Program

Time (Sydney)	Central	Town Hall	Wynyard	Foyer
Wednesday, November 20				
08:45 am-09:00 am	W1: ***Welcome***			
09:00 am-09:45 am	AK1: ***Academic Keynote 1 - The Energy Transition in Canada and Ontario***			
09:45 am-10:30 am	IK1: ***Industrial Keynote 1 - Faster, cheaper decarbonisation through integrating Distributed Energy Resources (DER)***			
10:30 am-10:45 am				MT1: ***Morning Tea***
10:45 am-12:15 pm	T1: ***Tutorial 1 - Design and Control of Grid Connected Power Electronic Converters***	T2: ***Tutorial 2 - Distribution System Modelling Fundamentals***	T3: ***Tutorial 3 - Transforming distributed energy resources into valuable grid assets: Methods, technologies, and requirements***	
12:15 pm-12:45 pm	AM1: ***ACPE Annual General Meeting - (12:15-13:15, in Restaurant)***			L1: ***Lunch***
12:45 pm-02:45 pm	TS1: ***Renewable Energy Systems I***	TS2: ***Power Systems & Stability I***	TS3: ***Transportation Electrification***	
02:45 pm-03:00 pm				AT1: ***Afternoon Tea***
03:00 pm-04:30 pm	TS4: ***Renewable Energy Systems II***	TS5: ***Power Systems & Stability II***	TS6: ***Power Systems Planning I***	
04:30 pm-05:30 pm	TS7: ***Power Systems & Stability III***	TS8: ***Cybersecurity of Power Systems***	API-1: ***API workshop*** Creating and using industry-derived teaching resources in 2025	
05:30 pm-06:00 pm			API-2: ***API Forum on Career Pathways for PhDs candidates***	
06:00 pm-08:00 pm				WR1: ***Welcome Reception***
Thursday, November 21				
09:00 am-09:45 am	AK2: ***Academic Keynote 2 - Energy transition system engineering***			
09:45 am-10:30 am	IK2: ***Industry Keynote 2 - Engineering solutions and skills required to accelerate Australia's energy transition***			
10:30 am-10:45 am				MT2: ***Morning Tea***
10:45 am-11:45 am	IP1: ***Industry Panel 1*** Strategies to foster and support valuable relationship between universities and industry			

Time (Sydney)	Central	Town Hall	Wynyard	Foyer
11:45 am-12:45 pm	IP2: ***Industry Panel Session 2*** Addressing the gap between academic research and industry needs			
12:45 pm-01:15 pm				L2: ***Lunch***
01:15 pm-02:15 pm	AIF1: ***API Industry Forum***			
02:15 pm-03:15 pm	WIE: ***Women in Engineering - Transforming power engineering through women's leadership***			
03:15 pm-03:30 pm				AT2: ***Afternoon Tea***
03:30 pm-05:00 pm	IS1: ***Industry Session 1 - Grid connection of renewables***	IS2: ***Industry Session 2 - Challenges and opportunities in distribution networks***	IS3: ***Industry Session 3 - Power electronics applications in future grids*** Sponsored by Delta	
06:30 pm-10:00 pm	D1: ***Awards Dinner***			D1: ***Awards Dinner***
Friday, November 22				
08:45 am-09:30 am	AK3: ***Academic Keynote 3 - Integrating Active Learning to Elevate Student Experiences and Learning Outcomes in Power Engineering Curriculum***			
09:30 am-10:15 am	IK3: ***Industry Keynote 3 - Evolving long-term system planning for the Australian Energy system - incorporation of distribution network considerations.***			
10:15 am-10:30 am				MT3: ***Morning Tea***
10:30 am-12:00 pm	TS9: ***Energy Storage***	TS10: ***Power Systems Planning II***	TS11: ***Power Electronics I***	
12:00 pm-12:10 pm	BRK1: ***Changeover Break***			
12:10 pm-01:40 pm	TS12: ***Electricity Markets and Economics***	TS13: ***Electric Machines and Drives I***	TS14: ***Power Electronics II***	
01:40 pm-02:10 pm				L3: ***Lunch***
02:10 pm-03:40 pm	TS15: ***Power Systems Planning III***	TS16: ***Power Electronics and Drives***	TS17: ***Power System Protection***	
03:40 pm-03:55 pm				AT3: ***Afternoon Tea***
03:55 pm-05:25 pm	TS18: ***Renewable Energy Systems III***	TS19: ***Distributed Energy Resources***	TS20: ***Other Topics in Power***	
05:25 pm-05:40 pm	C1: ***Closing Session***			

Wednesday, November 20

Wednesday, November 20 8:45 - 9:00

W1: Welcome ⤒
Room: Central, Town Hall

Wednesday, November 20 9:00 - 9:45

AK1: Academic Keynote 1 - The Energy Transition in Canada and Ontario ⤒
Claudio Canizares (University of Waterloo, Canada)

This talk will provide an overview of Canadian provincial and remote community power grids, and a more detailed discussion of Ontario's grid, market, and future expansion plans, considering that zero-emission power systems will be the backbone of the energy transition. A critical overview of the decarbonization status and policies for energy systems in Canada will be also presented, focusing on zero-emission power grid, EV, and Hydrogen plans and strategies to enable a Next-Zero 2050.
Room: Central, Town Hall

Wednesday, November 20 9:45 - 10:30

IK1: Industrial Keynote 1 - Faster, cheaper decarbonisation through integrating Distributed Energy Resources (DER) ⤒
Gabrielle Kuiper

While Australia has more rooftop solar per capita than any other nation, engineering and regulation lags mean the potential for Distributed Energy Resources to assist the energy transition has yet to be fulfilled. This talk will outline the $19billion in energy system benefits from DER integration that could be unlocked by 2040 and what needs to happen to achieve these benefits. Regulation and power engineering need to work jointly to ensure dynamic operating envelopes/flexible exports are rolled out across the NEM and WEM; distribution network voltages are within regulated limits; DER are able to provide distribution network services and household and commercial appliances are able to provide much greater flexible demand capacity. Engineers have a vital role to both make the changes to the operation of the distribution network to support DER integration and to inform policy makers to ensure Australia can meet its target of 82% renewable supply by 2030.
Room: Central, Town Hall

Wednesday, November 20 10:30 - 10:45

MT1: Morning Tea ⤒
Room: Foyer

Wednesday, November 20 10:45 - 12:15

T1: Tutorial 1 - Design and Control of Grid Connected Power Electronic Converters ⤒
Grahame Holmes (RMIT)

Current regulation plays a key role in power electronic conversion systems. While the central concept is straightforward, i.e. minimise the error between a target and a measured current, achieving this outcome in practice for AC systems has proved to be very challenging. The issues become especially important for grid connected inverters, where low per-unit (p.u.) filter inductances, unbalanced grid voltages with harmonics, a preference for digital implementation, and PLL stability concerns, create unique current regulation challenges.

This tutorial will present the current state-of-the-art for digital current regulation of grid connected AC converter systems. It will begin by identifying how PWM sampling delays are the primary constraint for a current regulator, and then show how they can be overcome using stationary frame PR or d-q synchronous frame implementation, together with an analytical approach to calculate gains. These concepts will then be extended to current regulation for grid connected inverters, looking at implementation in the z-domain, gain determination for low p.u. (LCL) filters, modulation saturation, and the effect of common mode EMI filtering. Issues such as grid harmonics, unbalanced grid voltages and high impedance grid networks, will then be explored using cascaded PR and positive/negative sequence current regulators. Finally, the tutorial will present a new approach for current regulation that resolves many phase locked loop limitations. All theoretical material presented is supported by detailed matching simulations and experimental confirmation.
Room: Central

Wednesday, November 20 10:45 - 12:15

T2: Tutorial 2 - Distribution System Modelling Fundamentals ⤒
Rahmat Heidarihaei (CSIRO)

Modelling unbalanced multi-conductor distribution systems is crucial for assessing and improving grid performance and reliability at the local level. Unlike traditional transmission system modelling, which focuses on balanced three-phase networks, distribution system models need to account for phase unbalance. Phase unbalance occurs due to unbalanced loading, such as single-phase loads or generators connected to a three-phase network, or unequal branch impedance caused by non-transposed conductors with non-equilateral geometry.

Distribution system modelling involves creating mathematical representations that include network components like transformers, lines, and loads, to simulate power flow and voltage profiles. The physics of power flow in networks with phase unbalance is described using Kirchhoff's circuit laws, where impedance matrices account for both self-impedance (diagonal) and mutual impedances (off-diagonals) between conductors. Physics-based distribution system models are important for making informed decisions about grid expansion, equipment sizing, and operational strategies to enhance efficiency and resilience.

Additionally, optimal power flow (OPF) techniques are integrated into these models to determine the most efficient operating conditions. OPF helps minimise power losses, manage voltage levels, and optimise the use of distributed

energy resources. By leveraging OPF, distribution system models can better handle the complexities of unbalanced conditions, ensuring stable and cost-effective grid operation.
Room: Town Hall

Wednesday, November 20 10:45 - 12:15

T3: Tutorial 3 - Transforming distributed energy resources into valuable grid assets: Methods, technologies, and requirements
Reza Razzaghi (Monash) and Mohsen Khorasany (Monash)

The transition to a low-carbon, climate-resilient, and sustainable future hinges on the decarbonisation of the energy sector. Integrating Distributed Energy Resources (DER) into power systems will expedite this process, contributing to the global goal of maintaining temperature rise below 1.5°C above pre-industrial levels. However, the grid infrastructure is designed to deliver large-scale centralised generation to consumers rather than to integrate millions of consumer owned energy resources. Hence, the challenge is to coordinate large volumes of small-scale energy resources and integrate them into existing energy networks without undermining their integrity. Coordination of these grid-edge resources will unlock additional values which make a major contribution to energy sector decarbonisation. This tutorial will explore various DER coordination methods, focusing on system characteristics and the design requirements of coordination frameworks. The tutorial covers topics including impact of DER integration on power system operation, technical and market integration of DER, requirements for DER coordination, and network-aware coordination methods. Real-world case studies and project demonstrations will be presented to illustrate the concepts discussed.
Room: Wynyard

Wednesday, November 20 12:15 - 12:45

AM1: ACPE Annual General Meeting - (12:15-13:15, in Restaurant)
Get your lunch from the buffet before heading to the room.
Room: Central, Town Hall, Wynyard

Wednesday, November 20 12:15 - 12:45

L1: Lunch
Room: Foyer

Wednesday, November 20 12:45 - 2:45

TS1: Renewable Energy Systems I
Room: Central
Chair: Richard Yan (University of Queensland, Australia)

Implementation Options and Trade-offs in Emergency Generation Shedding to Mitigate Inverter Oscillations in Low-Voltage Distribution Networks

Leila Rajabpour (The University of Newcastle, Australia); Julio H Braslavsky (Energy Systems, CSIRO & The University of Newcastle, Australia); Maria M Seron (University of Newcastle, Australia)

The Emergency Generation Shedding (EGS) mechanism is a last-resort measure applied by curtailing distributed solar generation during periods of high photovoltaic (PV) generation and low demand when the system is at risk of losing system security. EGS aims to force disconnection of legacy distributed PV (DPV) systems by temporarily raising the zone substation voltage setpoint. While EGS has proven effective in supporting the power grid during critically low demand periods, reports indicate that it can induce voltage and power oscillations from inverters cycling between disconnection and reconnection, which may be triggered by the steep increase in voltage setpoint. This oscillatory effect is worse in low-voltage (LV) networks where mutual inductance between phases can propagate these oscillations even in systems not connected to the same phase. This study investigates EGS-induced oscillations in unbalanced 3-phase distribution systems and assesses different settings options to gradually step up voltage setpoint in order to minimise the occurrence of these oscillations. Using power flow simulations on a representative Australian low-voltage network model, we analyse how different transformer voltage step-up tap scenarios can influence the number of inverter switch-offs and mean aggregated power generation. The results indicate that while the power generation shed remains relatively consistent across different tapping sequence scenarios, there is a significant variability in the resulting number of inverter trip-offs. In conclusion, a gradual voltage rise strategy for EGS can substantially reduce inverter disconnection-reconnection oscillations as compared to those obtained after the application of a single step voltage raise approach.

Presenter bio: I am a current PhD student at the University of Newcastle. My research focuses on the integration of distributed energy resources (DER) and addressing voltage control issues in unbalanced 3-phase distribution networks with high penetration of renewable energy sources. My work involves optimizing the integration of renewable energy resources, voltage control in distribution networks, optimal power flow (OPF), and power inverter modeling and control.

Frequency Control using Dynamic Demand Response and Grid-Scale Battery Energy Storage Systems: An Australian Case Study

Andrew S Roberts, Lasantha Meegahapola and Arash Vahidnia (RMIT University, Australia)

This study analyses power system frequency response with dynamic demand response (DR) schemes and battery energy storage systems (BESSs) with a high share of renewable power penetration. The frequency control ancillary services (FCAS) controllers developed and deployed in the model are based on a droop controller for regulation and a step controller for contingency. These controllers are modelled in dynamic DR enabled loads and grid-scale BESSs to provide FCAS. A dynamic simulation study is conducted using a simplified model of the Australian eastern seaboard grid developed in DIgSILENT PowerFactory. This work demonstrates both the DR, and the large-scale BESS are effective at reducing frequency excursions and decreasing the rate of change of frequency (RoCoF) during sudden load and supply disturbances in grids with high renewable power penetration. Key findings highlight the importance of strategic grid planning in considering distributed resources and hosting appropriate FCAS reserves for regulation and contingency frequency support.

Comparison of Clustering Methods for Aggregation of Distribution Grid Flexibility at the Nodes of an adjusted REI equivalent

Lars Stark (Leibniz University Hannover, Germany); Lutz Hofmann (Leibniz Universität Hannover, Germany)

In this paper different clustering methods to aggregate distribution grid flexibilities at the nodes of an adjusted REI equivalent are compared with each other. The adjusted REI equivalent enables the flexibility exchange between transmission and distribution system operator considering multiple vertical interconnections between them. First, a literature review identifies clustering methods whose clustering is based on distance matrices. In addition, a purely topological clustering method is developed. Second, the clustering methods are compared with each other on the basis of two high-voltage test grids with multiple interconnections to an EHV grid. The evaluation criterion is the replication accuracy of the vertical active and reactive power potential called Feasible Operation Region. The complete grid model is used as a reference scenario. A distance matrix relying on power transfer distribution factors proves to be the most promising.

Presenter bio: At the end of 2022, I completed my Master's degree in Electrical Engineering and Information Technology at Leibniz University Hannover, Germany. Since 2023, I have been working as a research assistant at the Institute for Electrical Power Systems in Hannover, where I am involved in a project funded by the German Research Foundation (DFG). My research focuses on the provision of flexibility across voltage levels between distribution and transmission system operators.

Stability-Assured ARMA-Kalman Filter Based Adaptive Short-Term Solar PV System Forecasting

Muhammad Ahsan Zamee, Sadnan Sakib, Md. Morshed Alam, Md Ahasan Habib and Jahangir Hossain (University of Technology Sydney, Australia)

Photovoltaic (PV) plant output forecasting is a key factor for the efficient operation and decision-making of modern renewable energy-based systems. Numerous research has focused on improving prediction accuracy; however, these models often fail to maintain performance over time due to changing system dynamics, necessitating frequent retraining. Retraining hampers real-time application as it is a time-consuming process. Furthermore, forecasting models are typically selected based on performance accuracy, which does not ensure long-term stability. Since these models are not mathematically robust, their performance on future unknown data remains uncertain. This paper proposes a stability-guaranteed ARMA-Kalman filter-based short-term forecasting model. The ARMA model develops the forecasting framework, while the Kalman filter is employed to predict and update the states to enhance prediction accuracy. The models developed by the ARMA approach are selected based on spectral radius stability analysis for discrete systems. When applied to multiple-horizon solar PV plant forecasting tasks (15, 30, and 60 minutes), the developed algorithms demonstrated that smaller time horizons yield better accuracy with smaller datasets. In contrast, longer forecasting horizons require larger datasets, resulting in lower accuracy than shorter ones. This approach ensures stability and improved PV forecasting performance, addressing traditional models' limitations.

Presenter bio: Sadnan Sakib is a Master's by Research student in the Higher Degree Research (HDR) program at the University of Technology Sydney (UTS), under the supervision of Professor Dr. Jahangir Hossain. His research focuses on power system stability, renewable energy zones, and microgrids. Sadnan holds a bachelor's degree with Dean's Award in Electrical-Electronics Engineering from the University of Technology Malaysia (UTM). He was born on July 14, 2000, in Rajshahi, Bangladesh.

Combined PV-EV-HP Hosting Capacity Analysis of a Belgian Low-Voltage Distribution Network

Amina Benzerga (University of Liège, Belgium); Maurizio Vassallo (University of Liege, Belgium); Simon Gérard and Julien Vandeburie (Resa, Belgium); Damien Ernst (University of Liège, Belgium)

This paper presents an analysis of the combined hosting capacity (HC) of photovoltaic panels (PVs), electric vehicles (EVs), and heat pumps (HPs). The HC problem is defined using a generic formalism previously introduced in the literature. It is applied to a digital twin of a low-voltage Belgian electrical distribution network, which was reconstructed using a topological path identification (TPI) methodology. Exogenous data needed for the HC analysis is provided by an observation tool developed by the Belgian distribution system operator (DSO), RESA. To ensure a realistic representation of the impact of the combined technologies, time-series with a granularity of 15 minutes are used. Results show that under-voltage is encountered rapidly for both EV and HP penetrations higher than 50%. Over-voltage is not faced before 75% of PV penetration.
By contrast, even with high penetration rates for all three technologies, the lines of the case study network are not overloaded.

Presenter bio: Amina Benzerga is in the final year of her PhD, with a Master's degree in Computer Science Engineering from the University of Liège in Belgium. Her research focuses on assessing hosting capacity in low-voltage distribution networks, with the goal of enhancing grid reliability and integration efficiency.

Technical Feasibility Analysis and Design of Adding Electrolyser to an Existing Solar Farm: Case Study in Deakin Solar Farm

Hossein G. Sahebi, Ali Reza Sattarzadeh and Saman A. Gorji (Deakin University, Australia)

In conjunction with net zero goals, adding a hydrogen cycle to a renewable energy microgrid becomes of interest to industry partners and government sectors. However, investing in a green hydrogen system requires a strategic feasibility study, which might face difficulties in addressing the technical challenges in water and power engineering, particularly in regional areas. In this project, we developed a digital platform to evaluate the water and power consumption as well as hydrogen and oxygen production yields, considering two scenarios. In the first scenario, we targeted the existing solar farm at Deakin University, and attempted to calculate the feasible size of electrolyser to add to the solar farm. The digital platform will provide us with the water and power consumption needed to produce hydrogen and oxygen. In the second scenario, we attempted to generalize the design for different locations and inputs. The project has been carried out based on a current practical need for renewable energy systems that are capable of accommodating water electrolysis to better complement the energy storage capability of batteries.

Presenter bio: He is a PhD student at Deakin University, specializing in control system designs for power electronics systems in DC microgrids. His current research explores nonlinear MPC for efficient energy management and control in complex converter systems, aiming to advance practical applications in renewable energy and energy storage.

Pre-commissioning Platform for Large-scale Battery Farms

Ramesh Naidu Bonu, Richard Yan and Tapan Kumar Saha (University of Queensland, Australia)

The ambitious net-zero emission targets led to an exponential uptake of large-scale renewable energy (RE) and storage plants in Australia. The planning and operational security of the power systems can be endangered without proper regulations that dictate the installation and operation of these large-scale plants. Currently, the regulations mandate a stepped progression in the commissioning of the large-scale plants where each step is related to the ability of the plant to accurately match the field performance with that of the simulation models submitted for the initial approval. Currently, many large-scale projects have experienced lengthy time delays and significant financial losses due to the mismatch in performance, which has substantially eroded confidence in the RE industry and has contributed directly to the failure of some projects and businesses.

This presentation details the establishment, validation, and technology demonstration of the real-time pre-commissioning platform for large-scale battery farm at UQ's Renewable Energy Laboratory that is targeted to de-risk the commissioning process. The developed platform encompasses three primary components: a workstation, a real-time experimental interface, and hardware. The hardware is the Siemens cabinet that incorporates metering, and inverter control capabilities, and enables the testing of large-scale battery farms in both Grid Forming (GFM) and Grid Following Mode (GFL), facilitating comprehensive HIL studies. Testing results of the virtual synchronous machine control functions like inertia, droop, fault ride through etc. will be presented to demonstrate the functionality of the developed platform followed by a discussion on its prospective applications.

Leveraging Hydrogen Integration to Optimise Wind Energy Utilisation and Minimise Fuel Costs in Remote Mines

Venkata Satyavani Varanasi, Li Li and Kaveh Khalilpour (University of Technology Sydney, Australia)

The integration of hydrogen technology into microgrids represents a significant advancement in sustainable energy strategies for the mining industry, which is increasingly pivoting towards renewable resources due to escalating fuel costs and stringent emissions regulations. This paper discusses the application of a microgrid combining solar PV, wind, gas engines and advanced energy storage systems, including hydrogen and batteries, to minimise renewable energy curtailment, fuel costs and Operational Expenditures (OPEX) at remote mining sites. The study leverages a mixed integer linear programming model to assess the effectiveness of integrating electrolysers for hydrogen production using curtailed wind energy and using it in gas engines to reduce natural gas consumption costs, which has a larger share in OPEX. The findings illustrate that hydrogen and additional battery storage serve as a robust storage medium capable of managing the microgrid's energy surplus with minimal losses. In addition, hydrogen integration plays a pivotal role in decreasing OPEX and improving the mine's environmental footprint by reducing natural gas consumption and providing a clean power supply.

Wednesday, November 20 12:45 - 2:45

TS2: Power Systems & Stability I
Room: Town Hall

Stability-Constrained Unit Commitment in GFL/GFM-Penetrated Systems - An Overview

Cristobal Esser and Claudia Rahmann (Universidad de Chile, Chile); Rodrigo Moreno (Universidad de Chile & Imperial College London, Chile); Pierluigi Mancarella (The University of Melbourne, Australia)

Synchronous generators (SGs) have been displaced by Grid-Following (GFL) inverters which have threatened system strength, traditionally quantified as ShortCircuit Levels (SCL). The reduction in system strength can lead to the emergence of stability issues in power systems. However, promising technologies as Grid-Forming (GFM) inverters may improve system strength, though having limited fault currents. In this way, some authors have proposed stability constraints in Unit Commitment (UC) models to address stability issues caused by GFLs, taking into account the stability support provided by GFMs. This work aims to study the constraints according to the type of stability they encompass and how they are modeled in a UC problem.

Presenter bio: Received their B.Sc. degree in Electrical Engineering from Universidad de Chile and is currently pursuing their M.Sc. degree at the same institution. Their research interests lie in the field of power system stability, with a specific focus on the challenges and solutions associated with high penetration of inverter-based resources (IBRs) in modern power systems.

Oscillation Source Identification from Inverter-based Renewable Energy Resources

Tapan Kumar Saha and Richard Yan (University of Queensland, Australia); Feifei Bai, Ting Kai Chia and Feng An (The University of Queensland, Australia); Dylan Nguyen and Praveen Pillai (Iberdrola Australia, Australia)

A 6.25 Hz oscillation event occurred on 23 June 2022 in South Australia. The delay in locating the oscillation source caused the oscillation to spread throughout the network. This oscillation lasted 5 hours due to the lack of a scientific method to identify the right oscillation source, which caused the disconnection of the power generation from two wind farms and 95% of the residential battery fleet from one manufacturer. Iberdrola Australia provided the field-recorded oscillation data and the network model of this event for further investigation. This presentation will introduce the identified root causes of oscillations (too fast reactive power tracking, slow sampling rate of the hybrid power plant controller, and the lack of reactive power compensation), and insight into a scientific method to identify the source of oscillations arising from the wind farm or the grid in real time.

Presenter bio: Dr Feifei Bai is a Senior Lecturer at the School of Electrical Engineering and Computer Science at the University of Queensland, Australia. She is also an Adjunct Senior Research Fellow at Griffith University. She is the Chair of the IEEE PES/DEIS Queensland Chapter from 2023 to 2024. Her research interests are renewable energy integration to the power grid and Phasor Measurement Unit (PMU) applications.

Presenter bio: Ruifeng (Richard) Yan is Associate Professor in the School of Electrical Engineering and Computer Science at the University of Queensland (UQ). He was an DECRA Fellow of Australian Research Council from 2018-2021. His expertise includes power system dynamics analysis, renewable energy (solar photovoltaic and wind) modelling and integration to power grids. He has worked on a range of different industry projects. He is currently served as an Associate Editor of IEEE Transactions on Power Systems and CSEE JPES. He is a Committee Member of CIGRE C4.

Multi-Objective Optimization for Energy Management in Residential Microgrids with Local Energy Markets

Haesum Ali, Daniel Burmester and Ramesh Rayudu (Victoria University of Wellington, New Zealand)

Improper management of increasing distributed rooftop solar photovoltaic (PV) and electric vehicles (EVs) can impact distribution network stability and lead to the degradation of critical assets. Local energy markets (LEM) have emerged as a potential solution to optimise energy management, especially in residential communities. This paper proposes a novel LEM-based multi-objective optimisation scheme for energy management in a microgrid (MG) network comprising of a residential community. The objective is to minimize operational costs while mitigating peak grid import and reverse power flow. The optimisation framework integrates mixed-integer linear programming (MILP) based decision-making for power trading and scheduling of flexible devices. This study considers real-time data and utilizes statistical models for numerical simulations. Simulation results demonstrate reductions in peak grid import and reverse power flow, alongside operational cost savings compared to traditional home energy management system (HEMS) and LEM-based approaches. These findings underscore the effectiveness of the proposed approach in enhancing the stability and cost-efficiency of residential MGs considering increasing PV and EV integration.

Presenter bio: Hi! I am Haesum Ali, a PhD student at Victoria University of Wellington. My research focuses on microgrids, low-voltage distribution networks, optimization, and energy management. I am especially interested in integrating and managing distributed energy resources to improve energy resilience and efficiency in residential networks.

After Diversity Maximum Demand Enabled Congestion and Constraint Analyses for Distribution Transformers

Abdullah Attahir Yusuf (The University of Auckland, New Zealand); Nirmal Nair (University of Auckland, New Zealand)

This paper analyses low voltage (LV) networks using After Diversity Maximum Demand (ADMD) to assess and address operational challenges such as transformer overload, network congestion, and voltage constraints. Utilizing data from Horizon Networks, the paper conducts congestion and constraint analyses for high-risk transformers under various future scenarios. The analyses, which are performed using PowerFactory, identify potential bottlenecks and operational limits in LV networks to inform future grid development and investment decisions. The results demonstrate that while network congestion may not pose an immediate threat, voltage constraints, especially in longer LV feeder runs, represent a significant risk by 2050. Mitigating these risks through optimizing ADMD-based planning is crucial for ensuring a sustainable and reliable power supply in the face of growing electrification demands. Recommendations for network enhancements and further research into smart meter data integration for validating ADMD assumptions are also discussed.

A Comparative Analysis of Power System Inertia Estimation Methods

Louis Rahal Goonasekara and Lasantha Meegahapola (RMIT University, Australia); Shuo Yan (RMIT University, Hong Kong)

Precise online inertia estimation is essential for the stability of power system operations. It is an important tool for power system operators to control the dispatch and ancillary services accordingly. This study chose three estimation techniques from the relevant literature. Which captures the different base theories that express online inertia estimation. The estimation techniques include inertia constant-based approach, acceleration time constant based procedure and kinetic energy theorem based method, each with distinct advantages and limitations. Inertia constant methods often suffer from location and size dependencies, leading to underestimations during large disturbances. The kinetic energy theorem's accuracy is influenced by the sampling window size, which can result in over or underestimation of values. Our findings highlight the necessity for improved phasor measurement unit (PMU) measurement accuracy and advanced noise filtering techniques with the addition of increased numerical stability to capture only parameters that affect generator inertia in an extreme contingency event. Future research should aim to develop practical, measurement-based online estimation methods which express inertia in a time varying basis to enhance the precision of inertia estimation for power system operators.

Techno-Economic Assessment of Inertia Measurements: Australian case

Bastian Moya Ureta (University of Melbourne, Australia); Pierluigi Mancarella (The University of Melbourne, Australia)

The declining system inertia presents significant challenges for system operators. To maintain stability, they are exploring the roles of Frequency Control Ancillary Services (FCAS) and inertia. In Australia, inertia concerns have led to the implementation of an inertia market in the Wholesale Electricity Market (WEM) and a very Fast FCAS market in the National Electricity Market (NEM). This study investigates the value of accurate inertia measurement in the NEM. We show the differences between theoretical and actual inertia values by analysing real-time inertia data collected through a pilot project. The data analysis reveals a correlation between, renewable penetration, demand and system inertia. The techno-economic assessment suggests potential cost savings through reduced FCAS requirements and deferred planning decisions. The results highlight the potential role of inertia measurement in optimizing system operation and planning under low inertia conditions.

Presenter bio: Bastian Moya Ureta received the B. Sc. And M. Sc. Degrees in electrical engineering from the University of Chile, Santiago, Chile in 2018 and 2021, respectively. He is currently a research fellow at the University of Melbourne. His research interests include operation and planning of low inertia power systems.

Enhanced System Frequency Response Model Considering Network Parameters and Distributed Energy Resources

Jayamini Upeka Fernandopulle (Royal Melbourne Institute of Technology, Australia); Lasantha Meegahapola and Inam Nutkani (RMIT University, Australia)

Power system frequency is a critical parameter for system stability and should be maintained within a specific range to ensure stability during a contingency. A simplified system frequency response (SFR) model is often used to analyse the system frequency following a contingency. With the integration of power electronic interfaced renewables, it is essential to improve the SFR model. This paper proposes enhancements to the SFR model considering network losses, voltage drop and the voltage dependency of load. The enhanced SFR model is validated with a detailed power grid model developed in DIgSILENT PowerFactory. The enhanced SFR model is in good agreement with the detailed system model.

Presenter bio: Jayamini Fernandopulle received her B.Sc.Eng.(Hons) in Electrical Engineering from the University of Moratuwa, Sri Lanka and M.Eng.(Electrical Engineering) from the Royal Melbourne Institute of Technology (RMIT), Australia in 2017 and 2021 respectively. Miss Fernandopulle was a tutor and a laboratory demonstrator at the University of Moratuwa for two years (2017-2019). Currently, she is reading for her PhD at RMIT. Her research interest is 'Provision of Ancillary Services Via Virtual Power Plants', focusing on combined frequency and voltage regulation.

Wednesday, November 20 12:45 - 2:45

TS3: Transportation Electrification
Room: Wynyard
Chair: Sara Deilami (Macquarie University, Australia)

Design and Development of a Multi-Port EV Fast Charger with Dynamic Control Strategy

Muhammad Naveed Naz (The University of Queensland, Australia); Junwei Lu (Griffith University, Australia); Mohammad Arif (Deakin University, Australia)

Electric vehicles (EVs) demand is increasing due to their significant impacts on different aspects of society, the economy, and the environment. Unlike a normal-charger, a fast EV charger is critical for EV charging because it reduces the EV charging time significantly from several hours to just 30 minutes to 1 hour. To charge multiple EVs simultaneously and reduce the waiting time of other EVs, more power electronics converters are required which may also increase the infrastructure cost. To minimize the waiting time and infrastructure cost, and accommodate more EVs, a multiport EV fast charger is designed in this paper. A dynamic mode control strategy is developed which not only controls the individual EV charging but also controls the charging of other EVs connected for charging in the meantime. In the developed dynamic control strategy, the charging current is controlled based on the state of charge (SoC) of each EV. When the SoC of any EV achieves its next predefined level, it triggers the mode synchronization and the level of charging current to all EVs connected to this multiport charger adapts to change in a real-time. Instead of a fixed charging current, the charging current level for each EV dynamically changes even when one EV connected to a multiport fast charger reaches the next predefined SoC level. To design a multi-port offboard EV-fast charger, EVTECH & espresso charge standard specifications are used. The simulation is carried out using a Simulink environment to verify the effectiveness of the developed control strategy.

Presenter bio: Mr Muhammad Naveed Naz is a PhD student at the University of Queensland, Australia where he is focused on renewable energy resources, EVs charging, power system stability, and cost optimization. He holds a B.Sc. in Electronic Engineering from Bahauddin Zakariya University, Multan, Pakistan (2012), and an M.S in Electrical Engineering from COMSATS University Islamabad, Wah Campus, Pakistan (2016). With a strong background in both academia and industry, Mr. Muhammad has served as a part-time lecturer at the NFC Institute of Engineering & Technology, Multan, Pakistan, and gained valuable experience as a full-time Electrical Engineer at ESOLS, Pakistan.

Urban Autonomous Electric Vehicles Fleet Operation Strategy-From the Perspective of Operators

Huayu Zhang (Xi'an Jiaotong-Liverpool University, China); Ding Jin (Imperial College London, United Kingdom (Great Britain)); Bing Han and Fei Xue (Xi'an Jiaotong-Liverpool University, China); Shaofeng Lu (South China University of Technology, China); Lin Jiang (Liverpool University, United Kingdom (Great Britain))

The complex traffic environment and severe emissions pollution increasingly challenge urban development. The electrified autonomous mobility-on-demand (EAMoD) system is expected to address these issues and promote sustainable urban development. This paper proposes a mixed-integer linear programming (MILP) model designed to optimize the operation of an autonomous electric vehicle (AEV) fleet under the dilemma of passenger orders selection when facilities are limited. This model comprehensively optimizes the received and abandoned passenger orders, rebalancing operation, as well as charging and discharging of AEVs from the perspective of the AEV fleet operator under time-varying travel demands. The effectiveness of the proposed strategy was verified on a 25-node transportation network, and the operation profit of the AEV fleet under the proposed strategy was 59% higher than the benchmark. Furthermore, the result showed that various factors, such as rebalancing operations, driving speed, fleet size, charging pile size, charging rate, driving range, and electricity usage type, significantly impact the AEV fleet operator's profits.

Analysis of Australian EV Charging Behaviour for Network Hosting Capacity Analysis

Chen Rui Geach and Gregor Verbic (The University of Sydney, Australia)

The growth in the adoption of electric vehicles (EV) poses significant challenges for the power grid, which calls for novel approaches for distribution network hosting capacity analysis. One of the main challenges is the modelling of the charging behaviour. In this context, this paper analyses real-life smart meter data from 109 Australian prosumers. A unique feature of the dataset is that it covers users who also have rooftop solar, which is increasingly common in Australia. The analysis shows that the presence of rooftop solar is the main driver of EV charging patterns, which stands in contrast to data from the UK used as a benchmark. The downside of the dataset is the lack of information about the battery state-of-charge, battery size and EV charger type. Still, the analysis shows that hidden information, including charger types, travel distance, and daily plug-in factor, can be inferred from the data. This shows that the charging data alone provide sufficient information for hosting capacity analysis. To address the challenge of the limited size of the dataset, we also propose a method for generating synthetic EV charging profiles using the Markov Chain model and Gaussian Kernel Density Estimation. The preliminary results demonstrate the effectiveness of the proposed modelling approach.

Presenter bio: A PhD student at the University of Sydney, focused on research in distributed energy resources and hosting capacity analysis.

ADMM-based Coordinated Control of Electric Vehicles in an Unbalanced Distribution Grid: Assessing Tolerance to Communication Failures

Nanduni Indeewaree Nimalsiri (CSIRO, Australia); Elizabeth Ratnam (The Australian National University, Australia)

In this paper, we propose an Alternating Direction Method of Multipliers (ADMM) approach combined with consensus optimization to coordinate electric vehicle (EV) charging and discharging in an unbalanced distribution grid. The underlying optimization problem has an objective function to minimize the customer energy costs, subject to a globally coupled network constraint in the form of a linear inequality (representing grid voltage and transformer core temperature limits) and local polyhedron constraints (representing customer charging requirements and limitations in charging infrastructure capacity). EV coordination is achieved by means of an iterative routine, wherein EVs (agents) exchange limited information with their neighboring EVs through a connected peer-to-peer communication network. Our proposed approach is also designed to accommodate time-varying communication networks arising from communication link faults and random disconnection of agents from communication channels. Numerical simulations verify

the performance of the proposed approach in terms of network-aware operation and communication-failure tolerant operation.

Presenter bio: Nanduni Nimalsiri is a Research Scientist at CSIRO, where her research addresses complex engineering challenges across diverse domains, with a primary focus on energy and power systems. Her research interests include mathematical modeling, optimisation and control, and machine learning to drive advancements in power systems research and support the transformation of the energy sector. Before her current role, she held postdoctoral positions at The University of Melbourne and The Australian National University. Nanduni earned her PhD in Engineering and Computer Science at The Australian National University in collaboration with CSIRO Data61.

Accurate Distance Estimation of Battery Locomotive Based on Energy Balance Approach

Sakura Mukhopadhyay (Macquarie University, Australia & Arcadis, Australia); Sara Deilami (Macquarie University, Australia); Foad Taghizadeh (Macquarie University Sydney, Australia)

In this paper, an energy balance approach has been proposed to determine the maximum distance travelled by the lithium-ion battery driven electric locomotive during catenary-free operation for any railway environment. Through an energy balance approach, an algorithm has been developed of maximum distance the battery can deliver as a function of several variables and further optimized proposing an algorithm to maximize the distance. This research further presents a mathematical model and dynamic simulation of an electric train from a railway electrification designer's perspective, with real-life issues and design constraints considered and input into the model. Using MATLAB, the simulation model consists of the battery train's longitudinal dynamics, electric system, and on-board energy storage has been developed. The results have been compared and validated with real life data of Australian railway standards to ensure accuracy and validity.

Presenter bio: Sakura is a mechatronics engineer graduated from Macquarie University. She has 5 years experience of working in the design of railway electrification with an interest for smart electrification and decarbonization for the next generation of modern railways.

Assessing the Impacts of Electrification on Australian MV-LV Distribution Networks

Jing Zhu, Luis (Nando) Ochoa and Orlando Pereira (The University of Melbourne, Australia)

Hundreds of thousands of Australians are embracing the use of distributed energy resources (DERs), including rooftop solar photovoltaics (PVs), electric vehicles (EVs), residential batteries, and gas electrification technologies (e.g., heat pumps). However, in the meantime, these DER technologies will potentially pose significant challenges to the very infra-structure they are connected to: the distribution networks. Distribution networks were originally designed to manage peak residential demand only, and are not engineered to host significant solar PV generation (which can lead to excessive voltage rise) and/or the additional demand from EVs and gas electrification (which can exacerbate voltage drops and cause asset congestion). Consequently, it is critical for distribution companies to understand these technical barriers and identify solutions to accommodate more DERs within their networks.

As part of C4NET's Enhanced System Planning (ESP) pro-ject [1], this study aims to assess the electrification impacts on medium voltage (MV) and low voltage (LV) parts of Victorian distribution networks, considering different DER technology mixes and network types (e.g., CBD, urban, rural) [2]. Both network solutions (e.g., augmentation) and non-network solu-tions (e.g., inverter functions) are explored for DER orchestra-tion. Ultimately, this study will provide valuable recommenda-tions to inform Victorian distribution companies about their network planning beyond 2030, thereby accelerating the elec-trification of distribution networks toward net-zero emissions.

Presenter bio: Born in San José, Costa Rica, in 1994, he earned his Bachelor's and Licentiate degrees in Electrical Engineering from the University of Costa Rica in 2017 and 2020, respectively. Currently, he is a doctoral student at the University of Melbourne. His research focuses on the modeling and simulation of distribution networks and planning for the integration of distributed energy resources.

Integrated Location-Arc Routing Optimization for Waste Logistics with Battery Swapping Stations

Jun Li (UNSW, Australia); Yuchen Zhang (Queensland University of Technology, Australia); Z Y Dong (The University of Sydney, Australia)

This paper discusses the incorporation of Battery Swapping Stations (BSS) into the waste logistics system with the goal of reducing overall system costs. A new location-arc routing problem (LARP) model is designed to optimize the locations of BSS and waste collection centers, as well as the routes of Electric Garbage Trucks (EGT). To address the computational difficulties of this NP-hard problem, a modified Simulated Annealing (SA) algorithm is created. The effectiveness of the proposed method is verified through numerical simulations using benchmark scenarios, showing notable improvements in cost efficiency and operational viability. The results highlight the potential of the combined BSS and EGT system in cutting emissions and lowering operational costs in municipal waste management logistics.

Presenter bio: Dr Yuchen Zhang is an ARC DECRA Fellow and Lecturer at Queensland University of Technology, Brisbane, Australia. He obtained his PhD from University of New South Wales in 2018 and was previously a researcher with ARC Research Hub of Integrated Energy Storage Solutions. His research aims to address the critical challenges in energy system transition using interdisciplinary knowledge and technologies. His research interests include power system stability, power infrastructure planning, grid integration of inverter-based resources, and data-driven applications in power systems.

Paper Optimal Capacities of Electric Ferry Charging Stations by Hybrid Metaheuristic Algorithm

Rajib Baran Roy, Sanath Alahakoon and Petrus A. Janse van Rensburg (Central Queensland University, Australia)

Maritime transport significantly contributes to greenhouse gas emissions, which necessitates the implementation of electric ferries and renewable energy-powered harbor charging stations to mitigate these emissions, particularly in urban coastal areas and islands. Proper planning and optimal capacity determination of the charging stations are critical to maintaining the stability and reliability of the connected distribution networks. This research emphasizes the importance of optimizing the capacity of ferry charging stations to prevent system overloads, maintain voltage levels, avoid power outages, and reduce infrastructure upgrade costs. Metaheuristic optimization algorithms are selected for their superior capability to address intricate, nonlinear problems, presenting a more adaptable and practical approach than conventional methods. This research explores the balanced hybrid PSO-BFO (Particle Swarm Optimization-Bacterial Foraging Optimization) algorithm to determine the optimal capacities of electric ferry charging stations within a simulated distribution network in regional Australia. The hybrid PSO-BFO algorithm, integrated with OpenDSS (Open Distribution System Simulator) for power flow analysis, ensures compliance with voltage and current constraints while minimizing power losses and deviations in bus voltages and line currents. The simulation results underscore the co-simulation approach's effectiveness in determining the optimal capacities for charging infrastructure, thereby facilitating the broader adoption of electric marine transportation.

Wednesday, November 20 2:45 - 3:00

AT1: Afternoon Tea
Room: Foyer

Wednesday, November 20 3:00 - 4:30

TS4: Renewable Energy Systems II
Room: Central
Chair: Behrooz Bahrani (Monash University, Australia)

Assessing the Environmental Impact of Recycling End-of-Life Solar Panels: A Case Study of the Sunshine Coast Solar Farm

Fadi Almaghrbi (The University of Queensland, Australia); Wayes Tushar and Rahul Sharma (University of Queensland, Australia)

This paper analyzes the environmental impact of recycling end-of-life solar PV panels from the Sunshine Coast Solar Farm in Queensland. By quantifying the mass of recovered materials and emissions produced, the study identifies the potential for substantial emissions savings through recycling compared to landfilling. The results indicate that recycling generates significantly lower emissions and can mitigate 1,017,410.6 kg of CO2-e emissions. These findings emphasize the importance of sustainable waste management practices in maximizing the environmental benefits of solar PV systems.

Presenter bio: Fadi is currently a PhD candidate at the University of Queensland, focusing on the evaluation and management of PV waste. Fadi's research is sponsored by the government of Saudi Arabia, aiming to contribute to the development of sustainable renewable energy solutions in the country.

Context-aware Hosting Capacity Analysis and Forecasting of Distribution Networks with Distributed Energy Resources

Md Tariqul Islam, Jahangir Hossain and Md Ahasan Habib (University of Technology Sydney, Australia)

In modern power systems, integrating distributed energy resources (DER) such as solar photovoltaic systems, electric vehicles, and energy storage systems necessitates accurate forecasting of network hosting capacity and estimation of network parameters. Traditional deep learning models frequently fail to consider the dynamic and temporal relationships of network and DER variables on contextual factors, resulting in inaccurate predictions of network hosting capacity. This paper

introduces the Context-aware Hosting Capacity Forecasting Model (Ca-HCFM), which enhances the forget gate output with contextual inputs, effectively capturing the dynamic nature of network and DER variables and improving the accuracy of hosting capacity forecasts. The effectiveness of Ca-HCFM is tested against various standard models, including Support Vector Regression (SVR), Long-Short Term Memory (LSTM), Convolution LSTM (ConvLSTM), Bidirectional LSTM (BiLSTM), Stack LSTM (StackLSTM), and Gated Recurrent Unit (GRU). The results demonstrate that Ca-HCFM outperforms these baseline models, offering engineers and network operators a robust tool for the sustainable and efficient integration of DER into distribution networks.

Presenter bio: Md Ahasan Habib is currently pursuing his PhD at the School of Electrical and Data Engineering, University of Technology Sydney (UTS), Australia. He completed his B.Sc. and M.Sc. in Electrical and Electronic Engineering from Rajshahi University of Engineering and Technology (RUET), Bangladesh, in 2016 and 2019, respectively. His research interests include terahertz waveguides, optical fiber communication, machine learning, deep learning, renewable energy, feed-in tariff, and dynamic tariff. To date, he has authored over 40 articles in international journals and conferences.

A Novel Data-Driven Optimization for Cost-Effective Home Energy Management with PV-EV Integration

Muhammad Irfan (Macquarie University, Australia); Tayyab Tahir (University of Toulon, France); Sara Deilami, Shujuan Huang and Binesh Puthen Veettil (Macquarie University, Australia)

As electric vehicle (EV) adoption accelerates; it increases power grid demand but also offers significant benefits. EVs can act as energy storage units, managing grid load and facilitating renewable energy use. Integrating renewables like photovoltaic (PV) systems with EVs through a Home Energy Management System (HEMS) eases grid stress and reduces carbon emissions. In this study, we present a novel Data-Driven-Model (DDM) based on the pioneer Proximal Policy Optimization (PPO) algorithm, a recent advancement in machine learning. The aim is to optimize policy formulation in sequential decision-making tasks in HEMS, specifically to minimize household monthly electricity costs. This approach leverages a grid-assisted bidirectional PV-EV system in Sydney, Australia households, operating in both vehicle-to-grid and vehicle-to-home modes. The performance of this method is comprehensively assessed and compared with the base case, demonstrating a significant reduction in monthly electricity costs.

Presenter bio: Muhammad Irfan was admitted as a PhD student in the School of Engineering at MQ University, Australia. He received his Master's degree in Electrical Engineering from the University of Gujrat, Pakistan.

Analysing Harmonic Resonance Behaviour of a Grid-Connected PV Plant

Anuradha Abeysekara, Chandima Ekanayake and Hui Ma (University of Queensland, Australia)

The incorporation of inverter-based resources (IBR) into the power grid has led to new power quality challenges, including higher-order harmonics (supra-harmonics), frequent transient voltages, power oscillations, etc. The supra-harmonics could damage assets that were originally designed to operate under power frequency. Furthermore, power quality standards have not yet set limits for higher-order harmonics. Moreover, the configuration of IBRs may result in higher-order resonance, potentially exacerbating these harmonic levels. Hence, in this paper, the effect of harmonics due to resonance characteristics of a grid-connected PV plant has been studied through simulations to understand the factors that affect forming resonance conditions at supra-harmonics levels. This study was extended by incorporating measured harmonic currents to understand the level of harmonic voltages that could appear at the transformer terminal under these resonance conditions. The results show the significance of considering the higher-order harmonics in Voltage Total Harmonic Distortion (VTHD) calculations, where existing limits by the standards could be violated at these resonance conditions

Presenter bio: Anuradha Abeysekara received his Bachelor of Science in Engineering (Honours) in Engineering from the University of Peradeniya in 2015. After graduation, he joined the industry as a transformer design engineer at a local transformer manufacturing facility. Subsequently, he joined the Ceylon Electricity Board and pursued his Master of Science in Engineering at the University of Peradeniya. He started his PhD at the UQ School of EECS under Dr. Chandima Ekanayake, Prof. Tapan Saha and Dr. Hui Ma in 2023. He is investigating the impact of current and voltage harmonics on transformer insulation ageing. His research interests include harmonic resonance, insulation ageing, and transformer condition assessment.

Solar Powered Smart Irrigation System with Battery Backup for Maximum Output Power in Rural Areas by Solar Angle Optimization

Sisir Regmi (Central Queensland University Australia, Australia); Narottam K. Das (Central Queensland University, Australia)

Agriculture has become one of the backbones for the development of a country as it helps in economic growth. Being one of the major factors that contribute to the overall development of a country, it has not progressed in the way it should. For proper agriculture and its production timely irrigation is important. Although plain

land and urban areas are connected to the national grid system and the power can be used for the irrigation, the rural areas (i.e., hilly and mountain) still suffer from the lack of proper irrigation system. Solar energy can be used to generate electricity for powering the water pump along with battery backup system that will continuously supply power to pump. Modern irrigation technology which has been developed cannot be assumed that it will work in the low economic and developing nations. This study is solving the issue of the irrigation in rural areas which is operated from solar energy along with battery backup system which can be used to supply power during low irradiance and nighttime and gives maximum power for longer time using solar angle optimisation technology which has also benefit for low carbon emission. This research developed a solar powered smart irrigation system with battery backup in rural areas by solar angle optimization.

Presenter bio: Dr Narottam Das received his PhD degree in Electrical Engineering from Yamagata University, Japan in 2000. His PhD research project was funded by the Ministry of Education, Science, Sports and Culture of Japan. Dr Das has about 3-decades experience as an academia and industrial Engineer in Australia and overseas. Prior to join at CQUniversity as a Senior Lecturer in Electrical Engineering, he worked at University of Southern Queensland, Curtin University, Edith Cowan University, Monash University, Australia and NEC Yamagata Ltd., Japan. Dr Das is the author/co-author over 240 peer-reviewed journal and international conference papers. Dr Das is a senior member of the IEEE, USA; Fellow of the Institution of Engineers, Australia; CPEng, NER, Fellow of Higher Education Academy (UK), and Life Fellow of the Institution of Engineers, Bangladesh. His research interests include in Power and Energy Systems, such as, renewable energy, modelling of high-efficiency solar cells, multi-junction solar (PV) cells, Power Systems Communication (Smartgrids) using IEC 61850, and modeling of high-speed communication devices.

Assessment of Satellite-Derived Hourly Solar Weather Data in Java-Bali Island

Indra Darmawan Budi (PT PLN (Persero), Indonesia); Mochamad Fajar Rinaldi Utomo (University of New South Wales, Indonesia & PT PLN (Persero) Indonesia, Indonesia); Dimas Palgunadi (The University of New South Wales, Australia & PT Perusahaan Listrik Negara (Persero), Indonesia); Adetya Devritama (PT PLN Nusantara Power, Indonesia)

Solar irradiation resource assessment for different weather data sources was used to find the correlation between modelled data and the measured data. The analysis encompasses 55 different locations scattered in Java Bali Island, Indonesia. Those locations were set as centroids to cluster the area within Java-Bali Island. The correlation between satellite-derived data to the measured data was indicated by the deviation value. The deviation analysis was presented by using the normalized mean bias deviation (nMBD) and the normalized root mean square deviation (nRMSD) for the daily energy generation density (kWh/m2.day). After excluding the outlier, the nMBD value has a range between -15.95% to 34.11% for NREL, -22.55% to 54.25% for NASA-SSE, and -13.94% to 39.07% for PVGIS-TMY. In addition, the nRMSD value has a range between 25.01% to 55.37% for NREL, 31.39% to 68.51% for NASA-SSE, and 26.77% to 55.72% for PVGIS-TMY.

Wednesday, November 20 3:00 - 4:30

TS5: Power Systems & Stability II
Room: Town Hall
Chair: Rahmat Heidari (CSIRO, Australia)

Memory and time savings by superposition of DC-modeled contingencies in grid optimization

Thomas Leveringhaus (Leibniz Universität Hannover, Germany); Julian Waßmann (Leibniz University Hannover Hanover, German, Germany); Lars Stark (Leibniz University Hannover, Germany); Lutz Hofmann (Leibniz Universität Hannover, Germany)

This paper contributes to the goals of memory- and time-saving optimization methods based on DC approximations. It presents a superposition method for contingencies based on the superposition method for short-circuit calculations. A case study shows very noticeable advantages of the superposition method with regard to memory and time requirements.

Presenter bio: 2017 - 2024: Student of Energy Technology (M. Sc.) at Leibniz University Hannover (Germany) Since 2024: PhD at Institute of Electric Power Systems, Leibniz University Hannover (Germany) Working on topic "Security Constrained Optimal Power Flow"

Impact of Renewable Energy Sources on Artificial Neural Networks for Optimal Power Flow: A Contemporary Analysis

Sultan Bawazeer and Ali Maher Mohammed (KFUPM, Saudi Arabia); Waleed M. Hamanah (King Fahd University of Petroleum and Minerals & Applied Research Center for Metrology, Standards and Testing (ARC-MST), Saudi Arabia); Mohammad A. Abido (KFUPM, Saudi Arabia)

Artificial neural networks (ANN) have significantly improved speed and frequency of solving optimal power flow (OPF) problems. It also proved its ability to capture generation outputs and their characteristics for renewable energy sources (RES) and integrate them in OPF problems. This paper presents an evaluation of the impact of RES units on ANN accuracy when the ANN is trained with no presence of RES units in the system. It analyzes how accuracy of this ANN is affected compared

to OPF solution from MATPower library; firstly when wind and solar RES units are injected as additional power sources and then when the existing conventional generation units are replaced by RES units. This work promotes for better understanding of how RES units affect ANN trained for OPF with no RES units. A case study of IEEE 30 bus system is presented along with numerical comparisons between OPF solutions from the ANN and MATPower and illustrated using 3D plots.

Presenter bio: M. A. Abido received the B.Sc. and M.Sc. degrees in EE from Menoufiya University, Egypt, in 1985 and 1989, respectively, and the Ph.D. degree from King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia, in 1997. He is currently a Distinguished Professor at KFUPM. His research interests are power system stability, planning, operation, and optimization techniques applied to power systems. Dr. Abido is the recipient of KFUPM Excellence in Research Award, 2002, 2007 and 2012, KFUPM Best Project Award, 2007 and 2010, First Prize Paper Award of the Industrial Automation and Control Committee of the IEEE Industry Applications Society, 2003, Abdel-Hamid Shoman Prize for Young Arab Researchers in Engineering Sciences, 2005, Best Applied Research Award of 15thGCC-CIGRE Conference, Abu-Dhabi, UAE, 2006, and Best Poster Award, International Conference on Renewable Energies and Power Quality (ICREPQ'13), Bilbao, Spain, 2013. Dr. Abido has published more than 250 papers in reputable journals and international conferences.

Presenter bio: WALEED M. HAMANAH received his BSc degree in Electrical Engineering from Sana'a University, Yemen, in June 2008. He worked as an instructor at Taiz University, Yemen, from September 2008 to December 2011. He earned his MSc and Ph.D. in Electrical Engineering—Power and Control—from King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, Saudi Arabia, in 2016 and 2021, respectively. He completed a postdoctoral fellowship at the IRC for Sustainable Energy Systems at KFUPM. Currently, he works at the Applied Research Center for Metrology, Standards, and Testing Research and Innovation at KFUPM as a Research Engineer III (Assistant Professor). His research interests include Renewable Energy, Intelligent Control Systems, Power Electronics, and High Voltage.

Capacity Planning for Virtual Synchronous Generator Batteries to Enhance Small-Signal Stability of Grid-Following Converters

Yunda Xu, Hankun Cui, Richard Yan and Tapan Kumar Saha (University of Queensland, Australia)

The transition to renewable energy sources has presented significant challenges to power system stability, particularly with the increased deployment of inverter-based resources (IBRs). Grid-following (GFL) converters are effective in maintaining stability under strong grid conditions but become unstable in weaker grids. Conversely, grid-forming (GFM) controls, such as virtual synchronous generators (VSGs), enhance stability through voltage support and frequency regulation but may become unstable under high system strength. This paper investigates the combined application of GFL and GFM control strategies to improve overall system stability. A small-signal model is developed for a multi-converter system integrating both GFL and VSG converters connected to an infinite bus. The study examines the impact of varying VSG/GFL capacity ratios on system stability. The proposed methodology demonstrates effective stabilization across different grid conditions, with PSCAD simulations validating that incorporating 20% VSG converters into GFL systems enhances stability under diverse grid strengths. This research provides an analytical framework for assessing stability in multi-converter systems and offers practical guidelines for integrating VSG batteries with existing IBR infrastructure.

Adaptive Layers Based Atomic Orbital Search for the Co-Optimization of Network Reconfiguration with Battery Storage

Muhammad Ahmad Iqbal and Raheel Zafar (Lahore University of Management Sciences (LUMS), Pakistan); Hemanshu Pota (UNSW@adfa, Australia)

Network reconfiguration (NR) is a widely recognized strategy for enhancing the distribution network (DN) performance by minimizing power losses and improving the voltage profile. This study introduces a novel variant of the atomic orbital search (AOS) algorithm that features adaptive layers selection, an improvement over the canonical AOS algorithm, applied for the first time to the NR problem. The number and span of layers in the proposed variant are adaptively calculated at each iteration per the log-normal distribution of the particles in the solution space. It is generic and converges more rapidly to optimal solution because of the adaptive layers selection feature. The proposed variant performance is evaluated by optimizing three benchmark NR cases of the IEEE 33-bus feeder. Moreover, to address the scalability concerns during the day-ahead electricity market operation, a multiperiod co-optimization problem of NR with battery energy storage system and photovoltaic units having 264 decision variables, is solved in an acceptable time. The simulation results outperform the reported results in the literature in terms of standard deviation in achieving the final solution.

Presenter bio: Raheel Zafar (Member, IEEE) received his Ph.D. degree in Electrical Engineering from the University of New South Wales (UNSW), Sydney, Australia, in 2019. He has 5+ years of teaching experience and four years of industry experience. He is currently working as an Assistant Professor at Lahore University of Management Sciences (LUMS), Pakistan. His research interest includes the operation decision-making in smart distribution grids.

A Systematic Review of Data-driven Methods in Emergency Control of Power Systems

Abdul Basit Khan (University of New South Wales, Australia); Yuchen Zhang (Queensland University of Technology, Australia); Rui Zhang (University of New South Wales, Australia); Zhao Yang Dong (Nanyang Technological University, Singapore)

Emergency control in power systems is crucial for maintaining stability and preventing widespread outages. Data-driven methods have emerged as vital tools in optimizing response-driven and event-driven emergency controls, particularly in Under-Voltage Load Shedding (UVLS), Under-Frequency Load Shedding (UFLS), and event-driven load shedding (ELS). This systematic review aims to synthesize the current state of research on data-driven methods in the emergency control of power systems, focusing on UVLS, UFLS, and ELS. A systematic review was conducted using the PRISMA framework, examining research papers published between 2014 and 2024. Databases such as IEEE Xplore and ScienceDirect were searched using relevant keywords. Inclusion and exclusion criteria were applied to ensure the relevance and quality of selected studies. The review identified various data-driven techniques, including optimization algorithms, machine learning approaches, probabilistic methods, and real-time data analytics and control, applied in both response-driven and event-driven emergency controls. Each cluster is analyzed for its application, advantages, disadvantages, and complexity. This review highlights the advancements in these methodologies and suggests future research directions to enhance power system stability during emergencies.

Adaptive switching based control mechanism for mitigating frequency oscillations due to large load drops in low inertia systems

Binula R Gunawardana and Manuja Gunawardana (University of Moratuwa, Sri Lanka); Narendra De Silva (Lanka Electricity Company, Sri Lanka); KTM Udayanga Hemapala (University of Moratuwa, Sri Lanka)

This paper provides an overview on a simple adaptive switching based control mechanism which could be utilized for frequency control in grid following inverters for the PSCAD software platform. The models are meant for system integration research, including transient stability evaluations of power systems with significant inverter-based generating penetration. In order to confirm the functionality of the model, it is integrated into an IEEE 9-bus system with low inertia. As grid following inverters require a reference, a synchronous generator is utilized as the grid forming device as well as to provide backup power. A key part of the simulation is the scaling factor which can be used to simulate any number of inverters through PSCAD

Presenter bio: recent electrical engineering graduate from the university of malaya

Wednesday, November 20 3:00 - 4:30

TS6: Power Systems Planning I
Room: Wynyard
Chair: Gregor Verbic (The University of Sydney, Australia)

Modelling and Comparative Analysis of Low-Voltage Distribution Networks at Varying Levels of Approximation

Jiawei Zhang (University of Sydney, Australia); Gregor Verbic (The University of Sydney, Australia); Rahmat Heidari (CSIRO, Australia); Frederik Geth (GridQube, Australia)

This paper focuses on the modelling of low-voltage (LV) distribution networks at various levels of approximation. Based on an Australian representative LV network topology provided with only approximate sequence impedances, we construct a comprehensive unbalanced three-phase four-wire LV network model with Australian standard conductors. In addition, we adopt three widely applied approximations: (i) neutral Kron reduced model, (ii) sequence impedance model; and (iii) single-phase equivalent model. Real-life load data are used in power flow studies conducted across the four models. Then, comparative analyses are performed that evaluate bus voltage magnitudes, network losses, and utilisation of transformer capacity. Through comprehensive analyses, this paper provides insight into the fidelity of various approximation levels in representing the original four-wire LV network model, as well as the risks to anticipate in the adopted assumptions. It underscores the importance of employing a detailed model that includes neutral voltage considerations, providing researchers with a clear understanding of how their modelling choices may impact the outcomes for LV distribution network studies.

Presenter bio: A PhD student in the University of Sydney, working in the areas of low-voltage network modeling, hosting capacity assessment, and electricity market.

Analysing Power System Component Failures under Two-state and Three-state Weather Models

Osanda Galagoda, Ashish Agalgaonkar and Kashem Muttaqi (University of Wollongong, Australia); Hadi Lomei (Essential Energy, Australia)

Power transmission and distribution systems are highly susceptible to disruptions caused by the physical environment, particularly during extreme weather events. Extreme weather has a significant effect in power system and this vulnerability can lead to cascading failures and widespread power outages. To improve the system resilience, it's crucial to assess the impact of weather conditions on component failures. This paper explores the influence of weather on power systems by evaluating two models: a two-state weather model and a three-state model. By analyzing these models, this article aims to understand the effect of varying weather severity on component failure rates and overall reliability of power systems. Also, through this work the results are compared according to the weather conditions and repair times

Presenter bio: I have received my bachelor's degree in electrical and electronic engineering from the University of Peradeniya, Sri Lanka in 2023. Currently I am a PhD applicant at University of Wollongong, Australia. I am working under the research titled, "Enhancing Resiliency of Electricity Networks to Counteract Weather Adversities".

Constructing Three-Phase LV Networks using Smart Meter Data

Eshan Karunarathne, Luis (Nando) Ochoa and Tansu Alpcan (The University of Melbourne, Australia)

Accurate electrical network models are essential for distribution companies to carry out electrical analyses involving power flows. However, in the low voltage (LV), many companies have incomplete or non-existent network models, leading to simplifications and limited analyses. An opportunity exists to construct and improve these models using smart meter data. This study proposes an approach to construct three-phase LV network models using historical smart meter data without any other prior network knowledge. It combines multiple linear regression models, clustering techniques, Spearman correlation, and physical network aspects for identification and estimation. Using real Australian LV networks in Victoria under complete and partial smart meter coverage scenarios, this study demonstrates how the proposed approach constructs network models. The approach has the potential to assist distribution companies in constructing precise models for planning and operational applications.

Presenter bio: Eshan Karunarathne is a Ph.D candidate and a Research Associate in Smart Grids at the University of Melbourne, Australia. His research interests include advanced operation and planning applications of DER-rich electricity distribution networks, with a specific focus on developing low-voltage network models from smart meter data. Eshan holds a B.Sc in Electrical and Electronic Engineering from the University of Peradeniya, Sri Lanka, and an M.Sc in Electrical Engineering from Universiti Tenaga Nasional (UNITEN), Malaysia. He has also worked as an Electrical Design Engineer in Sri Lanka, specializing in HV grid substations.

Virtual Power Plant for EV Coordination at Higher EV Penetration Level for Better Grid Performance

Adithya Ravikumar (Macquarie University, Australia); Foad Taghizadeh (Macquarie University Sydney, Australia); Sara Deilami (Macquarie University, Australia)

The rise in plug-in electric vehicle (EV) has been a cause for concern to the disruption in the distribution grid. To manage this disruption, EV coordination strategies are used to charge/discharge EVs without causing any grid issues. The coordination strategies are generally implemented through a platform called Virtual Power Plant (VPP). But, the VPP has issues, when handling higher EV penetration the voltage deviation and power losses are higher. Additionally, the customer satisfaction at higher penetration is also reduced and EV owners are needed to be satisfied. To improve the grid performance of the VPP, this paper proposes a state of the art multi-objective optimization based EV charging coordination strategy. Using the proposed method, both the grid performance and the customer satisfaction can be maintained at higher EV penetration level. The results of the proposed method are demonstrated using MATLAB and Open-DSS.

Presenter bio: Adithya Ravikumar received the MEngSc in Energy systems from the University of New South Wales, Sydney, Australia, in 2020. He is currently pursuing PhD degree at Macquarie University, Australia. His research interests include virtual power plants, energy management, power system optimization, and EV coordination.

Planning for Australian Power System Transition under Low-Carbon Policies

Amir Fayaz Heidari (The University of Melbourne, Australia); Amin Masoumzadeh (FTI Consulting, Australia); Tansu Alpcan (The University of Melbourne, Australia)

Environmental and economic concerns drive Australia's power system transition to a low-carbon system, which necessitates the adoption of efficient long-term policies. One of the most effective policies is to implement a carbon emission budget, leading to the retirement of coal and gas generation due to their high carbon dioxide emission rates. However, Australia will face an extremely high level of contingency because of a remarkable penetration level of RESs in its system. Since fossil-fuel power plants are the main sources to cover the system's contingency, the system security will be endangered after the retirement of coal and gas generations. In this context, we propose a near-term planning model to investigate how different decarbonization targets affect the retirement of inertia sources in Australia, which we expect to be replaced by energy storage systems. Furthermore, we calculate the optimal investment strategies for each technology to cover the system's contingency. Our findings under the drastic decarbonization scenario indicate the necessity of investing 0.36 GW/6.97 GWh in pumped hydro and 13.29 GW/13.57 GWh in battery energy storage systems for Australia's power system, leading to the retirement of 6.51 GW of coal generation in New South Wales and 5.7 GW in Queensland.

Presenter bio: Amir Fayaz Heidari received an M.S. degree in power systems engineering from the Sharif University of Technology, Tehran, Iran, in 2017. He joined the Sharif Energy Research Institute, Iran, in 2017–2021, as an Energy Analyst. He is currently working toward a Ph.D. degree with the Department of Electrical and Electronic Engineering at the University of Melbourne, Australia. Furthermore, he joined the Economic Regulation Authority, Perth, Australia, in 2024 and is currently working remotely as an energy market analyst. His research interests concentrate on energy market analysis, power system planning, frequency control ancillary services, and optimization and game theory in developing energy sector policies.

Optimal Coordination of Energy Sources for Standalone MG Incorporating the Concepts of Locational Marginal Price

Mainul Islam, Mahmood Nagrial, Jamal Rizk and Ali Hellany (Western Sydney University, Australia)

Microgrids (MGs) are emerging as an essential means in the energy sector due to their many advantages. Power sharing between MGs or MG to the grid, which can lower MGs' investment and operating expenses, is one of the advantages. In this paper, the locational marginal price (LMP) concept is introduced in a standalone MG to share the power among the generators efficiently and reduce network congestion and losses. A modified IEEE 14-bus test system is utilized as an MG to confirm the viability of the suggested approach. A new binary jellyfish search algorithm is suggested to handle the optimization problem. The obtained results show that the suggested technique, when compared to the binary particle swarm optimization technique, can significantly reduce the average LMP by up to 7% and, as a result, minimize network congestion and power loss costs by up to 5% and 15%, respectively.

Presenter bio: Mainul Islam received his BSc from KUET, Bangladesh, MSc from UKM, Malysia, and PhD from WSU, Australia in 2008, 2016 and 2023, respectively. Ha has published over 25 peer reviewed articles in energy systems. His current research interests include renewable energy technologies, energy management, artificial intelligence, and smart grid optimization and controls. He is a member of IEEE.

Wednesday, November 20 4:30 - 6:00

TS7: Power Systems & Stability III
Room: Central
Chair: Frederik Geth (GridQube, Australia)

Robust Decoupling Control Based on Linear Extended State Observers for Grid-Forming Inverter

Yue Qu (The University of Queensland, Australia); Hui Li (Shanghai University of Electric Power, China); Feifei Bai (The University of Queensland, Australia); Junwei Lu and Fuwen Yang (Griffith University, Australia)

Grid-forming inverters (GFMIs) based on virtual synchronous generators (VSGs) have emerged as a promising solution for providing inertia and enhancing renewable system stability. However, the inherent power coupling caused by the low reactance-to-resistance ratio in low-voltage networks negatively impacts the control performance of VSGs. Commonly used feedforward decoupling methods rely heavily on system parameters. Although these methods can effectively reduce power coupling under nominal systems, their decoupling capability is significantly limited when dynamic variations occur in the system. Therefore, a robust decoupling control strategy based on linear extended state observers (LESOs) is proposed in this paper. The proposed method achieves faster and more efficient decoupling and demonstrates strong robustness in the non-nominal system. Finally, the effectiveness and decoupling ability of the proposed strategy are verified by simulation results.

Presenter bio: Yue Qu received the M.Eng. degree in control engineering from Shanghai University of Electric Power, China, in 2020. She is currently working toward a Ph.D. degree in the School of Electrical Engineering and Computer Science, the University of Queensland. Her research interests include microgrid stability and control.

Two Layer Control Strategy for Voltage Stability of Renewable Energy based Direct Current Microgrid

Hafiz Muhammad Mehdi (Macquarie University, Australia); Muhammad Kashif Azeem (University of Tasmania, Australia); Sara Deilami and Aman Maung Than Oo (Macquarie University, Australia)

Power system stability of an island direct current (DC) microgrid is crucial when it is equipped with renewable energy sources which are intermittent in nature. It requires a robust control mechanism which promises the constant power delivery to the user specially during extreme events. For this purpose an advance nonlinear controller i.e. double integral sliding mode control (DISMC) has been proposed for a three source DC microgrid which include photovoltaic (PV), battery and ultracapacitor (UC) connected to DC-DC converters. Energy management among the sources is accomplished by the state of charge (SoC) based mechanism which is responsible to generate the reference values for energy storage system (ESS) encompass battery and UC. The proposed controller is simulated in MATLAB/Simulink along with other comparison controllers including Lypunov redesign (LRD) and sliding mode control (SMC). It outperforms the LRD and SMC in terms of minimal overshoot and undershoot. The settling time and steady-state error are 0.025 seconds and 0.35V respectively, highlighting the tight voltage regulation of the DC bus, which translates to enhanced power system stability.

Presenter bio: I am a higher degree research student in the Department of Engineering at Macquarie University. My area of research includes the modeling and control of microgrids.

Performance Analysis of Hybrid Power Plant under varying Grid Conditions

Ashan Imantha Malala Hetti Bandara (University of Queensland, Australia); Fatemeh Shahnazian (Technical University of Denmark, Denmark); Richard Yan and Tapan Kumar Saha (University of Queensland, Australia)

Large synchronous generators are being retired, while inverter-based renewable energy sources (IBR) are increasing, weakening future power system strength. As the grid weakens, grid-following (GFL) IBRs may become unstable. However, grid-forming (GFM) IBRs can reinforce weak grids, ensuring stability. Hybrid power plants (HPPs) with GFM and GFL can operate in very weak grids. However, the dynamic differences of IBR plants complicate interactions between plant-level controllers in HPPs.

This study uses advanced modelling and time-domain simulations to examine HPP dynamic behaviour under various grid strengths. An HPP with three IBR power plants is used to evaluate the centralised, hierarchical control system under different system strengths and X/R ratios. The HPP's stability boundary is maintained across different system strengths. The findings improve our understanding of the interactions between the HPP and the grid and support optimised design and operation strategies for future energy systems.

Presenter bio: Ashan is a second-year PhD student from the Power Energy and Control Engineering (PEC) research group at the University of Queensland (UQ), School of Electrical Engineering and Computer Science (EECS). He commenced his PhD in 2023 under the supervision of Prof. Tapan Saha (Principal Advisor) and Associate. Prof. Richard Yan (Associate Advisor). He is investigating the controller coordination and mitigation of control counteractions in hybrid power plants connected to weak grids. He received his Bachelor of Science in Engineering (Honours) and Master of Philosophy in Engineering, majoring in Electric Power Systems, respectively, from the University of Peradeniya in 2013 and 2020. His research interest is system strength enhancement strategies for power systems with a high share of inverter-based resources (IBRs). He is an active member of the IEEE PES UQ Student branch and IEEE Young Professionals.

Enhanced Active Power Control Capability of Grid Coupled Solar PV System

Mohammad Faisal (University of Wollongong & International Islamic University Chittagong, Austria)

Grid-tied solar photovoltaic-based distributed generation systems are required to provide consistent and controlled levels of active and reactive power to the grid. However, the intermittent nature of the solar resource available to PV systems makes the use of energy storage system indispensable for enhancing balance of supply and demand and reliability. The PV inverter controller plays a pivotal role in ensuring the proportional percentage output of the active and reactive power, contributing to system stability. Most of the research in the literature focuses on the design and control of small-scale power converters to enhance performance, however, ongoing research persists regarding the practical integration of these converters onto the grid. Upon integration of the system with the grid, the voltages at the point of common coupling synchronize with those of the grid. This paper evaluates the potential of regulating the voltage level of grid coupled solar system and upholding the power quality within a medium voltage distribution network. The control of active and reactive power was achieved through manipulation of the dq-component of the grid current. No additional PI loop is used to regulate the DC-side voltage, which is another advantage of this configuration.

Presenter bio: Mohammad Faisal is currently a Ph.D. student (University of Wollongong, Australia) He completed MSc in Electrical Power Engineering, National Energy University, Malaysia. His research interests include Renewable integration, energy storage, microgrid, power quality (voltage sag), optimization, motor drive, and artificial intelligence systems.

Screening Voltage Disturbance Sources Using Aggregated Data from Power Quality Measurement Systems

Krzysztof Chmielowiec (AGH University of Krakow, Poland); Grzegorz Wiczynski (Poznan University of Technology, Poland)

In recent years, power quality (PQ) measurement system have become essential for enhancing the performance and reliability of power distribution networks. The number of {PQ} analyzers installed in these networks has increased significantly. Moreover, {PQ} measurements are now often integrated into various devices, including balance and industrial energy meters. However, the sheer volume of data generated by these meters makes manual inspection and analysis impractical. This highlights the need for advanced automated tools to manage and interpret these vast datasets. This paper presents an approach that uses aggregated 10-minute {PQ} measurement data from these meters as a~screening method to locate sources of {PQ} disturbances. By employing both deterministic indicators and machine learning techniques, specifically neural network classification, this approach opens new possibilities for automating the analysis process, enabling network operators to effectively identify and prioritize significant sources of disturbances in distribution networks.

An MPC-based Coordinated Fast Frequency Control Method for Inverter-based Resources

Ning Ma and Qiu Jin (University of Queensland, Australia)

Nowadays, the power grid is experiencing low inertia and high RoCoF problems with an increasing amount of renewable energy resources. To tackle the issues, fast frequency response (FFR) services are currently applied. However, these different resources, such as wind power, solar PV, and battery energy storage system (BESS) have various frequency response characteristics, thereby coordinated control is necessary. In literature, model predictive control is popular for load frequency control (LFC) because of its advantages in dynamically adjusting its outputs considering the system constraints and uncertainties. However, few authors paid attention to MPC-based FFR, and the differences in response characteristics result in the interactions between resources and power angle swing. In this paper, a coordinated control method based on model predictive control (MPC) is proposed to achieve the frequency adjustment for FFR-based PV farms, wind farms, and BESS considering the existing primary frequency response (PFR) controlled synchronous generators (SGs) from the first seconds after contingencies to the frequency recovery. The proposed method was then verified in the IEEE 39-Bus system by co-simulation of MATLAB and PSCAD.

Presenter bio: Ning Ma received the B.S. degree in electrical engineering and automation from Southeast University, Nanjing, China, and M.S. degree in business administration from Dalian University of Technology. She worked as Secondary system engineer in Dalian Power Supply Company, State Grid Corporation of China for several years. She is currently pursuing the Ph.D. degree in electrical engineering with the school of electrical engineering and computer science, the University of Queensland, Brisbane, QLD, Australia. Her research interest is frequency control with renewable energy integration in the bulk system.

Wednesday, November 20 4:30 - 6:00

TS8: Cybersecurity of Power Systems
Room: Town Hall
Chair: Guo Chen (UNSW Sydney, Australia)

Resilience Enhancement Techniques in Cyber Physical Distribution System: an Overview

Jialun Zhang (ETH Zurich & Singapore-ETH Centre, Singapore); Jimmy Peng (National University of Singapore, Singapore); Gabriela Hug (ETH Zurich, Switzerland)

The evolution of power systems into cyber-physical distribution systems (CPDSs) integrates complex communication networks with traditional power infrastructures, thereby exposing systems to both cyber and physical disruptive events. This paper investigates resilience enhancement strategies designed for CPDS, focusing on countermeasures against natural hazards, malicious attacks, technical failures within communication networks, and interdependent cyber-physical failures. First, we present the structure of CPDS and define resilience within this context and differentiate it with the definition of reliability and cybersecurity. Subsequently, we categorize failures into four types of disruptive events and evaluate the state-of-the-art resilience enhancement strategies, respectively. Finally, we highlight key research gaps and propose future directions to enhance the resilience of CPDS.

Battery Sensing Data Recovery Model Based on Self-learning and Feature Transfer

Yixin Nie, Wanxu Cai and Anqi Wang (Tsinghua University, China); Liqin Yan (Shanghai Institute of Space PowerSources, China); Jingying Xie (Shanghai Institute of Space Power-Sources, China); Fan Yang (Tsinghua University, China)

With the development of industrial production towards large-scale, refined, and intelligent directions, the health management and operation maintenance of industrial equipment have become increasingly important. However, factors such as equipment failures and environmental disturbances in industrial application scenarios can lead to missing operational state data of the equipment, thereby hindering the application of data-driven methods in equipment health state management. This paper, based on the context of data missing due to battery sensor failures, proposes a data recovery model based on self-learning and feature transfer. First, multiple health indicators are extracted from the operational data of the battery, and then scenarios of missing Health Indicator Sequence are simulated. Next, various self-learning methods and feature transfer methods are compared in terms of data recovery accuracy under different data missing scenarios and missing ratios. Finally, a fusion model is constructed through a model selection strategy. The proposed model demonstrates excellent data recovery performance under different data missing scenarios, and the recovered key variables can be used for accurate assessment of the equipment degradation process.

Innovative Observer-Based Framework for Attack Reconstruction and Mitigation in AC Microgrids

Hamidreza Shafei (University of Technology, Sydney, Australia); Subrata Kumar Sarker and Li Li (University of Technology Sydney, Australia); Ricardo Aguilera (UTS, Australia); Hassan Haes Alhelou (Massachusetts Institute of Technology (MIT), USA)

In this article, an observer-based technique is proposed to address false data injection attacks (FDIAs) in ac microgrids (MGs). To achieve this, unknown input observers (UIOs) are developed in each distributed generation (DG) unit according to the number of its neighbors to estimate the states of the neighboring DGs. The equations of each DG are augmented by considering attack signals in both the voltage and current channels, which serve as communication links between the neighboring DGs. The proposed UIO-based method is then utilized to detect the FDIAs by estimating the states of all neighboring units. After reconstructing the attacks, their destructive impacts are mitigated by purifying the contaminated signals. Simulation results demonstrate the effectiveness of the proposed scheme in providing accurate frequency and voltage regulation, as well as active and reactive power sharing among DGs.

Cybersecurity of Grid-Connected PV Systems: Analysis and Impacts on the Australian Grid

Abdulrahman Summan M Al Fayi, Engr. (University of New South Wales, Australia & Jubail Industrial College, Saudi Arabia); Ahmed S. Musleh (University of New South Wales, Australia); Guo Chen (UNSW Sydney, Australia)

The integration of grid-connected Photovoltaic (PV) Systems is significantly transforming the energy sector by promoting sustainable energy solutions. These systems play a crucial role in reducing dependence on fossil fuels and lowering greenhouse gas emissions, making it vital to address any vulnerabilities. However, PV systems are increasingly susceptible to cybersecurity threats, particularly False Data Injection Attacks (FDIA), which can compromise their stability and security. This work investigates the impacts of FDIA on grid-connected PV systems within the Australian grid using the Australian 14 Generators System model, which represents the National Electricity Market (NEM). By developing and simulating various attack scenarios in MATLAB, the study assesses the effects on system stability and performance. The results indicate substantial fluctuations in voltage, current, and power, with pronounced instability observed in regions like Queensland and South Australia. Notably, South Australia experienced system failures under severe attack conditions, while Victoria exhibited relative resilience. These findings underscore the urgent need for comprehensive cybersecurity measures to protect PV grid systems and ensure their stable and reliable integration into the energy infrastructure.

Presenter bio: Abdulrahman Summan M. Al Fayi Electrical Engineer, Lecturer at Jubail Industrial College Graduated from The University of New South Wales, Sydney, Australia, majoring in Electrical Engineering. Currently a lecturer at Jubail Industrial College in Jubail, Saudi Arabia. His expertise and research interests lie in: Power grid stability Cybersecurity False data injection attacks Photovoltaic (PV) systems Solar energy Advanced technologies in electrical engineering Abdulrahman is committed to advancing the field of electrical engineering, particularly through research and teaching in renewable energy and grid security.

A Data-driven Multivariable Adaptive Cybersecurity Framework for Isolated Microgrids

Subrata Kumar Sarker (University of Technology Sydney, Australia); Hamidreza Shafei (University of Technology, Sydney, Australia); Tianling Shi, Li Li and Jahangir Hossain (University of Technology Sydney, Australia); Ricardo Aguilera (UTS, Australia)

Dynamic attack estimation in isolated microgrids (IMGs) is a significant concern due to their presence in various operating environments and the advancement of digital

technologies. This paper introduces a dynamic online cybersecurity framework based on a data-driven approach for adaptive estimation and mitigation (EM) of IMG attacks with unknown inputs. The proposed framework utilizes a generative deep learning approach to process an unknown set of inputs, which is then used for EM of attacks in IMGs. The efficacy of the proposed framework is tested using a two-area connected IMG simulated in MATLAB. The performance is measured for simultaneous and separate occurrences of different forms of false data injection attacks. The results demonstrate that the proposed framework can provide adaptive EM of attacks with fast training speed, making it suitable for real-time applications and scenarios with limited computational resources.

Wednesday, November 20 4:30 - 5:30

API-1: API workshop
Creating and using industry-derived teaching resources in 2025
4.30pm Intro, overview of the 3 categories we want to explore and goals at the end.
4.40pm Feedback on using the existing online API modules. Users signup
4.50pm Input on developing SEVI modules for teaching. Users signup
5.15pm Input on industry contributing short videos. Users signup
5.27pm input on interest in common thesis topic modules. Users signup
Room: Wynyard

Wednesday, November 20 5:30 - 6:00

API-2: API Forum on Career Pathways for PhDs candidates
Room: Wynyard

Wednesday, November 20 6:00 - 8:00

WR1: Welcome Reception
Room: Foyer
Thursday, November 21

Thursday, November 21 9:00 - 9:45

AK2: Academic Keynote 2 - Energy transition system engineering
David Hill (Monash University, Australia)

The talk will give a view of the Australian energy transition through the lens of a systems engineer with an international outlook over several decades of research, but also one with insights obtained from consulting including in recent years about the status of the Australian NEM. The aim is to present the energy transition as based on a nation building engineering project of unprecedented complexity that has an unacceptable level of risk of failing to meet declared goals in emissions, prices and reliability without more proactive action on systemic aspects including revised regulation, more coordination, vastly improved skills capacity, many research issues (across climate, technology to consumers). Particular mention will be made about the potential for more timely and better optimised grid resources. Further, a major contribution could be made with higher level use of systems engineering and related sciences to give evidence-based advise into the various decision processes making sure the future energy system actually delivers on the stated goals.
Room: Central, Town Hall

Thursday, November 21 9:45 - 10:30

IK2: Industry Keynote 2 - Engineering solutions and skills required to accelerate Australia's energy transition
Alex Wonhas

Australia's energy transition is not progressing fast enough to meet legislated targets and ensure a smooth, orderly retirement of coal generators while enabling industry electrification to drive a new era of growth and prosperity. This talk will explore the key obstacles currently hindering this transition. While some of these challenges are power system engineering challenges, many others lie outside traditional engineering domains. However engineers can and must play a vital role in overcoming these broader barriers. To do so effectively, they need a diverse set of interdisciplinary skills, including stakeholder engagement, communication, commercial acumen, project management, and leadership. Through real world examples from Australia's energy transition, this talk will demonstrate how engineers with a solid technical foundation and these broader skills can accelerate the transition, contributing to a sustainable, prosperous, and community-supported energy future.
Room: Central, Town Hall

Thursday, November 21 10:30 - 10:45

MT2: Morning Tea
Room: Foyer

Thursday, November 21 10:45 - 11:45

IP1: Industry Panel 1
Strategies to foster and support valuable relationship between universities and industry
Chair: Prof John Fletcher (UNSW)
Speakers:
Dr Matthew Priestley: Lead of Technology Translation Squad (TRaCE Trailblazer)
Mark Lewis: Business Development Manager, Electrification and Energy Systems Network, NSW Government's Decarbonisation Innovation Hub
Dr Hua Chai: Workforce challenges and training building
Daniel Rehling R&D technology (Industry partner)

Room: Central, Town Hall
Thursday, November 21 11:45 - 12:45

IP2: Industry Panel Session 2
Addressing the gap between academic research and industry needs
Chair: Prof Glenn Platt (The University of Sydney)
Speakers:
Ian Hiskens, EIC IEEE Transactions on Power Systems
Fredd Geth, Principal power system engineer, GridQube
John Ward, Research Director, Energy Systems, CSIRO
Ragu Balanathan, Vestas
Room: Central, Town Hall
Thursday, November 21 12:45 - 1:15

L2: Lunch
Room: Foyer
Thursday, November 21 1:15 - 2:15

AIF1: API Industry Forum
Chair: David Pointing (API)
Speakers:
Peter Langdon, Endeavour Energy, experienced technical engineer (API Board Chair)
Renee Anderson, TasNetworks, head of people
Prof Tapan Saha, The University of Queensland
Room: Central, Town Hall
Thursday, November 21 2:15 - 3:15

WIE: Women in Engineering - Transforming power engineering through women's leadership
WIE Chair, Dr. Sara Deilami, Macquarie University.
A/Prof. Anna Bruce, Deputy Head of School (Equity, Diversity and Inclusion), UNSW
Marija Petkovic, Managing Director, Energy Synapse
A/Prof. Liz Ratman, Monash University
Kasia Kulbacka, General Manager of Network Planning at TransGrid Sydney
Room: Central, Town Hall
Thursday, November 21 3:15 - 3:30

AT2: Afternoon Tea
Room: Foyer
Thursday, November 21 3:30 - 5:00

IS1: Industry Session 1 - Grid connection of renewables
Chair: A/Prof Georgios Konstantinou (UNSW)
Speakers:
Josias Visagie, AURECON Group
Yiju Ma, AEMO
Charbel Antoun, Spark Renewables
Benjamin Zhang, Transgrid
Room: Central
Thursday, November 21 3:30 - 5:00

IS2: Industry Session 2 - Challenges and opportunities in distribution networks
Chair: Nando Ochoa (The University of Melbourne)
Speakers:
Ana Erceg, Manager, Future Network Programs, AusNet
James Brown, Head of Network Strategy, SA Power Networks
Alan Luc, DSO Systems Lead, Distribution System Operator, Market Development & Strategy, Ausgrid
Eddie Thanavelil, Future Network Portfilio Lead, Planning and Future Networks, Strategy and Operations, Evoenergy
Room: Town Hall
Thursday, November 21 3:30 - 5:00

IS3: Industry Session 3 - Power electronics applications in future grids
Sponsored by Delta
Chair: Prof Dylan Lu (UTS)
Speakers:
Tom Hew: Country Manager
Farhad Azizian: Engineer Manager
Wael Babar: Lead BESS Solutions Engineer
Kent Lin: Senior solution engineer
Room: Wynyard
Thursday, November 21 6:30 - 10:00

D1: Awards Dinner
Room: Central, Town Hall, Foyer
Friday, November 22
Friday, November 22 8:45 - 9:30

AK3: Academic Keynote 3 - Integrating Active Learning to Elevate Student Experiences and Learning Outcomes in Power Engineering Curriculum

Bill Rosehart (University of Calgary, Canada)

Most engineering courses are structured with separate lecture, laboratory, and tutorial components. However, it is widely recognized that students learn at different paces and benefit significantly from hands-on experiences. Traditional lecture formats, even with the most engaging instructors, often leave many students struggling to keep up or becoming disengaged. Tutorial and laboratory sessions can provide valuable guided learning, but only if students have adequately absorbed the lecture material.

Based on feedback from graduating students, an active learning approach, named Integrated Learning System (ILS) was introduced in one semester of the electrical engineering program at the University of Calgary. Due to its success, ILS was subsequently incorporated into first-year courses. In ILS, lectures, tutorials, and laboratory experiences are not scheduled separately; instead, they are delivered in a manner that best supports student learning and accommodates individual learning paces. Additionally, traditional laboratories are, when possible, replaced with design projects, encouraging students to transition from merely following instructions to designing, building, and operating engineering components, thereby enhancing their learning experience.

This session will focus on the development of an ILS and Design based approach for power engineering curriculum, from introductory courses to final senior year electives. Framed for power engineering curriculum, challenges and their potential solutions are explored.
Room: Central, Town Hall

Friday, November 22 9:30 - 10:15

IK3: Industry Keynote 3 - Evolving long-term system planning for the Australian Energy system - incorporation of distribution network considerations.
James Seymour (C4NET, Australia)

The Australian energy sector benefits from having a long-term integrated system plan (ISP). The ISP is developed by AEMO and updated every two years in a well-honed, highly collaborative process. To date, the ISP has been primarily focused on investment in new transmission, large-utility generation and storage across the NEM. As technology evolves, electrification increases and CER/DER become ubiquitous, distribution system investment, operation, and optimisation become critical issues that need to be included within a more whole-of-system approach to integrated system planning. C4NET has led a consortium of universities, CRCs, industry, governments and AEMO in taking the first pass at developing methodological approaches to addressing this gap. James will share insights on the problem at hand, the need for incorporation of distribution system elements, the approach taken and early findings.
Room: Central, Town Hall

Friday, November 22 10:15 - 10:30

MT3: Morning Tea
Room: Foyer

Friday, November 22 10:30 - 12:00

TS9: Energy Storage
Room: Central
Chair: Saad Mekhilef (Swinburne University of Technology, Australia)

Optimal BESS Allocation in Radial and Meshed Distribution Network

Ali Ahmed (Australian National University, Australia); Kylie Catchpole (The Australia National University, Australia); Anna Skobeleva (Australian National University, Australia)

Continuous proliferation of energy demand caused by the electrification of conventional loads and Electric Vehicle (EV) charging poses various operational challenges for Electric Power System (EPS) planners, in particular on distribution network expansion and congestion. Network reconfiguration and Battery Energy Storage Systems (BESS) play a vital role in minimization of network congestion/expansion, and it is therefore essential to understand how optimal design can enhance their role in network support. In this paper we compare centralized and decentralized allocation of BESS in radial and meshed distribution networks, using Grey Wolf Optimizers and using IEEE standard distribution networks. We show that converting existing radial networks into meshed networks saves significant amount of total expense under long-term planning. Also, decentralized BESS integration is more cost effective in radial networks as compared to a centralized scheme.

Presenter bio: I am a PhD student at Australian National University, Australia. I am doing research in electric power network congestion minimization, electric vehicle controlled charging, battery energy storage system and renewable energy systems integration in electric power network.

Sizes and Their Tradeoff Between Power Generator/Load and Energy Storage for a Robust Power System against Fluctuations

Saher Javaid (Japan Advanced Institute of Science and Technology (JAIST), Japan); Kaneko Mineo (Japan Advanced Institute of Science and Technology, Japan); Yasuo Tan (Japan Advanced Institute of Science and Technology & National Institute of Information and Communications Technology, Japan)

Renewable Energy Sources (RESs) like photovoltaic (PV) and wind power are environmentally friendly options for generating electricity. However, the significant variability in the energy output of renewable sources presents a major challenge for integrating these sources into the power grid. Additionally, fluctuations in consumer activity increase the risk of power imbalances. Controllable power devices, including storage systems, enable a power system to be stable and robust against these fluctuations. This paper studies the sizing of controllable generators, controllable loads, and storage systems and the tradeoff between them based on the worst-case analysis of energy balancing. The energy balancing concept discussed in this paper involves understanding the behavioral power patterns of fluctuating generators and fluctuating loads, as well as their upper and lower-bound envelopes, which allow for the analysis of the long-term behavior of a power system by examining a single cycle of power pattern of operation. During energy balancing, the power system behavior, including collaboration between the controllable generator, load, and storage, is analyzed, and minimum sizes for power devices are obtained. Then, a tradeoff between controllable generators, loads, and storage sizes is studied, and simulation results are presented using real PV generation data and power consumption data. The finding given in this paper provides us with a novel interpretation of the minimum size of storage systems, which can be fundamental to various generator-load-storage sizing in various practical situations.

Presenter bio: She has been working at Japan Advanced Institute of Science and Technology (JAIST) as an assistant professor. Her research interests include distributed sensing and control, energy on demand, power flow coloring, smart energy management systems, renewable energy, and storage management systems.

The role of residential PV-battery system within Australian Energy Market operation

Ekaterina Bayborodina, Michael Negnevitsky and Evan Franklin (University of Tasmania, Australia)

Penetration of residential PV systems in Australia is growing steadily and is projected to increase significantly in coming years. Battery energy storage systems may improve the efficiency of PV applications mitigating challenges related to stochastic nature of solar energy. Traditionally, households use batteries to increase PV self-consumption. This approach allows households to buy less electricity from the grid resulting in economic benefits. Customers have the potential to generate additional revenues by providing ancillary services to the energy market participants. In this paper, a techno-economical model is developed to determine the role of a residential PV-battery systems within Australian Energy Market operation. The market operation from both a retailer and consumer perspectives are considered. Two cases are compared: the first, when households use their batteries to maximize PV self-consumption; and the second, when batteries are used in coordination with the retailer. Results suggest that in the second case, both the consumer and the retailer benefit.

Feasibility Study of Hybrid Energy Systems at Remote Locations in Australia

Sami Ullah and Narottam K. Das (Central Queensland University, Australia); M A Parvez Mahmud (University of Technology Sydney, Australia)

Reliance on conventional fossil fuels to fulfil the energy demands in this era of industrial development is becoming a financial burden and a huge source of global warming. Almost 70% of Australia's electricity generation from conventional energy resources, such as coal (57%) and gas (13%). Using traditional fuels at vast level causes considerable greenhouse gas emission. Because the integration of renewable energy production systems has potential to address the electrical demands of distant places, this research provides a feasibility study concentrating on integrating hybrid energy generation into Australia's energy system. This research investigates the design and implementation of hybrid energy systems (HES) evolved to the specific needs of distant commercial markets in three remote regions across Australia: Norseman in Western Australia, Marla in Southern Australia, and Traralgon in Victoria. Hybrid Optimization of Multiple Energy Resources (HOMER) Pro software has adopted to model the HES comprising photovoltaic systems, wind turbines, diesel generators, and energy storage systems as primary and secondary backups for the selected locations. These results show surplus electricity production in all locations, with Marla having the best financial outcomes. Norseman and Marla have similar fuel consumption patterns and emissions; however, Traralgon has higher fuel consumption and emissions due to increased energy demand. The study outlines future research and recommendations, emphasizing cooperation and sustainability in improving renewable energy technologies.

Presenter bio: Dr Narottam Das received his PhD degree in Electrical Engineering from Yamagata University, Japan in 2000. His PhD research project was funded by the Ministry of Education, Science, Sports and Culture of Japan. Dr Das has about 3-decades experience as an academia and industrial Engineer in Australia and overseas. Prior to join at CQUniversity as a Senior Lecturer in Electrical Engineering, he worked at University of Southern Queensland, Curtin University, Edith Cowan University, Monash University, Australia and NEC Yamagata Ltd., Japan. Dr Das is the author/co-author over 240 peer-reviewed journal and international conference papers. Dr Das is a senior member of the IEEE, USA; Fellow of the Institution of Engineers, Australia;

CPEng, NER, Fellow of Higher Education Academy (UK), and Life Fellow of the Institution of Engineers, Bangladesh. His research interests include in Power and Energy Systems, such as, renewable energy, modelling of high-efficiency solar cells, multi-junction solar (PV) cells, Power Systems Communication (Smartgrids) using IEC 61850, and modeling of high-speed communication devices.

Application of electrochemical impedance spectroscopy on overcharged lithium iron phosphate batteries: A review

Umair Afzal and Weixiang Shen (Swinburne University of Technology, Australia)

Lithium Ion (Li-ion) batteries are susceptible to abuses and faults. They have the potential to be overcharged due to a faulty battery management system, failure of operation of charging devices, sensor inaccuracies, and inconsistency between battery cells in a pack. Overcharge faults can be very dangerous and may potentially result in thermal runaway, explosion and fire. Slight overcharging may not cause thermal runaway but can irreversibly damage a battery and accelerate ageing. Impedance is affected by different abuses and faults including overcharge faults and hence has the potential to be used as an indicator to detect an overcharging fault. Electrochemical Impedance Spectroscopy (EIS) is a powerful technique that can distinguish impedances related to different elementary chemical processes in a battery and gives rich information about changes happening inside the battery. In this paper, we present a focused review summarising the non-invasive application of EIS on overcharged lithium iron phosphate batteries. The results show the increase in ohmic and polarisation impedance values.

Presenter bio: Professor Weixiang Shen received his BEng., MEng., and PhD degrees all from Electrical Engineering. He worked in several universities as a Lecturer, Associate Professor and Research Fellow in China, German, Singapore and Malaysia. Currently, he is a Professor at School of Science, Computing and Engineering Technologies, Swinburne University of Technology, Melbourne, Australia. Professor Shen's research interests are (1) battery applied research and control strategy for electric vehicles (EVs), (2) integration of EVs and renewable energy systems (e.g. solar photovoltaic systems and wind systems) into conventional power systems. In these areas, he has published more than 140 journal papers, one monograph "Advanced battery management technologies for electric vehicles"

Optimal Sizing of Isolated Hybrid Microgrid for Residential Community in Saudi Arabia

Ahmed S. Menesy (King Fahd University of Petroleum and Minerals, Saudi Arabia); Hamdy M. Sultan (Minia University, Egypt); Waleed M. Hamanah (King Fahd University of Petroleum and Minerals & Applied Research Center for Metrology, Standards and Testing (ARC-MST), Saudi Arabia); Ibrahim Habiballah (King Fahd University of Petroleum & Minerals, Saudi Arabia); Mohammad A. Abido (KFUPM, Saudi Arabia); Salah Kamel (Aswan University, Egypt)

This research study mainly focus on the optimal design of microgrid hybrid renewable energy system (RES). The proposed system in this work consists of photovoltaic (PV), wind turbine (WT), diesel generator (DG), along with an energy storage component comprising a battery system. The optimal components sizes of the proposed hybrid generating system has been achieved using a novel metaheuristic optimizations technique called artificial rabbits optimization (ARO). The presented algorithm aim to address a multi-objective optimization challenge, seeking to minimize the cost of energy (COE), the reliability index characterized by the loss of power supply probability (LPSP), and excess energy within specified constraints. The suggested hybrid system is proposed for deployment in the coastal residential community of Yanbu, located in the Medina province of Saudi Arabia (at 24.16° north latitude and 37.32° east longitude), with a planned operational lifespan of 25 years. To guarantee the precision, stability, and robustness of the proposed algorithm in solving the studied optimization problem, thorough comparative analysis has been conducted to assess the outcomes generated by the proposed algorithm. This evaluation encompass a comprehensive comparison with the results produced by well established optimization algorithms, including grey wolf optimizer (GWO) and whale optimizer algorithm (WOA). This comparative study assesses the impact of reliability indices on the optimal sizing of the proposed isolated hybrid RES, highlighting that the ARO algorithm excels in identifying the most efficient system configuration to be the most cost-effective and eco-friendly option.

Presenter bio: WALEED M. HAMANAH received his BSc degree in Electrical Engineering from Sana'a University, Yemen, in June 2008. He worked as an instructor at Taiz University, Yemen, from September 2008 to December 2011. He earned his MSc and Ph.D. in Electrical Engineering—Power and Control—from King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, Saudi Arabia, in 2016 and 2021, respectively. He completed a postdoctoral fellowship at the IRC for Sustainable Energy Systems at KFUPM. Currently, he works at the Applied Research Center for Metrology, Standards, and Testing Research and Innovation at KFUPM as a Research Engineer III (Assistant Professor). His research interests include Renewable Energy, Intelligent Control Systems, Power Electronics, and High Voltage.

Friday, November 22 10:30 - 12:00

TS10: Power Systems Planning II
Room: Town Hall
Chair: Ghulam Mohy-ud-din (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia)

AC-DC Power Systems Optimization with Droop Control Smooth Approximation

Ghulam Mohy-ud-din (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia); Rahmat Heidari (CSIRO, Australia); Frederik Geth (GridQube, Australia); Hakan Ergun (KU Leuven, Belgium); S M Muslem Uddin (CSIRO, Australia)

This paper addresses the challenges of embedding common droop control characteristics in ac-dc power system steady-state simulation and optimization problems. We propose a smooth approximation methodology to construct differentiable functions that encode the attributes of piecewise linear droop control with saturation. We transform the nonsmooth droop curves into smooth nonlinear equality constraints, solvable with Newton methods and interior point solvers. These constraints are then added to power flow, optimal power flow, and security-constrained optimal power flow problems in ac-dc power systems. The results demonstrate significant improvements in accuracy in terms of power-sharing response, voltage regulation, and system efficiency, while outperforming existing mixed-integer formulations in computational efficiency.

Presenter bio: Dr Ghulam Mohy Ud Din is a power systems research engineer specializing in mathematical modelling, optimization, simulation, and advanced tool development. His research involves physics-informed decision support tools and numerical methods to perform integrated system planning supporting future energy transition ensuring system reliability, security, and resilience.

Assessing the Effects of Demand and Voltage Forecast Methods on Operating Envelopes

Fernando Jose Lanas Montecinos, Luis (Nando) Ochoa and Michael Liu (The University of Melbourne, Australia)

The increasing adoption of residential solar panels challenges distribution companies to maintain safe operation for their low voltage (LV) networks. Operating Envelopes (OEs) provide time-varying export limits at customer point of connection to prevent voltage and thermal issues. Calculating OEs in advance requires forecasts of customer demand and transformer voltage, but the effect of forecasting on OEs has not been studied yet. This study assesses the effects of nine forecasting methods on OEs and, in turn, on customer voltages and asset utilization. Using two real Australian LV networks and smart meter data, the results show Long Short-Term Memory reduced the effect of forecast error the most for active power, but a time-based Machine Learning ensemble can achieve similar results in a fraction of the time

Presenter bio: Fernando Lanas Montecinos is a PhD candidate at the University of Melbourne. Currently, his PhD research focuses on forecasting low voltage (LV) networks using classical and machine learning techniques. Passionate about renewable energies and computational intelligence, Fernando pursued a Bachelor's in Electrical Engineering and Master's in Engineering Sciences from Universidad de Chile, graduating with maximum distinction. Fernando's professional experience includes nearly a decade at "Centro de Energia" research center, integrating intelligence into renewable energy projects. His work focuses on machine learning, energy management systems, renewable energy, energy storage, smart grids, forecast and distribution networks.

Assessing the Impact of DER Flexibility and Uncertainty in Shaping the Expansion of Australia's NEM

Pablo Apablaza (The University of Melbourne, Australia); Sleiman Mhanna (The University of Melbourne, United Kingdom (Great Britain)); Pierluigi Mancarella (The University of Melbourne, Australia)

In transitioning towards low-carbon power systems, distributed energy resources (DER) can play a central role in providing flexibility services and economically displacing new network investments, particularly in transmission lines and energy storage, given their ability to reduce the system peak and net load. However, due to the deep uncertainties and various future scenarios surrounding DER growth and deployment, traditional deterministic planning approaches could over- or under-estimate their benefits. In this work, we investigate how the operational flexibility provided by controllable DER could influence the integrated expansion of transmission lines and energy storage. Given the interplay of different technologies that could provide operational flexibility, accurately representing uncertainties and the system operation is fundamental to developing a robust investment portfolio. To address this challenge, we propose a multi-stage stochastic expansion planning model that optimises transmission and storage investments and the operation of DER against detailed operational constraints and long-term uncertainties modelled using a four-stage decision tree. Case studies performed on real scenarios from AEMO's Integrated System Plan (ISP) showcase that a deterministic planning approach could increase investment uncertainty and overestimate the capabilities of controllable DER to displace transmission investments, particularly in the early stages. Conversely, the proposed stochastic model increases decision-makers' long-term investment robustness while providing a steadier estimate of the potential for

DER controllability to produce economic displacements in new transmission line investments.

Presenter bio: Pablo Apablaza is a PhD student in Power and Energy Systems at the Department of Electrical Engineering at the University of Melbourne. He holds a Master's and Bachelor's degree in electrical engineering from the University of Chile. He has experience working with the Chilean National System Operator, designing and implementing mathematical programming and simulation tools to enhance system operation and long-term planning. He also contributed as a researcher with the University of Melbourne in Topic 4, "Planning", of the CSIRO-GPST research roadmap. His research interests include low-carbon energy system planning under uncertainty, stochastic optimization, and risk analysis.

Surviving the Blackout: A Review of Household Electricity-Dependent Patients under Power Failures

Zhe Gong and Jimmy Peng (National University of Singapore, Singapore)

The impact of power outages on patients who rely on electricity-powered durable medical equipment (hereinafter referred to as DME patients) is often underestimated or overlooked, potentially leading to severe consequences for these vulnerable individuals. This review synthesizes the literature on power outages and household electricity-dependent patients. We analyzed 38 relevant studies from the fields of medicine, sociology, and engineering, uncovering several key findings: 1) Power outages have serious health implications for DME patients, yet less than 50% of them have backup power sources, and they face significant challenges and reluctance in evacuating. 2) DME patients are more concentrated in economically disadvantaged and rural areas, and there is no unified standard for considering the social vulnerability index (SVI) of these patients during power outages. 3) PV-storage systems are a potential alternative to generators as backup solutions, but the economic feasibility of this option has not been thoroughly discussed. Energy justice decisions that use SVI as an indicator may overlook the specific needs of individual DME patients. Research on DME patients under power outages is still nascent, but with the growing emphasis on humanitarian care and energy justice, this issue has gained increasing attention in recent years. This review aims to bridge the gaps between different disciplines and calls on healthcare systems, governments, and utility companies to collectively shoulder the responsibility of protecting vulnerable lives during power outages.

Performance Improvement of Grid-Tied Cascaded H-Bridge Inverter Using Advanced Single-Carrier PWM Scheme

Sudipto Mondal and Md. Kamal Hosain (Rajshahi University of Engineering & Technology, Bangladesh); Shuvra Prokash Biswas (University of Wollongong, Australia); Joysree Nath (Rajshahi University of Engineering & Technology, Bangladesh); Md. Rabiul Islam (University of Wollongong, Australia); M A Parvez Mahmud (University of Technology Sydney, Australia); Narottam K. Das (Central Queensland University, Australia)

The popularity of grid-connected solar photovoltaic (PV) systems has gained a lot of traction due to the recent developments and the accessibility of solar panels. The control strategy used has a significant impact on these systems' dependability and performance. In order to link PV systems to medium-voltage grids, this paper presents a seventh harmonic injected single carrier pulse width modulation (SHISCPWM) technique for a cascaded H-bridge (CHB) inverter. In contrast to the conventional phase disposition PWM (PDPWM) method, the suggested SHISCPWM generates gate pulses in the MMC by utilizing only a single carrier and a seventh harmonic saturated signal. On DSP/FPGA platforms, this innovative SHISCPWM technique eases implementation and lessens computational load. However, the goal of the proposed SHISCPWM is to guarantee the thermal stability of junction temperature of the power semiconductor devices. Again, the SHISCPWM seeks to minimize the total harmonic distortion (THD) of CHB inverter, which will result in lower semiconductor power losses and higher efficiency. In addition to optimizing DC bus consumption, the proposed SHISCPWM reduces switching and conduction losses. These claims are verified using the PLECS and MATLAB/Simulink simulation platforms in addition to a smaller-scale laboratory prototype that validates the simulation results.

Presenter bio: Shuvra Prokash Biswas received the B.Sc. degree in electronics and telecommunication engineering (ETE) and the M.Sc. degree in electrical and electronic engineering (EEE) from the Rajshahi University of Engineering and Technology (RUET), Rajshahi, Bangladesh, in 2017 and 2021, respectively. He is currently pursuing the Ph.D. degree with the School of Electrical, Computer and Telecommunications Engineering (SECTE), University of Wollongong (UOW), Wollongong, NSW, Australia. His research interests include power electronics, motor drives and grid integration of renewables. He received the Best Paper Awards at ICECTE 2019, IEEE ASEMD 2020, IEEE IAS GUCON 2021, IEEE IAS ICCCA 2021, ICEEE 2022, ICECE 2022, IEEE ASEMD 2023, and EICT 2023. He was also a recipient of the Star Reviewer Award from IEEE Transactions on Energy Conversion, in 2022.

Optimisation and Evaluation of Electric Vehicle Charging Strategies for Electric Grid: A Techno-Economic Perspective

Muhammad Ali (MathWorks, Australia); Chris Lee (MathWorks, USA)

The surge in electric vehicle (EV) adoption is challenging the existing electric grid infrastructure. This situation demands smart control strategies that enable grid operators to effectively manage power contributions from individual EVs, aligning them with broader system objectives. This research proposes and evaluates an optimisation strategy for controlling the charging of EVs to meet both technical and economic targets across the grid. By employing a MATLAB-based optimisation framework, our goal is to ease peak grid demands by treating EVs as flexible resources. Additionally, we aim to lower electricity costs by strategically timing charging based on anticipated energy demand and price fluctuations. Our analysis shows that these optimised schedules can successfully maintain peak grid loads within a specified limit, unlike uniform charging methods, and can significantly reduce electricity costs over a 24-hour period by selling electricity back to the grid during high-price periods. The study involves 906 grid-connected EVs, using an IEEE European Test Feeder to simulate the electrical distribution network. Our simulations enable the execution of various scenarios through parallel computing, highlighting the need for a time efficient simulation framework to deepen our understanding of grid dynamics. To further accelerate the simulation speed, we introduce a phasor matrix representation of the model that simplifies the relationship between system inputs and outputs at the operating frequency. Our findings consistently demonstrate that optimised charging effectively reduces peak loads and lowers energy costs. The optimisation strategy enhances risk management and profitability through initial techno-economic assessments, incorporating operational, pricing, and forecasting aspects.

Presenter bio: Dr Muhammad Ali is an Application Engineer at MathWorks and works closely with Simulink and Simscape customers to understand their business objectives and ensure that they are getting the most value out of our products and services. Ali has a background in renewable energy integration, microgrids, battery management systems and retrofitting existing aircraft into electric. He did his PhD from UNSW Australia where he got the opportunity to work on dispatchable inverter control techniques for microgrids, and testing off-the-shelf PV inverters while working on ARENA funded project.

Friday, November 22 10:30 - 12:00

TS11: Power Electronics I
Room: Wynyard
Chair: Dylan Lu (University of Technology Sydney, Australia)

Impact of Current Limiting Design on the Transient Stability of Grid-Forming Converters

Tianyi Xu (University of New South Wales, Australia); Shan Jiang (UNSW Sydney, Australia); Georgios Konstantinou (The University of New South Wales, Australia)

Grid-forming (GFM) converters are designed to provide grid support services such as fast frequency response, voltage support, virtual inertia, and damping during grid disturbances. Due to the low overcurrent capability of power semiconductors, current limiting control needs to be incorporated into GFM converters. However, the use of current limiters makes GFM converters more prone to loss of synchronism with the external grid. This paper investigates the transient stability of GFM converters with different current limiters (circular, d-priority, and q-priority) by deriving a generalised equivalent circuit model that establishes the $P - \delta$ relationships. The voltage support capability, critical active power reference, critical clearing time (CCT), critical clearing angle (CCA), and recovery time are compared under voltage sag disturbances. It is found that GFM converters with the d-priority current limiter have advantages in terms of CCT, CCA, critical active power reference and recovery time, the q-priority current limiter provides the greatest voltage support, and the circular current limiter exhibits balanced performance across all aspects.

Presenter bio: Tianyi Xu received the joint B.E. and M.E. degrees in electrical engineering in 2023 from the University of New South Wales, Sydney, NSW, Australia, where he is currently working toward the Ph.D. degree in electrical engineering. His current research interests include the design and analysis of grid-forming control for power converters.

LQG Current Control Strategy for a CHB Converter-Based Second-Life Battery Energy Storage System without Steady-State Error

Pablo Poblete and Ricardo P. Aguilera (University of Technology Sydney, Australia); Abraham M. Alcaide (Unversidad de Sevilla, Spain); Rodrigo Cuzmar Leiva (University of Technology, Sydney, Australia); Yam Siwakoti (University Technology of Sydney, Australia); Dylan Lu (University of Technology Sydney, Australia)

Optimal control strategies for cascaded H-Bridge (CHB) converters have attracted significant interest in recent decades due to their high performance and flexibility in including multiple control objectives. Nevertheless, the steady-state performance of these control strategies can deteriorate if the converter model has parameter mismatches and/or sub-module capacitor voltage ripples are not measured. This work proposes a linear quadratic Gaussian (LQG) current control strategy for a

CHB-based second-life battery energy storage system. The main novelty of the proposed LQG strategy lies in an augmented state space model that allows a Kalman Filter observer to estimate the instantaneous arm voltage disturbances representing the converter modelling errors in the second-life battery packs. These estimated voltage disturbances are used to enhance the arm current predictions and compute the steady-state arm voltage references used by a linear quadratic regulator current control strategy. As a result, the proposed LQG strategy eliminates the steady-state error in the CHB converter currents even if the second-life batteries are modelled as ideal constant voltage sources. Experimental results are provided for a three-phase CHB converter with nine SMs directly connected to second-life battery packs to validate the effectiveness of the proposed LQG strategy.

Presenter bio: Pablo Poblete received the B.Sc. degree with highest honors in electrical engineering from the Pontificia Universidad Catolica de Chile in 2018, and the Ph.D. degree in electrical engineering from the University of Technology Sydney (UTS), Ultimo, NSW, Australia, in 2024. From 2017 to 2024, he was a member of the Power and Energy Conversion Laboratory at Pontificia Universidad Catolica de Chile. Since 2024, he has been with the School of Electrical and Data Engineering at UTS, where he currently holds a Research Assistant and Casual Academic position. His research interests include control in power electronics, second-life battery energy storage systems, and multilevel converters.

Reliability and Efficiency Evaluation of Cascaded Two-stage Boost Converters

Dylan Lu (University of Technology Sydney, Australia)

This study investigates the impact of variations in the intermediate DC bus voltage on the efficiency and reliability of cascaded two-stage boost converters. The assessment of reliability follows the AS/NZS IEC 61709:2019 standard and references MIL-HDBK-217F. The findings indicate that there is not always a direct correlation between conversion efficiency and converter reliability. The optimal condition for both reliable and efficient operation is when the electrical stresses are evenly distributed between the two boost converters.

Presenter bio: Professor Dylan Lu received his PhD in Electronic and Information Engineering from the Hong Kong Polytechnic University in 2004. He began his career as a Senior Design Engineer at PowereLab Ltd. and was a faculty member at The University of Sydney from 2006 to 2016. Now a Professor and Head of the Discipline of Electrical Power and Energy Systems at the University of Technology Sydney, his research focuses on efficient power conversion for renewable energy and microgrids. He serves as an Associate Editor for two IEEE journals and was Chair of the IAS/IES/PELS Joint Chapter from 2020 to 2023.

The Impact of Current Limiting on Voltage Support from Inverter-Based Resources

Thomas A Perrau (University of Sydney, Australia); Gregor Verbic and Jin Ma (The University of Sydney, Australia)

Grid-forming inverters (GFMIs) have emerged as a solution to declining system strength and inertia in modern power systems. Despite this, these devices often fail to improve transient stability due to their low fault current capability. New current limiting strategies have shown promise in overcoming this challenge. However, existing works often neglect the effect of neighbouring grid-following inverters (GFLIs) on performance. This paper proposes a simulation-based approach to explore the impact of GFLI penetration on voltage support capability. The model presented enables the responses of neighbouring grid-following and grid-forming inverter-based resources to be recorded during a large voltage dip. The data is used to compare three GFMI current limiting strategies against their ability to prevent GFLI tripping. GFLI penetrations that result in a violation of voltage limits are established for each case. The virtual power method was found to create large voltage drops at GFLI penetrations above 42% when used for voltage control grid-forming. The virtual impedance method resulted in excessive overcurrents at penetrations above 55%. The findings reveal that significant barriers still exist for GFMIs towards improving transient stability.

Presenter bio: PhD candidate at the School of Electrical and Information Engineering at the University of Sydney. Research focused on the role of inverter-based resources (IBRs) in low-voltage distribution networks on broader power system stability.

Design of Adaptive-SMC based Multifunctional Inverter under Smart Grid Initiative for Grid-Tied PV System

Kamran Zeb and Muhammad Khalid (King Fahd University of Petroleum and Minerals, Saudi Arabia)

Smart Inverters (SI) are essential for controlling and integrating distributed generation (DG) into the power grid, offering advanced functionalities. This paper successfully presents an in-depth design and analysis of a 5 kVA Single Phase Voltage-Source Smart Inverter (SPV-SSI) under the Smart Grid Initiative (SGI) of the U.S. Department of Energy. SPV-SSI combined functions include powering local loads, injecting energy into the grid, controlling the voltage at the Point of Common Coupling (PCC) during voltage sags or faults, storing energy in a bank of lead acid batteries, powering utility loads up to the inverter's rated capacity, and real-time decision-making capability through advance metering. Further, the complete design of SI in a dq-synchronous reference frame with current and voltage control loops, bidirectional DC-DC Buck-Boost converter, IEEE standard 1547 islanding and recloser, and Static Synchronous Compensator (STATCOM) functions are included in this paper. In addition, the designed Adaptive Sliding Mode Controllers (ASMC) has robust, stable, and superior performance compared with the PI controller.

Presenter bio: Kamran Zeb He was graduated as a full-time Ph.D. student from the department of electrical engineering and computer science Pusan National University, Busan, South Korea (Sep 2017-Aug 2020) under the Faculty Development Program of NUST, Pakistan.He is currently working as Postdoctoral Fellow at Interdisciplinary Research Center for Sustainable Energy Systems, King Fahd University of Petroleum and Minerals, Dhahran, 31261, Saudi Arabia. Previously He worked as an Assistant Professor (16 Sep. 2020 to 16 Jan. 2024) at the School of Electrical Engineering and Computer Sciences, National University of Sciences and Technology, SEECS-NUST, H-12 Islamabad, Pakistan (number one university in Pakistan). He was a visiting researcher (Faculty) from Oct. 2022 - Jan 2023 at Khalifa University, Abu Dhabi, United Arab Emirates. He served University of management and technology, Lahore, Pakistan for one and half year as a lecturer. His research areas are power converters, control systems, renewable energies, robotics, Modular Multilevel Inverter, and electrical drive. He has contributed 76 papers published in various reputed journals and conferences.

Presenter bio: Muhammad Khalid is Assistant Professor in the Department of Electrical Engineering at King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

Performance Analysis of Active/Reactive Power Control of a Grid Following Voltage Source Inverter using Sliding Mode Control

Janith Wijesingha (RMIT University, Australia & School of Engineering, Australia); Lasantha Meegahapola and Xinghuo Yu (RMIT University, Australia)

Due to the high penetration of renewable energy and the presence of dynamic loads, uncertainties and disturbances in the electricity network have increased significantly. Consequently, the active and reactive power requirements of the network fluctuate rapidly. The conventional control architecture of the grid following a voltage source inverter (VSI) is based on proportional-integral (PI) controllers. Even though PI controllers are more reliable, they are less robust against sudden system variations, leading to slower response time and overshoots that may adversely affect the network's power quality. The proposed control architecture includes sliding mode control (SMC) at the outer active and reactive power control layer and PI controller at the inner current control layer, offering a more robust inverter for larger grid applications. Initially, the main drawback of SMC, known as "chattering," is discussed, and a boundary layer approach is introduced to minimize this issue. Subsequently, the performance of the SMC method is compared to that of a conventional PI-based controller. The proposed SMC controller shows better robustness against disturbances.

Presenter bio: Mr Janith Wijesingha is currently pursuing a PhD in Electrical and Electronic Engineering at RMIT University, specializing in Accelerated Finite-Time Dynamics-based Methods for Real-Time Control of the Smart Grid. His research interests include Smart grids, Sliding mode control and Power electronic inverters. As a first-year doctoral student, Janith is dedicated to advancing knowledge in the field of electrical engineering. Prior to embarking on his doctoral journey, he earned his Bachelor of Science (Hons) degree in the Department of Electrical Engineering from the University of Moratuwa. Subsequently, he gained experience as a research assistant within the same department. Through his PhD studies, he aims to contribute to the development of robust and reliable control systems for smart grids.

Friday, November 22 12:00 - 12:10

BRK1: Changeover Break
Room: Central, Town Hall, Wynyard

Friday, November 22 12:10 - 1:40

TS12: Electricity Markets and Economics
Room: Central
Chair: Archie Chapman (The University of Queensland, Australia)

A Turvey-Shapley Value Method for Distribution Network Cost Allocation

Donald Azuatalam and Archie Chapman (The University of Queensland, Australia); Gregor Verbic (The University of Sydney, Australia)

This paper proposes a novel cost-reflective and computationally efficient method for allocating distribution network costs to residential customers. First, the method estimates the growth in peak demand with a 50% probability of exceedance (50POE) and the associated network augmentation costs using a probabilistic long-run marginal cost computation based on the Turvey perturbation method. Second, it allocates these costs to customers on a cost-causal basis using the Shapley value solution concept. To overcome the intractability of the exact Shapley value computation for real-world applications, we implement a fast, scalable and efficient clustering technique based on customers' peak demand contribution, which drastically reduces the Shapley value computation time. Using customer load traces from an Australian smart grid trial (Solar Home Electricity Data), we demonstrate the efficacy of our method by comparing it with established energy- and peak demand-based cost allocation approaches.

Robust Energy Management of VPPs Integrated with Hydrogen Fuel Cell Vehicles

Khalil Gholami, Mohammad Arif and Enamul Haque (Deakin University, Australia)

The adoption of hydrogen fuel cell vehicles (HFCVs) is becoming popular for achieving environmental sustainability. However, managing these resources individually poses challenges, paving the way for the development of virtual power plants (VPPs) by aggregation and appropriate management of renewable energy sources (RES), battery storage, electric vehicles (EVs), and HFCVs to participate in electricity markets and optimize profits. However, market price uncertainties complicate precise bidding. This study therefore introduces a robust uncertainty management approach to enable VPPs to bid accurately in the energy market using mixed integer linear programming (MILP) and powerful solvers like GUROBI. The proposed robust model is evaluated against Monte Carlo Simulation (MCS) to assess its accuracy and efficiency. The findings reveal that integrating HFCVs into VPPs enhances energy conversion balance and flexibility. Furthermore, the robust model is more efficient in identifying worst-case scenarios with less computational effort compared to MCS.

Presenter bio: Khalil Gholami is working toward a PhD in electrical engineering at Deakin University, Australia. His PhD thesis is mainly about the development of some optimization frameworks to enable VPP service providers to participate in ancillary service markets. He is also interested in the planning and operation of power systems, as well as the integration of distributed energy resources and cutting-edge technologies in this domain.

Green and low-carbon hydrogen - the impact of classification rules and subsidies on asset sizing and energy sourcing for electrolytic hydrogen production

Owen Palmer (PSL Université, France & Verso Energy, France); Hugo Radet (Verso Energy, France); Simon Camal (PSL Université, France); Robin Girard (Mines ParisTECH, France)

The production of green hydrogen from renewable energy and water by electrolysis is considered an important technology for decarbonation of many industries. To improve the competitiveness of this burgeoning industry, many jurisdictions are introducing incentive programs, such as the Hydrogen Bank subsidy auctions in Europe and the 45V tax credit in the US. Eligibility for these incentives is linked to electricity sourcing rules to promote the use of renewable and low-carbon sources. However, definitions of green and low-carbon hydrogen vary between jurisdictions. One key difference is the measurement of temporal correlation between renewable sources and electrolyser consumption, with hourly, monthly, and yearly time-matching proposed. Additionally, some regions with cleaner grid mixes can produce low-carbon hydrogen without these rules. This paper studies the impact of these differing green and low-carbon classification rules on sourcing strategy, equipment sizing, and final cost of the produced hydrogen. A market-focused 2-stage stochastic model of a green hydrogen producer supplying an industrial hydrogen demand is used, with uncertainty in renewable production and electricity spot market prices. It is concluded that stricter hourly time-matching in carbon-intense networks is likely to increase demand for diversified power purchase agreement (PPA) portfolios, and requires greater electrolyser and hydrogen storage capacities. For grids with a low carbon intensity, significantly less renewable PPA capacity is required, and some green subsidies are foregone in order to avoid the risk of over-hedging.

Presenter bio: Owen is a 3rd year PhD student at the PERSEE Centre for Renewable Energy, Systems and Processes of Mines Paris and PSL University, France. His research involves using stochastic programming methods to reduce risk in energy projects, with a focus on green hydrogen production. Owen has a bachelor's in Electrical Engineering from the University of Newcastle, Australia, and a Masters in Energy and Smart Grids from Grenoble INP- UGA, France, and 10 years experience working as an electrical engineer at the DSO Ausgrid, Australia.

A Network-Oriented and Economically-Viable Power Dispatch Coordination Scheme for Battery-Integrated Solar Photovoltaic Systems

Shilpa Bindal (Indian Institute of Technology Delhi, India); Abhijit Abhyankar (IIT Delhi, India)

Integration of battery energy storage systems with solar photovoltaic provides a perpetually accessible and dispatchable alternative that can be deployed to improve network performance. The high-cost implications of battery energy storage systems (BESS) have necessitated the development of optimal charging/discharging schedules to meet network requirements and preserve the longevity of these resources. This paper presents a novel network-oriented BESS and solar-PV coordination approach to determine the optimal charging and discharging schedules for the BESS system. The proposed approach allows the Solar-BESS integrated system to efficiently provide optimal dispatch service throughout the day while minimizing battery cycles. Further, the optimal power dispatch by the integrated system generates grid benefits and gets remunerated according to its contribution. Implementing the proposed approach on the IEEE European network for different

sizes of solar PVs and batteries illustrates that optimal coordination generates significant financial benefits to offset the associated expenses. This research offers valuable insights for system operators planning to deploy battery energy storage systems to improve network efficiency.

Presenter bio: Shilpa Bindal (Student Member, IEEE) is currently working toward the Ph.D. degree in electrical engineering with the Indian Institute of Technology Delhi (IIT Delhi), New Delhi, India. Her research interests include the operation and planning of power distribution systems, and the economics of renewable energy integration.

Interactive Learning - Implementation of ChatGPT and Reinforcement Learning in Local Energy Trading

Yong Chen (University of New South Wales, Australia); Guo Chen (UNSW Sydney, Australia)

Within the Local Electricity Market (LEM), Distributed Energy Resources (DERs) are permitted to trade their excess energy to others under the scheme of peer-to-peer (P2P) energy trading. During the trading procedure, DERs in the prototype are required to participate in each trading activities across various time slots, which can be a pain point for real human beings. To address this, AI technologies like Reinforcement Learning (RL) are introduced to alleviate this pain, aiming to provide end users with more free time. In typical RL methods, the system learns from end users' historical data to simulate their trading behaviour, known as auto trading. However, unforeseen situations not covered in historical data may arise. In this paper, the author proposes an interactive learning scheme based on ChatGPT and Reinforcement Learning to support both auto trading and interactive trading simultaneously.

Real-Time Economic Dispatch Considering Adverse Weather Conditions in Renewable Generation

Mainul Islam, Mahmood Nagrial, Jamal Rizk and Ali Hellany (Western Sydney University, Australia)

Economic dispatch (ED) of the microgrid (MG) is challenging for real-time power generation and storage because of the unpredictability of renewable energy sources. The MG ED with the battery storage system is therefore essential to diminish the uncertainty. This study suggests a novel binary jellyfish search algorithm to solve the MG ED problem with adverse weather conditions. The results show that incorporating the battery storage unit can appreciably reduce the real-time operating costs more than 5%. Furthermore, the simulation results also show the effectiveness of the suggested MG ED approach.

Presenter bio: Mainul Islam received his BSc from KUET, Bangladesh, MSc from UKM, Malysia, and PhD from WSU, Australia in 2008, 2016 and 2023, respectively. Ha has published over 25 peer reviewed articles in energy systems. His current research interests include renewable energy technologies, energy management, artificial intelligence, and smart grid optimization and controls. He is a member of IEEE.

Friday, November 22 12:10 - 1:40

TS13: Electric Machines and Drives I
Room: Town Hall
Chair: John Fletcher (The University of New South Wales, Australia)

Reduction on Longitudinal End Effect of High-Speed-Maglev DC-Excited Linear Synchronous Motors

Tengfei Qiu (China Academy of Railway Sciences Corporation Limited, China); Jun Di (Beijing Jiaotong University, China); Huang Chen (China Academy of Railway Sciences Corporation Limited, China); Huiying Chen (Beijing Jiaotong University, China); John Fletcher (The University of New South Wales, Australia)

The DC-excited linear synchronous motor (DCELSM) is one of the major types of electrical machine used in high-speed maglev trains. But the longitudinal end effect is a flaw that may cause side effects such as over-saturation due to the structure of linear machines. To suppress the longitudinal end effect, subsided end field-poles are usually adopted in real-world industrial applications. This paper proposes a theoretical model that takes the longitudinal end effect into account. Via the field analysis, the theoretical method to design the subsided end field-poles are established, as well as the estimation on thrust and levitation force by virtue of the subsidence distance of the end field-poles. Using the proposed theory, the subsided end-field poles are determined for a DCELSM utilised in a real-world maglev application. Besides, practical conclusions are obtained by further investigation into the air-gap field and electromagnetic forces in terms of the subsidence distance. The model and the analysis in this paper provide a general method to compensate for the longitudinal end effect in the DCELSMs.

Performance Benchmark of Three-Phase Neutral Point Clamped Inverter Using Si IGBTs, SiC MOSFETs and GaN HEMTs for Motor Drive Applications

Joysree Nath and Mst. Fateha Samad (Rajshahi University of Engineering & Technology, Bangladesh); Shuvra Prokash Biswas and Md. Rabiul Islam (University of Wollongong, Australia)

The introduction of wide bandgap devices in the field of power electronics has led to significant improvements in motor drive systems because of remarkable advantages such as high switching frequency, low conduction loss, high efficiency and improved thermal performance. This paper investigates the potential of integrating Si-IGBT, SiC-MOSFET, and Gallium nitride (GaN) HEMT power devices at 600V class into a 3-level (3-L) neutral point clamped (NPC) inverter fed induction motor drive. Comparative evaluations are conducted on the switching performance, inverter efficiency, and power loss performance of the power devices. Out of three technologies, GaN outshines itself with its superior switching performance in comparison to Si and SiC devices. The GaN-based inverter reached a 98.74% efficiency with a heat sink temperature of 30°C. The total power loss of the motor drive converter is 34.58 W at 55 kHz with GaN device, which is 1.21% less than SiC and 57.87% less than Si, respectively. The aim of this paper is to simplify the decision-making process in selecting the best switches for motor drive applications in order to enhance certain performance metrics. The simulation study is conducted by using realistic dynamic models of power devices obtained from the manufacturer's datasheet and verified in the PLECS software environment.

Presenter bio: Shuvra Prokash Biswas received the B.Sc. degree in electronics and telecommunication engineering (ETE) and the M.Sc. degree in electrical and electronic engineering (EEE) from the Rajshahi University of Engineering and Technology (RUET), Rajshahi, Bangladesh, in 2017 and 2021, respectively. He is currently pursuing the Ph.D. degree with the School of Electrical, Computer and Telecommunications Engineering (SECTE), University of Wollongong (UOW), Wollongong, NSW, Australia. His research interests include power electronics, motor drives and grid integration of renewables. He received the Best Paper Awards at ICECTE 2019, IEEE ASEMD 2020, IEEE IAS GUCON 2021, IEEE IAS ICCCA 2021, ICEEE 2022, ICECE 2022, IEEE ASEMD 2023, and EICT 2023. He was also a recipient of the Star Reviewer Award from IEEE Transactions on Energy Conversion, in 2022.

Design and Analysis of Different Topologies of 4kW Double-Sided Axial-Flux Induction Motor

Zhi Cao and Amin Mahmoudi (Flinders University, Australia); Solmaz Kahourzade (University of Sought Australia, Australia); Wen L Soong (University of Adelaide, Australia); Apel Mahmud (Flinders University, Australia)

This paper presents the design, modelling, and analysis of the 4kW double-sided axial-flux induction motor (AFIM). The proposed double-sided AFIMs consists of three different topologies, single reduced back-iron rotor with two outer stators, two outer rotors with a single toroidal-wound stator, and single distributed-wound stator with reduced back-iron and two outer rotors. The finite-element method (FEM) is employed to predict the electromagnetic performance of each configuration. The objective is to compare these topologies regarding their efficiency, starting performance, torque/power density and material weight, thereby highlighting the strengths and weaknesses of each proposed topology.

Presenter bio: Zhi, A PhD candidate from Flinders University, Adelaide, Australia. His reseaerch focuses on the axial-flux induction motor for line-start application.

Detection of Partial Discharges under Repetitive Pulsed Voltage Excitation using Deep Learning

Mengchen Yang and Toan Phung (University of New South Wales, Australia)

Premature failure of motor winding insulation is a critical issue for variable speed drives (VSDs), with partial discharges (PD) being a primary cause. The high-frequency switching of the pulse width modulation (PWM) voltage driving the motor introduces strong interference, complicating the measurement to detect PD for winding insulation assessment. This study applies deep learning to identify the presence of PD within the switching remnants of the repetitive pulsed excitation voltage. Raw data, collected from actual experimental circuits, are classified using a recurrent neural network (RNN) architecture. The different classes comprise the measured signals with only the interference from the switching remnants of the pulsed excitation voltage with varying duty cycles (10%, 30%, 50%, 70%) and with the additional PDs submerged in the interference. Results demonstrate that deep learning can effectively classify switching sequences with and without PD. Specifically, the long-short-term memory (LSTM) model achieves a recognition accuracy of up to 99.4%. Additionally, an autoencoder is employed to filter out the switching remnants from the PD signals, further enhancing the capability of the proposed method to isolate and identify PD occurrences. This demonstrates the potential of deep learning methods not only in classification but also in denoising applications, providing a robust approach for PD detection in the presence of high-frequency switching noise.

Presenter bio: Mengchen Yang received the B.S. degree in electrical engineering from North China Electric Power University, Beijing, China, in 2016, and the M.S. degree in electrical engineering from the University of New South Wales, Sydney, Australia, in 2020, where she is currently pursuing the Ph.D. degree in electrical engineering. Her research interests include PD detection and analysis under PWM excitation, signal processing, and PD simulation.

Accurate determination of null-point between Overlapped Planar Spiral Coils

Kyle J Williams (Macquarie University, Australia); Foad Taghizadeh (Macquarie University Sydney, Australia); Sara Deilami and Graham Town (Macquarie University, Australia); Steve Mitchell (Ampcontrol Pty Ltd, Australia)

Within the context of multi-coil inductive power transfer (IPT) systems, the presence of mutual induction between same side coils has been a considerable challenge since it directly impacts system stability and performance. In this paper, a mathematical model is presented to accurately estimate the location of a null point in mutual inductance between two planar spiral circular coils. The impact of coil design parameters such as vertical separation, fill factor and outer radius are investigated for impact on null point location. This model is then verified against finite element analysis simulation results. The identified location of the null point is within a maximum of 0.39% error. The findings of this work are directly applicable to the design of multi-coil inductive power transfer systems where decoupling between same-side coils is advantageous to achieving high efficiency and power capability.

Friday, November 22 12:10 - 1:40

TS14: Power Electronics II
Room: Wynyard
Chair: Josep Pou (Nanyang Technological University, Singapore)

Simplified Modelling of a Three-Phase Interleaved Buck Converter for State Feedback Control

Yunxun Mo, Galina Mirzaeva and Colin Coates (University of Newcastle, Australia); Yuan Liu (The University of Newcastle, Australia)

Interleaved DC-DC converters are widely used in applications requiring low current ripple, such as onboard power systems in electric transportation. Such applications have to successfully deal with input voltage variation and sudden load changes. These challenges necessitate the use of advanced control schemes, to control DC-DC converters effectively. However, the high-order nature of the interleaved converter model complicates the control design, especially for model-based control methods. This paper proposes a simplified model of a 3-phase interleaved buck converter for the implementation of state feedback control, enabling a simple and practical design. It validates the proposed model and the proposed control method by detailed simulation results.

MPC-Based Current and Local Cluster Balancing Controls for Low-Frequency AC Transmission Systems

Rodrigo Cuzmar Leiva (University of Technology, Sydney, Australia); Ricardo Aguilera (UTS, Australia); Javier Pereda (Pontificia Universidad Católica de Chile, Australia); Pablo Poblete (University of Technology Sydney, Australia); Andres Mora (Technical University Federico Santa Maria, Chile); Dylan Lu (University of Technology Sydney, Australia)

This work proposes an model-predictive-control (MPC) strategy applied to Modular Multilevel Matrix Converter (M3C) for Low-Frequency AC (LFAC) transmission systems. The novelty of the proposal is the use of a current, local-cluster balancing (LCB) and inter-cluster balancing (ICB) control based on MPC for a LFAC transmission system which is composed by at least one grid-forming and grid-following control for M3Cs. As a results, the MPC-based strategy allows to control cluster currents and to regulate the local and cluster energies with low capacitor voltage ripple and operate at low frequency while generating a low-frequency grid and extracting/injecting power from the LFAC system. Simulations are presented to validate the proposed strategy for both M3Cs. The first M3C generates the low-frequency voltage grid and the second M3C transfers power from one side to the other.

Dependencies of Temperature Sensitive Electrical Parameters and Influence of Degradation in Silicon Carbide MOSFETs: A Review

Shuheng Chen (UNSW Sydney, Australia); Ye Zhu and Georgios Konstantinou (The University of New South Wales, Australia)

SiC MOSFETs are widely used as the core component in various power converter applications. To ensure a consistent performance and maximising the operation lifetime of SiC MOSFETs, their reliability is a critical aspect to be considered and monitored throughout their operation. From this perspective, the junction temperature is an important factor determining the reliability of SiC MOSFETs as it is highly correlated to the failure of SiC MOSFETs. As a popular temperature

monitoring method, the use of temperature sensitive electrical parameters (TSEPs) provides a noninvasive way to monitor the junction temperature during converter operation. This paper compares the threshold voltage, on-state resistance, turn-on and turn-off delay time as candidates for TSEPs. Their temperature dependency is discussed by reviewing previous studies. External dependencies, sensitivity and linearity of the TSEPs are also reviewed to identify the required packaging and challenges for online junction temperature measurement. Additionally, the impacts of gate-oxide and bond wire degradation on deviating the value of the four TSEPs are discussed. The comparison facilitates the selection of TSEPs for temperature and degradation monitoring in specific power electronics applications.

Presenter bio: Shuheng Chen received the B.Eng. in Electrical Engineering and B.Science degree in Computer Science from UNSW, Sydney, Australia in 2024. He is currently working towards the Master of Philosophy degree in Electrical Engineering at UNSW. His current interests of research include the temperature and health monitoring on power electronics converters and their real-time applications.

Comparison of State Feedback Control and PI Control for an Interleaved Buck Converter

Galina Mirzaeva (University of Newcastle, Australia); Yunxun Mo and Colin Coates (The University of Newcastle, Australia)

Demanding applications such as electric transportation require advanced topologies and control schemes for DC-DC converters to improve their performance. This paper compares traditional double-loop PI control and state feedback control with observers (proposed by the authors) applied to a three-phase interleaved buck converter. Detailed design and tuning of both control options are presented. Simulation results included in this paper closely emulate real-time implementation and realistic conditions. They show significant performance advantages of the proposed state feedback control. Deep insight into the performance difference is obtained by converting state feedback control into an equivalent traditional structure.

Mission Profile-Based Preventive Maintenance for Modular Multilevel Converters in MVDC Systems

Yumeng Tian (UNSW Sydney, Australia); Georgios Konstantinou (The University of New South Wales, Australia)

Preventive maintenance of modular multilevel converters (MMCs) improves reliability by minimising unexpected breakdowns and replacing faulty components in converters. This paper evaluates the converter reliability and preventive maintenance of MMCs with multiple SM topologies under different operating conditions in medium-voltage DC (MVDC) systems. It demonstrates that for converters integrating solar farms, the SFBSM can provide the greatest reliability, while the FB-SM has the lowest reliability. Depending on the objectives, the maintenance strategies for MVDC MMCs have been optimised based on cost-efficiency and availability-prioritised criteria. It proves that greater converter reliability allows for longer optimal maintenance intervals, resulting in higher cost efficiency and converter availability. Additionally, the assessment provided in this paper reveals that mission profiles in MVDC systems have significant effects on converter reliability, with systems connected to wind farms typically exhibiting greater reliability than systems that operated at the grid side of photovoltaic (PV) systems. Therefore, preventive maintenance of MVDC MMCs needs to be considered according to anticipated operating scenarios and conditions, even within the same MVDC system.

Presenter bio: Yumeng Tian received the M.Eng. degree in electrical engineering from the University of New South Wales (UNSW) Sydney, NSW, Australia, in 2020. She was a research assistant at UNSW Sydney from April 2020 to December 2020. She is currently pursuing the Ph.D. degree at the School of Electrical Engineering and Telecommunications, UNSW Sydney, Australia. Her research interests include the reliability of modular multilevel converters, medium-voltage DC (MVDC) systems, and high-voltage DC (HVDC) transmission.

Improved Performance of Battery Energy Storage in a Wind Energy Conversion System using an Optimal PID Controller

SeyyedMorteza Ghamari (ECU, Australia); Mehrdad Ghahramani, Daryoush Habibi and Asma Aziz (Edith Cowan University, Australia)

This article explores the dynamics and transient performance of a Battery Energy Storage System (BESS) connected to the output of a wind energy conversion system. The BESS is integrated into a DC-link, which is powered by a back-to-back converter utilizing droop controllers on both ends. These droop controllers manage the distribution of reactive and active power, maintaining system frequency and voltage stability. Variations in wind turbine speed can lead to fluctuations in the DC-link voltage, affecting the voltage stability on the battery side. To address this, an optimal Proportional-Integral-Derivative (PID) controller, an advanced version of the classical PID controller, is designed. The PID controller gains are optimized using the Antlion Optimization (ALO) algorithm, a modern metaheuristic algorithm known for its effectiveness in constrained problems and diverse search spaces. This optimization enhances the controller's robustness against disturbances, particularly supply voltage variations. To validate the system's performance, Hardware-in-Loop (HIL) Typhon technology is employed, allowing real-time testing of the BESS and power converters under various conditions. This ensures the reliability and effectiveness of the system before actual implementation.

Friday, November 22 1:40 - 2:10

L3: Lunch
Room: Foyer

Friday, November 22 2:10 - 3:40

TS15: Power Systems Planning III
Room: Central

Upsampling Impedance Data in Existing Network Datasets Considering Likely Errors

Ching Hong Tam (University of Queensland, Australia); Frederik Geth (GridQube, Australia); N. Mithulananthan (The University of Queensland, Australia)

Four-wire low-voltage distribution networks invariably have unbalanced impedance, and overhead lines and cables of different configurations exist. Many network datasets represent impedance in sequence components, which inherently assumes balanced network impedance. This assumption impacts impedance data quality and compromises the accuracy of power flow studies. To improve data quality of low-voltage networks, this paper proposes a methodology to up-sample impedance data given in sequence components, through maximum likelihood estimation and mapping to standard conductor and geometry types. Likely errors in the sequence component data are validated and considered in the mapping process. A proof-of-concept study is conducted to determine whether the diagonal sequence components belong to an overhead line or a cable. Presented results include an up-sampled version of a publicly available Australian low-voltage network model.

Presenter bio: UQ PhD student

Integrated Transmission and Distribution Expansion Planning: Overview on Practical Applications

Cristian Alcarruz, Sleiman Mhanna and Pierluigi Mancarella (The University of Melbourne, Australia)

Distributed energy resources (DER) have the potential to defer or complement expensive large-scale investments such as new transmission infrastructure, decentralising power systems around the world. However, particular focus should be put on capturing and analysing the impact of DER and small-scale resources on distribution network planning, as well as how transmission and distribution system operators jointly coordinate their planning frameworks to capture trade-offs between small- and large-scale resources, and find more robust and cost-effective solutions from a whole-systems' perspective. In this vein, this extended abstract presents a summary of the different methodologies for integrated transmission and distribution expansion planning, identifying challenges and views on the practical real-world implementation of these approaches.

Presenter bio: Electrical Engineer from the University of Chile, and two and a half years of experience as a consultant in Chile. Currently is a first year PhD student from the University of Melbourne, studying the integrated planning of transmission and distribution systems for its real-world applicability.

Assessing the Robustness of Model-Free Voltage Calculation Techniques for LV Networks

Orlando Pereira, Tansu Alpcan and Luis (Nando) Ochoa (The University of Melbourne, Australia)

The integration of distributed energy resources (DERs) into low-voltage (LV) distribution networks requires distribution companies to assess customer voltages for new generation (e.g., solar PV) and demand (e.g., EVs) scenarios. As most distribution companies lack accurate LV electrical models, machine-learning techniques have recently been proposed to produce alternative models trained on historical smart meter data (P, Q, and V). These techniques capture the underlying physics of the LV network, allowing the calculation of customer voltages without electrical models; hence, model-free. However, the robustness (accuracy) of such model-free techniques decreases with scenarios outside the scope of the training data (e.g., when assessing new PVs or EVs). This study explores the robustness of model-free voltage calculations via Neural Networks (NN) and Ridge Regression

(RR). The analysis compares model-free voltage calculation techniques with model-based power flows, demonstrating that model-free techniques need to be improved to fully capture the physics of the networks when assessing scenarios far from the historical data.

Presenter bio: Born in San José, Costa Rica, in 1994, he earned his Bachelor's and Licentiate degrees in Electrical Engineering from the University of Costa Rica in 2017 and 2020, respectively. Currently, he is a doctoral student at the University of Melbourne. His research focuses on the modeling and simulation of distribution networks and planning for the integration of distributed energy resources.

Value of non-network solutions in Distribution System Planning: A review

Gabriel Alejandro Chavez Rojas (University of Melbourne, Australia); Pierluigi Mancarella (The University of Melbourne, Australia); Rodrigo Moreno (Universidad de Chile & Imperial College London, Chile)

n the coming years, the integration of Consumer Energy Resources (CER) is expected to significantly impact the design and planning of distribution systems, introducing challenges such as voltage issues and overloads. From a techno-economic perspective, this integration increases investment risks due to uncertainties in CER operation and adoption. To ad- dress these challenges, distribution network operators (DNOs) are increasingly considering non-network solutions (NNS) for deferring investments in network assets, leveraging their flex-ibility to address network constraints.However, in order to be considered a viable option for the DNO, these technologies must be assessed and subsequently implemented at a certain cost. Consequently, it is necessary to develop a methodology that allows evaluating the benefits that these solutions, under different schemes, technologies and perspectives, provide to the network. This paper provides an overview of different flexible options as well as methodologies and perspectives to value them.Finally it presents recommendations to correctly assess the value of NNS.

A PLEXOS generation expansion model for interconnected Philippine main grids

Ivan Pyotr A Doloeras, Keila Abigail S Bataller and Lynille G Magbanua (University of the Philippines Diliman, Philippines); Luigi S Teola (University of the Philippines - Diliman, Philippines); Adonis Emmanuel D. C Tio (University of the Philippines Diliman, Philippines)

The Philippine power grid is composed of three major grids: Luzon, Visayas, and Mindanao. While the Luzon and Visayas Grids have been interconnected since 1998, the Mindanao grid was considered to be isolated until the establishment of the Mindanao-Visayas Interconnection Project (MVIP) in 2023. A simplified model of the Philippine grid was built in PLEXOS across a planning horizon from 2022 to 2040. Different scenarios were established for the model by varying the transfer capacities of the Luzon-Visayas and Visayas-Mindanao interconnections. Key parameters such as generation mix, levelized cost of electricity (LCOE), capacity expansion, and transmission line flows were analyzed for each scenario. The obtained results, given the assumptions and data used for building the model, showed that interconnection enables higher share of wind and solar power in regions with better availability curves such as Luzon and Visayas to achieve the RE targets and lower LCOE. This transforms Visayas into a net power exporter, sending surplus power to Luzon and Mindanao due to their lower demand. Meanwhile, unlimited transfer capacities essentially unify the grids, allowing Visayas and Mindanao to contribute to meeting Luzon's high demand. These indicative results illustrate what the model can do given publicly available data and some model assumptions. Areas for future work include modeling of generator capacity contribution for reserves and transmission line losses and costs, as well as modeling the major grids by decomposing them into interconnected regional nodes.

Presenter bio: Luigi Sayon Teola is a faculty member at the Electrical and Electronics Engineering Institute of the University of the Philippines Diliman in Quezon City, Philippines. He obtained his Master of Science in Energy Engineering from the same university and is looking forward to undertaking his PhD at the University of Sydney. His research interests are in power and energy system modeling, energy planning, renewable energy, and sustainable energy. He is a member of IEEE, IEEE Power and Energy Society, and IEEE Young Professionals.

An Attack-resilient and Center-free Energy Dispatch Framework for Power Generation Considering Renewable Sources

Ijaz Ahmed (Pakistan Institute of Engineering and Applied Sciences, Islamabad, Pakistan); Abdul Basit (Pakistan Institute of Engineering and Applied Sciences (PIEAS), Pakistan); Kamran Zeb (King Fahd University of Petroleum and Minerals, Saudi Arabia); Muhammad Rehan (Pakistan Institute of Engineering and Applied Sciences, Pakistan); Muhammad Khalid (King Fahd University of Petroleum and Minerals, Saudi Arabia)

With the increasing integration of clean energy sources into existing power networks, it is critical to discover innovative ways to successfully govern these

sources while also prioritizing data center security. Distributed control protocols widely address the energy dispatch of hybrid energy networks (HEN) due to their exceptional adaptability and resilience. However, these algorithms also introduce a higher danger of cyberattacks in HENs. To handle this problem, this work presents the consensus-based control protocols for energy dispatch of HENs considering cyberattacks over a directed graph. The developed system successfully establishes incremental cost con- sensus across thermal power units under the environment of hybrid attacks and ensures that the data centers achieve optimal power dispatch. Furthermore, we implement the consensus- based distributed protocols in a center-free manner and offer them as an optimization strategy to address the challenge of minimizing generating costs, while also ensuring resilience and robustness against hybrid attacks like deception and denial- of-service. Finally, the efficacy of the suggested approach is confirmed by simulation trials.

Presenter bio: Kamran Zeb He was graduated as a full-time Ph.D. student from the department of electrical engineering and computer science Pusan National University, Busan, South Korea (Sep 2017-Aug 2020) under the Faculty Development Program of NUST, Pakistan.He is currently working as Postdoctoral Fellow at Interdisciplinary Research Center for Sustainable Energy Systems, King Fahd University of Petroleum and Minerals, Dhahran, 31261, Saudi Arabia. Previously He worked as an Assistant Professor (16 Sep. 2020 to 16 Jan. 2024) at the School of Electrical Engineering and Computer Sciences, National University of Sciences and Technology, SEECS-NUST, H-12 Islamabad, Pakistan (number one university in Pakistan). He was a visiting researcher (Faculty) from Oct. 2022 - Jan 2023 at Khalifa University, Abu Dhabi, United Arab Emirates. He served University of management and technology, Lahore, Pakistan for one and half year as a lecturer. His research areas are power converters, control systems, renewable energies, robotics, Modular Multilevel Inverter, and electrical drive. He has contributed 76 papers published in various reputed journals and conferences.

Friday, November 22 2:10 - 3:40

TS16: Power Electronics and Drives
Room: Town Hall
Chair: Galina Mirzaeva (University of Newcastle, Australia)

Switching Performance Evaluation of two State-of-the-Art SiC MOSFETs

Fredrick Nkado (The University of New South Wales, Sydney, Australia); John Fletcher and Hang Zhou (The University of New South Wales, Australia); Scott Tyo and Fatemeh Babaeian (Monash University, Australia)

This paper compares the switching performance of two state-of-the-art Silicon Carbide (SiC) Metal-Oxide- Semiconductor Field-Effect Transistors (MOSFETs) utilising the Double Pulse Test method. The evaluation focuses on assessing the impact of key parameters such as total gate charge (Qg) and on-resistance (RON) on the switching characteristics of the MOSFETs. Through experimental investigation, the switching behaviours, including turn-on and turn-off times, switching losses, and body-diode reverse recovery characteristics (Qrr), are analysed and compared between the two devices. The results demonstrate that a SiC MOSFET with a lower total gate charge and higher on-resistance exhibits superior switching performance compared to a SiC MOSFET with a higher total gate charge and lower on-resistance. The study concludes that prioritising low total gate charge for faster switching for pulsed power applications is more critical than minimising conduction losses through a lower RON.

Presenter bio: PhD Student at the University of New South Wales, Sydney, Australia.

Comparative Performance Investigation of Control Techniques for Solar PV Fed Induction Motor Drives

Nazmul Islam Nahin (Rajshahi University of Engineering & Technology, Bangladesh); Md. Azad Hossain (Chittagong University of Engineering and Technology, Bangladesh); Joysree Nath (Rajshahi University of Engineering & Technology, Bangladesh); Shuvra Prokash Biswas and Md. Rabiul Islam (University of Wollongong, Australia); M A Parvez Mahmud (University of Technology Sydney, Australia); Narottam K. Das (Central Queensland University, Australia)

This paper investigates the application of three prominent control strategies for solar photovoltaic (PV) fed induction motor drives (IMDs): field-oriented control (FOC), direct torque control (DTC), and model predictive control (MPC). FOC utilizes linear controllers and pulse width modulation (PWM) to regulate the fundamental components of load voltages. In contrast, DTC and MPC are nonlinear approaches that directly generate voltage vectors without needing a modulator. The study begins by examining the theoretical operating principles of each method, followed by an analysis of their control structures and implementation considerations. A comprehensive experimental assessment is conducted to evaluate the performance of these strategies in various operating conditions, including starting response, step torque response, and low-speed operation. The comparative analysis aims to highlight the advantages and limitations of each control method when applied to solar PV-fed IMDs. This work provides valuable insights into the trade-offs between dynamic performance, steady-state behavior, and implementation complexity for

each control strategy, assisting designers in selecting the most suitable method for specific renewable energy applications.

Presenter bio: Shuvra Prokash Biswas received the B.Sc. degree in electronics and telecommunication engineering (ETE) and the M.Sc. degree in electrical and electronic engineering (EEE) from the Rajshahi University of Engineering and Technology (RUET), Rajshahi, Bangladesh, in 2017 and 2021, respectively. He is currently pursuing the Ph.D. degree with the School of Electrical, Computer and Telecommunications Engineering (SECTE), University of Wollongong (UOW), Wollongong, NSW, Australia. His research interests include power electronics, motor drives and grid integration of renewables. He received the Best Paper Awards at ICECTE 2019, IEEE ASEMD 2020, IEEE IAS GUCON 2021, IEEE IAS ICCCA 2021, ICEEE 2022, ICECE 2022, IEEE ASEMD 2023, and EICT 2023. He was also a recipient of the Star Reviewer Award from IEEE Transactions on Energy Conversion, in 2022.

Design of DC-Excited Linear Synchronous Motors for High-Speed Maglev Transport

Tengfei Qiu (China Academy of Railway Sciences Corporation Limited, China); Jun Di (Beijing Jiaotong University, China); Huang Chen (China Academy of Railway Sciences Corporation Limited, China); Huiying Chen (Beijing Jiaotong University, China); John Fletcher (The University of New South Wales, Australia)

The high-speed maglev train driven by the DC-excited linear synchronous motor (DCELSM) has been a promising type of transport due to its advantages such as no limitation on wheel-rail interaction, high-speed large-thrust target, and relatively lower cost compared to superconductive linear machines. This paper proposes a design strategy of the DCELSM for high-speed maglev applications. The target speed aims at 600km/h and the design strategy takes fully consideration on the large-scale linear machines. With the proposed design method, a feasible solution of the DCELSM is revealed, including its main geometry dimensions, circuit parameters, and steady-state characteristics. Besides, the decoupling analysis is carried out based on steady-state power-angle characteristics of thrust and levitation force. The design and analysis in this paper provide a general method for the DCELSMs in large-scale applications and two practical guidelines for the high-speed maglev transport.

A Novel Approach for Measuring Phase Resistance and Inductance in Double-Rotor Permanent Magnet Axial Flux Machines

Ahmed A Alhaidari (UNSW, Australia); John Fletcher (The University of New South Wales, Australia)

Measuring phase inductances and resistances in 3-phase axial flux machines with double-rotor, single-coreless stator configurations, surface-mounted permanent magnets, and Y-connected windings presents significant challenges, particularly when star point access is unavailable. To address these challenges, this paper introduces a novel method for experimentally measuring line-to-line resistances and inductances using an LCR meter, followed by the derivation of a transformation matrix to convert these measurements into per-phase values. This approach overcomes the challenges posed by the absence of star point access and ensures accurate measurement of low inductance values. The key contribution of this work is the experimental derivation of phase inductances from line-to-line measurements, along with the development of a transformation matrix that enables precise parameter determination. The results demonstrate the effectiveness of the proposed method in overcoming the challenges associated with Y-connected windings lacking star point access.

Modelling and Design of Virtual Synchronous Generator Control for Back-to-Back Inverter Testing in Renewable Energy Systems

S M Muslem Uddin and Rahmat Heidari (CSIRO, Australia); Julio H Braslavsky (Energy Systems, CSIRO & The University of Newcastle, Australia); Ghulam Mohy-ud-din (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia)

This paper presents a Virtual Synchronous Generator (VSG) based control method for back-to-back (B2B) inverters testing configuration in renewable energy applications. The test configuration includes two inverters (both are 3-leg inverters) which are B2B connected through an LCL filter, where one inverter acts as a Grid-Forming (GFM) mode and the other operates as a Grid-Following (GFL) mode. In the proposed control method, active power controller (APC) is designed based on VSG concept which forms the frequency at the point of connection (POC), and the reactive power controller (RPC) establishes the voltage magnitude at the POC. On the other hand, the GFL inverter utilizes an input current control method and maintains synchronization with the POC which is formed by the GFM inverter through the use of a Phase-Locked Loop (PLL). This B2B inverters configuration enables power to recirculate through the GFL inverter back to the common DC-link, allowing continuous power flow. A key feature of this B2B configuration is that it eliminates the need for high-power DC supplies and AC loads to test high-power inverters, requiring only a low-power DC supply to offset minor losses in the

system. The concept is validated through MATLAB simulations and experimental results.

Presenter bio: S M Muslem Uddin received his Ph.D. in Electrical Engineering from the University of Newcastle, Australia, in 2021 and is a Member of IEEE. With over 10 years of experience in power electronics and machine drives, he also brings extensive industry expertise in power systems modeling and grid connection studies for large-scale renewable energy integration (typically 300MW projects). Muslem has published more than 25 technical papers in power electronics and power systems area and has presented his work at leading conferences and symposiums worldwide. He currently serves as a Research Scientist at the Energy Centre, Commonwealth Scientific and Industrial Research Organisation (CSIRO), in Newcastle, Australia. His research interests include power electronics, grid-forming and grid-following inverter control systems, renewable energy applications, and power systems.

Dimensionless Two-Vector Model Predictive Current -Torque Control of Induction motor drives

Qazwan Abdullah (UTHM, Malaysia); Nabil Farah (UTeM, Malaysia); Mustafa Sami (Communication Engineering, Iraq); Nor Shahida Mohd Shah (Universiti Tun Hussein Onn Malaysia (UTHM), Malaysia); Mohammed Hamood Othman Ahmed (The SPIN Group, Australia); Mogeeb Mosleh (TAIZ, Malaysia); Md Hairul Nizam Talib (UTeM, Malaysia)

Model predictive controls (MPCs) have gained significant attention in induction motor drives due to their simplicity, non-linear control capabilities, and multi-objective control. However, conventional MPCs often face performance issues, such as high starting torque and torque ripples in model predictive current control (MPCC), and slow dynamic response and high current ripples in model predictive torque control (MPTC). This paper proposes a novel model predictive current torque control (MPCTC) for induction motor drives, combining the strengths of MPCC and MPTC by evaluating two separate cost functions for torque and current to generate an optimal switching vector. The fuzzy decision-making (FDM) principle is employed to evaluate these cost functions in a dimensionless manner, eliminating the need for weighting factors. Additionally, to enhance steady-state performance, an additional voltage vector is generated based on the current cost function and applied alongside the first vector generated using FDM, with appropriate duty cycle control. The effectiveness of the proposed MPCTC is validated through simulation and quantitative analysis, demonstrating superior performance in balancing dynamic and steady-state responses, as well as torque and current performance, compared to conventional MPCC and MPTC

Presenter bio: QAZWAN Abdullah was born in Taiz, Yemen. He received the bachelor's degree in electrical and electronic engineering from Universiti Tun Hussein Onn Malaysia (UTHM), in 2013, and the master's degree of science in electrical and electronic engineering from UTHM, in 2015. He is currently pursuing the Ph.D. degree. His research interests are in control systems, wireless technology, and microwaves.

Presenter bio: Master student in electrical engineering UTeM

Friday, November 22 2:10 - 3:40

TS17: Power System Protection
Room: Wynyard
Chair: Md. Rabiul Islam (University of Wollongong, Australia)

Adaptive Overcurrent Relay Protection Strategy for Demand-side in Offshore DC Microgrids

Avy Sheina and Ramon Zamora (Auckland University of Technology, New Zealand); Aman Maung Than Oo (Macquarie University, Australia); Kosala Gunawardane (University of Technology Sydney, Australia)

The integration of renewable energy sources such as solar, wind, wave, and tidal energy into microgrids is becoming increasingly popular. DC microgrids are preferred over AC microgrids due to their ease of the integration of energy storage systems (ESS) and renewable energy sources (RES). DC microgrids mitigate challenges faced by AC microgrids, such as voltage imbalance, harmonic currents, and frequency deviations. However, DC microgrids face unique challenges, particularly in protection systems, due to a lack of standards, limited research, and insufficient expertise. Current protection strategies need modification to adapt to the integration of multiple renewable energy sources, ESS, and various type of loads. This paper proposes an adaptive approach utilizing rule-based algorithm for DC microgrid protection systems to govern the overcurrent protection setting. First, the protection system of the DC microgrid is modelled and current for several schemes of demand are monitored. Then, the protection system is controlled by coordinating the current-time curve of the overcurrent relay setting. This can be achieved by controlling the pick-up current, the time multiplier settings (TMS), and the high-set current. The setting will adapt accordingly based on predefined rule-based algorithm. Finally, the simulation result will verify that the rule-based algorithm works properly to make the protection relay setting adaptive for the demand side of the DC microgrid application.

Presenter bio: Avy Sheina received the BSc. in electrical power engineering from Bandung Institute of Technology (ITB), Indonesia, in 2014 and MSc. in power distribution engineering from Newcastle University, UK, in 2017. She has worked as an electrical engineer for PT. Wijaya Karya (Persero), Tbk. and PT. Siemens Indonesia, Indonesia. She is currently a PhD candidate in electrical engineering at Auckland University of Technology, New Zealand. Her current research interests include protection in DC microgrid, offshore renewable energy integration, and artificial intelligence-based protection system.

Ground Flash Density Mapping in Nepal: Enhancing Lightning Performance and Resilience of Distribution Lines

Barun Ghimire (Institute of Engineering, Tribhuvan University, Nepal & University of Sannio, Italy); Khem Narayan Poudyal (Institute of Engineering Tribhuvan University, Nepal); Nava Raj Karki (Institute of Engineering, Tribhuvan University, Nepal); Shriram Sharma (Tribhuvan University, Nepal & South Asian Lightning Network (SALNet), Nepal); Pasquale Daponte (University of Sannio, Italy); Amedeo Andreotti (University of Napoli, USA); Naganathini Ravichandran (University of Naples Federico II, Italy)

This paper presents the first comprehensive Ground Flash Density (GFD) map of Nepal, an essential tool for addressing the high incidence of lightning strikes that significantly threaten the country's power infrastructure. Analyzing data from the GLD360 network over 2015-2019, the study maps lightning activity across Nepal, highlighting its year-round occurrence with a peak during the pre-monsoon season. The findings show the highest frequency of lightning strikes in the Terai region, decreasing with elevation. The GFD map specifically identifies a critical 30 km segment of a 33 kV distribution line, which recorded an extraordinary 10,751 flashes, peaking at a density of 25.31 strokes/km². Additionally, the study advocates for ongoing monitoring to assess the efficacy of implemented mitigation strategies. This includes tracking arrester currents and deploying high-speed cameras for detailed lightning strike analysis, which will contribute to a deeper understanding of lightning behavior and further improve protective measures for Nepal's power systems.

Presenter bio: I am a PhD research scholar and currently a visiting researcher at the University of Sannio in Benevento, Italy, through the Erasmus Exchange Mobility Program. My research focuses on improving power systems to mitigate the effects of lightning and other types of faults, with a particular emphasis on the impact of lightning on distribution lines.

Revisiting the Need for Conventional Safety Measurements in Modern Power Grids

Hamed Pourazad (University of Newcastle Australia, Australia); Julio H Braslavsky (Energy Systems, CSIRO & The University of Newcastle, Australia); Maria M Seron (University of Newcastle, Australia)

The growing adoption of inverter-based resources in power grids has enabled the integration of renewable energy sources as viable alternatives to fossil-fuel-based thermal generators. Historically, conventional power grids have relied on synchronous generators, with safety indicators such as the Rate of Change of Frequency (RoCoF) being essential for handling reactions to disturbances and faults. However, due to the fundamental differences in the operation of inverters, the utilisation of such safety indicators can yield unintended and adverse outcomes, potentially compromising the reliability of the network. This paper investigates the impact of integrating inverter-based resources in the grid and examines the applicability of RoCoF as a safety indicator in modern power networks dominated by inverter-based generation. Through detailed simulations, we explore the behaviour of the grid during fault conditions and the subsequent frequency response of inverters. Our results demonstrate that, despite experiencing very high RoCoF values at the onset and clearance of faults, inverters can successfully maintain frequency synchronisation, even when inverter-based generation forms the majority of the grid's supply. These findings suggest that traditional safety measures, such as the automatic disconnection of inverters based on high RoCoF values, may no longer be appropriate.

Presenter bio: Hamed Pourazad is a PhD student at the University of Newcastle, Australia, specialising in Power Systems. His research investigates the effects of increasing penetration of Inverter-Based Resources (IBRs) on system strength in power networks by analysing the interactions between IBRs and traditional grid components. Specifically, he explores how a system dominated by IBR-based generators responds to disturbances and faults, aiming to enhance the understanding of the dynamic behaviour of modern power systems in environments with high levels of renewable energy integration. He is motivated by the rapid transition of power networks towards renewable energy sources and the associated challenges in maintaining system reliability and stability.

Parameter Selection Method for Avoiding Resonance and Reducing Voltage Harmonics by Adopting C-Type Filters on A LCL Filter

Jae Woong Shim, Hyo Lee and Hyo Geun Kwak (Sangmyung University, Korea (South))

This paper introduces the method of avoiding resonance and reducing voltage harmonics by connecting a C-type filter to the capacitor section of an inverter containing an LCL filter connected to the power system. For this purpose, we set the parameters of the inverter and LCL filter. Then, various equations were employed to appropriately determine the values of the capacitor, inductor, and resistor of the C-type filter. Utilizing these configured values, the overall transfer

function was represented using the transfer functions of the inverter and filter. Subsequently, it was examined whether unstable resonance, as compared to the system impedance, could be avoided when using the C-type filter. Furthermore, in the frequency domain, the Total Harmonic Distortion (THD) was utilized to assess how much the voltage harmonics decreased when the C-type filter was included, compared to when only the LCL filter was present.

Synchronization Instability Analysis of Phase-Locked-Loop Interfaced Grid-Tied Inverter Under Abnormal Grid Conditions

Shuvra Prokash Biswas and Md. Rabiul Islam (University of Wollongong, Australia); Arindam Ghosh (Curtin University, Australia)

Grid synchronization is essential for grid-tied inverters because it needs crucial information on the phase, frequency, and voltage amplitude of the grid. For grid-connected inverters (GCIs), phase-locked loop (PLL) is considered as an indispensable part of the control system to synchronize the inverters to the power grid. However, for abnormal grid operations, the PLL synchronized inverters typically exhibit low stability, phase error, frequency overshoot and frequency error problems which lead to synchronization instability of the inverters to the grid. Very few studies have been addressed all the concerns and challenges regrading synchronization of GCIs when the grid suffers from various abnormalities like voltage sag/swell, phase jump, frequency jump and harmonic distorted conditions. In this study, the performance of widely used synchronous reference frame PLL (SRF-PLL) and dual second order generalized integrator PLL (DSOGI-PLL) against various grid abnormal conditions is studied. This analysis clearly reveals the synchronization challenges, concerns, and research opportunities of designing robust PLL for power electronics dominated future grid which will suffer from various abnormalities and instability issues. A three-phase LCL filter based GCI system is considered to investigate the response of the PLLs under abnormal grid conditions.

Presenter bio: Shuvra Prokash Biswas received the B.Sc. degree in electronics and telecommunication engineering (ETE) and the M.Sc. degree in electrical and electronic engineering (EEE) from the Rajshahi University of Engineering and Technology (RUET), Rajshahi, Bangladesh, in 2017 and 2021, respectively. He is currently pursuing the Ph.D. degree with the School of Electrical, Computer and Telecommunications Engineering (SECTE), University of Wollongong (UOW), Wollongong, NSW, Australia. His research interests include power electronics, motor drives and grid integration of renewables. He received the Best Paper Awards at ICECTE 2019, IEEE ASEMD 2020, IEEE IAS GUCON 2021, IEEE IAS ICCCA 2021, ICEEE 2022, ICECE 2022, IEEE ASEMD 2023, and EICT 2023. He was also a recipient of the Star Reviewer Award from IEEE Transactions on Energy Conversion, in 2022.

A New Design of Switched-Capacitor based Fault-Tolerant Boost Multilevel Inverter Topology

Marif Daula Siddique, Mehdi Seyedmahmoudian, Saad Mekhilef and Alex Stojcevski (Swinburne University of Technology, Australia)

With the use of a high number of components in the multilevel converters, the chances of converter failure due to malfunction in components are high leading to reduced reliability and performance. In this paper, a new converter topology along with the fault-tolerant configuration which can be operated in two modes of operation has been proposed which incorporates the boosting feature as well. A detailed analysis for considering the faults in different switches for different modes of operation has been analyzed. Simulation results have been presented in this paper to show the performance and efficacy of the proposed topology.

Friday, November 22 3:40 - 3:55

AT3: Afternoon Tea
Room: Foyer

Friday, November 22 3:55 - 5:25

TS18: Renewable Energy Systems III
Room: Central
Chair: Ricardo Aguilera (UTS, Australia)

Degradation Mode Quantification and Analysis of Lithium-ion Battery Cell Over Dynamic Load Profile and Different State of Charge Conditions

Ali Kharal (Lahore University of Management Sciences, Pakistan); Muhammad Khalid (King Fahd University of Petroleum and Minerals, Saudi Arabia); Waleed M. Hamanah (King Fahd University of Petroleum and Minerals & Applied Research Center for Metrology, Standards and Testing (ARC-MST), Saudi Arabia); Ijaz Haider Naqvi (LUMS School of Science and Engineering (SSE) & LUMS SSE, Pakistan); Naveed Arshad (Syed Babar Ali School of Science and Engineering, Pakistan)

Identification and quantification of degradation modes in lithium-ion batteries are critically important to protect the batteries from thermal runaway. Battery packs, composed of individual cells, are complex systems that must be operated within specified limits to ensure safe and reliable performance. As the battery ages, the cells begin to degrade; however, this degradation can be managed by carefully monitoring the aging behavior. Degradation is divided into three interdependent modes, all of which must be identified to avoid sudden breakdowns. Accurate degradation estimation requires diagnostic tests to estimate the State of Health (SOH) of the battery. There are several articles that address cyclic aging under constant current discharging cycling, However, very few have addressed aging under dynamic loading conditions. In this paper, we used an open-source dataset provided by Stanford's Energy Control Lab that consists of the cyclic aging of cells under 225 cycles of the Urban Dynamometer Drive Schedule. Electrochemical Impedance Spectroscopy (EIS) and capacity tests were used to diagnose battery degradation. Our analysis estimated 5.91% conduction losses, whereas 28.16% and 32.1% lithium inventory and active material losses, respectively.

Presenter bio: WALEED M. HAMANAH received his BSc degree in Electrical Engineering from Sana'a University, Yemen, in June 2008. He worked as an instructor at Taiz University, Yemen, from September 2008 to December 2011. He earned his MSc and Ph.D. in Electrical Engineering—Power and Control—from King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, Saudi Arabia, in 2016 and 2021, respectively. He completed a postdoctoral fellowship at the IRC for Sustainable Energy Systems at KFUPM. Currently, he works at the Applied Research Center for Metrology, Standards, and Testing Research and Innovation at KFUPM as a Research Engineer III (Assistant Professor). His research interests include Renewable Energy, Intelligent Control Systems, Power Electronics, and High Voltage.

Joint Multi-stage Planning of Electricity and Hydrogen Systems: An Australian case study

Ronggen Chen (The University of Melbourne, Australia); Sleiman Mhanna (The University of Melbourne, United Kingdom (Great Britain)); Pierluigi Mancarella (The University of Melbourne, Australia)

The integration of large-scale hydrogen (H2) and variable renewable energy (VRE) presents challenges for achieving cost-effective integrated system expansion and energyefficient operational management of electricity and hydrogen systems. This paper leverages state-of-the-art optimisation techniques and develops a joint multi-stage planning framework that maximises H2 export while minimising investment costs of transmission and storage infrastructure needed to support the increase in electricity and domestic H2 demand from 2027 to 2037. The developed multi-stage planning framework incorporates a network-aware unit commitment model and a quasi-dynamic H2 flow model for pipeline sizing and linepack assessment, as well as realistic investment timing. Case studies numerically demonstrate that incorporating H2 pipelines in the integrated planning enables a more cost-effective system expansion and unlock more opportunities for H2 export. Additionally, the inclusion of battery energy storage systems as an investment option is shown to improve the overall interplay among new and existing assets, manifesting in less VRE curtailment and an increase in H2 export.

Presenter bio: Mr. Ronggen Chen is pursuing a PhD in electrical and electronic engineering at University of Melbourne. His research interests include stochastic optimisation methods applied to integrated electricity and hydrogen systems.

Solar System: A Comprehensive Review of Predictive Maintenance

Ali Mahmood Ahmed, Kaveh Khalilpour and Li Li (University of Technology Sydney, Australia)

Over the recent decades, solar photovoltaic (PV) technologies have revolutionized the energy market. Ensuring the high reliability of important assets is imperative in PV power systems, which encompass several PV elements. Maintenance programs are designed to maximize the lifespan of equipment while minimizing the occurrence of unexpected failures and downtime. Predictive maintenance (PdM) employs equipment condition modelling to schedule maintenance tasks and identify defect types before occurring. Nevertheless, forecasting the fault of PV equipment is intricate since the status of the equipment cannot be directly measured; it is susceptible to several types of conditions. Consequently, there is an increase in research focused on creating predictive analytic tools to enhance operational management. This study explores the literature on PV systems, focusing on their design, crucial components, operation, and maintenance approaches.

Presenter bio: PhD student at university of Technology Sydney. My research is focusing on Predictive Maintenance of Solar farm.

Maximizing Solar PV Utilization in EV Charging Stations: An Intelligent Scheduling and Load Balancing Approach

Lorenz Edgar Mandac and Narottam K. Das (Central Queensland University, Australia); Md. Rabiul Islam (University of Wollongong, Australia)

This study presents how solar photovoltaic (PV) utilisation in electric vehicle (EV) charging stations in a workplace parking lot can be maximised using intelligent scheduling (IS) and load balancing (LB). The integration of renewable sources, particularly solar energy, and electric vehicles (EVs) holds significant potential for reducing carbon footprints and achieving net-zero emissions by 2050. The

increasing number of EVs, however, has a detrimental impact on the power quality of the power grid. By simulating and evaluating the effectiveness of IS and LB, the utilisation of PV and the self-sufficiency of EV charging stations (EVCS) will increase. Additionally, the LB will further mitigate the EVCS effect on the power grid. MATLAB/Simulink was used as the simulation software along with data/graphical analysis to determine the key investigating parameters. The simulation model includes equivalent circuits of solar PV, battery storage, and the power grid, and mathematical modelling for IS and LB. The IS maximised the utilisation of PV as it distributed the charging power throughout the working hours. This led to a reduction in the cost of electricity consumption and increased EVCS self-sufficiency. Further, varying the charging power has an effect on the LB of the EVCS, which can be controlled to counter the current or load unbalance of the distribution network. However, various factors can be considered in future studies, such as increasing the number of EVs, use of machine learning, and a detailed techno-economic analysis for the battery storage.

Presenter bio: Dr Narottam Das received his PhD degree in Electrical Engineering from Yamagata University, Japan in 2000. His PhD research project was funded by the Ministry of Education, Science, Sports and Culture of Japan. Dr Das has about 3-decades experience as an academia and industrial Engineer in Australia and overseas. Prior to join at CQUniversity as a Senior Lecturer in Electrical Engineering, he worked at University of Southern Queensland, Curtin University, Edith Cowan University, Monash University, Australia and NEC Yamagata Ltd., Japan. Dr Das is the author/co-author over 240 peer-reviewed journal and international conference papers. Dr Das is a senior member of the IEEE, USA; Fellow of the Institution of Engineers, Australia; CPEng, NER, Fellow of Higher Education Academy (UK), and Life Fellow of the Institution of Engineers, Bangladesh. His research interests include in Power and Energy Systems, such as, renewable energy, modelling of high-efficiency solar cells, multi-junction solar (PV) cells, Power Systems Communication (Smartgrids) using IEC 61850, and modeling of high-speed communication devices.

Smart EV Charging-Discharging Management with Grid-Home-PV Interaction using V2X Charger

Md Ariful Islam, Kazi N Hasan and Manoj Datta (RMIT University, Australia); Geoff Lamb (Climate Equity, Australia)

Electric Vehicle (EV) charging and discharging can be rapid and reliable when it is connected to a dedicated charging station. Charging and discharging an EV at home is challenging as constrained by the grid connection capacity because a rated power level is not always available due to other household loads. Smart EV charging and discharging can be achieved in solar PV-connected modern houses using a V2X (vehicle-to-everything)-enabled EV charger. This paper proposed a novel eight-mode control strategy to perform smart EV charging and discharging without affecting the operation of the household appliances. At the same time, other operations such as V2G (vehicle-to-grid), V2H (vehicle-to-home), or V2L (vehicle-to-load) can be achieved using the V2X-enabled EV charger by applying the proposed control strategy. The simulation results demonstrated by MATLAB Simulink show eight coordinated modes of operation depending on the availability and unavailability of grid supply, solar PV generation, and EV battery power based on its state of charge (SoC).

Presenter bio: He received his B.Sc. degree in Electrical and Electronic Engineering from the Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh, and his M.Eng. degree in Electric Power System Management (EPSM) from the Asian Institute of Technology (AIT), Thailand. He was awarded the dean merit and the Asian Development Bank-Japanese Scholarship Program (ADB-JSP) scholarship to pursue his BSc. and M.Eng. degrees, respectively. He had been working as an assistant professor with the Electrical department, AUST, from 2019 to 2023. Prior to that, he also worked as an assessor of electrical and fire safety in Alliance. Currently, he is doing his Ph.D. degree at RMIT University, Melbourne, Australia, focusing on a V2X EV charger prototype. To pursue his Ph.D. degree, he has been awarded a combined RMIT university and Smart Lifestyle Australia scholarship. His research interests include renewable energy technology and applications, power management, and load profile analysis on the distribution side. He has authored and coauthored more than 15 technical papers, including book chapters, journals, and conference papers in electrical engineering.

Development of Fault-Tolerant Versions of a Three-Source Multilevel Inverter Topology for Optimal Performance with Reduced Number of Auxiliary Switches

Marif Daula Siddique, Mehdi Seyedmahmoudian, Saad Mekhilef and Alex Stojcevski (Swinburne University of Technology, Australia)

For a reliable power electronic system, fault-tolerant power converters play an important role. Most of the power converter are highly prone to faults due to various operating conditions. A power quality assessment of a three-source MLI topology has been carried out. Further, in literature, several fault-tolerant versions of the three-source MLI topology have been proposed. In this paper, three different fault-tolerant topologies have been discussed along with their fault-tolerant abilities. A power quality assessment has also been carried out for three source topologies as well as the fault-tolerant version of the three-source MLI topology. A fault-tolerant analysis along with the simulation results have been provided to demonstrate the performance of the fault-tolerant version of the three-source MLI topology.

Friday, November 22 3:55 - 5:25

TS19: Distributed Energy Resources
Room: Town Hall
Chair: Georgios Konstantinou (The University of New South Wales, Australia)

Multi-Objective Optimisation for Energy Scheduling in Smart Grids using Peer-to-Peer Trading

Chinweike Paul Ezeokafor, Pratik Harsh and Hongjian Sun (Durham University, United Kingdom (Great Britain))

Efficient scheduling of the sources within a community is essential to reduce the electricity-related cost as well as the carbon emissions from the community. A novel energy management strategy for community grids is introduced in this research, leveraging peer-to-peer trading and the multi-objective optimisation of the cost and carbon emissions in scheduling the diverse energy sources and battery storage systems within the community. The grid, photovoltaic farms, Combined Heat and Power plants, and battery energy storage are considered in this paper, and our approach, underpinned by real-life data analysis, is used to find effective schedules for each source. The model is implemented on MATLAB and solved using the YALMIP optimisation toolbox to obtain optimal scheduling based on the various objectives of the community in a range of scenarios. An operation cost savings of up to 62.5% is achieved in a range of scenarios, highlighting the importance of optimal source scheduling in smart grids.

Optimal Scheduling of Distributed Energy Resources Aggregators in Energy and Flexibility Markets

Afshin Najafi-Ghalelou (Monash University (Australia), Australia); Mohsen Khorasany, Imran Azim and Reza Razzaghi (Monash University, Australia)

This paper investigates the stochastic scheduling of a Distributed Energy Resources Aggregator participating in wholesale day-ahead energy and flexibility markets. The proposed framework focuses on maximizing the aggregator's profit while representing entities such as PV-based prosumers, electric vehicles, and large-scale battery within an unbalanced distribution network. It incorporates uncertainties related to PV generation, market prices, and flexibility deployment requests. In addition to profit maximization, the framework manages the distribution network's voltage and line congestion while meeting the basic energy demand of the players. The aggregator leverages the flexibility of these players to participate in the flexibility electricity market, enabling it to adjust its total power production as requested by the flexibility market operator. The study evaluates two cases: Case 1, where the aggregator participates only in the energy market, and Case 2, where the aggregator joins both energy and flexibility markets. The results show that participating in both markets significantly increases profit, while maintaining compliance with the distribution network's voltage and thermal limits and meeting participants' demand requirements.

Time-Varying Import and Export Tariffs for Optimal Prosumers Integration

Mohsen H Aldaadi, Gregor Verbic and Cuo Zhang (The University of Sydney, Australia)

The growing adoption of distributed energy resources (DERs) has transformed passive consumers into active prosumers, necessitating advanced energy management strategies to fully leverage their flexibility. This paper proposes a bilevel optimization model capturing the interaction between system operators and prosumers, represented by Virtual Power Plants (VPPs). The upper level determines optimal time-varying tariffs, while the lower level models prosumer responses. Unlike existing studies, our approach implements separate import and export tariffs, reflecting real-world conditions and promoting efficient energy use. To address computational challenges posed by the non-convex lower-level problem, we employ a novel solution method based on decomposition and column-and-constraint generation (C&CG) algorithms. Preliminary results show promising improvements in the VPP flexibility utilization and overall system efficiency when tested on a simplified model of Australian National Electricity Market with significant penetration of renewable generation.

Presenter bio: A PhD student at the University of Sydney, with research interests in the integration of renewable energy into power systems and markets, as well as the optimization and control of distributed energy resources.

Assessing Peak Demand Reduction and Electricity Cost Savings of a Behind-the-Meter Battery for Commercial and Industrial Customers

Imran Azim, Mohsen Khorasany and Reza Razzaghi (Monash University, Australia)

This paper presents an analysis of peak demand reduction and electricity cost savings for commercial and industrial (C&I) customers deploying behind-the-meter battery storage systems (BSSs). To do so, a BSS scheduling strategy is proposed that facilitates battery charging, both from the solar system and the grid, as well as discharging during demand charge-, peak time-of-use (ToU) rate-, and shoulder ToU rate-applicable periods in succession to peak demand and maximize cost savings. The proposed grid charging is conducted during off-peak ToU periods by taking factors like possible solar supply, BSS size and available BSS capacity, and demand during peak and shoulder periods into account. Finally, the performance of the proposed charge and discharge scheduling of the BSS is investigated for three C&I customers with different demand profiles. The simulation results are also compared with the business as usual, in which C&I customers buy and sell energy at ToU and feed-in-tariff (FiT) rates, respectively, without possessing any BSS at their premises. It is observed from the case study that the reductions in peak demand and electricity costs vary between 35.62% and 98.07% and between 4.61% and 11.01%, respectively.

Presenter bio: Dr Imran Azim has received PhD in Electrical Engineering from The University of Queensland in 2022. Currently, he is working at Monash University as a Research Fellow. His research interests include local energy management and markets, peer-to-peer energy trading, smart grids, and green transporation.

Bayesian Optimized Supervised Learning for Short-Term Net Load Forecasting in Distribution Grids with Net-Metering

Abdul Haseeb and Shahid Nawaz Khan (Lahore University of Management Sciences, Pakistan); Naveed Arshad (Syed Babar Ali School of Science and Engineering, Pakistan); Muhammad Waseem (Maynooth University, Ireland); Md. Rabiul Islam (University of Wollongong, Australia); Jahangir Hossain (University of Technology Sydney, Australia); Shuvra Prokash Biswas (University of Wollongong, Australia)

As power systems evolve into more intelligent, flexible, and interactive networks with a higher penetration of Renewable Energy Sources (RES) on the demand side, net load forecasting has become a cost-effective and essential technique for planning, stability, and reliability of modern power grids. This study explores both direct and indirect methodologies for short-term net load forecasting (STNLF) in distribution grids considering solar net-metering using deep learning (DL) and machine learning (ML) techniques. The proposed models begin with feature engineering and filtering using Pearson Correlation and Mutual Information (MI) indices, followed by developing a forecasting models employing a Bayesian Optimized Long Short-Term Memory (BO-LSTM) network and Bayesian Optimized Random Forest (BO-RF). The model's effectiveness was validated using historical net load data from the Lahore Electric Supply Company (LESCO) spanning January 2022 to January 2024, as LESCO has the highest number of net-metering customers among all Distribution Companies (DISCOS) in Pakistan. Results demonstrate the BO-RF model's capability to deliver accurate and robust STNLF, achieving a Mean Absolute Percentage Error (MAPE) of 3.56% for the test data and 2.21% for the train data. This study also compares the efficiency of indirect and direct methods for STNLF, demonstrating that the indirect method generally performs better than direct method in distribution grids.

Presenter bio: Shuvra Prokash Biswas received the B.Sc. degree in electronics and telecommunication engineering (ETE) and the M.Sc. degree in electrical and electronic engineering (EEE) from the Rajshahi University of Engineering and Technology (RUET), Rajshahi, Bangladesh, in 2017 and 2021, respectively. He is currently pursuing the Ph.D. degree with the School of Electrical, Computer and Telecommunications Engineering (SECTE), University of Wollongong (UOW), Wollongong, NSW, Australia. His research interests include power electronics, motor drives and grid integration of renewables. He received the Best Paper Awards at ICECTE 2019, IEEE ASEMD 2020, IEEE IAS GUCON 2021, IEEE IAS ICCCA 2021, ICEEE 2022, ICECE 2022, IEEE ASEMD 2023, and EICT 2023. He was also a recipient of the Star Reviewer Award from IEEE Transactions on Energy Conversion, in 2022.

Data Driven Approach for User-owned Renewable Energy Sources Allocation in Community Microgrid

Md. Morshed Alam and Jahangir Hossain (University of Technology Sydney, Australia); Raihan Bin Mofidul (Kookmin University, Korea (South))

Massive integration of photovoltaic (PV) and energy storage systems (ESS) in the energy system increases the utilization of renewable energy and system complexity. Optimal and centralized scheduling and management of these sources can make them more effective and acceptable in the energy community. In this regard, we consider a community microgrid where multiple energy storage systems and photovoltaic systems are connected. The user-owned PV-ESS systems are controlled by the community microgrid. This paper proposes a virtual scheduling of the PV-ESS system based on a deep learning-based, data-driven approach. The proposed system divides the time span into two segments based on the availability of PV generation. A deep learning model is applied to predict the day-ahead PV

generation and demand during the two-time segments. An optimization algorithm is then applied to schedule the PV and ESS based on the predictive outcomes. The simulation results demonstrate the proposed system's performance in terms of reliability and sustainability.

Friday, November 22 3:55 - 5:25

TS20: Other Topics in Power
Room: Wynyard

Experimental Assessment of the Impact of Sustained Supply Voltage Magnitude on Consumer Appliance Lifespan

Dinidu Srimal Jeewandara (University of Wollongong, Australia & Australian Power Quality Research Centre, Australia); Sean Elphick, Duane Robinson and Jeffrey Moscrop (University of Wollongong, Australia)

The proliferation of electronic devices which comprise household appliances potentially increases susceptibility to sustained higher voltage magnitudes. Thus understanding how supply voltage magnitude affects appliance lifetime and performance is crucial for ensuring energy efficiency, reliability, and safety. This study presents an experimental methodology implemented in a laboratory setting to investigate the impact of sustained supply voltage magnitudes on electrical parameters and lifetime of household appliances. The experimental work in this research was separated into two distinct studies: long-term and accelerated life testing. The long-term experiments utilise a wide range of appliances from different categories, including audio-visual, information technology, refrigeration, lighting, motor, heating, and cooling, tested under normal operating conditions. For the accelerated life testing, switched mode power supply circuits of appliances are studied under increased ambient temperature in order to analyse their reliability over a shorter period than their intended real-world use. The importance of setting a suitable nominal voltage and ensuring appropriate voltage regulation in low voltage residential electrical systems is evidenced through appliance performance and impact on lifespan.

Presenter bio: Dinidu Jeewandara graduated from the University of Moratuwa, Sri Lanka with a BSc (Hons) in Electrical Engineering in 2020. Following this, he continued at the same university as a research student, completing his MSc with a specialization in Power in 2022. Currently, he is a PhD student at the Australian Power Quality Research Centre (APQRC) at the University of Wollongong, with research interests in power system planning and power quality analysis.

Demand flexibility characterisation of heat pump water heater system

Sheikh Khaleduzzaman Shah, Muhammad Zaheer Zulfiqar and Mark Goldsworthy (CSIRO, Australia)

The demand flexibility of a residential heat pump water heater system was experimentally characterised. The heat pump water heater system was installed and instrumented with power, temperature and flow sensors. Two scenarios were considered: baseline or normal operation and load decrease (load shifting) which tested the heat pump's ability to reduce power demand in response to a request for demand response. Demand flexibility is quantified in terms of the following parameters: capacity, electrical energy storage, round trip efficiency, heat storage, activation time delay, response duration, minimum time between events, and cycle duration. In the load decrease scenario, the demand flexibility capacity was found to be 0.42 to 0.49 kW over a response duration of 47-51 mins. The average electrical energy storage, round trip efficiency and heat storage were 0.25 kWh, 91% and 40 MJ respectively. The average activation time delay, cycle duration, and minimum time between events were 258, 317, and 269 minutes respectively. These results may be useful for evaluating demand response potential from heat pump water heater systems.

Presenter bio: Dr Khaled is a research scientist in the Energy Systems Program at CSIRO, Australia. Khaled's research at CSIRO currently focuses on the demand flexibility of various building energy systems, such as heat pumps, HVAC, energy storage, and solar rooftop PV. Before CSIRO, Khaled was a postdoctoral research fellow at the University of Melbourne and Monash University, Australia, and an energy consultant at Global Building Performance Network. He obtained his PhD in Building Energy Systems from The University of Melbourne in 2020.

Enhancing PV Forecasting Accuracy through Optimal Clustering Method Selection and Impact Assessment

Md Ahasan Habib and Jahangir Hossain (University of Technology Sydney, Australia)

This study investigates the impact of clustering on photovoltaic (PV) power prediction by utilizing two openly accessible datasets obtained from an Australian Microgrid. It evaluates the performance of five popular clustering algorithms-KMeans, DBScan, Gaussian Mixture Model (GMM), Spectral Clustering (SC), and Fuzzy C-Means (FCM)-by comparing their accuracy through metrics such as the

Calinski-Harabasz (CH) Score, Davies-Bouldin (DB) Score, and Silhouette Score (SS). Additionally, the research examines two deep-learning models to assess how clustering influences forecasting accuracy. Performance metrics including Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), R-squared (R^2) score, and Standard Deviation of Error (SDE) are used to compare the results of clustered versus non-clustered data. The findings suggest that clustering improves forecasting performance, with the most effective clustering method providing the best overall predictions, highlighting it as the most optimal approach.

Presenter bio: Md Ahasan Habib is currently pursuing his PhD at the School of Electrical and Data Engineering, University of Technology Sydney (UTS), Australia. He completed his B.Sc. and M.Sc. in Electrical and Electronic Engineering from Rajshahi University of Engineering and Technology (RUET), Bangladesh, in 2016 and 2019, respectively. His research interests include terahertz waveguides, optical fiber communication, machine learning, deep learning, renewable energy, feed-in tariff, and dynamic tariff. To date, he has authored over 40 articles in international journals and conferences.

Electric field modeling of 11KV XLPE cable with rectangular voids at multiple locations

Haider Hussain and M. Tariq Nazir (Royal Melbourne Institute of Technology (RMIT University), Australia); Arup Kumar Das (Amrita Vishwa Vidyapeetham, India)

In this paper, an electric field simulation study is performed on an 11 kV XLPE cable model consisting of rectangular voids. XLPE cables are one of the pivotal components of electrical power transmission and distribution. However, the presence of internal defects, aging and moisture ingression can lead to the inception of partial discharge (PD) activities, which severely affect the insulation quality of XLPE. Considering this, in this simulation study, electric field enhancement in XLPE insulated is calculated under different void configurations (series and parallel). Simulation studies are also performed in varying void locations. Based on the result presented in this simulation study, it can be observed that electric field enhancement is higher when the voids are in serial configuration and the distance between the voids is minimum. Results presented in this simulation study will help visualize the PD inception in XLPE cable. This study is also helpful in insulation design and condition monitoring of XLPE cable.

Presenter bio: Haider Hussain is a PhD student at RMIT, which he began in April 2024. His research focuses on condition monitoring of high-voltage power cables using machine learning models and partial discharge data. He completed his Master's degree from UNSW in 2019 and has four years of industrial experience as a Senior Electrical Engineer. His research aims to enhance asset management and predictive maintenance strategies for power cable networks.

Stability Indices for Modern Power Systems Integrated with IBRs and Composite Load Models: A Review

Muhammad Ismail (Federation University, Australia); Tanveer A Choudhury (Federation University Australia, Australia)

This review paper examines the impacts of inverter-based resources (IBRs) and composite load models (CLMs) on power system stability studies, highlighting the limitations of existing stability indices. The integration of renewable energy sources has significantly altered grid stability dynamics, necessitating advanced assessments. Traditional stability indices, developed in an era with minimal IBR presence, often fail to account for the complex interactions between diverse load types, their schedules, and evolving grid characteristics. Additionally, these indices do not leverage modern data analytics, machine learning, and AI capabilities. This paper critically analyzes the impacts of different load models as well as the dynamics of IBRs on overall power system stability including often ignored stability aspects such as resonance and inverter-driven stability. Following that it compiles and provides a summary of existing voltage and frequency stability indices. This review paper underscores the urgent need for modern composite stability indices that integrate these advanced technologies to provide a comprehensive and accurate evaluation of power system stability in contemporary grids. Future recommendations are made to design robust controllers considering composite stability indices to achieve higher modeling accuracy and avoid erroneous stability estimates.

Modal Analysis of Transformer Winding under Clamping Pressure Changes

Amita Singha (The University of Queensland, Australia); Jakob Pallot (Schneider Electric, Australia); Chandima Ekanayake (University of Queensland, Australia)

This paper presents an investigative analysis on the applicability of modal analysis to identify clamping pressure changes imposed on transformer winding in terms of extracting modal parameters. Both experimental modal analysis (EMA) and operational modal analysis (OMA) were executed to observe the appearance of natural frequencies during the changes of clamping pressure. Both uniform and

non-uniform clamping pressure changes were considered. Alteration of natural frequencies were observed during the laboratory experiments during every pressure change. The results obtained may contribute to online condition monitoring of transformers.

Friday, November 22 5:25 - 5:40

C1: Closing Session
Room: Central