Conference Program

2026 8th International Conference on Smart Power & Internet Energy Systems (SPIES 2026)

Sunshine Coast, Queensland, Australia

September 28-30, 2026

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Message from the Conference General Chair

It is my great pleasure to welcome you to the 8th International Conference on Smart Power & Internet Energy Systems (SPIES 2026), held on the Sunshine Coast, Queensland, Australia, from September 28 to 30, 2026.

The SPIES conference series is held annually to provide an interactive forum for the presentation and discussion of the latest developments in smart power, intelligent energy systems, and related fields. The SPIES series was launched in 2019 and was successfully held in Deakin University Geelong campus. This year, SPIES 2026 is co-sponsored by the University of the Sunshine Coast, Queensland, Australia, IEEE IAS, and IEEE PES.

SPIES 2026 brings together researchers, academics, engineers, and industry professionals from around the world to exchange ideas and share the latest advances in smart power, energy systems, and related emerging technologies. We are particularly honored to welcome three distinguished keynote speakers: Prof. Hua Geng from Tsinghua University, China; Prof. Kashem Muttaqi from the University of Wollongong, Australia; and Prof. Bikash Pal from Imperial College London, UK. Their participation will provide valuable perspectives and stimulate meaningful discussions on the future development of smart power and energy systems.

After more than one year of preparation, we have received more than 70 submissions from researchers and scholars from China, Australia, Brazil, Japan, Qatar, India, New Zealand, Malaysia, Sri Lanka, the United Arab Emirates, Canada, and other countries. More than 80 committee members have contributed to the organization and development of this conference. We sincerely appreciate their time, expertise, and dedicated efforts.

With a diverse program of keynote presentations, invited speeches, and technical sessions, we hope SPIES 2026 will provide a valuable platform for academic exchange, professional networking, and international collaboration.

On behalf of the Organizing Committee, I sincerely welcome all participants to the Sunshine Coast and wish you a productive, inspiring, and enjoyable conference.



Prof. Aman Oo
Conference General Chair, SPIES 2026
University of the Sunshine Coast, Australia

Organizing Committee

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Onsite Conference Notice

Conference Venue

Holiday Inn & Suites Sunshine Coast

Address: 42 First Avenue and Fairway Drive, Maroochydore QLD 4558, Australia

https://www.ihg.com/holidayinn/hotels/us/en/maroochydore/mcysc/hoteldetail



Important Information for Onsite Participants

About Onsite Presentation

• Timing: a maximum of 15 minutes total, including speaking time and discussion. Please make sure your presentation is well timed.

• Each speaker is required to meet her / his session chair in the corresponding session rooms 10 minutes before the session starts and copy the slide file (PPT or PDF) to the computer.

• It is suggested that you email a copy of your presentation to your personal in box as a backup. If for some reason the files can' t be accessed from your flash drive, you will be able to download them to the computer from your email.

• Please note that each session room will be equipped with a LCD projector, screen, point device, microphone, and a laptop with general presentation software such as Microsoft Power Point and Adobe Reader.

Name Badge

For security purposes, delegates, speakers, exhibitors and staff are required to wear their name badge to all sessions and social functions. Lending your participant card to others is not allowed. Entrance into sessions is restricted to registered delegates only. If you misplace your name badge, please ask the staff at the registration desk to arrange a replacement.

Gentle Reminder

• Please ensure that you take all items of value with you at all times when leaving a room. Do not leave bags or laptops unattended. The conference organizer does not assume any responsibility for the loss of personal belongings of the participants.

• Accommodation is not provided. Delegates are suggested make early reservation.

• Please show the badge and meal coupons when dining.

Emergency

Police / Fire / Ambulance: 000 (Triple Zero)

Call 000 in an emergency and specify the service you require.

Simple Program

September 28th (Monday)

Onsite Registration & Materials Collection for Onsite Participants
Time: 13:00-16:00 (GMT+10)
Venue: the ground floor-Holiday Inn & Suites Sunshine Coast
Address: 42 First Avenue and Fairway Drive Maroochydore 4558 QLD, Australia
Registration Steps:
1. Arrive at the Registration Desk;
2. Inform the conference staff of your paper ID;
3. Sign your name on the Participants list;
4. Sign your name on Lunch & Dinner requirement list;
5. Check your conference kits;

Zoom Test for Online Participants	
Zoom ID: 89876772858	
Zoom Link: https://us02web.zoom.us/j/89876772858	
Online Test (GMT+10)	
13:30-14:30	Test for Online Presenters
15:30-16:30	Test for Online Presenters

September 29th (Tuesday)

Morning Sessions		
Opening Remark & Keynote Speeches & Onsite Session Meeting Room1&2-the ground floor Zoom ID: 89876772858 Zoom Link: https://us02web.zoom.us/j/89876772858		
9:00-9:05	**Opening Remark**	**Prof. Aman Oo** University of the Sunshine Coast, Australia
9:05-9:45	**Keynote Speech I**	**Prof. Hua GENG** Tsinghua University, China
9:45-10:25	**Keynote Speech II**	**Prof. Kashem Muttaqi** University of Wollongong, Australia
10:25-10:50	**Group Photo & Coffee Break**	
10:50-11:50	**Session 1**	**AI-Driven Modeling and Safe Operation Strategies for Advanced Energy Storage Systems** PS0003, PS0041-A, PS0006, PS0008
11:50-13:30	**Lunch Time**	
Onsite Afternoon Sessions		
Onsite Sessions & Online Keynote Speech Meeting Room1&2-the ground floor Zoom ID: 89876772858 Zoom Link: https://us02web.zoom.us/j/89876772858		
13:30-14:30	**Session 2**	**Frontier Technologies of Power Electronic System Control and Electromagnetic Drive** PS0011-A, PS0023, PS0024, PS0013-A
14:30-15:10	**Coffee Break**	
15:10-16:10	**Session 3**	**Resilience Enhancement and Market Trading Mechanisms for New Power Systems** PS0033, PS0009-A, PS0017, PS0014
16:10-16:50	**Keynote Speech III**	**Prof. Bikash Pal** Imperial College London, UK
18:30-20:00	**Dinner Time**	

September 30th (Wednesday)

Online Sessions		
Invited Speeches & Online Sessions Zoom ID: 89876772858 Zoom Link: https://us02web.zoom.us/j/89876772858		
11:30-11:50	**Invited Speech I**	**Prof. Yu Wang** Chongqing University, China
11:50-13:50	**Session 4**	**Integrated Energy Systems, Optimal Scheduling and Energy Management** PS0007, PS0040, PS0010-A, PS0055, PS0053, PS0037, PS0012, PS0066
13:50-14:10	**Invited Speech II**	**Prof. Hui Hou** Wuhan University of Technology, China
14:10-16:25	**Session 5**	**Renewable Energy and Energy Storage: Modeling, Estimation and Safe Operation** PS0043, PS0018, PS0051, PS0054, PS0062, PS0048, PS0038, PS0050, PS0059
16:25-16:30	**Break Time**	
16:30-16:50	**Invited Speech III**	**Assoc. Prof. Yongli Zhu** Sun-Yat Sen University, China
16:50-19:05	**Session 6**	**Smart Grid Operation, Forecasting, Protection and Distribution System Resilience** PS0031, PS0032, PS0068, PS0022, PS0039, PS0021, PS0067, PS0063, PS0065
19:05-20:50	**Session 7**	**Advanced Power Electronics, Electric Drives and Power Conversion Technologies** PS0057, PS0020, PS0064, PS0060, PS0061, PS0045, PS6001

Detailed Program

Opening Remarks

(General Chair)



Prof. Aman Oo

University of the Sunshine Coast, Australia

Venue: Meeting Room 1&2 **Period: 9:00-9:05**

Biography

Professor Aman Oo is a highly esteemed higher education leader with extensive international experience and a proven track record of excellence in both academia and industry. Currently serving as the Dean of Science, Technology and Engineering at The University of the Sunshine Coast, Australia. He previously held the same distinguished position at Deakin University and Auckland University of Technology, Macquarie University where he led Engineering, Computer, and Mathematical Sciences. A strong advocate for global collaboration, Professor Oo has successfully forged strategic partnerships with academic institutions across continents and spearheaded significant university-industry joint projects.As a Full Professor of Electrical Engineering, Professor Oo has made substantial contributions to electrical power engineering, renewable energy, smart grid, engineering education, and academic leadership. His prolific scholarly work includes over 350 high-impact publications (with H index of 50 and 10743 citations) in peer-reviewed journals, books, and conference proceedings.Renowned for his expertise, Professor Oo actively engages with international and national professional communities and industries. He is frequently sought after as a keynote speaker at premier global workshops and conferences.

Keynote Speaker I



Prof. Hua GENG

Tsinghua University, China

Venue: Meeting Room 1&2 **Period: 9:05-9:45**

Biography

Hua Geng received the B.S. degree in electrical engineering from Huazhong University of Science and Technology, Wuhan, China, in 2003 and the Ph.D. degree in control theory and application from Tsinghua University, Beijing, China, in 2008. From 2008 to 2010, he was a Postdoctoral Research Fellow with the Department of Electrical and Computer Engineering, Ryerson University, Toronto, ON, Canada. He joined Automation Department of Tsinghua University in June 2010 and is currently a full professor.

His current research interests include advanced control on power electronics and renewable energy conversion systems, AI for energy systems. He has authored more than 300 technical publications and holds more than 30 issued Chinese/US patents. He was the recipient of IEC 1906 Award and IEEE PELS Sustainable Energy Systems Technical Achievement Award. He is the Editor-in-Chief of IEEE Trans. on Sustainable Energy, IEEE IAS Distinguish lecture. He served as general chair, track chairs and session chairs of several IEEE conferences. He is an IEEE Fellow and an IET Fellow, convener of the modeling working group in IEC SC 8A.

Speech Info.

Mode Switching Induced Instability of DC microgrid

Abstract: Building reliable, efficient DC microgrids is crucial for protecting human safety and ensuring the dependable operation of critical equipment in extreme environments. Compared with large power systems, DC microgrids rely more on distributed renewable energy sources and feature multiple power supplies with comparable support capabilities. They must withstand sustained impacts under extreme conditions, which places higher demands on the autonomy of energy supply. At the same time, the system' s multi-source heterogeneity and distributed interconnection further increase reliance on energy coordination and self-organization. This report examines autonomous stability control theory for DC microgrids, focuses on design considerations under extreme environments, and proposes a “weakly centralized, strongly distributed” stability control approach for special requirements. Finally, it outlines directions for future research.

Keynote Speaker II



Prof. Kashem Muttaqi

University of Wollongong, Australia

Venue: Meeting Room 1&2 **Period: 9:45-10:25**

Biography

Professor Kashem Muttaqi is the Director of the Australian Research Council Industrial Transformation Training Centre in Energy Technologies for Future Grids (ARC Future Grids ITTC), which is sponsored by the Australian Government, and several industries and Universities in Australia. He is also the Director of the Australian Power and Energy Research Institute (APERI) at the University of Wollongong (UOW), New South Wales, Australia. He is a Distinguished Professor and Discipline Leader - Electrical Engineering at the School of Electrical, Computer and Telecommunications Engineering, University of Wollongong.

Professor Muttaqi received the B.Sc. degree in electrical and electronic engineering from Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh in 1993, the M.Eng.Sc. degree in electrical engineering from the University of Malaya (UM), Kuala Lumpur, Malaysia in 1996 and the Ph.D. degree in Electrical Engineering from the Multimedia University (MMU), Selangor, Malaysia in 2001 Professor Muttaqi has 30 years of academic experience and authored or co-authored more than 600 papers in international journals and conference proceedings. He has supervised around 35 higher-degree research students to completion. He has attracted more than $20 million research fundings.

Professor Muttaqi is the Editor-in-Chief of the IEEE Transactions on Industry Applications. He is an Executive Member of the IEEE Industry Applications Society (IAS) Board. He is also the Past Chair of the Industrial Automation and Control Committee (IACC) for the IEEE Industry Applications Society (IAS). He has been an Associate Editor for several journals, including IEEE Trans on Industry Applications, IEEE Trans on Sustainable Energy, and IET Generation, Transmission & Distribution. He is the General Chair for the IEEE International Conference on Energy Technologies for Future Grids (IEEE ETFG 2025) to be held on 7-11 December 2025 at Wollongong, Australia. He was the General Chair for the IEEE International Conference on Energy

Technologies for Future Grids (IEEE ETFG 2023) held on 3-6 December 2023 at Wollongong, Australia. He is a Member of the EEE Industry Applications Society, IEEE Power & Energy Society, IEEE Industrial Electronics Society, and IEEE Power Electronics Society.

Professor Muttaqi is the Editor-in-Chief of the IEEE Transactions on Industry Applications. He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), USA. He is a Fellow of the Institution of Engineering and Technology (IET), UK. He is also a Fellow of the Institution of Engineers Australia (IEAust).

Speech Info.

Grid-Enhancing Technologies for Unlocking Hidden Network Capacity

Abstract: Modern power grids possess significant hidden capacity that remains underutilised due to operational constraints, conservative planning assumptions, ageing infrastructure, and limited system visibility. Unlocking this latent capacity is critical for supporting the rapid integration of renewable energy while reducing the need for costly and time-consuming network expansion. This presentation explores the role of Grid-Enhancing Technologies (GETs) in improving the utilisation, flexibility, and resilience of existing power systems. The talk will highlight key technologies, including advanced power electronic converters, grid-forming technologies, smart grid solutions, energy storage systems, and digital monitoring platforms that enable dynamic power flow control, improved voltage and frequency stability, and enhanced real-time network visibility. It will also discuss how advanced control, optimisation, and market-driven operational strategies can maximise network utilisation, alleviate congestion, and increase renewable energy hosting capacity while maintaining secure and reliable grid performance. The presentation will provide insights into emerging pathways for transforming conventional power networks into intelligent, flexible, and renewable-ready infrastructures. By unlocking hidden network capacity through the deployment of GETs, power systems can accelerate decarbonisation, support large-scale renewable energy integration, and deliver a more sustainable and resilient energy future.

Coffee Break & Group Photo

(10:25-10:50)

Keynote Speaker III (GMT+10)



Prof. Bikash Pal

Imperial College London, UK

Zoom ID: 89876772858 **Period: 16:10-16:50**

Biography

Bikash Pal is a Professor of Power Systems at Imperial College London (ICL). He has his BEng degree (1990) from Jadavpur University (1990), and MEng degree (1992) in power engineering from The Indian Institute of Science, Bangalore and a PhD degree (1999) from Imperial College London as a Commonwealth Scholar. He is research active in power system stability, control, and estimation. He led three multinational and multi universities research collaboration between UK-China and UK-India in renewable energy integration and control. His research is conducted in strategic partnership with ABB, SIEMENS, GE Grid Solutions, UK, and National Grid, UK. UK Power Networks. SIEMENS R&D collaborated with him to develop fast power flow and volt-var control tools in Spectrum Power, an advanced module for distribution management system solution from SIEMENS running many power distribution utilities around the world. GE commissioned sequel of projects with him to analyse and solve wind farm HVDC grid interaction problems (2013-2019). Prof Pal was the chief technical consultant for a panel of experts appointed by the UNFCCC CDM (United Nations Framework Convention on Climate Change Clean Development Mechanism). He has offered trainings in Chile, Qatar, UAE, Malaysia and India in power system protections, stability and control topics. He has developed and validated a prize winning 68-bus power system model, which now forms a part of IEEE Benchmark Systems as a standard for researchers to validate their innovations in stability analysis and control design. He has published about 140 papers in IEEE Transactions and authored four books in power system modelling, dynamics, estimations and control.

In 2016, his research team won the President' s outstanding research team award at Imperial College London (ICL). He is a Fellow of IEEE for his contribution to power system stability and control. He is a Fellow of the Chinese Society of Electrical Engineers and a Fellow of The IET UK. He received 2025 IEEE PES Prabha Kundur Power System Dynamics and Control Award for his

technical contribution to power system control and estimation. He is elected a Fellow of The Royal Academy of Engineering, UK in 2023 for the impact of his contribution to the field of power engineering. He is elected as a foreign member of Chinese Academy of Engineering and Indian National Academy of Engineering in 2025. He is an IEEE Distinguished Lecturer in power distribution system estimation and control. He was Otto Monsted Professor at Denmark Technical University (DTU) (2019) and Mercator Professor sponsored by German Research Foundation (DFG) at University of Duisburg-Essen in 2011. He worked as faculty at IIT Kanpur, India. He holds a distinguished Visiting Professorship at the North China Electric Power University and Tsinghua University, China.

He was the Editor-in-Chief of IEEE Transactions on Sustainable Energy (2012-2017) and Editor-in-Chief of IET Generation, Transmission and Distribution (2005-2012). He was Vice President, PES Publications (2019-2023). He is elected as IEEE Power and Energy Society President Elect (2026-2027) for the office of The President in 2028-2029.

Beyond his profession, he has founded KAJALBABU MEMORIAL TRUST, an education charity in India to mentor children from economically disadvantaged background.

Speech Info.

A Journey through Power System Dynamics, Estimation and Control

Abstract: Large, interconnected power systems are inherently oscillatory. With more uptake from asynchronous generations, although the nature of oscillations has evolved, they are always difficult to control. Mainly robustness of the system control performance has been an issue. Model based linear robust control has been explored over the past 30 years, the control is not simple requiring model reductions. Model based control design strategy is effective if the model is very accurate, but they are not. Faster estimation of system dynamics, phasor estimation, point of wave estimation are now very useful for time critical monitoring and control of a real-world power networks. This talk will highlight the importance of linear robust control, model and control simplifications, various other robust low order dynamic estimation and control of power networks for their stable operation. It will discuss both centralised and decentralised options. It will consider the handling of feedback signal delays, sensitivity-based volt and Var control in large practical power distribution systems. The speaker will share his research experience in this topic.

Invited Speaker I (GMT+10)



Prof. Yu Wang

Chongqing University, China

Zoom ID: 89876772858 Period: 11:30-11:50, Sept. 30th

Biography

Yu Wang is a Professor and PhD Supervisor at Chongqing University, Deputy Academic Director of the State Key Laboratory of Power Transmission and Transformation Equipment Technology, and has been selected for the National Youth Talent Program. He received his PhD degree from Nanyang Technological University, Singapore, and formerly worked as a Marie Curie Research Fellow at Imperial College London.

He is an editorial board member of journals including *IEEE Transactions on Smart Grid, Journal of Modern Power Systems and Clean Energy,* and *IET Generation, Transmission & Distribution*. He has presided over scientific and technological projects such as the General Program of the National Natural Science Foundation of China, Chongqing Municipal Special Fund projects, and guideline projects of State Grid Corporation of China.

His research focuses on power system operation and control and smart microgrids. He has published more than 100 SCI/EI-indexed papers in related fields, with over 5,000 cumulative citations.

Speech Info.

LLM Agent Workflow for Power System Operation and Control

Abstract: Driven by the carbon peaking and carbon neutrality goals, the new-type power system is rapidly evolving toward high penetration of renewable energy and power electronics, bringing profound transformations across the source-grid-load-storage chain. As system complexity and uncertainty keep rising, traditional approaches to simulation modeling, dispatch decision-making and stability analysis are facing common industry bottlenecks: long iteration cycles, slow scenario adaptation, and high labor costs. Focusing on the practical deployment of large language model (LLM) and intelligent agent technologies in power system operation and control, this report systematically reviews the technological evolution of AI-enabled power regulation and presents two core research outcomes. The first is a full closed-loop method for LLM-driven transient stability assessment: it enables automated simulation via prompt engineering, retrieval-augmented generation (RAG) and feedback mechanisms, and achieves automatic neural architecture search through multi-agent collaboration, delivering classification accuracy and parameter efficiency that significantly outperform manual baselines. The second is a text-to-control LLM agent workflow for networked microgrids, which generates reinforcement learning scheduling strategies with expert-level performance in a short time through chained multi-agent collaboration covering task interpretation, mathematical modeling, algorithm design and code generation. The report also introduces the self-developed PSASP AI Agent power system analysis platform, and discusses future directions including multi-agent collaboration under physical mechanism constraints and domain knowledge enhancement, offering a novel technical paradigm and practical pathway for the digital and intelligent operation of new-type power systems.

Invited Speaker II (GMT+10)



Prof. Hui Hou

Wuhan University of Technology, China

Zoom ID: 89876772858 Period: 13:50-14:10, Sept. 30th

Biography

Prof. Hui Hou received the B.S. degree from Wuhan University, Wuhan, in 2003, and the Ph.D. degree from the Huazhong University of Science and Technology, Wuhan, in 2009. During 2015-2016, she was a visiting scholar at the University of Sydney. She is currently professor and Ph.D supervisor, as well as the Department Head of Electrical Engineering， School of Automation, Wuhan University of Technology. Her research interests include risk assessment of power system, energy internet, electric vehicles, etc. She has been AE for a number of journals such as PCMP (Protection and Control of Modern Power Systems), etc. She has been nominated as World's Top 2% Scientists by Stanford and Elsevier in 2024 and 2025

Speech Info.

Power System-Oriented Extreme Weather Scenario Identification: Hybrid Classical-Quantum Learning

Abstract: The increasing penetration of weather-dependent renewable energy has made modern power systems more vulnerable to extreme weather, highlighting the need for reliable identification of rare but operationally critical scenarios. This talk presents a power system-oriented framework for extreme weather scenario identification using hybrid classical-quantum learning. The framework combines meteorological anomalies, power system responses, and external event evidence to construct structured extreme-weather labels. To address the scarcity and severe class imbalance of extreme events, a quantum generative model is introduced for training-side minority-class augmentation, while hybrid classical-quantum classifiers are explored for scenario identification. Case studies using multi-region weather-power data from China demonstrate that quantum-assisted generation can preserve important risk characteristics of minority scenarios, while selected hybrid architectures achieve competitive identification performance with compact parameterization. The results also reveal the current computational limitations of quantum-enhanced learning. Finally, perspectives will be discussed on integrating identified extreme-weather scenarios with power system reliability assessment, resilience evaluation, reserve allocation, and risk-informed operation.

Invited Speaker III (GMT+10)



Prof. Yongli Zhu

Sun-Yat Sen University, China

Zoom ID: 89876772858 **Period: 16:30-16:50, Sept. 30th**

Biography

Yongli Zhu is presently an Associate Professor at the School of System Science and Engineering, Sun-Yat Sen University, Guangzhou, with a study focus on supporting the reliable and resilient operation of modern power grid. He received the B.S. degree from the Huazhong University of Science and Technology in 2009 and the Ph.D. degree from The University of Tennessee, Knoxville. His research interests include power grid reliability, power grid stability, and the applications of artificial intelligence to power grid operations. His previous working experience includes researcher and engineer roles, respectively, in TAMU, ISU, Amazon, and China State Grid Corporation.

Speech Info.

Quantum Computing for Loss of Load Probability: A Machine Learning-Assisted Approach

Abstract: As modern power systems increase in scale and complexity, evaluating network-constrained reliability indices such as Loss of Load Probability (LOLP) poses severe computational challenges for classical Monte Carlo simulations paired with AC Optimal Power Flow (OPF). This invited talk presents a novel machine learning-assisted quantum computing framework tailored for efficient power system reliability assessment. The proposed methodology first encodes component failure probabilities (derived from MTTF and MTTR) into quantum states via rotation gates. To bypass the computational burden of directly embedding non-linear AC OPF into quantum circuits, a classical Decision Tree surrogate model is trained to learn the loss-of-load criteria. The positive-leaf rules extracted from the decision tree are then converted into a compact quantum decision-tree oracle using reversible multi-controlled gates, dramatically reducing oracle complexity from exponential O(2^n) to O(L_+d). Finally, the Grover operator coupled with maximum-likelihood amplitude estimation is applied to compute the exact LOLP. Validated across IEEE 9, 14, 30, and 39-bus test systems, the approach achieves an average absolute error of 0.21%, matching classical Monte Carlo precision while providing vastly superior computational scalability. This presentation highlights how bridging artificial intelligence and quantum algorithms opens up new frontiers for smart grid reliability and operational planning.

Oral Session 1

AI-Driven Modeling and Safe Operation Strategies for Advanced Energy Storage Systems

10:50-11:50, September 29 @Meeting Room 1&2

Session Chair: Prof. Yutaka Sasaki, Hiroshima University, Japan

PS0003

Battery activity driven representative day selection to accelerate degradation estimation process

Shah Mohammad Mominul Islam[1], S. Ali Pourmousavi[1], Wen L. Soong[1] and Hossein Ranjbar[2]
1. Adelaide University, Australia
2. OptiGrid Pty Ltd, Adelaide, Australia

Abstract-Representative-day methods are widely used to reduce the computational burden of long-term battery degradation analysis in planning and design studies. However, conventional selection methods for representative days, such as cluster-mean or drought-day selection, are not always suitable for degradation analysis because they may not identify the battery activity patterns that drive ageing. This paper proposes two representativeday selection methods for the existing degradation estimation framework: 1) balanced positive and negative area (MethodI) and 2) frequent zero crossings (Method-II). The proposed selection methods are tested over ten years of data and compared against the Base Case and the existing cluster-mean selection method. The results show that both proposed methods improve the accuracy of the annual degradation estimation, with average relative errors reduced from 21.83% for the cluster-mean method to 5.12% and 6.71% for Method-I and Method-II, respectively. Among the two methods, Method-I gives the best overall performance.

PS0041-A

Electro-Thermally Feasible BESS Dispatch for Imbalance Settlement Markets via Safe Reinforcement Learning

Bingsong Tong, Xiang Zhu, Boman Su, Chao Wang, Hua Geng, Benben Jiang
Tsinghua University, China

Abstract-Battery energy storage systems (BESSs) can exploit short-term fluctuations in imbalance

settlement prices for energy arbitrage, leveraging their fast response capability and operational flexibility. However, profit-oriented dispatch may push battery operation toward electrical and thermal limits, while existing safe reinforcement learning methods often rely on post-hoc action correction and do not explicitly characterize coupled electro-thermal feasibility. To address these challenges, this work proposes an Electro-Thermal Feasibility-Aware Soft Actor-Critic framework (ETFA-SafeSAC) for BESS dispatch in the imbalance settlement market. A control-oriented thermal model is first converted into a thermal power envelope and combined with state of charge (SoC) and power limits to explicitly define an electro-thermal feasible action region, allowing infeasible control commands to be analytically projected onto admissible actions. Feasibility information is further incorporated into policy learning, enabling the actor to better capture the structure of the feasible region and generate more directly executable actions, thereby reducing both the frequency and magnitude of safety-layer interventions. Case studies using historical Belgian imbalance settlement market data across seven common random seeds demonstrate that, compared with Projection-only SafeSAC, ETFA-SafeSAC increases average lifetime-adjusted profit by 9.0%, reduces raw joint infeasibility by 8.68 percentage points, and decreases the mean projection residual by 62.6%. Further evaluation confirms that the proposed framework eliminates thermal violations while maintaining nominal BESS operation.

PS0006

A Multi-Source Data Fusion Approach for Early Warning of Sudden Wind Direction Change in Offshore Wind Farms

Feiyang Wen[1], **Jie Yan[1]**, Binghao Hou[1], Jian Yue[2] and Hangyu Wang[1]
1. North China Electric Power University, China
2. Beijing Goldwind Smart Energy Technology Co., Ltd. Beijing, China

Abstract-In offshore wind farms, Sudden Wind Direction Change Events (SWDCEs)—rapid, large-amplitude shifts affecting numerous turbines—induce severe yaw lag, power drops, and load surges, threatening operational safety. However, current research lacks quantitative field-level identification criteria, exhibits insufficient understanding of spatiotemporal dynamics, and suffers from poor generalization under extreme small-sample conditions. To address this, we propose a multi-source data fusion early warning framework using two-year SCADA and LiDAR data. First, we establish a “turbine-to-field” dual-level criterion to quantitatively detect SWDCEs. Subsequently, we construct a six-dimensional physical feature system that drives a LightGBM-based classification model. Results reveal that SWDCEs peak during seasonal transitions and afternoons, propagating spatially in a "sweeping" pattern. LightGBM consistently outperforms LSTM and 1D-CNN across all lead times, achieving the highest F1 (0.780) for immediate warning and outperforming LSTM and 1D-CNN by 37% and 85% at the 15-min lead time, respectively.

Furthermore, feature analysis confirms that SCADA data drives immediate warnings, while LiDAR provides critical distant foresight for advance warnings. Bounded by sensor coverage, the effective lead time is approximately 15 minutes. Ultimately, this framework delivers a robust, lightweight solution for SWDCE early warning.

PS0008

ANN-Based Prediction of Thermal Energy Storage Performance in Phase Change Material – Metal Foam Composites

Gul Muhammad[1,2], Canjun Yang[2], Ruiyin Song[1], Zesheng Yao[2], Sana[2] and Qingchao Xia[2]
1. Zhejiang University , China
2. Ningbo-Tech University, China

Abstract-Phase change material–metal foam (PCM/MF) composites have attracted significant attention for thermal energy storage applications due to their enhanced heat transfer performance. However, traditional numerical simulations for anticipating their thermal behavior are computationally and timeconsuming. In this study, artificial neural network (ANN)-based reduced-order models are utilized to quickly forecast the thermal energy storage capability of PCM/MF composites. Training data are derived from approved numerical simulations performed under various operational circumstances. Three neural network models are defined and compared: nonlinear autoregressive with exogenous inputs (NARX), long short-term memory (LSTM), and fully connected neural networks (FCNN). The findings demonstrate that the suggested ANN models can properly predict the transient thermal behavior of PCM/MF composites while greatly lowering computational time. The suggested method offers an effective and fast prediction tool for the design and optimization of PCM/MF-based thermal energy storage systems.

Oral Session 2

Frontier Technologies of Power Electronic System Control and Electromagnetic Drive

13:30-14:30, September 29 @Meeting Room 1&2

Session Chair: Assoc. Prof. Ahmed Bedawy Khalifa Hussien, Hiroshima University, Japan

PS0011-A

Composite forming technology for aluminum alloy corrugated hollow panels based on wireless coil pulsed current technology

Huiru Feng[1] and Xiong Qi[1,2]

1. China Three Gorges University, China

2. Wuhan National High Magnetic Field Center and State Key Laboratory of Advanced Electromagnetic

Abstract-Corrugated aluminum alloy hollow panels are promising lightweight structural and thermal-management components for electrical equipment and advanced engineering structures. However, conventional processes, including roll forming, superplastic forming/diffusion bonding, and welding-based assembly, still face limitations in forming accuracy, processing efficiency, equipment cost, and joining stability for complex aluminum hollow structures. This study proposes a coil-free pulsed- current-based composite electromagnetic forming method. Opposite pulsed currents are introduced into paired aluminum sheets to generate a transient magnetic field and Lorentz repulsive force, driving high-speed hollow cavity bulging, while electromagnetic pulse welding is used to join both sheet ends. The process is divided into two key stages: hollow cavity bulging and sheet-end electromagnetic pulse welding. A coupled circuit–magnetic–structural finite element model is established in LS-DYNA to analyze the dynamic deformation behavior, electromagnetic field evolution, and effects of system parameters. Results show that a stable aluminum hollow cavity with a height of about 9.2 mm can be achieved within 4 ms, and the sheet-end collision satisfies the dynamic requirements for effective welding. Increasing discharge voltage and capacitance enhances input energy, improving cavity height and forming quality. The proposed method offers an efficient manufacturing route for complex lightweight aluminum alloy hollow components.

PS0023

Stochastic Day-Ahead Scheduling Considering Local Microgrid Imbalance Management under Electric Vehicle Uncertainty

Yutaka Sasaki, Kenji Konishi, Ahmed Bedawy, Yoshifumi Zoka and Naoto Yorino
Hiroshima University, Japan

Abstract-In power systems, electric vehicles (EVs) are utilized as “mobile batteries” through charging and discharging technologies such as Vehicle-to-Grid (V2G). Since grid-connected battery energy storage systems (BESS) and similar systems are relatively expensive, having EVs function as alternatives offers significant benefits to utility operators. However, EVs are difficult to predict due to owner behavior, making them a highly uncertain resource. To address this uncertainty, Virtual Power Plants (VPPs), which integrate and operate EVs and Variable Renewable Energy (VRE) as resources, serve as Energy Management Systems (EMS) that maintain the balance between electricity supply and demand in real time. In this paper, the authors propose a probabilistic day-ahead supply-demand schedule that accounts for EV uncertainty. In actual operation, electricity procurement from the power market is planned the day before, and the system is operated while responding to the unpredictability of VRE, EVs, and other factors on the day of operation. Given the current trend of an increasing number of retail electricity suppliers, the authors conduct an economic evaluation focusing on the operating costs of grid-connected microgrids (MG). Furthermore, this study adopts a more realistic and refined model that accounts for multiple EV travel behavior patterns.

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Fault Response Characteristics of Grid-Forming Inverters During High-Impedance Earth Faults

Raul Barrera[1], Narottam Das[1], Shantanu Kumar[2] and Shaminda Da Silva[1]
1. Central Queensland University Australia, Australia
2. ARUP Australia, Australia

Abstract-The modern power grid is transitioning from a conventional architecture dominated by synchronous generators (SG) toward systems with increasing penetration of inverter-based resources (IBRs). Unlike SGs, IBRs provide limited fault-current contribution, with their fault response governed by converter control algorithms and semiconductor operating constraints rather than electromechanical dynamics. Consequently, fault currents in IBR-dominated networks are typically limited in magnitude and duration, presenting significant challenges for the detection and protection of high-impedance earth faults (HIEFs).The influence of these elements and their control mechanisms on earth-fault behaviour, particularly under high-impedance fault conditions, remains

insufficiently understood. This paper investigates the response of grid-forming inverters (GFM) during high-impedance earth faults using electromagnetic transient simulation models. Here, attention is given to fault-current characteristics, zero-sequence voltage and current behaviour, control-system interactions, and the influence of inverter operating constraints on fault observability. The findings of this study aim to provide new insight into the mechanisms governing earth-fault response in IBR power systems and establish the foundation for the development of next-generation protection methods based on high-frequency and travelling-wave phenomena.

PS0013-A

Numerical Simulation and Parameter Optimization of Electromagnetic Expansion Forming of Aluminum Alloy Tubes Assisted by a Hollow Field Shaper

Lingran Xi, Yuying Wei, Huiru Feng and Qi Xiong
China Three Gorges University, China

Abstract-To address the problems of structural redundancy, ineffective eddy-current loss, and insufficient energy utilization in traditional solid field shapers during electromagnetic expansion forming of aluminum alloy tubes, this paper pro-poses an electromagnetic tube expansion forming method assisted by a hollow field shaper. Based on the skin effect and the distribution characteristics of in-duced currents, the conventional solid field shaper is modified into a hollow structure. A coupled electromagnetic–structural finite element model is estab-lished to comparatively analyze the expansion performance, circumferential uniformity, and electromagnetic field distribution of aluminum alloy tubes un-der solid and hollow field shapers. The results show that, under the same dis-charge parameters, the hollow field shaper effectively increases the radial ex-pansion at the middle of the tube. The maximum single-side expansion increases from 6.75 mm to 7.42 mm, representing an improvement of approxi-mately 10%, while the effective forming range increases from 49.13 mm to 53.11 mm, an improvement of approximately 8%. This is mainly because the hollow structure suppresses ineffective eddy currents inside the field shaper, allowing more induced current to concentrate in the working region near the tube, thereby enhancing the local magnetic field and radial electromagnetic force. Further parametric analysis indicates that appropriately reducing the in-ner and outer wall thicknesses of the field shaper and optimizing the inner wall height can further improve tube expansion performance. This study demon-strates that hollow field shapers can improve the forming efficiency of alumi-num alloy tubes while maintaining forming uniformity, providing a reference for efficient forming of lightweight tubes and structural optimization of field shapers.

Oral Session 3

Resilience Enhancement and Market Trading Mechanisms for New Power Systems
15:10-16:10, September 29 @Meeting Room 1&2
Session Chair:

PS0033

A Severity-Based Voltage Sensitivity Control for Simultaneous Voltage Regulation and Voltage Imbalance Mitigation in Active Distribution Networks

Ahmed Bedawy, Yutaka Sasaki, Yoshifumi Zoka and Naoto Yorino
Hiroshima University, Japan

Abstract-The increasing penetration of photovoltaic (PV) generation in active distribution networks intensifies both voltage deviation and voltage imbalance problems, particularly in unbalanced feeders. Conventional voltage regulators primarily target voltage regulation and may offer only limited improvement in voltage imbalance. This paper proposes a severity-based sensitivity control strategy that simultaneously regulates voltage and mitigates voltage imbalance. At each control interval, signed voltage deviation and voltage imbalance severity indices are evaluated for each control area, and the index corresponding to the more severe voltage-quality condition is selected as the dominant control signal. The selected severity index is subsequently incorporated into a voltage/tap sensitivity-based control framework to determine the required tap action. Consequently, the regulator dynamically adjusts its control priority based on the dominant voltage-quality problem, without requiring predefined weighting factors or complex multi-objective optimization. The proposed strategy extends the conventional sensitivity-based voltage-regulator control framework to simultaneously account for voltage deviation and voltage imbalance while retaining a simple distributed control structure. The proposed strategy is evaluated through a 24-h simulation of an unbalanced IEEE 123-node distribution feeder with high PV penetration. Simulation results show that the proposed controller effectively reduces both voltage deviation and voltage imbalance, achieving better voltage regulation than the voltage-deviationbased controller while maintaining nearly the same imbalancemitigation performance as the dedicated voltage-imbalance-based controller. The proposed approach therefore offers a simple and practical extension of sensitivity-based voltage control for renewable-rich distribution networks.

PS0009-A

Identification of the Phase Transition Between Centralized and Distributed Energy Systems: Implications for Distributed Datacentres

Ryoga Ono, Farhan Mahmood, Motoki Suwabe, Miho Iwamoto, Miki Ueshima and Toshihiro Hayashi

Space Environment and Energy Labs., NTT, Inc., Japan

Abstract-Energy transition can be regarded as a phase transition from centralized to distributed energy systems. This transition is becoming increasingly important with the rapid deployment of renewable energy resources and the growing electricity demand of digital infrastructures such as datacentres. However, fully distributed systems may require substantial investment and operational costs. Therefore, integrated energy systems combining centralized and distributed structures are expected to play an important role in achieving a sustainable and renewable-based energy future, although the governing factors remain unclear. This study aims to identify the phase transition region and the factors governing the transition between centralized and distributed energy systems through network analysis and parameter-sweep simulations, with implications for future datacentre-integrated energy systems. Energy exchange among regions is modelled as a maximum-flow problem solved on four representative graph topologies: the Barabási–Albert model, Erdős–Rényi model, Watts–Strogatz model, and Random Geometric Graph. To evaluate the degree of operational decentralization, the flow distribution Gini coefficient is introduced as a quantitative indicator of distributed energy transportation. The results reveal that network topology influences the emergence of distributed operations; however, decentralized operation is not uniquely determined by graph topology alone. In contrast, the spatial distributions of energy demand and supply strongly affect the transition between centralized and distributed operational states. Specifically, centralized operation emerges when energy supply is spatially distributed while demand remains concentrated, whereas decentralized operation tends to emerge under the opposite condition. These findings suggest that demand and supply distributions have a greater influence on operational decentralization than network topology itself. At the conference, we will present the identified transition factors and discuss their implications for future integrated energy systems involving geographically distributed datacentres in Japan. The findings provide a fundamental perspective on how demand redistribution enabled by digital infrastructure may contribute to the energy transition.

PS0017

Flexible Inertia Support Using Adjustable Synchronous Compensator for Enhancing Stability of Modern Power Systems

Kevin G. H. Mangunkusumo[1], N. Mithulananthan[1] and A. Rizqiawan[2]

1. The University of Queensland, Australia

2. Institut Teknologi Bandung, Indonesia

Abstract-The increasing penetration of inverter based resources (IBR) poses new challenges to power system stability due to its fluctuating output characteristics and the lack of physical inertia. During high IBR production and low load, the number of operating synchronous generators can be reduced to avoid inefficient thermal operation. However, reducing the number of online synchronous machines causes a decrease in system inertia and increase in the Rate of Change of Frequency (RoCoF) due to disturbance. Higher RoCoF means the system frequency changes too rapidly causing less time control and protection systems to respond, thereby increasing the risk of frequency collapse, or even blackout. This study proposes a twostage evaluation framework to assess the inertia requirements and contribution of adjustable inertia synchronous compensators in systems with high IBR penetration. The first stage uses a quasi static hourly dispatch model to connect the daily operating profile and synchronous generator unit commitment to the total system inertia and RoCoF estimation. The second stage uses dynamic simulations during the most critical period to evaluate the frequency and voltage stability with a contingency scenario. The simulation results show that under existing conditions, the period from 7:00 to 14:00 is the most critical period with a total inertia of approximately 30 MWs and a RoCoF of approximately 2.48 Hz/s. The adjustable inertia synchronous compensator reached the RoCoF requirement of approximately 1 Hz/s delaying the nadir time from 3.902 to 5.692 s and improving the minimum voltage from 0.9513 p.u. to 0.9747 p.u. These results indicate that the adjustable inertia synchronous compensator not only improves frequency stability through additional physical inertia but also supports voltage stability at required period. This study confirms that system inertia requirements are temporal and need to be evaluated based on daily operating conditions, rather than solely through a fixed capacity approach.

PS0014

Development and Evaluation of a Probabilistic Area Price Forecasting Method for the Japan Electric Power Exchange Using Bayesian Inference

Hidetaka Baba[1], Yoshifumi Zoka[1], Yutaka Sasaki[1], Ahmed Bedawy[1], Seiji Kawauchi[2] and Hironori Kakui[2]

1. Hiroshima University, Japan
2. The Chugoku Electric Power Co., Inc., Japan

Abstract-This paper proposes an area price forecasting method for the Japan Electric Power Exchange (JEPX) spot market based on the Time-Aligned Weighted Bayesian Estimation Method (TAW-BEM). The proposed method employs a computationally efficient Bayesian linear regression model that utilizes historical data collected at the same time of day to probabilistically forecast

electricity prices by explicitly modeling the relationship between net load and area prices. This method aims to improve forecasting accuracy while maintaining model interpretability and quantifying predictive uncertainty. Furthermore, its simple model structure makes it suitable for realtime applications. The performance of the proposed approach was evaluated by comparing it with a LightGBM-based forecasting method. The results demonstrate that the proposed method achieves comparable or superior predictive performance while simultaneously providing reliable uncertainty estimation. Therefore, the proposed method can provide reliable information to support decision-making processes in electricity market operations.

Online Session 4

Integrated Energy Systems, Optimal Scheduling and Energy Management	
11:50-13:50, September 30	**Zoom ID: 89876772858** **Zoom Link: https://us2web.zoom.us/j/89876772858**
Session Chair: Ahmed Bedawy, Hiroshima University, Japan	

PS0007

Electric vehicle adoption in Brazil: A techno-economic assessment under vehicle-to-grid operation with residential photovoltaic systems

Daywes Pinheiro Neto[1], Isabela Lopes Magalhaes[1], Thiago Augusto Mendes[1], Antonio Paulo Coimbra[2], Pedro Moura[2] and An´ ıbal T. de Almeida[2]

1. Federal Institute of Goiás, Brazil
2. University of Coimbra, Portugal

Abstract-This study assesses the techno-economic viability of residential electric vehicle (EV) adoption in Brazil considering vehicle-to-grid (V2G) operation and photovoltaic (PV) integration. A case study for a residence in Goiania was conducted, including a sensitivity analysis of Net Present Value (NPV) as a function of daily mileage and PV capacity. The results indicate the existence of an optimal PV sizing that maximizes economic performance. For a daily mileage of 35 km, the optimal PV capacities were 4.4 kWp without V2G and 1.4 kWp with V2G, showing that bidirectional operation reduces the required PV capacity due to the operational flexibility provided by the EV battery. The base scenario without PV and without V2G presented an NPV of USD 188.08 and a discounted payback period (DPB) of 14.00 years, while the best economic performance was obtained for the PV scenario without V2G, with an NPV of USD 3,962.28 and a DPB of 7.33 years. Although V2G improved the economic indicators compared to the base scenario, the additional costs associated with the bidirectional charger reduced the economic attractiveness under the evaluated conditions. Overall, the results demonstrate the economic potential of PV integration for residential EV applications in Brazil.

PS0040

System-Value-Based EV Prioritization for Differentiated Multi-Market Allocation

Zhe Yuan, Weiyi Tian, Jing Qiu, Zongting Xie, Jiafeng Lin and Sihai An

The University of Sydney, Australia

Abstract-Aggregated electric vehicles (EVs) can provide flexible capacity to energy and ancillary service markets, but individual EVs differ in their contribution to system operation and the participating markets differ in economic value. This paper proposes a contribution-priority multi-market allocation method that couples these two dimensions. Historical network-constrained operation is reconstructed, and each EV is evaluated through the increase in minimum system operating cost caused by its removal from the fleet. The resulting marginal contributions are normalized and mapped into differentiated market-access profiles, while day-ahead, regulation, and reserve markets are ranked ex ante according to expected economic value. These two priorities are coupled through cumulative access constraints within a scenario-based scheduling model. Case studies on a 33-bus distribution network with 24 heterogeneous EVs show that the top 50% of EVs provide 90.6–94.0% of priority-market commitment. Compared with the resourcebased baseline,expected profit increases by 18.6–35.1%, while differentiated access provides a further 1.2–7.0% gain over the nondifferentiated case.

PS0010-A

Renewable-Energy-Aware Site Planning for Distributed Data Centers to Bridge the Geographic Gap Between Renewable Energy Resources and AI Demand

Miki Ueshima, Farhan Mahmood, **Motoki Suwabe**, Ryoga Ono, Miho Iwamoto, and Toshihiro Hayashi
Space Environment and Energy Laboratories, NTT, Inc., Japan

Abstract-The growth of AI services is expected to increase data center electricity demand. At the same time, renewable energy resources are often located far from major computing demand centers. This spatial mismatch contributes to challenges such as renewable energy curtailment and grid interconnection constraints. This mismatch is particularly evident in Japan, where renewable energy potential is high in regions such as Tohoku and Kyushu, whereas data center demand is concentrated in metropolitan areas such as Tokyo and Osaka.
Deploying distributed data centers in renewable-energy-rich regions is a promising approach to mitigating this mismatch. However, selecting suitable locations requires comprehensive evaluation from energy, business, and regional perspectives.
This study proposes a multi-criteria decision-making (MCDM)-based framework for evaluating distributed DC locations to maximize renewable energy utilization. The framework integrates objective weighting derived from regional datasets related to energy, economics, and infrastructure with subjective weighting reflecting the preferences of stakeholders, such as data center operators and local governments, enabling evaluation from diverse decision-making perspectives and

enhancing site-selection transparency. Candidate locations are assessed by integrating multiple heterogeneous indicators, including renewable energy potential, business feasibility, and regional economic impacts.

A case study in Japan demonstrates that the proposed framework can identify locations balancing renewable energy utilization and business feasibility while accommodating stakeholder priorities. The results indicate that location rankings vary with stakeholder priorities, highlighting the importance of incorporating diverse perspectives into the site-selection process. The proposed method supports data center site planning that considers the geographic gap between renewable energy resources and AI computing demand, contributing to improved renewable energy utilization and reduced curtailment. Furthermore, it supports Watt-Bit integration, a concept that aims to coordinate energy and information-communication infrastructures through distributed data center deployment. By facilitating coordination between power and ICT systems, the proposed approach contributes to sustainable renewable energy use and efficient infrastructure planning.

PS0055

Time-Coupled Flexibility Regions of ElectricityHydrogen Ports With Logistics and Onboard Fuel Constraints

Lin Liu, Hongming Yang, Sicheng Li and Sheng Xiang
Changsha University of Science and Technology, China

Abstract-Traditional hour-by-hour power limits cannot fully capture the cross-temporal coupling between port logistics and hydrogen energy states. This paper therefore constructs a temporal flexibility domain for an electro-hydrogen port, integrating ship loading/unloading, hydrogen vehicle operations, onboard hydrogen states, and stationary hydrogen storage, to characterize feasible gridinterface power trajectories. A mixed-integer linear model describes port operations, while directional optimization and commandfollowing are used to identify flexibility boundaries and sustained regulation capacity. In a 24-hour case study, considering cross-time coupling reduced the hourly average adjustment amplitude by only 0.03%, but the sustainable 8-hour upward regulation capacity decreased from 360.00 kW to 236.28 kW, a 34.37% reduction. For two consecutive 4-hour windows, the convex-hull area of sampled feasible trajectories was only 82.78% of the corresponding hourly rectangular region. Ablation results show that this reduction mainly arises from logistics-task completion requirements and hydrogen-state recovery constraints. Thus, large hourly margins do not necessarily imply deliverable flexibility over extended periods continuously. These results demonstrate that hourly power boundaries may substantially overestimate sustained regulation capability, highlighting the need to evaluate port flexibility using temporally feasible power trajectories.

PS0053

LLM-Assisted Adaptive Unit Commitment Formulation with Guaranteed Feasibility

Xiyuan Zhou[1], Mo Chen[2], Yuheng Cheng[2], Yan Xu[1], Junhua Zhao[2] and Kashem Muttaqi[3]
1. Nanyang Technological University, Singapore
2. The Chinese University of Hong Kong, Shenzhen, China
3. University of Wollongong, Australia

Abstract-Unit commitment (UC) is essential for reliable and economic power system operation, yet fixed formulations are often insufficient to meet varying operating requirements. Large language models (LLMs) provide a flexible way to understand task requirements, identify appropriate formulations, and construct UC models, but their nondeterministic outputs and potential hallucinations may lead to modeling errors and infeasible solutions. To address this issue, we propose an LLMassisted adaptive UC formulation framework with guaranteed feasibility, supported by three Retrieval-Augmented Generation(RAG) libraries for formulations, code templates, and constraints.The LLM is restricted to formulation identification and templatebased model construction using verified and traceable knowledge.Solver-based validation and independent constraint auditing ensure that only solvable and constraint-compliant models are accepted, while verification feedback enables closed-loop formulation adaptation. Experiments on 100 UC tasks with varying modeling requirements show that the proposed framework successfully generates numerical solutions for 98% of the tasks, achieving a 100% feasibility rate among the generated solutions. These results demonstrate the effectiveness of the proposed framework in enabling reliable and feasible LLMassisted UC modeling.

PS0037

Game-Consistent Player Reduction for Scalable Nucleolus Allocation in Cooperative Energy Sharing

Weiyi Tian, **Zhe Yuan**, Jing Qiu, Jiafeng Lin and Xin Lu
The University of Sydney, Australia

Abstract-The computational burden of nucleolus allocation grows rapidly with the number of participants in cooperative energysharing systems. This paper proposes a WRT-inspired fidelitycontrolled player-reduction framework for scalable nucleolus allocation. Participants are represented using physical-economic signatures and grouped through entropy weighting and densitybased clustering. Candidate partitions are screened using feature compactness, member-wise game consistency, and aggregationinteraction consistency. Reduced coalitions are restored to their original participants before network-constrained valuation, and the reduced-space nucleolus is then recovered to participant-level payoffs. For the N=10 benchmark, the proposed method retains

6.07% of the original coalition space with a normalized L_1 allocation error of 3.67%, compared with 14.31% under feature-only reduction. At N=30, the coalition space is reduced by approximately 6.55 x 10^4.

PS0012

A Robust Optimisation Model for Reliable, Flexible, Cost-Effective, and Self-Sufficient Smart Microgrids

Sobhan Dorahaki[1], Mohd Zamri Che Wanik[2], Syed Islam[3], Fei Gao[4] and S. M .Muyeen[1]
1. Qatar University, Qatar
2. Hamad Bin Khalifa University, Qatar
3. Federation University Australia, Australia
4. University of Technology of Belfort-Montbéliard, France

Abstract-Smart microgrids have emerged as an effective solution for improving economic efficiency and increasing local utilisation of distributed energy resources (DERs). This paper proposes a mixed-integer linear programming (MILP) optimisation framework for smart microgrids operating under sharing economy principles. The proposed model coordinates shared DERs, including photovoltaic (PV) systems, electrical and thermal energy storage systems (ESSs and TSSs), and combined heat and power (CHP) units, while incorporating flexibility constraints and explicitly considering Energy Not Supplied (ENS) in the scheduling process. PV generation uncertainty is addressed using a robust optimisation approach. The proposed MILP model is solved using CPLEX and evaluated over a one-week case study. The results indicate that ESS deployment eliminates ENS under the investigated interruption scenarios and reduces operating costs by more than 50%. Moreover, increasing the flexibility limit from 1 kW to 10 kW reduces operating costs by over 35%, while maintaining high levels of self-sufficiency during most operating hours. These results demonstrate the capability of the proposed framework to coordinate DER operation under the considered uncertainty scenarios.

PS0066

Coordinated Reactive Power Dispatch for Overvoltage Mitigation in PV-Rich Distribution Networks

T. D. A. V. Thuduwage, Kashem M. Muttaqi and Ashish P. Agalgaonkar
University of Wollongong, Australia

Abstract-High penetration of solar photovoltaic (PV) systems can cause overvoltage problems in distribution networks during periods of high generation and low demand. Reactive power support from PV inverters is an effective solution for voltage regulation, but sensitivity based dispatch may

overuse a small number of highly effective inverters and drive them to saturation. This paper proposes a coordinated reactive power dispatch strategy that considers both voltage sensitivity and inverter headroom for overvoltage mitigation. Time-series simulation results show that the proposed method maintains voltages within acceptable limits while proportionally allocating reactive power through participating inverters. Compared with conventional sensitivitybased dispatch, the proposed approach improves the utilization of available inverter capability and preserves reactive flexibility for subsequent control actions.

Online Session 5

Renewable Energy and Energy Storage: Modeling, Estimation and Safe Operation	
14:10-16:25, September 30	**Zoom ID: 89876772858** **Zoom Link: https://us2web.zoom.us/j/89876772858**
Session Chair: Prof. Hui Hou, Wuhan University of Technology, China	

PS0043

A Probabilistic Forecasting Method for eVTOL Battery Power-Delivery Margins Using Learned-Prior Diffusion Model

Jiabao Zhai and Xiangyu Li
The Hong Kong University of Science and Technology (Guangzhou), China

Abstract-Safe operation of electric vertical take-off and landing (eVTOL) aircraft requires batteries to sustain landingpower demand without falling below the powertrain cut-off voltage. Because battery aging and operating conditions cause the minimum landing voltage to evolve non-monotonically across missions and cells, forecasting its trajectory and uncertainty is important for mission planning. We formulate the minimum landing voltage, a measurable proxy for the margin above a fixed cut-off, as an eight-step probabilistic forecasting problem. Our learned-prior diffusion forecaster uses a Transformer to derive a condition-dependent prior center and denoising context from mission histories and operating protocols, with a learnable forward transformation and a DDIM-style sampler. On the CMU eVTOL battery dataset, using a cell-wise split and five random seeds, the model attains the lowest mean absolute error and continuous ranked probability score among the evaluated methods, though its margin over the strongest baselines falls within seed-to-seed variation. The raw diffusion samples are under-dispersed, but conformalized quantile regression brings the empirical coverage of the nominal interval close to its target level. These results indicate that learned conditional priors can improve probabilistic voltage forecasting, while reliable intervals still require explicit calibration.

PS0018

Control Strategy for PV-HESS Based on Adaptive Virtual Synchronous Generator

Changke Zhao[1], Xiaolu Li[1], **Qiuchen Guo[1]**, Jinsong Liu[2], Hongzhong Li[1] and Shunfu Lin[1]
1. Shanghai University of Electrical Power, China

2. State Grid Shanghai Municipal Electric Power Company Shanghai China

Abstract-Variations in grid strength significantly alters the synchronizing stiffness and closed-loop dynamics of grid-forming virtual synchronous generators (VSGs), making fixed inertia and damping control strategy unsuitable for different operating conditions. Furthermore, conventional adaptive strategies based solely on frequency deviation and the rate of change of frequency (RoCoF) cannot determine whether a disturbance occurs under strong- or weak-grid conditions or at a light or heavy loading level. Thus, this article proposes a grid-strength-aware adaptive inertia-damping control strategy for a photovoltaic system integrated with hybrid energy storage. The predicted short- circuit ratio (SCR) is normalized by operating apparent power and combined with local synchronizing stiffness to estimate the effective strength of the current operating point. Additionally, a frequency-driven fast correction mechanism is introduced to enhance transient support, while the admissible parameter space is rigorously bounded by dc-link, storage, and converter-current margins. An averaged dq-domain model is utilized to evaluate the proposed strategy's SCR adaptability, grid-strength recovery, active-power support, and frequency-support energy. The simulation results demonstrate that the enhanced frequency and power regulation, reduced unnecessary storage depletion, and robust operation across a wide range of SCRs. The proposed strategy effectively decouples slow, grid-aware prescheduling from fast, event-driven corrections, thereby avoiding the uniform, inefficient deployment of storage support for disturbances arising from different network conditions.

PS0051

Enhanced State-of-Charge Estimation for Lithium-Ion Batteries Using a NIS-Based Adaptive Extended Kalman Filter

Kuya Matsushita[1], Izumi Kadowaki[1], Long Ton-That[2] and **Nguyen Gia Minh Thao[1]**
1. Shimane University, Japan
2. International University, VNU-HCM, Vietnam

Abstract-In recent years, to achieve a decarbonized society, implementations of electric vehicles (EV) and renewable energy systems have accelerated substantially. From this background, lithium-ion batteries are the essential parts of cutting-edge devices. To ensure battery safety and efficiency, the battery management system (BMS) is continuously developed and optimized; in particular, estimating state of charge (SOC) precisely is a critical task. Motivated above, this research proposes a high-accuracy SOC estimation method against disturbance and initial error using an adaptive extended Kalman filter (AEKF) with a changeable forgetting factor adjusted by the normalized innovation squared (NIS), that is an efficient way to optimize noise parameters based on observer

data. From simulation results, the proposed NIS-based AEKF significantly improves accuracy and decreases spike-like errors in battery SOC estimation under both discharge and charge conditions, as compared to the conventional extended Kalman filter (EKF).

PS0054

Sequential Planning of Modular Energy Storage for Power Quality Enhancement in Rural Distribution Networks

Peng Wang[1], Hongming Yang[1,2], Shang Ma[2] and Yu Zheng[2]
1. Hunan University, China
2. Changsha University of Science &Technology, China

Abstract-To address the heavy overloading of distribution transformers and nodal voltage limit violations caused by seasonal source-load mismatch, this paper proposes a sequential planning approach of modular mobile energy storage (MMES) to enhance power supply quality in rural distribution networks. First, leveraging the standardized and plug-and-play electrical characteristics of MMES, a flexible integration architecture is constructed, which is characterized by centralized deployment, on-demand relocation, and idle-time retrieval. Second, an MMES sequence with differentiated power-to-energy ratios is formulated to accommodate the complex regulation requirements characterized by the coexistence of short-term power spikes and long-term energy deficits. Building upon this, a coordinated planning model encompassing the centralized deployment and on-demand relocation scheduling of both energy-type and power-type MMESs is established. Finally, case studies on a county-level rural distribution network in Hunan Province demonstrate that, compared with traditional stationary energy storage schemes, the proposed approach can mitigate voltage violations and transformer overloading at a lower energy storage investment cost. Furthermore, the sequential configuration of MMES avoids the poor power adaptability and capacity underutilization issues inherent in single-type energy storage under complex operating conditions. Consequently, it achieves an optimal trade-off among the costs of energy storage investment, relocation scheduling, and grid violation penalties, thereby effectively enhancing the power supply quality of rural distribution networks.

PS0062

Salt Cavern Compressed Air Energy Storage Technology and Feasibility Analysis

Yifan YANG[1], Fei YUAN[1], **Ye XIA**[2] and Shaoxu HAO[3]
1. China Energy Engineering Corporation Limited, China
2. China Electric Power Research Institute, China
3. State Grid Beijing Electric Power Company, China

Abstract-Salt cavern energy and gas storage, as a novel large-scale, clean, and efficient energy storage approach, is of great significance for accelerating the planning and development of a new energy system, ensuring energy security, and promoting green, low-carbon, and high-quality development. This paper reviews the current development status of salt cavern energy storage both in China and abroad and systematically introduces the technical pathways, key technologies, and core equipment of compressed air energy storage (CAES). Taking the Shandong power grid as a case study, the feasibility of salt cavern compressed air energy storage (SC-CAES) is investigated from the perspectives of supporting grid infrastructure, rock salt resources, and investment returns. Finally, targeted recommendations are proposed to accelerate the development and deployment of SC-CAES.

PS0048

Physics-Informed Joint Estimation of Core Temperature and State of Charge for Lithium-Ion Batteries

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Abstract-Lithium-ion batteries underpin modern electrification, from electric vehicles to grid-scale renewable storage. As these batteries' safe operation hinges on the temperature inside the cell core, understanding internal electro-thermal dynamic mechanisms and accurately estimating core temperature are both essential for enhancing thermal management of lithium-ion batteries. Through systematic investigation, we reveal a strong coupling between core temperature and state of charge (SOC). The results demonstrate that SOC plays a dominant role in governing internal thermal evolution. Building on these insights, we further develop a physics-informed neural network that leverages the identified coupling relationships to jointly estimate core temperature and SOC with high accuracy (0.34% error). This integrated framework illuminates the governing electro-thermal dynamics and enables more accurate and efficient battery thermal management.

PS0038

Coordination of Battery Bank Operation Based on DC Link for Improved Energy Storage Systems

Tinghao Niu and Weidong Xiao
The University of Sydney, Australia

Abstract-The battery energy storage system (BESS) market has experienced rapid growth in recent

years to mitigate the intermittency of renewable power sources, e.g., solar and wind, and to ensure grid stability and resilience. Battery packs are required and connected for a high-capacity BESS. It is impossible to parallelize two battery packs with different ratings to increase storage capacity without power conversion interfaces. Conventional AC-coupled solutions introduce additional conversion stages, system complexity, cost, and low efficiency. To address this issue, this paper proposes a DC-coupling solution in which the voltage ratio between battery packs is used to coordinate bidirectional power transfer. The topology of a dual-active bridge (DAB) enables bidirectional power conversion between battery packs with different ratings. The system dynamics are derived, analyzed, and used for the model-based controller design. A novel voltage-ratio feedback control is proposed for the coordination. Simulation results with 400-V and 50-V battery packs connected through a 1:8 DAB converter show that the voltage ratio converges to its reference within approximately 0.4 s under both discharging-to-charging and charging-to-discharging transitions, verifying the effectiveness of the proposed coordination approach.

PS0050

Machine Learning-Enhanced Digital Twin Framework for Proactive Renewable Energy Coordination in Smart Grids

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2. University of Wollongong, Australia

Abstract-The increasing penetration of renewable energy resources is creating new operational challenges for power systems due to the variability and uncertainty of weather-dependent generation. This paper presents a machine learning-enhanced digital twin (ML-DT) framework for proactive renewable energy coordination, validated using 104,544 real 15-minute observations from the ENTSO-E Transparency Platform for Germany spanning 2022–2024. The proposed framework comprises five interconnected layers: physical infrastructure, data acquisition and communication, digital twin representation, forecasting and scenario simulation, and coordination and decision-making. A set of 34 engineered features is used to train and evaluate Ridge Regression, Random Forest, LightGBM, XGBoost, and Long Short-Term Memory (LSTM) models for short-term demand forecasting. Compared to other forecasting techniques, LightGBM is found to be promising and has provided the best balance between accuracy and computational efficiency, delivering a testset RMSE of 120.0 MW and a 97.9% reduction relative to a persistence benchmark. The selected model was integrated into the digital twin coordination layer to support predictive battery scheduling and renewable energy management. Simulation results demonstrate renewable curtailment reductions of 26.1 GWh and 50.8 GWh under renewable penetration levels of 54% and 66%, respectively. The framework provides a practical and transferable approach for forecast-

informed renewable energy coordination in future smart grids.

PS0059

Uncertainty-Aware Satellite-Based Solar Nowcasting for Photovoltaic Production and Renewable Energy Management

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Abstract-High solar penetration increases the uncertainty of reserve allocation, battery scheduling, and real-time power balancing by introducing short-term generation fluctuation. This research introduces SUNFLOW, a probabilistic solar nowcasting framework enabled by satellites that generates uncertainty-aware global horizontal irradiance forecasts and PV-generation scenarios for smart-energy applications using near-realtime INSAT-3D measurements. Cloud-field extraction, optical-flow motion estimates, physics-based advection, ensemble perturbation, and percentile-based forecasting at 15-minute intervals over 15–180-minute horizons are all integrated by SUNFLOW. For operational decision assistance, P10–P90 projections measure uncertainty and offer low-, median-, and high-generation scenarios.SUNFLOW cuts 120-min RMSE from 170.3 W m^{-2} for persistence and 119.7 W m^{-2} for optical-flow/advection to 81.2 W m^{-2}, indicating improvements of 52.3% and 32.2%, respectively, according to preliminary daytime study over eastern India. The framework shows how probabilistic solar nowcasting can be used for reserve planning, battery scheduling, flexibility assessment, and ramp-event management.

Online Session 6

Smart Grid Operation, Forecasting, Protection and Distribution System Resilience	
16:50-19:05, September 30	**Zoom ID: 89876772858** **Zoom Link: https://us2web.zoom.us/j/89876772858**
Session Chair: Assoc. Prof. Yongli Zhu, Sun-Yat Sen University, China	

PS0031

Intelligent Design of Power Supply and Distribution System for Typical Suzhou Commercial Users

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Abstract-This study takes one Plaza commercial area in Suzhou as the specific research object, integrates the regional characteristics of high humidity and high load density, and carries out the intelligent design of a full process power supply and distribution system based on the elec calc electrical calculation software. By conducting on-site research and collecting power grid parameters and meteorological conditions, a four level architecture of "10kV incoming line - dual transformers - low-voltage distribution - emergency power supply" is constructed. On this basis, the system completed core parameter calculations such as short-circuit current calculation (three-phase/single-phase), voltage drop verification, power flow analysis, protection selective coordination (TCC curve), and arc fault incident energy evaluation, and optimized the selection of transformers, cables, and circuit breakers. Specifically, this article innovatively completed the DC side selection, inverter matching, grid simulation, and analysis of the impact on the short-circuit current and protection of the 225 kWp distributed photovoltaic power generation system. Multi condition simulation verification shows that the calculation error is $\leq 5\%$, the voltage deviation is $\leq \pm 5\%$, the three-phase imbalance is $\leq 10\%$, the power factor is ≥ 0.95, the fault switching time is ≤ 0.5s, and the short-circuit current increment after photovoltaic grid connection is<2%. The research results provide a complete technical solution and engineering reference for the intelligent and low-carbon construction of commercial user power supply and distribution systems in high humidity and high load density areas.

PS0032

Task-Bottleneck-Guided Power-Communication Collaborative Restoration for Distribution Networks

Chenyuhao Ma, Weijiang He, Chenhao Cui, Chuanxiong Sun, Yigeng Huangfu and Daming Zhou
Northwestern Polytechnical University, China

Abstract-After extreme events, distribution network restoration is affected not only by line faults and distributed generator capacity constraints, but also by distribution automation communication status and emergency power supply task requirements. To address the limitation that conventional load-priority restoration methods cannot reflect the integrity of emergency tasks, this paper proposes a task-oriented power-communication collaborative restoration method for distribution networks. First, emergency power supply tasks are modeled as combinational objects jointly supported by multiple necessary loads, and restoration performance is evaluated by task completion value. Second, a collaborative restoration optimization model is established by jointly considering fault isolation, node energization, load restoration, distributed generator output, radial topology, and communication controllability. Then, a task-bottleneck-guided feasibility self-repairing memetic algorithm is designed to improve restoration scheme quality through communication executability repair, fault isolation repair, radial topology repair, electrical violation repair, and task-bottleneck-guided local search. Simulation results on the IEEE 33-bus system show that the proposed method completes 4 emergency tasks, achieves a task value of 350, and restores 2820 kW of load. Compared with the load-priority genetic algorithm, the task value increases from 280 to 350, and the number of completed tasks increases from 3 to 4. Communication availability analysis shows that when communication availability increases from 40% to 100%, the task value increases from about 332 to 405, verifying the significant impact of communication status on executable restoration performance.

PS0068

Reliable Pseudo-Label Guided Consensus AnchorGraph Multi-View Clustering for Equivalent Modeling of Large-Scale Renewable Energy Plant Groups

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2. City University of Hong Kong, China

Abstract-Grouping renewable-energy plants is essential for equivalent modeling. Existing methods often derive similarity from a single information source, limiting the representation of multidimensional operating differences; pairwise graph learning scales quadratically with plant count, and pseudo-labels lack reliable screening. We propose reliable pseudo-label guided

consensus anchor-graph learning (PAGR-CAGL), which constructs sparse sample-anchor relations with shared anchors, aligns cross-view structures, and selects reliable pseudo-labels using label agreement and clustering confidence. On public multi-view datasets, PAGR-CAGL achieves the best results on all four metrics for 100Leaves and UCI, reaching an ACC of 0.9615 on UCI. For 167 photovoltaic plants, grouping results are used to construct capacity-weighted group outputs with hourly active-power conservation, followed by validation in a distributed AC power-flow model. Under the three-view configuration, the leave-one-out NRMSE and correlation coefficient are 0.0890 and 0.9270, respectively; lineflow MAEs are 0.8001 MW, and all test scenarios converge. The results demonstrate that PAGR-CAGL converts multi-view grouping into physically consistent group-level equivalent outputs, supporting model reduction and steady-state analysis.

PS0022

Intraday Temporal Heterogeneity-Aware Multi-Step Forecasting of Highly Fluctuating Power Loads

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Abstract-Power load forecasting under highly fluctuating scenarios remains challenging due to the intraday temporal heterogeneity of load behaviors, as different periods exhibit distinct stability and fluctuation characteristics. Existing models usually employ a unified model for the entire day, limiting their capability to simultaneously capture smooth patterns and abrupt variations. To address this issue, we propose an adaptive timesegmented multi-step forecasting method. First, intraday periods are adaptively partitioned based on load volatility characteristics to reveal heterogeneous temporal patterns. Then, a heterogeneityaware forecasting strategy is developed, where an LSTM-GRU is used to capture periodic and smooth behaviors, while a Transformer is employed to characterize abrupt fluctuations and long-range dependencies. A segment-wise similar-day weighting strategy combining clustering and load pattern matching is developed to obtain reliable multi-step forecasting baselines. Finally, a frequency-domain error correction module is further introduced to reduce systematic forecasting bias caused by multistep error propagation. Experiments on an industrial load datasetcovering 709 days shows that the proposed method reduces the 1-day-ahead MAPE by 0.24 percentage points relative to the bestperforming baseline model, and achieves average MAPE values of 4.30%, 4.87% and 5.60% for 1-day, 3-day and 5-day multi-step forecasting, respectively. The results verify the effectiveness of the proposed method in improving forecasting accuracy and robustness for highly fluctuating power load scenarios.

PS0039

Integrating Cross-Year High-Temperature Responses into a Large Language Model for Load

Forecasting

Gaiping Sun, **Jiahai Zhi**, Ronghui Liu, Shunfu Lin and Fan Yang
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Abstract-At the onset of persistent hot weather, recent load history may not fully represent the resulting increase in demand. This paper proposes a day-ahead load forecasting method in which a large language model incorporates historical hightemperature responses for distribution transformer supply zones. Seven input channels distinguish recent load and temperature, historical pre-event conditions, subsequent load and temperature responses, and target-day temperature forecasts. Cross-attention matches current conditions with historical pre-event features and extracts response information, which is mapped into a frozen Llama model through numerical reprogramming. Hourly load statistics, forecast temperature, and load-scale information condition 24 forecast queries before decoding the next-day loading-ratio curve. Training and validation use a 2025 hightemperature dataset, which also provides historical references for the 2026 test. On July 7, 2026, the proposed method achieves an overall mean absolute error of 0.04015 across 376 supply zones, improving on a same-input iTransformer by 7.79 percent overall and 9.14 percent in the load-surge group. Three retrained ablation variants support the contributions of historical response transfer, load–temperature association attention, and hourly conditioning. The regular group has a higher error than iTransformer, indicating that the improvement is not uniform across groups.

PS0021

Current Signature Analysis Using Distributed Sensor Networks and AI: A Practical Build for Multi-Node Fault Detection in Electrical Systems

Alireza Gheitasi, Harpreet Singh, Randeep Singh, Charanpreet Singh, and Smit Jitendrabhai Patel
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Abstract-This paper presents a low-cost, scalable fault detection system based on motor current signature analysis (MCSA), a distributed sensing network, and an artificial intelligence (AI)-based classification framework. The proposed system employs three noninvasive current transformer (CT) sensors installed on separate electrical circuits, interfaced with an Arduino Uno for real-time current acquisition. The acquired signals are transmitted to a Pythonbased processing platform, where fast Fourier transform (FFT) analysis and statistical feature extraction are performed to characterize the operating conditions. The extracted features are used to train and evaluate a machine learning classifier, achieving an overall classification accuracy of 92% with an F1-score of 0.920 on the test dataset. To improve fault localization, a propagation-aware decision layer

integrates measurements from multiple sensors and applies an attenuation-based model to identify the fault origin across interconnected circuits. Experimental results demonstrate a fault localization accuracy of 93% (28 of 30 test cases; 95% Wilson confidence interval 78.7%–98.2%), correctly identifying the fault source in the large majority of multi-node trials. The developed prototype was successfully deployed and continuously operated for 48 hours in a laboratory setting using resistive test loads, demonstrating reliable real-time performance. The proposed approach provides a practical, cost-effective foundation for distributed electrical fault detection and localization, with potential applications in industrial monitoring and predictive maintenance pending validation on real induction-motor loads.

PS0067

Dynamic Optimization Strategy for Aggregated EV Charging Regulation in a Joint Market Environment

Mengge Shi, **Yujia Guo**, Jiashuo Hu and Youwei Jia
Southern University of Science and Technology, China

Abstract-With the rapid growth and increasing popularity of electric vehicles (EVs), maintaining charging-station (CS) profitability while reducing users' charging costs has become increasingly challenging. To address this challenge, this paper proposes a closed-loop aggregated regulation strategy for CS clusters in a joint electricity-market environment. The framework integrates an anti-strategic pricing mechanism, a day-ahead charging invitation strategy, and an intra-day dynamic charging guidance strategy to coordinate fixed market commitments with uncertain EV charging responses. A case study based on real-world charging data shows that day-ahead invitation reduces the mismatch between committed and realized loads, while intra-day guidance further improves load tracking and economic performance across participation scenarios. The proposed approach connects market-oriented scheduling with operational charging coordination for large-scale EV charging resources.

PS0063

Frequency Stability Assessment of Synchronous and Grid-Forming Inverter-Dominated Power System Using Electromagnetic Transient Analysis

Sangay Nidup, G. M. Shafiullah and Martina Calais
Murdoch University, Australia

Abstract-High penetration of inverter-based resources displaces synchronous generation and reshapes the frequencyresponse mechanisms essential to power-system security. Gridforming (GFM) inverters can deliver fast, controllable powerfrequency support, while synchronous

condensers provide complementary physical inertia and voltage support. However, converter-dominated systems exhibit control-defined frequency, rate-of-change-of-frequency (RoCoF), powersharing and fault-recovery dynamics that cannot be interpreted solely through classical synchronous-machine concepts. This paper presents a staged electromagnetic-transient benchmark of synchronous, 50% IBR, 80% IBR and 100% GFM operation on a modified 50 Hz IEEE 9-bus network as a foundation for future GFM-Synchronous Condensers coordination. PSCAD simulations apply matched 40 MW load disturbances, validation and robustness events, and a temporary three-phase fault to assess frequency extrema, RoCoF, power response, voltage recovery and synchronism. For the 40 MW load increase, the maximum frequency deviation decreases from 0.600 Hz in all-synchronous operation to 0.362 Hz at 50% IBR, 0.258 Hz at 80% IBR and 0.177 Hz at 100% GFM, while systemrate-of-change-of-frequency (RoCoF) magnitude increases from 0.620 to 0.930, 1.293 and 1.650 Hz/s. The 40 MW load decrease case show a similar trend.

PS0065

Modelling and Stimulating the Effect of Electric Vehicle Charging on a Rural Transformer

Haiqa Ali[1,2], **Saifullah Shafiq[1],** Peter Kilby[2] and Mithulananthan Nadarajah[1]
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2. Energy Queensland, Australia

Abstract-With a significant acceleration in electricity demand with the introduction of solar photovoltaic (PV) systems and electric vehicles (EVs), managing the electrical network has neverbeen as challenging as it is now and requires thorough study. Infact, the increased EV charging load mainly impacts the lowvoltage (LV) distribution systems. Therefore, this paper presents a case study that evaluates the impact of EV charging on an ENERGEX rural transformer LV system. The presented case study highlights that the increase in load demand due to EV charging significantly contributes to added system losses and power quality issues. Moreover, transformer and line losses increase across all scenarios considered, with the largest increase in the worst-case scenario, where all customers charge their EVs during peak load hours. This study highlights theimportance of promoting ‘smart’ charging and urges distribution network service providers (DNSPs) to develop strategies to encourage more customers to charge their vehicles during PV hours.

Online Session 7

Advanced Power Electronics, Electric Drives and Power Conversion Technologies	
19:05-20:50, September 30	**Zoom ID: 89876772858** **Zoom Link: https://us2web.zoom.us/j/89876772858**
Session Chair:	

PS0057

GaN Based Modified Transformerless NPC Inverter with DPWM for Grid Tied Applications

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1. University of Cagliari, Italy
2. National Institute of Technology, India
3. University of Wollongong, Australia

Abstract-Transformerless neutral point clamped (NPC) inverters are widely used in grid connected photovoltaic applications due to their reduced size and cost with high efficiency; however, conventional configurations suffer from common mode voltage (CMV) fluctuations and leakage current issues creates from parasitic coupling between the DC source and common ground. To address these issues, this paper proposes a modified transformerless NPC inverter (NPC-TLI) structure with active clamping switches and a discontinuous pulse width modulation (DPWM) strategy. This topology effectively reduces the CMV variations and leakage current with stabilised DC link voltage in grid connected system. In the proposed configuration, parallel connected switching devices are used at each main switch position to increase the inverter current handling capability with reduced electrical stress per device in the medium power transformerless applications. In addition, the power loss and thermal performance of the GaNbased NPC-TLI is investigated, considering its low on state resistance and minimal reverse recovery losses. A detailed simulation study using PLECS is carried out to evaluate the impact of the proposed NPC-TLI on CMV behaviour, leakage current suppression, power loss characteristics, efficiency, and harmonic performance. The results confirm that the combined use of active clamping, DPWM, parallel device configuration, and GaN switches significantly enhances the performance of the transformerless NPC inverter, making it a compact, efficient, and reliable solution for threw phase grid connected systems.

PS0020

A Digital-Twin Framework for Integrated Electro-Thermal-Economic Evaluation of Superconducting Electric Motors

Alireza Gheitasi and Nick Kusari
Manukau Institute of Technology, New Zealand

Abstract-High-temperature superconducting (HTS) motors promise substantially higher power density and lower resistive losses than conventional induction machines, but realising these benefits in practice depends on cryogenic refrigeration overhead, thermal stability, and life-cycle economics that are rarely evaluated together. This paper proposes an integrated evaluation framework, and a corresponding MATLAB/Simulink digital-twin architecture, that couples electrical machine performance, cryogenic refrigeration modelling, overall system efficiency, powerdensity analysis, life-cycle cost, and multi-objective design optimisation. The electrical subsystem is modelled in the synchronous dq reference frame; cryogenic heat loads are derived from conduction, radiation, structural, current-lead, and boil-off contributions; and a coupled thermal state equation governs winding temperature and quench risk. Lifecycle cost and net-present-value models translate these technical outputs into economic terms, and a Pareto-based
genetic-algorithm optimiser is specified to search for designs that jointly balance efficiency, cooling demand, weight, and cost. This paper develops the mathematical formulation and digital-twin architecture in full and works through a closedform illustrative numerical example, grounded in published induction-motor and cryocooler data, that shows how cryogenic overhead can erode a superconducting motor's efficiency advantage beyond an identifiable break-even heat load; full MATLAB/Simulink implementation, simulationbased validation, and Pareto-optimal design results are left to a subsequent stage of this work.

PS0064

Self-Resonant Coil – Plate Structure for Wireless Power Transfer

Javad Nekoui, Neda Zahedi Saadabad, Ambrish Chandra and Qingsong Wang
École de technologie supérieure, Canada

Abstract-This paper presents a self-resonant hybrid wireless power transfer (HPT) coupler that integrates inductive and capacitive coupling within a coil plate structure. The proposed coupler employs double layer planar coils and aluminum plates to establish magnetic field and electric field coupling paths, respectively. The two coil layers are internally interconnected to reinforce their magnetic fields and enhance the effective inductance. In addition, the conductor width and inter turn gap distributions are designed using the track width ratio (TWR) and track gap ratio (TGR) to

reduce AC losses and improve the coil quality factor. In the proposed topology, each coil is connected in series with the capacitance provided by the aluminum plates, thereby forming a self resonant series HPT system without external compensation inductors or capacitors. The transmission characteristics are evaluated over different air gaps and operating frequencies. Simulation results indicate that the proposed HPT coupler provides higher transmission power and improved stability against air gap variation compared with IPT, while achieving better transmission distance capability, power transfer, and efficiency than CPT.

PS0060

Prediction-Horizon Admissibility Under Digital Actuation Timing and Voltage-Limited Operation in PMSM Drives

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North University of China, China

Abstract-Prediction horizon is normally treated as a tuning variable in predictive current control. In a digitally implemented PMSM drive, however, the previous command may remain active over part of a control interval while the available inverter voltage collapses near saturation. This work shows that these implementation effects change whether a shorter horizon is beneficial at all. Dual-horizon control is therefore posed as an admission problem: the aggressive horizon is exposed only when a fixed timing-speed region is satisfied and the nominal-horizon voltage request remains inside the available axis limit. A complete signal-level PMSM Simulink model with 100-microsecond control and 50-microsecond short-horizon timing separates mechanism discovery from independent confirmation. The discovery study shows that voltage limitation can reverse the relative benefit of the two candidate horizons and invalidate timing- speed-only admission. The resulting headroom-aware rule is then fixed and evaluated on 600 new operating points, where it suppresses severe speed-degradation behavior while preserving the current-control benefit of the shorter horizon when sufficient voltage authority is available. The results identify horizon validity as a joint function of digital chronology and control authority rather than a purely algorithmic tuning choice.

PS0061

Dual-Bus Harmonic Propagation and Onboard RLS-Based Active Filtering for a 25 kV Diode-Rectifier Locomotive

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2. Alasala University, Saudi Arabia

Abstract-Harmonic currents from diode-rectifier traction loads propagate through railway supply networks and can degrade power quality at buses remote from the nonlinear load. This paper evaluates whether compensation applied at an onboard low-voltage bus reduces distortion simultaneously at the 25 kV traction feeder and the 110 kV utility interface. A PSCAD/EMTDC model represents a 110/25/1.06 kV supply chain, a single-phase diode bridge, four 600 kW dc traction motors, and a shunt active power filter (SAPF) connected at the 1.06 kV rectifier bus. Recursive least squares (RLS) estimates the selected harmonic components used to generate the compensation reference. At the investigated full-load operating point, the SAPF reduces voltage total harmonic distortion from 6.6% to 2.3% at 25 kV and from 3.3% to 1.5% at 110 kV. The corresponding current-distortion indices decrease from 18.4% to 6.7% and from 14.7% to 3.1%, respectively. The results show that supplying harmonic current locally reduces its transmission through the intervening network and attenuates upstream voltage distortion. The findings are limited to the documented operating point and are reported as comparative indices, not as evidence of IEEE Std 519 compliance or hardware readiness.

PS0045

A Novel Unbounded ZVS Region of Class-E Inverters for Propellantless Satellite Propulsion Power Supplies in LEO

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Abstract-—Class-E inverters constitute an appealing candidate for power processing units in low-Earth-orbit (LEO) propellantless satellite propulsion power systems, owing to their topological simplicity and high radio-frequency efficiency. Their practical feasibility, however, depends critically on the maintenance of zero-voltage switching (ZVS), which is notoriously susceptible to load-impedance variations. In LEO plasma thrusters, the radio-frequency load presented by the discharge evolves substantially during normal operation, rendering conventional fixed-tuned designs incapable of guaranteeing ZVS across the entire operating envelope. To overcome this limitation, this paper proposes a geometric analyse methodology that maps the ZVS criterion onto the complex load plane via a closed-form expression for the normalized turn-on voltage. This mapping reveals that the ZVS boundaries universally form a pair of circles, whose relative configuration, namely containment, intersection, or external disjointness, is governed solely by the frequency ratio. It is demonstrated that the externally disjoint case yields a fundamentally distinct regime: the ZVS region therein becomes the common exterior of the two circles. This common exterior constitutes a connected and unbounded domain in the complex plane, theoretically

removing any finite upper bound on load-impedance excursions, a previously unidentified behavior that is termed unbounded ZVS operation. Finally, experimental measurements on a GaN-based prototype validate the proposed geometric criterion and confirm the existence of the unbounded regime, demonstrating that the inverter sustains ZVS across a wide, and theoretically unbounded, load spectrum while maintaining high conversion efficiency.

PS6001

Demand Side Management Based on Smart Grid Power Supply System

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Abstract-DSM is a demand side resource. Currently, the biggest challenge facing the world is the issue of resources and environment, and optimizing the allocation and development of power supply and DSM resources is one of the most important issues. This article attempts to explore resource allocation and DSM resource development from both theoretical and practical perspectives. Through the summary and analysis of China's electricity load management and energy-saving practices Attempting to reveal the objective laws of resource optimization allocation, development, especially DSM resource development.

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Notes