Conference Program

2024 7th International Conference on Renewable Energy and Power Engineering

Beijing, China | September 25-27, 2024

Co-sponsored by

Tsinghua University IEEE

Hosted by

清华大学 电机工程与应用电子技术系 Department of Electrical Engineering Tsinghua University

Hosted by

中国科学院工程热物理研究所 Institute of Engineering Thermophysics, Chinese Academy of Sciences

Patrons

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Note

Conference Venue

北京中成天坛假日酒店 Holiday Inn Beijing Temple of Heaven

地址：中国北京南三环定安东里 1 号 北京, 100075

Address: No. 1 Ding An Dong Li, 3rd South Ring Road Beijing, 100075 Mainland China

Access to Holiday Inn Beijing Temple of Heaven

- 距 **14** 号线景泰站 **10** 分钟步行距离
  10 min walk to Subway Line 14 (Jingtai)
- 距 **5** 号线蒲黄榆地铁站 **15** 分钟步行距离
  15 min Subway Line 5 (Pu Huang Yu)
- 距北京大兴国际机场 **40** 分钟车程
  40 min drive to Beijing Daxing International Airport
- 距北京首都国际机场 **70** 分钟车程
  70 min drive to Beijing Capital International Airport
- 距北京火车站 **15** 分钟车程
  20 min drive to Beijing Railway Station
- 距北京南站 **20** 分钟车程
  20 min drive to Beijing South Railway Station
- 距天坛公园 **20** 分钟步行距离
  20 min walk to Temple of Heaven
- 距前门步行街 **20** 分钟车程
  20 min drive to Qian Men Street

Attention Please 注意事项：

✓ Don't stay too late in the city, don't be alone in the remote area. Be aware of the strangers who offer you service, signature of charity, etc., at scenic spots.

请勿在会议召开城市长时间逗留，请勿独自前往偏远地区。留心在景点为你提供服务、慈善签名的陌生人。

✓ You can search more Beijing Tourist Information and Security tips online:
https://www.travelchinaguide.com/cityguides/beijing/

更多北京旅游信息和安全提示请提前在网络上查询了解: https://www.travelchinaguide.com/cityguides/beijing/

✓ If you have Wechat, you can scan the QR code and send "REPE 2024-Paper ID "to add conference assistant Wechat for better communication

为会议信息能及时传达给各位作者，保障文章顺利出版，会务组开通了微信服务，建议文章每一位作者添加微信号 iconf-ee-1 并发送 REPE 2024-PAPER ID 添加会议助理，以免错过重要通知。

Conference Information and Tips

1) Onsite Registration

Registration desk (Reception table in the lobby of Holiday Inn Beijing Temple of Heaven) → Inform the staff of your paper ID→ Sign-in→ Claim your conference kit.

2) Devices Provided by the Organizer

Laptops (with MS-Office & Adobe Reader) / Projectors & Screen / Laser Sticks

3) Materials Provided by the Presenter

Oral Session: Slides (pptx or pdf version). Format 16:9 is preferred.

Official language: English.

4) Duration of Each Presentation

※ Keynote Speech: 45min, including Q&A

※ Invited Speech: 30min, including Q&A

※ Oral Presentation: 15min, including Q&A

5) Notice

※ Please wear your delegate badge (name tag) for all the conference activities. Lending your participant card to others is not allowed.

※ Please take good care of your valuables at any time during the conference. The conference organizer does not assume any responsibility for the loss of personal belongings of the participants during conference day.

※ **UTC+8. Please be aware of time difference between this and your region/country.**

6) Online Presentation Tips

	Meeting ID	Link
zoom Zoom Download	Room A: 831 9781 0538	https://us02web.zoom.us/j/83197810538
	Room B: 821 1151 7346	https://us02web.zoom.us/j/82111517346

Note:

We recommend that you install the Zoom platform on your computer before the conference starts. New users can participate in the Zoom meeting without registration.

Participants who are going to do an online presentation are required to join the rehearsal in Zoom on Wednesday, September 25. Duration: 3min apiece. Feel free to leave after you finish the test.

◆Name Setting

Keynote Speaker: KN-Name

Committee: Position-Name

Author: Paper ID-Name

Delegate: Delegate -Name

◆Useful Links

✧ Conference Banner
✧ Zoom Background

7) No-Show Policy

Papers unpresented at the conference, without prior written approval by the Conference Technical Program Chair, will be removed from the final conference proceedings before uploading to IEEE Xplore. No refund will be approved to authors of those papers.

Welcome Message

On behalf of Conference Committee, we welcome you to attend 2024 7th International Conference on Renewable Energy and Power Engineering (REPE) held in Beijing, China during September 25-27, 2024, co-sponsored by Tsinghua University and IEEE, hosted by the Department of Electrical Engineering at Tsinghua University, co-hosted by Institute of Engineering Thermophysics(Chinese Academy of Sciences).

REPE 2024 welcomes author submission of papers from any branch of renewable energy and power engineering, and their applications or other topic areas. The areas covered by the include, but not limited to: New Power System and Operation Management, Wind Farm Power Generation Model and Power Generation Prediction, Modern Integrated Energy System and Intelligent Electrical System, System Control, Model Simulation and Reliability Analysis in Power Systems, Digital Power Equipment Design and Function Control, Smart Grid Control Model and Reliability Evaluation, New Battery Development and Voltage Control Technology, Energy Configuration, Optimization and Management in New Energy Power Systems and Integrated Energy Systems.

The conference aims to provide an interactive communication platform for practitioners to learn about the most cutting-edge academic and industrial application trends, to share the latest scientific research and technological achievements, innovative ideas and scientific methods in the field of renewable energy and power engineering, to improve the level of academic research and industrial application in the field of intelligence so as to serve the global strategic deployment of new and old kinetic energy conversion, and promotes technology research, development, and application home and abroad.

We feel deeply grateful to all that have contributed to make this event possible: authors, the conference steering committee, the conference speakers, and the peer reviewers. Thanks are also extended to the conference administrative committee and the supporters for their tireless efforts throughout the course of the conference.

We hope that all participants benefit from the conference, and enjoy the architectural, cultural and natural beauty of Beijing, China.

With Warmest Regards,

Conference Organizing Committee

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Agenda Overview (UTC+8)

Wednesday, September 25, 2024		
Onsite Registration	**10:00-17:00**	**Reception table in the lobby of Holiday Inn Beijing Temple of Heaven 一层大厅**
Zoom Test for online presenters	**14:00-16:30**	**Room A: 831 9781 0538**

Zoom Test Timetable

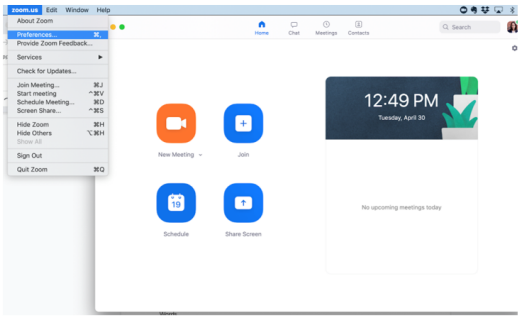
- ✧ Participants who are going to do an online presentation are required to join the rehearsal in Zoom on Wednesday, September 25, 2024. Duration: 3min apiece. Feel free to leave after you finish the test.
- ✧ We will test control panel including screen sharing, audio, video and "Raise Hand" feature, etc. Please get your presentation slides and computer equipment prepared beforehand.

14:00-14:30	PR356 PR329 PR345 PR3002 PR351 PR3003 PR342
14:30-15:00	PR317 PR376 PR354 PR328 PR369 PR359 PR364
15:00-15:30	PR324 PR306 PR331 PR308 PR326 PR313
15:30-16:00	PR332 PR301 PR333 PR312 PR361 PR302 PR371
16:00-16:30	Alternative time for participants who are unavailable at allocated time. Other online participants, includes but not limited to keynote speaker, invited speaker, session chair, committee member, delegate

Zoom Guidance

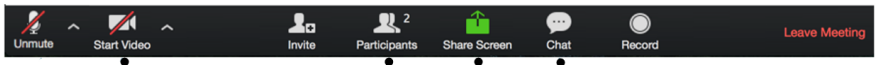
You can join the meeting without sign-in process.
Just put the meeting ID and join us.

URL: https://zoom.us/download



Each meeting has a unique **9, 10, or 11-digit** number called a **meeting ID** that will be required to join a Zoom meeting.

For any questions on the meeting day, you can text privately to "Assistant" for help.



Audio muted and video off (both indicated by a red slash).

Click to open the Participants box. This will allow you to "Raise Hand".

To share screen or contents.

Click to open the Chat box. This will allow you to chat with Hosts and Participants.

Thursday, September 26, 2024		
Plenary Session (Onsite)	**Conference Room: Temple of Heaven, 2nd floor 2 楼地坛厅**	**Room A: 831 9781 0538**
Host: Prof. Lin Chen, Institute of Engineering Thermophysics, Chinese Academy of Sciences, China		
09:00-09:10	Opening Speech: TBA	
09:10-09:55	Keynote Speech I: New-type Power System Stabilizer for Renewable Powered Systems **Prof. Xiaorong Xie,** (IEEE Fellow), Tsinghua University, China	
09:55-10:40	Keynote Speech II: Research Progress of the Dynamic Control Strategy of Compressed Air Energy Storage System **Prof. Xinjing Zhang,** Institute of Engineering Thermophysics, Chinese Academy of Sciences, China	
10:40-11:10	Group Photo & Coffee Break (2nd Floor)	
11:10-11:40	Invited Speech I: TBA **Assoc. Prof. Zhanle Wang,** University of Regina, Canada	
11:40-13:00	Lunch Heavenly Cafe, 1st Floor/1 楼穹宇咖啡厅	
Thursday, September 26, 2024 | Parallel Session (Onsite)		
13:00-15:15	**Forum: Online Power Supply Reliability Management in New Type Power System** PR383 PR377 PR379 PR378 PR380 PR382 PR384 PR381 PR385	Temple of Heaven, 2nd floor 2 楼地坛厅
13:00-15:30	**Onsite Session 1: Wind Farm Power Generation Model and Power Generation Prediction** PR325 PR336 PR340 PR304 PR341 PR349 PR368 PR353 PR367 PR330	Meeting Room 2, 2nd floor 2 楼会议室 2
15:30-15:45	Coffee Break	2nd Floor
15:45-18:30	**Onsite Session 2: Modern Integrated Energy System and Intelligent Electrical System** PR303 PR365 PR315 PR337 PR360 PR338 PR363 PR370 PR375 PR3005 PR374	Temple of Heaven, 2nd floor 2 楼地坛厅
15:45-18:30	**Onsite Session 3: System Control, Model Simulation and Reliability Analysis in Power Systems** PR310 PR344 PR327 PR334 PR335 PR372 PR373 PR3007-A PR307 PR362 PR323	Meeting Room 2, 2nd floor 2 楼会议室 2
18:45-20:00	Dinner Heavenly Cafe, 1st Floor/1 楼穹宇咖啡厅	

Friday, September 27, 2024	
Keynote Speech (Online)	**Room A: 831 9781 0538**
09:00-09:45	Keynote Speech III: Power electronics and hybrid transformers in distributed energy system - opportunities and challenges **Prof. Mariusz Malinowski,** (IEEE Fellow), Warsaw University of Technology, Poland
09:45-10:30	Keynote Speech IV: Overlay Multi-Terminal HVDC Network (OVANET): Acceptance-friendly Power Transmission for Large-Scale Renewable Power Integration **Prof. Kai Strunz,** Technical University of Berlin, Germany

Friday, September 27, 2024 | Parallel Session (Online)		
10:30-12:15	**Online Session 1: Digital Power Equipment Design and Function Control** PR356 PR329 PR345 PR3002 PR351 PR3003 PR342	Room A: 831 9781 0538
10:30-12:15	**Online Session 2: Smart Grid Control Model and Reliability Evaluation** PR317 PR376 PR354 PR328 PR369 PR359 PR364	Room B: 821 1151 7346
12:15-13:30		Break Time
13:30-15:00	**Online Session 3: New Battery Development and Voltage Control Technology** PR324 PR306 PR331 PR308 PR326 PR313	Room A: 831 9781 0538
13:30-15:15	**Online Session 4: Energy Configuration, Optimization and Management in New Energy Power Systems and Integrated Energy Systems** PR332 PR301 PR333 PR312 PR361 PR302 PR371	Room B: 821 1151 7346

Keynote Speaker I (UTC+8)

Thursday, September 26, 2024 9:10-9:55	Temple of Heaven, 2nd Floor/2 楼地坛厅 Room A: 831 9781 0538

Prof. Xiaorong Xie
IEEE Fellow, Tsinghua University, China

Speech Title: New-type Power System Stabilizer for Renewable Powered Systems

Abstract: The multi-time-scale dynamic interaction among "mechanic-electric-magnetic-control" may lead to sustained exchange or even continuous amplification of non-fundamental power energy among "generation-transmission-distribution-storage", further resulting in wide-band oscillation. There remains a scarcity of adaptive damping control technologies and universal suppression devices for wide-band oscillation in renewable powered systems. This talk begin with an overview of research background and status of wide-band oscillation suppression. Then, the mechanism of wide-band oscillation caused by multi-time-scale dynamic interaction is analyzed. Framework of new-type power system stabilizer for electric power system is then proposed. After that, a broad-spectrum identification method for time-varying multi-modal wide-band oscillation characteristics and an adaptive damping control method for dealing with varying operating conditions and oscillation frequency are presented. Lastly, the prototype of new-type power system stabilizer is demonstrated.

Xiaorong Xie (Fellow, IEEE and IET) is Professor and Director of the Flexible Transmission and Distribution Systems Research Institute at the Department of Electrical Engineering, Tsinghua University, China. He has been engaged in research on power system stability analysis and control, sub-synchronous resonance/oscillation, grid integration of renewable energy, and flexible transmission and distribution systems for more than 25 years. His research is supported by China National Science Funds for Distinguished Young Scientists and National Key Research and Development Programs. He has published 4 monographs, over 300 papers, and more than 70 authorized invention patents, and won 1 National Science and Technology Progress Award and over 10 provincial-level/industry association awards. He is currently serving as Editor of several international journals, including the IEEE Transaction on Power Delivery. He is a member of the IEC TC8/SC8A JWG5, CIGRE WG C4/B4.52 and CIGRE WG C4.49.

Keynote Speaker II (UTC+8)

Thursday, September 26, 2024 9:55-10:40	Temple of Heaven, 2nd Floor/2 楼地坛厅 Room A: 831 9781 0538

Prof. Xinjing Zhang
Institute of Engineering Thermophysics, Chinese Academy of Sciences, China

Speech Title: Research Progress of the Dynamic Control Strategy of Compressed Air Energy Storage System

Abstract: Compressed air energy storage (CAES) is an effective solution for future high penetration of renewable generations. Various types of CAES technologies are developed including adiabatic CAES (ACAES), isothermal CAES (ICAES), liquid air energy storage (LAES), supercritical CAES (SC-CAES), underwater CAES (UWCAES), and CAES coupled with other technologies. The principles and configurations of these advanced CAES technologies are briefed. Comparison and discussion of all these CAES technologies are summarized in terms of technical maturity, power sizing, storage capacity, operation pressure, roundtrip efficiency, components' efficiency, operation duration, invested cost, etc.

The CAES system has to be operated dynamically to manage the imbalance between renewable generations and electricity demand. Moreover, the compressed air is usually stored in the isochoric vessel or carven. Thus, the power output and operation pressure have to be adjusted and controlled accordingly. These technologies that adjust and regulate the air flow are reviewed and summarized, which are throttling valve control, ejector, guided vane adjustment, switching expansion reducing and some others. The characteristics and effect to the CAES system are also discussed.

A new method of Switching Expansion Reduction (SER) was proposed to manage the power fluctuation. A thermodynamic modelling of a 10 MW CAES system with thermal storage integrated pressure control unit was established. The discharging process of TS-CAES system based on SER was proposed, which was effective for control accuracy and exergy loss comparing with throttle reduction. Modellings were development and validated by experimental results. Taking 10MW TS-CAES discharging system as an example, the operation law and control method of the simulation unit are investigated under the dynamic application background of participating in secondary frequency modulation service. The dynamic control strategy under off-design operation conditions of CAES was revealed. While, the exergy destruction was calculated, which was smaller than throttle valve-only configuration. The optimized parameters of this SER configuration were also studied.

Xinjing Zhang, Ph.D, Professor, Institute of Engineering Thermophysics, Chinese Academy of Sciences. He was elected as Beijing Municipal Distinguished Young Scholar, Beijing Nova Program Member. He is the Deputy Secretary General of International Energy Storage Alliance. He is also the Guest Supervisor for North China Electric Power University, Hohai University. His research interest includes R&D of large scale Compressed Air Energy Storage (CAES), energy storage with renewable energy, distributed energy storage, micro-grid with energy storage, etc.

He has been Principle Investigator of over 10 research projects including three grants of National Natural Science Foundation of China (NSFC). He is the author / co-author of over 90 academic papers. Dr. Zhang has applied over 40 patents, 9 of which were transferred to industries with Dr. Zhang as the first inventor. He has organized/co-organized over 10 international conferences, acted as Co-organizing Chair / Organizing committee member, session Chair, etc.

Keynote Speaker III (UTC+8)

Friday, September 27, 2024 09:00-09:45	Room A: 831 9781 0538

Prof. Mariusz Malinowski
IEEE Fellow, Warsaw University of Technology, Poland

Speech Title: Power electronics and hybrid transformers in distributed energy system - opportunities and challenges

Abstract: The fast development of distributed generation systems (DGS), including an increasing number of renewable energy sources (RES), demands the change of classical grids into smart grids (SG), integrating all new distributed elements, e.g., active loads/sources/energy storages. Currently used conventional transformers cannot fulfill all SG requirements. Therefore, a new solution is needed due to the highly different types of energy sources and loads and the frequent voltage disturbances occurring in DGS. The proposed modern solutions are the applications of multifunctional power electronics, fault-tolerant power electronics, and hybrid transformers that are able not only to meet the main requirements of SG but also respond to the future challenges defined by the constant progress of technology in all new fields (e.g., electromobility, energy store systems, etc.).

Mariusz Malinowski received the Ph.D. degree with honors in Electrical Engineering from the Warsaw University of Technology (WUT) in 2001. He then attained a habilitation in 2012 and professorship in 2019.

Mariusz Malinowski has been granted the following awards and distinguishments: the Siemens Prize for his PhD thesis in 2002, a Polish Minister of Science and Higher Education award for his contribution to the book Control in Power Electronic in 2003, the Siemens Prize for research achievements in 2007, the Polish Minister of Science and Higher Education awards for research achievements in 2008, the Prime Minister of Poland award for habilitation in 2013, the first prize of the Prime Minister of Poland for his research team in 2017. Moreover, he received the prestigious international IEEE IES David Irwin Early Career Award for "Outstanding research and development of modulation and control for industrial electronics converters" in 2011 (Melbourne, Australia), IEEE IES David Bimal Bose Award for Industrial Electronics Applications in Energy Systems for „Contributions in control of industrial electronics converters applications in energy systems" in 2015 (Yokohama, Japan), IEEE IES Anthony J. Hornfeck Service Award for "Outstanding and Meritorious Service to the IEEE Industrial Electronics Society" in 2021 and Power Electronics and Motion Control Istvan Nagy Award "for his outstanding contribution to control in power electronics and for continuous support of PEMC conferences" in 2022.

Mariusz Malinowski has published almost 200 journal and conference papers. He is the author of six patents (two implemented by industry) and co-author of six books. He has participated in over 20 research and industrial projects (12 in a leader role) and he has been a reviewer and PhD commission member for numerous PhD theses in Germany, Spain, Denmark, Australia, India, Switzerland, Italy and Poland. Mariusz Malinowski public service include activity in IEEE, where he was Chair of IEEE Poland Section. Mariusz Malinowski is currently junior past President in IEEE Industrial Electronics Society and he has in IEEE highest Fellow status. Moreover Mariusz Malinowski is Vice Reactor for Research at WUT, Member of Polish Academy od Science and Member of Polish Council of Research Ecellence. Mariusz Malinowski participated in the development of technologies which received many prizes e.g. three times the recognition in the competition Polish Product of the Future organized by the Polish Agency for Enterprise Development (PARP), the Grand Prix of TECHNICON, the Gold Medal of Automaticon, the Grand Prix Exhibition of Innovations in Geneva (Gold Medal), the Exhibition in Brussels "Eureco" (Bronze Medal), International Exhibition of Inventions in Warsaw (Silver Medal) and special prize of Polish Ministry of Economy "eCO2 Innovation" for development of ecological innovative product. Mariusz Malinowski was visiting scholar and professor in following institutions: Aalborg University (Denmark), University of Nevada (Reno, USA), Technical University of Berlin (Germany), Universidad Tecnica Federico Santa Maria (Valparaiso, Chile), University of Cergy-Pontoise (France), ENSEEIHT - Laplace, Toulouse (France) and ETH Zurich (Switzerland). He also cooperate with industry e.g. ABB Corporate Research Center (Poland), PSE Operator (Poland), TWERD (Poland), TRUMPF Huettinger (Poland), Wave Dragon (Dania), Danfoss Drives (Dania) and Vestas (Dania).

Keynote Speaker IV (UTC+8)

Friday, September 27, 2024 09:45-10:30	Room A: 831 9781 0538

Prof. Kai Strunz
Technical University of Berlin, Germany

Speech Title: Overlay Multi-Terminal HVDC Network (OVANET): Acceptance-friendly Power Transmission for Large-Scale Renewable Power Integration

Abstract: The large-scale integration of wind and solar power relies on a grid that allows for the renewable electric power to securely reach the load centers. In the concept OVANET (overlay network) this is realized through a multi-terminal DC network that is developed as an overlay to the existing AC grid. The connections are made with modular multi-level converters (MMCs). As the resulting integrated AC-DC grid may stretch across multiple countries and therefore also diverse transmission system operator (TSO) control areas, it is important that a desired degree of data privacy and autonomy within those areas is preserved. This is made possible by the proposed distributed AC-DC power flow optimization based on a modified fully parallel Alternating Direction Method of Multipliers (ADMM). The formulated local physical consensus constraints for boundary variables at the locations of tearing only rely on exchange of information with immediate neighbors. Beyond the distributed optimization, a method of contingency analysis is introduced to perform contingency analysis. The contingency analysis makes use of novel sensitivity factors and optimization that allow for the fast identification and relief of security issues. The effectiveness of the methods is illustrated by case studies. Social acceptance of OVANET is boosted by allowing the transmission lines to share corridors with other transport infrastructures such as motorways, thus leading to a combination of infrastructures.

Dr. KAI STRUNZ received the Dr.-Ing. degree (summa cum laude) from Saarland University, Saarbrücken, Germany. From 1995 to 1997, he was with Brunel University London. From 1997 to 2002, he was with the Division Recherche et Dévelopment of Electricité de France (EDF) in Paris. From 2002 to 2007, he was an Assistant Professor of electrical engineering with the University of Washington, Seattle, WA, USA. Since 2007, he has been a Professor of Sustainable Electric Networks and Sources of Energy with Technische Universität Berlin (TU Berlin), Germany.

Dr. Strunz received the IEEE PES Prize Paper Award, in 2015 and 2023, the IEEE Journal of Emerging and Selected Topics in Power Electronics First Prize Paper Award, in 2015, and the 2020 Best Paper Award in the field of electric machines and drives by IEEE Transactions on Energy Conversion. He was the Chairperson of the Conference IEEE PES Innovative Smart Grid Technologies Europe, in 2012. He is the Chair of the IEEE PES Committee on Energy Development and Power Generation and the Co-Chair of the IEEE PES Working Group on Dynamic Performance and Modeling of HVDC Systems and Power Electronics for Transmission Systems. On behalf of the Intergovernmental Panel on Climate Change (IPCC), he acted as the Review Editor of the Special Report on Renewable Energy Sources and Climate Change Mitigation. He is a section editor of IET's The Journal of Engineering.

Invited Speaker (UTC+8)

Thursday, September 26, 2024 11:10-11:40	Temple of Heaven, 2nd Floor/2 楼地坛厅 Room A: 831 9781 0538

Assoc. Prof. Zhanle Wang
University of Regina, Canada

Speech Title:

Abstract: TBA

TBA

Forum (UTC+8)

Thursday September 26, 2024 13:00-15:15	Temple of Heaven, 2nd Floor 2 楼地坛厅

Online Power Supply Reliability Management in New Type Power System

Chairperson: Dr. Yu Zhang, Shijiazhuang Power Supply Branch, State Grid Hebei Electric Power Co., Ltd., China

PR383 13:00-13:15	Research on Weak Point Dependency Relationship Identification for Power Supply Reliability Management in New Type Power Systerm **Qingguang Yu,** Tsinghua University, China Abstract-The weak points of the power system play a vital role in the safe and reliable operation of the power system. This paper summarizes the types of weak points that exist in power systems as well as their identification methods and prime number relationships. Aiming at the characteristics of new power system with high proportion of new energy and load fluctuation, the method of modeling and data identification is proposed. Taking the 34-node distribution system as an example, a program is written to realize the identification of the weak points of the power system, and the correctness of the identification method is verified. Finally, based on the study of the above weaknesses, the reliability management of the power system is analyzed to provide a reference for the planning and operation and maintenance of the power system.
PR377 13:15-13:30	Exploration on the Practice of Improvement Measures for the Power Supply Reliability in Distribution Network in New Type Power System **Jun Tan,** State Grid Electric Power Research Institute, Nanjing, China Abstract-With the changes of power structure, grid shape and operation characteristics under the new type power system (NTPS), the power supply reliability (PSR) has become an important challenge for the power system. This article analyzes the current status and problems of PSR management under the NTPS, and puts forward the improvement measures to enhance the reliability in three aspects, namely, technical measures, management mode, and evaluation system, which provides a valuable resource for studying and applying of PSR management under the NTPS.
PR379 13:30-13:45	Research on Weak Point Location and Relation Analysis of Power Supply Reliability in New Tpye Power System **Yu Zhang,** Shijiazhuang Power Supply Branch, State Grid Hebei Electric Power Co., Ltd., China Abstract-The reliability of power supply in distribution network is determined by grid structure and equipment attributes. To find the weak point of distribution network reliability, identify the weak point by scientific means, analyze the comprehensive benefits of different improvement measures, and optimize the strategy of power supply reliability improvement is particularly important to improve the reliability and quality of power supply. In this paper, the relationship between reliability vulnerability and index mapping of medium and low voltage distribution network is studied, a ridge regression analysis model is established to locate the weak point of distribution network reliability, and a mapping model between reliability index and weak point is established by using time-weighted improved grey correlation analysis. Finally, the weak point of positive definite distribution network is analyzed from the perspective of network framework.
PR378 13:45-14:00	Research on Online Evaluation and Optimization of Power Supply Reliability Considering Distributed **Jinyue Shi,** Shijiazhuang Power Supply Branch, State Grid Hebei Electric Power Co., Ltd., China

	Abstract-The component types of distributed generator distribution network tend to be diversified. The renewable energy power generation system because its primary energy is limited by natural conditions, its output power shows strong volatility and intermittency. The operation mode of isolated island plays an important role in improving the reliability of load power supply in isolated island. However, due to the strong volatility and intermittency of the output of the renewable energy power generation system represented by photovoltaic and wind power generation, it is not guaranteed that the load point on the island can obtain the power support of DG at any time. This paper first analyzes the influence of distributed power supply on the reliability of photovoltaic and the isolated operation mode of distributed power supply, and puts forward a reliability evaluation model of distribution network considering distributed power supply. Then, an online evaluation method of distribution network reliability based on real-time data is proposed from the two aspects of real-time operating status and reliability online evaluation efficiency. The power supply reliability index is obtained by loop search method based on load point, and finally verified by simulation.
PR380 14:00-14:15	Research and Implementation on Dependency **Leidong Yuan,** Tsinghua University, China Abstract-Aiming at electric vehicle (EV) cluster and distributed photovoltaic (PV) access to distribution network, a power supply reliability management (PSRM) scheme of integrated photovoltaic-storage-charging station (PVSC) system is proposed. Firstly, a complex risk model is constructed, which can effectively reflect the dependency relationship between the failure rate of distribution network nodes and state quantities such as voltage and power. Then, the optimal control scheme of PVCS is established according to the complex risk model to minimize the mathematical expectation of failure frequency and power loss. Finally, the effectiveness of the scheme is verified in case study.
PR382 14:15-14:30	Research on Online Pictures Recognition of Fault Scenario for Power Supply Reliability Management Based on Improved AI Algorithm **Ding Liu,** Tsinghua University, China Abstract-Data is the foundation of power supply reliability management and is used throughout the reliability management process. However, in the process of data management, manual data supplementation is still dominant, which greatly restricts the efficiency of data transmission, and at the same time there are certain problems with its accuracy and completeness. For this purpose, online reliability management can be utilized to identify and archive pictures or videos of faulty equipment. In this paper, based on YOLOv8, adopted DCNv3 and put forward the novel global attention mechanism to improve the performance, which improves the recognition accuracy, and meets the requirements of online reliability management after dataset testing.
PR384 14:30-14:45	Research on Flexible Load Control Strategy and Power Supply Reliability Management Based on Sensitivity Analysis in New Type Power System **Min Guo,** Tsinghua University, China Abstract-With the increasing proportion of new energy and power electronic equipment in the power system, the stability of the power system is facing challenges. Overload of transmission line is a common fault problem. The traditional method mainly relies on sensitivity analysis to solve it, but it is limited by the unadjustable characteristic of traditional load. This paper combines flexible load with load sensitivity and Power Supply Reliability and Sensitivity. By adjusting flexible loads such as temperature control air conditioning, electric vehicles and distributed energy storage, the overload branch power of the power system can be adjusted to improve the power supply reliability of the new type power system.

PR381 14:45-15:00	Research on Delay Reliability of Doubly-Fed Induction Generator of Wind Farm Participating in Frequency Modulation of Power System **Xin Yao,** Tsinghua University, China Abstract-With the increase of wind power penetration, the frequency of power system is faced with safety problems. Gridconnected wind turbines participate in frequency regulation through rotor kinetic energy control, where power response is based on frequency deviation, inevitably leading to time delays. The time delay in the frequency modulation process will worsen the dynamic performance of the system, and even lead to the unreliability of the system, which means that the fan frequency modulation is reliable in the case of delay. This paper analyzes the sources of these delays in the frequency regulation process of wind turbines and develops an LFC model incorporating time delays to derive the system's state equations. By performing frequency domain calculations, we determine the delay-independent reliability boundary for wind turbine droop control at various levels of wind power penetration and assess the actual delay margin in operational settings. Finally, this paper validates the findings through simulations using the DIgSILENT platform, constructing a two-area system model that includes both traditional synchronous generators and wind turbines.
PR385 15:00-15:15	Research of Monitoring and Evaluation Approach for Power Supply Reliability Management Based on Online Data Acquisition in New Type Power System **Xiaoyu Che,** Tsinghua University, China Abstract-With the improvement of social requirements for power supply reliability, it is necessary to quickly investigate and correctly dispose of power grid failures in New Type Power System. Currently, the outage events in reliability statistics come from various outage information, and each outage event needs to be confirmed manually in the reliability system, and the topological relationship of each user is judged manually to complete the affected users of the outage event. However, the process of manually confirming and completing the affected users is time-consuming and labour-intensive, and at the same time, there are correctness deviations and a large number of omissions, which will lead to a large number of missing affected users, etc., which will lead to inaccurate calculation of the grid reliability indexes, and will affect the guiding effect of the reliability indexes on the actual work. Therefore, this paper analyzes the main sources of real-time data and data types and other information, based on real-time data on power outage information to carry out a comprehensive study and judgment, and finally establishes the reliability analysis index system of medium and low-voltage users from a multi-dimensional perspective, summarizes and analyzes the monitoring data, and discovers the defects, hidden dangers, and potential hazards of medium- and low-voltage grid equipment in a forward-looking and timely manner, so as to achieve the reliability of the weak points to find and accurately locate the realtime mastery of the power grid's operation condition of the power grid in real time.

Onsite Session 1 (UTC+8)

Thursday September 26, 2024 13:00-15:30	Meeting Room 2, 2nd Floor 2 层会议室 2

Wind Farm Power Generation Model and Power Generation Prediction

Chairperson: Prof. Lin Chen, Institute of Engineering Thermophysics, Chinese Academy of Sciences, China

PR325 13:00-13:15	Wind Speed Forecasting Based on Trend Augmentation and Dual-phase Inverted Transformer **Yuqing Qi,** Beihang University, China Abstract-Wind speed prediction is crucial for power system operation management and electricity trading. Accurate wind speed prediction relies on the extraction of temporal features and correlation characteristics between different variables. However, existing methods, especially recurrent neural network-based models and Transformer-based models, typically focus on extracting temporal features, often neglecting the extraction of inter-variable correlation characteristics. In this paper, a Dual-phase Inverted Transformer with trend augmentation is introduced. By deploying dual-phase encoders and inverted attention mechanism considering phase difference between sequences, model's capacity to capture covariate dependency is enhanced. Measured wind speed data collected from three wind stations is applied to test model's performance. The results demonstrate that by applying the proposed model, the performance of wind speed forecasting is improved, enabling more accurate wind power prediction. The proposed strategy enhances the predictability and controllability of wind power generation, promoting the wider application of wind energy.
PR336 13:15-13:30	Reinforcement Learning for Reliable Power Allocation and Load Mitigation in Wind Farm **Yazhou Wu,** Nanjing University of Aeronautics and Astronautics, China Abstract-Wind energy is increasingly recognized as a key element in advancing a sustainable energy infrastructure and achieving carbon neutrality. However, the integration of wind power into the electrical grid presents significant challenges, particularly in maintaining grid frequency stability due to the variable and unpredictable nature of wind. This often necessitates precise control of power generation, which, in turn, imposes additional fatigue loads on wind turbines. Mitigating these loads is essential for lowering maintenance costs and enhancing turbine longevity. Recent advances in data-driven approaches have shown promise in optimizing power generation and grid frequency control. Notably, reinforcement learning has a natural advantage in solving complex optimization and control problems. This paper presents a novel application of RL for active power control within wind farms, aiming to devise effective power allocation strategies that minimize fatigue loads. Based on shaft torque and tower bending moment information, which are related to wind turbine fatigue, an advanced RL-based controller is designed and trained through iterative interaction with the operational environment. Furthermore, the control effectiveness is evaluated across various operational conditions. The findings confirm that the controller performs satisfactorily in mitigating fatigue loads, highlighting its viability for real-world implementation.
PR340 13:30-13:45	Fault Ride-through Strategy of MMC in Series with DR for Offshore Wind Farms **Wang Ziquan,** Xi'an Jiaotong University, China Abstract-Compared with the conventional MMC, a DR in series with MMC DC transmission system is highly promising because it has a smaller MMC voltage level and capacity, leading to drop in construction cost. However, there is a lack of literature on its

	AC fault ride-through strategy. In this paper, a fault ride-through strategy for DR in series with MMC systems based on the active energy control of MMC is proposed, considering the characteristics of DR. Firstly, the topology of DR in series with MMC system and the active energy control strategy are introduced. Subsequently, the fault ride-through strategy applicable to this system is proposed based on the feature that the capacitive energy of MMC submodules can reach 2.25 pu in a short time. And the preset curves account for the smaller capacity of the offshore MMC and the coupling between the DR AC voltage, DC current and DC voltage. Finally, simulation results from MATLAB/SIMULINK with different types of AC faults demonstrate the reliability of the proposed strategy.
PR304 13:45-14:00	Sustainability, climate change and the Electric Grid: the case of Spain **Jieyi Zhou,** Nebrija University, Spain Abstract-Many electricity and electrical firms in Europe have been transitioning to clean and renewable energy sources through the past 15 years. However, some of these resources require specific environmental conditions which could be at risk considering the impact of climate change in each region. Following the impact of COVID-19 and Ukraine armed conflict, the energy sector was severely affected and in some countries such as Spain. Meanwhile, climate-related risks have stressed the availability of natural resources vital to the energy transition. To this end, the present paper explores the links between sustainable sourced energy and geographical conditions, with a specific focus on the impact of climate change on these variables. Lastly, it offers the three possible scenarios for the Spanish electricity system over the next five years.
PR341 14:00-14:15	Start-up Strategy of DR-MMC based on Thyristors in Parallel for Offshore Wind farms **Ziquan Wang,** Xian Jiaotong University, China Abstract-Modular multilevel converters (MMCs) based HVDC is the primary technological pathway for far offshore wind power delivery. MMC contains numerous sub-modules, leading to high costs for the offshore converter platform, which is sensitive to both volume and weight. To reduce the cost of offshore platforms, the diode rectifier (DR) is configured in series with MMC. However, the unidirectional current flow characteristics of DR make the start-up difficult. To realize the start-up, onshore converter encompasses two MMCs with their voltage levels corresponding to offshore MMC and DR respectively. What's more, thyristors are utilized to provide a power route from onshore to offshore. The detailed start-up process consists of three steps. Firstly, two onshore MMCs are charged and triggered to control the DC voltage. Next, offshore MMC is charged through thyristors in parallel with offshore MMC and activated to control the offshore AC voltage. With this AC voltage, wind turbines (WTs) start up and DR is put in. After the normal power achieve normal power output, the thyristors are naturally switched off. Wind power is then transferred through the MMC and DR, completing the start-up. The start-up strategy is validated by simulation results in PSCAD.
PR349 14:15-14:30	Extended Wind-Storage Frequency Response Model Considering Temporal Factors **Yiming Fang,** Shanghai University of Electric Power, China Abstract-Traditional frequency-domain wind-storage frequency response models often neglect the temporal sequence issues and source-side fluctuations during the frequency regulation process, making it difficult to accurately grasp the system frequency characteristic changes when renewable energy stations and energy storage participate in frequency characteristic variations during system frequency regulation. Firstly, the study constructs a frequency response model considering source-side uncertainty based on the traditional model. Secondly, the frequency response characteristics of grid-forming energy storage are analyzed, and a frequency response model for a combined wind-storage system incorporating grid-forming energy storage is established. Furthermore, a wind-storage coordinated control system frequency response model considering temporal sequence is established by introducing temporal factors. Finally, a high wind power penetration system is constructed for simulation-based verification.

PR368 14:30-14:45	Low-Frequency Offshore Wind Power Transmission System with Dual-end Grid-forming Control **Nan Fu,** Tsinghua University, China Abstract-The offshore wind power has been gaining increasing attention in recent years. Low-frequency alternating current (LFAC) transmission is emerging as a promising technology with specific advantages for offshore wind power transmission. This paper discusses the structure and control of the offshore wind power transmission system based on LFAC. In order to enhance the support for the power system, grid-forming control can be implemented on both sides of the modular multilevel matrix converter (M3C) used in LFAC. Additionally, the capacitor voltage control of M3C is briefly introduced. Furthermore, power reserve control is utilized to enable wind turbines to participate in primary frequency regulation. Finally, the effectiveness of the designed control system is verified through simulation using PSCAD/EMTDC, further demonstrating the efficacy of the strategy.
PR353 14:45-15:00	A Renewable Energy Farm Forecasting model Based on Ensemble Learning **Xinge Xu,** North China Electric Power University, China Abstract-With the continuous increase in the penetration rate of renewable energy sources such as wind and light in the power grid, their inherent randomness, volatility, and intermittency pose challenges to the safe and stable operation of the power system. Regional wind and solar power prediction is an effective measure to address the above issues. However, the prediction performance of a single model still has some limitations. As an effective method, ensemble learning can improve the prediction accuracy and enhance the generalization ability of the model. This paper proposes a wind and solar cluster power prediction model based on feature dimensionality reduction using the Stacking integration framework, which integrates Long Short-Term Memory (LSTM), Extreme Gradient Boosting (XGBoost), Least Absolute Shrinkage and Selection Operator (LASSO), and Support Vector Machine (SVM) models, and the model hyperparameters are optimized using grid search method. The results show that the proposed fusion model performs better in evaluation indicators such as Root Mean Squared Error (RMSE) and Mean Average Error (MAE) than other models. It has strong robustness and enhances the model's generalization ability, verifying the effectiveness of the proposed fusion model and effectively improving the wind and solar power prediction performance.
PR367 15:00-15:15	Simultaneous Deployment of Battery Electric Vehicles and Hydrogen Fuel Cell Vehicles to Manage Surplus Wind Power Generation: A Case Study of Orkney **Junyuan Wu,** The Hong Kong University of Science and Technology (Guangzhou), China Abstract-This study evaluates the potential for reducing wind curtailment on Orkney Island, Scotland, UK by increasing the deployment of Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs). The daily activities of BEVs and FCEVs were simulated using a vehicle load time distribution model based on Monte Carlo simulations in MATLAB. A 20-year microgrid model, accounting for inflation and facility expansion, was established using the HOMER power system model. Both single-objective and multi-objective optimizations show that higher BEV proportion is optimal. In single-objective optimization, the optimal solution at 95% BEV proportion showed a 22.92% decrease in Levelized Cost of Energy (LCOE), but excess electricity increased by 18.60 points and unmet load by 0.25 points. In multi-objective optimization, the 100% BEV solution was closest to the ideal, with a 7.31 point decrease in excess electricity, a 0.91 point decrease in unmet load, but a 9.41% increase in LCOE.

PR330 15:15-15:30	Research on Deep Sea Offshore Wind Energy DRU-MMC Transmission Scheme **Shaohua Zhu,** Shandong Electric Power Engineering Consulting Institute Co., Ltd., China Abstract-With the development of offshore wind power towards deep and distant seas, long-distance power transmission forms have become a focus of attention. Compared to the AC scheme with poor power transmission capacity and the low-frequency scheme with less mature technology, the DC transmission scheme has become an ideal long-distance transmission scheme. This article proposes a profound sea wind energy DRU-MMC transmission scheme, analyzes its topology, elaborates on its working principle, and designs the main parameter design scheme of the offshore wind power transmission system through diode valves, laying the foundation for subsequent key control strategy research and economic comparison.

Onsite Session 2 (UTC+8)

Thursday September 26, 2024 15:45-18:30	Temple of Heaven, 2nd Floor 2 楼地坛厅

Modern Integrated Energy System and Intelligent Electrical System

Chairperson: Prof. Qingguang Yu, Tsinghua University, China

PR303 15:45-16:00	Life cycle Cost Evaluation of Energy-saving Transformers for New Power System **Yinan Wang,** School of Energy Power and Mechanical Engineering, North China Electric Power University, China Abstract-In the context of growing global demand for electricity and the ongoing restructuring of the energy mix, the share of the power sector in energy consumption is becoming increasingly important. As a crucial component of the power system, power transformers should develop in the direction of saving energy. The aim of this paper is to compare the life cycle cost (LCC) of conventional transformers with that of energy-efficient transformers and to predict the power savings of energy-efficient transformers in the next ten years using the GM(1,1) model. Through this study, we can derive the amount of electricity saved over the operating life of the energy efficient transformer, the reduction in pollutant emissions, as well as the savings in electricity bills, carbon trading commutation benefits, and carbon tax commutation benefits as a result of the electricity savings.
PR365 16:00-16:15	A general controller test method of HVAC system based on combination of virtual and reality **Pengdan Fan,** Beijing University of Technology, China Abstract-The controllers of various forms and functions in HVAC system are essential for the efficient operation of the system. With the increasing intelligence level of HVAC equipment, the test of controllers has become more demanding, and traditional test methods cannot meet the current needs of controller test. To improve the efficiency of controller development, this paper proposes a virtual-reality combined controller test method to improve test efficiency and ensure the applicability of the test method. Firstly, a development method for a Virtual-Reality Combined Simulation Laboratory (VRCSL) for HVAC controller is presented. Secondly, a VRCSL is constructed using the fan coil system as an example. Finally, the applicability and economy of the VRCSL are analysis. The results show that the VRCSL can change equipment parameters arbitrarily based on equipment samples to complete more test tasks. Compared with actual laboratory test, the VRCSL has an energy-saving rate of 95.8%, and the VRCSL can adjust the test speed with the fastest speed of 30 times. The VRCSL can also apply meteorological data from multiple regions around the world, improving the comprehensiveness of test conditions. Therefore, the VRCSL can overcome the drawbacks of high energy consumption, low efficiency, and limited test conditions in actual laboratories, and greatly improve the test efficiency.
PR315 16:15-16:30	Study on the Influence of Topology, Load Distribution and PV Installation Location on PV Hosting Capacity **Zihan Lin,** Xi'an Jiaotong University, China Abstract-Among numerous renewable energy sources, solar energy is the most widely utilized resource. By deploying photovoltaic (PV), solar energy is converted into electricity. The accessible capacity of PV is influenced by many factors such as load, topology and PV installation location. However, most studies only focus on the impact of total load on PV hosting capacity (PVHC), the impact of load, topology and PV installation location on PVHC has not been studied. In response to the above problems,

	two problems are mainly explored in this paper. First, considering constraints such as reverse power transmission, a PVHC evaluation model is established to evaluate the maximum PV accessible capacity of the distribution network. Second, different topological structures, load distribution and PV installation location are used to evaluate PVHC, the influence of different topologies and load distribution and PV installation location on PV capacity are explored.
PR337 16:30-16:45	Research on Neutral Point Voltage Balance Control Method of NPC Energy Storage Converter **Hang Su,** Harbin Institute of Technology, China Abstract-Due to the characteristics of low total harmonic distortion and high breakdown voltage, neutral point clamped (NPC) energy storage converter is more suitable for high-permeability renewable energy system to provide power support. However, the inherent neutral point voltage unbalance issue of NPC converter affects the grid-connected compensation quality of energy storage. To solve this issue, a neutral point voltage balance control method based on three-level space-vector pulse-width modulation (SVPWM) is proposed in this paper. Considering both the neutral point voltage fluctuation and power flow direction, the positive and negative level time adjustment coefficients are introduced to dynamically adjust the medium and small vector action time, minimizing the voltage dynamic fluctuation while reducing the steady-state offset. The overall performance of the proposed control method is illustrated with the analysis of neutral point voltage unbalance problem, influencing factors and its suppression mechanism. Finally, the simulation verification proves the effectiveness of the proposed method under different working conditions.
PR360 16:45-17:00	Performance Analysis of Hydrogen-Powered Gas Turbine Engines: A Parametric Study **Youssef Elmeknassi,** Nanjing University of Aeronautics and Astronautics, China Abstract-The demand for environmentally sustainable energy is rapidly increasing each year. This study investigates the performance of a hydrogen-powered gas turbine engine by analyzing the effect of varying compressor inlet temperature, compression ratio, and equivalence ratio. A numerical model was established for a two-stage compressor gas turbine engine using hydrogen properties during combustion. Performance metrics used in this research include air intake required for different equivalence ratios, products resulting from the combustion of hydrogen, temperature at the combustion chamber exit, and thermal efficiency. The results indicate a decrease in the required air amount as the equivalence ratio increases, from approximately 69.59 at an equivalence ratio of 0.5 to 35.3 at an equivalence ratio of 1. The decrease in the amount of air required affects the products of combustion concentrations by volume, particularly nitrogen, water, and oxygen. From an equivalence ratio of 0.5 to 1, we have noted a 9.3% and 88.9% decrease in nitrogen and water, and oxygen disappears completely. The equivalence ratio demonstrates a well-known characteristic of hydrogen combustion, showing extremely high temperatures at the exit of the combustion chamber as equivalence ratios approached stoichiometric conditions. The thermal efficiency showed good results at high compression ratios and low compressor inlet temperatures. Optimal conditions were recorded at an equivalence ratio of 0.9, a compression ratio of 25, and an inlet compressor temperature of 250K.
PR338 17:00-17:15	Research on Virtual Impedance Compensation Control Method of Parallel Compensator with Energy Storage **Yihua Wang,** Harbin Institute of Technology, China Abstract-With the increasing proportion of distributed energy application, the resonance problem caused by the mutual coupling of the grid-connected inverter output impedance and the grid impedance cannot be ignored. To solve the above problem, this paper establishes the output impedance model of the grid-connected inverter and analyzes the stability of the distribution network system. On this basis, a

	virtual impedance compensation control method based on parallel compensator with energy storage is proposed, which can adaptively adjust the virtual impedance according to the grid voltage resonance component to absorb resonant current, thus effectively suppressing the resonance and improving the stable operation ability of the system. Finally, the simulations and experimental verification based on RT-BOX hardware-in-the-loop platform are carried out, proving the effectiveness of the proposed control method.
PR363 17:15-17:30	PEMEC System Economic Operation Model Considering Renewable Energy Output Fluctuations and Equipment Operating Characteristics **Zhengsong Wang,** Shandong University, China Abstract-The economics of hydrogen production via electrolysis closely correlates with the output characteristics of renewable energy sources and the operational features of electrolysis equipment. This paper proposes an economic operation model of electrolytic hydrogen production systems considering renewable energy output fluctuations and equipment operating characteristics. To explore the relationship between system efficiency and key operational parameters, a model of a hydrogen production system was constructed, comprising a proton exchange membrane electrolysis cell (PEMEC), a dryer, and a compressor. Moreover, renewable power generations are used as sources of system power input, and energy storage devices are introduced to smooth out fluctuations. The proposed economic operation model has the optimization objective of minimizing system cost, of which the effectiveness is validated using a case.
PR370 17:30-17:45	Security Analysis of Battery Energy System to Cyber and Physical Attacks On Sensors **Rui Wang,** Zhejiang University, China Abstract-Nowadays, to tackle the issue of global warming and fossil fuel over-exploitation, the burgeoning penetration of renewable sources such as solar and wind power is proposed as the most effective solution. However, due to the intermittent and fluctuating feature of weather resources, it's hard for the grid to get stable power from renewable sources. To improve the reliability of renewable energy, the battery energy storage (BES) system is largely used as a carrier to absorb and release power. The strong integration with renewable energy sources, such as photovoltaics, places the BES system in a more complex and open environment, making it more accessible to adversaries. In light of this characteristic, this paper conducts a security analysis of the BES system, especially the power conversion system (PCS) within the BES. The analyzed security vulnerabilities primarily involve cyber or physical means to spoof the sensors on the PCS. The vulnerabilities can be exploited to manipulate the sensor measurements and further mislead the control algorithm of PCS. thereby manipulating the power output to the grid. Specifically, we analyzed the impact and feasibility of cyber and physical attacks that tamper with sensor outputs. We experimentally verified sensor attacks by modulating physical signals and validated the results of manipulating the PCS power output in Simulink. Finally, we discussed hardware and software countermeasures to mitigate such security vulnerabilities.
PR375 17:45-18:00	Technical Method and Model of Boiler Peakregulation Based on Artificial Intelligence Algorithm **Xiaobo Li,** North China Electric Power University, China Abstract-In the context of deep peak shaving, this article explores a machine prediction model based on artificial intelligence algorithms. Real time and historical data from power plants are processed to select relevant feature values, and LSTM and random forest models are used to construct the model. By continuously adjusting the data model, the final model parameters are determined to obtain a more accurate prediction model that predicts the flue gas temperature at the tail of the boiler. This will help solve the problem of high flue gas temperature at the tail of the boiler during peak shaving in

	power plants. At the same time, it also provides a new solution for the problems arising from peak shaving of power plant boilers.
PR3005 18:00-18:15	Research on Key Technologies of Power Grid Side 100MW Energy Storage System **Zhang Fuxing,** HNAC Technology Co. Ltd., Changsha, China Abstract-To improve the construction specifications and operational benefits of the grid-side 100MW energy storage system, this paper, based on government policies, academic research, and industrial applications, first summarizes the research status at home and abroad in terms of the grid-side energy storage system's function, power regulation, frequency regulation, investment income, and safety protection. Secondly, the "4S" architecture for the grid-side energy storage power station is proposed, and the similarities and differences with the traditional "3S" architecture are described in terms of structure, function, and response speed. Thirdly, from the three dimensions of energy monitoring, coordinated control, and energy storage converter, this paper expounds the key technologies of grid energy storage power station under the "4S" framework. Finally, the research contents of this paper are summarized, and future research directions are discussed from the physical and information levels.
PR374 18:15-18:30	Rapid Quantification of Scheduling Uncertainty in Integrated Energy Systems Under Extreme Scenarios **Shupei Chen,** Nanjing Normal University, China Abstract-The occurrences of extreme scenarios typically represent low probability events. The limited historical sample data and their lack of representativeness contribute to significant errors in output prediction, thereby reducing the quality of scheduling, which has a serious impact on the reliability of power supply in the power system. In this paper, a rapid quantification method for the scheduling uncertainty of integrated energy systems under extreme scenarios is proposed. This method directly establishes a mapping relationship between meteorological data and dispatching, thereby improving the speed and accuracy of integrated energy dispatch forecasting. Firstly, the Maximal Information Coefficient (MIC) was employed to select the typical characteristics of meteorological features. Subsequently, in order to solve the problem of lack of historical data in extreme scenarios, an improved generative adversarial network with gradient punishment (WGAN-GP) was proposed, and the Principal Component Analysis (PCA) method was utilized to reduce the dimension. Finally, Gaussian Process Quantile Regression (GPR-Q) is employed to predict the scheduling results of integrated energy systems (IES) in extreme scenarios. The proposed method was applied to an integrated energy system in extreme scenarios and subjected to comparative analysis against existing methods. Experimental results demonstrate that the proposed method can effectively enhance the capability for rapid and accurate scheduling of integrated energy systems under extreme scenarios.

Onsite Session 3 (UTC+8)

Thursday September 26, 2024 15:45-18:30	Meeting Room 2, 2nd Floor 2 层会议室 2

System Control, Model Simulation and Reliability Analysis in Power Systems

Chairperson: Assoc. Prof. Zhanle Wang, University of Regina, Canada

PR310 15:45-16:00	Optimal Pricing Model for Electric Vehicle Charging Stations Considering Competition **Zhanle Wang,** University of Regina, Canada Abstract-In today's world, technology is booming, and people are more aware of how their actions affect the environment. One big change we are seeing is the rise of electric vehicles (EVs). The surge in EV adoption necessitates efficient and fast EV charging stations, but challenges such as extended charging times, limited facilities, and their impact on power systems must be addressed. This paper proposes an optimized pricing model, considering the integrated operation of the transportation network and the power distribution system. This model accounts for both competitive and non-competitive charging demand. The proposed model can effectively reduce peak demand, ensure power system stability, increase EV charging station profit and decrease EV users' waiting time for charging.
PR344 16:00-16:15	Simulation study of biomass-to-high-value product conversion via steam gasification and methanol synthesis **Woranee Mungkalasiri,** Faculty of Engineering, Thammasat School of Engineering, Thammasat University, Thailand Abstract-In the pursuit of sustainable energy solutions and efficient resource usage, the conversion of biomass into high-value products has emerged as interesting topics of research and development. Therefore, the aim of this research was to discover possibilities in converting biomass to high-value product. The study focused on the simulation to evaluate optimal operating conditions of steam gasification coupled with the methanol synthesis processes for methanol production, using the Aspen Plus program. Within the gasification process, the operating conditions of gasification temperature and steam to biomass ratio (S/B) were studied, while the methanol synthesis process was examined in terms of temperature and pressure conditions. The feedstocks employed were rice straw and sugarcane bagasse and processed at a rate of 100 kg/hr. The results revealed that characteristics and behaviors of syngas derived from each biomass type in relation to gasification temperature and S/B ratio, directly impacting methanol generation. Moreover, the optimal operating conditions were determined. Rice straw presented an optimum gasification operating temperature of 800°C with an S/B ratio of 0.3, whereas sugarcane bagasse presented optimal conditions at the same temperature but with an S/B ratio of 0.4. For methanol synthesis, the process efficiency was achieved at an operating temperature of 220°C and a pressure of 50 bar, leading to the high methanol production rates of 31.88 kg/hr and 53.90 kg/hr for rice straw and sugarcane bagasse, respectively.
PR327 16:15-16:30	Research on User-Side Self-regulatory Voltage Regulation Method Considering Responsibility Definition **Jiatao Zhou,** Zhejiang University of Technology, China Abstract-With the increasing severity of energy shortage and environmental pollution, a high proportion of renewable energy is connected to the power grid. Renewable energy is greatly affected by weather and other factors, leading to increasing difficulties in voltage regulation in various aspects of the power grid. This article focuses on the sharing of voltage regulation responsibilities between the power grid and users and the protection of user privacy. Taking a 10kV distribution network as an example, a new

	decentralized reactive power compensation voltage regulation method is proposed. This method requires users to self regulate on-site compensation to offset the impact of load fluctuations on line voltage drop, effectively suppressing the fluctuation of voltage difference between two points, and achieving the goal of stable load voltage at controlled nodes. This article uses Matlab to control OpenDSS to simulate compensation schemes, and the verification results of actual case models show that this control strategy is practical and feasible under various operating conditions.
PR334 16:30-16:45	Optimization of PV Microgrid Group Scheduling based on Cooperative Alliance in Xizang **Xiuhan Song,** Shanghai University of Electric Power, China Abstract-With the promotion of photovoltaic microgrid construction in Xizang, a multi-microgrid cooperative alliance model is proposed to address the energy consumption issues of photovoltaic microgrid clusters on the distribution network side. In this paper, the objective of independent operation scheduling is illustrated through the mathematical modeling of microgrid. Additionally, a cooperative alliance model is constructed and the benefits are distributed by using the Shapley value method. Through simulation, the proposed method effectively reduces the operating costs of the multi-microgrid system, promotes the local consumption of photovoltaic power generation, and mitigates the impact of the multi-microgrid system on the power grid in Xizang.
PR335 16:45-17:00	A Bridgeless PFC-Modified Voltage-Doubler Rectifier with Shared Components **Mingyuan Ding,** Harbin Institute of Technology, China Abstract-This article extends the component sharing concept to the single-phase bridgeless dual-Cuk rectifier and hence, a novel bridgeless voltage-doubler rectifier with shared components is pro-posed. Instead of integrating two Cuk units, the presented rectifier adopts a common set of energy-storage capacitor and inductor to operate at both positive and negative half-line cycles, thus greatly improving the passive component utilization. By adopting voltage-doubler output structure, the proposed rectifier provides reduced voltage stress on the switches at the same output voltage level. The output polarity can be reversed by changing the access direction of the switches at the output side. Moreover, the rectifier operates in discontinuous conduction mode (DCM), and the input current in a switching cycle is proportional to the input voltage. Thus, a near-unity power factor is obtained with no current-loop control. The topology structure, working principle, characteristic analysis, and control scheme are covered in detail. Finally, a 200-W simu-lated model is constructed, and the results verify the proposal well.
PR372 17:00-17:15	An assessment method of negative sequences aiming at the continuous co-phase traction power supply system **Weilan Li,** Southwest Jiaotong University, China Abstract-The electrified railways are the largest single consumer of the power grid, in which the neutral sections between traction networks are always a major constraint to the stability and reliability of traction power supply system(TPSS). A continuous co-phase TPSS is an effective approach to achieve the goal that the electrical neutral sections between traction networks be eliminated. However, the negative sequences issues is very crucial in the systems, it is necessary to make an accurate assessment of the negative sequence to determine whether it needs to be managed. Therefore, a comprehensive and accurate mothod of negative sequence assessment has been proposed in this paper aiming at the continuous co-phase TPSS, without neglecting the traction calculation of the train, the coupling effects between the TPSS and the power grid. Firstly, the structure of the continuous co-phase TPSS is introduced, which is possible to realize the compensation of negative sequences to the power grid. The traction calculation of the train is accomplished so that the positions, speeds, and power of the trains at each moment can be obtained, which is the basis for the accurate

	calculation of the system's power flow. Next, the chain circuit model of the continuous co-phase TPSS is constructed to solve the power flow calculation(PFC) of the entire system. Finally, the method of negative sequence assessment is developed with the above analysis and then applied to the assessment of the negative sequences caused by an actual electrified railway to the power grid.
PR373 17:15-17:30	Output Power Prediction of Thermal Power Plants Based on Optimized Random Forest Algorithm **Zichun Zhao,** North China Electric Power University, China Abstract-Based on the operation data of a power plant with a rated power of 660MW unit in one week in January 2024, this paper proposes a prediction model of the random forest algorithm (AM-RF) with the introduction of the attention mechanism. The input variables of the model are filtered by calculating the Pearson correlation coefficient and the attention weighting coefficient of each operating parameter, and the model is calibrated using the test data after the model training is completed, and the prediction results are finally obtained. By analyzing the prediction results and comparing with other prediction models, it is concluded that the MAE, RMSE, R2 and computation time of the AM-RF model are better than those of other single models, which proves that the AM-RF soft measurement model has a better prediction effect for the forecasting of the unit output power, and the random forest algorithm with the addition of the attention mechanism can effectively improve the forecasting accuracy of the unit output power.
PR3007-A 17:30-17:45	Design of Fault-tolerant ANPC three-level inverter topology **Qiannuo Zheng,** Nanjing University of Science and Technology, China Abstract-With the gradual increase of voltage level and power level in industrial field, inverters are widely used in high power applications such as medium and high voltage wind power generation systems. Multilevel inverters, with the characteristics of being able to withstand higher voltage levels, generating higher output power and higher stability, have gradually drawn attentions in academia as well as industry. However, due to complex structure of multilevel inverters, switching devices suffer from defects such as loss imbalance and high switching stresses that limit output power of the system. Accordingly, multilevel inverters are subject to high probability of failure, especially in high-power applications such as wind power, resulting in abnormal operation and serious damage to the system. To address the aforementioned problems, this paper carries out research on fault-tolerant control methods for multilevel inverters and proposes a fault-tolerant Active Neutral-Point Clamped (ANPC) three-level inverter and its control strategy. This strategy plays an important role in enhancing reliability of the ANPC inverter system. Firstly, a novel ANPC three-level inverter topology design with fault tolerance and its control scheme is proposed. The new topology is characterized by adding a Double-pole, Double-throw (DPDT) relay and four bidirectional thyristors in each phase of an ANPC three-level inverter. Once a fault is detected in either switch, these auxiliary devices can be triggered and used for topology reconfiguration. A MATLAB/Simulink simulation model is built for the fault-tolerant ANPC three-level inverter and experiments are tested on a platform with DSP F28335 as the controller to validate the proposed method. Results show that the fault-tolerant ANPC three-level inverter designed in this paper adopts a combination of switching hardware topology and fault-tolerant control algorithm to ensure that the system can be restored to sub-healthy operation state in case of outer open-switch faults and inner open-switch faults occurring in a single phase under both high and low regulation regimes. The topology and its control method proposed are able to maintain the stable operation of the inverter system under fault conditions, effectively reduce system cost, size, control difficulty and various types of losses, and have certain advantages in restoring the three-phase current total harmonic distortion rate and the midpoint voltage balance performance. The present study provides a reference basis for research of fault-tolerant control theory and fault-tolerant control methods for multilevel inverters.

PR307 17:45-18:00	Fast Calculation of Transient Temperature Rise of Duct Cable based on Fitting Function **Xiaoyi Zhao,** Hebei University of Science and Technology, China Abstract-Quickly and accurately calculating the transient temperature rise of power cables in a short period of time is of great engineering significance for deeply exploring the load capacity of power cables under emergency loads. According to the uniqueness of the thermal field and temperature superimposability, the group of row-pipe cables is simplified into the sum of the self-heat of each cable and the mutual heat of the neighboring cables. Finite element method is used to calculate the self-heat temperature rise data of a single cable and the mutual heat temperature rise data of the neighboring cables. The fitting function of the cable's self-heat and mutual heat is given to establish the computational model of the fitted transient temperature rise for the given line. Using the obtained fitted model, it is possible to calculate the temperature rise of the cable population under different load conditions. Examples show that the method has high accuracy and is easy to calculate, and can be used for fast calculation of transient temperature rise engineering under emergency loading of existing lines.
PR362 18:00-18:15	Load-Side Shared Energy Storage New Energy Consumption Strategy Based on Nash Bargaining **Runpeng Hao,** North China Electric Power University, China Abstract-Load-side shared energy storages and new energy stations alliance for new energy consumption has become a hot topic in high-proportion new energy power systems. A mixed-integer linear programming model is adopted to optimize the decision-making of the load-side shared energy storage charging and discharging strategy, and a Nash bargaining model is used to analyze the profit distribution pattern among stakeholders in the alliance. Firstly, aiming at the multilateral alliance formed by the new energy station cluster and the load-side shared energy storage, a power trading simulation model for the alliance participating in the electricity and ancillary service markets is established. Secondly, addressing the internal profit distribution equilibrium issue within the alliance, a Nash bargaining game simulation model is established to optimize the multilateral profit distribution pattern between new energy stations and shared energy storage stations, using the ADMM algorithm to solve the Nash bargaining game.Finally, based on the market environment of a certain new energy-rich area, a cost-benefit game analysis is conducted between the load-side shared energy storage and the multilateral alliance of new energy station clusters, verifying the effectiveness of the model and analyzing the sensitivity of the key factors.
PR323 18:15-18:30	Energy Price Management Systems for Households **Thokozile Fortunate Mazibuko,** Durban University of Technology, South Africa Abstract-The high cost of electricity in South Africa has had a significant impact on low-income families, leading to considerable economic challenges. With a large portion of their income going towards electricity expenses, the increasing prices have placed them at risk of energy poverty. This study examines the potential and efficiency of integrating photovoltaic systems into the energy infrastructure of low-income communities to address this issue. The analysis covers both technological and economic aspects, aiming to ensure equitable access to clean and affordable energy for all. Additionally, the research identifies potential obstacles and difficulties in implementing solar energy in low-income households, along with proposing practical solutions to overcome these issues. The study evaluates the economic viability of a grid-connected hybrid (PV) power system for rural areas in the southern region of Durban, South Africa. By exploring the solar energy potential and utilizing data from NASA, the investigation utilizes the Hybrid Optimization Model for Electric Renewable (HOMER) program to assess the economic feasibility of the proposed hybrid power system. A comparison between grid-only and grid PV integrated configurations is conducted to determine the financial viability of both options. The simulation outcomes indicate that the

	recommended grid-connected hybrid (PV) power system is the most suitable and cost-effective solution for the specified location.

Online Session 1 (UTC+8)

Friday, September 27, 2024 10:30-12:15	Room A: 831 9781 0538

Digital Power Equipment Design and Function Control

Chairperson: Dr. Yu Chen, Huazhong University of Science and Technology, China

PR356 10:30-10:45	Improved MPC Method Based on Model Parameter Online Estimation for MMC **Yu Chen,** Huazhong University of Science and Technology, China Abstract-The modular multilevel converters (MMCs) are widely used in power system. Model predictive control (MPC) is an effective control scheme for MMCs. However, the parameter perturbation will seriously affect the performance of the MPC. In this paper, the influence of the parameter perturbation on the MMC arm current direct control using MPC is analyzed. The arm resistance and inductance parameter mismatch will affect the MPC performance. The inductance parameter mismatch has a greater impact on the MPC performance. Then, an improved MPC method based on model parameter online estimation is proposed. A voltage feedback and least squares algorithm are introduced to achieve model parameter accurate estimation. Finally, the effectiveness of the model parameter online estimation based MPC is verified by simulation.
PR329 10:45-11:00	PMSM Zero-low Speed Rotor Position Estimation Control Strategy based on Improved SOGI-ANF **Fang Wang,** Nanjing University of Science and Technology, China Abstract-For the traditional Pulsated High-frequency Voltage Injection Method, the position sensorless control of PMSM requires the use of band-pass filter (BPF) and low-pass filter (LPF) in the zero-low-speed domain, and the use of the filters will bring about the filtering delay, which will cause the reduction of the precision of the position estimation and other problems, this paper proposes a method of combining the second order generalized integrator (SOGI) and the adaptive notch filter (ANF), i.e., SOGI-ANF, replacing the BPF and LPF with the SOGI-ANF, which does not generate displacement and amplitude drop at the selected frequency, effectively eliminates the estimation errors caused by conventional filters, thus improving the estimation accuracy. SOGI-ANF has a better rejection effect in the low and high frequency filtering stages compared with the traditional second order generalized integrator. Finally, the effectiveness of the strategy is verified on simulation software.
PR345 11:00-11:15	A substation power equipment detection method and system based on infrared and visible light fusion **Junyi Yu,** Wuhan University, China Abstract-This paper first uses the feature set to perform multi-scale attention mechanism feature fusion to generate an attention output feature set. Then, the feature set and the corresponding attention output feature set are used to reconstruct the image to generate an infrared reconstructed image and a visible light reconstructed image. All infrared reconstructed images and corresponding visible light reconstructed images are used to calculate the bulldozer distance, and a visible light and infrared fusion image set corresponding to the power equipment is constructed. The multi-scale attention mechanism feature fusion method is used to realize the interaction between features of different modes and scales, strengthen the feature fusion of multi-modal image sources and multi-scales, and improve the target details of the fused image. This enables effective monitoring and maintenance of the reliability and safety of power equipment.

PR3002 11:15-11:30	Design of nonlinear control system based on operator theory for WPT system considering constant power load **Yuta Ono,** Tokyo University of Agriculture and Technology, Japan Abstract-In recent years, wireless power transfer (WPT), which transmits power wirelessly, has attached much attention. WPTdoes not need to use cables to trans power and can transmit power when there are obstacles between the transmitter and receiver, or when the power supply side is moving. There are constant power loads that consume only a certain amount of power and are used as practical loads. On the other hand, they have instability due to negative impedance characteristics, so control system design must consider load characteristics. This paper proposes a nonlinear control system based on operator theory for a WPT system with resonant coupling of magnetic fields that considers constant power loads, and shows modeling, control system design, and results of simulation.
PR351 11:30-11:45	Arc Extinction Moment Identifying Method for Flexible Grounding System Based on SOGI **Guang Li**, China University of Petroleum, China Abstract-To shorten the operating time of flexible grounding devices in flexible grounding systems, extend their service life, and reduce maintenance costs, it is necessary to provide a fast and accurate judgment basis for their timely withdrawal after fault arc extinction. This paper establishes an equivalent model of grounding faults in flexible grounding systems to analyze the electrical characteristics before and after fault arc extinction. Subsequently, the study investigates SOGI-based filters and frequency-locked loops. Combining these with the characteristic of constant line voltage in distribution network grounding faults, a method for identifying the fault arc extinction moment in flexible grounding systems based on SOGI is proposed. Finally, to verify the effectiveness of the proposed method, a 10kV flexible grounding system simulation model is built using MATLAB/Simulink. The method is validated under various system detuning degrees and transition resistance conditions, demonstrating its good applicability and robustness in accurately identifying the arc extinction moment of grounding faults. The research findings provide a new technical approach for handling grounding faults in distribution networks, with significant engineering application value.
PR3003 11:45-12:00	Partial neural network based modeling of 3-degree of freedom soft actuator and its tip position control **Koichi Sakata,** Tokyo University of Agriculture and Technology, Japan Abstract-A soft actuator is a type of actuator made of flexible materials such as rubber. It has a simple structure, so it is easy to miniaturize. In addition, it is highly safe for human-body and is expected to be used in medical field. The McKibben artificial muscle is a type of soft actuator producing contraction.3-Degree of Freedom (3-DOF) Soft Actuator using in this study is made of three McKibben artificial muscles attached in parallel. Purpose of this study is to perform tip position control that addresses the nonlinear characteristics of it.
PR342 12:00-12:15	Distributionally Robust Optimization Scheduling for Off-grid Hydrogen Systems Considering Wind and Solar Uncertainty **Yi Shen,** China University of Petroleum, China Abstract-The surge in renewable energy penetration rates has unveiled the limitations of off-grid power systems in effectively integrating and accommodating renewable energy resources, as well as in reliably meeting load demands. This challenge is primarily attributed to the absence of active regulation equipment. This paper addresses the challenge of insufficient flexibility in existing off-grid grids by proposing

	an optimization strategy for an off-grid DC hydrogen energy system that incorporates the uncertainty of wind and solar energy. The strategy commences with the establishment of a hydrogen energy unit, comprising electrolyzers, hydrogen fuel cells, and hydrogen storage, based on historical wind power generation data. The objective is to minimize the expected values of start-stop costs for the electro-hydrogen system units and operational costs under various scenarios. It employs a data-driven distributionally robust optimization approach with norm-1 and norm-∞constraints on the probabilistic distribution of typical wind and solar power output scenarios. The resulting optimization model is solved using a column-and-constraint generation (CCG) algorithm. Finally, simulation case studies are presented to validate the effectiveness of the proposed method in enhancing the operational flexibility of the system.

Online Session 2 (UTC+8)

Friday, September 27, 2024 10:30-12:15	Room B: 821 1151 7346

Smart Grid Control Model and Reliability Evaluation

Chairperson: Assoc. Prof. Guangqiang Lyu, Nanjing University of Science and Technology, China

PR317 10:30-10:45	A Three-Phase State Estimation Method for Low-Voltage Distribution Networks Considering the Measurement and Control Characteristics of Three-Phase Three-Wire Inverter Power Supplies **Yiming He,** Chongqing University, China Abstract-Driven by national strategic needs, wind and photovoltaic energy, as important sources of energy, are commonly integrated into the grid using three-phase three-wire inverter power supplies, with an increasing penetration rate in low-voltage distribution networks. However, there is currently no state estimation method that takes into account their integration into low-voltage distribution networks. Therefore, a three-phase state estimation method for low-voltage distribution networks that considers the measurement and control characteristics of three-phase three-wire inverter power supplies is proposed. In terms of measurement characteristics, measurement equations for the line-to-line power, line-to-line voltage, and phase current of the inverter power supply are established based on the two-meter method. In terms of control characteristics, symmetrical current control constraints and asymmetric zero-sequence current constraints considering the three-phase three-wire inverter power supply are established. Combining the aforementioned measurement and control characteristic equations with exponentially weighted least squares estimation, a three-phase state estimation model for low-voltage distribution networks is constructed. The model is efficiently solved using the Lagrange multiplier and Newton's method. Finally, the effectiveness and accuracy of the proposed method are verified through simulation analysis based on the IEEE 13-bus system.
PR376 10:45-11:00	Situation Awareness of Distribution Network Based on TPA-BiLSTM **Qingshan Li,** State Grid Zhejiang Electric Power Co., Ltd., China; Quzhou Power Supply Company Quzhou, China Abstract-Aiming at the increasingly complex distribution network operation and in order to improve the reliability of distribution network power supply, this paper proposes a security posture sensing method based on Temporal pattern attention- Bi-directional Long Short-Term Memory (TPA-BiLSTM) for distribution networks. The method constructs a comprehensive security posture assessment system considering voltage margin and system load factor, and determines the security posture level using hierarchical analysis. The collected multi-source data are subjected to data preprocessing and input as samples into the improved BiLSTM model based on the TPA attention mechanism to realize the safety posture sensing. The accuracy of the TPA-BiLSTM method is verified by analyzing it with Long Short-Term Memory neural network and Bi-directional Long Short-Term Memory neural network using the IEEE 33-node distribution network as an example. Finally, the method is used in the backend of the constructed distribution network information platform to visualize the distribution network security situational awareness.
PR354 11:00-11:15	Analysis of Electric Ferry's Coordinated Charging Impacts on Distribution Network **Rajib Baran Roy,** Central Queensland University, Australia Abstract-The maritime industry is a significant contributor to greenhouse gas emissions. There is a growing tendency towards using renewable-powered electric vessels, which require effective storage solutions for the mitigation of greenhouse gas

	emissions by the marine sector. This study investigates the impacts of coordinated electric ferry charging on a local distribution network, using Gladstone Marina in Queensland, Australia, as a case study. OpenDSS software is used for power flow analysis based on actual load data, with four BESSs (Battery Energy Storage Systems) modeled as proposed charging stations. The analysis compares system parameters like bus voltage, load current, and power flow in coordinated mode relative to the base case without BESSs. A MATLAB Simulink-based dynamic model of the BESS is linked to the OpenDSS environment through a DLL (Dynamic Link Libaray), and a Python-based DLL regulates BESS's charging and discharging according to load demand and SOC (State of Charge). Results show that in the coordinated mode, bus voltages increase by 1% to 1.5%, and load currents decrease by 2% to 2.5% compared to the base case. Power flow remains consistent across selected lines and transformers which demonstrates that the storage controller effectively manages BESS operations, maintaining system parameters within permissible limits by aligning charge-discharge times with load demand for peak shaving and valley filling.
PR328 11:15-11:30	Multi-area Microgrid Leader-follower Game Strategy for Fuel-cell Hybrid Electric Vehicles **Yu Zhang,** Nanjing University of Science and Technology, China Abstract-As the number of new energy vehicles continues to increase, the coupling between multi-area microgrid and transportation networks becomes increasingly tight, making the coordinated optimization problem of multi-area microgrid more complex. This paper takes hydrogen as the link connecting multi-area microgrid and establishes an equivalent mileage model for fuel-cell hybrid electric vehicles. It proposes a multi-area microgrid leader-follower game model considering real-time electricity prices and dynamic hydrogen prices. In this model, microgrid operator (leader) set the electricity / hydrogen prices of replenishing stations, while clusters of fuel-cell hybrid electric vehicles (follower) adjust their replenishing strategies based on price signals. Subsequently, the leader-follower game model is transformed into a mixed-integer linear programming problem using linear relaxation techniques, Karush-Kuhn-Tucker conditions and duality theory, and solved using YALMIP/GUROBI. Finally, the proposed scheme is analyzed with a multi-area microgrid multi-energy flow coupling system, validating its effectiveness in increasing microgrid operator revenues and reducing replenishing costs for fuel-cell hybrid electric vehicles.
PR369 11:30-11:45	Research on the Architecture and Application of Digitalization of Power Grid Standards Based on CPS **Zhen Xia Zhao,** State Grid INFO&TELECOM GROUP CO., LTD, China Abstract-Facing the complex and massive system characteristics of the new power system and the requirements for digital grid construction, the digitalization of standards is an essential requirement for constructing the business rules and logic of a digital grid. Based on an analysis of the current state of standard digitalization and the development of CPS (Cyber-Physical System) architectures, this paper explores the mechanism of standard digitalization in the context of power grid digital transformation and designs a theoretical framework for standard digitalization from the CPS perspective. Finally, the specific application of standard digitization is illustrated using the example of GB/T 17215.701 "Standard Electric Energy Meters." The study reveals that standard digitalization enhances the flexibility and adaptability of standards through digital tools, thereby improving the efficiency of power grid standardization. The research aims to provide theoretical guidance and reference for the application of standard digitalization in the power grid sector.
PR359 11:45-12:00	Network Intrusion Detection Method for Smart Grid Based on PCA-ISBO-GRU-AM **Zhiying Wang,** State Grid Henan Information & Telecommunication Company (Data Center), China

	Abstract-Network communication technology plays an extremely important role in the construction of smart grid, but this also makes the smart grid network security protection has become the key to the operation of the system. Advanced metering infrastructure (AMI) as the core component of the smart grid, the characteristics of its two-way communication makes itself has been facing the threat of network intrusion, and the current detection methods are difficult to effectively detect network intrusion. The current detection methods are difficult to effectively detect network intrusion. In this paper, we propose a deep learning-based network intrusion detection method for smart grid AMI in response to the lack of accuracy of network intrusion detection. Firstly, the AMI system of smart grid is designed, and principal component analysis (PCA) is used to complete the data dimensionality reduction. Then the gate recurrent unit (GRU), which introduces the attention mechanism (AM), is used as the base detection model, and the satin bowerbird optimization (SBO) algorithm, which is improved by the introduction of the risk avoidance principle, is used to realize the hyper-parameter optimization of the GRU, so as to get the network intrusion detection model based on ISBO-GRU-AM. model. The resulting model is finally tested on KDDCup 99 and NSL-KDD datasets to check the detection performance of the model. The experimental results show that the method proposed in this paper can accurately detect the network intrusion of smart grid AMI and distinguish the type of intrusion, which has obvious advantages over other methods, and is conducive to promoting the progress of AMI network security protection technology and ensuring the network security of smart grid.
PR364 12:00-12:15	Detection of Abnormal Electricity Usage in Smart Grids Based on TCN-DAE-IOOA **Ziang Duanmu**, Zhenjiang Power Supply Company, China; State Grid Jiangsu Electric Power Co., LTD., China Abstract-In order to solve the problem of low accuracy of abnormal electricity usage detection in Advanced Metering Infrastructure (AMI) environment of smart grid, this study proposes a detection strategy based on deep learning technology. Firstly, a model of users' abnormal electricity usage behaviours is constructed in the smart grid AMI environment, and standard electricity load sequence features are set for different types of abnormal electricity usage behaviours, while smart meters are used to collect users' electricity usage data. In this method, Time Convolutional Network (TCN) is adopted as the core hidden layer of Deep Auto-encoder (DAE), and the TCN-DAE structure is used for the effective feature extraction and data reconstruction of the time-series data of electricity consumption load. To enhance the fitting ability of the TCN model, the activation function is optimised in this paper to overcome the neuron collapse problem faced by traditional neural networks, and the fully connected layer is changed to an adaptive linear layer to reduce the overfitting phenomenon. In addition, the learning efficiency and generalisation of the model are improved by optimising the hyperparameters of the DAE using the Improved Osprey Optimization Algorithm (IOOA). The TCN-DAE-IOOA model is applied to detect the abnormal power usage behaviour of users in the AMI environment of smart grids with high accuracy, which verifies the excellent performance of the method in the detection of abnormal electricity usage behaviour.

Online Session 3 (UTC+8)

Friday, September 27, 2024 13:30-15:00	Room A: 831 9781 0538

New Battery Development and Voltage Control Technology

Chairperson: Dr. Kenza Maher, Qatar Environment and Energy Research Institute (QEERI), Hamad Bin Khalifa University (HBKU), Qatar

PR324 13:30-13:45	Battery Cells and Materials Performance Evaluation **Kenza Maher,** Qatar Environment and Energy Research Institute (QEERI), Hamad Bin Khalifa University (HBKU), Qatar Abstract-The performance evaluation of Li-ion battery cells and materials is critical for advancing energy storage technologies and enhancing the efficiency and longevity of LIB batteries. This study focuses on a comprehensive assessment of various battery materials and cell configurations, aiming to identify key factors that influence performance metrics such as energy density, cycle life, and thermal stability. Additionally, we follow changes in the electrochemical, thermodynamic properties, and crystal structure characteristics of lithium-ion battery cells during aging to better understand the elemental mechanisms behind the degradation of anode and cathode materials. By systematically evaluating these properties through a combination of experimental analyses, including cycling, thermodynamic assessment, and materials characterization, we investigate the changes that occur in the battery cells as they age. Our findings contribute to a deeper understanding of the degradation processes affecting both the anode and cathode, providing insights that can guide the development of high-performance, durable, and safe lithium-ion batteries for a wide range of applications. This evaluation not only enhances the fundamental understanding of battery behavior but also supports the innovation of next-generation energy storage solutions.
PR306 13:45-14:00	Emergency control strategy of steady-state voltage after DC blocking **Zhan Yu Duan,** Chongqing University, China Abstract-The existing research on emergency control strategies for voltage after DC blocking faults mainly focuses on transient voltage safety. However, DC blocking can also lead to steady-state voltage violations, causing a series of steady-state high and low voltage issues, seriously affecting the safe and economical operation of the power system. Therefore, this paper proposes an emergency control strategy for steady-state voltage regulation after DC blocking, which can quickly adjust the steady-state voltage of electric power system with minimal switching costs to ensure the safety of steady-state voltage during emergency DC blocking situations. The strategy aims to minimize the number of discrete device operations as the optimization objective, while simultaneously involving both continuous and discrete devices in the adjustment of steady-state voltage, with the goal of minimizing switching costs to rapidly adjust the system's steady-state voltage. The model proposed in the article is formulated as a mixed-integer programming problem and solved using a "three-stage" hybrid algorithm combining interior point method and whale optimization algorithm. Simulation analysis using real grid data demonstrates that the proposed method not only obtains the minimum number of discrete device operations for emergency situations, effectively adjusting the system's steady-state voltage level, but also further reduces network losses.
PR331 14:00-14:15	Test and Analysis of Ice Flashover Characteristics of 500kV Segment Composite Insulators for Heavy Ice Area **Haining Wang,** State Key Laboratory of Disaster Prevention & Reduction for Power Grid, China

	Abstract-In order to reduce the difficulty of installation and transportation, segmented composite insulators are generally used to replace traditional composite insulators. However, in heavy ice areas, the ice flashover characteristics of segmented composite insulators are not completely clear. In this paper, the ice flashover experiment of 500kV segmented composite insulators was carried out in the multifunctional artificial climate chamber, and the flashover characteristics of 500kV segmented composite insulators are compared with those of traditional 500kV composite insulators. According to the experimental results, the AC flashover voltage of 500kV segmented composite insulators was not much different from that of traditional 500kV composite insulators under full bridging ice conditions. The combination of large, medium and small umbrellas is helpful to increase AC flashover voltage under the condition of full bridging ice. The experimental results can provide guidance and reference for the engineering application of 500kV segmented composite insulators.
PR308 14:15-14:30	An Annual Time Series Production Simulation Method for Regional Power Grids Considering Provincial Balance-inter-Provincial Medium and Long-Term Mutual Assistance **Yiyu Wen,** State Grid Corporation of China Southwest Branch, China Abstract-In order to take into account the independence of provincial power generation and the ability of inter-provincial medium and long-term coordination and mutual assistance, an annual time series production simulation method for regional power grids considering provincial balance and inter-provincial medium and long-term mutual assistance is proposed. The annual power and energy balance problem of regional power grid is decomposed into two stages: annual daily power balance based on provincial balance and monthly time series power and energy balance considering inter-provincial medium and long-term mutual aid. The maintenance plan of hydropower and thermal power and the storage capacity plan of hydropower at the end of the month are taken as the two-stage connection variables, and the power shortage of provincial power grid is taken as the start-up decision quantity of inter-provincial monthly coordination and mutual aid. This method takes into account long-term coupling constraints such as hydro-thermal power maintenance, hydropower storage capacity balance, and inter-provincial tie-line ladder transmission power. It can better quantify inter-provincial power demand and adapt to the current situation of inter-provincial medium-and long-term power trading with physical curves in China. Through the simulation analysis based on the actual data of a regional power grid in China, it is verified that the proposed method can better realize the evaluation of the profit and loss degree of power and electricity in the regional power grid and give full play to the medium and long-term mutual aid ability between provinces.
PR326 14:30-14:45	Performance and Safety of Lithium-Ion Batteries Under Hot Desert Climates **Kenza Maher,** Qatar Environment and Energy Research Institute (QEERI), Hamad Bin Khalifa University (HBKU), Qatar Abstract-The performance, lifespan, and safety of lithium-ion batteries (LIBs) are critically influenced by temperature variations, particularly in challenging environments such as desert conditions where high temperatures can accelerate degradation mechanisms and compromise safety. This study investigates the reliability, performance, and safety of four commercially available 18650 LIBs sourced from different manufacturers under accelerated cycle aging conditions up to 500 cycles at temperatures of 25°C, 45°C, and 55°C. Advanced electrochemical analyses and thermal stability tests were employed to assess the impact of prolonged high-temperature exposure on cell capacity and cycle life. The results highlight that state of health (SOH) and capacity loss are significantly influenced by cell chemistry and aging conditions, with pronounced capacity degradation observed at higher temperatures. Specifically, cells with NCA-based compositions (Type A and Type B) exhibited better thermal stability and maintained higher SOH compared to NMC-based cells (Type C and Type D),

	which showed increased susceptibility to thermal stress and degradation. These findings underscore the importance of selecting appropriate cathode materials and implementing effective thermal management strategies to enhance the reliability and extend the cycle life of LIBs, crucial for applications ranging from consumer electronics to electric vehicles and renewable energy systems.
PR313 14:45-15:00	Designing of solar photovoltaic parking infrastructure at Ufa International Airport- A case study on EV charging potential **Md Nafeez Rahman**, Ufa University of Science and Technology, Russia Abstract-Since solar electricity is less expensive to produce than grid electricity, solar-powered EV charging is more cost effective than grid-powered charging. Uninterrupted charging of electric vehicles is ensured by solar power charging, even in cases of grid power disruptions. By utilizing renewable energy to charge electric cars, solar-powered EV charging stations at airports can play a significant role in attaining more environmentally friendly transportation. The 150kW DC fast charging station at Ufa International Airport, Russia, can be powered by a solar photovoltaic system that has been developed and evaluated in this research. Nevertheless, real-time surveys were conducted during the system model design to ascertain the proposed charging station's location, the availability of free parking, the priority charging of buses based on their departure times to guarantee that all buses are fully charged on schedule, and the charging time variations between buses with larger (200 kWh) and smaller (150 kWh) batteries.

Online Session 4 (UTC+8)

Friday, September 27, 2024 13:30-15:15	Room B: 821 1151 7346

Energy Configuration, Optimization and Management in New Energy Power Systems and Integrated Energy Systems

Chairperson: Dr. Siyu Zhang, State Grid Energy Research Institute, China

PR332 13:30-13:45	Joint Scheduling Model of Distributed Generation, Energy Storage and Flexible Load under Resource Aggregator Mode **Jinyou Wang,** State Grid Shandong Electric Power Company Weifang Power Supply Company, China Abstract-Resources such as distributed power supply, energy storage and flexible load are widely dispersed, and direct power grid dispatching is difficult. The resource aggregator successfully executes the power grid dispatching instruction by means of internal integration. According to the operation characteristics of resource aggregators, a joint scheduling model is constructed to integrate the direct scheduling of large-capacity resources and the indirect scheduling of small-capacity resources. Under this framework, with the core goal of maximizing the profit of resource aggregators, the scheduling performance difference of large-capacity resources is dynamically evaluated, and flexible scheduling priorities are set accordingly. Faced with the uncertainty of indirect scheduling of small capacity resources, this paper introduces the chance scheduling constraint of fuzzy parameters. With the help of improved particle swarm optimization (PSO), the fuzzy chance constraint is successfully transformed into a clear expression and the scheduling model is solved efficiently. The validity and scientificity of the proposed model and algorithm are verified by IEEE33-node distribution network.
PR301 13:45-14:00	Configuration Optimization of Energy Storage in New Power System for Renewable Energy Exploitation **Xi Tong,** North China Electric Power University, China Abstract-Traditional power systems are facing increasingly severe challenges in terms of energy efficiency, environmental friendliness, and sustainability. The new power system, dominated by its intelligence, distribution, and renewable energy, is leading the power industry towards a new era. This article is based on the research of a new power system containing a high proportion of new energy such as wind and solar power. Different energy storage configurations and capacities are set up to conduct a detailed study on the consumption of new energy after energy storage participation. The results show that when energy storage is involved, the consumption rate of new energy increases from 90% to over 95%, and the output of thermal power units also decreases by nearly 5000kWh, equivalent to a reduction of 615kg of standard coal consumption. And it was found that the 1:1 participation scheme of lithium battery energy storage and compressed air energy storage can meet various goals.
PR333 14:00-14:15	Research on the Coordinated Control Method for Distributed Power Generation Cluster under Peak Load Shifting Strategy **Mingguo Tian,** State Grid Shandong Electric Power Company Weifang Power Supply Company, China Abstract-In response to the increasing challenges posed by the pressure on the main grid for peak regulation due to large-scale distributed photovoltaic (PV) grid integration, this paper delves into and proposes an innovative coordinated control strategy for distributed power generation clusters. First, with the core objectives of minimizing system operating costs and net load variance, a peak load shifting model for distributed power sources is constructed by integrating adjustable resources on the

	distribution network side, such as distributed PV and energy storage devices. Then, leveraging the boundary coupling relationships among clusters, an innovative cluster partition decoupling mechanism is proposed to achieve effective coordination and complementarity among clusters. Finally, the Alternating Direction Method of Multipliers (ADMM) is employed to solve the optimization models of each cluster in parallel, ensuring efficiency and accuracy in the solution process. Simulation results demonstrate that this method significantly reduces the net load peak-to-valley difference while ensuring the efficient and economical operation of the distribution network.
PR312 14:15-14:30	Research on the Value Evaluation of Electricity-Hydrogen Synergy **Siyu Zhang,** State Grid Energy Research Institute, China Abstract-The coordinated development of electricity and hydrogen could provide important support to addressing the challenges posed by the large-scale development of renewables. Electricity and hydrogen will exist in a stronger synergistic relationship. The significance and value of "electricity-hydrogen synergy" are multifaceted. On the one hand, it can enhance the flexibility of power systems to a certain extent, promote the utilization rate of renewable resources, and facilitate the low carbon transition of the energy and power system. On the other hand, "electricity-hydrogen synergy" can help ensure the stable operation of the power system and promote national energy security. Additionally, it can reduce overall system construction costs and the production cost of green hydrogen, effectively enhancing project economic benefits and driving investment in emerging industries. This study will quantitatively assess the value of "electricity-hydrogen synergy" after proposing the indicator system and building the assessment model from both a macroscopic and a microscopic perspective based on case study. The research results could provide important guidance for the coordination of the power and hydrogen industry.
PR361 14:30-14:45	Impact on Generalization Performance under Diverse Domain Shifts of Energy Disaggregation for Non-Intrusive Load Monitoring **Gerui Zhao,** Xi'an Jiaotong University, China Abstract-Non-Intrusive Load Monitoring (NILM) refers to a technique that separates a household's overall electricity usage into the consumption of individual appliances. When applying a trained NILM model to practical situations, the gap in data distribution between the training samples and those encountered in practice can result in a deterioration of energy disaggregation performance. In this article, we propose four data augmentation methods suitable for NILM that account for variations in appliance characteristics to generate household energy consumption scenarios with diverse data distributions. The impact on generalization performance is also analyzed when a NILM model is trained in a single scenario compared to being trained in multiple scenarios. Experiments conducted on the REFIT dataset indicate that a NILM model trained on a single scenario exhibit poor energy disaggregation performance in other scenarios. In contrast, a NILM model trained with a mix of multiple scenarios show significantly improved generalization performance. This study highlights the effectiveness of multiscenario training for NILM model generalization, providing a valuable framework for developing robust and adaptable energy disaggregation models.
PR302 14:45-15:00	Analysis of Company Project Reservation under the Evolution of New Power System **Mingyuan Zhou,** North China Electric Power University, China Abstract-In order to clarify how the power grid company can support the construction of a new power system through project reserves, this article conducts a statistical analysis of the special categories and quantities of project reserves of a certain power grid company in northern China in 2022. Finally, it is found that among the special categories of project reserves of the company in 2022, the largest quantity is power grid infrastructure, followed by production technology renovation and major maintenance,

	and the fourth is sporadic procurement, which accounts for 89.85% of the total project reserves. In the process of production technology renovation and major overhaul, the primary projects of the power grid account for the majority. All power grid infrastructure projects are exchange projects. Electricity marketing focuses mainly on electricity metering.
PR371 15:00-15:15	Techno-economic comparison of 9 MW floating PV (FPV) solar farms in Indonesia and the UK **Muhammad Bahrul Ulum,** University of Edinburgh; PT PLN (Persero), UK Abstract-This study presents a comparative analysis of 9.36 MW floating photovoltaic (FPV) solar farms in Indonesia and the UK, focusing on installations at the Karangkates reservoir in Indonesia and Loch Awe in Scotland. Utilizing PVSyst simulations, the research evaluates solar energy potential, system design, and economic feasibility. Indonesia benefits from high year-round solar irradiance, while the UK has cooler temperatures and seasonal sunlight. The findings indicate that FPV systems in Indonesia exhibit superior technical and economic performance, with a capacity factor of 20.3% and an annual energy production of 16 GWh. In the UK, lower ambient temperatures contribute to improved solar panel efficiency. Both locations gain advantages from integrating FPV with existing hydropower plants, which enhances grid stability and optimizes land use. This study underscores the significance of geographic and climatic factors in FPV deployment and provides valuable insights for policymakers and stakeholders in the renewable energy sector.

Delegates

Yuyan Wu	Power Construction Corporation of China, China
Di Lu	Power Construction Corporation of China, China
Yuchen Du	Power Construction Corporation of China, China
Krittaya Maneeruengdej	Electricity Generating Authority of Thailand, Thailand
Porntip Eiamsai	Electricity Generating Authority of Thailand, Thailand
Prasit Chanthong	Electricity Generating Authority of Thailand, Thailand
Wiwat Limtrakul	Electricity Generating Authority of Thailand, Thailand
Krit Kongurai	Electricity Generating Authority of Thailand, Thailand
Perawat Silapa-Ariya	Electricity Generating Authority of Thailand, Thailand
Samun Pimton	Electricity Generating Authority of Thailand, Thailand
Pajira Akehankamol	Electricity Generating Authority of Thailand, Thailand
Apichat Kemngern	Electricity Generating Authority of Thailand, Thailand

Note