between 10 and 60% could be achieved.



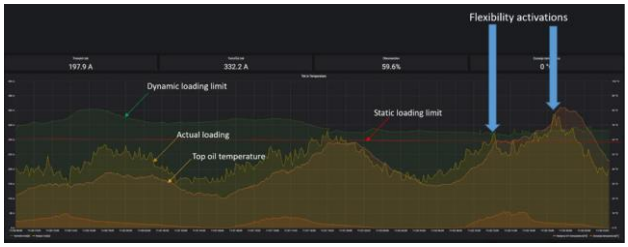


Figure 47: Multi physics thermal mode, load, oil temperature and resulting dynamic load limit at distribution transformer- Paper 10986

Paper 11478 from Germany discusses the challenge of integrating a bus fleet and discusses a thermal rating approach to easily achieve the required grid capacity.

Paper 10987 from Norway presents results from evaluation of thermal modelling for medium voltage cables. Authors conclude that there is some need of further investigations.

The Probability of critical system states due to limits violations in respect to voltage levels or currents is calculated in paper 10585 from Germany by using a Bayesian distribution. The authors conclude, that the proposed method can further be extended to process input parameters, like load profile correlation, topology, or measurement uncertainties.

Paper 10945 presents results from thermal modelling and fiber optic systems used for monitoring the temperature to increase of capacity.

On HV Distribution level transits from transmission can strongly limit free capacities. Paper 10389 from Germany

presents an almost a real time analysis tool, based on Analytical Hierarchy Process (AHP) and fuzzy logic. A demonstration was successfully validated for snapshots from a real German 110-kV-grid.

Reducing peak demand at customer sites can mitigate the requested capacity in public grids. Paper 11409 from Norway demonstrates a solution for habour industry.

The German research project flexQgrid, presented in paper 11190 and 10387 investigates demand side management at very small customers (even households) with PV, batteries, EVs and heat-pumps in a field test, demonstrating that proactive management works with the quota concept. The authors of both papers conclude that, the best option is a minimum of complexity, meaning to announce congestions and enable households to voluntarily prepare individual measures instead of real time or close to real time control. Demand side management should be supported by regulatory and market incentives.

A field test implementation of automatic topology changing in LV-Grids to resolve constraints Is presented in paper 10188 from Spanish DSO. A paper from Iran (10124) reports about a very practical problem with capacitors installed in former days at different load conditions and topologies. These capacitors are actually causing congestions. Authors conclude that the installation of capacitors should be monitored and adopted to actual needs.

Paper 11071 from Germany presents an algorithm for congestion management in MV-grids changing first the topology and in case this is not sufficient, performing redispatch. This work is done within the German research project ENSURE.

Paper 11103 discusses the operational risk assessment for industrial networks in respect to N-1 security and overloading components.

Sub block 4: Planning of operation

During outages and planned maintenance work reconfigurations of LV Grids to be partly supplied from neighbor grid is standard. Paper 10377 from Spanish DSO reports about comparison of forecasted and measured load characteristic to identify topologies which are not compliant with planned ones.

The relevance of regional and local forecasts for planning operation of grids is increasing as electricity grids are operated close to their limits. Paper 10749 from Norway presents successful forecasts for load and generation to be used in future also for optimization of Power flow. Paper 10761 from Switzerland also deals with forecasts but focuses on local PV-Generation regarding microgrids based on Machine learning algorithms.

“From hindsight to foresight” is a central statement in paper 11339 from Germany discussing the new challenges and concepts for operation fitting up the system for the future.

Paper 11170 from Belgium investigates the complexity and therefrom the risk of reduced reliability of switching operations. Enhanced automation in this field will save time and improve the quality of work.

Sub block 5: Detection and operation of Islanded grid

Paper 10177 presents modeled behavior of several voltage parameters for islanding detection with universal grid forming inverters. Parameters are voltage vector shift, voltage angle difference, unbalance and harmonic distortion. Paper 10492 reports about investigations on placement of virtual inertia in islanded distribution networks with high penetration of inverter-based resources. Main findings are the need of adopting protection relay’s settings of synchronous generators in case these mixed with high share of inverter based resources (IBR), that 100% IBR Grid Forming Inverters can provide better performance in island mode than mixed resources do and finally it has to be mentioned that the dispatching of VI is quite complex as it is strongly dependent on any network characteristic.

The German project LINDA ensuring the local supply with water even in case of outage or even blackout is presented in paper 10779. A medium hydro plant is ready to generate between 2 MVA and 5 MVA for supplying critical infrastructure like water supply system. The field tests performed, were all successful but various settings still can be optimized.

Sub block 6: Interaction between DSO and TSO

Paper 10592 from Switzerland presents a concept to coordinate the use of flexibility between TSO and DSO. A demonstration with a real battery use for tertiary control by TSO and for congestion management by DSO. A paper from Germany (10307) focuses on the possible effects of distribution level flexibility as a fast-responding curative congestion measure on the transient behaviour of bus voltages during upstream provision of flexibilty.

Another TOPIC of TSO DSO coordination is the short circuit current issue in paper 10532 presenting the OneNet project from Portugal. Short circuit currents are forecasted day ahead to be able to identify possible risk of operation due to dynamic electromagnetic forces exceeding the limitations ore to ensure the accuracy at calculation of fault locations. Contributions to the short circuit currents are allocated either to the 63 kV Grid or to medium voltage.

Paper 10668, from Germany suggests to use the DER (>100 kW) installed at distribution grid not only for active power (redispatch 2.0 but also for reactive power. The potential inductive and capacitive reactive power are resulting from load flow calculations regarding compliance with voltage levels and loading requirements. For some 15 min intervals (around 2000) there is no availability of capacitive reactive power.

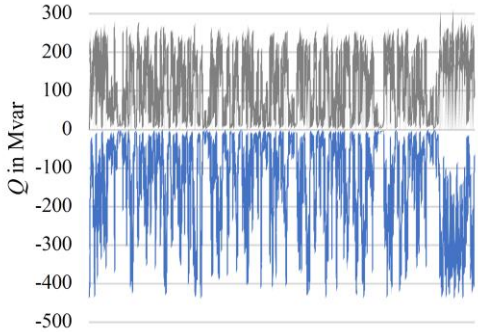


Figure 58: available capacitive (blue) and inductive (grey) reactive power at up to 1 GW active power for 15-min-intervals of one year from simulation. (paper 10668)

Sub block 7: Crisis management, Blackout and restoration strategies

In 2020 just within the pandemic in Croatia an earthquake also heavily affected the transmission and distribution system. Paper 11105 reports the major facts, experiences, and learnings. The analysis of damages, the prioritization of repair and safety in case of temporarily supply where challenging DSOs and TSOs in those days.

In the past years in the Austrian region Carinthia weather conditions caused storm, heavy snow and flooding causing damages in the distribution grid. Paper 10320 shows the holistic approach for emergency preparations of Kärnten Netz GmbH in case of numerous emergency scenarios, being ready to handle various crisis scenarios on a technical, organizational and operational basis in close cooperation with external partners.

Also in Japan during recent years many natural disasters occurred, damaging lot of electricity stuff. In paper 10997 Japanese TSO and DSO reports about the changes in procedure for restoring outages where communication to customers and municipalities now is fully integrated. Smart phones are used for fieldworkers but are also basis for the information to the customers.

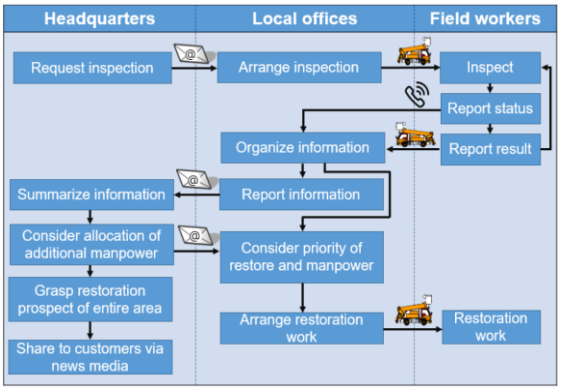


Figure 19: Former procedure and overall system for restoring outage (Paper 10997)

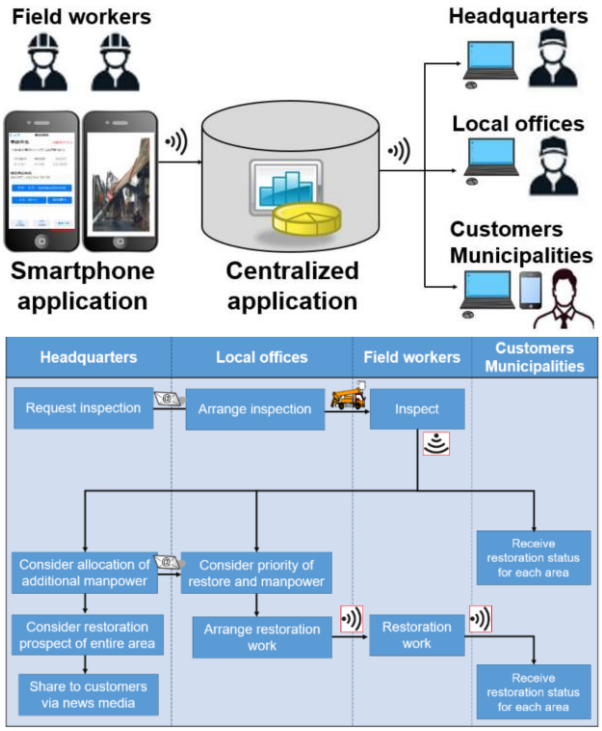


Figure 20: modern procedure and overall system for restoring outage (Paper 10997)

Paper 10333 from Italy reports about enquiries regarding feasibility of involving generators of grid users to supply portions of MV-grid during Blackout. Issues regarded are the balancing of active and reactive power as well as safety and protection. The enquiry is ongoing.

The Stability of the electric power system of Nepal is analyzed in paper 10734 from Nepal and Norway University.

From Sweden paper 11039 reports about a resilience state and stepwise alert up till blackout calculated from data to support strategies to react on the alerts.

In case blackout occurs and the restoration of transmission system requires long time depending on availability of power plants local and regional supply will be set up. Therefore, plants need be able to perform a black start. In the Austrian Region Upper Austria almost 1 Mio customers and lot of Industry two hydro plants are deemed to perform a black start fore energizing the 110-kV-grid. Paper 10573 reports about a project called “Fitness-Check power plants” testing the system start without and with load and finally even starting and synchronizing a 400 MW Gas and steam turbine. The tests succeeded. Relevant employees are now trained.

Sub block 8: Operation in Case of cyber security disturbances

Paper 10145 from France presents an analysis regarding a malfunction of voltage var control in distributed PV inverters. It is assumed that parametrization was induced by cyberattack. The result demonstrates that there is a real

risk at high penetration of components from same manufacturer. The distribution grid being used for this analysis succeed compensate the reactive power consumption reducing voltage levels by stepping up oltc transformers. A second contribution on cyber security issue, paper 10534 from Germany reports about the development of a co-simulation environment for electric load flow and communication even providing a hardware in Loop interface. The system presented can be used as a training environment for ICT failures.

Sub block 9: State estimation

The observability of distribution grid is the basis for real optimization for more efficient use of the grid and control of flexibilities in future. Missing data need to be replaced by calculated ones, resulting for example from state estimation. Therefore, adequate models for loads and generation units are required. Paper 10415 provides observed reactive power consumption for different customers which is deemed to be used for estimation of reactive power. The best performing state estimation generates from minimum input data most accurate results for all nodes.

Paper 10667 from Germany and Switzerland presents results from analyzing the accuracy of state estimations results from two different data sources (4 PMUs or 18 RTUs). The accuracy of Distribution system state estimation from few PMUs for voltage results is much better (<10% close to primary substations and <5% in more distant nodes) than from RTUs (up to 80%). For Currents the accuracy from RTUs is better than for voltages but again the state estimation from PMUs is much better.

The assessment of free capacity in distribution systems to validate bids and combination of bids for future flexibility markets requires simplified network calculations. Paper 10637 from Austria presents a method applying sensitivities. These simplified models are used within the Austrian R&D project I4RD (industry for redispatch) where flexibility from customers at DSO level is used for congestion management in transmission grid. DSOs provide such model to TSO to be used for the selection of bids.

Table 2: Papers of Block 2 assigned to the Session 3

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10124.: Expansion of the Distribution Network Capacity by Monitoring low voltage Capacitors due to Changes in Topology				x
10145.: Impact of Cyberattacks Targetting Distributed Photovoltaic Inverters				x
10177.: Islanding Detection with Universal Grid-forming Inverter-based Generation				x
10188.: Low Voltage Grid “Flex-efficiency”: Automatized Low Voltage Switchgear				x
10216.: Reactive Power Forecasting At The Transmission-Distribution Interfaces Using Physics Based Machine Learning				x
10307.: On Dynamic Behaviour of Active Distribution Grids during Flexibility Provision				x
10320.: Holistic Emergency and Crisis Management of an Austrian DSO				x
10333.: Suppling Of Portion Of MV Network During Blackout Periods Involving Generators Of Grid Users				x
10349.: Load And Generation Forecast On Substation Level				x
10377.: E-REDES's New Method To Identify Non-optimal LV (Low Voltage) Grid Reconfiguration After Outages and Planned Maintenance Actions				x
10387.: Evaluation of Quota-based Predictive Congestion Management in Active Distribution Networks			x	
10389.: Evaluation of Transit Power Flows in High Voltage Distribution Grids using Fuzzy Logic				x
10394.: Optimizing DER Reactive Power Setpoint For DSO Operational Planning For MV Grid				x
10405.: Real-time Circulating Currents Calculation In The Distribution Management System		x		
10415.: Analysis and Insights from Reactive Power Measurements of Low Voltage Users				x
10492.: Placement of Virtual Inertia in Islanded Distribution Networks With High Penetration of Inverter-based Resources				x

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10529.: Pilot Application of a Rule-Based TSO-DSO Coordination Concept in Switzerland		x		
10532.: Short-Circuit Currents Information Exchange Between DSO and TSO, an Approach From the Portuguese Demonstration of the OneNet Project				x
10534.: Towards a Control System Simulator Based on a Digital Twin for Cyber-Physical Power Systems				x
10573.: Fitness-check for Power Plants in Distribution Networks for Black Start and Regional Islands		x		
10585.: Calculating Probability of Critical System States by Using Bayesian Distribution System State Estimation				x
10637.: Accuracy Analysis of a Sensitivity-Based Distribution System Model for the Centralized Redispatch of Distributed Flexibilities			x	
10667.: Field Validation of Distribution System State Estimation Based on a Limited Number of Measurement Devices				x
10668.: Robust Determination of Reactive Power Potentials from Subordinate Networks in Close-to-Real-Time Operation				x
10732.: Techno-economic Estimation of Reactive Power Related Additional Losses in Wind Farms During Reactive Power Supply				x
10734.: Simulating the Voltage Stability in a Power System Network using OpenModelica and Comparing the Results with PowerFactory				x
10749.: Improved Load and Generation Forecasting for Extended Day-Ahead Estimates in the Nordic Grid		x		x
10761.: Geolocalized Photovoltaic Energy Prediction Methodology using Machine Learning				x
10779.: Automated Emergency Power Supply For Drinking Water Supply By A Hydro Power Plant In Islanded Grid Operation				x
10945.: Increased Electrical Transmission And Resilience Of Distribution Systems By The Use Of Optical Fibre Systems		x		x
10986.: Advanced Concept of Efficient Use of Transformers Leveraging the Dynamic Thermal Rating Technology				x
10987.: Data Driven Analytical Model Optimizing Grid Capacity Utilization				x
10997.: "Development of Support System for Restoration of Power Outage in Distribution Facilities"				x
11071.: Congestion Anticipation and Preemptive Resolution in Distribution Networks Using Grid Internal and Redispatch Measures				x
11089.: Dynamic Operation of MV Grids Based on Losses Optimisation				x
11093.: High-level Resilience Strategizing Using Data-Driven Inputs		x		
11103.: Essential Aspects of Operational Risk Assessment and its Application: Issues and Challenges				x
11105.: Management of the Distribution System Operation During the Crisis – Earthquakes in Republic of Croatia in 2020.				xx
11170.: An Automation Approach Towards The Preparation Of Switching Orders Involved In The Planned Outages of Network Elements				
11190.: Challenges in Proactive Congestion Management in Distribution Grids - Practical Findings from the flexQgrid Project				x
11339.: Rethink Grid Management – Challenges, Use Cases And Design Principles For The Next Generation Of Grid Operation Systems				x
11408.: Black Start In Distribution Grids Through Solid-State Transformer			x	
11409.: “Energy Package” as a Tool to Reduce Environmental Footprint and Withhold Grid Capacity Limit at Harbour Areas				x
11478.: A Novel Method To Efficiently Reduce The Impact of Increasing Penetration Of Electric Bus Fleets on the Electric Grid				x

Block 3: "Operation in field"

In Paper 10772, deep learning algorithms are used to automatically recognize dangerous situations and risky behaviors during the execution of dead working activities through the analysis of pictures collected in the field. This new procedure enables to reduce by 70% the time of analysis currently done by technicians, to standardize the verification process and to implement corrective actions to improve safety.

Paper 11454 defines and computes two indicators based on the EN 50522 standard, the factor and the margin of safety, to assess the safety of MV/LV substations in case of ground faults. These indicators are functions of touch voltage (see Figure 21) and earth potential rise. They are used to compare the impacts of the type of the incoming and outgoing conductors (overhead, underground) and the earthing system (isolated or compensated) of the substation on its safety.

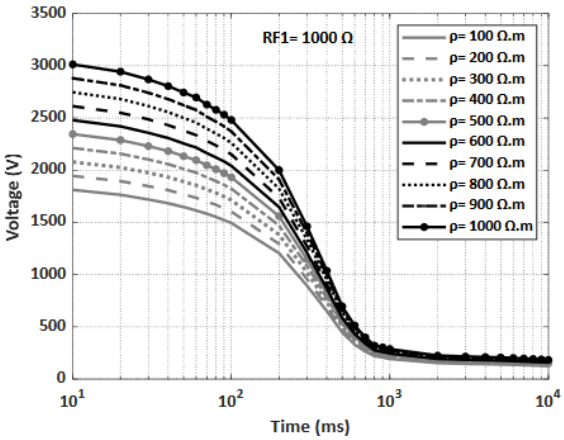


Figure 21: Permissible touch voltage as a function of fault duration and soil resistivity

Paper 11327 proposes a state of the art of the interest of extended reality to improve distribution system performances. Though the reviewing of 44 papers, four domains of application have been identified: protection and control, training, safety enhancement and energy management system. Remaining open questions and challenges related to the improvement of grid operation are also pointed out in the conclusion.

Table 3: Papers of Block 3 assigned to the Session 3

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10772.: How Disruptive Artificial Intelligence Solutions Can Enhance Safety Of Field Operations In The Electrical Sector				x
11327.: Extended Reality in Power Distribution Grid: Applications and Future Trends				x
11454.: Electrical Safety Performance Assessment of MV/LV Distribution Substations				x

Block 4: "New Use Cases & Special Applications"

Sub block 1: New applications in grid operation

Perspectives of DC for the distribution network

Paper 10265 proposes a sequential power flow algorithm based on the Newton Raphson method for hybrid AC/DC distribution networks with multi-terminal medium voltage (MT-MV) bipolar DC grids. The active and reactive control method of converter stations is considered. Also, networks are modelled without any approximation to single-line diagram to capture potential network imbalances. The algorithm is validated on the IEEE 33 buses.

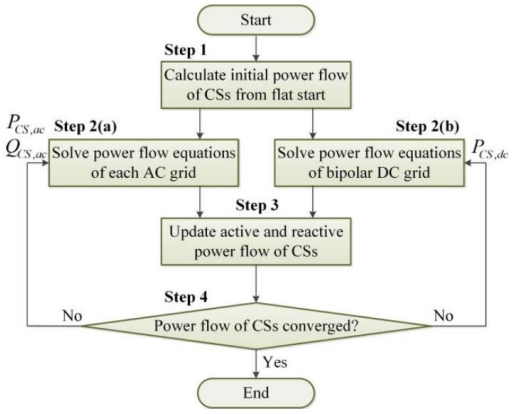


Figure 22: Flowchart of the sequential power flow algorithm for hybrid AC/DC networks with MT-MV bipolar DC grids.

Paper 11003 proposes a 2-stages algorithm to optimally place and operate soft open points (SOP) in the distribution network in order to minimize power losses. First, distribution network reconfiguration based on a genetic algorithm finds the optimal topology i.e. the optimal number of SOPs. Then an algorithm based on a particle swarm optimization computes the optimal P and Q values of each voltage source converters of the SOPs. This algorithm enables to reduce losses by 53,8% of the IEEE 33 buses network.

Artificial intelligence & new algorithms to improve the performance of distribution network

Paper 10273 compares a black-box model based on artificial intelligence (machine learning) and a white-box model based on building modelling for electrical energy flexibilities prediction of a building. Simulations show that the black-box model can be more accurate compared to white-box model when data is available. In the case study, as the AI was not trained using building flexible operational data, the results obtained were not good (see Figure23).

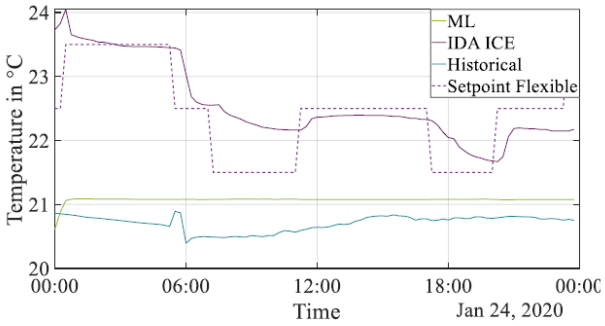


Figure 23: Temperature behavior based on flexible set points (green=black-box and magenta=white-box model)

Paper 10479 proposes a fully decentralized smart charging control based on a multi-agent approach in order to solve the drawbacks of centralized control. Uncertainties are considered using multi-armed bandit learning. shows the good performance of the decentralized charging compared to basic charging (no control) and centralized control (no uncertainty on PV production).

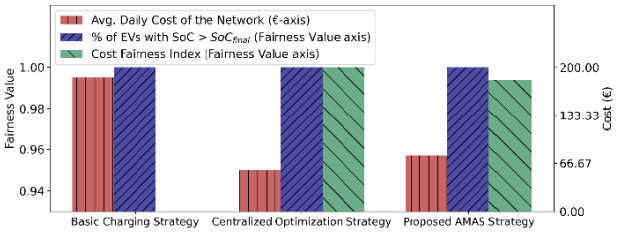


Figure 24: Basic versus centralized versus decentralized strategy

In Paper 10490, two types of objective functions are studied for the management of an EV fleet in a parking lot: energy cost minimization and power demand smoothing. The proposed algorithm uses reinforcement learning techniques and considers random arrival and departure times of EVs, capacity and battery information.

Paper 10672 have developed and tested a deep learning-based methodology to classify the alerts related to quality of service sent by smart meters located at the distribution substation. It enables to reduce by 75% the number of non-relevant alerts as shown in Figure 25Figure.

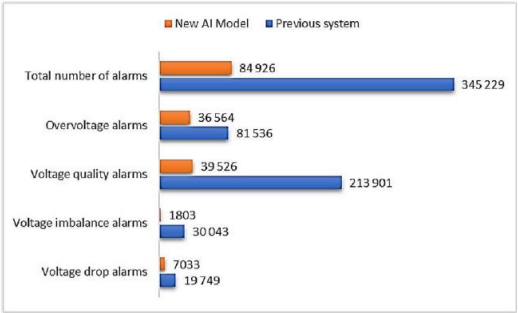


Figure 25: Alerts received of 1000 MV/LV substations during two years (blue) and after AI algorithm analysis (orange)

New services brought by communicating devices and network

Paper 10274 presents the return of experience of the French DSO on new services for the distribution network and customers thanks to smart meters. The use cases presented are: smart meter ping on LV incident, LV predictive maintenance, cable renewal investment prioritization, collective self-consumption, open data platform and public lighting management.

Paper 10290 points out how edge devices can improve the observability of the distribution network by presenting the results of the European project edgeFLEX. In particular, voltage unbalance is simulated in a digital twin of a distribution network where real edge device are connected. A set of controllable devices enables to regulate the voltage.

Paper 10754 proposes an algorithm to detect power outages in the LV network by detecting telecommunication failures. In that purpose, DOCSIS network, GSM-based smart meter network, fixed wireless access communication and fiber-optic network are considered. The performance of this method depends on the amount of communicating devices and similarity between the power and telecommunication network.

Paper 11429 presents an AMI-based methodology in order to have the updated LV topology in near real time i.e. the status of the switches. It consists of two processes: one daily (reference) and the other executed when a change in the communication structure is detected.

Paper 11449 presents a graph theory-based simulator to catch the inter-dependencies of both the power and telecommunication networks. The example of a failure of a power line is considered as a case studied (see

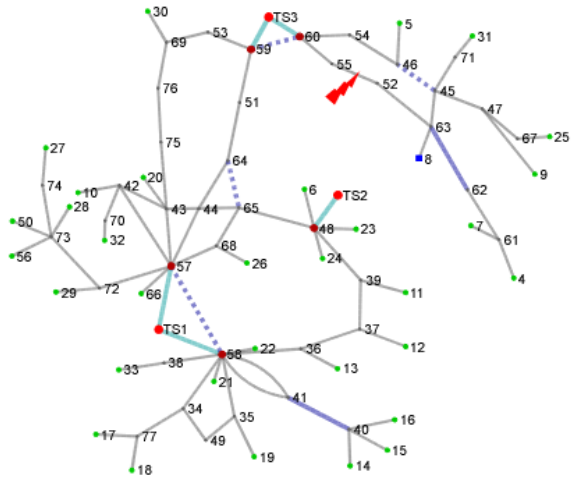


Figure). The impact of the reconfiguration procedure is assessed for both the power and telecommunication networks.

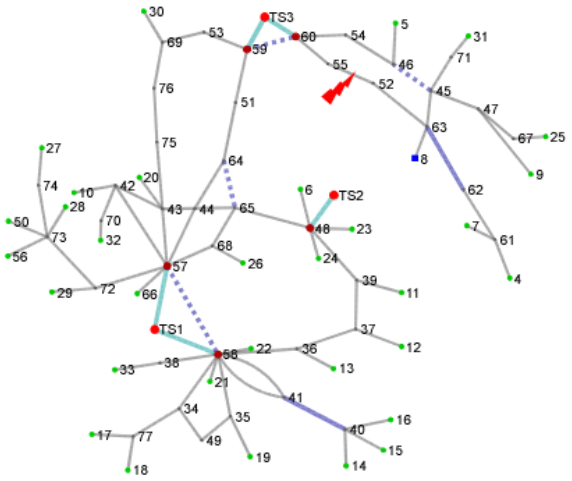


Figure26: Graph representing power networks and couplers (dark blue lines)

Digital twins

Paper 10372 discusses the issue around the deployment of digital twins in the energy sector. It provides the definition of digital twins, rank their benefits in terms of value and realization easiness for various use cases and discuss on the challenges regarding their deployment.

Paper 10676 generates automatically and every night a digital twin for the LV network using CIM CGMES. It is stored in various and open formats in order to be used by both DSO and player with various tools as shown in Figure 27. This digital twin is used for various use cases: monitoring and control of the grid, planning, grid documentation.

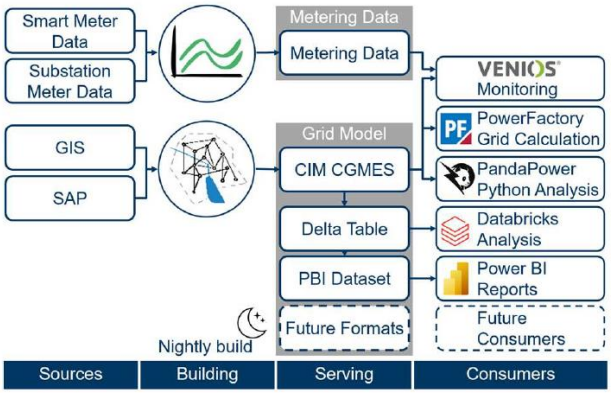


Figure 276: Inputs, outputs and building of the digital twins

Paper 10624 from Germany provides a model of a heating networks deemed to be used for modeling the load for electric heating with heat pumps.
Paper 10920 from Korea discusses Demand Response solutions suggesting for increase of convenience IoT as useful Interface.

Sub block 2: Multi-energy system operation – storage

and power2X

Paper 10905 presents an algorithm to optimize the operation of an electricity-gas multi energy system. The objective function to minimize consists of the total operational cost of this system and the curtailment of wind power generation subjected to constraints related to both systems and their coupling. Symmetrical semidefinite programming is applied to convexify the model. This algorithm was applied to an IEEE123-node power network and a 6-node natural gas network. Simulations show the interest of considering bi-directional energy flows.

Paper 11351 addresses the optimal operation a multi-energy virtual power plant (MEVPP) with distributed energy and P2H resources at the day-ahead market scale considering power system stability issues. The proposed optimization problem aims at maximizing profits at each hour subjected to constraints related to stability and SOC. The IEEE-33 bus system was used as a case studied using SGSim.

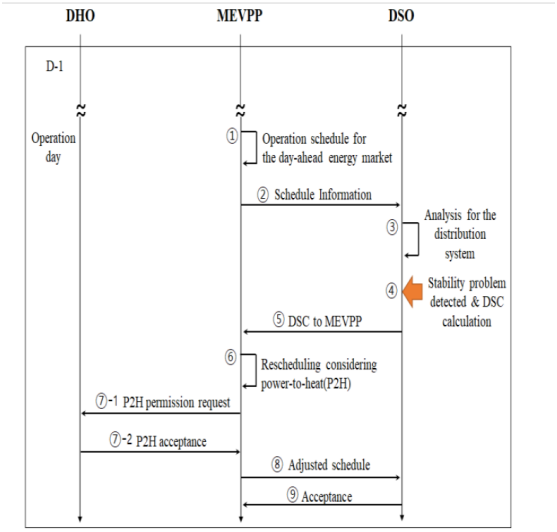


Figure 28: Sequence flow of MEVPP operations

Sub block 3: Operation of microgrids and local energy communities

Microgrids operation

Paper 10338 investigates the possibility of operating a portion of the LV distribution network as a microgrid using available local renewable generations. Based on Matlab Simulink simulations, it draws preliminary conclusions on the necessary conditions for a stable operation of the inverter-based microgrid. In particular, if the ratio of the grid-forming (GFM) over the grid-following (GFL) inverters capacities is lower than a threshold (dependent on the scenario), the microgrid is not stable. Figure 29 shows the occurrence of voltage instability for three scenarios (total GFM capacity of 6 kW in case A and C and 12kW for B) when increasing the power injected by GFL sources.

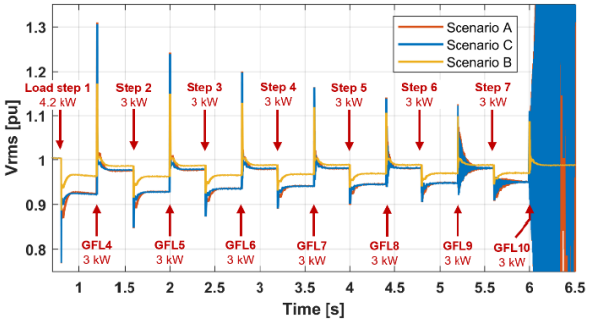


Figure 29: RMS voltage at the output of the master GFM inverter for three scenarios

Paper 10895 proposes to recharge electric vehicles on highways with microgrid equipped with storage. In that purpose, an optimal management of the battery formulated as a MILP problem is proposed integrating the presence of local generation and considering Time of Use Tariffs. In general, it is more interesting to inject the excess of generation to the grid rather than recharging the battery due to its 5% efficiency loss.

Paper 10901 proposes a stochastic scheduling model for the optimal operation of a microgrid considering both the economic and security objectives and the uncertainties related to renewable energy generation. The problem is formulated as a MILP and spherical simplex unscented transformation method is used to account for forecasting errors of renewable energy sources.

In Paper 11097, a stochastic energy management procedure for a DC microgrid including internal reserve provision by energy storage and electric vehicles to cope with uncertainties on PV production and EV state is presented. The problem is formulated as a MILP. The chance-constrained approach is used to define the level of positive and negative reserves provided by storage systems in order to compensate the uncertainties.

Paper 11359 evaluates how the optimal PV orientations and spatial distribution can enhance PV output smoothing and consequently decrease frequency fluctuations of a microgrid. A comparative analysis of two different response speeds of the battery energy storage is made to highlight the potential of PV smoothing in reducing the requirements of fast frequency control in a microgrid.

Real microgrids deployment (laboratories or field)

Paper 11147 describes the topology of an AC charging hub for electric vehicles with photovoltaics and batteries to minimize the energy from the grid. Real field tests were performed to validate the good behavior of the hub: battery charge/discharge, transition from off-state, off-grid and grid-connected modes.

Paper 10900 describes the Lac-Mégantic microgrid

structure and operation. In grid-connected mode, the grid-controller can handle functions of peak shaving and global demand peak reduction. In off-grid mode, it can handle the transition and operation of both planned and un-planned island. Finally, some learnings and perspectives are provided to improve the operation of the microgrid.

Paper 11459 describes a hybrid microgrid developed in a laboratory to study the operational modes of microgrids as well as the behavior of distributed energy resources under various scenarios. In particular, tests on the dynamic behavior of the charge and discharge of a lithium-ion battery are presented.

Paper 11503 describes the architecture and operation of the 450 kWp Semau solar hybrid interactive microgrid. In operation since 2019, the paper provides some return of experience as for example the analysis of the evolution of the renewable mix and the fuel consumption between 2020 and 2022 (see Figure 30).

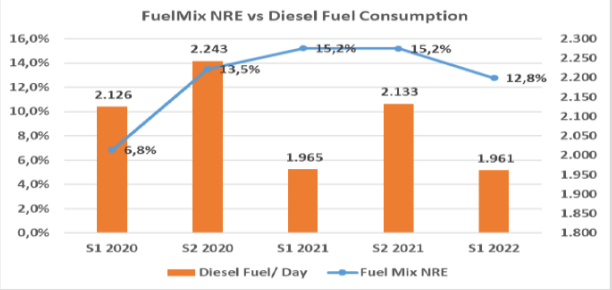


Figure 30: Diesel fuel consumption and renewable mix between 2020 and 2022

Local energy communities

Paper 10343 presents a toolbox developed in the European project H2020 eNeuron to optimally design and operate integrated local energy communities (ILECs) with multiple energy carriers. It consists of two levels as depicted in Figure 31: energy hub (community) and mico-energy hub (prosumer). In the first layer, the optimal design and day ahead operation is computed whereas in the second layer real time operation is performed. The interaction of the two layers is realized through a peer-to-peer market.

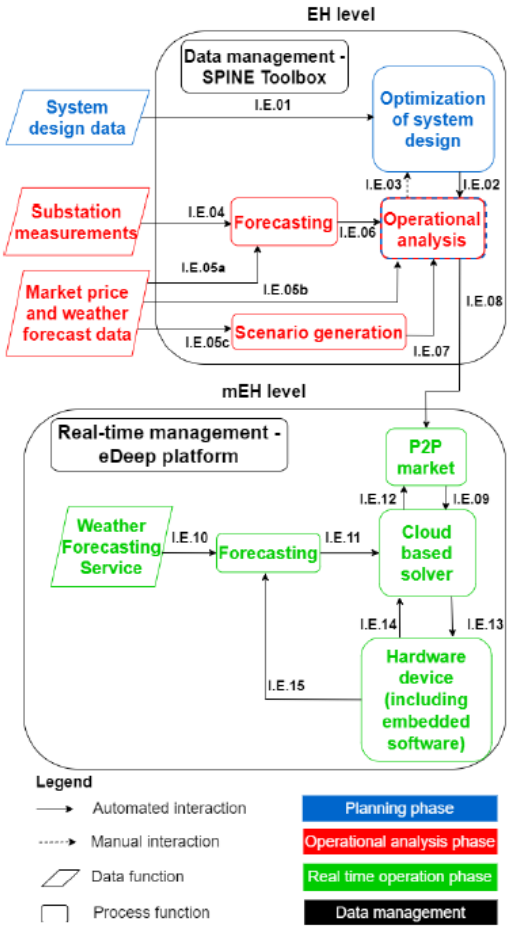


Figure 31: Conceptual architecture of the eNeuron toolbox

Paper 10515 investigates the impact of uncertainties forecasting on the optimal grid-friendly operation of renewable energy communities for day-ahead and intra-day scenarios. Uncertainties are assessed using naïve shifting of historic measurements. Results are compared to a business-as-usual rule-based method and an optimized method considering a perfect foresight assumption. The proposed algorithm enables to reduce both the demand (up to 21%) and feed-in peaks (up to 49%) compared to business-as-usual case.

Paper 10883 aims at solving simultaneously the optimal operation of a local energy community and the cost allocation among its members. The latter is allowed with "keys of repartition" that denote the ratios of community energy surplus allocated to the different members. The simulation of real pilot project of 7 members shows a reduction of 10.7% of the community bill and 5.3% of the individual bill.

Paper 11017 investigates the operational impacts of local energy communities on the distribution network through real time simulation. Results show that the operation of the community could lead to an overloading of the MV/LV transformer if only market prices and incentives are

considered.

Table 4: Papers of Block 4 assigned to the Session 3

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10265.: Power Flow Analysis of Multi-Terminal Medium Voltage Bipolar DC Distribution Networks				x
10273.: Electrical Energy Flexibilities' Prediction and Validation of a Real Non-Residential Building Through Methods of Machine Learning				x
10274.: Smart Metering And Grid Data Services : French Experience And International Perspectives		x		
10290.: Benefits for the Distribution Network from the Installation of Synchronized Edge Devices				x
10338.: Using Local Renewable Energy To Energize a Portion of a LV Grid in Islanded Mode			x	
10343.: An Innovative Toolbox for the Optimal Design and Operation of Integrated Local Energy Communities				x
10372.: Digital Twins Handling : The Real Deployment Stakes!		x		
10479.: Decentralized Smart Charging of Large-Scale EVs using Adaptive Multi-Agent Multi-Armed Bandits				
10490.: Energy Charging of a fleet of electric vehicles based on Reinforcement Learning				
10515.: Implications of Forecast Uncertainty on the Optimal Operation of Renewable Energy Communities		x		
10624.: Modelling of a Heat Network Infrastructure to Investigate the Stability of a Gas-independent, Sectoral-coupled Multi-energy System				x
10672.: An Experience Of Detection And Classification Of Quality-Of-Service Problems In MV/LV Distribution Substations Using Artificial Intelligence: Senegal Case Study		x		
10676.: Digital Twin Based on CIM CGMES for Smart Grid and Data Based Use Cases				x
10754.: Detecting Power Outages In Low-Voltage Networks From Telecommunications Networks Data		x		
10883.: Coupling Optimal Energy Management and Allocation through Keys of Repartition in Energy Communities			x	
10895.: EV Charging Microgrid: Electrical and Operation Modeling of Energy Management				x
10900.: The Lac-Mégantic Microgrid: A Shared Vision of Energy Transition and the new role for Microgrid Control		x		
10901.: Stochastic Reliability-Constrained Scheduling of Multi-Resource Microgrids				x
10905.: Coordination Operation of Electricity and Natural Gas Network Considering Power-to-Gas based on the Symmetrical Semidefinite Programming				x
10920.: DR Business Model Suggestion Applying IoT Solutions with Mesh Network Technology Based on IEEE 802.15.4				x
11003.: Distribution Network Reconfiguration Strategy with Soft Open Point using GA and PSO				x
11017.: Demonstrating Interactions of Distribution Network and Local Energy Communities Operating in Hierarchically Autonomous Control Architecture Paradigm				x
11097.: Chance-Constrained Method for Reserve Provision in EV-based DC Microgrids			x	
11147.: Impact of Charging Stations on Voltage Quality - Island and Grid Operation of Real Installation			x	

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
11351.: An Economical Operation Strategy of Multi-Energy Virtual Power Plant in a Distribution Network			x	
11359.: Frequency Response Of A Microgrid Under The Influence Of Enhanced Spatial And Orientational Smoothing Of Photovoltaic Output			x	
11429.: Near Real-Time Topology Estimation in LV Network with PLC Smart Meters				x
11449.: Application of Graph Theory in Urban Infrastructure Analysis				x
11459.: Assessment of Battery Energy Storage System Operating Modes in a Microgrid for EV Charging				x
11503.: Electrifying East Nusa Tenggara with Smart Microgrid - Study Case on Semau Subsystem				x