58th UNIVERSITIES POWER ENGINEERING CONFERENCE 2023

Technological University Dublin, Ireland

30 August to 1 September 2023

BOOK OF ABSTRACTS

28 August 2023

Wednesday 30 August 2023, 11:30 - 13:00

Technical Session 1a: Active Distribution Networks
Room: CQ-009
Chair: Prof. Mattia Martinelli (Technical University of Denmark, Denmark)

42 **Optimal power exchange of two electric vehicle charging stations with solar-hydrogen-battery storage systems**
Lijia Duan (Brunel University London); Chun Sing Lai (Brunel University London); Gareth Taylor (Brunel University); Xin Zhang (University of Sheffield)*
ABSTRACT: This paper presents an optimisation method for the direct power exchange between two electric vehicle (EV) charging stations located in the UK. Each EV charging station consists of solar panels, hydrogen and battery energy storage systems (SHBS). The stations are interconnected through a power exchange system that enables the transfer of excess energy from one station to the other. The objective function of SHBS-EV charging stations is to minimize the installation and maintenance costs of the stations. The system constraints are the power output of individual components, as well as the power balance between SHBS-EV charging stations and EV charging demand. Genetic Algorithm (GA) is used to optimize the system, considering various factors such as the size of the solar panels and hydrogen storage tanks, the capacity of the electric vehicle chargers, and the amount of energy exchanged between the two stations. The optimized system yields substantial cost savings.

57 **Influence of Remanent Magnetization on the Accuracy of Industry Typical Metering Current Transformers**
Michael Freiburg (TH Köln); Christoph Mayrhofer (Ritz Instrument Transformers); Dieter Braisch (Friedrich-Alexander-Universität Erlangen-Nürnberg); Norbert Koch (Redur); Roland Bürger (Senseleq)*
ABSTRACT: The accuracy of metering current transformers (CTs) according to IEC 61869 needs to be tested with reference test setups in demagnetized condition. A possible influence of remanent magnetization resp. remanent flux is not considered. The sensitivity of metering CTs regarding remanent flux in the core or related verification tests for CTs are not further specified. This paper presents investigations on the influence of remanent flux on the accuracy of industry typical metering CTs. During normal operation in the field, e.g., after switching events, faults or fluctuating loads and related DC components or DC transients, metering CTs are not explicitly demagnetized. Thus, remanent flux may be present in the cores during operation. In this paper, the accuracy of industry typical metering CTs with remanent flux, conditioned with a DC magnetization before accuracy tests, is discussed.

73 **Developing an Adaptive Protection Scheme Towards Promoting the Deployment of Distributed Renewable Sources in Modern Distribution Networks: Operational Simulation Phase**
Ayatte Atteya (Robert Gordon University); Dalia Ali (Robert Gordon University); Amany El-Zonkoly (Arab Academy for Science, Technology and Maritime Transport); Hamdy Ashour (Arab Academy for Science and Technology)*
ABSTRACT: This paper presents an adaptive protection scheme developed to allow automatic adjustment of optimal relay settings in response to multiple network topologies arising from renewable energy systems integration towards promoting their deployment in modern distribution networks. A Simulink model is developed to simulate the operation of adaptive protection scheme, interlinked with linear-programming technique to allow optimizing relay settings in response to dynamic changes of network topology associated with DG integration. The performance of adaptive protection scheme in accommodating dynamic changes of network topology is assessed under 2 proposed network topologies via a small-scale network that has been built in the lab as part of experimental work for the purpose of implementing the adaptive control unit. Results have demonstrated effectiveness of the developed approach in minimizing relay trip times while satisfying suitable relay coordination in each of tested network topologies.

98 **Impact of Profile Orientation and Position on Soil Resistivity Measurement for Earthing Applications**
Omar Kherif (Cardiff University); Stephen Robson (Cardiff University); Noureddine HARID (Khalifa University of Science Technology, Emirats Unis); David Thorpe (Kingsmill Industries (UK) Limited); Salah Mousa (Cardiff University); Silvio Stivanello (University of Exeter); A. Manu Haddad (Cardiff University)*
ABSTRACT: Providing an effective earthing design is one of the primary challenges in electrical engineering as it encompasses various parameters and factors of different types. Soil resistivity measurements and modelling are among the key aspects considered in earthing analysis, alongside many other important parameters. In light of this, the present paper aims to demonstrate the significance of soil resistivity in relation to earthing performance, while also highlighting the impact of profile selection on the accuracy of measurements. Multiple scenarios assessing soil resistivity are considered, and the obtained results are thoroughly analysed and discussed. Through these measurements, a comprehensive understanding of the soil structure's heterogeneity is gained. The findings unequivocally demonstrate that soil cannot be regarded as a uniform medium, as evidenced by the observed variations in its structure at different depths and lateral distances.

104 **Investigation on the Loss Allocation Properties in Distribution Networks with Distributed Generation**
Andrea Mazza (Politecnico di Torino); Soheil Saadatmandi (Politecnico di Torino); Salvador Safina (Politecnico di Torino); Gianfranco Chicco (Politecnico di Torino)*
ABSTRACT: The allocation of the losses that occur during the operation of the distribution system to the distribution network nodes is useful to understand whether there could be a deficit or an excess of load or local generation in the nodes. This concept is extended in this paper by looking at the zones of the distribution network in which there is an interaction among the generations and loads. The sign of the allocated losses is considered as a useful indicator of the need to provide more load or more local generation in the zone. Specific findings are extracted from the analysis of balanced and unbalanced distribution systems with time-varying load and distributed generation.

138 **SLP Optimization-Based Voltage Profile Improvement in Unbalanced Distribution Networks With SOP devices**

Mohammed Bamatraf (Istanbul Technical University); Oguzhan Ceylan (Marmara University); Ioana Pisica (Brunel University London); Aydogan Ozdemir (Istanbul Technical University)*

ABSTRACT: The deployment of renewable energy resources such as photovoltaic and wind turbine systems has significantly improved the operation of active distribution networks. However, since these resources are intermittent, they usually cause voltage and frequency fluctuations that lead to increased system losses and instability. This paper uses sequential linear programming (SLP) to improve the voltage profile of unbalanced distribution networks. The method is applied to a modified IEEE -34 node test feeder. Three PV systems are installed in the system and two of them are connected through a soft open point. The method optimizes the reactive power flow through the SOP and the third PV coming from the smart inverter, as well as the taps of the voltage regulators to reduce the voltage deviation. The voltages in the base and optimum cases are compared for each time simulation with and without the use of SOP. The results show that a better voltage profile is obtained with SOP.

Technical Session 1b: Condition Monitoring and Diagnostics
Room: CQ-010
Chair: Prof Dan Micu (Technical University of Cluj-Napoca, Romania)

26 **Development of Real-Time Trouble Shooting Guide for Maintenance Support System Hydropower**

Uthai Kumthai (Chiang Mai University); Suttichai Premrudeepreechacharn (Chiang Mai University)*

ABSTRACT: A real-time troubleshooting guide was developed in this paper for the maintenance support system hydropower plant. Root cause analysis of emergency cases have to use real-time data in the application program interface (API) via Internet of Things (IoT) and Accumulated knowledge of power plant logic, drawing, equipment manuals, test reports, corrective maintenance reports, and history event. After that system analysis by fault tree analysis (FTA) method and experience of maintenance and operation staff from then develop to the platform for Realtime trouble shooting guide. Finally, all data will prepare to the logic flow and graphic user interface design by Node-red program and dashboard in troubleshooting guide pattern for assist in the decision and solve emergency problem events more effectively.

35 **Real-Time Simulation-based continuous Thévenin Impedance Monitoring using Phasor Measurements**

Kevin Schäfer (Fraunhofer IOSB); Ilia Hosseini (Fraunhofer IOSB); Stephan Ruhe (Fraunhofer IOSB-AST); Mansour Alramlawi (Fraunhofer IOSB); Steffen Nicolai (Fraunhofer IOSB); Peter Bretschneider (Fraunhofer IOSB)*

ABSTRACT: The grid impedance of a power system is a significant parameter that characterizes the overall electrical behavior of the system. This paper presents an in-depth analysis of invasive and non-invasive methodologies for estimating grid impedance. It gives a review of both methodology types and evaluates their practicability for a continuous monitoring. In the paper a non-invasive method for the estimation of Thévenin equivalent impedance was selected, which employs data from Phasor Measurement Units. The focus of the approach lies on the coupling of the evaluation with real-time (RT) simulation systems to continuously determine grid impedance under different scenarios. Since RT simulations allow the emulation of the dynamic behavior of electrical networks, a phase drift correction is implemented to compensate for the angular deviation due to frequency fluctuations. Selected results are presented to validate the effectiveness and general feasibility of the proposed method.

51 **Wind Turbine Fault Prediction Based On A Novel Gated Recurrent Neural Network Model**

*Shuo Zhang (Technological University Dublin)**

ABSTRACT: Due to the harsh environmental issue and hard accessibility, offshore wind turbines (WTs) have more challenges for operation and maintenance (O&M). Thus, it is crucial to develop effective condition monitoring (CM) methods for WT fault prediction to detect incipient faults before their occurrences, thus preventing durable downtimes. In this paper, eight specific faults are classified for fault prediction using status information from Supervisory Control and Data Acquisition (SCADA) data. The classification steps are based on fault prediction from 10 to 210 minutes prior to faults. By embedding a model-agnostic vector representation for time, Time2Vec (T2V), into Gated Recurrent Unit (GRU), a novel deep learning neural network model, T2V-GRU, is applied for fault classifications. As a result, T2V-GRU successfully predicts over 84.62% of faults and outperforms its counterpart, vanilla GRU, in both overall and individual fault predictions in terms of accuracy, recall scores and F-scores.

55 **Open Circuit Fault Diagnosis Technique for Inverter Switches and Gate Drive Malfunction**

*Chukwuemeka N Ibem (Glasgow Caledonian University)**

ABSTRACT: Open circuit faults (OCFs) in voltage source inverters (VSIs) can significantly affect their performance and reliability. In this paper, a novel fault diagnosis technique (FDT) is presented for the detection and classification of two types of OCFs in VSIs: gate drive malfunction (GDM) and open switch fault (OSF). The effect of these OCFs on the output current of the VSI is analysed, this shows that they can be identified and distinguished using the average and root mean square (RMS) ratio of the current parameters. The proposed FDT is simple to implement and can identify switch faults with quick response, without the need for additional equipment. In this work the authors adopted the ensemble bagged tree classification method to detect and classify the GDM and OSF, the results show the credibility of the proposed technique in identifying different open circuit faults.

85 **Long-term Wind Power Forecasting Using Variational Mode Decomposition and Convolutional Neural Network**

Danya I Al-Hindawi (Teesside University); Maher Dr Al-greer (Teesside University); Gobind Pillai (Teesside Univeristy)*

ABSTRACT: This research paper presents a two-step wind power forecasting in wind turbine applications. The proposed approach incorporates Variational Mode Decomposition (VMD) as a feature extraction method, followed by Convolutional Neural Network (CNN) model. The effectiveness of this method is evaluated using real wind power data, results demonstrate the accuracy and reliability of the proposed technique. Specifically, the VMD-CNN model trained with a 90% training and 10% testing split achieves the highest accuracy, yielding an RMSE value of 0.1307. The comparative analysis with previous architectures that do not employ decomposition reveals the superior performance of the proposed method. Moreover, it exhibits promising potential for long-term wind power forecasting, outperforming recently proposed methods.

133 **Correlation between Partial Dishcarge Parameters measured by UHF, IEC and HFCT methods**

*Noureddine Harid (Khalifa University of Science Technology, Emirats Unis)**

ABSTRACT: Partial discharge amplitudes measured using a UHF sensor are correlated with peak charge, average discharge power measured using the standard IEC and HFCT methods. Surface discharge and cavity discharge are simulated in the laboratory with different insulation materials in air. The results show strong correlation between the UHF signal amplitudes and the peak apparent charge and discharge power over an applied voltage between 1.1 and 1.6 times the partial discharge inception voltage, with a linear relation linking the discharge parameters. The UHF pulse repetition rate for the case of surface discharge shows a strong correlation with those measured with the IEC and HFCT methods with an exponential fit of the data. At higher voltages, the correlation between the UHF data and the data obtained by the IEC and HFCT methods becomes weaker, presumably due to different discharge processes occurring at these voltages.

Technical Session 1c: Energy Storage
Room: CQ-020
Chair: Prof Ghanim Putrus (Northumbria University, UK)

50 **Investigation of different acidic battolyser conditions for energy storage and hydrogen production**

John P Barton (Loughborough University); Elizabeth Ashton (Loughborough University); Dani Strickland (Loughborough University)*

ABSTRACT: A purpose built battolyser, using the combined technologies of a battery and an electrolyser, has been developed for energy storage and hydrogen production. Various acidic conditions and electrode materials were used to evaluate the performance of each battolyser configuration. Only low-cost, abundant, low toxicity and low environmental hazard materials were selected. Performance was evaluated by durability and degradations tests. The vanadium redox flow battery achieved hydrogen yields over 98 % and an electrical storage capacity of 2.55 Ah, with a coulombic efficiency of 45 %, whilst the iron flow battery achieved an electrical store capacity of 62 mAh with a coulombic efficiency of 70 %. The manganese/sodium and manganese/titanium configurations achieved a lower electrical storage capacity of 20-75 mAh and an efficiency of 40-50 %. Materials deposited on the electrodes after cycling were characterized using power x-ray diffraction.

74 **The Assessment Potential of PV/Wind Powered Hydrostorage Systems in the Desert: Case of Algriffa City, Libya**

Farag S Alargt (The Centre for Solar Energy Research and Studies); Ahmed Said Ashur (EE Dept. University of tripoli); Ahmad Kharaz (The School of Engineering and Technology, University of Derby)*

ABSTRACT: This paper presents a proposal to establish and build a PV-Wind hybrid system with hydroelectric pumped storage for a city located in the heart of the Libyan desert. The system consists of two parts: one for generating electricity using photovoltaic and wind energy, and another for storing excess energy using Pumped Hydro energy Storage (PHS). this work, propose the basic components of this system, using climatic data for the area under study to assess the available capabilities and feasibility of using these systems. In this work, mathematical models and simulations using MATLAB were used to clarify and calculate the energy produced from the resources available at the site under study. A clear visualization of the system as a whole is presented along with the options available for design, in order to assist in making the decision to start the full design and build of this system.

82 **Battery Energy Comparison With and Without a Balancing Circuit using Ragone Theory**

*Jingxi Yang (Loughborough Univeristy)**

ABSTRACT: This paper presents a comparison in batteries with and without a balancing circuit, by Ragone theory. The aim is to assess the impact of balancing circuit implementation on the overall energy drawn. The Ragone theory provides a tool to evaluate the energy-storage performance. We analyse the energy characteristics under varying load conditions. Through a series of experiments and simulations, the results demonstrate that balancing circuits can be advantageous in scenarios involving high power loads or significant differences in battery capacities. However, when both battery cells are sufficiently healthy and subjected to low loads, the balancing circuit incurs substantial energy losses.

89 **Sector-Coupled Distribution Grid Analysis for Centralized and Decentralized Energy Optimization**

Felicitas Müller (KIT - Karlsruher Institut für Technologie); Steven M de Jongh (Karlsruhe Institute of Technology (KIT)); Xuanhao Mu (Karlsruhe Institute of Technology (KIT)); Michael Suriyah (Karlsruhe Institute of Technology (KIT)); Thomas Leibfried (Karlsruhe Institute of Technology (KIT))*

ABSTRACT: In this work, different battery control strategies are modelled, simulated and applied for the optimal operation of a sector-coupled distribution grid. For the evaluation of the impact on the electrical grid, a Model Predictive Controller
(MPC) is chosen as a predictive control algorithm which is compared to a typical non-predictive controller. The resulting line and transformer loading of a centralized and a decentralized MPC approach, as well as a non-predictive, heuristic controller method, are analyzed. The grid equations and technical limits are implemented in the centralized optimization. The minimization of the quadratic power exchange with the medium voltage grid is chosen as the objective function to achieve peak shaving. For the selected benchmark grids from the literature, it has been shown that the central MPC achieves the best performance with respect to avoiding grid overloads and the optimal usage of flexibilities.

93 **Reliability assessment with distributed energy resources in a medium-voltage network**

Francisco G Fabrin (Universidade Federal de Santa Maria); Daniel Bernardon (Universidade Federal de Santa Maria); Vinícius J Garcia (Federal University of Santa Maria)*

ABSTRACT: An approach is proposed to reduce the transgressions of the indicators that evaluate the quality of the product in sets containing class A4 irrigating consumers (2.3kV to 44kV), using the use of Energy Storage Systems - SAE, and photovoltaic solar generation through PhotoVoltaic Plants (UFV). The approach is based on the values of the indicators and the consumption in the feeders to determine the adequate sizing of the SAE and the UFV to be installed in strategic points of the Feeder (AL). A study is presented in a sbstation containing six feeders, which contains the largest number of irrigators in the concessionaire. For data validation, the Net Present Value method (VPL) and the Internal Rate of Return (TIR) are used, resulting in a positive value consumers, using the use of energy storage systems (SAE) and photovoltaic solar generation through photovoltaic plants (UFV). The approach is based on the values of the indicators and the consumption in the feeders to determine the adequate sizing of the SAE and the UFV to be installed in strategic points of the feeder. A study is presented in a substation containing six feeders, which contain the largest number of irrigators in the concessionaire. For data validation, NPV and IRR are used, resulting in a positive result.

100 **Optimizing Electric Vehicle Charging and Discharging with Renewable Energy Sources in a Modified IEEE 14 Bus System**

Gillian L Lacey (Teesside University); Md Atiqur Rahman (Teesside University)*

ABSTRACT: Vehicle-to-grid (V2G) technology, which enables electric vehicles to send their surplus energy back into the grid during times of peak demand is seen as a solution to the grid stress caused by a high penetration of EVs; additionally lowering energy costs, improving grid reliability, and avoiding expensive infrastructure modifications. This paper analyses the impact on power consumption in the UK of various charging techniques for electric vehicles at different degrees of penetration. Active power control (peak shaving, valley filling), reactive power compensation, and uncontrolled controlled charging are compared. Both controlled and uncontrolled V2G charging in private households are explored as applications to learn more about the benefits of V2G charging. Cutting-edge technology, such as vehicle-to-grid (V2G) development and battery energy storage, will be essential if the United Kingdom is to achieve its goal of net-zero emissions by 2050.

Wednesday 30 August 2023, 14:00 - 15:30

Technical Session 2a: Data Analytics and AI Applied to Power Systems (1)
Room: CQ-009
Chair: Dr Oguzhan Ceylan (Marmara University, Turkey)

24 **Computational Platform for Identification of Atypical Billings in Low Voltage Consumer Units in Distribution Companies in Brazil: Focus on Comba**
Douglas B. S. Figueiredo (Neo Domino); Arlan Bettiol (A Vero Domino); Phablo Gomides (Chesp); Renato Medeiros (ELFSM)*
ABSTRACT: The work addresses the development of a computational platform to identify atypical billings in consumer units using Artificial Intelligence techniques, specifically the Isolation Forest algorithm. The methodology seeks to detect consumer units with peculiar changes in consumption and/or evidence of frauds. The algorithm analyzes a set of historical data and identifies "atypical" monthly billings among consumer units of the same type of load, generating a list of candidate units for field inspection. Preliminary tests carried out at ELFSM showed an assertiveness rate of 91.70%, a result higher than that mentioned in the literature, indicating the effectiveness of the proposed algorithm for identifying anomalies in billing data.

36 **Real-time object detection on high-voltage powerlines using an Unmanned Aerial Vehicle (UAV)**
Elisavet Bellou (Brunel University London); Ioana Pisica (Brunel University London); Konstantinos Banitsas (Brunel University London)*

ABSTRACT: Unmanned Aerial Vehicles (UAVs) are gaining significant scientific interest in critical infrastructure inspection due to their flexibility, cost-effectiveness and advanced computer vision capabilities. This research focuses on high-voltage powerline surveillance, where automatic inspection is a priority for grid companies to prevent power failures. To address the need for real-time detection with limited computational power, we evaluate the recently developed object detection algorithm, YOLOv5. We propose a fine-tuned model trained on a custom dataset to detect key components, i.e. towers, insulators and conductors. The proposed method achieves an overall accuracy rate of 82.3% (mAP@0.5) and enables real-time detection, demonstrating its suitability for inspection tasks and visual-based navigation. Our model was also tested on a custom-built quadcopter with an Nvidia Jetson Nano (4GB) on board, achieving a frame rate of 33fps on live video under real environmental conditions.

46 **Wind Power Generation Forecast using Artificial Intelligence Techniques**
Talal Alazemi (Brunel University); Mohamed Darwish (Brunel University); Maysam Abbod (Brunel University London)*
ABSTRACT: It is crucial to be able to forecast wind power generation with the greatest degree of precision because wind has a significant degree of instability and the energy generated cannot be conserved on a big scale due to expensive costs. This research compares the efficiency of wind energy predictions one hour in advance employing artificial intelligence-based techniques. RNN and LSTM are the two DL approaches while Decision Tree Regression, Support Vector Regression (SVR), and Random Forest Tree are three ML algorithms which have been developed then compared among themselves based on MSE scores to determine the best performing model. Additionally, Time Series Analysis (TSA) on MATLAB is also performed to get more detailed understanding of the data in sequence on regular intervals of time.

67 **Artificial Intelligence-based Optimised Energy Management System for Microgrids**
Muhammad Majid Hussain (University of South Wales); Mian Hammad Nazir (University of South Wales); Muhammad Naveed Akhtar (Rachna College of Engineering & Technology); Waqas Javed (University of Glasgow); Abdul Razaq (Abertay University); Ahmad Hesham Pasha (University of SouthWales)*
ABSTRACT: Electric power consistency is one of the essential variables in the social and economic growth of a smart city. In contrast, innovative energy sources and intelligent electricity networks are the primary components in making a city smart. This paper describes an artificial neural network (ANN)- based controller for increasing power supply consistency by employing a dynamic voltage restorer. The optimisation approach particle swarm optimisation (PSO) is also discussed in this work, used to compute the maximum power point tracking (MPPT) of wind/photovoltaic hybrid power systems. The proposed PSO and ANN techniques can detect load, wind velocity, and solar irradiation fluctuations to optimize generating device power output, allowing hybrid power systems to function steadily, safely, and economically.

70 **Automatic High Voltage Data Analysis Tools Using Mathematical Techniques and AI**
Iwan L Williams (Cardiff University); Maurizio Albano (Cardiff University)*
ABSTRACT: This paper investigates the methods used in analysing performance of high voltage insulators in HV laboratory tests. The performance of high voltage insulators requires analysis for the purposes of design improvement and comparison. The analysis can be supported using visual and infra-red cameras to record the insulator under stress in addition to the electrical parameters such as leakage current and voltage signals. A new procedure based on mathematical and AI techniques was developed to create a new engineering tool as an alternative to the current ones in use. The developed methods can be used on already recorded data as well as future data. The methods can be used as tools to investigate the performance of insulators. The discussion of deep learning opens further opportunities for the use of deep learning in dry band detection and classification.

78 **A Coherency Identification Approach for Low-Inertia Power Systems**
*Bwandakassy Elenga Baningobera (Norwegian University of Science and Technology (NTNU))**

ABSTRACT: This paper presents a new approach for identifying coherent groups in synchronous generators for frequency stability assessment. A combined Calinski-Harabasz criterion and k-means clustering algorithm is developed for the determination of the cluster groups in power system. The electrical distances between different generators in the system are considered for partitioning the clusters into frequency control areas. A progressive decommissioning of generation units with rotating masses and their replacement by large-scale integration of inverter-based renewable generation influences the current and future power system dynamic behavior due to the decrease of system inertia. Also, low-inertia power system impacts the system frequency, operation of protection systems and shedding of loads/generators for System Protection Schemes. The proposed approach is successfully implemented and validated on New England IEEE 39-bus test system for evaluating power system frequency stability robustness.

Technical Session 2b: Smart Grids
Room: CQ-010
Chair: Dr Malabika Basu (Technological University Dublin, Ireland)

34 **Energy Management for Building-Integrated Microgrids Using Reinforcement Learning**
Christos Athanasiadis (Democritus University of Thrace); Kalliopi Pippi (Democritus University of Thrace); Theofilos Papadopoulos (Democritus University of Thrace); Christos Korkas (Democritus University of Thrace); Christos Tsaknakis (Democritus University of Thrace); Vasiliki Alexopoulou (Democritus University of Thrace); Vassilis C Nikolaidis (Democritus University of Thrace); Elias Kosmatopoulos (Democritus University of Thrace)*

ABSTRACT: As more energy-intensive electrical appliances and active assets appear in the residential sector, electricity end-users are able to provide various demand response services, aiming to balance demand and supply profiles. This paper proposes a state-of-the-art energy management system for a microgrid. The study focuses on a four-apartment building incorporating heat pumps, an energy storage system, and photovoltaic generation. A smart control mechanism based on reinforcement learning is introduced aiming to improve thermal comfort, minimize energy consumption and ensure minimum degradation of the storage system. The reported results offer insights into the optimal residential management practices and evaluate the performance of the proposed control strategy in comparison to other alternative demand response solutions.

41 **Penetration of distributed generation in Microgrids: characteristics and challenges**
Kypros Tillyros (Frederick University); Nicholas G Christofides (Frederick Univeristy); Michael Komodromos (Frederick University)*
ABSTRACT: Exploitation of sustainable distributed energy sources is associated with the energy resilience and power optimization of power grids. This study introduces a model of a Microgrid and investigates methods to optimise power quality with the integration of multi-renewable generation to the system. In addition, there is a discussion on the feasibility towards islanded operating microgrids. The proposed work is a result of a careful evaluation of the current literature on the topic. Consequently, the outcome of the given study is anticipated to facilitate future work on Microgrid implementation functioning in islanded mode.

54 **Application of Advanced Model Reference Adaptive Control for Bidirectional AC-DC Converters**
*Muhammad Ahmed Qureshi (Politecnico di Torino); Salvatore Musumeci (Politecnico Torino); Francesco Torelli (Politecnico di Bari); Alberto Reatti (University of Florence); Andrea Mazza (Politecnico di Torino); Gianfranco Chicco (Politecnico di Torino)**
ABSTRACT: Bidirectional AC-DC converters are used in many applications to renewable energy systems, communication systems, and grid connection of electric vehicles. In this paper, a non-linear controller based on the Lyapunov-based model reference adaptive control approach is proposed for single-phase bidirectional AC-DC converters that incorporate active power factor correction circuits. The proposed controller dynamically adjusts the output power according to the grid conditions and user preferences while maintaining a nearly unitary power factor and a constant output DC voltage set as the reference value. The proposed controller also ensures the stability and robustness of the system under various operating conditions and disturbances. The performance of the proposed controller is compared with another Lyapunov-based control proposed in the literature to show that the proposed controller performs at least on par with the other controller in all aspects.

91 **A Novel Energy Balancing Considering Periodic Behavior Pattern of Power System**
Saher Javaid (Japan Advanced Institute of Science and Technology); Mineo Kaneko (JAIST); Yasuo Tan (JAIST)*
ABSTRACT: Renewable Energy Sources (RESs) such as wind and photovoltaic are environment-friendly energy sources for power generation. However, the largely varying output energy of RESs is a major obstacle to their integration into the power grid. In addition, variations in consumer activity increase the risks of power fluctuations. The ability of power systems to deal with power fluctuations caused by renewable sources and dynamic demand has to be improved to keep the stable operation of a power system. This paper proposes a novel robust energy balancing concept to reduce energy imbalance due to the mismatch between fluctuating generation and demand. The proposed concept targets the long-term operation of a power system and aims to guarantee its safe operation under any dynamic fluctuations of RESs and demands.

114 **Assessing the Electrical Energy Consumption for Designing and Developing an Energy Management System in an Educational Building in Romania**
Timea Farkas (Universitatea Tehnica din Cluj-Napoca); Gianfranco Chicco (Politecnico di Torino); Levente Czumbil (Technical University of Cluj-Napoca); Andrei Ceclan (Technical University of Cluj-Napoca); Alexandru G Berciu (Technical University of Cluj-Napoca); Dan Doru Micu (Technical University of Cluj-Napoca)*

ABSTRACT: The building sector is a key pillar in the efforts of decarbonisation and achieving a Net Zero Emissions scenario by 2050. Buildings are accounted for 30% of global energy consumption and 27% of energy sector emissions in 2021. Without immediate action, the building sector will not align with decarbonisation goals. Energy management systems play a crucial role in managing energy usage and rely on forecasting algorithms and energy management schemes. A case study was conducted on the main building of the Faculty of Building Engineering Services at the Technical University of Cluj-Napoca, Romania. The study aims to assess electrical energy consumption and identify key correlations between factors, using multilinear regression and, also, consumption pattern identification. Two scenarios are proposed and assessed.

121 **Precision Time Protocol (PTP) using LinuxPTP on Single Board Computers**

John B O Raw (Atlantic Technological University); David Laverty (Queen's University Belfast); Daniel McFadden (Atlantic Technological University)*

ABSTRACT: Precision time, traceable to Coordinated Universal Time, is a requirement for some applications. Accuracy in milliseconds is achievable using Network Time Protocol over wide area networks. Accuracy in microseconds is achievable using GNSS as a basis for time synchronization and this is a minimum standard for some applications. However, satellite signals are easy to jam over wide areas. Precision Time Protocol (PTP) may provide an adequate source of precision time over wide area networks. For it to be utilized, uncertainty in measurement must be quantifiable and a range of network design constraints are required to match the application. In this paper, an inexpensive test bed is constructed and tested, and initial measurements are made of precision.

Technical Session 2c: Load and Generation Forecasting
Room: CQ-020
Chair: Dr Gobind Pillai (Teeside University, UK)

39 **Synthetic Electricity Consumption Data Generation using Tabular Generative Adversarial Networks**

Thet Paing Tun (Brunel University London); Ioana Pisica (Brunel University London)*

ABSTRACT: In this paper, we propose using Tabular Generative Adversarial Networks (Tabular GAN) to generate synthetic data for residential electricity consumption. Tabular GANs have been used in various domains and have shown promising results in generating high-quality synthetic data. The performance of our proposed method was evaluated by comparing the probability density, mean, standard deviation, and variances of the synthetic data with the original data. The results showed that the Tabular GAN method generated synthetic data that closely matched the statistical characteristics of the original data, and the simulation outcome indicated that the synthetic data generated by Tabular GAN could effectively simulate the patterns and behaviours observed in the original data. Overall, the proposed method demonstrates the effectiveness of using Tabular GANs for generating synthetic electricity consumption data.

65 **Investigating an Ensemble of ARIMA Models for Accurate Short-Term Electricity Demand Forecasting**

Daniil Hulak (Brunel University London); Gareth Taylor (Brunel University)*

ABSTRACT: This paper examines ensemble modelling's effectiveness for time series forecasting using Autoregressive Integrated Moving Average (ARIMA) models. Ensemble modelling combines multiple models to improve forecasting accuracy. Our study explores simple averaging of ARIMA models and compares their performance to individual models. Real-world datasets were used, and metrics such as Mean Absolute Percentage Error and Root Mean Squared Error were employed to evaluate model performance. Our experiments encompassed both short and long datasets, showcasing the higher performance of ensemble models over individual models for short datasets. The ensemble consistently outperformed individual models in terms of accuracy, indicating that ensemble modelling is a valuable tool for time series forecasting, improving accuracy by leveraging different models' strengths to capture underlying patterns and make precise predictions.

75 **Quantifying the risk when using single year PV data in South African electricity system models**

Christina Auret (Stellenbosch University); Bernard Bekker (Stellenbosch University)*

ABSTRACT: Numerous studies have been conducted where a single year of photovoltaic (PV) electricity production data is used to study the impact that PV production has on electricity systems. In this paper the potential margin of error when using a single year of PV production data to approximate long-term PV production is analyzed in the South African context. It is found that while a single year of data performs poorly in general, it does give reasonable estimates of annual electricity production in areas with very high annual average Global Horizontal Irradiation. Combining PV production from various randomly selected locations does not significantly increase accuracy from what is achieved using individual locations when using a single year to represent long-term electricity production. These findings are relevant to researchers scoping future PV related research projects and to the analysis of results from studies that have used a single year of PV production data as input.

76 **How will Air Source Heat Pumps affect Electricity Load Profiles in Buildings in Ireland? A data logger used to model electrical energy profiles**

*Michael McDonald (TU Dublin)**

ABSTRACT: There are many global factors that are challenging the colossal transition to Zero Carbon Economy, ranging from regional conflicts, possible new cold wars, inflation to rising interest rates. The climate challenge is, de facto, an energy transition challenge, which historically take generations. Governments all over the world are working to implement policy that encourages society to foster clean energy and low-carbon technologies. It is a fine balance between supply and demand of energy networks, whilst maintaining energy security. This was evident in Ireland during the winter of 2022 which witnessed several Systems Alerts, from the Transmission System Operator (TSO), EirGrid. This paper aims to analyse datasets produced from a Power and Energy Data Logger which consisted of time series data recorded at ten minute intervals from two different load sources.

79 **Reliability parameterised distribution grid flexibility aggregation considering renewable uncertainties**

Neelotpal Majumdar (Leibniz University of Hannover); Kengkat Prapatsara (Leibniz University of Hannover); Rauan Yermekbayev (Leibniz University of Hannover); Lutz Hofmann (Leibniz University Hannover)*
ABSTRACT: Active distribution networks (ADNs) are increasingly assuming an important role in future power system operations. Due to incremental phasing out of thermal power plants, a shift of ancillary services provision from the renewables is underway. Active and reactive power flexibility (PQ-flexibility) quantification from the underlying distribution grid at the vertical interconnection to the overlaying grid is a topic of current research. A two dimensional PQ-flexibility map at the vertical interconnection serves as a basis for flexibility provision between grid operators. The task of flexibility aggregation is complicated when renewable power injection uncertainties are considered. Therefore, a reliability parameterized flexibility aggregation segregated into confidence intervals is practical. The paper provides a method for generation of correlated renewable uncertainties, and based on the inherent statistical properties, reliability parameterized PQ-flexibility maps are determined.

106 **Power Load Forecasting: A Time-series Multi-step ahead and Multi-model analysis**

Aristeidis Mystakidis (International Hellenic University); Aristeidis Mystakidis (Centre for Research and Technology Hellas); Nikolaos Tsalikidis (Centre for Research and Technology Hellas); Paraskevas Koukaras (International Hellenic University); Paraskevas Koukaras (Centre for Research and Technology Hellas,); Christos Tjortjis (International Hellenic University)*
ABSTRACT: Distribution System Operators and Aggregators can derive benefits from innovative approaches in Power or Energy Load Forecasting (PLF-ELF). Enhanced accuracy in PLF-ELF can support the management of energy imbalances between production and consumption or operations like Demand Response. This research aims to assess a wide range of models as potential solutions for multi-step PLF-ELF, utilizing time-series machine learning models for power consumption. The experimentation encompassed multi-step PLF-ELF across various resolutions, ranging from 15-minute intervals up to one day. Results indicate that while Long Short-Term Memory recurrent Neural Networks and Lasso Regression with Cross-Validation perform better for very short-term PLF-ELF, tree-based regressors like Gradient Boosting, Histogram Gradient Boosting, Light Gradient Boosting Machine and CatBoost outperformed other models in the upcoming steps. The optimal PLF-ELF technique proposes different algorithms per forecasting horizon.

Wednesday 30 August 2023, 16:00 - 17:30

Technical Session 3a: Power Engineering Education
Room: CQ-009
Chair: Dr Jane Courtney (Technological University Dublin, Ireland)

27 **Review on Power Electronics Curriculums in Academia and Framework Development**
Walid Issa (Sheffield Hallam University); Maher Dr Al-Greer (Teesside University); Faris I Al-Naemi (Sheffield Hallam Univ.); Imran IB Bashir (Teesside University)*
ABSTRACT: The Department for Business Innovation and Skills (BIS) in the UK has recognized ensuring a good supply of talented Power Electronics engineers as a challenge. The use of outdated or inappropriate curriculums at universities has been identified as a gap to address this challenge. Some academic institutions have well-recognized power electronics, machines and drives (PEMD) programs where their undergraduate courses are also linked to their research interests. However, other academic institutions do not provide that depth of knowledge required by the PEMD industry, considering it as optional knowledge and do not have suitable training materials. This paper reviews the current state of Power Electronics curriculums and contribute to filling the gaps in skills, talent and training for the PEMD industry by developing a framework for academic curriculum, which is supported by industrial-oriented knowledge and inputs.

30 **Phasor Diagrams of Symmetrical Components for Vector Space Decomposition Transformation in Symmetrical Nine-Phase Machine**
Živa Stare (University of Ljubljana, Faculty of Electrical Engineering); Rastko Fišer (University of Ljubljana, Faculty of Electrical Engineering); Klemen Drobnič (University of Ljubljana, Faculty of Electrical Engineering)*
ABSTRACT: In this paper, the phasor diagrams of the symmetrical components of a symmetrical nine-phase motor with a single neutral point have been studied. The symmetrical component transformation, which is the basis for the vector space decomposition (VSD) method, is used in the field of electric drives because it simplifies the modelling of a symmetrical multiphase machine. The VSD method is based on the transformation of the input signals into different decoupled subspaces by summing two symmetrical components. Using the phasor diagrams of the symmetrical components of a nine-phase machine, we can then analytically predict how different voltage excitations of the system are transformed into the decoupled subspaces. Of great interest is the prediction of how the various voltage excitations affect the first two-dimensional subspace, which is responsible for torque generation in the machine. We will analyse input voltages with higher harmonics and different amplitudes.

53 **Analysis of some plotting skills of junior engineering students**
*Aidan O'Dwyer (TU Dublin)**
ABSTRACT: Manual plotting of data on appropriate graph paper, and the plotting of phasor diagrams using setsquares and/or a compass, are examples of important practical skills for power engineering students. Plotting skills of this sort have traditionally been developed in pre-university education in Ireland. However, the author has established that a large minority of engineering students, in the first half of their degree studies (first and second year students in Ireland), are not practiced sufficiently in these skills, as revealed in student answers to assessment questions. The author suggests that, in some cases, a simple refinement in question design can assist in student understanding of the task required. The improvement of more sophisticated plotting skills remains a work in progress, and some suggestions for further work are provided.

90 **Developing an adaptive dynamic model of the KSA interconnected national grid**
Saad AlQahtani (Cardiff University); Liana Cipcigan (Cardiff University)*
ABSTRACT: Dynamic simulation is a powerful tool for exploring the impact of Renewable Energy Sources (RESs) on the power system stability before being physically implemented. This paper describes the process of developing an adaptive dynamic model of the Kingdom of Saudi Arabia (KSA) national grid using actual parameters obtained from the system operator and using generic models. The purpose of this model is to provide an accurate representation of the KSA national grid that can be used for various analyses and simulations. Both static and dynamic modelling of key components of the KSA national grid has been modelled and simulated using professional DIgSILENT PowerFactory Software. The accuracy of the adaptive model was tested against the actual system data. The simulation results show the model's validity of resembling the actual KSA interconnected national grid.

116 **Conversion of Power Flow Models into Real-Time Simulation Models: A Case Study of OpenDSS to Matlab/Simulink Conversion for a Large-Scale Distribution Network**
Brian Dowling (University College Cork); Ibrahim Sengor (MaREI SFI Centre, University College Cork); Barry P. Hayes (University of Cork, Ireland)*

ABSTRACT: Given the recent carbon-neutral pledges made by countries around the world, there is clearly a growing need for updating existing distribution grids, which will be essential in facilitating the integration of renewable energy sources and the electrification of the transport and heating sectors. Real-time simulation of these networks can allow for analysis of various power quality issues and enable a better understanding of the challenges and solutions in controlling distributed energy resources. Accordingly, this paper presents a comprehensive study on the conversion of power flow models into real-time simulation models, focusing on a case study of a large-scale distribution network. A comparative analysis between the OpenDSS and Matlab/Simulink simulations validates the accuracy of the converted models. The outcome of this comparison showed a high degree of accuracy for specific test areas of the model and therefore confirmed proof of concept for this method moving forward.

122 **PySDDP: An Open-Source Python Tool Applied to the Operation Planning Problem in the Age of Energy Transition**

Amanda Pávila Silva (Universidade Federal de Juiz de Fora); André Marcato (Universidade Federal de Juiz de Fora); Alessandro Castro (StudioApp); Diogo Barros (Universidade Federal de Juiz de Fora); Camila Cunha (Universidade Federal de Juiz de Fora)*

ABSTRACT: There is a strong movement towards energy transition in the current context of large-scale power systems worldwide. In this dynamic scenario, the existence of computational tools capable of providing an environment that work as an interactive laboratory becomes essential for engineering education. PySDDP is a free Python computational tool applied to the operation planning of large-scale power systems and is available through the PyPI and GitHub repositories. PySDDP's name comes from Sthocastic Dual Dynamic Programming, one of the most popular algorithms applied to solve long-term hydro-thermal operating planning. PySDDP has mechanisms for manipulating all data used to solve the operation planning problem of Brazilian official models. However, it can friendly receive contributions from third parties to include data from energy systems of other countries. Moreover, its implementation in Python makes the tool easy to understand and allows easy extension with third-party libraries.

Technical Session 3b: Electric Vehicles and e-Mobility (1)
Room CQ:010
Chair: Dr Garret Brady

23 **Laboratory validation of electric vehicle smart charging strategies**

Anna Malkova (DTU); Simone Striani (DTU); Jan Martin Zepter (DTU); Mattia Marinelli (DTU); Lisa Calearo (Ramboll Danmark A/S)*

ABSTRACT: Electric vehicles (EVs) are the connecting point of the transportation and electricity sectors and are an important milestone towards the decarbonization goal. Smart charging of EVs is considered a key enabler for the broad deployment of EVs. Acting as flexible demand, smart charging releases stress on the grid infrastructure and enables potential flexibility to the renewable energy sources (RES), thereby enhancing the power system. This paper presents results from experimental tests with two smart charger prototypes developed within the ACDC project. The autonomously and distributed controlled chargers connecting four EVs are integrated into the Energy System Integration Lab (SYSLAB) of the Technical University of Denmark. The conducted tests aim at different flexibility services, namely power sharing, RES following, and transformer (TRAFO) protection. The developed chargers fulfil the assigned tasks and are able to provide ancillary services to the grid and RES.

29 **A Critical Evaluation of Eco-driving Strategies for Connected Autonomous Electric Vehicles at Signalized Intersections**

Xinxing Ren (Brunel University London); Chun Sing Lai (Brunel University London); Gareth Taylor (Brunel University)*

ABSTRACT: Signalized intersections are significant spots of energy consumption because of frequent stop-and-go behavior. Eco-driving aims to reduce energy usage by optimizing driving behavior. Researchers have reviewed optimization-based method while lack of them reviewed the learning-based approaches. This work critically reviewed two different types of approach. In addition, one well-known rule-based car-following model and two state-of-the-art optimization-based and learning-based methods are selected to test in a signalized intersections environment with the metrics of energy consumption, travelling time and algorithm execution time. The experiment results show that the travelling time of three algorithms are similar, while the energy consumption of the learning-based method and optimization-based method are 30.72% and 51.82% less than that of the ruled-based method respectively. However, due to algorithm execution time, the optimization-based method is not suitable to be used in real-time.

40 **Multi-Agent RL Framework for EV charging scheduling driven by energy costs and user preferences**

Christos Korkas (CERTH); Christos Tsaknakis (Democritus University of Thrace); Elias Kosmatopoulos (Democritus University of Thrace)*

ABSTRACT: The increasing popularity of electric vehicles (EVs), calls for more grid-connected charging stations. Managing these stations, poses a complex problem that requires balancing station profitability, user preferences, grid needs, and stability. Finding the ideal charging schedule is difficult because it involves factors such as electricity prices, available renewable resources, the stored energy of other vehicles, as well as the unpredictability of EV arrival and departure times. This paper presents a multi-agent and distributed reinforcement learning framework, achieving high performance under various conditions. The charging spots make their own charging decisions independently, aiming to minimize costs, without exchanging any information. Numerical studies show that the proposed framework improves the scalability and the sample efficiency of DDPG algorithm, offering significantly better results compared to Rule-Based Controllers (RBCs) and other state-of-the-art RL algorithms.

47 **A Comparison of PI and RBF Brushless DC Motor Speed Control Methods**

Mostafa Farrag (Brunel University London); Chun Sing Lai (Brunel University London); Mohamed Darwish (Brunel University)*

ABSTRACT: Abstract— Brushless Direct Current (BLDC) motors are widely used in electromobility and industrial robots. BLDC motors are essential in many production applications. However, they encounter significant challenges when it comes to executing control of speed. Due to their simplicity, speed controllers are often designed using Proportional Integral (PI) regulation. The saturation of standard PI control makes the system unreliable, hence an online radial basis function (RBF) neural network is proposed. The paper compares and evaluates the speed response of two regulators under a reference speed of 3000 RPM. The purpose is to examine and contrast the performance of these regulators in regulating the speed of the system. In comparison to the traditional PI controller, the presented controller demonstrates superior characteristics such as lower overshoot, improved response speed and greater anti-disturbance capability. The studies are conducted in MATLAB/Simulink.

120 **Energy efficiency assesment of sustainable public transport solutions: a comparative analysis fuel cell vs battery in real life scenarios**

*Dan Doru Micu (Technical University of Cluj-Napoca); Dan Moldovanu (Technical University of Cluj-Napoca)**

ABSTRACT: Given the current paradigm in the field of sustainable mobility, an urgent need to modernize public transport systems, has become undoubtably vital. The increasing concerns regarding climate change and the tightening of emissions standards, have directed public transport operators towards the large-scale adoption of alternative propulsion vehicles. The most notable option in this area are Battery Electric Buses (BEBs), a mean of transport that has gained tremendous popularity in the past decade. However, Fuel Cell Electric Buses (FCEBs) emerged as a prospective option in this sector. The aim of this paper is to provide a thorough assessment between these alternative transport solutions, with the ultimate goal of determining the energy efficiency of both BEBs and FCEBs.

Technical Session 3c: Renewable Energy Systems (1)
Room: CQ-020
Chair: Prof Eugene Coyle (Technological University Dublin, Ireland)

2 **Introduction of Grid Forming Converters in the European Grid Codes**
Kyriaki Nefeli Malamaki (Aristotle University of Thessaloniki); Dimitrios Tampakis (Aristotle University of Thessaloniki); Charis Demoulias (Aristotle University of Thessaloniki)*
ABSTRACT: The increased penetration of Converter-Interfaced Distributed Renewable Energy Sources (CI-DRES) and the simultaneous decommitment of Synchronous Generators (SGs) have led to displacement of SG support functions, e.g., inertia, and Ancillary Services (AS), e.g., reactive power, and caused problems related to electric grid robustness and stability. The advanced controllability of Voltage Source Converters (VSCs) and the use of Storage Systems can be exploited to boost the CI-DRES functionalities beyond their current operation, i.e., uncontrolled power provision. In the H2020 project EASY-RES such VSC has been developed. In this paper, suggestions for modification of European grid codes are presented, so that such units are integrated in distribution grids to provide existing and new AS and achieve 100% RES penetration. Finally, suggestions are presented for: introduction of new grid codes regarding AS quantification; specifications on ICT systems; development of a CI-DRES registry.

7 **Performance Evaluation of 1 MW On-grid Solar Photovoltaic Plant with Single Axis Tracker in Muscat, Oman**
Mazin A Al-Shidhani (Petroleum Development Oman); Mazin Al-Shidhani (Petroleum Development Oman); Arwa Al Mayasi (Petroleum Development Oman)*
ABSTRACT: This research paper presents a data comparison of two different simulation software with actual on-grid results of a 1 MW bifacial solar plant under real meteorological conditions. The solar PV plant of 1 MW incorporated with a single-axis tracker is one of the largest installed capacities in one single location for an oil and gas company in Muscat, Oman. The data analysis evaluation in this study is carried out for one full year (2022). The site receives very good solar insolation and temperature with an average of 7056 kWh/m2/month and 35.6 °C, respectively. The integration of 1MW solar PV results in a 3% bill reduction for the same year. The plant experienced a very high annual average performance ratio of 90.40%. The energy yield simulations are made on two broadly used PV design software: PVsyst and Helioscope. This research provides the first-time comparative study for a 1 MW solar plant with a single-axis tracker. The actual results show a significant power generation output.

22 **Variable Shunt Reactor Technology to Improve Dynamic Reactive Power Compensation in Wind Farm Power Stations**
*Seyed Alireza Mousavi Mirkalaei (Hitachi Energy)**
ABSTRACT: Abstract—For a large-scale power system such as offshore Wind Farm Power Stations (WFPS) with an extended Offshore Transmission System (OFTS), it is imperative to have a well-designed strategy to manage reactive power effectively. Over the last decade, there has been significant development in Variable Shunt Reactor (VSR) technology, allowing for the realization of large-scale VSRs with a regulating range of 60% to 80%. The implementation of variable shunt reactors offers a practical solution for improving the reactive power scheme of the system to a certain extent. In this paper, VSR technology is utilized to create a Dynamic Reactive Power Compensation (DRC) system for an actual WFPS. A conventional system is also designed as a point of comparison to evaluate the effectiveness of the new methodology.

60 **Distance Protection of Transmission Lines Connected to Inverter-Based Resources**
Michael O'Donovan (Munster Technological University); Noel Barry (MTU); Joe Connell (MTU)*
ABSTRACT: The increasing integration of inverter-based resources, such as wind and photovoltaic systems, poses significant challenges for protection devices. Reduction in fault current is expected to compromise power system protection performance. Traditional overhead line protection schemes have primarily been designed focusing on the dynamic behaviour of rotating machines as the primary generation sources, neglecting the unique dynamic response of inverter-based resources governed by inverters.
This study developed a comprehensive model of a 110 kV network comprising traditional and inverter-based resources using DigSilent PowerFactory. Electromagnetic transients (EMT) analysis is conducted on distance protection devices within the network. The findings presented in this paper highlight the complex challenges encountered when employing distance relay protection in the presence of inverter-based resources.

61 **Capacitive Transfer System Cable for Application in Offshore Microgrids**
Edward JS Mair (Enertechnos); Owen Johnson (Enertechnos); Charles Lucas-Clements (Enertechnos); Hafiz Milhan (Enertechnos)*
ABSTRACT: Through collaboration and challenge, operators from across the North Sea are required to find economical and sustainable solutions to electrify offshore oil and gas platforms. Enertechnos was part of a consortium, completing a study that provided a new approach to electrify oil & gas platforms in the Central North Sea (CNS) area.
This approach is founded on sending power from floating wind turbines, supported by highly efficient and responsive gas-powered reciprocating generators and battery storage on floating distribution hubs. Enertechnos was responsible for defining the power distribution system, using patented CTS cable technology to reduce costs and emissions intensity by minimizing fuel gas volumes and reducing the requirement for compensating equipment on platforms.

64 **Analysis of electricity usage for households with electric vehicles and photovoltaics in the UK**

Dervla Scully (University College Dubllin); Adamantios Bampoulas (University College Dublin); Eleni Mangina (University College Dublin)*

ABSTRACT: The integration of photovoltaic (PV) systems with electric vehicles (EVs) will contribute to decarbonising the UK's energy system. However, achieving this requires substantial investment in grid and generation capacity due to changing electricity usage. EVs' carbon emissions reduction depends on the power source's carbon footprint, and expanding PV generation necessitates local storage development to mitigate negative grid impacts. This study compares energy consumption patterns for UK households with PVs and EVs using two data sources. Peak consumption times that may overload networks with high renewable energy uptake are identified. Additionally, energy consumption data from households with an unknown energy mix are analyzed to identify potential EV customers. The findings show PV generation reduces net demand during the day, resulting in net export, particularly outside winter. These insights inform network implications and facilitate planning for the UK's low-carbon future.

Thursday 31 August 2023, 9:30 - 11:00

Technical Session 4a: Data Analytics and AI Applied to Power Systems (2)
Room: CQ-009
Prof Gianfranco Chicco (Politecnico di Torino, Italy)

88 **Graph Algorithms for Topology Identification in Electrical Medium Voltage Grids**
Steven M de Jongh (Karlsruhe Institute of Technology (KIT)); Felicitas Müller (KIT - Karlsruher Institut für Technologie); Fabian Osterberg (Karlsruhe Institute of Technology (KIT)); Michael Suriyah (Karlsruhe Institute of Technology (KIT)); Thomas Leibfried (Karlsruhe Institute of Technology (KIT))*

ABSTRACT: The availability of realistic grid topologies is of central importance for the usability of grid models in calculations. However, especially in distribution grids, poor documentation, limited digitization and insufficient data quality can lead to faulty topologies, which result in errors in subsequent calculations. Methods of topology identification (TI) offer possibilities to use measurement data of voltages to validate and correct the topology used for calculations. This paper robust presents methods for TI in medium voltage grids based on an adapted form of Prim's algorithm, which is based on measurements of node voltage magnitudes. Methods to include spatial priors in the process are investigated. The developed method is applied to realistic models of medium voltage networks and its robustness to unadapted graph-based methods is shown. The correlation of injection correlations, as well as noise on measured data, is addressed to show the proposed methods can handle these conditions.

95 **On the Impact of Socioeconomic Variables on Non Technical Losses in Low Voltage Distribution Systems**
Vinícius J Garcia (Federal University of Santa Maria); Natalia Sousa (Federal University of Santa Maria); Leonardo N. F. da Silva (UFSM); Kamila Kamila (Federal University of Santa Maria); Antônio Kaminski Júnior (Federal University of Santa Maria); Daniel Bernardon (Federal University of Santa Maria); Alzenira Abaide (UFSM); Otacílio Carneiro Filho (Federal University of Santa Maria)*
ABSTRACT: Non-technical losses in distribution systems be represented by the consumed energy amount without billing, mainly due to energy theft and connection frauds. Analyzing non-technical losses in low voltage consumer contexts, mostly residential units, relationships between socioeconomic aspects and losses are observed, due to the heterogeneity of the population's living conditions, mainly in developing countries like Brazil. Due to advances in data processing techniques and the current volume of information, the influence of these exogenous aspects can be included in loss expectation models, improving the assertiveness of inspection planning. The study has been developed to the demographic units that compose a capital city from the south region of Brazil, however, being a model easily replied to other regions. The results showed greater relationships between non-technical losses and aspects of population income and literacy.

99 **Prediction of aggregated EV representation using XGBoost and LightGBM**
Marko Kovačević (University of Zagreb, Faculty of Electrical Engineering and Computing); Mario Vasak (Unknown)*
ABSTRACT: Electrical vehicles (EV) presence forecasting on a parking lot with charging points is critical for charging schedule optimisation with providing demand response to the power grid. The paper leans on our previous work where we proposed innovative aggregated representation of EV population. The historical dataset is transformed in the aggregated representation, and it is analysed and used for training of two radient boosting models in order to forecast future EV population. The predictions are generated on 2 hours forecasting horizon. Achieved accuracy is compared to week-of-day average and persistence.

103 **A Markov Chain Model for Imputation of Electricity Consumption Time Series**
Jawana Gabrielski (TU Dortmund); Ulf Häger (TU Dortmund)*
ABSTRACT: The energy transition goes along with the digitization of the energy sector. This leads, among others, to a rising use of smart meters in distribution grids and thus to an increasing collection of metering data from the energy system. At the same time, the demand for metering data is growing, as it forms the basis for many data-based innovations. However, the amount of real measured data has been limited so far and connection failures or outages of measuring devices can lead to missing periods in measured time series. Since, for many application areas, complete time series are indispensable, this paper proposes a method to impute missing or defective periods in electricity time series based on statistics from existing data. The method uses a combination of Markov Chains and Gaussian Mixture Models as well as a tree search.

110 **Optimization of Maintenance Scheduling for Generator Units in Hydroelectric Power Plants Using Ant Colony Optimization**
Elisa Oliveira (Federal University of Juiz de Fora); Marcos Oliveira (Federal University of Juiz de Fora); André Marcato (Federal University of Juiz de Fora); Patrícia Sousa (Federal University of Juiz de Fora); Giovani Santiago (Santo Antônio Energia); Edimar Oliveira (Federal University of Juiz de Fora)*
ABSTRACT: Efficient scheduling of generator maintenance is crucial to ensure the reliability and availability of a power generation system. However, the complexity of these tasks, along with the specific regulatory constraints, this process is challenging for large Brazilian hydro plants. In this context, this article presents an approach based on Ant Colony Optimization to optimize the maintenance schedule of generator units in a hydroelectric power plant, considering regulatory aspects related to the Availability Factor. The objective is to determine the optimal timing for the maintenance of each generator unit within an annual timeframe with daily discretization.

139 **Grid Search Based Hyperparameter Optimization for Machine Learning Based Non-Intrusive Load Monitoring**
Burak Cem Sayılar (Peakup); Oguzhan Ceylan (Marmara University)

ABSTRACT: This paper solves the Non-Intrusive Load Monitoring problem by using two machine learning based models: Xgboost and Recurrent Neural Network. We utilize and develop models using a publicly available dataset. To improve the performance we have implemented hyperparameter optimization using grid search. The numerical simulation results show that proposed Xgboost model outperforms the RNN based model. With the implementation of hyperparameter optimization an improved numerical accuracy is obtained.

Technical Session 4b: Power System Economics and Electricity Markets
Room: CQ-010
Chair: Dr Keith Sunderland (Technological University Dublin, Ireland)

49 **Impact of the National Energy and Climate Plan on the Italian Distribution Networks Infrastructure**
Giacomo Viganò (RSE); Marco Rossi (RSE); Diana Moneta (RSE); Chiara Michelangeli (RSE)*
ABSTRACT: To achieve the 2030 decarbonization objectives, a rapid growth is expected in distributed generation and demand electrification. This will result in significant investments to upgrade the distribution network and the need for a proper planning, able to consider both traditional infrastructure reinforcement and local flexibility. Due to the lack of public detailed information on the network infrastructure and connected users, the limited data available is used to create a synthetic distribution system, which, according to previous analyses, was found to be a reasonable approximation of the actual Italian distribution system. Based on this model, a simplified planning procedure is applied to estimate the necessary investments and to determine the benefits of smart solutions. The results show that the planning costs depend on the geographical position of new users and that they could be reduced by adopting smart grid solutions.

59 **Techno-economic Analysis of Offshore Wind farms Connected to Superconducting MVDC Cables**
Cathal Doherty (UCD); Terence O'Donnell (UCD)*
ABSTRACT: As society moves from fossil fueled generated energy to renewable energy to offset climate change, there will be a growth in offshore wind generation. Transferring the large amounts of energy generated offshore to onshore may be aided by the use of superconducting cables. The use of lower voltage superconducting cables for the transmission could facilitate the use of alternative wind farm topologies. This paper compares several DC wind farm topologies connected to a DC superconducting cable with a base case AC/HVDC wind farm in terms of the levelized cost of energy (LCOE). The results show that as the wind farm capacity increases, a dispersed parallel topology becomes the most economical choice while the traditional AC wind farm is most optimal for lower power capacities.

66 **Investigation and Evaluation of the Adoption of Locational Marginal Pricing in Electricity Markets**
Muhammad Jamil J Mustapha (Brunel University); Gareth Taylor (Brunel University)*
ABSTRACT: This research paper investigates and evaluates the adoption of locational marginal pricing (LMP) in electricity markets. The study examines the effects of active power generation and line constraints on LMP as it relates to price volatility and electricity costs. To conduct the research, the study uses a six bus network to model advanced market arrangements for the Great Britain power system using analytical methods and software such as Power Factory and Power World. The results suggest that LMP can lead to more efficient electricity markets by incentivising generators to locate in areas with high demand and low transmission costs.Also huge investments are needed in transmission networks to relieve network congestion to allow consumers to enjoy the benefits of LMP. The findings of this study have implications for policymakers and market participants in electricity markets, as they provide insights into the potential benefits and drawbacks of LMP as a pricing mechanism.

105 **The Thermal and Optical Characterization of Semi-transparent Photovoltaics Samples for Buildings Energy Evaluations**
*Haytham Musameh (Sheffield Hallam University); Faris I Al-Naemi (Sheffield Hallam Univ.); Hameed Alrashidi (University of Exeter); Walid Issa (Sheffield Hallam University)**
ABSTRACT: Using Semi-transparent PV (STPV) as glazing in buildings might improve the building's energy profile. However, the characterization method has to be identified. This work aims to establish the experimental methodology utilized in characterizing various glazing SPTV samples and draw its potential impact on buildings. The results indicate that STPV-based CdTe solar cells tend to reduce the amount of natural light that can enter the indoor environment, therefore, increasing the lighting demands and reducing the passive heating element, which would increase the heating demand. Furthermore, it minimizes the heat gain caused by solar radiation passing through the glazing. This suggests that CdTe STPV glazing samples can serve as effective shading devices, ultimately reducing the cooling requirements of buildings. Finally, the CdTe STPV glazing systems exhibit better insulation properties compared to conventional single and double-glazing samples, regardless of their structure.

135 **Fair Prosumer Participation in P2P Energy Markets: An Iterative Water-Filling Algorithm for Congestion Control**
Emad Jamil (University College Cork); Barry P. Hayes (University of Cork, Ireland)*
ABSTRACT: This paper proposes a novel solution that ensures fair prosumer participation in Peer-to-Peer (P2P) energy markets while controlling congestion through the use of a Fair Water-Filling algorithm. The proposed method guarantees the exchange of energy between participants without violating network constraints through fair allocation of curtailments among the prosumers' injections. The algorithm is employed to achieve near-optimal performance and impart higher degree of fairness among different market participants. The proposed methodology is tested on the IEEE 33-node test feeders, and the results indicate that the algorithm effectively ensures fair participation among market participants while accommodating network constraints and promoting economic benefits to all participants. The results of this are expected to attract interest from policy-makers, energy providers, and researchers exploring fairness during energy transactions in local energy markets respecting the network constraints.

141 **Enhance the Effectiveness of Peer-to-Peer Trading in Renewable Energy Community by Innovative Imbalance Price Settlement**

Dharmesh Mr Dabhi (Technological University Dublin); Rene Peeren (Technological University Dublin); John Dalton (Technological University Dublin)*

ABSTRACT: This paper proposes a CosyGrid (CG) system, to achieve the objective of Renewable Energy Communities (RECs), such as maximizing self-consumption, through Peer-to-Peer (P2P) trading. The unfilled not flexible orders from the peers at the start of the delivery period are matched with the peer's retailer as per the Supply Agreement (SA), based on actual volumes imported or exported. In the proposed design, contracts are instead settled based on contracted volumes of consumption and production and the difference between actual and contracted volumes, and the retailer contracts for unfilled orders are settled at a higher spread between buy and sell price than the SA. These adapted SA allow for stronger p2p price signals and are referred as Framework Agreements (FA). The imbalance price in the proposed approach will incentivize end-users to respond to price changes and motivate them to use accurate forecasts for their orders, which will further improve the effectiveness of P2P trading.

Thursday 31 August 2023,11:30 - 13:00

Technical Session 5a: Power System Modelling and Analysis
Room: CQ-009
Chair: Dr Stephen Robson (Cardiff University, UK)

48 **Design and Optimization of a Hybrid Renewable Energy System for Weizhou Island**
Ziyu Fang (University of Edinburgh); Jonathan Shek (University of Edinburgh)*
ABSTRACT: The increasing population of remote islands has led to a surge in the demand for power generation, prompting researchers to explore solutions such as HRES. By integrating renewable sources with existing conventional generators, HRES can reduce LCOE and minimize GHG emissions. However, limited research exists on optimizing economic configurations and evaluating system stability, particularly for peak load demand. This paper focuses on the design, optimization, and evaluation of a large HRES for Weizhou in Guangxi, China—a densely populated island. The findings demonstrate the technical and economic feasibility of implementing HRES on this island, meeting a saturated load demand of 120 MW at $0.122/kWh. The proposed system utilizes wind, solar, natural gas, diesel, and storage batteries as energy resources. Power flow simulations, based on configuration optimization results from HOMER, reveal favorable system performance in power quality, supply-demand balance, and stability.

81 **Inertia Estimation Using the Modal Sensitivity Concept: Validation on Heterogeneous Multi-Machine Power Systems**
*Achilleas Sfetkos (Aristotle University of Thessaloniki); Eleftherios Kontis (Aristotle University of Thessaloniki); Theofilos Papadopoulos (Democritus University of Thrace); Grigoris K Papagiannis (Aristotle University of Thessaloniki)**
ABSTRACT: The high penetration of converter-interfaced renewable energy sources reduces the inertia levels of modern power systems, jeopardizing grid stability. Therefore, to ensure the safe and reliable operation of their grids, power system operators shall monitor close to real-time the overall inertia levels. Towards this objective, in this paper an inertia estimation technique, based on the modal sensitivity concept, is formulated and validated on heterogeneous multi-machine power systems. Several cases are considered and examined to demonstrate the applicability range of the developed method.

101 **DB-TENG Model Development**
Seán P O'Connor (TUDublin); Jane Courtney (TU Dublin)*
ABSTRACT: In recent years a significant amount of research has been done on triboelectric nanogenerators (TENGs), with recent studies achieving energy outputs comparable to solar cells. One such device is the single electrode mode droplet-based TENG (DB-TENG). These devices have many potential applications, however, exploring them can be cumbersome as simulated models of these devices have not yet been developed. This study aimed to fix this issue by developing the first DB-TENG model, with the intention of creating a foundation model that future researchers could build on and further improve. The model produced could predict the time intervals at which the voltage spikes occurred in the output of the physical rig; however, it was found that the models' energy output significantly underperformed. This model shows that these devices can be modelled somewhat accurately and could provide future researchers with the tools needed for understanding, designing, and analysing these devices.

107 **Unveiling the Potential of Shadow Capacity Analysis for Enhancing Power Grid Loadability: Towards Future Applications**
*Arash Beiranvand (Technological University Dublin)**
ABSTRACT: The recently articulated concept of "Median Shadow Capacity" (MSC) offers valuable insights into the topological factors impacting a power grid's loading capacity under (− 1) security constraints. An important finding is that imbalances in the reactance structure can lead to unbalanced power redistribution and subsequent overloading after an outage, violating (− 1) security constraints. Analyzing the MSC suggests certain lines within the grids, referred to as "constraining lines", are responsible for limiting the loadability of other lines. This paper proposes introducing fixed reactances to these lines to modify the grid's reactance structure and improve loadability. A sample grid is used for testing, and a feasibility analysis is conducted for numerous operational scenarios generated by Monte Carlo simulations. Results showed that modifying constraining lines' impedances can enhance grids' loadability under (− 1) security constraints

108 **Towards the Use of Sink Ancestors and Source Descendants as a Clustering Method in a Directed Acyclic Graph**
Justin Ugwu (University College Dublin); Paul Cuffe (University College Dublin)*
ABSTRACT: Clustering techniques play an important role in analysing complex networks such as electrical power systems grids. They can help in identifying congestion bottlenecks and other planning and operation activities. This paper presents a clustering method for partitioning a power network by grouping the nodes and edges based on their reachability to or from the various sources and sinks in the system. These clusters can be discussed using familiar terminology from river networks, such as tributaries and distributaries. A goal is to concretely visualise how nodes and edges are related, and their operational dependencies within the network. The clustering results may give power system operators new insights into the system's structure, enabling situational awareness, fault/vulnerability analysis, and planning. The proposed methodology is applied to two sample grids to demonstrate the types of clusters it can identify.

109 **Applying a reduced order network simplification method: A South African example**
Johannes de Bruyn (Department of Electrical and Electronic Engineering, Stellenbosch University); Bernard Bekker (Stellenbosch University); Amaris Dalton (Stellenbosch University)*

ABSTRACT: With the increased penetration of variable renewable energy sources globally, academic literature increasingly highlights the value of using probabilistic methodologies in power system planning although these methods can be prohibitively slow when applied to large power systems. Stochastic-probabilistic hosting capacity analysis using numerical load flow is especially slow. One way to reduce the simulation time is to use network simplification techniques which reduce the system size while retaining solution accuracy. This article considered the literature available on network simplification and applied a Ward equivalent circuit to a deterministic model of the South African transmission network. It was found that time reductions of up to 67 % were achieved after simplifying the network model, with, at most, a 7 % accuracy reduction. This is considered significant enough to warrant further research for the South African case.

Technical Session 5b: Power Quality
Room: CQ-010
Chair: Dr Mohammed Elgendy (Newcastle University, UK)

31 **DC Measurement in HVAC-Systems: Status Quo and Recent Developments**
Philipp Schachinger (Graz University of Technology); Dennis Albert (Graz University of Technology); Alexander Fröhlich (Graz University of Technology); Herwig Renner (Graz University of Technology); Joahnnes Mandl (Graz University of Technology); Philipp Trampitsch (Graz University of Technology); Reinhard Klambauer (Graz University of Technology); Alexander Bergmann (Graz University of Technology); Werner Schöffer (ARTEMES GmbH)*
ABSTRACT: The measurement of small direct currents in presence of high AC currents on high voltage potential is a challenging task. Inductive current transducers (CT) are not able to measure DC and other non-conventional CTs are also not designed for DC. Therefore, DC measurements are done in transformer neutral points on ground potential. In this work, the state of the art on DC measurements in the high-voltage transmission grid is given, including the measurement in the transformer neutral point, the indirect measurement with the differential magnetometer method, and the indirect method of measuring a compensating current. In addition an optical current measurement system under development is presented.

38 **Modeling and Dynamic Simulation of Non-standard Operating Conditions in Low-Voltage Grids Considering Different Network Topologies**
Frederik Gielnik (Karlsruhe Institute of Technology); Olga Kinas (Karlsruhe Institute of Technology); Thomas Leibfried (Karlsruhe Institute of Technology)*
ABSTRACT: The transition towards renewable energy sources creates new challenges for power distribution grids. As a result, new requirements and specifications are needed to ensure network stability. Especially in low-voltage (LV) grids, where the majority of electricity consumers and distributed generators are connected, high network utilization and possible power quality (PQ) disturbances are expected. This paper presents a model of a real LV grid to assess dynamic behavior of PQ disturbances and the risks associated with non-standard operating conditions. The propagation of PQ disturbances using sensitivity analysis in both heavily and lightly loaded grids is investigated through dynamic simulations. Additionally, two network topologies, radial and ring, are considered. The utilization of a ring topology in the LV grid shows notable advantages compared to the radial topology, particularly in case of voltage unbalance.

58 **Design and Optimal Placement of Static VAR Compensator for Voltage Stability and Power Quality Improvement in Oman's 132 kV Power Grid**
Abdullah M Al Shibli (Petroleum Development Oman); Dr. Satish Tanavade (National University of Science and Technology); Saif Al Kalbani (Petroleum Development Oman)*
ABSTRACT: This study investigates the impact of Static Var Compensator (SVC) on a 132 kV power system grid in Oman. The grid comprises 55 busbars, over 90 transmission lines, and a generation capacity exceeding 1500 MW. Focusing on the north region, the study identifies voltage profile issues using Load Flow Analysis (LFA) and assesses the effect of SVC. Installing SVC at T bus reduces voltage drop and reactive power losses by 21.7%, decreasing overall losses from 59.8 MVAr to 46.8 MVAr. Additionally, the power factor improves from 0.909 to 0.931. The SVC is designed with fixed capacitor ratings of 160 MVAr and thyristor controlled reactor rating of 250 MVAr, based on compensation requirements for voltage drop scenarios. This study demonstrates the effectiveness of SVC in enhancing voltage stability, minimizing reactive power losses, and improving power factor in the 132 kV power system grid in Oman.

83 **Wideband Measurement of Grid Impedance using Chirp Signals in Grid-Connected Inverters**
Chris Vickery (University College Dublin); Ramy Ali (University College Dublin); Hamed Heydari-Doostabad (University College Dublin); Terence O'Donnell (University College Dublin)*
ABSTRACT: Grid connected inverters can suffer harmonic instability when connected to the grid due the interaction between the converter output impedance and the grid impedance seen at the point of common coupling (PCC). To counteract this it could be useful if the inverter were able to measure the impedance at the PCC over a wide frequency range. This can be done by injecting a current disturbance signal to the grid and measuring the resulting voltage disturbance. This paper investigates the use of a chirp signal injection in combination with Welch's method for signal analysis, as a means to measure the grid impedance up to 2 kHz. The accuracy of the approach is first investigated using MATLAB/Simulink simulations for a single phase inverter. The results demonstrate a good ability to accurately determine grid impedance with relatively low amplitude chirp signal injection. Experimental results show that the amplitude of signal injection needs to be higher in order to improve accuracy.

92 **Frequency Fluctuations in European Isolated Systems: A Review on Standards, Available Recordings and Grid Code Requirements**
Johanna Geis-Schroer (Karlsruhe Institute of Technology); Michael Suriyah (Karlsruhe Institute of Technology); Thomas Leibfried (Karlsruhe Institute of Technology)*

ABSTRACT: Frequency control in the Continental Europe (CE) synchronous area will become more challenging in the future with decreasing levels of rotational inertia, especially after systems splits. For isolated power systems, e.g. on remote islands, the European standard EN 50160 specifies much larger possible frequency fluctuations than for large synchronous areas. In this contribution, we locate 28 specific examples of European isolated grids. By taking into account available frequency recordings and grid codes, we identify which of those grids are actually operated in a wider frequency range than the CE system (47.5–51.5 Hz). As a result, we suggest that following the example of isolated systems and allowing for larger dynamic frequency excursions might be a feasible approach to handle future system splits.

119 **Dual-Ćuk High Step-up Bridgeless PFC Converters with Continuous Input and Output Currents**

Maryam Pourmahdi-Torghabe (University College Dublin (UCD)); Hamed Heydari-Doostabad (University College Dublin); Terence O'Donnell (University College Dublin)*

ABSTRACT: This paper proposes two novel types of dual-Ćuk bridgeless rectifiers for voltage conversion in power systems. These rectifiers overcome the limitations of conventional boost rectifiers and offer several significant advantages. The proposed rectifiers ensure high reliability by eliminating the shoot-through problem and feature low voltage stress across the semiconductors. They also provide continuous input and output current, making them suitable for grid-friendly applications. Additionally, the proposed rectifiers exhibit high step-up voltage conversion ratios, offering versatility for various power system applications. Specifically, Type-I rectifiers provide positive output voltage, while Type-II rectifiers yield negative output voltage. The proposed rectifier is experimentally validated for 110 Vac to ±200 Vdc at 500 W. The results demonstrate the effectiveness of the proposed rectifier.

Friday 1 September 2023,9:30 - 11:00

Technical Session 6a: Electric Vehicles and e-Mobility (2)
Room: CQ-009
Chair: Dr Alexis Polycarpou (Frederick University, Cyprus)

86 **A Power Budget Analysis of an Electrical Uncrewed Air Vehicle (UAV) Flying a Basic Mission Profile**
Robert Bolam (Wrexham Glyndwr University); Jhon Roque (Wrexham Glyndwr University); Yuriy Vagapov (Wrexham Glyndwr University); Richard Day (Wrexham Glyndwr University); Mikhail Slepchenkov (TAE Technologies)*
ABSTRACT: The aim of this paper is to determine the feasibility of developing a medium sized Uncrewed Air Vehicle, of 4.4m wingspan, for flight-testing electrical motors, drive units and ancillary equipment. The objectives of this initial study were to select a candidate airframe for the purpose of conducting this initial analysis, to define a mission profile that would enable the safe autonomous flight to be achieved and to estimate the power required for each of the flight phases of the mission and the electrical current consumption. The results were assessed to determine whether such an endeavour could be achieved using existing lithium-ion battery technology and to provide information about the flight endurance that could be expected of such an aircraft. In conducting this study an aircraft weight breakdown analysis has been accomplished and wing geometry and performance characteristics have been established.

127 **Multiagent-Based Power Flow Control for Plug-and-Play Battery Energy Storages in DC Microgrids**
Mudhafar A H Al-Saadi (Teeside University); Michael Short (Teesside University)*
ABSTRACT: Multiagent reinforcement learning has proven remarkably effective at finding near-optimal solutions to complex non-linear control problems when compared to classical schemes. Such problems typically arrive when considering power management problems arising in advanced power distribution applications, such as micro/smart grids, smart buildings, and electric vehicle applications. The achievement of balanced synchronized charge/discharge of energy storage systems in real-time is often a critical factor in fulfilling optimized power flow and enhancing battery health and lifetime. It is also critical to reducing power losses, supporting energy/power balance, and integration of renewable/intermittent energy. This paper proposes a control adaptation to optimize the power flow of battery energy systems in a DC autonomous microgrid. Multiagent neighbor-to-neighbor information related to the variation in the load participation and measured state of charge is locally exploited.(Refer to the PDF).

111 **Design, Simulation & Test of an Integrated Powertrain for a low voltage EV**
James Millington (University of Derby); Amar Bousbaine (University of Derby); David Wilson (University of Derby)*
ABSTRACT: This paper describes the research, design, simulation and testing of an integrated powertrain module for a low voltage electric vehicle. Power electronics were used and simulation tools were developed before a hardware version was constructed and tested. In addition, the hardware and software for an embedded system controller were developed, with the finished program being tested on a PCB based version of the hardware. Physical testing of the embedded system controller was achieved, and the results showed that it is capable of controlling the whole vehicle, including the powertrain and driver input and output functions. Additional work was conducted using modern engineering tools, including CAD and additive manufacture, in order to integrate all of the powertrain components.

112 **Dynamic Characterisation of a Linearised Transfer Function of Non-Ideal Boost Converters**
David Wilson (University of Derby); Amar Bousbaine (University of Derby); Bruce Wiggins (University of Derby)*
ABSTRACT: The inherent nonlinear behaviour of DC-DC power supplies complicates the task of working out their linear models, which are essential for a model-oriented control. In a model-oriented control design approach, the accuracy of the plant model directly influences the performance of the control system as the plant parameters tend to be linked to the gains of the controllers. This paper presents a dynamic analytical model of a DC-DC boost converter based on small signal analysis with a closed loop control for power conditioning of a hydrogen fuel cell system for automotive application. The small signal model is used to analyse the small deviations around the steady-state operating point of a boost converter leading to an accurate modelling of the closed loop converter parameters. A complete state-space analysis is undertaken where the output voltage to duty ratio transfer function for a non-ideal boost converter including the parasitic elements is developed.

43 **A Comprehensive Exploration on Different Machine Learning Techniques for State of Charge Estimation of EV Battery**
Mohamed Farrag (Glasgow Caledonian University); Mithul Raaj (VIT); Rani Chinnappa Naidu (VIT University); Rajesh Kumar M (Vellore Institute of Technology, Vellore)*
ABSTRACT: The State of Charge (SoC) is a measurement of the amount of energy available in a battery at a specific interval of time, mostly expressed as percentage. Proportional relationships between the electromotive force of a battery, current, terminal voltage and temperature determine the SoC. There can be a considerable error in the calculations due to a sharp drop of the terminal voltage at the end of discharge. This research has explored how important SoC is, as a factor in Battery Management Systems. The work focuses on using machine learning techniques to obtain an accurate and reliable status of battery charge, this includes Random Forest, Decision Tree, Gradient Boosting, Support Vector Regression, Polynomial Regression and Multilayer Perceptron. In this paper, these techniques are tested and compared with two real world captured datasets of Lithium-ion batteries which includes LG Battery and Unibo Powertools Battery.

124 **Wireless Power Transfer System for Electric Vehicle Charging with Frequency Hopping – A Concept and Circuit Design**
Graham A Blankson (Brunel University London); Mohamed Darwish (Brunel University); Chun Sing Lai (Brunel University London)*

ABSTRACT: With the apparent reliability of wireless power transfer (WPT) technology Original Equipment Manufacturers (OEM) are gradually migrating electric vehicle (EV) production charging modes from conductive to wireless. The increased users of EV WPT will introduce additional electromagnetic (EM) signals in the low frequency bandwidth which could cause interferences to various wireless operating systems. It is worth noting, vice versa, that the operation of the WPT can also be affected by near field propagated EM signals. This study shows a simplistic method to secure the WPT from interference by providing simple resonant frequency hopping. A WPT system with a consolidated 85kHz, recommended by the society of automotive engineers (SAE) and non-standardized operating frequency of 250kHz was designed to this effect. The selection of 250kHz was based on a separate study detailed in this report.

Technical Session 6b: Renewable Energy Systems (2)
Room: CQ-010
Chair: Mr Michael O'Donovan (Munster Technological University, Ireland)

80 **An approach to calculate marginal CO2 emissions factor based on historical emissions**
Abbas Rabiee (University College Dublin); Arash Alavi (University College Dublin); Andrew Keane (University College Dublin); John McCann (Sustainable Energy Authority of Ireland (SEAI))*
ABSTRACT: The importance of the marginal emissions factor is to evaluate the climate action policies enacted by the governments to deal with climate change. In this paper, a mathematical approach has been presented to calculate the marginal emissions factor in a quarter-hourly resolution, based on the average emissions factors, which are readily available by the generation schedule and the corresponding fuel mix. The method employs the time series of historical mean carbon intensity as well as the system generation dataset, that are publicly available on the Irish transmission system operator's data portal. The results show that even a small fluctuation in demand might result in a drastic rise in marginal carbon emissions depending on the system situation in terms of perturbations in renewable generations, and interconnectors flow.

94 **Analysing the relationship between weather systems and wind resource potential and variability in South Africa**
Paulemari E Van Aarde (Stellenbosch University); Amaris Dalton (Stellenbosch University); Bernard Bekker (Stellenbosch University)*

ABSTRACT: Many countries employ variable renewable energy (VRE), like wind, for decarbonization goals. However, variability from wind sources poses challenges in power systems. Variability stems from large-scale atmospheric circulation patterns at time scales of hours to days. Quantifying the relationship between atmospheric circulation and wind power variability is an ongoing research area. Limited research exists in South Africa despite implications for network stability. This study investigates wind resource potential and variability in synoptic-scale circulation over South Africa. After reviewing weather classification methods, it was established that self-organizing maps (SOMs) is well suited to classify atmospheric states in this study. Extra tropical cyclones exhibit the greatest resource potential and variability. Their consideration in wind generation integration is essential. Systematically assessing weather regimes improves VRE generation forecasts and informs generator siting.

96 **Fostering End Users' Flexibility in Renewable Energy Communities**
Riccardo Trevisan (University of Cagliari); Simona Ruggeri (University of Cagliari); Emilio Ghiani (University of Cagliari); Fabrizio Pilo (University of Cagliari)*
ABSTRACT: Energy communities represent a new paradigm for increasing the deployment of renewable energy, contributing significantly to the decarbonisation of the electricity system through a bottom-up approach with environmental, social, and economic benefits. Energy communities are a group of entities, individuals, or companies that join together for the production, sharing and virtual exchange of electricity generated by renewable resources. They benefit from economic contributions of three types: valorisation of shared energy through the return of tariff components (distribution, transmission and avoided grid losses); incentivisation of shared energy; and payment for electricity fed into the grid. The paper focuses on the valorisation of the flexibility of end users' demand aimed at increasing economic benefits, presenting an optimization algorithm for flexibility exploitation and a techno-economic analysis with a case study of a local energy community assuming the Italian regulatory scenario

113 **Case Study on Energy Storage Using Hydrogen Via Power to Gas Conversion**
Ria George (Teesside University); Terry Jermy (The Faraday Centre); G. Lacey (Teesside University); G. P. Pillai (Teesside University)*
ABSTRACT: A case study and implementation of MATLAB simulation model on hydrogen storage via power to gas conversion taking the SOFIA project as the basis and foundation of this research. this is a wide spectrum and tremendous research is still going on with hydrogen storage and the results obtained are satisfactory.

129 **Semi-analytical Electro-Thermal Modelling of a Photovoltaic Module for Evaluation of Spatial Temperature Distribution**
Aldo Amodio (Università della Basilicata); Antonio D'Angola (Università della Basilicata); Diana Enescu (Valahia University of Targoviste); Antonio Ferraro (University Of Basilicata); Gabriele Malgaroli (Politecnico di Torino); Filippo Spertino (Politecnico di Torino)*

ABSTRACT: The paper presents a two-dimensional thermal model coupled with the electrical model to investigate the performance of a PV module. An iterative procedure is implemented by calculating analytically the boundary conditions for each cell of the PV module placed in the environment, considering the effect of solar irradiance and Joule heating. The temperature distribution is then calculated in each cell using a numerical model where an accurate description of connections is included. The electric current can be calculated inside each cell, starting from cell temperature distributions. An updated source term, including Joule dissipation, is evaluated to enhance boundary conditions by applying the eigenfunctions expansion method. Stationary solutions are obtained at the end of the iterative procedure showing the effects of Joule dissipation on the module performance. The effects of environmental conditions, irradiance and ambient temperature on the module temperature are also investigated.

130 **The role of Photovoltaic Systems in Reduction of CO2 Emissions in the UK: A Case Study**

*Rafiqul Islam Chowdhury (Teesside University)**

ABSTRACT: The growth of PV systems is rising tremendously and playing a crucial role in achieving NetZero by 2050. Many countries started to use grid-connected PV systems to generate electricity. In the UK, there is remarkable growth in using PV systems, whether they are stand-alone systems or grid-connected. It is paramount to study how PV systems are contributing to achieving NetZero by 2050 in the UK. Thus, our main objective in this paper is to find how much energy is injected into the grid when 120MW of grid-connected PV power plants are installed across 4 regions in the UK, the carbon intensity calculation and the cost- effectiveness of a solar power plant. The computational simulations are conducted in PVsyst software.

Technical Session 6c: Transient Analysis and EMTP Modelling
Room: CQ-020
Chair: Prof Grigoris K Papagiannis (Aristotle University of Thessaloniki, Greece)

33 **Potential Benefits and Challenges of Employing Inertia Distribution Indexing in RMS Simulations**

Stephen J Sommerville (Brunel University); Gareth Taylor (Brunel University); Maysam Abbod (Brunel University London)*

ABSTRACT: Globally there has been a trend towards increasing penetration of Converter Fed Generation (CFG) into main power systems, and a reduction of conventional synchronous generation. One of the recent research areas, that has attracted some significant consideration is the uneven distribution of inertia through a power system and the potential local variations of frequency and Rate of Change of Frequency (RoCoF). This paper uses the IEEE 9-Bus test network to develop show how measurement of frequency within RMS simulation packages is of critical importance and that the current use of an Inertia Distribution Index (IDI) can overlook critical generators when a very uneven distribution of inertia exists. An alternative approach based on frequency difference magnitude is developed as a more robust approach.

62 **Comparison of Power Cables Current Rating Calculation Methods**

Theofilos Papadopoulos (Democritus University of Thrace); Andreas Chrysochos (Hellenic Cables); Michael Fotos (Democritus University of Thrace)*

ABSTRACT: In the industry practise power cables current rating calculations are on the majority of cases made on the basis of the IEC 60287 standard. The standard is build on a number of well-established methods and techniques, though, based on specific assumptions. An alternative approach is to use more sophisticated tools, such as the finite element method (FEM). In this paper comparison of the IEC 60287 standard and the FEM current carrying calculations is performed. A benchmarking underground cable system proposed by the CIGRE working group B1.56 is used. Results reveal that non-conservative approach of the IEC 60287 standard resulting into poor estimation of power cables current rating capability.

68 **Analysis of Trapped Charge Effects on Very Fast Transient Overvoltages in 400 kV Gas Insulated Substations: Modelling, Simulation, and Implicati**

Mohammed Alhazmi (Cardiff University); Maurizio Albano (Cardiff University); Jonathan James (Cardiff University); A. Manu Haddad (Cardiff University)*

ABSTRACT: This paper investigates the impact of trapped charges on Very Fast Transient Overvoltages (VFTOs) in a 400 kV Gas Insulated Substation (GIS). VFTOs present significant challenges to GIS system design, insulation coordination, and long-term reliability. To study the effects of trapped charges on VFTO magnitudes, the paper utilises ATP-EMTP and MATLAB for modelling and simulation. The analysis is performed at various locations within the GIS system and under different trapped charge conditions. The results reveal that trapped charge significantly influences VFTO magnitudes. The paper emphasises the importance of considering trapped charges when modelling high voltage systems to obtain a more accurate representation of electrical behaviour. The findings presented in this paper contribute to a better understanding of VFTO behaviour in GIS systems, which can help improve insulation coordination, GIS design, and overall system performance and reliability.

102 **Assessment of Field Data Related to the Lightning Performance of Overhead Lines in the Context of Validating Lightning Performance Estimation Methodologies**

Zacharias G Datsios (Aristotle University of Thessaloniki); Alexios Ioannidis (Aristotle University of Thessaloniki); Diamantis Patsalis (Aristotle University of Thessaloniki); Pantelis Mikropoulos (Aristotle University of Thessaloniki); Thomas Tsovilis (Aristotle University of Thessaloniki)*

ABSTRACT: Evaluating the lightning performance of overhead lines is crucial for ensuring the reliability of the transmission system. Several methodologies for the evaluation of the lightning performance have been proposed yielding considerably different lightning flashover rate predictions due to different assumptions and simplifications. Hence, the validation of these methodologies requires further attention. In this context, this work first deals with the assessment of field data related to the lightning performance of overhead lines; recently published field data are reviewed. Factors impeding straightforward comparisons as well as assumptions due to lack of critical information are discussed in an effort to contribute to a more accurate assessment of the lightning performance of overhead lines. The analysis is complemented by fast-front electromagnetic transient and fractal-based lightning attachment simulation results, as well as lightning flashover rate computations.

115 **Design and development of integrated data acquisition system to replace power analyser for power quality measurement and analysis**

Paul Howkins (Teesside University); Imran IB Bashir (Teesside University); Maher Dr Al-Greer (Teesside University); Gobind Pillai (Teesside Univeristy); Michael Short (Teesside University)*

ABSTRACT: There are significant fast paced developments within the renewable energy industry and being able to monitor, report and further analyse power quality during prototype testing, which can aid in accelerating the development stages more efficiently, for both commercial and research projects. Due to the limitations of using a power analyser (PA) for advanced signal processing and storage of raw data, a data acquisition (DAQ) system with an embedded real-time controller is proposed as an alternative solution. As such, the application of real-time advanced signal processing is possible for defining developments in innovative technology during testing. Therefore, using a DAQ system as an alternative to a PA allows more flexibility with processing and analysing data during and after testing.

125 **Implementation of Recorded Lightning Current Waveforms in ATP-EMTP software for Fast-Front Transient Simulations**

Zacharias G Datsios (High Voltage Laboratory, Aristotle University of Thessaloniki); Diamantis Patsalis (High Voltage Laboratory, Aristotle University of Thessaloniki); Pantelis Mikropoulos (Aristotle University of Thessaloniki); Thomas Tsovilis (High Voltage Laboratory, Aristotle University of Thessaloniki)*

ABSTRACT: This study deals with the implementation of recorded lightning current waveforms in ATP-EMTP. These can be employed as excitation in fast-front transient simulations. A generalized code is developed in MODELS language to import arbitrary waveforms expressed in the form (time, voltage/current) pairs. An investigation is presented on the influence of the time interval used for digitizing recorded lightning current waveforms and of the interpolation method applied between points. ATP-EMTP simulations of direct lightning strikes to 150 kV overhead transmission lines are performed. Fast-front overvoltages are computed across line insulators and the minimum backflashover currents are determined. Cases with Line Surge Arresters (LSAs) are also treated and the energy stressing the LSAs is computed. It is shown that the digitization time interval is not important as long as it reproduces the main features of the recorded waveforms. This applies also for the interpolation method.

Friday 1 September 2023, 11:30 - 13:00

Technical Session 7a: High Voltage Engineering
Room: CQ-009
Chair: Dr Theofilos Papadopoulos (Democritus University of Thrace, Greece)

28 **Investigation of High Voltage Electrical Cable Loading in Electricity Transformer Substations**
Callum D Bergin (UCD); Donal Finn (UCD); Tom Looby (ESB)*
ABSTRACT: This project examines the thermal effects of continuous and emergency loading on a 110 kV transmission cable in air within a high-voltage transformer substation to ascertain whether there is a risk of overheating in such an environment. A validated multiphysics thermal-CFD model was used for this purpose, simulating such operation. The overall current carrying capability of the cable in unrestricted air convection settings was confirmed to be greater than the underground cable section with existing continuous current rating specifications. It was also determined for the cable type examined, that during short-term emergency overloading, electrical current in the air-filled basement section of the cable circuit can be increased to higher levels than existing emergency ratings applicable to the ducted cable buried in soil. The potential for cable overheating at transformer substations does not pose a risk to the electrical grid with scope for increased current ratings in air sections.

69 **Relative Permittivity of Natural Ester Oil-Based Nanofluids With Iron Oxide Nanoparticles**
Evangelos T Staikos (Aristotle University of Thessaloniki); Thomas Tsovilis (Aristotle University of Thessaloniki); Alexandros Hadjicostas (Aristotle University of Thessaloniki); Zacharias G Datsios (Aristotle University of Thessaloniki); George Litsardakis (Aristotle University of Thessaloniki); Eleftheria Pyrgioti (University of Patras); Aristeidis Bakandritsos (Czech Advanced Technology and Research Institute); George Peppas (Raycap SA)*

ABSTRACT: The real part of the relative permittivity and the electrical conductivity of a natural ester oil, that serves as a liquid matrix for nanofluids, are measured for a wide frequency and electric field range. The focus of this work is the exploration of the modification of these basic electrical parameters of the liquid matrix after the integration of iron oxide nanoparticles. A series of experiments with the aid of an impedance analyzer, an LCR meter, and a variable-frequency power supply employing two different liquid test fixtures reveal an increase of both real and imaginary parts of relative permittivity with increasing nanoparticles concentration up to 0.5% w/w.

77 **Correlation between grounding grid design parameters and safety thresholds in MV/LV networks**
*Christos Christodoulou (NTUA)**
ABSTRACT: As the demand for clean, efficient and reliable supply of energy increases, the impact of substation grounding grid design parameters on safety performance of grounding systems, in power distribution networks, has become a critical aspect that has yet to be thoroughly examined. This paper investigates the influence of various grounding grid design parameters, such as the number of rods installed as well as the grid size and mesh layout density, on safety thresholds in scenarios where the soil exhibits both homogenous and non-homogeneous characteristics. The study aims to provide comprehensive data on how these design parameters correlate with impedance, touch and step voltages, and consequently evaluate the safety performance of the grounding systems of distribution substation.

84 **Investigations of Corona Discharge Images for Rod-Rod Electrode System under HVDC**
Halil Ibrahim Uckol (Istanbul Technical University); İdris Ozdemir (Istanbul Technical University); Suat Ilhan (Istanbul Technical University)*

ABSTRACT: This study presents the investigations of visual images originating from various corona discharge forms occurring under +DC and -DC voltages. The experimental setup included two hemispherical tip rod electrodes with a tip radius of 2 mm, and the gap spacing between them was set to 5 cm to observe corona discharge forms. The voltage was increased in steps and a corona camera was used to determine the corona inception voltage. The transitions between different forms of corona discharges were observed. Images of corona discharges were taken at each voltage level using a digital single-lens reflex (DSLR) camera. Furthermore, the pulses generated by the corona discharges were examined using a high-frequency current transformer (HFCT) and a shunt resistor. The main objective of this investigation was to analyze the severity of corona discharge on the system based on the obtained corona images. Also, the usability of the HFCT and shunt resistors as measurement sensors was discussed.

118 **Electroporation for Water Disinfection: A Proof of Concept Experimentation**
Mohamed A Elgenedy (Glasgow Caledonian University); Mohamed Farrag (Glasgow Caledonian University); Jake Simpson (Glasgow Caledonian University)*
ABSTRACT: This paper is a proof of concept showing the effectiveness of using irreversible electroporation (IRE) as a stage of water disinfection in the water treatment process. The IRE process essentially requires relatively high voltage pulses to pose a pulsed electric field across harmful microorganisms. In this paper, a laboratory-based solid-state Marx generator was built for this purpose and decontaminated water samples have been used to test the effectiveness of applying variable pulse width, magnitude and rate. All the pulses are unipolar rectangular. The tested samples are all from the same water source with the same coliform count. After performing the electroporation disinfection process the coliform count reached zero proving the effectiveness of IRE.

128 **Evaluation of Surface Properties of Zinc Borate Filled HTV Silicone Rubber**
İdris Ozdemir (Istanbul Technical University); Halil Ibrahim Uckol (Istanbul Technical University); Abdullah Aydogan (Istanbul Technical University); Gurkan Soykan (Bahcesehir University); Refat Ghunem (National Research Council Canada); suat ilhan (Istanbul Technical University)*

ABSTRACT: This study presents an investigation of the surface properties of high-temperature vulcanizing (HTV) silicone samples filled with different percentages (5%, 10%, 15%, 20%, and 30%) of Zinc Borate (ZB) filler. Base HTV samples were the reference for the comparison. Physical analyses, including density and hardness measurements, were conducted on each sample. Beside these physical analyses, to investigate the hydrophobicity characteristics of the samples, various analyses were performed, including contact angle measurements, surface roughness analysis, and scanning electron microscopy (SEM) imaging. The results of these analyses indicated that an increase in the ZB filler ratio to 10 wt% resulted in a notable reduction in surface roughness, which also led to a notable increase in the surface contact angle. The Dynamic Drop Tests (DDTs) revealed that an increase in the ZB filler content by 30wt% led to an improvement performance in the DDT.

Technical Session 7b: Power System Optimisation and Planning
Room: CQ-010
Chair: Prof Emilio Ghiani (University of Cagliari, Italy)

63 **A Data Driven Approach to Enable Proactive Low Voltage Network Development**
Padraig Coughlan (ESB Networks); Emma Silke (ESB Networks)*
ABSTRACT: In line with the 2023 Climate Action Plan set by the Government of Ireland [1], Ireland has the ambitious targets of 1 million Electric Vehicles on the road and 680,000 heat pumps installed by 2030. The loads required to facilitate these low carbon technologies will put significant strain on the Low Voltage (LV) network connecting these customers. ESB Networks, the Distribution System Operator of Ireland, has been tasked to take a data driven and proactive approach to updating and reinforcing the LV network. This paper will detail how smart meter voltage violation data, asset information and customer complaint data are presented and analysed to understand where the LV network needs reinforcement. This paper will also detail the newly developed prioritisation logic applied to identify and programme system reinforcements using the collected data. The output of these new tools and prioritisation logic is the creation of strategically identified work areas across Ireland.

71 **Methodology for identification of the optimal structure of hybrid AC DC Microgrids and micro energy hubs**
Chrysanthos Charalambous (University of Cyprus); Alexis Polycarpou (Frederick University); Venizelos Efthymiou (FOSS); George E. Georghiou (University of Cyprus)*
ABSTRACT: With the increasing availability of DC consumer appliances as well as the increasing penetration of direct current (DC) Distributed Energy Resources (DERs) such as photovoltaics (PV) and Energy Storage Systems (ESS), the concept of DC and hybrid AC-DC distribution systems and microgrids attract more and more attention. This paper presents the advantages of DC and hybrid AC-DC microgrids over the AC systems, based on the literature and proposes a methodology for identification of the optimal structure of a hybrid AC-DC microgrid to achieve high efficiency with lower losses and lower cost. In addition, a real test case was used as a case study in order to examine and validate the proposed methodology. The main outcome of this study is that the implementation of a hybrid AC-DC microgrid can bring a lot of benefits to consumers and system operators and plays an important role in reducing losses and increasing the overall system performance in terms of energy efficiency and power quality.

72 **Active Power Curtailment-Oriented Operation Strategy for PV Penetrated Distribution Networks**
Hilal Ozdemir (Brunel University London); Ioana Pisica (Brunel University London); Aligül Selim Türkoğlu (Yıldız Teknik Üniversitesi)*
ABSTRACT: Renewable energy sources (RES) are increasingly utilized in distribution networks to reduce greenhouse gas emissions. However, challenges like overvoltage and power quality issues arise with higher RES penetration. This study aims to minimize curtailed active power while maximizing PV penetration under the operational limitations by introducing a Key Performance Indicator (KPI) called MAPCR. The optimization problem is formulated as a Mixed-Integer Quadratically Constrained Program (MIQCP), considering losses. The problem is solved using a combination of Active Power Curtailment (APC) in coordination with Reactive Power Control (RPC). The impact of high photovoltaic (PV) systems penetration, along with APC and RPC, on bus voltages is comprehensively analysed, and the results are compared. The analysis based on MAPCR clearly demonstrates that the proposed algorithm, integrating both APC and RPC, achieves a significant reduction in power curtailment.

87 **Centralized operational cost optimization of a multi-microgrid system using second-order cone programming and power flow tracing**
Seyed Ashkan Nejati (Newcastle University); David Greenwood (Newcastle University)*
ABSTRACT: Modern electricity networks face many issues due to the high demand for electricity and the rapid increase of distributed energy resources (DERs). Although, it must satisfy the security and reliability of the system. Hence, it is essential to carry out optimal microgrids (MG) scheduling. In this paper, operational cost optimization of multi-microgrid is done by second-order cone programming (SOCP). Each MG operates its optimal cost in a centralized manner and delivers it to the system. The GUROBI solver solves the problem in MATPOWER and YALMIP extension in MATLAB software. The effectiveness of the proposed method is verified through two different scenarios.the generation units of the MMG are the only renewable energy sources to satisfy the net-zero emission target. The simulation results of all scenarios are compared and used to demonstrate the features of the proposed method with the power flow tracing method.

126 **Using Nonlinear Optimization Solvers to Improve PAR(p) Coefficients Estimation in Synthetic Inflow Scenarios Generation**
*André Marcato (Federal University of Juiz de Fora); Paulo Correia (RegE Barros Correia Advisers); Vinícius Mr. Kohl (Federal University of Juiz de Fora)**
ABSTRACT: In this paper, we showed that, using the nonlinear optimization to estimate the PAR(p) model coefficients can, sometimes, improve adherence to historical data when for generating synthetic inflows, which is for the Stochastic Dual Dynamic Programming implemented by NEWAVE in the Brazilian energy operation planning. The used solvers were IPOPT and the Python toolbox SciPy. The accuracy of the model was checked by generating inflows via Monte Carlo simulation and outperformed, in some cases, the well established Box-Jenkins algorithm for obtaining these coefficients.