Conference Program

IEEE IAS I&CPS Asia 2021

2021 IEEE IAS INDUSTRIAL AND COMMERCIAL POWER SYSTEM ASIA

IEEE IAS I&CPS Asia 2021

July 18-21, 2021 | Chengdu, China

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IEEE

IAS IEEE INDUSTRY APPLICATIONS SOCIETY Linking Research to Practice

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Welcome Message

It is our great pleasure to invite you to attend the 2021 IEEE IAS Industrial and Commercial Power System Asia (IEEE IAS I&CPS ASIA 2021), which is held in Chengdu, China during July 18-21, 2021. IEEE IAS I&CPS ASIA 2021 is sponsored by IEEE, IEEE IAS, and organized by the University of Electronic Science and Technology of China.

The conference has made new progress both in research and standardization, providing a forum for multidisciplinary discussion with the aim of combining the research ideas in various aspects such as smart grid technology & application, power system protection, network intelligence, power system engineering and renewable energy integration etc.

We are very grateful to welcome distinguished keynote speakers Prof. Wei-Jen Lee, the IEEE IAS President, IEEE Fellow, from University of Texas Arlington; Prof. Kaushik Rajashekar, NAE Member, IEEE Fellow, NAI Fellow, SAE Fellow, from University of Houston, USA; Dr. Jessica Bian, IEEE PES President-Elect, Grid-X Partners; Prof. Xinzhou Dong, IEEE Fellow, IET Fellow, from Tsinghua University; Prof. Jizhong Zhu, IEEE Fellow, IET Fellow, CSEE Fellow, from South China University of Technology; Dr. Xiaoyan Han, from State Grid Sichuan Electric Power Company; Prof. Chaohai Zhang, from Nanjing University of Aeronautics and Astronautics; Prof. Can Wan, from Zhejiang University; Prof. Zhe Chen, IEEE Fellow, IET Fellow, from Aalborg University. We are also very delighted to invite Dr. Kent Sayler, IEEE IAS I&CPS President from P2S Inc to give us a warm welcome at the opening ceremony.

This year IEEE IAS I&CPS ASIA 2021 has received a great response from universities, research institutes and industries all over the world. And the accepted papers had been peer-reviewed by the committees, external reviewers, and editorial board depending on the subject matter of the papers based on the paper originality, significance and clarity.

We wish to express our sincere appreciation to the keynote speakers, international advisory committee, session chairs who selflessly contributed to the success of this conference. Also, we are thankful to all the participants.

Finally, we would like to wish all the participants having a productive and enjoyable conference experience in Chengdu, China!

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IEEE IAS I&CPS ASIA Program at a Glance

Date / Time	18 July, 2021	
09:00-18:00	09:00-18:00 | Onsite Sign In	
	10:00-12:00/13:30-15:30 **Online Testing**	15:00-16:00 **Online Tutorial**

Date / Time	19 July, 2021	20 July, 2021	21 July, 2021
08:30-08:50	Opening Ceremony		
08:50-10:10	Keynote Speeches	Parallel Sessions	Parallel Sessions
10:00-10:30	Coffee Break &Group Photo	Coffee Break	Coffee Break
10:30-12:30	Keynote Speeches	Parallel Sessions	Parallel Sessions
12:30-13:30	Lunch		
13:30-15:30	Keynote Speeches	Parallel Sessions	Parallel Sessions
16:00-18:00	Parallel Sessions		Free Discussion
18:30-20:30	Dinner	Banquet	

Useful Information

Conference Venue

成都融通祥宇宾馆(CHENGDU RONGTONG XIANGYU HOTEL)

Add: No. 103, Wuhou District, Chengdu, China, 610091

地址：中国四川省成都市武侯区新南路 103 号

Mainland China Tel: +86 28 8555 1111

Traffic Information:

Metro Moziqiao Station - Exit A [79m]
Chengdu East Railway Station - [12km]
Chengdu Shuangliu Airport - [19km]
Tianfu Square - [3.8km]
Chunxi Road - [2.1km]
Jinli Site - [2.7km]
Kuan Alley and Zhai Alley - [3.7km]
Chengdu Research Base of Giant Panda Breeding - [12.9km]

Temperature

Average Temperature in July in Chengdu
21℃-31℃

Attention Please

♣Due to COVID-19 Pandemic, delegates must show health QR code and wear face mask to attend conference. for health consideration, please wash hands before meals and please use serving chopsticks and serving spoon during meals.

♣Please take care of your belongings in public area. For your personal and property safety, delegates are suggested to wear representative card during conference and not to lend it to those unconcerned to enter event rooms. Conference does not assume any responsibility for loss of personal belongings of participants.

♣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. You can search more Tourist Information and Security tips online.

Emergency

Ambulance: 120 Police: 110

Follow us on We-chat

We-chat Group for attendees

Oral Presentation(on-site and online)

About the Presentation

The duration of a presentation slot is 15 minutes. Please prepare your presentation for about 12 minutes plus about 3 minutes for questions from the audience.

An LCD projector & computer will be available in every session room for regular presentations.

Presentations MUST be uploaded at the computer at least 15 minutes before the session starts.

Poster Presentation

We expect that at least one author stands by the poster for (most of the time of) the duration of the poster session. This is essential to present your work to anyone interest into it.

If you wish to leave your poster to attend a lecture, please leave a message on the board to inform visitors.

Posters should be set-up at least 15 minutes before the session starts and removed at the end of the session. Left behind posters at the end of the session will be disposed of.

The size of poster is A0(841×1189mm). Posters must be in portrait format(height>width). This cannot be modified.

Materials to hang the poster will be made available on-site. Our staff will be available onsite to assist you.

Dress Code

All participants are required to dress formally. Casual wear is unacceptable.

National formal dress is acceptable.

Online Conference Information

Date	Arrangement	ZOOM Link
JULY 18	Online Presentation Test	https://zoom.com.cn/j/93096909579
	Tutorial Session	https://zoom.com.cn/j/98668688070
JULY 19	Keynote Speeches Live Broadcast	https://zoom.com.cn/j/97564318768
JULY 20	Online Session 1, 3, 5	https://zoom.com.cn/j/97564318768
	Online Session 2, 4	https://zoom.com.cn/j/94976900821

Note*: Conference rooms will be open 30 mins before scheduled time. Please join the zoom 10-15 mins before your session start and be prepared.

Time Zone

China Standard Time(CST)

UTC/GMT+08:00

Please make sure that both the clock and the time zone on your computer are set to the correct China standard time.

Platform:Zoom

*For Users from mainland China

https://www.zoom.com.cn/download

*For General Users

https://zoom.us/support/download

Sign in and Join

*Join a meeting without signing in.

A Zoom account is not required if you join a meeting as a participant, but you cannot change the virtual background or edit the profile picture.

*Sign in with a Zoom account.

All the functions are available.

Additional Suggestions

- A computer with an internet connection (wired connection recommended)
- USB plug-in headset with a microphone (recommended for optimal audio quality)
- Webcam (optional): built-in or USB plug-in
- Stable Internet Connection
- Quiet environment
- Proper lighting
- Formal dress

Online Test Timetable and Online Sign-in(July 18)

*Please enter the room 10 minutes before the test session start
***Test Room No.**: https://zoom.com.cn/j/93096909579
Password:ICPS2021

Test Paper ID	Test time
Online Session 1, 2 S0044, S0219, S0085, S0058, S0072, S0065, S0076, S0078, S0061, S0007 S0083, S0137, S0172, S0084, S0169, S0318, S0200	10:00-12:00
Online Session 3, 4, 5 S0136, S0133, S0068, S0079, S0099, S0047, S0210, S0255, S0281, S0030, S0035, S0049, S0163, S0108, S0291 S0191, S0156, S0192, S0274, S0273	13:30-15:30

Rename your screen name before entering the room	Example
Authors: Paper ID-Name	**S0001-San Zhang**
Keynote Speaker: Keynote-Name	**Keynote-San Zhang**
Session Chair: Position-Name	**SC-San Zhang**
Committee Member: Position-Name	**Committee-San Zhang**

Tutorial Session on July 18
Presenter: Dr. Sidun Fang
Speech Title: Overview of Low-Carbon Maritime Multi-energy Systems
Room No.: https://zoom.com.cn/j/98668688070 **Zoom ID: 986 6868 8070** **Password:ICPS2021**
Time:15:00-16:00(UTC/GMT+08:00)

Daily Schedule

Day 1, July 18, 2021

10:00-18:00	Sign in and Collect Conference Materials in the Lobby **CHENGDU RONGTONG XIANGYU HOTEL 成都融通祥宇宾馆** **Add: No. 103, Wuhou District, Chengdu, China, 610091** **地址：中国四川省成都市武侯区新南路 103 号**

Day 2, July 19, 2021

Morning Program-Location: **Xiangrui Hall/祥瑞厅(3rd Floor/3 楼)**

[Online Zoom No. :https://zoom.com.cn/j/97564318768] Password:ICPS2021

Host	Dr. Zhenyuan Zhang, University of Electronic Science and Technology of China
08:30-08:50	**Opening Remarks** Prof. Qi Huang, University of Electronic Science and Technology of China Vice President, Chengdu University of Technology Dr. Kent Sayler, P2S Inc, IEEE IAS I&CPS President
Host	Dr. Zhenyuan Zhang, University of Electronic Science and Technology of China
08:50-09:20	**Keynote Speech 1** Prof. Wei-Jen Lee IEEE IAS President, IEEE Fellow, University of Texas Arlington ***Speech Title: Impact of Extreme Weather in February 2021 on ERCOT***
09:20-09:50	**Keynote Speech 2** Prof. Kaushik Rajashekara NAE Member, IEEE Fellow, NAI Fellow, SAE Fellow, University of Houston ***Speech Title: Propulsion Systems and Power Electronics for Electric, Hybrid, and Fuel Cell vehicles***
09:50-10:10	**Keynote Speech 3** Dr. Jessica Bian IEEE PES President-Elect, Grid-X Partners ***Speech Title: TBA***
10:10-10:40	***Tea break&Group photo at the first floor***
10:40-11:10	**Keynote Speech 4** Prof. Xinzhou Dong IEEE Fellow, IET Fellow, Tsinghua University ***Speech Title: Challenges And Countermeasures of Safe Operation of Zero Carbon Power Grid***
11:10-11:40	**Keynote Speech 5** Prof. Jizhong Zhu IEEE Fellow, IET Fellow, CSEE Fellow, South China University of Technology

	Speech Title: New Technologies and Applications of Smart Grid
11:40-12:10	**Keynote Speech 6** Prof. Chaohai Zhang Nanjing University of Aeronautics and Astronautics ***Speech Title: Integrated Energy Service Technology for Intelligent Park Based on Building Refined Modeling Method***
12:20-13:30	***Lunch Time*** ***Xiangjing Hall 祥景厅/2nd Floor 2 楼***
13:30-14:00	**Keynote Speech 7** Prof. Xiaoguang Wang Chengdu University of Technology ***Speech Title: Geothermal Energy: An Important Carbon-neutral Pathway for China***
14:00-14:30	**Keynote Speech 8** Prof. Can Wan Zhejiang University ***Speech Title: Probabilistic Forecasting for Renewable Energy Integration***
14:30-15:00	**Keynote Speech 9** Prof. Zhe Chen IEEE Fellow, IET Fellow, Aalborg University ***Speech Title: Energy Systems Transition***
15:00-15:30	**Keynote Speech 10** Dr. Xiaoyan Han State Grid Sichuan Electric Power Company ***Speech Title: Research and Application on Complementary Generation System of Cascaded Small-Hydropower, Photovoltaic and Pumped Storage***
15:30-16:00	***Coffee Break***
15:00-17:00	**Poster Session 1** *[Lobby@2F/大厅@2楼]* *S0094, S0029, S0297, S0129, S0113, S0062, S0266, S0254, S0181, S0164, S1004, S0132, S1005, S0067, S0022, S1010, S0027, S0159, S1023, S0217*
15:00-18:00	**Onsite Oral Session 1(Panel Session)** *[Xiangqing Hall@2F/祥庆厅@2楼]* *Panelists: Qian Zhang, Chengcheng Shao, Yue Xiang, Kai Liao, Jianxiao Wang*
16:00-17:45	**Onsite Oral Session 2** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S0010, S0048, S0054, S0252, S0321, S0233, S0176*
16:00-18:00	**Onsite Oral Session 3** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0148, S0031, S0042, S0091, S0143, S0193, S0214, S0216*
16:00-17:00	**Onsite Oral Session 4** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0183, S0248, S0299, S0314*
18:30-20:30	***Dinner Time*** ***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Day 3, July 20, 2021

09:15-10:15	**Onsite Oral Session 5** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S0052, S0081, S0103, S0114*
10:45-12:00	**Onsite Oral Session 6** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S0166, S0152, S0204, S0311, S1007*
09:15-10:15	**Onsite Oral Session 7** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0020, S0089, S0130, S0188*
10:45-11:45	**Onsite Oral Session 8** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0021, S0300, S0098, S0221*
09:00-10:00	**Onsite Oral Session 9** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0304, S0100, S0086, S0037*
10:30-11:45	**Onsite Oral Session 10** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0087, S0095, S0102, S0063, S0249*
08:45-10:15	**Onsite Oral Session 11** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0096, S0286, S0056, S0070, S0186, S0090*
10:30-12:00	**Onsite Oral Session 12** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0264, S0185, S0092, S0194, S0196, S0232*
10:00-12:00	**Poster Session 2** *[Lobby@2F/大厅@2楼]* *S0306, S1017, S1018, S0309, S0001, S1001, S0066, S0197, S0012, S0230, S0241, S0243, S0244, S0208, S0261, S0050, S0207, S0218, S1020, S0240*
09:30-12:15	**Online Session 1** ***[https://zoom.com.cn/j/97564318768] Password:ICPS2021*** *S0044, S0219, S0085, S0058, S0072, S0065, S0076, S0078, S0061, S0007, S0200*
09:00-10:30	**Online Session 2** ***[https://zoom.com.cn/j/94976900821] Password:ICPS2021*** *S0083, S0137, S0172, S0084, S0169, S0318*
11:00-12:15	**Online Session 4** ***[https://zoom.com.cn/j/94976900821] Password:ICPS2021*** *S0191, S0156, S0192, S0274, S0273*
12:00-13:30	***Lunch Time*** ***Xiangjing Hall祥景厅/2nd Floor 2楼***
13:30-15:45	**Onsite Oral Session 13** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S0147, S0258, S0280, S0283, S0295, S0298, S0279, S0319, S0154*
16:15-18:00	**Onsite Oral Session 14** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S0151, S0125, S0153, S0155, S0182, S0222, S0238*
14:00-15:45	**Onsite Oral Session 15** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0008, S0064, S0120, S0123, S0277, S1009, S0289*
16:15-17:30	**Onsite Oral Session 16** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0043, S0209, S0045, S0213, S0275*

14:00-15:45	**Onsite Oral Session 17** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0073, S0127, S0128, S0165, S0170, S0173, S0203*
16:15-17:45	**Onsite Oral Session 18** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0215, S0231, S0235, S0325, S0326, S0327*
14:00-15:45	**Onsite Oral Session 19** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0126, S0261, S0251, S0329, S1011, S0237, S0301*
16:15-18:15	**Onsite Oral Session 20** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0131, S0135, S0247, S0223, S0272, S0293, S0322, S1016*
15:00-17:00	**Poster Session 3** *[Lobby@2F/大厅@2楼]* *S0187, S0303, S0305, S0276, S0259, S0115, S0174, S1012, S0077, S0205, S0220, S0119, S0139, S0140, S0141, S0142, S0161, S0162, S0177, S0315*
13:30-15:45	**Online Session 3** ***[https://zoom.com.cn/j/97564318768] Password:ICPS2021*** *S0136, S0133, S0068, S0079, S0099, S0047, S0108, S0210, S0291*
16:00-17:30	**Online Session 5** ***[https://zoom.com.cn/j/97564318768] Password:ICPS2021*** *S0255, S0281, S0030, S0035, S0049, S0163*
18:30-20:30	***Banquet*** ***Xiangyun Hall祥云厅/1st Floor 1楼***

Day 4, July 21, 2021

10:00-12:00	**Onsite Oral Session 21** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S0227, S0069, S0082, S0150, S0175, S0180, S0242, S0287*
09:00-10:15	**Onsite Oral Session 22** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0121, S0006, S0059, S0093, S0116*
10:45-12:00	**Onsite Oral Session 23** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0101, S0250, S0112, S0270, S0284*
09;00-10:00	**Onsite Oral Session 24** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0278, S0285, S0174, S0253*
10:30-12:00	**Onsite Oral Session 25** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0282, S0051, S0257, S0292, S1021, S1022*
09:00-10:00	**Onsite Oral Session 26** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0158, S0308, S0080, S0013*
10:30-12:00	**Onsite Oral Session 27** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0105, S1013, S0124, S0014, S1008, S1019*
10:00-12:00	**Poster Session 4** *[Lobby@2F/大厅@2楼]* *S0312, S0015, S0202*
12:00-13:30	***Lunch Time*** ***Xiangjing Hall祥景厅/2nd Floor 2楼***
13:30-15:00	**Onsite Oral Session 28** *[Yuchun Hall Room I@2F/玉春堂1号厅@2楼]* *S1014, S0011, S0023, S0046, S0104, S1015*
13:30-15:00	**Onsite Oral Session 29** *[Yuchun Hall Room II@2F/玉春堂2号厅@2楼]* *S0317, S0226, S0271, S1003, S0320, S1006*
13:30-14:30	**Onsite Oral Session 30** *[Xiangqing Hall@2F/祥庆厅@2楼]* *S0038, S0107, S0195, S0224*
13:30-15:15	**Onsite Oral Session 31** *[Xiangtai Hall@2F/祥泰厅@2楼]* *S0026, S0144, S0179, S0145, S0198, S0236, S0316*

Keynote Speakers

Keynote Speaker

Prof. Wei-Jen Lee

University of Texas at Arlington
President of IEEE Industry Applications Society, IEEE Fellow

Bio: Professor Lee received the BS and MS degrees from Taiwan University and the PhD degree from the University of Texas, Arlington, in 1978, 1980, and 1985, respectively, all in Electrical Engineering.
In 1986, he joined the University of Texas at Arlington, where he is currently a professor of the Electrical Engineering Department and the director of the Energy Systems Research Center. He has been involved in the revision of IEEE Std. 141, 339, 551, 739, 1584, 3002. 8, and 3002. 9. He is the President of the IEEE Industry Application Society(2021-2022), a Prominent Lecturer(PL)of IEEE IAS(2019-2021), and an editor of IEEE Transactions on Industry Applications and IAS Magazine. He is the project manager of IEEE/NFPA Collaboration on Arc Flash Phenomena Research Project. Prof. Lee has been involved in research on Utility Deregulation, Renewable Energy, Arc Flash Hazards and Electrical Safety, Smart Grid, MicroGrid, Industrial Internet of Things(IIoT)and Virtual Power Plants(VPP), AI for Load, Price, and Wind Capacity Forecasting, Power Quality, Distribution Automation, Demand Response, Power Systems Analysis, Short Circuit Analysis and Relay Coordination, Distributed Energy Resources, Energy Storage System, PEV Charging Infrastructure Design, AMI and Big Data, On Line Real Time Equipment Diagnostic and Prognostic System, and Microcomputer Based Instrument for Power Systems Monitoring, Measurement, Control, and Protection. He has served as the primary investigator(PI)or Co-PI of over one hundred funded research projects. He has published more than one hundred and ninety journal papers and three hundred conference proceedings. He has provided on-site training courses for power engineers in Panama, China, Korea, Saudi Arabia, Thailand, and Singapore. He has refereed numerous technical papers for IEEE, IET, and other professional organizations. Prof. Lee is a Fellow of IEEE and registered Professional Engineer in the State of Texas.

Speech Title: Impact of Extreme Weather in February 2021 on ERCOT

Abstract: The severe winter storm that hit the US during the week of February 14, 2021 has wreaked havoc with the electric power generation and delivery system in the United States, putting large numbers of customers under rotating outage and extended power outage for many customers. The situation in the Electric Reliability Council of Texas(ERCOT) has been especially glaring and harsh. Large amount of gas fired units and renewable energy were offline and ERCOT has ordered rotating outage. The Settlement Point Prices(SPP)reached US$9000/MWH for an extended period. This presentation introduces the ERCOT system, the structure of the deregulated market in ERCOT, the sequence of the event that has happened between February 14, 2021 and February 19, 2021, and possible measures to mitigate the impact to the customers.

Keynote Speaker

Prof. Kaushik Rajashekara

University of Houston
NAE Member, IEEE Fellow, NAI Fellow, SAE Fellow

Bio: Kaushik Rajashekara received his PhD(1984)degree in Electrical Engineering from Indian Institute of Science. In 1989, he joined Delphi division of General Motors Corporation in Indianapolis, IN, USA as a staff project engineer. In Delphi and General Motors, he held various lead technical and managerial positions, and was a Technical Fellow and the Chief Scientist for developing electric machines, controllers, and power electronics systems for electric, hybrid, and fuel cell vehicle systems. In 2006, he joined Rolls-Royce Corporation as a Chief Technologist for More Electric architectures and power conversion/control technologies for aero, marine, defense, and energy applications. In August 2012, he joined as a Distinguished Professor of Engineering at the University of Texas at Dallas. Since September 2016, he is a Distinguished Professor of Engineering in University of Houston.

Prof. Rajashekara was elected as a Member of the National Academy of Engineering in 2012 for contributions to electric power conversion systems in transportation. He was also elected as 2015 Fellow of the National Academy of Inventors and 2013 Fellow of Indian National Academy of Engineering. He is the recipient of the IEEE Richard Harold Kaufmann award for outstanding contributions to the advancement of electrical systems in transportation; IEEE Industry Applications Society Outstanding Achievement Award, and EEE IAS Gerald Kliman award for contributions to the advancement of power conversion technologies through innovations and their applications to industry. He is a Distinguished Alumnus of Indian Institute of Science, Fellow of IEEE, and a Fellow of SAE International.

Prof. Rajashekara has published more than 160 papers in international journals and conferences. TX. He has published more than 160 papers. He has 35 U. S. and 10 foreign patents. He has given more than 150 invited presentations in international conferences and universities. He has co-authored one IEEE Press book on Sensorless Control of ac motor drives and contributed individual chapters to six published books. His research interests are in the area of power electronics, drives, transportation electrification, renewable energy, and energy management of microgrid systems.

Speech Title: Propulsion Systems and Power Electronics for Electric, Hybrid, and Fuel Cell Vehicles

Main Contents: Electric Vehicles, Hybrid Vehicles，Toyota Prius Operation，FUEL CELL VEHICLES，Electric Vehicle Charging， Power Electronics is the Enabling Technology for Transportation Electrification.

Keynote Speaker

Dr. Jessica Bian

Grid-X Partners
IEEE PES President-Elect

Bio: Jessica Bian is a visionary leader and architect who has spearheaded the electric industry's reliability metrics and grid-risk assessment. She is currently with Grid-X Partners. Before that, she was with the Federal Energy Regulatory Commission, Washington, D.C. Previously, she was the director of performance analysis at the North American Electric Reliability Corporation (NERC) in Atlanta, Georgia. Under her leadership, a total of 18 industry-wide reliability indicators were established for the first time to determine grid reliability, adequacy, and associated risks. She is widely recognized as a pioneer and trusted world leader in the field.

Before joining NERC, Bian was with PJM, ERCOT, and Westinghouse Electric. She received her B.Sc. degree from the Taiyuan University of Technology, China, her M.Sc. degree from the Electric Power Research Institute, Beijing, China, and her Ph.D. degree from Tulane University, New Orleans, Louisiana. Bian has had more than 70 articles published, and she received the 2014 PES Wanda Reder Pioneer in Power Award for her technical achievements. She is a Senior Member of the IEEE.

Keynote Speaker

Prof. Xinzhou Dong

Tsinghua University
IEEE Fellow, IET Fellow

Bio: He was born in Zhouzhi county of Shanxi province, china in 1963 and received Ph. D. degree. from Xi'an Jiao Tong University 1996 and Post-Doctor from Tianjin University in 1999 in china.
Now he is a professor with Dept of EE, Tsinghua University, China. He is also IEEE Fellow, IET Fellow, Fellow of CSEE, Trustee of CES, Member of the technical committee of Cigre China, Chairman of PSRC of IEEE China, Member of the technical committee of Cired China, Convener of Cigre B5 WG55, Member of IEEE PSRC Fellow WG. He mainly engaged in electric power system fault analysis and protection Teaching and Research, and the major research area are as follows: Traveling waves-based protection, Travelling waves-based-fault location, Traveling waves-based-line selection, Non-communication protection, UHV transmission line's protection, Intelligent substation, System protection, Application research on wavelet transform.
He is the winner of the Second National Innovation Competition Award; He two times got State Technological Invention Award of Chinese government, 2nd Prize respectively in 2007 and 2017;He also got 2016 Cigre Distinguished Member Award and 2017 China Power Science and Technology Outstanding Contribution Award; He is also Chinese Most Cited Researchers from Elsevier.

Speech Title: Challenges and Countermeasures of Safe Operation of Zero Carbon Power Grid

Abstract: The zero carbon grid, which is centered on renewable energy generation, is coming to us. There is no doubt that this is the future of the energy and power industry. But the zero carbon power grid faces great challenges in the safe and stable operation, which is mainly manifested in: intermittent fluctuation of renewable energy generation causes the uncertainty of power supply, and causes the frequency, voltage to fluctuate greatly until it cannot operate stably; Because new energy generation is connected to AC power grid through inverter, the increasing proportion of DC transmission in the grid, the risk of power outage in the whole network is increasing due to the cascading failure of AC DC hybrid grid, which becomes the biggest security threat to the operation of the power grid. The report analyzes the security challenges faced by zero carbon power grid, and then puts forward the technical countermeasures for developing energy storage technology and building system protection.

Keynote Speaker

Prof. Jizhong Zhu

South China University of Technology
IEEE Fellow, IET Fellow, CSEE Fellow

Bio: Prof. Jizhong Zhu received the B. S. degree, M. S. degree and Ph. D. degree in electrical engineering from Chongqing University in 1985, 1987, and Feb. 1990, respectively. Dr. Zhu was a professor in Chongqing University. He won seven provincial and ministerial awards for scientific and technological progress, and was selected as one of four outstanding young scientists working in China by The Royal Society of UK and China Science & Technology Association and awarded Royal Society Fellowship in 1994, as well as the national research prize "Fok Ying-Tung Excellent Young Teacher Medal" in 1996. He worked in a variety of places all over the world, including Chongqing University in China, Brunel University in UK, National University of Singapore, Howard University in USA, and ALSTOM Grid Inc. , China Southern Power Grid and South China University of Technology(SCUT).
He is currently a Professor and director of ISESOOC center in SCUT and National Distinguished Expert in China. He is Chair of IEEE P2781 and P2783 Standard working groups since 2018, core member of IEEE PES SBLC Technical Committee, member of IEEE SMC Technical Committee on intelligent power and energy systems, and member of IEEE SMC Standard Committee, as well as was Chair of IEEE PES SBLC Loads Subcommittee during 2017-2019. He worked at ALSTOM Grid as a Senior Principal Power Systems Engineer and Senior Expert during 2000-2015, and became a Fellow of Alstom Expert Committee in 2013. His research interest is integrated smart energy system optimal operation and control(ISESOOC), as well as smart grid and renewable energy applications. He has published six books as a sole author, and published over 200 papers in the international journals and conferences.

Speech Title: New Technologies and Applications of Smart Grid

Abstract: This presentation introduces the definition, scope, operation objectives and technologies of smart grid(SG). The SG technologies include: Integrated communications, Sensing and measurement technologies, Advanced components, Advanced control methods, and Improved interfaces and decision support. These new technologies speed up the development of smart grid in modern power system. Robust smart grid is promoting large scale of application of renewable energies. In addition, the relationship of smart grid and energy internet is analyzed, and their application scenarios are discussed. Finally, this topic will address the application of smart grid on the areas of smart microgrid, electric vehicles and energy storages.

Keynote Speaker

Prof. Chaohai Zhang

Nanjing University of Aeronautics and Astronautics

Bio: Prof. Zhang was born in Nanjing, China. He obtained his BA, MS and PhD degrees from Harbin Institute of Technology(HIT), Navy Aeronautical Engineering Academy(NAEA)and Hong Kong Polytechnic University(HKPU), respectively. After some years experiences of research working as a JSPS Research Fellow in Kumamoto University, Japan, as a consultant engineer at IREQ and professor in Canada, respectively. Currently he is a professor at Nanjing University of Aeronautics and Astronautics, and he had experienced 5-years as a chief expert at State Grid EPRI, China, his research interests are in high voltage engineering, electrical discharges, pulsed power&plasma application, renewable energy and the condition monitoring of electric power equipment.

Speech Title: Integrated Energy Service Technology for Intelligent Park Based on Building Refined Modeling Method

Abstract: The energy consumption of buildings accounts for approximately 40%of the total energy consumption. Accurate analysis of the energy consumption of buildings not only promises significant energy savings but also helps to more accurately estimate the demand response potential and consequently brings benefits to the upstream power grid. This paper will focus on integrated energy service technology for intelligent park. Application forms of building energy analysis in areas such as energy efficiency promotion, electricity safety, user behavior analysis, and grid interaction will be discussed. This has great significance for the construction of integrated energy service system centered on residents or load aggregators. This paper proposes a novel physical-data fusion method for modeling smart buildings that can achieve an accurate assessment of energy consumption. The thermal process model of buildings and the electrical load model focusing on building heating, ventilation, and air conditioning(HVAC)systems are presented to analyze the thermal electrical conversion process of building energy consumption. The physical-data fusion method is used to improve the accuracy of the energy consumption analysis model of buildings, including modifying the parameters that are difficult to measure in the physical model, effectively modifying the electrical load model based on the proposed physical-data fusion method. Finally, the author will take an actual intelligent park in Jiangsu Province, China, as an example to introduce the research work of their team and the outlook for the future.

Keynote Speaker

Prof. Xiaoguang Wang

Chengdu University of Technology

Bio: Xiaoguang Wang is a Professor at the Department of New Energy Engineering, College of Energy, Chengdu University of Technology, China. He received his Bachelor degree (2010) in Petroleum Engineering from China University of Petroleum (East China) and Master degree (2012) in Petroleum Engineering from University of Oklahoma, USA, and obtained his PhD degree (2016) in Hydrogeology from Imperial College London, UK. Prior to joining Chengdu University of Technology in 2020, he worked as a Postdoc and then Research Scientist in Hydrogeology at Laboratoire Hydrosciences, Montpellier, France.

Professor Wang's research interests are in coupled THMC processes in fractured rocks with many applications including contaminant transport, geothermal engineering, oil and gas recovery, geological carbon storage. He has over 40 scientific publications and is a selected candidate of the E'mei Scholars Program of Sichuan Province.

Speech Title: Geothermal Energy: An Important Carbon-Neutral Pathway for China

Abstract: Geothermal energy is a competitive clean and renewable resource, which is abundant and widely distributed in China. The development of geothermal energy can reduce pressure on energy demand and further promote the process of carbon neutrality in China. However, several key technologies on geothermal resource exploration, evaluation and utilization are required for the efficient development of geothermal energy, which are lagged behind other countries. Based on the Geothermal Research Center in Chengdu University of Technology, we developed some advanced technologies, including THMC coupled simulation techniques, inverse modeling, monitoring and real-time optimization systems, which will be thoroughly introduced in the presentation.

Keynote Speaker

Prof. Can Wan

Zhejiang University

Bio: Can Wan received the B. Eng. degree from Zhejiang University, Hangzhou, China, in 2008, and the Ph. D. degree from The Hong Kong Polytechnic University, Hong Kong, in 2015.

He serves as a Professor with the College of Electrical Engineering, Zhejiang University, Hangzhou, China. He was a Postdoctoral Fellow with the Department of Electrical Engineering, Tsinghua University, Beijing, China, and held research positions with the Technical University of Denmark, The Hong Kong Polytechnic University, and City University of Hong Kong. He was a Visiting Scholar with the Center for Electric Power and Energy, Technical University of Denmark, and Argonne National Laboratory, Lemont, IL, USA. His research interests include forecasting, renewable energy, active distribution network, integrated energy systems, and machine learning. He is an Associate Editor for the IEEE Transactions on Industrial Applications and the IEEE Systems Journal.

Speech Title: Probabilistic Forecasting for Renewable Energy Integration

Abstract: Accurate and reliable forecasting of renewable energy generation is essential to modern power system operation and control. Probabilistic forecasting becomes an effective tool for prediction uncertainty quantification in modern power systems with high penetration of renewable energy. This talk would give an overview of the development of renewable energy and the basics of probabilistic forecasting. A series of machine learning based probabilistic renewable energy forecasting methodologies would be introduced. With the aid of prediction intervals of renewable energy generation, the operating reserves of power systems could be optimally quantified. Numerical experiments demonstrate that the proposed probabilistic forecasting methodologies are effective for uncertainty quantification and could promisingly facilitate the integration of renewable energy.

Keynote Speaker

Prof. Zhe Chen

Aalborg University
IEEE Fellow, IET Fellow

Bio: Dr. Chen has been the leader of Wind Power System Research program at the Department of Energy Technology, Aalborg University. His main research interests are power electronics, power systems, energy systems and new energy technologies. He has led and participated in many research and industrial projects, and he has more than 800 publications in these fields.

Professor Chen has served as a panel member and/or an evaluator for research funding organizations in many countries. He is an Associate Editor of the IEEE Transactions on Power Electronics, a member of editorial boards for a number of international scientific and technical journals.

Dr. Chen is a Chartered Engineer in the U. K., a Fellow IEEE (FIEEE) , a Fellow of IET (FIET), a member of the Danish Academy of Technical Sciences (ATV).

Speech Title: Energy Systems Transition

Abstract: Modern energy systems are in the transition towards a renewable energy based clean energy system. Green power plants based on variable renewable energy sources, wind and solar PV, have been quickly developed and would become the important energy sources of the energy systems, even dominated power sources in some countries/regions for example, in Denmark. These modern renewable power plants have distinctive features from the traditional fossil fuel based power source, synchronous generators, which bring many challenges to the operators of energy systems.

The speech will overview the development of renewable energy technologies, the wind and solar PV power plants, describe some major types of power electronic interfaces, main features of variable renewable power plants, and discuss the major challenges and possible solutions.

Keynote Speaker

Dr. Xiaoyan Han

State Grid Sichuan Electric Power Company

Bio: Dr. Han is an expert in smart grid. He received the Ph.D. degree in Electrical Engineering from Zhejiang University in 1995. Now he is professor level senior engineer, deputy chief engineer and postdoctoral supervisor of the State Grid Sichuan Electric Power Company. He is the head of the CIGRE C4.45 China working group and the domestic expert group of State Grid Corporation. He has been engaged in power grid construction, operation, production, management and scientific research for a long time. His achievements have awarded by Chinese Society for Electrical Engineering, Sichuan Province, State Grid Corporation and so on. And, the power grid construction project he participated in has won gold prize of national high quality projects. He has published more than 30 scientific papers and 2 monographs.

Speech Title: Research and Application on Complementary Generation System of Cascaded Small-Hydropower, Photovoltaic and Pumped Storage

Abstract: To address the security, stability and scheduling problems of the complementary generation of cascaded small-hydropower and photovoltaic in the basin, the complementary generation technology of the cascaded hydropower-PV-storage system closely combines cascaded small-hydropower, photovoltaic and pumped hydro storage, and fully exploits the regulation capacity of cascade small-hydropower to realize the complementary optimization of various renewable energy sources. In this project, the multi time scale coupling stochastic optimization and control theory of cascade small-hydropower and photovoltaic system is constructed. Besides, a series of software for planning, operation, control and dispatching of the system is developed. In the end, the key technologies such as design and manufacturing of complete sets of equipment for full power variable speed constant frequency pumped hydro storage units are conquered. The project is being carried out in Xiaojin, Sichuan, China to validate the feasibility of the proposed technology.

Tutorial Session

Presenter:

Dr. Sidun Fang, The Chinese University of Hong Kong

Time: 15:00-16:00(UTC/GMT+08:00)

Zoom ID: 986 6868 8070 *Zoom Link: [https://zoom.com.cn/j/98668688070]*

Password:ICPS2021

Bio:

Sidun Fang (S'14-M'17) received the B. E degree in School of Electrical Engineering, Chongqing University, Chongqing, China, in 2012, and his Ph. D. degree of Power System and its automation in School of Electronics Information and Electrical Engineering, Shanghai Jiao Tong University, Shanghai, China, in 2017. In 2017-2020, he served as a Research Fellow in the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. From 2020, he joined the Chinese University of Hong Kong as a Postdoc fellow.

His research interest is the optimal operation of microgrid and he has published more than 30 SCI/EI journals/conferences in relevant fields. Dr. Fang was awarded the Outstanding Graduate prize of Shanghai Jiao Tong University and his doctoral dissertation was nominated as the Excellent Dissertation Papers in Shanghai Jiao Tong University in 2017. From 2020, he serves as an Editorial Member of International Transactions on Electrical Energy Systems. He was also invited as the guest editor of Energy, Sustainability, and eTransportation.

Email: sidunfang@cuhk. edu. hk

TALK ON

Overview of Low-Carbon Maritime Multi-energy Systems

Abstract:

In the last decade, maritime transportation has undertaken almost 90%global oversea trading logistics and correspondingly produces 3%-5%of the total global greenhouse gas emission, as well as more than 15%nitrogen dioxide. According to the research of International Maritime Organization(IMO), if no actions being taken, the gas emission by maritime transportation may increase by 50%~250%by 2050 in correspondence since the drastic oversea trading increments. The urgent need for a more efficient maritime transportation system motivates the electrification of all the attached sub-systems for higher energy efficiency, such as the all-electric ships, electrified ports, and various electrified ocean platforms. Different equipment and technologies also have been integrated into those sub-systems, such as fuel cell, energy storage, gas capture system, cold-ironing facilities, and alternative fuel, which gives birth to the "maritime grids". Typical maritime grids consist of generation, storage, and critical loads, and can operate either in grid-connected or in islanded modes, and operate under both the constraints of

energy system and maritime transportation system. Different types of energy flows coordinate in “maritime grids”, i. e. , electricity, thermal power, water, and so on, which makes “maritime grids” as special “multi-energy systems”. Main representatives of “maritime multi-energy systems” are shown as Figure 1.

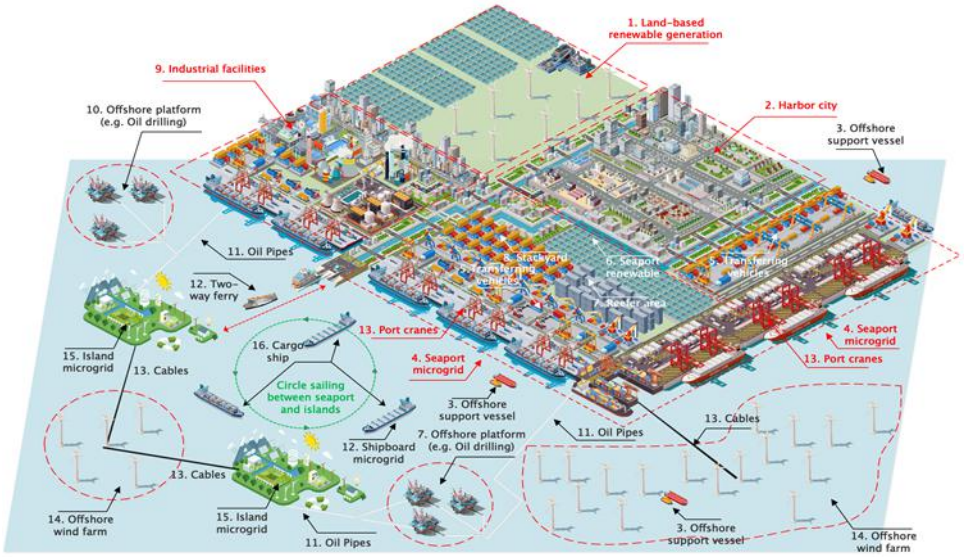

Figure 1. Future maritime multi-energy grids

In Figure 1, main types of maritime grids including harbour city grid(2), seaport microgrids(4), offshore platforms(10), shipboard microgrids(12), offshore wind farms(14), island microgrids(15).

In the first place, harbour city grid(2)is the core and acts as the main grid for the rest of maritime grids. The main functions include receiving the land-based renewable generation(1), supplying the industrial facilities(9), providing power to seaport microgrids(4), and operating two-way ferries(12)to island microgrid(15). The former four are energy connections and the fifth is a transportation connection.

Then seaport microgrid(4)is the network within a seaport, and this microgrid receives electricity from the harbour city grid(2)and providing raw materials to the industrial facilities(9). The seaport microgrid also receives energy from the seaport renewable(6). Seaport provides berth positions to the cargo ships(16), and handling the cargos by the port cranes(13). The cargos are then lifting by the transferring vehicles(5)to the stackyard(8), and the cold-chain containers are stored in the reefer area(7). Besides, seaport microgrid provides cold-ironing power to the shipboard microgrid(12).

The offshore platforms(10)include oil drilling platforms or other construction ships. They produce raw materials and transmit them to the industrial facilities(9)or island(15)by the oil pipes or other networks. The raw materials can be also transported by cargo ships(16). The shipboard microgrid(12)is the network installed in cargo ships(16), offshore support vessels(3), and other ships. It receives the cold-ironing power from the seaport microgrid(4), and it periodically sails between seaport and islands(15)or other places to transfer cargos. Offshore wind farm(14)is to harvest wind energy on the sea. It has underground cables(13)to connect with the seaport(4)and then with the harbour city(2). It can also support the energy for the island microgrid(15). The offshore support vessels(3)are used to construct and repair offshore wind farms.

Island microgrid(15)is the microgrid within an island, which involves various renewable energy and other distributed generations. The scale of island microgrid depends on the area of island, and large island microgrid may have environmental agriculture facilities.

As above, this tutorial focuses on the low-carbon maritime multi-energy systems and discusses their definition, development and future ways. The content of this tutorial consists of the following four aspects:

The development trend and definition of the maritime multi-energy systems and the main representatives, including all-electric ships, seaport microgrids, harbour city grid, and so on.

The mmanagement targets of maritime multi-energy systems and their main differences compared with conventional land-based multi-energy systems.

The optimization-based energy management methods of maritime multi-energy systems under different conditions, i. e. , for addressing uncertainties, or operating with large-scale of energy storage, and so on.

Future research roadmap for maritime multi-energy systems.

Onsite Oral Sessions

Session 1: Energy-Transportation Nexus towards Low Carbon Future
Session Chair: Dr. Zechun Hu, Tsinghua University
Co-Chair: Dr. Zhaohao Ding, North China Electric Power University
Venue: Xiangqing Hall@2F@祥庆厅@2 楼
Time: 15:00-18:00

Panel Session Abstract:

Facing the carbon-neutral target in 2060, transportation electrification has drawn more and more attention in both industrial and academic sectors. Considering the unique flexible operation characteristics of electrified transportation system, it becomes more and more critical to coordinate the operation and planning of energy and transportation systems to enhance the energy efficiency and reduce the carbon emission as an integrated system. The increasing energy demand from electrified transportation sector shall not only be met through renewable energy, but also provide flexibility to support the integration of intermittent renewable power generation. Meanwhile, the power grid shall address the opportunities and needs for the integration of large scale EVs and related emerging technologies.

Panelists:

Qian Zhang, Chongqing University, Interactive strategies for the participation of electric vehicles in electricity market

Chengcheng Shao, Xi'an Jiaotong University, Coordinated operation between renewable power system and transportation based hydrogen system

Yue Xiang, Sichuang University, Unlocking residential EV charging load pattern

Kai Liao, Southwest Jiaotong University, The Conception and Key Issues of Transportation and Energy Integration System

Jianxiao Wang, North China Electric Power University, Dispatching Fuel-Cell Hybrid Electric Vehicles toward Transportation and Energy Systems Integration

Time Arrangement:

Each presentation is around 30 min. After the presentation part, there would be a closed-door discussion among the panelists and organizers for 30 min.

Session 2: S2. Power System Protection>b. Medium Voltage Protection Session Chair: Dr. Yongliang Liang, Shangdong University Venue: Yuchun Hall Room I@2F 玉春堂一号厅@2 楼 Time: 16:00-17:45		
Time	**Paper ID**	**Title & Author**
16:00-16:15	S0010	Integrated Model for Recognition of Single-Phase-to-Ground Fault Caused by Insulation Deterioration in Medium-Voltage Distribution Networks **Presenter: Yongliang Liang** *Shandong University* Abstract: Insulation deterioration is one of the key causes of the single-phase-to-ground fault(SPGF)in medium-voltage distribution networks, and accurate recognition of the SPGFs caused by insulation deterioration can improve the maintenance efficiency and prevent the development of faults. An integrated model for recognition of SPGFs caused by insulation deterioration is proposed in this paper. Multiple waveform features in the time, frequency, and time–frequency domains are extracted, and their feasibility is analyzed through a multivariate analysis of variance. Then, recognition models based on the fuzzy inference system, extreme learning machine, and support vector machine are designed, and an integrated recognition model based on Dempster–Shafer evidence theory is proposed. The recognition result of onsite data indicate that the integrated model outperforms any single model, confirming the advantages and feasibility of the proposed model.
16:15-16:30	S0048	Identification of Root Causes and Weak Points of Power Grid Based on Probabilistic Risk Assessment **Presenter: Jun Zhang** *State Grid Energy Research Institute* Abstract: Risk assessment in power system operation shall take into account both probabilities and impact of time-varying contingency. This paper proposes a new computational method to identify the root causes and weak points of power system based on probability risk assessment theory. In the proposed method, the formulas of calculating the risk indices of root causes and weak points are derived. According to our observations, there are constant terms that require a large number of continuous multiplication calculations in the derivation process. The calculation result is not affected and the calculation amount is greatly reduced which without consideration of constant term. Subsequently, the indices of root causes(or weak points)of real-time and intra-day are proposed respectively. Accordingly, the real-time and intra-day root causes(or weak points)of power grid can be identified. The efficacy of the proposed method is tested on IEEE 39-bus system. The obtained results indicate that the proposed method can effectively help system operators to monitor weak points and root causes of power grid.

16:30-16:45	S0054	Traveling Wave Feature Classification-based Fault Location in Active Distribution Network **Presenter: Chenjie Xu** *Chang'an University* Abstract: With the access of distributed generators(DG), the power flow direction and structure of distribution networks have changed, and therefore many traditional fault location methods are no longer applicable. Single-phase grounding fault is a common fault in power distribution network, which may bring secondary fault and even blackout. Starting from the relationship between the wavelet eigenvalues of traveling waves and the fault section of distribution lines with DG, the optimal fault features were selected by dimension reduction of linear discriminant analysis(LDA), and then the Bayesian classification model based on kernel distribution was used to realize the new method of Single phase grounding fault location. The IEEE 33-bus model with DGs was constructed to test the faults in different sections of active distribution network, the locating accuracy of the optimal three-dimensional feature sample is 97.9%. The result shows the method can achieve accurate fault location.
16:45-17:00	S0252	Data Mining based Power System Fault Type Prediction Method **Presenter: Shaorui Wang** *Shandong University* Abstract: Currently used power system fault diagnosis methods have the problem of low accuracy and efficiency while classifying and predicting the types of faults. In recent years, big data technology has been applied to power system failure classification and prediction. This paper proposes a predictive model of each fault type based on using different data mining algorithms three times: First, cluster the original failure data samples by using a K-means clustering algorithm and simplify them with a self-encoding method. Second, it then uses Apriori algorithm to extract some potential rules, and mine the data that meets the legal requirements to form training datasets. Third, the stochastic gradient descent algorithm is applied to train a prediction model for each fault type. Finally, a simulation example shows that the proposed method results in high accuracy of fault classification and prediction. Irrelevant data is eliminated by this method to reduce over-fitting.
17:00-17:15	S0321	A Multi-Dimensional Performance Test Method for Process Layer Switch of Smart Substations **Presenter: Daxing Wang** *State Grid Sichuan Electric Research Institute* Abstract: The process layer switch system is the core piece of equipment of smart substation process layer network. Its performance is directly related to the safe and reliable operation of the substation. Currently, there are few

		projects testing process layer switches, so their status and performance cannot be accurately assessed under abnormal and unexpected situations, such as network overloading. Therefore, it is necessary to conduct an effectiveness evaluation of the switch performance. This paper combines the smart station network topology and field engineering practice to conduct an analysis of the performance test methods and methods of smart substation process layer switches. For normal, abnormal, and extreme operating environments, we propose a multi-dimensional process layer switch performance test method.
17:15-17:30	S0233	Research on Fault Isolation Technology and Device Development of LVDC System **Presenter: Jianhai Yan** *Nanjing Golden Cooperate DC Power Distribution Technology Co. , Ltd* Abstract: In view of the current research status of the protection device of LVDC system with single protection function and high protection cost, corresponding protection methods for different fault types are put forward in this article. Integrating the protection method, a comprehensive isolation protection device is developed, which is composed of fault detection circuit, single-chip microcomputer control circuit and isolation unit, and integrates short-circuit protection, grounding protection, AC intrusion into DC protection and ring network protection. The experimental results show that the comprehensive isolation device can quickly cut off the short circuit, and can limit the fault in the fault branch when the faults occur, so as to ensure the normal operation of the LVDC branches.
17:30-17:45	S0176	An Active Protection Scheme for Microgrids Based on the Harmonic Injection **Presenter: Aimin Xia** *Power Dispatching and Control Center State Grid Songjiang Company* Abstract: Inverter Interfaced Distributed Generation brings major challenges to the protection of microgrids, the traditional passive fault observation that does not use IIDG controllability, and the protection scheme based on the premise that the fault and non-fault characteristics are significantly different are no longer applicable. This paper proposes an active protection scheme for microgrid based on harmonic energy injection. The IIDG interface electrical signals are used for fault detection. In case of fault, the IIDG inverter started the harmonic energy injection function based on equivalent impedance modulation. The adjacent IIDG injected different frequencies'harmonic energy. The closer the fault point was to IIDG, the greater the harmonic energy injected. The scheme collects the fault harmonic current in the relay, and sets the protection criterion based on the ratio of the detected harmonic currents of different IIDGs. The minimum range of fault clearing is realized by blocking logic. A harmonic current ratio relay is designed for the protection scheme. The proposed active protection scheme was suitable for microgrids with

		multiple IIDGs, and can meet both connected and island operation mode. A benchmark radial system practically under use in Canada was established in PSCAD/EMTDC, and the effectiveness of the scheme under different fault conditions was verified through simulation research.
Dinner Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 3: S3. Energy Systems>a. Energy Efficiency
Session Chair: Dr. Zhixia Zhang, Shandong Agriculture and Engineering University
Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼
Time: 16:00-18:00

Time	Paper ID	Title & Author
16:00-16:15	S0148	Estimation of Lithium Battery SOC Based on Fuzzy Unscented Kalman Filter Algorithm **Presenter: Ruiping Zhang** *Lanzhou Jiaotong University* Abstract: Because unscented Kalman Filter(UKF)is affected by system noise and measurement noise when estimating the State of Charge(SOC)of lithium battery, which leads to slow convergence and easy dispersion of the algorithm. A Fuzzy Unscented Kalman Filter(FUKF)combining Unscented Kalman Filter with Fuzzy reasoning is proposed to estimate the SOC of lithium battery online. Firstly, a second-order battery model suitable for FUKF estimation of SOC is established, and the corresponding parameters in the model are identified by off-line parameter identification method. Secondly, the accuracy of the model is verified, and then the accuracy of FUKF algorithm is verified. The simulation results show that under the condition of unknown noise, FUKF algorithm has faster convergence speed and higher estimation accuracy than UKF algorithm, which effectively solves the deficiency of UKF algorithm.
16:15-16:30	S0031	Operational Security Assessment for Transmission System Adopting Dynamic Line Rating Mechanism **Presenter: Kaiyuan Yu** *North China Electric Power University* Abstract: The widely adopted dynamic line rating(DLR)mechanism can improve the operation efficiency for industrial and commercial power systems. However, the predicted envi¬ronmental parameters used in DLR bring great uncertainty to transmission line capacity estimation and may introduce system security risk if over-optimistic estimation is adopted in the opera¬tion process, which could affect the electrical safety of industrial and commercial power systems in multiple cases. Therefore, it becomes necessary to establish a system operation security assessment model to reduce the risk and provide operational guidance to enhance electrical safety. This paper aims

		to solve the electrical safety problems caused by the transmission line under DLR mechanism. An operation security assessment method of transmission lines considering DLR uncertainty is proposed to visualize the safety margin under the given operation strategy and optimally setting transmission line capacity while taking system safety into account. With the help of robust optimization(RO)techniques, the uncertainty is characterized and a risk-averse transmission line rating guidance can be established to determine the safety margin of line capacity for system operation. In this way, the operational security for industrial and commercial power systems can be enhanced by reducing the unsafe conditions while the operational efficiency benefit provided by DLR mechanism still exist.
16:30-16:45	S0042	Multi-time Scale Co-optimization Scheduling of Integrated Energy System for Uncertainty Balancing **Presenter: Zhenwei Zhang** *Shandong University* Abstract: Secure and economic operation of the integrated energy system(IES)is challenged by the high level of the uncertainty and fluctuation introduced by wind power sources. In this paper, a multi-time scale co-optimization scheduling scheme of IES is proposed, which considers tracking the wind power uncertainty to achieve accurate power balance and optimal economic operation of the whole system. First, a multi-time scale co-optimization model framework is established, and the electric *power* system, natural gas system and district heating system are coordinated to achieve more flexibility in each time scale. In the day-ahead stage, the optimal unit commitment is determined, furthermore, the operation scheme is adjusted on a rolling basis to track the random fluctuation of wind power in the intra-day stage. In the real-time stage, model predictive control(MPC)is used to achieve precise control, which takes the intra-day scheme as a reference to minimize operating deviations. Besides, the auto regressive moving average(ARMA)model and scenario method are employed to represent the wind power uncertainty by typical scenarios with corresponding probabilities. Finally, simulation results on an IEEE39-NGS20-DHS21 test system demonstrate the superiority of the proposed method in operational economy and wind power utilization, and also verify the effectiveness of the method to satisfy the uncertainty balancing.
16:45-17:00	S0091	Integrated Energy System Load Forecast Based on Information Entropy and Stacked Auto-Encoders **Presenter: Jindi Hu** *Zhejiang University* Abstract: The integrated energy system(IES)has the characteristics of complex coupling and huge demand for precise load forecasting(LF). This paper

		proposes an IES LF method based on the information entropy theory and stacked auto-encoders(SAEs)to forecast the power, cooling, and heating load. Firstly, all necessary primary input parameters are presented and described in detail. Then, the information entropy theory is introduced to select the most important parameters among the primary ones, which helps to reduce the complexity of the proposed model. Besides, the SAEs are utilized to learn the high order characteristics of input data and forecast the load demand of each load type with the wake-sleep algorithm to improve the training efficiency. The case study shows that compared with classic back-propagation(BP)artificial neuron networks(ANNs), the prosed method is of higher prediction accuracy, which provides references for comprehensive LF of IES.
17:00-17:15	S0143	An Optimization Model of CNG Refueling Station Considering Demand Response **Presenter: Chen-Xian Guo** *Shandong University* Abstract: The equipment in the CNG refueling station is highly electrified and consumes huge power. The electricity cost is an important part of the CNG refueling station operation cost. It is significant for the operators to lower the cost by carrying out economical optimization of the station under the guidance of the electricity market signal. In this paper, an optimization model is proposed for CNG refueling stations to study the economic impact after considering DR. This model further considers the pre-system electricity-gas cost model such as the dehydration device and the buffer tank. This model is a nonlinear 0-1 high-dimensional programming problem. It is solved by the SCIP solver in the MATLAB OPTI toolbox. The result shows 45.42% electricity-gas energy cost and 33.33%compressor switching frequency can be reduced comparing the original operating strategy under the guidance of Critical Peak Pricing. CNG refueling stations can participate in DR without changing the CNG filling load, reducing operating costs, and improving comprehensive energy utilization efficiency.
17:15-17:30	S0193	Distributed Collaborative Optimization Operation of Micro Energy Grid Based on Consensus Theory **Presenter: Jianfei Chen** *Shandong University* Abstract: In order to realize the optimal scheduling of distributed energy supply equipment in an micro energy grid, a distributed algorithm based on consensus theory is proposed in this paper. Each node only needs to exchange part of the information according to the communication topology and adopt the consensus algorithm to complete the iterative calculation, so that the consensus variable of each energy supply equipment in the system tends to be consistent, and the distributed optimization of the system is realized. Finally,

		an example is given to verify the effectiveness and dynamic response capability of the algorithm.
17:30-17:45	S0214	Research on Multi-objective Optimization of Integrated Energy System Considering Integrated Demand Response **Presenter: Qingsheng Zhao** *Taiyuan University of Technology* Abstract: This paper constructs a multi-objective opti-mization model for the economy, energy efficiency, and environmental protection of the park-level integrated energy system, which includes a combined cooling, heating and power system, heat storage, battery swapping station, electric vehicles, gas boilers, air conditioning, and photovoltaic and thermal. Take battery swapping station, electric vehicles, and air conditioning as the main body of integrated demand response implementation. Use exergy efficiency as an energy efficiency optimization indicator, and pollutant discharge treatment costs as an environmental protection evaluation indicator. The model established in this paper can be solved by Cplex. Finally, the calculation example analyzes the impact of different integrated demand response implementation scenarios on the system operation. The results show that the model can take into account the economy, energy efficiency and environmental protection of system operation, and the effect of peak shaving and valley filling is significant, which can provide a reference for operators.
17:45-18:00	S0216	Review of Economic Transmission Planning of Overseas Power Market and Its Enlightenment to China **Presenter: Xiaorui Hu** *North China Electric Power University* Abstract: Power market is booming in China right after the 9th order. Conventionally, transmission planning is performed mainly based on purpose of transmission security in a regulated environment. However, when power market takes place, economic planning of transmission system should be carefully designed and considered, since transmission infrastructure could heavily impact the efficiency of the power market, as well as the benefit of all kinds of market participants. Transmission economic planning had been developed in almost all mature power markets overseas. In the paper, such practices in several RTOs/ISOs in United States and TSOs in Europe are investigated. The implementation process, evaluate method and key economic benefit indices of transmission economic planning are summarized in the paper. In the end, based on the current transmission planning and the development of power market in China, the suggestions how transmission economic planning should be performed is given.
Dinner Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 4: S6. Special Session > g. Forecasting Technology and Application of Power System Enabling Large-scale New Energy Integration
Session Chair: Dr. Mingyang, Shandong University
Dr. Jie shi, University of Jinan
Venue: Xiangtai Hall@2F 祥泰厅@2 楼
Time: 16:00-17:00

Time	Paper ID	Title & Author
16:00-16:15	S0183	Risk Assessment of Ferromagnetic Resonance in Series Compensation Lines with New Energy Access **Presenter: Xuemin Song** *Changsha University of Science & Technology* Abstract: In view of the multiple power quality problems caused by photovoltaic and wind power access, aseries compensation intergrated energy effciency optimization model for distribution lines with new energy sources is established. The optimal compensation capacity and compensation location are obtained by calculation. In order to avoid series compensation induced ferromagnetic resonance in distribution network,the mechanism and suppression measures of intensified ferromagnetic resonance in new energy access distribution network are studied, and the risk assessment model of ferromagnetic resonance in series compensation line with new energy access is established. The ferromagnetic resonance risk assessment is carried out to ensure the safe and stable operation of series compensation line.
16:15-16:30	S0248	Enhancing Model Adaptability Using Concept Drift Detection for Short-term Load Forecast **Presenter: Yuanfan Ji** *Zhejiang University* Abstract: Concept drift refers to the relation between input and target envolves over time in an online supervised learning scenario. With the development of smart grid and smart meter, mass data accessibility poses a huge challenge to learning model adaptability. To address such issue, this paper proposed a model adaptbility enhancement approaches based on concept drift detection for short-term forecast model. It exploits canonical correlation analysis to measure mapping relation between input and output of the forecast model. Then the correlation coefficient vector sequence will be monitored over an adaptive window to detect concept drift. Model is updated on data over the sliding window only when a concept drift happens. Experimental results shows this method reduces memory assumption and computing resources remarkably meanwhile guarantees the forecast accuracy.
16:30-16:45	S0299	Performance Improvement of Photovoltaic Power Forecasting Model Based on Hilbert Huang Transform **Presenter: Wenjie Song** *University of Jinan*

		Abstract: Photovoltaic power generation is fluctuation and intermittent, and the grid-connected operation of large-scale photovoltaic power plants may have an impact on the safe and stable economic operation of the power system. An effective way to solve the problem is to make scientific forecasts of the output power of PV power plants. In this paper, Back Propagation (BP) and Radial Basis Function (RBF) neural network prediction models are established by using the historical values of actual power generation of Guhe Runneng Photovoltaic Power Station in Gaotang County of Liaocheng City in 2017. According to the characteristics of photovoltaic power fluctuation, the output power is treated as a set of digital signals for short-term PV power prediction, and a prediction model based on the Hilbert Huang Transform (HHT) power data decomposition is proposed. Through the analysis of an example, it can be concluded that after HHT, the prediction effect is significantly improved, and the accuracy of PV power prediction is improved. Moreover, compared with BP neural network, RBF neural network has smaller prediction error.
16:45-17:00	S0314	Piecewise Clustering Prediction Model of Distributed Photovoltaic Power Based on Principal Component Analysis **Presenter: Jie Shi** *University of Jinan* Abstract: Photovoltaic power generation is an important field of renewable energy development. However, when photovoltaic power generation is connected to the grid, the random fluctuation and intermittence of solar photovoltaic power generation caused by various environmental factors should be fully considered. Reliable prediction of photovoltaic power is a solution. Based on the analysis of two data analysis theories, which are cluster analysis and principal component analysis, this paper proposes a piecewise clustering method to improve the accuracy of RBF photovoltaic power prediction model. Firstly, the historical operational data after cleaning process are systematically clustered, and the corresponding target similar sample sets are obtained by two clustering methods. The RBF neural network algorithm is used to verify the prediction of the output power, which can effectively improve the stability and accuracy of the prediction results and simplify the number of input samples. Secondly, principal component analysis is carried out based on historical data, and the extracted principal component is taken as the input of RBF neural network photovoltaic power prediction model. It is proved by a case study that the proposed method can effectively improve the accuracy of prediction results and reduce the dimension of input samples, thus simplifying the network structure and shortening the learning time of neural networks. The effectiveness and reliability of the piecewise clustering method are verified by the case study.
Dinner Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

On-site Sessions

2021 7/20 TUE

Session 5: S1. Power System Engineering>b. Power System Analysis
Session Chair: Dr. Bo Wang, Northeast Electric Power University
Venue: Yuchun Hall Room I@2F 玉春堂 1 号厅@2 楼
Time: 09:15-10:15

Time	Paper ID	Title & Author
9:15-9:30	S0052	Two-time Scale Operation Optimization of AC/DC Distribution Network **Presenter: Ruomei Zeng** *Shandong University of Science and Technology* Abstract: Fuzzy optimization model to deal with uncertainty of forecast data is limited. When there are large errors in the day-ahead forecast data, it is difficult to fully deal with the real-time data fluctuations. Using the feature of prediction data's accuracy is improved with the decrease of time scale, a fuzzy optimization model with two-time scale for AC/DC distribution network is proposed. On a long-time scale, using trapezoidal fuzzy number to represent long-time scale prediction data, active power loss as objective function structures cone optimization model for fuzzy day-ahead scheduling. In a short-time scale, short term forecast data expressed by triangle fuzzy number, active power loss and node voltage offset as objective function structure intra-day cone optimal model, which realize safe and economic operation of distribution network. The results of examples show that, double time scale can reduce the impact of uncertainty of forecast data on distribution network operation. meanwhile, it can improve the ability of the model to deal with real-time forecast data fluctuations.
9:30-9:45	S0081	Analysis of Power Flow Characteristics of Power Grid Considering Temporal and Spatial Correlation of Meteorological Factors **Presenter: Xueyong Jia** *Shandong University* Abstract: This paper analyzes the influence of the temporal and spatial correlation of meteorological factors on the power flow characteristics of the power grid based on the electro-thermal coupled power flow model of the unified iterative format. First, based on the IEEE 738-Standard heat balance equation, this paper establishes an electric-thermal coupling unified power flow calculation model considering meteorological factors, which incorporates the temperature and resistance of the transmission line into the power flow

		state variables and introduces environmental parameters into the power flow calculation. Then, by individually changing the wind speed, altitude and ambient temperature, quantitatively analyze the change trend and degree of influence on bus voltage amplitude, bus voltage phase angle, line temperature, line resistance, line active and reactive power loss. Finally, the meteorological data of area A and area B are used to calculate and analyze the range of line resistance, line temperature, line active and reactive power loss of each line of the regional power grid, and compare the transmission power limit of the line in different areas and different seasons. The case study shows that the temporal and spatial changes of area weather have a significant impact on the distribution of power flow, line active and reactive power losses, and power transmission limits by changing line resistance and temperature. Considering the temporal and spatial correlation of meteorological factors is of great significance to the safe and stable economic operation of the power grid.
9:45-10:00	S0103	Research on Cost and Benefit of Demand Response Related Entities Based on System Dynamics **Presenter: Ting Pan** *North China Electric Power University Energy Internet Research Center* Abstract: Studying the cost-benefit of demand response is helpful for participants to understand their own input and benefit. The system dynamics method provides a more systematic, dynamic, and clear causal feedback solution for the cost-benefit analysis of demand response. Based on the analysis of the cost-benefit sources of demand response related entities, this paper applies the system dynamics method to the cost-benefit model of demand response, and verifies the rationality and effectiveness of the model through simulation examples, which provides theoretical reference value for the further development of demand response resources.
10:00-10:15	S0114	Optimization of Emergency Load-shedding Based on Surrogate-Assisted Differential Evolution **Presenter: Chenhao Gai** *Shandong University* Abstract: Emergency load shedding(ELS)is an essential measure to keep system stability. Due to the high cost of load shedding, minimizing the amount is always the goal while satisfying security requirements. The optimization problem is highly nonlinear and can be solved with heuristic algorithms by generating a large number of candidates. However, it is time-consuming to check the feasibility of each candidate by numerical simulation. To address this issue, this paper presents an accelerated ELS optimization method based on surrogate-assisted differential evolution(SADE). The optimization process is driven by differential evolution(DE). Radial basis function(RBF)neural network is adopted as the surrogate model to replace the numerical simulation for checking the security constraints. Only the most promising

		candidates pre-screened by RBF are evaluated by numerical simulation. The validity of the proposed ELS optimization method is verified with a provincial power system.
Coffee Break		

Session 6: S1. Power System Engineering>b. Power System Analysis
Session Chair: Dr. Bo Wang, Northeast Electric Power University
Venue: Yuchun Hall Room I@2F 玉春堂 1 号厅@2 楼
Time: 10:45-12:00

Time	Paper ID	Title & Author
10:45-11:00	S0166	High-Order SOGI-based Observation Technology of Leakage Electrical Impedance **Presenter: Guangmeng Liu** *Chengnan Power Supply Branch of State Grid Tianjin Electric* Abstract: Aiming at the problem that the leakage impedance measurement results are easily affected by the harmonics of the power grid, a leakage current and leakage impedance observation technology based on a high-order generalized second-order integrator(SOGI)is proposed in this paper. The high-order SOGI observer is designed to observe the amplitude, phase angle and frequency information of the grid voltage and the leakage current, effectively filter out the influence of harmonics, and then the leakage loop impedance can be calculated by the instantaneous amplitude, phase angle of the voltage and leakage current. Finally, it is verified by simulation that the proposed leakage impedance estimation technology is of high accuracy and strong anti-harmonic ability.
11:00-11:15	S0152	Extension of Power Flow Algorithm in STEPS for AC/DC Hybrid Power systems with VSC-MTDC **Presenter: Zhenhe Ma** *Shandong University* Abstract: The open-source simulation toolkit for electrical power systems(STEPS)was released in Github with power flow and dynamic simulation functions. However, voltage source converter based multi-terminal direct current(VSC-MTDC)was not supported in STEPS. In this paper, the steady-state model of VSC-MTDC is introduced with diverse control modes. Then, the AC/DC power flow algorithm with VSC-MTDC is designed with alternating iteration method. The controlled variables exceeding limits with different control modes are handled in the algorithm. Besides, a general data structure of VSC-MTDC is established based on PSS/E and realized in STEPS. Finally, Two cases with VSC-MTDC are tested to verify the feasibility and effectiveness of the designed algorithm.
11:15-11:30	S0204	The Effects of Monolayer Planar Coil Turns Change in Low-frequency Wireless

		Power Transfer **Presenter: Pengcheng Cao** *Harbin Engineering University* Abstract: The structure of the coil in wireless power transfer affects the transmission performance. When a fixed excitation source is matched with appropriate transmitting and receiving coils, the electromagnetic energy can be fully utilized. In order to study the lightweight requirements on special occasions, the relationship between coil's turns and receiving performance must be investigated. This paper design and use the simplest structure of monolayer planar coils which winded closely by ordinary copper enameled wire and fixed in 25 mm inner diameter, 0. 5 mm strand diameter. According to modeling and simulation, the coil parameters and mutual inductance are obtained after the transmitting and receiving coils turns changed respectively, the simulation results are also verified by experiments. Finally, based on experiments, the variation empirical models of receiver voltage is concluded, which can provide a prediction model for the wireless charging power control of lightweight equipment.
11:30-11:45	S0311	Data-Driven Electromechanical Parameter Estimation in Dynamic Model of A Synchronous Generator **Presenter: Bo Wang** *Northeast Electric Power University* Abstract: The penetration rate of distributed power sourcesin the distribution network continues to increase, and the problem of voltage limit violations in the distribution network has gradually become prominent. This paper combines the linearization method and the voltage sensitivity to propose a two-stage linearization voltage regulation strategy. In the first stage, the optimal voltage regulation model is established. Aiming at the problem that the traditional model is difficult to solve by non-convex and nonlinearity, this paper analyzes the influence of transformer taps and distributed power reactive power on network loss and node voltage, and constructs linearized voltage regulation. The model effectively reduces the calculation complexity and calculation time of the optimization problem. In the second stage, in view of the uncertain factors in actual operation, an in-situ compensation based on droop characteristics and a comprehensive voltage adjustment strategy based on voltage sensitivity are proposed. Based on the linearized scheduling results of the first stage, the output of photovoltaic power is reproduced. The regulation ensures the robustness of the voltage regulation algorithm, and the effectiveness of the method proposed in this paper is verified through case analysis
11:45-12:00	S1007	Feasibility Analysis of HVDC Converter Transformer Neutral Grounding by A Small Reactance **Presenter: Ensheng Zhao**

		University of Electronic Science and Technology of China Abstract: Nowadays, the scale of power grid is increasing and there is a continuous reinforcement of the AC/DC hybrid system. Therefore, the level of single-phase short circuit current at the converter station is increasing, which may exceed the three-phase short circuit current in some cases. This large current can cause some problems during equipment selection and threaten the safety of equipment and people. The aim of this paper is to analyze the influence of the converter transformer connection on the single-phase short circuit current at the AC grid side. Also, the feasibility of limiting the single-phase short-circuit current using a small reactance at the neutral grounding point of the HVDC converter transformer is verified. In addition, the principle of selecting the suitable value of the small reactance is summarized. The results show that grounding the converter transformer neutral point by a small reactance can effectively limit the single-phase short-circuit current on the AC grid side. However, it leads to the increased overvoltage at the neutral point of HVDC transformer. Therefore, a small reactance at the neutral point might be implemented under the condition that the insulation level is satisfied.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 7: S1. Power System Engineering>c. Power System Reliability
Session Chair: Dr. Lei Yang, Key Laboratory of Solar Energy Utilization & Energy Saving Technology of Zhejiang Province
Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼
Time: 09:15-10:15

Time	Paper ID	Title & Author
9:15-9:30	S0020	Reliability Test Method of Power Grid Security Control System Based on BP Neural Network and Dynamic Group Simulation **Presenter: Junjun Pan** *CYG Sunri Co. LTD* Abstract: Aiming at the problems of imperfect dynamic verification of power grid security and stability control strategy and high test cost, a reliability test method of power grid security control system based on BP neural network and dynamic group simulation is proposed. Firstly, the fault simulation results of real-time digital simulation system(RTDS)software are taken as the data source, and the dynamic test data are obtained with the help of the existing dispatching data network, wireless virtual private network, global positioning system and other communication resources; Secondly, the important test items are selected through the minimum redundancy maximum correlation algorithm, and the test items are used to form a feature set, and then the BP neural network model is used to predict the test results. Finally, the dynamic

		remote test platform is tested by the dynamic whole group simulation of the security and stability control system. Compared with the traditional test methods, the proposed method reduces the test cost by more than 50%. Experimental results show that the proposed method can effectively complete the reliability test of power grid security control system based on dynamic group simulation, and reduce the test cost.
9:30-9:45	S0089	A Fast Reliability Assessment Method Based on Sequantial Monte Carlo Simulation Considering Historical Fault Data **Presenter: Yan Wang** *Shandong University* Abstract: This paper studies the reliability evaluation algorithm of complex distribution networks. In order to simplify the analysis process, components in the network are divided and equivalent to different virtual devices to eliminate the quantity of devices by the two-step process in fault process. According to the phenomenon of repeated fault analysis during the simulation process, a historical fault list is constructed to store the fault data for subsequent simulation. The data is dynamically updated by sequential list search method within the simulation process. On the basis of above methods, combining with the impact analysis, the reliability assssment method on historical fault is proposed. Finally, by using the proposed method and algorithm, this paper takes a modified RBTS BUS6 system to illustrate the high efficiency and correctness of the proposed method in the paper.
9:45-10:00	S0130	An Enhanced Active Damping Control Method for LCL-Type Shunt APFs with Proportional-Resonant-Differential Inverter-Side Current Feedback **Presenter: Lei Yang** *Key Laboratory of Solar Energy Utilization & Energy Saving Technology of Zhejiang Province* Abstract: This paper is focused on a dual-loop current control for digitally-controlled LCL-type shunt active power filters(APFs), which has an inherent active damping effect for LCL resonance. However, due to the system delays, the damping region is only up to one sixth of the sampling frequency(fs/6), leading to a limited robustness against grid impedance variation. To resolve this problem, an enhanced active damping method is proposed with proportional-resonant-differential inverter-side current feedback, where the proportional-differential term serves as a delay-compensation link. Then, two modified digital implementation schemes of proportional-differential term are given to overcome the gain amplification problem at Nyquist frequency. Theoretical analysis proves that the proposed active damping method can successfully extend the damping region to approximately(0, fs/4)and improve the system robustness. Finally, experimental results on a 30 kVA APF prototype have validated the effectiveness of the proposed method.

10:00-10:15	S0188	Power Supply Capability Evaluation of Distribution Network Based on Flexible Cooling and Heating Demand **Presenter: Jinchen Liu** *Tianjin University* Abstract: For the current supply capacity assessment failed to adequately consider the impact of heating and cooling load comfort and virtual energy storage characteristics of buildings, a power supply capability evaluation method of distribution network based on flexible cooling and heating demand is proposed. First of all, combined with the influence of cooling and heating load resources on the reliability of power supply, a calculation method of terminal user reliability index considering cooling heating and electrical load is proposed; Secondly, based on the indoor air thermal equilibrium model and the building envelope thermal equilibrium model, a virtual energy storage model for cooling and heating loads is established. Thirdly, based on the sequential Monte Carlo reliability evaluation process, distribution network power supply capacity evaluation model and solution method based on differentiated reliability constraints are proposed. Finally, a numerical example is used to verify the effectiveness and practicability of the method proposed in this paper.
Coffee Break		

Session 8: S1. Power System Engineering>c. Power System Reliability
Session Chair: Dr. Lei Yang, Key Laboratory of Solar Energy Utilization & Energy Saving Technology of Zhejiang Province
Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼
Time: 10:45-11:45

Time	Paper ID	Title & Author
10:45-11:00	S0021	Cyclic Verification Method of Security Control System Strategy Table Based on Constraint Conditions and Whole Process Dynamic Simulation **Presenter: Junjun Pan** *CYG Sunri Co. LTD* Abstract: The correctness of security control system strategy is very important to ensure the stability of power system. Aiming at the problem that the current security control strategy verification method is not enough to match the increasingly complex large power grid, this paper proposes a cyclic verification method of security control system strategy table based on constraints and whole process dynamic simulation. Firstly, the method is improved based on the traditional security control strategy model to make the strategy model meet certain generalization ability; And on the basis of this model, the cyclic dynamic verification of the strategy table is realized based on the constraint conditions and the whole process dynamic simulation, which

		not only ensures the high accuracy of strategy verification for the security control strategy of complex large power grid, but also ensures that the power system is stable and controllable. Finally, based on a certain regional power system, the optimal verification of strategy table verification experiment is realized. The experimental results show that the average processing time of the proposed method is 10. 32s, and it can effectively guarantee the controllability and stability of power grid.
11:00-11:15	S0300	Optimization of Backup Power Automatic Switching Strategy in The Distribution Network with Distributed Photovoltaics **Presenter: Piao Gao** *Shanghai Jiao Tong University* Abstract: Large-scale distributed photovoltaics(DPs)are connected to the distribution network. when a fault happens in the distribution network, the bus voltage at the fault location cannot immediately decrease to zero due to the existence of DPs, which invalidates the criteria of non-voltage detection and synchronism check and impedes the automatic switching of backup power. Therefore, considering the influence of DPs, this paper puts forward a configuration optimization scheme of backup power automatic switching(BPAS)strategy, which allows the BPAS devices in the distribution network with DPs to conduct non-voltage detection and synchronism check. The example analysis shows that the optimized BPAS strategy can effectively improve the load transfer capacity and reduce the cost of BPAS devices.
11:15-11:30	S0098	A Reliability Assessment Method Based on Convolutional Neural Network **Presenter: Yan Wang** *Shandong University* Abstract: With the expansion of the power grid, the performance bottleneck of traditional reliability evaluation methods are gradually becoming prominent, and improving the speed of reliability evaluation is becoming an urgent problem to be solved. Reliability evaluation usually uses Monte Carlo simulation for reliability index calculation. In this process, load shedding calculation occupies the main computing resources. In response to this problem, this paper designs an improved united convolutional neural network to perform load shedding calculations and proposes a reliability calculation process based on UCNN. According to the characteristics of the power system, a data set construction method for reliability evaluation is proposed. By introducing a hierarchical sorting method, it can effectively avoid the low density of the data set and the high time-consuming construction process. At the same time, the random first-three-permutation sampling algorithm and the n-ary index random method broaden the possible states of the data set and reduce the complexity of sampling time, thereby providing effective support for model training. Finally, the reliability of the IEEE-RTS79 system is evaluated, and the results show that the method proposed in this paper is fast

		and effective.
11:30-11:45	S0221	Reliability Evaluation of PV-ESS Microgrid System **Presenter: Zhipeng Weng** *North China University of Technology* Abstract: Unlike grid-connected microgrids, isolated microgrids are more susceptible to internal equipment capacity changes and external dispatching strategies, so it is necessary to analyze microgrid reliability from the perspective of capacity changes. Firstly, a time series model of equipment life process, a PV model with Beta distribution, a load model with time variability and stochasticity, and an energy storage model with operational constraints are studied. Secondly, the reliability index is used to characterize the system reliability level, and the power scheduling and load shedding strategy with minimum load shedding is proposed. Finally, the improved RBTS BUS6 F4 system is used as an example to deeply analyze the interaction mechanism of each device capacity on the reliability of the microgrid and to show the effectiveness of the proposed strategy.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 9: S4. Renewable Energy Integration>a. Renewable Energy Development and Integration **Session Chair: Dr. Shuai Zhang, Sichuan University** **Venue: Xiangqing Hall@2F 祥庆厅@2 楼** **Time: 09:00-10:00**		
Time	**Paper ID**	**Title & Author**
9:00-9:15	S0304	Mode Switch Control of Two-stage Photovoltaic Inverter after Losing Battery Storage in Islanded Microgrid **Presenter: Yujie Jiang** *Xi'an Jiao Tong University* Abstract: In order to deal with the energy shortage and environmental pollution, solar energy has been widely used, which can be organized with the energy storage as the microgrid. In islanded mode of the photovoltaic microgrid, due to the randomness of the output power, the photovoltaic inverter usually needs energy storage to keep power balance. As a result, in the absence of energy storage, photovoltaic inverter should stop working because of the loss of voltage synchronization and balanced power flow. To solve this problem, this paper proposes a mode switch strategy of two-stage photovoltaic inverter, which can operate both with energy storage and in standalone mode according to the state of the islanded microgrid. When working with energy storage, the photovoltaic inverter tracks the power point that derived from the energy management system. After losing the energy storage, the photovoltaic inverter supports the bus voltage and satisfies load demand. Moreover, a method is proposed to achieve seamless switch between

		these two control modes, where the balanced power flow between the photovoltaic inverter and load is promised at the same time. Finally, the simulation results verify the effectiveness of the proposed control method.
9:15-9:30	S0100	Voltage Sensitivity Matrix Based P-V Droop Control for Adaptive Voltage Regulation in Rural Distribution **Presenter: Yuanping Yang** *Southeast University* Abstract: With the promotion of photovoltaic poverty alleviation policy in China, voltage overruns in distribution network with high photovoltaic penetration is significant. Based on droop control method, this paper designs an adaptive method for voltage regulation using distributed battery energy storage. The droop coefficients are designed using the system voltage sensitivity matrix. A closed-loop model of the system droop control is established, consequently, a method for predicting the voltage recovered by droop control is also proposed to prevent voltage exceeding limit. A practical sample of a rural distribution network in Inner Mongolia is simulated in Matlab/Simulink to verify the proposed method.
9:30-9:45	S0086	Analysis of Delay Effect on LCL Filter-Based Inverter with Capacitor Current Feedback Active Damping **Presenter: Jiang xin** *Xi'an Jiaotong University* Abstract: This paper studies the delay effect on the capacitor current feedback active damping for the grid connected LCL filter-based inverter. It turns on that the delay may lead to right half plane poles(RHP)of the system open loop transfer function. This paper proposes a novel method based on mapping theory to judge the appearance of the RHP. It's found that the RHP is related with the capacitor current feedback coefficient and the resonant frequency of the LCL filter, reducing delay can improve the threshold of RHP. Finally, simulations are designed and the results verify the theoretical analysis.
9:45-10:00	S0037	Interval Probability Estimation of Wind Farm Cluster Ramp Events Based on Credal Network **Presenter: Xinyi Wang** *Shandong University* Abstract: High concentration large-scale wind power grid makes the impact of wind power ramp events on the power grid more impossible to ignore. Compared with single station prediction, cluster prediction can reflect the impact of power mutation on the power system more intuitively, and the prediction results are more conducive to the decision-making of dispatchers. Therefore, this paper proposed an imprecise probabilistic prediction method for wind power clusters. Data dimensionality reduction was carried out through correlation analysis and principal component analysis(PCA)to avoid

		problems such as excessive data dimension caused by too many input variables and the influence of calculation speed. The credal network(CN)was established to express the dependent relationship between wind power cluster ramp events and evidence variables, and the conditional dependent relationship was statistically quantified by using the imprecise Dirichlet model(IDM). Finally, combined with meteorological information, the ramp events were classified and inferred in the form of probability intervals, and the prediction performance was evaluated by using evaluation indexes. In this paper, the validity of the method was verified by using the data of a wind power cluster in Xinjiang.
Coffee Break		

Session 10: S4. Renewable Energy Integration>a. Renewable Energy Development and Integration
Session Chair: Dr. Long Wang, University of Science and Technology Beijing
Venue: Xiangqing Hall@2F 祥庆厅@2 楼
Time: 10:30-11:45

Time	Paper ID	Title & Author
10:30-10:45	S0087	Short-term Wind Generation Combined Forecast Considering Meteorological Similarity **Presenter: Yating Liu** *Shandong University* Abstract: High-precision short-term wind generation prediction results are conducive to making a scientific generation plan and improving the wind power absorption capacity of the power grids. Based on the analysis of the relationship between the numerical weather prediction and wind power, this paper proposes a short-term wind generation combined forecast model considering meteorological similarity to improve the prediction accuracy of short-term wind power. In this method, the meteorological similarity day model, the extreme gradient boosting algorithm and the back propagation neural network algorithm are selected for achieving the short-term wind power prediction. Then, the particle swarm optimization algorithm is applied to determine the weight of each single forecasting model. Finally, the prediction results are obtained through the combination of the single model prediction results. With the realistic wind power data collected from a wind farm in Xinjiang province, the short-term wind forecasting task is achieved by the proposed method. The simulation results illustrate that the combined model proposed in this paper can effectively improve the forecasting performance of the benchmark models.
10:45-11:00	S0095	Comprehensive Benefit Evaluation of Combined Operation of Wind Power and Electric Heating **Presenter: Meiqin Song**

		North China Electric Power University Abstract: For researching the feasibility of electric heating participation in electricity market operation, a comprehensive benefit evaluation index system is constructed in this paper. The key evaluation indexes are extracted by principal component analysis, assigned with entropy-order relationship method. Finally, the comprehensive benefits of electric heating before and after participation in the electricity market are evaluated by using TOPSIS method, and are put forward reasonable suggestions. The analysis results show that the comprehensive benefits are greater after the joint operation of wind power and electric heating, which is effective and feasible because it is conducive to peak shaving, valley filling, wind abandonment and environmental pollution reduction. Meanwhile, the proposed comprehensive benefit evaluation index system provides a theoretical basis for the analysis of the joint operation optimization model.
11:00-11:15	S0102	A Review on Impedance Modeling of Grid-Connected Renewable Energy Generation System **Presenter: Jinlong Wang** *Shandong University* Abstract: With the increasing proportion of renewable energy generation in the power grid, the stability issues induced by its grid connection becomes more and more important. The impedance-based approach has become an important method to analyze such issues because of its unique advantages. This paper gives a comprehensive review on impedance modeling of the grid-connected renewable energy generation system. Several commonly used impedance modeling methods are studied, including the dq-frame linearization and the harmonic linearization methods and their development. Then, the impedance modeling of the photovoltaic power generation system, direct-drive wind turbine, and doubly-fed wind turbine is introduced.
11:15-11:30	S0063	Trade-off Stochastic Game Based Bidding Strategy for Multiple Wind Farms **Presenter: Shiyuan He** *University of Jinan* Abstract: This paper addresses a stochastic energy bidding problem for multiple wind farms belonging to different entities. Considering competitive relationship among wind farms, a Cournot game based pricing function is introduced to describe dynamic market prices and the amount of energy bids from wind farms in day-ahead(DA)electricity market. Furthermore, the output power of wind power generations is modeled by stochastic scenarios and the Conditional Value-at-Risk(CVaR)method is applied to measure the cost of energy bids under uncertainty. Especially, a CVaR based risk term is added into the objective function to obtain trade-off bidding decisions between expected profits and financial risks. By the case study, the effectiveness and

		feasibility of the proposed Cournot stochastic game based bidding strategy are verified.
11:30-11:45	S0249	Simulation and Deduction Technology for The Result Of Spot Transactions for Cascade Hydropower Stations **Presenter: Shuai Zhang** *Sichuan University* Abstract: In order to adapt to the process of constantly deepening China's electricity market reform, this paper presents a simulation and deduction technology for the result of spot transactions for cascade hydropower stations. Combining with the market modes, transactions rules and scheduling, and production modes in Sichuan, China, the transaction results were simulated and deduced from four perspectives. Based on complex hydraulic and electric connections of cascade hydropower stations(CHSs), and multi-dimensional non-linear constraints, a simulation and deduction model for spot market transaction of CHSs was established and the block multi-sequential algorithm with specified outputs was designed for calculation. The results of spot transactions of eight CHSs in the Dadu River Basin in south-western China on a certain day were selected for verification of this method. The calculated results show that the method proposed in this paper can identify the bidding risk in a spot transaction. It provides an assistant decision support for the declaration of the bidding in spot transactions of CHSs and satisfies the mode of production of market-based production in the prevailing electricity market environment.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 11: S1. Power System Engineering>d. Power System Operation Session Chair: Dr. Lei Gan, Hohai University Venue: Xiangtai Hall@2F 祥泰厅@2 楼 Time: 08:45-10:15		
Time	**Paper ID**	**Title & Author**
8:45-9:00	S0096	Edge-cloud-coordinate Framework for Distribution Network Reconfiguration **Presenter: Liudong Chen** *North China Electric Power University* Abstract: Due to the emergence of prosumers, the energy trading changes from unidirectional to bidirectional, which complicates the power flow(PF)in the distribution system. In this paper, an edge-cloud coordinated reconfiguration framework is proposed to manage network structure when the PF changes. First, a minimum power losses model formulated as a nonlinear integer optimization problem is introduced. Moreover, the loop control is realized on the edge server(ES)based on load information. The loop information is transmitted from ES to cloud server(CS)and the operation requirement of distribution network(DN)is judged by CS. The branch-exchange algorithm is used to solve the complex and difficult NR problem. Finally, by using the collected data from realistic prosumers, the effectiveness of the model is verified in terms of the power losses of DN.
9:00-9:15	S0286	Application and Prospect of Behavioral Economics in The Field of Power System Economic Decision Based on Prospect Theory **Presenter: Lei Gan** *Hohai University* Abstract: Economic decision-making of electric power system plays a vital role in the planning, operation and transaction of the electric power system. While the achievement of behavioral economics tells us that all the decision making process with human involvement is not that simple. Limited to human's subjectivity on cognition and decision preference, the decision will become bounded rational. Sufficient knowledge on the behavior of power system economic decision can improve the accuracy and practicability of decision-making modeling, simulation and forecasting in power system, as well as improve the social elements in developing cyber-physical-social system of power system. Among different behavioral economic theories, prospect theory wins a wide range of research and application. Thus, prospect theory is first introduced here, and then the application of prospect theory is reviewed in the field of power system economic decisions. What follows is the analysis and discussion on key issues of the theory application and its possible further research prospects. Through literature review, it is found that economic decisions in power system based on behavioral economic theory are still pending problems noteworthy considering bounded rationality.
9:15-9:30	S0056	Orderly Charging Strategy for Electric Vehicles Based on Master-slave Game

		Presenter: Shutong Duan *Shandong University* Abstract: With the randomness of charging electric vehicles(EV), it's more challenging to formulate effective and reasonable electric vehicle scheduling strategies. Due to the price advantage of the power grid, a master-slave game model is developed, in which the grid is the game subject and the electric vehicle is the game subordinate. The particle swarm algorithm is used to obtain the optimal time-of-use electricity price strategy and grid dispatching strategy. Furthermore, the simulation experiment is designed with MATLAB. It is proved that the proposed model has an optimizing effect on the load curve and can reduce the peak-valley difference.
9:30-9:45	S0070	Multi-objective Optimization of Day-ahead and Intraday Rolling Scheduling Considering Unit Energy Coordination **Presenter: Han Zhang** *Xi'an Jiaotong University* Abstract: This paper proposes a multi-objective day-ahead and intra-day scheduling strategy that adapts to the power system with high proportion of new energy, which can better meet the requirements of the "open, fair and just "dispatching mode. The evaluation criteria of energy coordination from the time dimension and the space dimension are put forward firstly. By modeling the energy completion of each unit, this strategy not only coordinates the relationship between the execution of medium and long-term contracts and short-term power generation, but also considers the fairness of short-term power generation planning *arrangements*. Furthermore, chance constraints are utilized to deal with the variability and limited predictability of new energy sources. After solving the proposed model by the Goal Programming(GP)method, a scheduling plan can be obtained which comprehensively considers economy, new energy consumption, plan execution, and fairness. Finally, a numerical example based on a real-world provincial power system verifies the reasonableness of this method. The results show the superiority of the proposed models in the coordinate and balance control of unit energy completion.
9:45-10:00	S0186	Research on Multi-objective Optimization Strategy of Using Energy Considering Elastic Constraints of Air Conditioning Loads **Presenter: MinXi Pei** *Nanjing Normal University* Abstract: As one of the best candidates of flexible loads, Air Conditioning Loads(ACLs)can participate in the load shaving to support the active power balances through their thermodynamic characteristics. Existing optimization methods define the thermodynamic constraints of the ACLs as fixed constraint without considering the elasticity of ACLs users. This paper establishes a

		multi-objective elastic optimization model of ACLs. By introducing slack variables in the thermodynamic constraints, the original fixed constraints can be transformed into elastic constraints, so that the some comfort variables(including temperature variables and load scheduling times)can exceed the constraint limits in some extreme conditions to meet the objectives. Simulation results show the effectiveness of the proposed method.
10:00-10:15	S0090	The research of Transient Magnetic Field and Eddy Current Loss of Single Phase Three-Legged Transformer under AC/DC Condition **Presenter: Xia Dong** *Qilu University of Technology (Shandong Academy of Sciences)* Abstract: In order to analyze the local overheating of single phase three-legged transformer under AC/DC condition, the transient magnetic field and eddy current loss in the iron core of transformer are studied. This paper builds a coupling model of electric circuit and magnetic circuit considering nonlinearity of ferromagnetic materials and iron core topology. The distribution and variation of magnetic field and eddy current loss of single phase three-legged transformer are researched. The results show that the amplitudes of magnetic field and eddy current loss in the central leg are greater than those in two side legs without DC, and they grow nonlinearly as DC enlarges. The magnetic field amplitudes in the central leg grow faster than those in two side legs, while the eddy current loss amplitudes in two side legs grow faster than those in the central leg.
Coffee Break		

Session 12: S1. Power System Engineering>d. Power System Operation Session Chair: Dr. Lei Gan, Hohai University Venue: Xiangtai Hall@2F 祥泰厅@2 楼 Time: 10:30-12:00		
Time	**Paper ID**	**Title & Author**
10:30-10:45	S0264	Influence Factors of Converter Transformer Temperature Field with Finite Element Method **Presenter: Hongbin Wu** *Shandong University* Abstract: In order to study the temperature field distribution and its influencing factors of converter transformer, and explore the influence of oil flow velocity and internal structure on the temperature rise of converter transformer, this paper builds a simplified two-dimensional model of converter transformer based on finite element method. Besides, this paper simulates the multi fields coupling distributions of magnetic field, fluid field and temperature field and discusses the relationship between fluid field and temperature field. At the same time, the relationship between different axial oil passage width and winding temperature rise is also studied. The influence mechanism of different factors on the temperature field of converter transformer was analyzed. The research results have made great significance to improve the heat dissipation structure of converter transformer and solve the overheating of winding temperature rise.
10:45-11:00	S0185	Frequency Regulation Provided by ON/OFF Flexible Loads with Combined Fast-and-Slow Recovery Process **Presenter: Zili Yao** *Nanjing Normal University* Abstract: Demand response has been considered as an important way for the frequency control of the power systems by adjusting the power consumption of flexible loads. However, the ON/OFF flexible loads cannot rapidly respond to power fluctuations due to the lock out time limits. This paper proposes a frequency control method for ON/OFF flexible loads that combined the regulation and recovery process together. By defining a combined fast-and-slow recovery process, the activated ON/OFF flexible loads can still provide active power regulation in their fast recovery process. The testing examples verify the effectiveness of the proposed method.
11:00-11:15	S0092	The Simulation of Power Grid Cooperative Operation in Market Environment **Presenter: Jiangyang Yun** *Shandong University* Abstract: A new reform for electric power organizational structure has been promoted comprehensively in China, and each pilot area combined with their own characteristics to formulate the relevant operation rules and design

		electric power spot market technical support system. In this paper, a simulation system for the electricity spot market is developed based on multiple programming languages, such as Java, Python. And hierarchical framework design for the simulation system is proposed. Meanwhile, the system modules are decoupled and can be adjusted quickly under different operating environments. The simulation process and results of this system are presented on Web. The medium and long-term trading simulation experiments were carried out through this system, and the results show that this system can restore the actual situation of market trading to a certain extent.
11:15-11:30	S0194	Multi-objective Optimal Dispatching of the Integrated Energy System in the Industrial Park **Presenter: Keyi Xu** *North China Electric Power University* Abstract: The integrated energy system(IES)has great application prospect in future energy system. Due to the high coupling of energy flow in the system, the dispatch operation needs to consider the unified dispatch of multiple energy sources. At present, the operation scheduling research of the integrated energy system mostly focuses on the single-objective optimization problem with the best economic cost, and the environmental protection and efficiency of the system are less considered. A multi-objective optimization scheduling model is proposed in this paper, taking the lowest operating cost, the lowest pollutant emissions, and the highest comprehensive energy utilization rate as objective functions. The Normal Boundary Intersection(NBI)method is adopted to solve this model and the partial small fuzzy set decision is used to get the best solution. Finally, the proposed model is verified on an IES of an industrial park in central China. The case study demonstrates that the proposed optimization scheduling model can generally make the system operation more environmentally friendly and efficient.
11:30-11:45	S0196	Application of Kalman-filtering with Disturbance Estimation in Power System Frequency Control **Presenter: Qianqian Qian** *Nanjing Normal University* Abstract: Recently, Demand Response(DR)is receiving more and more attention in combination with traditional control methods to support the frequency control. However, the presence of noise affects frequency detection for DR resources, affecting the performance of frequency control. To solve this problem, the Kalman-filtering with disturbance estimation is applied to the system frequency control. By estimating the disturbance through rate of change of frequency(RoCoF), the Kalman-filtering can better model the dynamics of system frequency response model, and therefore improve the frequency control performance. Testing results verify the effectiveness of the

		method proposed in this paper.
11:45-12:00	S0232	Two-Stage Variable-Time-Scale Rolling Scheduling Model with Energy Storage **Presenter: Weizhuo Qiao** *Nanjing Normal University* Abstract: To address the fluctuation caused by renewable energies, the rolling scheduling is usually adopted, in which the day-ahead scheduling results is updated with the intra-day scheduling results according to near-term forecasting results of the load and renewable energies. However, this kind of scheduling result in problem in coping with energy storage resources, called "nearsightedness" which is caused by only taking the present scheduling period into account but ignoring benefits of the whole cycle. Focusing on the nearsightedness, this paper proposed a two-stage variable-time-scale rolling scheduling model with energy storage. By combining different energy storage resources and adjusting the length of scheduling period, not only the accuracy, but also the calculation efficiency of the scheduling can be improved. And through the test of the PJM-5 system, it is verified that the proposed method can effectively avoid the nearsightedness and therefore result in better scheduling performance.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 13: S4. Renewable Energy Integration>a. Renewable Energy Development and Integration Session Chair: Dr. Lin Zhu, Tianjin University Venue: Yuchun Hall Room I@2F 玉春堂 1 号厅@2 楼 Time: 13:30-15:45		
Time	**Paper ID**	**Title & Author**
13:30-13:45	S0147	Using Mobile Hydrogen Trucks to Transport Energy to Microgrids **Presenter: Bei Li** *Shenzhen University* Abstract: Nowadays, large amounts of renewable energy have been installed around the world, while the abundant renewable energy are often located in remote areas, and are transmitted to consumer centre through transmission networks. However, the power transmission will be commonly interrupted when the power transmission networks are destroyed under different disasters. Thus, how to transmit energy from renewable energy based power station(REPS)to microgrid becomes an essential problem. In this paper, we firstly transfer the renewable energy into hydrogen trough hydrogen storage system; then, transport the hydrogen to microgrid through transportation network. The mobile hydrogen truck can delivery hydrogen between REPS and microgrids multiple times. By the proposed framework, a multi-energy supply microgrid optimization model is built firstly; then, a real transportation network is adopted to delivery hydrogen; third, calculate the truck travelling time at each time; last, microgrid runs the operation strategy based on the arrived hydrogen. The simulation results demonstrate that using mobile truck can efficiently transport renewable energy to microgrids and improve the energy utilization.
13:45-14:00	S0258	Collaborative Planning of Integrated Energy System Considering P2H Technology **Presenter: Xueqian He** *Shandong University* Abstract: Due to the rapid development of the renewable energy, the installed capacity of wind and solar power increases quickly. However, the high penetration of the renewable energy also causes several problems, for example, the curtailment of wind power. Power to hydrogen(P2H)is a rapidly developing technology that uses electrical power to produce hydrogen. It is a possible solution to mitigate the curtailment issue by converting extra wind power to the hydrogen, playing the role of filling the load valley. This paper designs an integrated energy system optimization model considering P2H technology. Case studies on an integrated energy system demonstrate the effectiveness of the proposed methodology.
14:00-14:15	S0280	Impacts of AC Cable to the Risks of Multi-frequency Oscillations of Cable-Connected VSC

		Presenter: Zuanhong Yan *Southern Electric Power Research Institute, CSG* Abstract: Multi-frequency oscillation is a new type of oscillation issue in the power system caused by control interactions of renewable converters and power electronic devices. This paper investigates the impacts of cable parameters to multi-frequency oscillations of voltage source converter(VSC)connected through AC cable. The analysis is based on small-signal sequence impedance models. Due to cable capacitance, the frequency of impedance resonance of cable is much lower than that of transmission line, which raises the risks of oscillation. Also it is found that cable of lower rated voltage has higher risks of multi-frequency oscillations. The theoretical study is demonstrated by time-domain simulations based on PSCAD.
14:15-14:30	S0283	Role of Biomass toward 100%-Renewable Regional Energy System **Presenter: Pengya Wang** *North China Electric Power University* Abstract: Recent years have witnessed an increasing proliferation of biomass technologies since it is recognized as a natural carbon-neutral fuel. While the existing literature has focused on the modeling and planning for biomass, it remains a public interest regarding the role and merit of biomass technologies in future smart grid paradigm. Therefore, we propose an optimal planning framework to determine the sizing of biomass-to-gas(biogas)toward 100%-renewable regional energy system. The proposed planning model aims to minimize the annualized investment and operation costs of various forms of distributed energy resources(DERs)with respect to their physical constraints and a self-sufficiency requirement. In this paper, the production performance of biogas is captured by a detailed model considering the characteristics of anaerobic digestion under different temperature conditions. Due to its essential nonlinearity, a piecewise linearization(PWL)method is adopted to reformulate the nonlinear model into a mixed-integer linear programming(MILP), which can be readily optimized by off-the-shelf solvers. Case studies based on realistic datasets demonstrate that the planning strategy can be effectively improved by taking advantage of biogas toward fully renewable-powered distribution grids. In contrast to the case W/O biogas, about 27%of the total costs can be reduced when incorporating biogas.
14:30-14:45	S0295	Fast Frequency Support of a DFIG Based on Over-speed De-loaded Curve **Presenter: Dejian Yang** *Northeast Electric Power University* Abstract: This paper addresses a fast frequency support scheme of a doubly-fed induction generator(DFIG)based on over-speed de-loaded curve

		that is able to boost the frequency nadir and settling frequency, and reduce the maximum rate of change of frequency(ROCOF)with more efficiency. To address this, a novel power function is employed that increases the power to the torque limit and then decreases with the rotor speed toward to the maximum power point tracking operating conditions. Simulation results on various wind power penetrations clearly indicate that the proposed fast frequency support scheme is benefit to boost the frequency nadir and settling frequency, and reduce the ROCOF.
14:45-15:00	S0298	Exploring the Pathways toward a Carbon-Neutral Sichuan Power Sector in 2060 **Presenter: Shihua Luo** *University of electronic science and technology of China* Abstract: China has proposed the ambitious 2060 carbon-neutral goal to alleviate environmental deterioration. The deep decarbonization in the power sector is always the focus of attention, however, there are scientific gaps on how this change can be realized, especially in the context of China. The main objective of this paper is to explore the carbon-neutral transition pathways in Sichuan power sector and determine the capacity requirement of storage measures under different pathways. The EnergyPLAN tool is used to simulate the current and future Sichuan power sector in 2060, including four renewable scenarios. It is found that, all the renewable scenarios can achieve the goal of carbon-neutral in 2060 and their system costs are similar to the reference scenario. Their performance in biomass consumption and electricity exportation differs by scenario. With the introduction of the pumped storage power station, the largest storage capacity of 1229 GWh appears in the high renewable penetration scenario, with a system cost growth of 9. 3%. In brief, the methodological steps and results proposed in this paper can be helpful to realize the future decarbonization in the power sector in China.
15:00-15:15	S0279	A Hybrid Ensemble Learning Model for Short-Term Solar Irradiance Forecasting Using Historical Observations and Sky Images **Presenter: Long Wang** *University of Science and Technology Beijing* Abstract: A hybrid multi-modal ensemble learning model is proposed for short-term solar irradiance forecasting based on historical observations and sky images in this paper. In the proposed model, the historical time series of solar irradiance is utilized to extract temporal characteristics. Meanwhile, the sky camera images are used as an exogenous input to offer the cloud cover information. A powerful ensemble learning model, Extreme Gradient Boosting(XGBoost), is employed to capture the function relationships between input features and future observations. Since the mean squared error loss is sensitive to the extreme large or small historical irradiance, a novel loss function is proposed to improve the robustness of XGBoost. In order to find

		out the best controlling parameters, Rao-1 algorithm is employed due to its fast search capability. To validate the performance of the proposed method, a solar irradiance dataset containing three-year historical observations and ground-based sky camera images collected from the Folsom is employed. Meanwhile, four commonly applied methods, Lasso, Ridge regression, support vector regression and boosted regression trees, are considered as benchmarking methods. The forecasting horizons from 5 to 30 min are considered for all compared methods while two metrics, mean absolute error and root mean squared error, are computed. Experimental results prove that the proposed hybrid model has better forecasting performance compared with benchmarking methods over all forecasting horizons.
15:15-15:30	S0319	Centralized Dispatch Method of Heat and Electricity Integrated System Based on Network Simplification of Large-Scale Heating Networks **Presenter: Ziteng Xiang** *China Three Gorges University* Abstract: Integrated heat and electricity dispatch (IHED) is crucial to maintaining the safe operation of integrated energy systems and promoting new energy consumption. To deal with the solving problem of the IHED model under large-scale heating networks, a central dispatch method based on network simplification of large-scale heating networks is proposed in this paper. Firstly, a network simplification method(NSM)of the heating network is developed to simplify the heating network model, and the degree of simplification can be adjusted. Secondly, a practical scheduling framework and a dispatch model based on simplified heating network models are proposed for centralized dispatch. Case studies verify the accuracy and effectiveness of the proposed method for IHED.
15:30-15:45	S0154	Unequal Power Sharing Strategy in a Microgrid with Different Inverters for Capacity Reduction **Presenter: Wenyang Deng** *South China University of Technology* Abstract: For the microgrid system(MG), reactive power compensation is essential. Based on the different coupling structure, DG-based inverters can be divided as L-series inverter(LI)and C-series inverter(CI). Publications indicate the capacity of reactive power compensation of conventional LI is much smaller than CI, and the DC voltage of the CI is also lower than LI. Therefore, to enhance the reactive power capacity and increase the efficiency of the whole MG system, a hybrid MG structure, which combining LI and CI-based DG units, is proposed in the work. Additional, since the requirement of the DC voltage is lower of the CI, inverters in the MG may cannot share the same capacities, traditional equal power sharing is not proper. An unequally power sharing method is studied to achieve capacity reduction in this paper. Results of case

		study, simulation, and experiment tests proved the validity.
Coffee Break		

Session 14: S4. Renewable Energy Integration>a. Renewable Energy Development and Integration Session Chair: Dr. Dejian Yang, Nantong University Venue: Yuchun Hall Room I@2F 玉春堂 1 号厅@2 楼 Time: 16:15-18:00		
Time	**Paper ID**	**Title & Author**
16:15-16:30	S0151	Taylor Expansion Linearizing Control of MVDC Power System Feeding Constant Power Loads **Presenter: Xueshen Zhao** *Tianjin University* Abstract: Voltage stability in medium-voltage DC(MVDC)power systems is a key design goal. Based on Norton's Theorem and Thevenin's Theorem, the equivalent circuit model of MVDC power system is established. Furthermore, the supercritical reduced-order circuit model is established by ignoring the line parameters, and it is found that the negative impedance characteristic of CPL is the main reason for the oscillation instability of MVDC power system. Therefore, a state feedback control algorithm based on Taylor expansion for generation-side converters is proposed in this paper, which compensate for the negative incremental resistance of CPL in MVDC power systems. Obviously, the control strategy could be conveniently implemented in decentralized controller, which is the most simple and desirable control structure in MVDC power system. Numerous simulation results verify the rationality of the supercritical reduced-order model and the effectiveness of the proposed control algorithm.
16:30-16:45	S0125	Research on Initialization of EMT Simulation for Photovoltaic Grid-connected System **Presenter: Zhihong Liu** *Tsinghua University* Abstract: In this paper, an improved steady-state initialization method is proposed for electromagnetic transient analysis of photovoltaic grid-connected system, which enables an EMT simulation to start from steady-state directly. The improved method is based on power flow solution, and it determines the steady state operating characteristics of the system network from the given line and bus data. Then, based on the power flow, the ac system and the filter steady state are obtained by replacing converter bridge with a three-phase voltage. Furthermore, in consideration of the control system steady state, the PI controller initial values are set as the steady state values. EMT simulation for the photovoltaic grid-connected

		power generation system with 6-bus is performed on CloudPSS platform. Comparing with the traditional zero-state initialization method, the proposed method has faster response and smoother transient with necessary accuracy.
16:45-17:00	S0153	Oscillation Coupling Analysis of MVDC Distribution System Based on Impedance Measurement **Presenter: Lin Zhu** *Tianjin University* Abstract: Medium voltage direct current(MVDC)distribution system is an important development direction of modern distributed power network since it can connect new energy of different properties to the power grid through power electronic devices. This paper studies the possible oscillations in the MVDC distribution system, including the switch ripple and the uncertain oscillations introduced by cable. Firstly, the model of MVDC distribution system is constructed. Then, we introduce the principle of transfer function and impedance measurement, and gives some simulation results. Finally, based on the extra element theory, the impedance of the system is analyzed, and the possible oscillation caused by the longitudinal parameters in the system is further discussed.
17:00-17:15	S0155	Credible Reactive Power Regulation Capacity Assessment of DFIG Wind Farms **Presenter: Yaoxiang Wang** *North China Electric Power University* Abstract: Doubly-fed induction generator(DFIG)wind turbines can provide reactive power to participate in grid reactive power control, however the reactive power regulation capability provided by DFIG is uncertain due to the uncertainty of the active power output and terminal voltage of the generator. In this paper, we investigate the credible reactive power regulation capability of the wind farm considering the limit of all the reactive power compensation devices, also the uncertainty of the active power output from the wind turbines and the limit of the power flow is also considered to obtain a reliable reactive power regulation capability from the wind farm. First, the reactive power limit of the DFIG wind turbines is derived considering the limit of the power converter capacity and parameters of the wind turbine. Then the constraints considered to evaluate the credible reactive power regulation capability are investigated, and the method to evaluate the reactive power regulation capability of the wind farm is proposed. Finally, simulation study is presented with a power system model connected with a DFIG wind farm. The result shows a stricter reactive power regulation capability can be obtained considering all the constraints compare with the simple superposition method, which is more reliable and it can be used for further investigate on the reactive power control strategy.
17:15-17:30	S0182	Optimal Offering and Operating Strategy of CSP Plants under Different Support Mechanisms

		Presenter: Zhoubei Sun *Sichuan University* Abstract: The current support mechanism for CSP plants in China does not take into account the impact of offering and operating strategies on the economic value of CSP plants, which plays a crucial role for the viability of the CSP plant investment. This paper proposed a bi-level stochastic programming model investigating the market behavior and economic benefits of CSP plants under typical renewable energy support mechanisms. Firstly, four typical support mechanisms were introduced, and a cost-benefit model for the life-cycle of CSP plants was constructed. Secondly, a coordinated optimization of the operation and bidding model for CSP plants was established to study the market behavior of CSP plants under different mechanisms. Finally, the impact of key mechanism parameters on the economic benefit of CSP plants was quantitatively analyzed. The results have a certain reference value for the promotion of CSP support mechanisms.
17:30-17:45	S0222	Two-variable Admittance Modeling of DFIG Considering All Wind Speed Conditions **Presenter: Chengmao Du** *Chongqing University* Abstract: The stable operation capability of the doubly-fed induction generation(DFIG)based wind power grid-connected system will vary with the wind speed, yet the existing mathematical models of DFIG is limited to some specific wind speed points, which may not be directly applied to stability analysis in the all wind speed operating conditions. The wind speed is used to characterize the steady state operating point in this paper, while considering the single-input dual-output(SIDO)characteristics of DFIG, a two-variable admittance model are proposed. Further, the two-variable admittance model are used to analyze the stability of DFIG based grid-connected system. The simulation results indicate that the established admittance model can precisely reflect the frequency characteristics in the entire wind speed operating space, which provides basis for accurate analysis and effective improvement of the stability for new energy power generation equipment.
17:45-18:00	S0238	Wind Power Prediction Based on Kalman Filter and Non-parametric Kernel Density Estimation **Presenter: Daoqing Li** *Qilu University of Technology (Shandong Academy of Sciences)* Abstract: Wind power point prediction can only give the exact predicted power value at a certain time point, and the fluctuation range of the predicted value cannot be obtained, which brings a lot of problems and troubles to wind power grid connection. In this paper, a short-term wind power interval prediction method based on Kalman filter and non-parametric kernel density

		estimation is proposed. First, the predicted value of wind power points is obtained by Kalman filter method; Second, the prediction error is statistically analyzed, and the probability density function of the error is obtained by kernel density estimation method; Finally, the fluctuation interval of wind power is predicted under the given confidence degree. Simulation analysis on the data of a wind farm in Oklahoma show at the proposed interval prediction method not only has higher accuracy but also has better general applicability.
Banquet		***Xiangyun Hall 祥云厅/1st Floor 1 楼***

Session 15: S1. Power System Engineering>e. Power System Control
Session Chair: Dr. Xiaotian Tang, University of Electronic Science and Technology of China
Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼
Time: 14:00-15:45

Time	Paper ID	Title & Author
14:00-14:15	S0008	Research on Suppressing Continuous Commutation Failure of HVDC System Based on Virtual Capacitor **Presenter: Fengyuan Chen** *Guangxi University* Abstract: In order to solve the problem that continuous commutation failure has a serious impact on the operation of HVDC system, the mechanism of commutation failure is analyzed, and the concept of virtual capacitor is introduced. The virtual capacitor is used as the carrier of DC voltage change rate, and combined with VDCOL, the continuous commutation failure of HVDC transmission is suppressed. The method of introducing virtual capacitor can reflect the dynamic characteristics of DC voltage during fault and recovery process.
14:15-14:30	S0064	The Design of Cyber-physical Simulation Platform for Steam Turbine **Presenter: Yu Shen** *Nanjing University of Science and Technology* Abstract: Steam turbine is the key part of power plant, which is related to the secure and stable operation of generator. With the development of information and communication technology, the steam turbine of power plant has been developed into cyber-physical system(CPS). Existing simulation platforms of steam turbine focus on physical system, which are usually based on single software platform. Since existing simulation platforms simplify communication part of digital electro-hydraulic(DEH)control system, they cannot simulate the scenarios with communication. Therefore, a cyber-physical platform of steam turbine is proposed in this paper, which takes the communication part of DEH control system into account. The physical part of steam turbine is established in Matlab/Simulink, the DEH control system of steam turbine is operated in Beckhoff embedded controller,

		and cyber part of steam turbine is built by the communication between Matlab and embedded controller with TCP/IP and ADS protocol. Finally, the cyber-physical platform of steam turbine is tested under start-up and grid-connected operation conditions to verify its effectiveness and real-time capability. The platform is envisioned as a tool to help steam turbine researchers with the study of relevant problems such as verifying performance of speed control schemes and carrying out cyber security tests of steam turbine.
14:30-14:45	S0120	Power Smoothing Control of Energy Storage System for DC Systems Connected to Weak Grids **Presenter: Pengfei Li** *Tianjin University* Abstract: Grid-connected dc systems with high penetration of renewable power generations(RPGs)are prone to dc voltage impact and stability issues, especially when connected to a weak ac grid. In order to address these problems, a novel cascaded power and dc voltage control loops based power smoothing control for energy storage system(ESS)has been proposed in this paper. With this method, transient power fluctuations can be compensated, then transmission power of the grid-connected converter(GCC)from dc system to ac grid and dc voltage can be both smoothed. After transient power supporting, the output of ESS can be recovered according to the pre-scheduled power instruction. Moreover, a detailed small signal model of a dc system based on state-space equations has been derived for dynamic and stability analysis. Finally, the effectiveness of the proposed control method is verified by PSCAD/EMPTC based simulation results in a weak-grid-connected dc system with GCC, ESS and constant power load(CPL, to simulate RPG or real loads).
14:45-15:00	S0123	Energy Balancing between HBSMs and FBSMs of Hybrid MMC During Fault Blocking **Presenter: Yongfei Xing** *Huazhong University of Science and Technology* Abstract: Hybrid modular multilevel converter composed of full-bridge submodules(FBSMs)and half-bridge submodules(HBSMs)has the ability to block the dc fault current. For hybrid MMC, both FBSMs and HBSMs will discharge to the dc side when the dc fault occurs. However, after the converter is blocked, only FBSMs absorbs the fault energy from the dc side and the arm inductors. Thus, the FBSM capacitor voltage may get too high, and the voltage difference between the FBSMs and the HBSMs will be large, making restart of the converter difficult. Balancing the energy between the HBSMs and the FBSMs can solve the two problems. The circulating current caused by line voltage could be used to balance the fault energy by adjusting the specific FBSMs state dynamically. In this paper, a control method is proposed with a

		dual-loop control strategy, which can reduce the voltage difference between HBSMs and FBSMs in the same arm to around 1. 52%of their normal voltage. In the meantime, the overvoltage of the FBSMs is reduced to 35. 8%from 58. 2%. Thus, the overvoltage can be relieved and the restart can be accelerated.
15:00-15:15	S0277	Mitigation of Oscillations in Grid Converters Enabled Microgrids Based on Proportional Resonance and Model Predictive Control **Presenter: Qi Geng** *China Electric Power Research Institute* Abstract: Mitigation of oscillations in grid converters enabled microgrids based on proportional resonance and model predictive control" on Page 63 is completely wrong. I think the abstract of other paper was written here by mistake. The right version is " This paper proposes a robust control scheme for three phase LCL-filtered gird converters enabled microgrids to mitigate high frequency and subsynchronous or supersynchronous oscillations. Three phase LCL-filtered grid converter is partitioned into two components, i.e., LC filter component and grid side inductor component. The interconnection voltage of LC filter is regulated by model predictive control (MPC) with disturbance observer. The grid side current is regulated by proportional resonance (PR) control. The merits of MPC and PR can be combined. MPC can inherently realize active damping without additional control and reduce modulation delay, which improves the dynamic performance. PR control not only makes the steady state error zero, but also reduces the complexity of control compared with the overall grid converter is controlled by MPC. By analyzing the frequency response of transfer function and output impedance, the phase margin of the proposed control is sufficient, and the output impedance of grid converters is always resistive or inductive at the whole frequency when system and control parameters vary, which suppress the subsynchronous and high frequency oscillations. The comparative analysis of simulation results validates the effectiveness and robustness of the proposed control in current tracking, harmonic suppression and response to grid impedance varies..
15:15-15:30	S1009	Surrogate Model-Based Multi-Timescale Stochastic Control of Islanded Cascaded Hydro-Solar System Considering Non-Gaussian Uncertainty **Presenter: Zhipeng Yu** *Tsinghua University* Abstract: In many mountain areas in Southwest China, cascaded run-of-the-river hydropower plants and photovoltaic plants with local loads are connected by ac network comprise fully renewable microgrids. These microgrids are connected to the external large power systems via long-distance transmission lines in normal operation mode. However, when the transmission line's planned or emergency outage occurs, the microgrids are forced to operate in islanded mode. Considering the spatial-temporal

		coupling and limited energy storage of the cascaded hydropower plants and the non-Gaussian uncertainty of solar power generation, the frequency control and intra-day energy management, i. e. , power-sharing between the cascaded plants, can be challenging. In this paper, a multi-timescale control method is proposed to coordinate the secondary frequency control and intra-day energy management. Low-dimensional polynomial models of the expectation and variance of the response of the secondary frequency control over the short timescale are obtained first. Incorporating this model and a dynamic river model, the long timescale energy management problem is formed as chance-constrained programming. The expectational cost function defined over the multiple timescales is minimized by solving this model in a receding-horizon manner. The proposed method is verified by simulations of a real-life hydro-solar system in Sichuan Province, China.
15:45-16:00	S0289	Hybrid-Electric Aircraft Propulsion Drive Based on SiC Triple Active Bridge Converter **Presenter: JiangBiao He** *University of Kentucky* Abstract: Constrained by the low energy density of Lithium-ion batteries with all-electric aircraft propulsion, hybrid-electric aircraft propulsion drive becomes one of the most promising technologies in aviation electrification, especially for wide-body airplanes. In this paper, a three-port triple active bridge(TAB)dc-dc converter is developed to manage the power flow between the turbo generator, battery, and the propulsion motor. The TAB converter is configured based on Silicon Carbide(SiC)MOSFET modules operating at high switching frequency, so the size of the phase shifting magnetic transformer can be significantly reduced. Different operation modes of this hybrid-electric propulsion drive based on the SiC TAB converter are modeled and simulated including the takeoff mode, cruising mode, and the descendent mode.
Coffee Break		

Session 16: S1. Power System Engineering>a. Power System Planning Session Chair: Dr. Xiaotian Tang, University of Electronic Science and Technology of China Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼 Time: 16:15-17:30		
Time	**Paper ID**	**Title & Author**
16:15-16:30	S0043	Development of the Comprehensive Evaluation Theory of the Regional Internet of Energy **Presenter: Kai Yuan** *State Grid Economic and Technological Research Institute Co. Ltd.* Abstract: The Regional Internet of Energy(RIoE)is one of the important means to achieve China's "carbon peak and carbon neutral" strategic goals. It has the characteristics of complex energy structure, multi-energy interaction, and space&time uncertainty. Meanwhile, with the gradual applying of the RIoE related technologies and the continuous development of demonstration projects in recent years, comprehensive evaluation is becoming more and more important as a feedback link. The comprehensive evaluation theory covers two aspects including the index system and the evaluation method. Only through the support of a comprehensive and scientific index system, combined with an efficient evaluation method, can achieve objective assessment of RIoE technology and projects and then give appropriate suggestions. This paper combs the research status of comprehensive evaluation technology of the RIoE. According to the evaluation process, this paper firstly reviews the status of the index system including technical, economic and social indicators. Then, this paper summarizes and analyses the existing RIoE evaluation methods. Finally, considering the development appeal of China's RIoE, this paper proposes the prospects of future research direction of the comprehensive evaluation technology.
16:30-16:45	S0209	Planning and Evaluation of Electric Vehicle Charging Stations Considering the Service Range **Presenter: Donglin Liu** *Shanghai University of Electric Power* Abstract: The unreasonable of electric vehicle charging station(EVCS)planning scheme will reduce the utilization rate of EVCS and affect users satisfaction. This paper proposes an EVCS planning and evaluation method considering the service range. Firstly, taking the service range of EVCS, the power in the planning area and the charging power of EVCS as constraints, an EVCS planning model with the objective of minimizing the total annual cost of EVCS is established, and the particle swarm optimization is used to solve the model. Then, the evaluation indexes of facility utilization, distribution capacity and effective service rate of EVCS planning scheme are proposed. Finally, an example is simulated by MATLAB to analyze the evaluation indexes of the selected scheme, and the results verify the effectiveness of the model and

		evaluation indexes.
16:45-17:00	S0045	The Planning Evaluation Method of the Regional Energy Internet Based on the AHP **Presenter: Kai Yuan** *State Grid Economic and Technological Research Institute Co. Ltd.* Abstract: At present, a large number of researches on key technologies of regional energy internet planning and design have been carried out at home and abroad, and some results have been achieved, but there has not been a scientific, comprehensive and objective measure for the applicability and implementation effects of the proposed new technologies or planning schemes. To this end, this paper proposes a comprehensive evaluation method for regional energy internet planning and design based on the analytic hierarchy process, establishes a regional energy internet planning and design evaluation index system involving basic conditions, technical effectiveness, economic benefits and social benefits, and proposes coverage more than 70 evaluation indicators and their quantitative methods including key indicators such as equipment level, energy supply reliability, energy interactivity, energy supply quality, comprehensive energy utilization efficiency, information network connectivity robustness, information reliability, and investment income.
17:00-17:15	S0213	Integrated Energy System Planning for Battery Manufacturing Enterprises Considering Virtual Energy Storage of Production Process **Presenter: Xueying Cheng** *Tianjin University* Abstract: In view of the fact that the current integrated energy system planning method does not take into account the virtual energy storage characteristics that may occur in the production process, this paper proposes an integrated energy system planning method for battery manufacturing enterprises considering the virtual energy storage of production process. Firstly, taking the battery factory as an example, the production process of the typical battery factory is analyzed and the integrated energy system planning framework of the industrial park is put forward. Moreover, the integrated energy system planning model of battery manufacturing enterprise park is built, and the corresponding planning process and method are put forward. Finally, through a practical case study, the economic and technical benefits of the proposed planning method are verified. The method of the equipment planning and configuration proposed in this paper fully considers the virtual energy storage characteristics in the production process of typical process industries. It can brings economic benefits for the energy management and the planning of related industries.
17:15-17:30	S0275	Wind Power Interval Forecasting under Irregular Distribution **Presenter: Adil Hussain**

		Qilu University of Technology (Shandong Academy of Sciences) Abstract: In this article, a wind power interval forecasting method based on Parzen window estimation and interval optimization is proposed. First, the Parzen window estimation method is used to find the wind power forecast error distribution of arbitrary shape due to its property of good fitting and more compatibility with actual data. Second, the optimization method is used to find the shortest confidence interval under the irregular distribution. Finally, the wind power interval forecast result is obtained based on the precise and minimum interval width. Simulation results show that comparing with traditional method, the proposed method can obtain the minimum forecast interval under every confidence degree. The proposed approach is not only more precise but also more practical.
Banquet		***Xiangyun Hall 祥云厅/1st Floor 1 楼***

Session 17: S6. Special Session>c. Low-carbon Oriented Advanced Techniques for Power Systems Planning
Session Chair: Dr. Heng Zhang, Shanghai Jiao Tong University
Dr. Shenxi Zhang, Shanghai Jiao Tong University
Dr. Yue Xiang, Sichuan University
Venue: Xiangqing Hall@2F 祥庆厅@2 楼
Time: 14:00-15:45

Time	Paper ID	Title & Author
14:00-14:15	S0073	Research and Design of Interactive Intelligent Stations Based on Crowd Sensing **Presenter: Shuai Hu** Power Supply Bur*eau of Guangdong Power Grid Corp* Abstract: Aiming at the problems of incomplete data collection, low degree of informatization and intelligence, and lack of interaction between users and power grid in China's stations, combined with the impact of the wide access of distributed renewable energy, energy storage system and electric vehicles in the future stations on the power grid, and to meet the needs of power market reform in the future distribution grid, an interactive intelligent power system based on crowd sensing technology is studied and designed. Firstly, based on the idea of interconnection of all things, the intelligent stations'power Internet of things is constructed to realize the load sensing and data monitoring, and open up the information interaction channel. Based on the monitoring data, the economic operation and smart power supply of the stations are intelligently realized, and the self -balance and self-optimization of primary energy in the stations under multi control methods are studied. Finally, the multi energy complementary mechanism in the future is discussed. This paper analyzes and prospects the

		establishment of the stations, and strives to build the stations into a real agent, so as to provide a feasible reference for the construction and development of the intelligent stations in the future.
14:15-14:30	S0127	Data-driven Load Pattern Identification **Presenter: Mengqiu Fang** *Sichuan University* Abstract: Massive information on residential consumption provides data support for the mining and analysis of load patterns. This paper presents a complete framework including clustering module and classification module for load pattern identification. Firstly, an innovative mixture model based on R-vine copula(RVMM)is proposed for clustering load profiling data and obtaining typical load patterns. Then, random forest constructed with certain load characteristic indexes and RVMM clustering result is employed as a supervised classification model to predict the category of new customers. It is demonstrated that the proposed RVMM algorithm exhibits better performance in the clustering validity evaluation and a higher accuracy is achieved by random forest classifier.
14:30-14:45	S0128	A Short-term Rolling Prediction-Correction Method for Wind Power Output Based on LSTM and Markov Chain **Presenter: Shuxin Tian** *Shanghai University of Electric Power* Abstract: Wind power output prediction is the basis of the planning and operation for wind farms. To improve the prediction accuracy of wind power output based on digital driving, a short-term rolling prediction-correction method based on the combination model of t-Copula, LSTM and Markov Chain is proposed to forecast the change trend of wind power output. Firstly, the synchro-phasor measurement unit(PMU)with high precision and high-intensive makes it possible to provide large amounts of accurate data for wind power prediction. The important internal correlation factors reflecting immediate reaction of wind power offered by PMU and the external environment factors are screened by utilizing t-Copula correlation theory. Secondly, combined the input data set including the screened correlation factors and the history data of wind power output, the improved Long and short-term memory neural network(LSTM), which is modified by optimal inertia weight and adaptive mutation probability in particle swarm optimization, is put forward to realize the short-term rolling prediction of wind power output. Thirdly, Markov chain theory is introduced to correct the residual of LSTM output, so as to further improve the accuracy of wind power short-term prediction. Finally, this short-term rolling prediction-correction model are tested on the actual data of wind power and the correlation factors. The numerical results show the effectiveness of the proposed model and solution technique for enhancing the wind power prediction accuracy.

14:45-15:00	S0165	Agent-based Optimal Cooperative Operation of Multi-Energy System **Presenter: Bohan Xu** *Sichuan University* Abstract: With the rapid development of distributed renewable energy, the traditional energy node model becomes more complex to adapt to the energy information coupling system. Aiming at the problem that the traditional energy node model is challenging to combine information flow and energy flow to establish a rapid response mechanism, this paper uses machine learning to establish an agent model based on data and model, which can automatically balance disturbance and tend to operate well automatically. Firstly, the scheduling objective and energy converter of the multi-energy system(MES)are modeled. Then, the agent model is introduced, the observation variables and action space of the agent are defined, and the reward function is constructed. Moreover, the solution process of the DDPG algorithm is introduced, and the parameter of the DDPG algorithm is accomplished. Finally, a test case is given to verify the effectiveness of the proposed method.
15:00-15:15	S0170	Research on the Infrastruture for Data Resource Classification in the Energy Industry under Digital Transformation **Presenter: Ren Liu** *Sichuan University* Abstract: Energy data is the basic carrier for realizing energy supervision and promoting the market-oriented reform of the energy system. Besides, it is also an effective means to promote the transformation and upgrading of the energy system. Specially, the value mining and utilization of massive energy data depends on the scientific and efficient classification of energy data resources. Firstly, the composition and characteristics of energy data is analyzed. Secondly, combining the research results of bibliography and related public domain data resource classification, the principles and methods of energy data resource classification is presented. Finally, a classification system for energy data resources has been constructed to provide a data foundation for the digital transformation of the energy industry.
15:15-15:30	S0173	Evaluation Method of Peak Shaving Potential for Multi-type Users Considering the Promotion of New Energy Consumption **Presenter: Xiaoming Xiao** *Changsha University of Science&Technology* Abstract: Peak shaving on the user side is an effective means to promote the consumption of new energy. This study proposes a user-side participation in peak shaving potential evaluation model considering the promotion of new energy consumption in order to give full play to the advantages of user-side participation in peak shaving, fast response and high economy and to improve

		user participation enthusiasm. Aiming at the problem of multi-time scale volatility that traditional static methods cannot reflect the peak shaving potential index, this study proposes a dynamic incentive evaluation method by extracting the multi-day typical characteristics of multiple types of users participating in peak shaving. First, interval weights were constructed to reduce the impact of user load fluctuations on evaluation indicators; the idea of acceleration was introduced to describe the trend of changes in the observed values of indicators at different time scales; second, the gain range of the advantages and disadvantages of each type of indicator was calculated. In addition, assigning corresponding "reward" and "punishment" values can reflect the current state of the evaluated object more objectively and truly, thereby obtaining dynamic incentive index values; finally, based on interval weights and dynamic incentive index values, an interval-type decision matrix pair was formed. The potential of various types of users to participate in peak shaving was scored and sorted. Taking the load of five types of users in a certain area as an example, the results show that this method can effectively evaluate the peak shaving potential of different types of loads.
15:30-15:45	S0203	Energy Data Catalog Item Extraction Method Based on Semi Supervised Feature Selection **Presenter: Zhenwei Li** *Sichuan University* Abstract: With the development of energy technology, the variety and amount of energy data increase, which brings challenges to the construction of energy data catalog system and the use of energy data. In order to extract the energy data catalog items and reduce the redundancy of the energy catalog, this paper proposes an energy data catalog item extraction method based on the semi supervised feature selection algorithm of joint mutual information. Firstly, aiming at the problem of incomplete label information of energy catalog, semi supervised learning algorithm is used to transform semi supervised data set into supervised data set. Secondly, based on the joint mutual information, the importance of all items in the energy catalog is ranked. Then, according to the different feature subsets, the classification accuracy is calculated. Finally, the final energy data catalog item is obtained through comparative analysis. The results show that the proposed method can keep a high classification accuracy even if the label information of the data sample is incomplete, which verifies the rationality and effectiveness of the method.
Coffee Break		

Session 18: S6. Special Session>c. Low-carbon Oriented Advanced Techniques for Power Systems Planning
Session Chair: Dr. Heng Zhang, Shanghai Jiao Tong University
Dr. Shenxi Zhang, Shanghai Jiao Tong University
Dr. Yue Xiang, Sichuan University
Venue: Xiangqing Hall@2F 祥庆厅@2 楼
Time: 16:15-17:45

Time	Paper ID	Title & Author
16:15-16:30	S0215	Clean Energy Transition Evolution of Power Grid Based on System Dynamics P**resenter: Guangbo Peng** *Sichuan University* Abstract: Recently, the concept of carbon neutrality and the need for energy low-carbon transition have greatly promoted the development of clean energy. Therefore, we established a scenario analysis using system dynamics model to analyze the clean development goal of power grid. The model is divided into four sub-modules: electricity demand sub-module, power consumption sub-module, policy&clean power investment sub-module and CO2 emission sub-module. Meanwhile, three scenarios were set in this paper:scenario 1(business-as-usual transformation scenario), scenario 2(electrification acceleration scenario)and scenario 3(deep emission reduction scenario). The results indicate that the development of clean energy in China is mainly dominated by state policies, the capacity is about 4. 15-4. 92GW. And the carbon dioxide emissions will reach its peak around 2026, and the peak value is expected to be controlled below 10. 6 billion tons, which is also in line with the national strategy.
16:30-16:45	S0231	Regulation Capability Evaluation Method of EV Clusters Considering Travel Demand **Presenter: Ye Yang** *State Grid Electric Vehicle Service Co. , Ltd* Abstract: Electric vehicles(EVs)can be used as load-side mobile energy storage resources to control the balance of power system supply and demand, so it is particularly important to evaluate the regulation capability of electric vehicle clusters. Firstly, this paper establishes an evaluation model for the regulation capability of EV clusters based on EV battery capacity limitations and user charging requirements. Secondly, after dispatching instructions from the power grid, the status of the electric vehicles at the station is classified. Thirdly, the time margin and the state-of-charge(SOC)margin are comprehensively considered to make dispatching plans for different status types of EVs. The regulation capability is dynamically updated in real time while tracking the dispatching instructions issued by the power grid. Finally, a simulation case of an EV cluster in an office area verifies the effectiveness of the EV cluster regulation capability evaluation model and grid dispatching

		strategy proposed in this paper.
16:45-17:00	S0235	Research on the Impact of Outside Electricity on Thermal Power Companies in the Receiving Provinces and Strategies for Improving Economic Benefits **Presenter: Fengzhe Dai** *Changsha University of Science&Technology* Abstract: Outside electricity can effectively balance the geographical distribution of electricity, alleviate the shortage of electricity supply in the receiving-end grid during peak hours, and promote the development of electricity market-oriented transactions. In order to promote the high-quality consumption of outside electricity in the receiving-end grid and increase the scale of its consumption, the impact of outside electricity on the thermal power enterprises in the receiving-end grid is quantitatively analyzed and an ancillary service compensation mechanism is proposed. First, the impact of the external power on the thermal power enterprises of the outside electricity is quantitatively analyzed by comparing the thermal power operation mode of the receiving-end grid with or without external power feeding. Secondly, a cost model for peak-shaving of thermal power units is constructed, and the compensation mode of thermal power companies participating in peak-shaving is analyzed in combination with policy documents related to peak-shaving. Finally, This paper selects 300, 000 kW and 600, 000 kW thermal power units to participate in peak-shaving as typical scenarios, calculates the total peak-shaving cost input and peak shaving cost of the two under different power generation output, and gives the receiving end thermal power companies related suggestions and quotation strategies for the ancillary service market.
17:00-17:15	S0325	Optimal Operation of Integrated Electricity-Gas Systems for Renewable Energy Accommodation Considering Flexible Resources **Presenter: Yongtao Guo** *Sichuan University* Abstract: With the rapid development of wind power and photovoltaic power generation, it has become a major trend to establish an energy system centered on high proportion of renewable energy all over the world. Intermittence and volatility are the main features of renewable generation, which has brought challenges to the security and flexibility of energy system's operation. Making full use of the regulating capacity of flexible resources can effectively adapt to the stochastic characteristics of renewable generation and improve the renewable energy accommodation capacity. Considering the advantages of flexible resources such as flexibly reformed thermal power units, gas-fired units and electrical energy storage in the aspect of flexibility regulation, a day-ahead scheduling model of integrated electricity-gas systems for renewable energy accommodation is proposed. Firstly, the flexibility of the power system is quantified by the insufficient flexibility reserve capacity,

		which characterizes the renewable energy accommodation capacity of the system. Then, the economy of each flexible resource is investigated from the point of the total operation cost. Finally, the factors affecting the operation cost are analyzed. Case studies demonstrate the feasibility and effectiveness of the proposed models.
17:15-17:30	S0326	Coordinated Optimization of Electricity-Gas Integrated Energy System **Presenter: Jingrong Guo** *State Grid Sichuan Economic Research Institute* Abstract: This paper proposes a coordinated optimal dispatch model for the electricity-gas integrated energy system considering multiple reserve resources. The model takes into account the reserve resources including generator reserve capacity, energy storage equipment and interruptible load, and considers the transmission capacity of the reserve capacity in the electricity and natural gas network in the face of emergencies to ensure the safety and reliability of system operation. The simulation results confirm that the coordinated optimal scheduling model of the electricity-gas integrated energy system with multiple reserve resources proposed in this paper can reduce the total operating cost of the system and improve the flexibility of system operation.
17:30-17:45	S0327	Hybrid Models Based on LSTM and CNN Architecture with Bayesian Optimization for Short-Term Photovoltaic Power Forecasting **Presenter: Yaobang Chen** *Xidian University* Abstract: The precision and reliability of photovoltaic(PV)power forecasting play a crucial role in commercial PV plants. However, the stochastic and intermittent nature of solar radiation makes prediction difficult. Inspired by this, 4 different deep learning-based hybrid models are proposed to predict short-term PV power generation using long short term memory(LSTM)neural network and convolutional neural network(CNN)based on Bayesian Optimization(BO)in this paper. In addition, this paper explores feature selection using two benchmark models on different feature sets, and finally selects 5 features for prediction. The performances of direct forecasting results for both 1-hour ahead and 24-hour ahead of the above various models are compared on one year of hourly data from a real PV plant in Shandong, China. It is shown that using Bi-directional LSTM(BiLSTM)and CNN-BiLSTM models are more suitable for 1-hour ahead prediction, LSTM-CNN and CNN-BiLSTM models are more suitable for 24-hour ahead prediction. The case study shows that the model with Bayesian optimized optimal weights can reduce the error rate by up to 32. 80%compared to the benchmark model and demonstrates the good prediction performance of the proposed approach on commercial PV plants.
Banquet		***Xiangyun Hall 祥云厅/1st Floor 1 楼***

Session 19: S5. Smart Grid Technology&Application>c. Novel Information Technologies for Smart Grids
Session Chair: Dr. Yan Gong, University Of Electronic Science and Technology of China
Venue: Xiangtai Hall@2F 祥泰厅@2 楼
Time: 14:00-15:45

Time	Paper ID	Title & Author
14:00-14:15	S0126	Load Forecasting Combining Chaos Theory and Long-Short Term Memory in Absence of Key Information **Presenter: Qing Wang** *Wuhan University of Technology* Abstract: Power load forecasting used to rely on some key data such as weather information and regional information. However, it is usually difficult to obtain accurate data of all influencing factors. For this reason, we adopted phase space reconstruction of chaos theory to process the historical load series to avoid collecting some key data. To forecast ahead of time and solve the divergence of forecasting error caused by forecasting ahead of time, this paper proposes a rolling load forecasting method and apply long-short term memory(LSTM)to solve them. The rolling forecasting method is to predict a forecast length in advance, and the test data of LSTM is obtained by shifting a forecast length of training data. This method can not only predict ahead, but also predict the longer-term data through keeping shifting. The proposed methodology is implemented on the PJM power grid dataset in the United States. Compared with some other methods, the results show that the proposed rolling load forecasting model is of more accurate prediction.
14:15-14:30	S0261	Research on Big Data Query Optimization Method of Power System Substation Equipment Condition Monitoring **Presenter: Lixia Wang** *State Grid Liaoning Electric Power Co. , LTD.* Abstract: Power Internet of things is the application of Internet of things in smart grid, which will effectively integrate communication infrastructure resources and power system infrastructure resources, and provide important technical support for power grid generation, transmission, transformation, distribution, power consumption and other links. However, the existing scheduling algorithm has the problem that the node information level is not clear, which leads to the task span is too long. Therefore, a resource balancing scheduling algorithm of power Internet of things node based on big data is designed. Get the edge coefficient of power Internet of things node, release different degrees of pheromone according to the size of fitness function, extract resource scheduling characteristics, clarify the constraints between resources, sort the node information priority by big data, improve the task grouping scheduling strategy, set resource balanced scheduling module management function, and realize the algorithm design. Experimental

		results:compared with the other two existing scheduling algorithms, the average task span time-consuming of the designed scheduling algorithm is 83. 390s, 123. 300s and 124. 952s respectively, which proves that the scheduling algorithm integrated with big data technology has more perfect performance.
14:30-14:45	S0251	Correlation Analysis between Temperature and Electricity Consumption Behavior based on Random Matrix Theory **Presenter: Yixiao Li** *Shandong University* Abstract: Electric power companies have accumulated a large number of statistical data on load characteristics, and the quality and quantity of data have been continuously improved. In this situation, how to effectively extract the correlation characteristics between data and conduct effective correlation analysis of big data is of great significance. This paper proposes a correlation analysis method based on the random matrix theory to study data statistical correlation between temperature and electricity consumption behavior. Firstly, the augmented matrix is served as the data source using load data and temperature data. Then, based on the real-time split window analysis method and the random matrix theory, the statistical characteristics of the split window matrix elements are analyzed. Finally, a quarter time span is applied to compare the influence of temperature on the behavior of electricity consumption. The linear eigenvalue statistics, taking the mean spectral radius as an example, and the pearson correlation coefficient are employed as correlation quantification indicators. According to the actual measurement load data of a certain city power grid, the adaptability and effectiveness of the method are verified, and the approach has a good robust performance.
14:45-15:00	S0329	Mining Method of Voltage Sag Association Rules based on Multi-sources Monitoring Data **Presenter: Le Luan** *State Grid Guangdong Electric Power Co. Ltd* Abstract: With the development of digital technology, multi-platform monitoring data have changed from processed objects into the basic resource. This paper summarizes the rules of voltage sag events caused by lightning and mines the association rules with multi-platform data. These rules improve the safety and reliability of the distribution network. However, there is a lack of method to mine the association rules with lightning and voltage sags. By using data of lightning location system and power quality monitoring system, an association rule mining method, which consists of two main steps, is proposed:1)establish a database based on multi-platform and build a decision table by discrete attributes, 2)propose the improved AprioriTid algorithm considering nonuniform data to mine rules. A comparative study of multi-platform monitoring data is carried out on the use of the traditional and improved AprioriTid algorithms. And the accuracy of the proposed algorithm

		is validated by measured data.
15:00-15:15	S1011	Elimination of Overfitting of Non-intrusive Load Monitoring Model **Presenter: Lin Yang** *Sichuan University* Abstract: The sequence-to-point model has achieved remarkable results in load disaggregation. It relies on a trained deep neural network to identify the power consumption of a single appliance from aggregate load data. However, the model has an over-fitting phenomenon, which makes the loss of the model to the training set small, and it is difficult to obtain a high accuracy rate in the test set. Therefore, it is necessary to use appropriate methods to modify the model to eliminate over-fitting and achieve a higher appliance recognition rate. As a result, the power prediction deviation for a single appliance is relatively large. For example, in the washing machine, the deviation between the predicted value and the ground value can reach more than 90%. So far, there is no documented method to eliminate the over-fitting phenomenon of this model. Therefore, this paper proposes the use of L2 regularization and Dropout to adjust and modify its network. The results show that the increased network architecture and over-fitting elimination methods can improve the decomposition results. The prediction accuracy rate of a single appliance is improved to more than 10%.
15:15-15:30	S0237	Analysis of User Power Consumption Characteristics and Behavior Portrait Based on KS-RF Algorithm **Presenter: Qin Yan** *Tianjin University* Abstract: In order to adapt to the development trend of the interaction between supply and demand of power grid, the user's electricity behavior is fully excavated based on the actual data collected by smart meters, and the research on the method of resident electricity portrait is carried out. In this paper, a method based on KS-RF algorithm is proposed to analyze the user's power consumption characteristics and behavior portrait. Firstly, the cluster analysis method of user electricity consumption behavior is proposed based on k-shape clustering algorithm. Secondly, the random forest algorithm is used to extract four key feature tags from several common users'electricity consumption features, and a multi-dimensional electricity consumption feature tag system is established. Thirdly, the cluster partition results and feature tags are applied to make comprehensive portrait and visual presentation of users'electricity consumption. Finally, the actual electricity consumption data of residents is taken as an example to analyze the application effect.
15:30-15:45	S0301	Proportional Identification of Residential Air-Conditioning Loads Based on Graph Theory **Presenter: Dairui Li**

		Zhejiang University Abstract: Fine-grained demand-side management relies on a sound understanding of appliance-level power usage patterns, especially the air conditioning (AC) loads which can even account for 80%of the total power consumption. Considering the customers'concern of privacy leakage and the cost-saving needs for power supply companies, we apply a graph convolutional network (GCN) -based approach to infer the proportion of AC loads'power consumption for an entire residential load dataset only through a small ratio of labeled data. After the time index alignment and the data repair, the visibility graph (VG) algorithm is adopted to convert time-series power consumption data to a non-Euclidean graph. Then a GCN model utilizing the Chebyshev convolutional network is trained, where the inputs are the adjacent matrix of the constructed VG along with the node feature matrix that is composed of the total power consumption and the local temperature data. Accordingly, the proportional interval of AC loads can be inferred from the node-level output of the GCN model. Finally, the proposed approach is tested with the real-world electricity data from Pecan Street Dataport and the temperature data from NOAA. Different settings of intermittent AC proportion labels are employed to simulate the limited availability of fine-grained AC consumption data on the demand side, while all the numerical results validate the effectiveness of the proposed approach.
Coffee Break		

Session 20: S6. Special Session>a. Emerging Power Electronics for Reliable and Efficient Microgrids of Communication System Session Chair: Dr. Xin Meng, Sichuan University Venue: Xiangtai Hall@2F 祥泰厅@2 楼 Time: 16:15-18:15		
Time	**Paper ID**	**Title & Author**
16:15-16:30	S0131	A Single-switch Step-up DC-DC Converter Based on Switched-capacitor and Built-in-transformer **Presenter: Yu Fu** *Beijing Institute of Technology* Abstract: In this paper, a single-switch step-up DC-DC converter based on switched-capacitor (SC) and built-in-transformer (BIT) is proposed. By replacing one active switch in the Ladder switched-capacitor converter(SCC) with the primary side of a BIT and inserting the secondary side of the BIT to the multiplexed current path, the proposed topology integrates the high power-density feature of a Ladder SCC with the voltage-lift effect of a BIT. In addition, the issues of high current spikes and limited high-efficient voltage regulation range of the traditional Ladder SCC are tackled, making it suitable for distributed generation system, micro-grid and so forth. In this paper, a comprehensive analysis of the operation principle, ideal voltage gain, component stress and topology extension is given. A 100W prototype with input 36. 4V-73. 5V and output 400V is designed, built and tested to demonstrate the validity of the proposed converter.
16:30-16:45	S0135	A Step-down Series-Parallel Dual Resonant Switched-capacitor Converter with Extended Voltage Gain Range **Presenter: Chunxiao Hao** *Beijing institute of Technology* Abstract: In this paper, a step-down Series-Parallel(SP) Dual Resonant Switched-capacitor Converter(DRSC) is proposed, which is expected to be used for the first stage of a data center. The dual resonant core(DRC) is added to the traditional SP Switched-capacitor Converter(SCC) and the on-time fixed frequency modulation is adopted. Consequently, the resonant inductor current of one resonant tank is overlapped with the other one for a controlled time interval. By varying the overlapped period, the full-range voltage regulation can be achieved efficiently even at light load condition. Moreover, zero-current-switching(ZCS) turn-on for transistors and ZCS turn-off for diodes can be obtained. A comprehensive analysis of the operation principle, voltage-gain curve and component stress is presented. A 3X step-down SP DRSC prototype with output power of 100W and nominal voltage level of 48V-12V was designed and built to verify the operation principle.
16:45-17:00	S0247	Application of Resonance Modal Analysis Index for Resonance Frequency Shifting

		Presenter: Xing Sun *Xi'an Jiaotong University* Abstract: In this paper, the resonance modal analysis(RMA) and modal frequency sensitivity(MFS) are investigated, with a focus on the resonance frequency shifting(RFS) . Adjusting the components can shift the natural resonance frequency of the power grid, so as to suppress resonance. RMA can easily identify the resonance location. Based on the analysis of RMA index, a variable-limit genetic algorithm to shift resonance frequency is proposed. The position of the selected components and corresponding capacity is determined via participation factor and modal frequency sensitivity, respectively. Compared with the traditional method, the proposed method has higher iteration accuracy. Validity of the proposed method is verified using IEEE 14-bus test network.
17:00-17:15	S0223	Joint Workload Scheduling Method in Geo-distributed Data Centers Considering UPS Loss **Presenter: Guisen Ye** *Shandong University* Abstract: The rapidly growing energy consumption of modern data centers has drawn widespread attention and extensive research. Among all of the current researches, reducing the electricity cost in geo-distributed internet data center(IDC) is a hot spot. In this paper, electricity price, power output of photovoltaic and energy storage system(ESS) in geo-distributed IDC are optimized in combine with the computational tasks scheduling, while considering the power loss of uninterruptible power supply(UPS) . Case studies are simulated and provided, whose results have demonstrated the effectiveness of this proposed method.
17:15-17:30	S0272	Bidirectional Leakage Current-less Modulation of H6 Inverter With Reduced Switching Loss **Presenter: Zihong Zhang** *China University of Geosciences, Wuhan* Abstract: Transformerless photovoltaic(PV) inverters are more widely adopted due to their high efficiency, low cost, light weight, etc. H6 transformerless PV inverters can suppress leakage current while do not have the bidirectional capability for a photovoltaic-energy storage system(PV-ES) . Therefore, this paper proposes a bidirectional leakage current-less modulation strategy for H6 inverter topology, by improving the modulation strategy in the rectifier stage, only two switches are turned on at high frequency in rectifier mode. The leakage current in inverter and rectifier mode can be suppressed while switching loss can also be reduced. Finally, to validate the proposed modulation strategy, a simulation is also built and tested. The simulation results validate the theoretical analysis.

17:30-17:45	S0293	Stability Analysis of Single-phase Full H-bridge DC-AC Converter with Considering Time Delay and Parasitic Inductance Based on Small-signal Model **Presenter: Huyv Ji** *South China University of Technology* Abstract: With the development of renewable energy and distributed generation, DC-AC converters are widely used in the power system. For the safety of the power system, the analysis of the stability in the inverter is vital. For this issue, the small-signal model of the inverter is established in this paper. Some non-ideal components are investigated, like response delay time and the parasitic inductance of the resistance. This paper determines that these factors do affect the stability of the DC-AC converter. The slow-scale instability is detected by the small-signal analysis. In the final, the experimental device is carried out to verify the correctness of the investigation.
17:45-18:00	S0322	Unified Modeling and Analysis of Sequence Impedance of Grid-forming Converters with Multi-loop Control **Presenter: Yang Peng** *Xi'an Jiaotong University* Abstract: Impedance of a converter is the basis for analyzing the interaction stability of the converter and the grid. Conventionally, the impedance models are built and investigated individually under different control schemes and parameters, which renders time-consuming but low efficient work. Devoted to revealing the common features of diverse grid-forming converters, this paper proposes a unified sequence impedance model that is applicable to various grid-forming converters with multi-loop control. The unified model indicates that the converter impedance is dominated by inner loops in a wide frequency range, and hence is further simplified for inner loop parameter analysis. Focusing on the complex interaction coupling among inner loop parameters, their coupling influences on the converter impedance are investigated comprehensively, and the corresponding rules are highly generalized, which provides guidance on loop parameter tuning for the stability improvement. Experimental results verify the correctness of the theoretical analysis.
18:00-18:15	S1016	Experimental Research on Strong Transient Electromagnetic Interference in Substation **Presenter: Cheng Lin** *State Grid Shaanxi Electric Power Research Institute of Electric Power* Abstract: This paper proposes an experimental method to study strong transient electromagnetic interference in substation. A circuit breaker is used to control the turn-on and-off of the sphere gap arc to generate continuous multi-pulses to simulate the process of opening and closing strong transient electromagnetic interference of 330kV Air Insulated Switchgear(AIS) and Gas

		Insulated Switchgear(GIS) . The electromagnetic interference is measured under different voltage levels, different load conditions and different positions, which is used to evaluate the immunity characteristics of the secondary equipment. The experimental method in this paper can also be applied for the electromagnetic compatibility performance evalulation of electronic transformer, where the isolation switch is used to simulate the electromagnetic interference source.

On-site Sessions

2021 7/21 WED

Session 21: S4. Renewable Energy Integration>b. Energy Storage Technologies Session Chair: Dr. Junhui Li, Northeast Electric Power University Venue: Yuchun Hall Room I@2F 玉春堂 1 号厅@2 楼 Time: 10:00-12:00		
Time	**Paper ID**	**Title & Author**
10:00-10:15	S0227	Optimal Configuration Method of Energy Storage System for Improving Operation Flexibility of Wind Farm **Presenter: Junhui Li** *Northeast Electric Power University* Abstract: The output uncertainty and anti-peak shaving characteristics of large-scale wind power grid connection limit the flexibility of wind farms to participate in the dispatch plan, and the situation of wind abandonment and power rationing is severe. Aiming at the causes of wind power abandonment in wind farms, this paper analyzes the mechanism of energy storage assisting in improving the flexibility of wind farms after wind power is connected to the grid, and proposes an optimization method for battery energy storage system(BESS) configuration, and establishes the optimal configuration of BESS with the goal of maximizing the overall benefits of the system. Model, and iterative calculation method is used to obtain various indicators in the configuration plan. Finally, based on the measured data of a certain local power grid, the validity of the configuration scheme is verified, and its technical and economic performance is analyzed.
10:15-10:30	S0069	Energy Storage Control Strategy for Wind Farms Considering the Electro-thermal Elasticity of Overhead Lines **Presenter: Wang Yan** *Shandong University* Abstract: With the increasing penetration ratio of wind power, a large amount of abandoned wind is generated, which results in a waste of resources. In this paper,an energy storage regulation strategy considering the electro-thermal elasticity of overhead transmission lines (OTLs) is proposed, which can absorb more wind power on the basis of the existing grid structure. First, based on the equations of IEEE-738std, the OTLs' electro-thermal coupling model

		considering the correlation of temperature resistance is established. This model can analyze the influence of environmental parameters on power transmission limit of OTLs. Then, through linearizing the environmental parameters, the line temperature is tracked by synchronous timing simulation. Finally, taken the operating OTLs' temperature as the decision variable, energy storage system (ESS) regulation is combined with the transmission capacity of OTLs to absorb the wind power as much as possible. By analyzing the results, the benefits of the proposed strategy in taping the power transmission potential of OTLs and increasing wind power consumption capacity are demonstrated.
10:30-10:45	S0082	The Utility Analysis of LHSS Combined SMES System Based on Economic Benefit **Presenter: Xingyou Zhang** *State Grid Shandong Electric Power Research Institute* Abstract: Based on common characteristic that liquid hydrogen storage system(LHSS) and superconducting magnetic energy storage(SMES) has similar requirement for refrigeration, This paper analyzes advantages of joint operation of LHSS combined SMES system based on their common characteristics. Consider current situation of renewable energy utilization difficulties in recent years, this paper studies the optimal capacity configuration of LHSS combined SMES hybrid energy storage system to maximum use renewable energy. Based on above scene, a time series based method is proposed to simulate the operation scenario of a high penetration renewable energy system, and a capacity optimization method which objects to maximize the economic benefit of hybrid energy storage system is also proposed in this paper. Also, the effectiveness of the proposed strategy is verified by a simple case.
10:45-11:00	S0150	A Novel High Step-Up/Step-Down Transformer-less Bidirectional DC-DC Converter for Energy Storage Systems **Presenter: Muhan He** *Xi'an Jiaotong University* Abstract: In this article, a new type of bidirectional DC-DC converter with ultra-high voltage conversion capability applied in the field of energy storage systems is proposed. The new converter consists one inductor, two capacitors, and four power semiconductors. Compared with the traditional buck-boost converter, the proposed topology doubles the effective duty cycle, and can obtain a higher voltage gain without using extreme duty cycles. In addition, lower voltage stress of semiconductor devices can also be achieved. The control strategy is uncomplicated due to the simple structure. The steady-state analysis and small signal analysis of the topology in continuous conduction mode are introduced in detail, and the voltage stress of the

		components in the topology is deduced. Compared with other topologies in the existing literature, it shows the excellent performance of the proposed converter. Finally, a 48-400V/400-48V simulation model was established to verify the reliability and correctness of the proposed topology.
11:00-11:15	S0175	Distributed Coordinated Voltage Control of Photovoltaic and Energy Storage System Based on Dynamic Consensus Algorithm **Presenter: Zhengyang Lin** *Changsha University of Science and Technology* Abstract: The construction of a high-proportion new energy power system is conducive to the realization of renewable energy utilization and the achievement of dual-carbon goals. Aiming at the voltage overrun problem caused by large-scale photovoltaic grid-connected in new energy power generation, this paper proposes a distributed coordinated voltage control strategy for photovoltaic and energy storage system based on a dynamic consensus algorithm. The voltage control method of low-voltage distribution network is analyzed, and the distributed control model of photovoltaic and energy storage system is established, which realizes the coordinated control of photovoltaic and energy storage system. The results of the calculation example show that the proposed strategy can effectively coordinate the reactive power control of PV with the active power control of energy storage system, and suppress the voltage overrun problem in the low-voltage distribution network.
11:15-11:30	S0180	SWOT-based Analysis of Commercial Benefits of Electrochemical Energy Storage **Presenter: Weiyang Hu** *North China Electric Power University* Abstract: With the gradual transformation of the energy structure, energy storage has become an indispensable important support and auxiliary technology for low-carbon energy systems. The development of electrochemical energy storage technology has advanced rapidly in recent years. Cost reduction, technological breakthroughs, strong support from national policies, and power market reforms have created favorable conditions for the commercial application of electrochemical energy storage technology. However, energy storage, which has attracted much attention, is an emerging industry with great uncertainty, and its development is full of opportunities and risks. The article uses the SWOT model to analyze the commercial application of electrochemical energy storage, and summarizes a variety of internal and external factors that affect the commercial promotion of electrochemical energy storage. Then a case study of Xinjiang wind plant energy storage configuration is used to illustrate that electrochemical energy storage systems can participate in a variety of service application scenarios and achieve significant benefits. Our work provides a reference for companies

		to formulate strategic plans for energy storage projects, and puts forward suggestions on the commercialization and large-scale development of the energy storage industry.
11:30-11:45	S0242	A Novel Optimized Planning Approach of BESS Considering Investor Benefit and Wind Curtailment **Presenter: Qingsong Wang** *University of Electronic Science and Technology of China* Abstract: Energy storage system is a good solution to reduce the abandonment of electricity caused by highly penetrated renewable energy. With the liberalization of the electricity market, independent investor is permitted to participate in the planning and operation of the distribution network(DN) . In this paper, an planning method for battery energy storage system(BESS) to maximize the profits of the investors and reduce the wind abandonment, from the perspective of independent investors, is proposed. Considering the growth of load and renewable energy penetration, as well as the economy of investment, deployment of BESS is divided into several stages. This problem is formulated as a bi-level programming. In the upper level, the installation time, location, rated power and capacity of the battery are optimized using particle swarm optimization(PSO) method. In the lower level, the most profitable charging/discharging power of the battery is obtained by interior point method(IPM) , and then the optimal power flow(OPF) is carried out to dispatch wind energy considering the constraints. The proposed method is tested on a modified IEEE 33-bus system. Experimental results show that the proposed method can not only make independent battery investors profitable, but also reduce the wind curtailment of the DN.
11:45-12:00	S0287	Assessing the Degradation of Cloud Storage Sharing **Presenter: Chen Yin** *North China Electric Power University* Abstract: With an ever-increasing proliferation of distributed energy storage(ES) , the concept of sharing economy has been introduced to improve the utilization of idle storage capacity among neighborhoods, also known as“ cloud energy storage(CES) ”. While the existing literature shows significant grid-flexibility and economic benefits brought on by CES, few studies have evaluated the extra degradation of storage caused by energy sharing. Therefore, we propose an assessment method for the degradation of sharing cloud energy storage. In this paper, an equivalent circuit method(ECM) is developed to characterize the The venin equivalent voltage source and internal resistance of a storage. An index, state of health(SOH) , is calculated to quantify the remaining energy capacity of storage, and the analytical expressions of efficiency, resistance and other parameters are derived with respect to SOH. To assess the extra degradation of CES, two operation strategies are formulated for comparison with storage shared and localized,

		respectively. Case studies based on 600 residential customers in Texas, USA reveal that storage sharing may lead to 67. 2%of extra degradation of Tesla Powerwall, and thus 2. 75 years service life may be reduced.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 22: S5. Smart Grid Technology & Application>c. Novel Information Technologies for Smart Grids
Session Chair: Dr. Xiaotian Tang, University of Electronic Science and Technology of China
Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼
Time: 09:00-10:15

Time	Paper ID	Title & Author
9:00-9:15	S0121	Geometrical Observation Indexes of Distribution System Security Region **Presenter: Pengfei Li** *Tianjin University* Abstract: This paper proposes the geometrical observation indexes, including volume, surface area and volume to surface area ratio(VSR) and roundness of DSSR. Firstly, the two most basic geometrical indexes are proposed, that is the volume and surface area. Volume is defined as the size of DSSR and surface area is defined as the size of all security boundaries. Secondly, the algorithms of volume and surface area based on Monte-Carlo simulation sampling are proposed respectively. Thirdly, the relationship between DSSR volume and surface area is studied, and a new index, volume to surface area ratio(VSR) , is proposed, which is the reciprocal of the surface area required to form a unit volume. By comparing the VSR of DSSR with geometrical figures, the roundness of DSSR is defined, that is, the degree of closeness from the DSSR is to the circle. Finally, different distribution networks are used to verify the proposed concepts and methods. We find that two distribution networks with the same total supply capability have great differences in DSSR. Therefore, the results show that the new indexes can distinguish planning schemes more effectively and have direct guiding significance to the evaluation and planning of secure and efficient distribution network.
9:15-9:30	S0006	Intelligent Perception Method for Distribution Network Live Working Robot **Presenter: Yuhui Tong** *NARI Group Corporation* Abstract: Aiming at the influences on the operational positioning of distribution network live working robots caused by outdoor lighting, vibration of aerial devices, varied operation scenes, and other factors, this paper proposed an automatic operational positioning method. This method is based on scene semantics which integrated multidirectional data perception, automatic device object recognition, automatic assistance of device semantics and other technics as a whole to solve the problems of difficult target object

		recognition and low positioning accuracy in the operation of distribution network live connection of leads. This paper presented the spatial 3D point cloud perception and acquisition algorithm, which adopted the method of carrying laser radar on tail end of the operational mechanical arm to perform full situational awareness and scanning to realize multi-angle and multi-position point cloud data acquisition, avoided interference of strong light on the sensor. This paper discussed the point cloud connected domain search strategy algorithm based on device semantics, which conquered the challenge of the lead target recognition under the conditions of uneven data acquisition, edge noisy point and acquisition disconnection in strong light. With regard to the standard operational requirements on live connection of drainage leads, this paper realized automatic selection of the positions and postures of working row lines and lead operating points, by means of combining semantic location information of the leads, working arm and other devices.
9:30-9:45	S0059	Load Index Forecasting Method Based on Nonlinear Dimensionality Reduction of Correlated Factors and Generalized Regression Neural Network Fitting **Presenter: Wei Yang** *Sichuan University* Abstract: The power load characteristic index is an industry index that describes the characteristics of the load and the law of load change, and is an important reference basis for the decision-making of the power grid dispatching and planning department. However, the medium and long-term load characteristic index data points are sparse, and the forecasting method that only analyzes the data trend has great limitations. Therefore, it is necessary to consider the external influence factors of the load in the forecasting model to improve the effectiveness and accuracy of the forecast. First, the weight-improved gray correlation analysis method is used in the article to evaluate the degree of influence of external factors such as weather, economy, and society on the load characteristic indicators. The factors with low correlation are removed, and then t-SNE is used. Reduce the dimensions of multiple influencing factors to reduce data redundancy. Then build multiple linear and nonlinear regression models of mid and long term load indicators through generalized regression neural network, and determination of optimal super parameters by one dimensional optimization to achieve mid and long term load characteristic indicators prediction. Finally, the feasibility of the method is verified by using relevant data such as load in a certain area of southwest.
9:45-10:00	S0093	Research on Anomaly Detection of Smart Meters Data Based on feature Clustering Method **Presenter: Yuxi Wang** *State Grid Shandong Electric Power Company*

		Abstract: In recent years, electricity market has developed rapidly, the market trading modes and electricity price system have become more diversified. Because of these, energy metering is facing great revolution and the metering data has a significant influence on the interest of market members and even the development of the whole electricity market. This paper presents an approach to quantify the veracity of metering data. First, the accuracy index of metering data is defined. Then, based on the daily load curve composed of the hourly metering data, K-means clustering algorithm is used to classify the loads into several typical patterns. To ensure the clustering effect, a new clustering validity index is presented to determine the optimal clustering number. Deviation between the test load curve and the typical curve is measured, and the discriminant basis of the metering data veracity is established according to the similarity of the two curves and the smoothness of the test curve. At last, the accuracy index is calculated, and the veracity level is ranked in accordance to the setting standard. Experiments on existing data sets shows that the proposed method is feasible and effective.
10:00-10:15	S0116	State Evaluation of Electronic Transformers Based on Cross Weight Method AHP **Presenter: Xiangxi Duan** *University of Electronic Science and Technology of China* Abstract: This paper focuses on the problems of frequent faults, abnormal events, and the lack of operational state evaluation means for electronic transformers. Based on a large amount of equipment operation and state data, a cross weight method, namely Analytic Hierarchy Process(AHP) , which is driven by experts' experience and data, is proposed in this paper. This method solves the problem of single factor and low accuracy in the traditional status evaluation method for electronic transformers. In this method, the influence factors and comment sets are established according to the experience of experts and the operation standards. For the construction of weight matrix, a cross-weight method is innovatively proposed. Through a subjective weight assignment of fuzzy trigonometric numbers based on experts' experience and objective variable weights based on data, the accuracy of the state assessment of electronic transformer is improved. Finally, the proposed method is verified using an example, which shows that it can effectively improve the speed and accuracy of the state evaluation of electronic transformers.
Coffee Break		

Session 23: S5. Smart Grid Technology & Application>b. Design of Modern Energy Management Systems(EMS)
Session Chair: Dr. Xiaotian Tang, University of Electronic Science and Technology of China
Venue: Xiangtai Hall@2F 祥泰厅@2 楼
Time: 10:45-12:00

Time	Paper ID	Title & Author
10:45-11:00	S0101	Optimal Load Scheduling in Coupled Power and Transportation Networks **Presenter: Quan Yuan** *Southeast University* Abstract: As a part of the global decarbonization agenda, the electrification of the transport sector involving the large-scale integration of electric vehicles(EV) constitues one of the key initiatives. However, the introduction of EV loads results in more variable electrical demand profiles and higher demand peaks, challenging power system balancing, voltage and network congestion management. In this paper, a novel optimal load scheduling approach for a coupled power and transportation network is proposed. It employs an EV charging demand forecasting model to generate the temporal-spatial distribution of the aggregate EV loads taking into account the uncertainties stemmed from the traffic condition. An AC optimal power flow(ACOPF) problem is formulated and solved to determine the scheduling decisions for the EVs, energy storage units as well as other types of flexible loads, taking into account their operational characteristics. Convex relaxation is performed to convert the original non-convex ACOPF problem to a second order conic program. Case studies demonstrate the effectiveness of the proposed scheduling strategy in accurately forecasting the EV load distribution as well as effectively alleviating the voltage deviation and network congestion in the distribution network through optimal load scheduling control decisions.
11:00-11:15	S0250	Comprehensive Benefit Evaluation Model of Battery Energy Storage System Based on Combination Weighting **Presenter: Minyu Chen** *Shanghai Jiao Tong University* Abstract: The penetration of Battery Energy Storage System(BESS) in power system continuing to increase result in the necessity of analyzing the comprehensive benefits of BESS. This paper first establishes a comprehensive benefit evaluation indicator system for BESS, widely examining the impact of BESS in economic, technological, social, and environmental aspects. Secondly, evaluation methods are proposed in accordance with various types of indicators. Combined with expert scores, Borda function is used for subjective weighting. Meanwhile, entropy weighting method is used for objective weighting. An improved TOPSIS method is established on the basis. Finally, based on the existing BESS demonstration project in China and the simulation

		data from experiment, the results validate the indicator system and evaluation method proposed in this paper.
11:15-11:30	S0112	Optimal Power Consumption Method Based on Household Load Interaction Ability **Presenter: Mingkai Yu** *North China Electric Power University* Abstract: With the development of smart grid and communication technology, demand response has become an important role in enhancing the regulation ability of power system. This paper proposes an optimal power consumption method for residential users, considering load characteristics and rationality of interaction mechanism. and asset for the operation and planning of power systems. Based on power consumption characteristics and corresponding constraints, household appliances are classified into four types to model every load in home electricity system. Lexicographic method is used to form an optimal power consumption ordinal table for residential users, and an efficient solution algorithm base on dynamic feasible region optimization method is developed, in order to formulate power consumption plan precisely and appropriately. Case studies of distribution system of a residential area shows the result of optimal electricity utilization plan, illustrating the effectiveness of this power consumption optimization method.
11:30-11:45	S0270	Multi-objective Coordinated Operation of Source-storage-load for Residents Based on SPEA2 **Presenter: Mingli Chen** *South China University of Technology* Abstract: Photovoltaic and energy storage-based distributed generation(DG) system are gradually introduced to the residents, and since the rapid growth in the power capacity of smart home appliances, the resident load is increasing sharply, which increase the burden of the power system. To reduce the cost of electricity, enhance the power quality, and electricity consumption reliability, a multi-objective coordinated operation of source-storage-load model for residents is proposed in this paper. A multi-objective coordinated operation model is presented, and the whole model is based on the Strength of Pareto Evolutionary Algorithm 2. Besides, the classification of the loads is introduced, the resident load is divided into unscheduled load and schedulable load, according to the different ways of participating in scheduling, the schedulable load is divided into interruptible load and time shiftable load, as per the different flexibility of scheduling time, the time shiftable load is divided into arbitrary scheduling time load and fixed scheduling time load. According to the case study of a low voltage distribution network, the proposed method can achieve the reduction of the cost of electricity, correction of voltage deviation, and shortening the outage time at fault.

11:45-12:00	S0284	Distributed V2G Dispatching via LSTM Network within Cloud-edge Collaboration Framework **Presenter: Yitong Shang** *Southern University of Science and Technology* Abstract: The bidirectional energy flow between plug-in electric vehicles(PEVs) and power grids enables load flatting and self-consumption of the photovoltaic(PV)output. However, two critical issues should be addressed. One is how to conduct the gap between the decision makings optimized with predictive data and the reality, and the other is how to ensure efficiency of V2G dispatching. In order to tackle these problems, this work proposes a distributed V2G dispatching via long short term memory(LSTM)network within cloud-edge collaboration framework. In the cloud side, the LSTM network is applied merely utilizing the present data to obtain the prediction models of V2G dispatching. Then, these models are sent to the edge side and updated in a regular time. In edge side, the distributed dispatching is conducted to decrease the computational complexity. The proposed framework is verified by numerical analysis, which illustrates that the effectiveness, efficiency and applicability of the V2G operation.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 24: S6. Special Session>b. Planning and Management of Flexible Resources in Low-Carbon Integrated Energy Systems
Session Chair: Dr. Heng Zhang, Shanghai Jiao Tong University
Dr. Shenxi Zhang, Shanghai Jiao Tong University
Dr. Yue Xiang, Sichuan University
Venue: Xiangqing Hall@2F 祥庆厅@2 楼
Time: 09:00-10:00

Time	Paper ID	Title & Author
9:00-9:15	S0278	Dispatching Potential Evaluation of Purchased Power Load in Iron and Steel Plant Considering Production Process Optimization **Presenter: Lei Gan** *Hohai University* Abstract: Iron and steel industry is the pillar industry of China, providing a solid foundation for China's industrialization. While steel plants are energy intensive mainly consuming coal and electricity, and their power consumption tends to be higher proportional in the near future, due to China's"30–60"target of peak and neutrality carbon dioxide emission, electrical substitution, and ongoing energy use right transaction. Thus, these plants will have larger potential to participate in the friendly interaction between power supply and demand. The adjustable potential of purchased power load exists in two aspects: one is the controllable resources of inner energy supply and use system, and the other is the energy schedule regulation accompanied by production process adjustment, which is rarely considered in current energy management research of steel plants. Based on the flexibility analysis of production process control without affecting productivity, the adjustment model of steel-rolling lines, air separation and electric arc furnaces on iron-making line is formulated here, as well as the corresponding energy consumed in these processes. Combined with the optimization of multi-energy coupling system composed of electricity, stream, by-product coal gas, a novel dispatching potential evaluation method is proposed here to achieve the maximum adjustable outsourcing power from power grid according to the demand response situation. Simulation result shows the feasibility of the proposed dispatching potential evaluation method and the necessity to take the production process optimization into account.
9:15-9:30	S0285	Research on the Voltage Distribution and Short Circuit Features of Distribution Network with High Level of Clean Energy Penetration **Presenter: Jinchao Jin** *Xiamen University of Technology* Abstract: Economic decision-making of electric power system plays a vital role in the planning, operation and transaction of the electric power system. While the achievement of behavioral economics tells us that all the decision making process with human involvement is not that simple. Limited to human's

		subjectivity on cognition and decision preference, the decision will become bounded rational. Sufficient knowledge on the behavior of power system economic decision can improve the accuracy and practicability of decision-making modeling, simulation and forecasting in power system, as well as improve the social elements in developing cyber-physical-social system of power system. Among different behavioral economic theories, prospect theory wins a wide range of research and application. Thus, prospect theory is first introduced here, and then the application of prospect theory is reviewed in the field of power system economic decisions. What follows is the analysis and discussion on key issues of the theory application and its possible further research prospects. Through literature review, it is found that economic decisions in power system based on behavioral economic theory are still pending problems noteworthy considering bounded rationality.
9:30-9:45	S0174	Low-carbon Oriented Advanced Techniques for Power Systems Planning **Presenter: Heng Zhang** *Shanghai Jiao Tong University* Abstract: In the high-voltage DC transmission system, the converter station is a site established to complete the conversion of AC and DC power. Whether the AC filter can operate stably will directly affect the reliability of the DC transmission system. At the same time, AC filter also have higher fault rate than other circuit breakers in the converter station. If the operating conditions of the AC filter can be predicted to a certain extent and hidden dangers can be removed in advance, serious accidents such as fault trips can be avoided to a large extent. This paper proposes a fault early warning method of AC filter circuit breaker based on the extreme learning machine(ELM). Taking a converter station in Northwest China as the background, analyze the recorded waveform of the AC filter. The opening and closing current of the circuit breaker and the corresponding operating conditions when the AC filter is switched on and off are extracted, establishing a learning training library and verifying its effectiveness. The influence of different activation functions and the number of hidden layer nodes on this method is discussed. Finally, the fault diagnosis performance of intelligent learning methods such as BP neural network, RBF neural network and genetic RBF network is compared.
9:45-10:00	S0253	Energy Management of Microgrid Considering EV Integration Based on Charging Reservation Information **Presenter: Yang Yang** *Zhejiang University* Abstract: Under the background of low-carbon and Energy Internet, making full use of flexible resources such as energy storage systems(ESSs)and electric vehicles(EVs)is helpful for improving microgrids' economy and reducing microgrids' dependence on distribution networks. In this paper, an energy management strategy based on double-layer optimization is proposed. In

		day-ahead scheduling stage, based on the charging reservation information of EVs and the day-ahead forecasting on load and photovoltaic(PV), the ESS charging/discharging schedule and each EV's orderly charging plan for the next day are determined to minimize the operating cost and maximum demand of microgrid. In real-time dispatching stage, the charge/discharge power of ESS is adjusted to compensate for day-ahead forecasting errors. Day-ahead scheme updating mechanism is adopted to deal with EVs' default behaviors. Finally, a practical case is given to illustrate the optimization process and actual effectiveness of this strategy.
Coffee Break		

Session 25: S6. Special Session>b. Planning and Management of Flexible Resources in Low-Carbon Integrated Energy Systems **Session Chair: Dr. Heng Zhang, Shanghai Jiao Tong University** **Dr. Shenxi Zhang, Shanghai Jiao Tong University** **Dr. Yue Xiang, Sichuan University** **Venue: Xiangqing Hall@2F 祥庆厅@2 楼** **Time: 10:30-12:00**		
10:30-10:45	S0282	Secure Multi-Party Computation Scheme of Shared Energy Storage Index Based on Blockchain Environment **Presenter: Xinyue Jiang** *Zhejiang University* Abstract: With the rapid development of the shared energy storage market, an efficient comprehensive evaluation index system can reflect the effectiveness of the market construction. In order to meet the requirements of data authenticity and privacy protection in the computation of shared energy storage evaluation index, a secure multi-party computation(SMPC)scheme for shared energy storage index under blockchain environment is proposed. The scheme takes the characteristics of the hierarchical permissions of the alliance chain into account; and based on the multi-channel architecture, it protects the data encryption process against leakage of data privacy by means of homomorphic encryption method. Finally, an example is presented to verify the effectiveness of the proposed security multi-party computation scheme.
10:45-11:00	S0051	TCL Aggregators Based on Virtual Battery Model Participate in Energy Transaction **Presenter: Dejin Fan** *State Grid Xizang Electric Power Co. Ltd* Abstract: Flexible load is the main component of demand-side response resources, and its adjustment is of great significance to the realization of demand-side management. The thermostatically controlled load(TCL)is its important component with flexible adjustment ability. The aggregation of heterogeneous TCL is uncertain and complex. In this paper, the virtual battery

		model is used to equivalently aggregate TCL because of its thermal energy storage properties. Assuming that aggregators participate in the power market composed of power generation, system operators, and loads. When all aggregators spend the least amount of money the power allocation is performed. And the Lagrangian relaxation is used to solve this optimization question, finally the transactions of the various components are obtained. That TCL aggregator participates in power distribution under the virtual energy storage model is achievable and the result shows that the cost is less than that without its participation.
11:00-11:15	S0257	Quantitative Evaluation Method on Electric Vehicle Accommodation Capability of Urban Distribution Network **Presenter: Menghan Wang** *Zhejiang University* Abstract: Large scale of electric vehicles(EVs)integration will have a significant impact on the operation and planning of urban distribution network(UDN). The assessment of the adaptability of the UDN to the integration of large-scale EVs is an important factor to be considered in the future operation and planning of the UDN. Under this background, this paper proposes a quantitative evaluation method for the electric vehicle accommodation capability(EVAC)of UDN. Firstly, kernel density estimation(KDE)method is used to approximate the probability distribution function(PDF)over two characteristic variables of the charging behaviors of EVs in electric vehicle charging stations(EVCSs), namely, the charging start time and the charging duration. Secondly, Monte Carlo(MC)method is used to model EVs charging demand. On this basis, with the goal of maximizing the penetration rate of EVs in UDN, a quantitative evaluation model for EVAC of UDN is established. The EVAC of UDN under different scenarios is compared, and the model is verified to be effective. This method is a powerful tool for UDN operation and planning.
11:15-11:30	S0292	Data-Driven Scheduling of Electric Boiler with Thermal Storage for Providing Peak Shaving Service **Presenter: Likai Liu** *Tsinghua University* Abstract: The rapid development of renewable energy has increased the peak to valley difference of the netload, making the netload follwing being a new challenge to the power system. Electric boiler with thermal storage(EBTS)occupies a non-negligible part of the load in the winter season in Northern China. EBTS operation optimization can not only save its own energy cost but also reduce the peak shaving and valley filling pressure of the system. To this end, the operation optimization of EBTS for providing the power balancing service is studied in this paper, which mainly includes three parts: First, the joint probability distribution between the predicted and

		actual temperatures is built by utilizing the Copula theory; Secondly, the actual temperatures are sampled based on the predicted temperatures of the next day, and the scenario set is generated by clustering these samples, where K-means clustering method are used; Thirdly, the stochastic operation optimization model of EBTS considering the uncertainty of outdoor temperature is constructed. Through the case study, it is found that the proposed method can save the total operation cost of the EBTS compared with the deterministic EBTS operation optimization model.
11:30-11:45	S1021	Optimal Allocation of Multi-Energy Storage in Regional Integrated Energy System with High Penetration of PV Generation **Presenter: Hongpei Qin** *Zhejiang University* *Abstract: T*he rapid development of large-scale distributed photovoltaics in the regional integrated energy system(RIES)has brought about the challenges of system stability and photovoltaic accommodation, which can be solved by deploying multi-energy storage system(MESS). To increase the proportion of distributed photovoltaic accommodation and the flexibility of system, this paper proposes a novel integrated method for optimizing the allocation of multiple energy storage system. This approach can reasonably set the capacity of energy storage system under optimal economic and technical conditions. First, the operating characteristics of various energy storage devices were studied and analyzed, and a model was constructed to accurately characterize the MESS. Then, considering the technical economy and the actual situation of system, an optimal allocation model of MESS is constructed to set the capacity of MESS reasonably. Finally, based on the test system of a RIES, a case study was performed. And the results have proved that the proposed method can allocate capacity of MESS reasonably.
11:45-12:00	S1022	Distributionlly Robust Operating Rreserve Quantification of Integrated Electricity and Heating System **Presenter: Yuqi Xu** *Zhejiang University* Abstract: Nowadays, the uncertainty and variability of increasing wind power penetration has brought new challenges for electric power system (EPS) operation, putting forward higher requirements for its operational flexibility and reserve capability. To realize adequate reserve provision for EPS, massive flexible resources in integrated electricity and heating system (IEHS) have been aggregated to supply efficient reserve capacity. In this context, we first propose an operating reserve quantification scheme for analyzing both probabilistic reserve requirement and dynamic reserve capability of IEHS; Then, a simplified IEHS model is developed through convex relaxation and polyhedral approximation for computational tractability of DHS reserve

		capacity. A two-layer iterative algorithm based on the second order cone duality is developed to obtain a two-stage distributionally robust energy and reserve scheduling strategy. Finally, numerical experiments are implemented to validate the effectiveness and economic benefits of the proposed approach.
Lunch Time		***Xiangjing Hall 祥景厅/2nd Floor 2 楼***

Session 26:S3. Energy Systems>c. Distributed Energy Resources **Session Chair: Dr. Tengfei Ma, Chinese Academy of Science** **Venue: Xiangtai Hall@2F 祥泰厅@2 楼** **Time: 09:00-10:00**		
Time	**Paper ID**	**Title & Author**
9:00-9:15	S0158	Dynamic State Estimation for Integrated Natural Gas and Electric Power Systems **Presenter: Liang Chen** *Northeast Electric Power University* Abstract: A dynamic state estimation method of integrated natural gas and electric power systems(IGESs)in proposed. Firstly, the coupling model of gas pipeline networks and power systems by gas turbine units(GTUs)is established. Secondly, the Kalman filter based linear DSE model for the IGES is built. The gas density and mass flow rate, as well as the real and imaginary parts of bus voltages are taken as states, which are predicted by the linearized fluid dynamic equations of gases and exponential smoothing techniques. Boundary conditions of pipeline networks are used as supplementary constraints in the system model. At last, the proposed method is applied to an IGES including a 30-node pipeline network and IEEE 39-bus system coupled by two GTUs. Two indexes are used to evaluate the DSE performance under three measurement error conditions, and the results show that the DSE can obtain the accurate dynamic states in different conditions.
9:15-9:30	S0308	Operational Reliability Evaluation of Distributed Multi-Energy Systems Considering Optimal Control of Energy Storages **Presenter: Jindi Hu** *Zhejiang University* Abstract: Distributed multi-energy system(DMES)provides a flexible option to coordinate multiple energies, e. g. , electricity, gas, heating, and cooling, to realize a more optimal operation. However, the tight interconnection of multiple energies may bring challenges to maintaining its reliability. The previous studies mainly focus on long-term reliability, which cannot reflect the time-varying reliability during the operation. This paper proposes an operational reliability evaluation approach for the DMES. Firstly, the

		operational reliability models of two typical types of components in the DMES are established. Then, an optimal control problem when the components fail is formulated. Moreover, the time-sequential Monte Carlo simulation technique is utilized to evaluate the operational reliability. Finally, a test case is used to validate the proposed reliability evaluation technique.
9:30-9:45	S0080	Joint Bidding Strategy of Large-Scale Battery Storage Company in Energy, Reserve and Regulation Markets **Presenter: Liling Gong** State Gird Zhejiang Electric *Power Company* Abstract: In order to more profitable allocate the operations of large-scale battery storage stations(BSSs)with locational diversity across various electricity markets, a bilevel formulation is proposed to coordinate the bidding decisions of BSSs in energy, reserve and regulation markets. In which, total profit of BSSs can achieve a global optimum with the consideration of power flow constraints under locational marginal pricing(LMP)clearing schemes. Meanwhile, the battery degradation cost is molded and the stochastic extension with uncertainties are considered. Moreover, the bilevel problem can be converted to mixed-integer linear programming(MILP). Case studies validated the performance of proposed method.
9:45-10:00	S0013	Research and Application of Photovoltaic Power Station On-Line Hot Spot Detection Operation and Maintenance System Based on Unmanned Aerial Vehicle Infrared And Visible Light Detection **Presenter: Guanglei Li** *State Grid Shandong Electric Power Electric Power Research Institute* Abstract: The traditional operation and maintenance method of hot spot detection has some problems, such as low efficiency of inspection, difficult to identify the cause of hot spot under the influence of multiple factors. In this paper, based on the Unmanned Aerial Vehicle(UAV)inspection technology, combined with the slope constraint based infrared image and visible image registration method of hot spot location and based on the improved fish swarm gray combination prediction method, the hot spot information discrimination process was designed. On this basis, an on-line hot spot detection operation and maintenance system of photovoltaic power station(PVPS)based on UAV infrared and visible light detection was constructed, and the accuracy of hot spot detection results of the system was verified by experiments. The system has high accuracy of hot spot location, can actively screen out the external influencing factors of photovoltaic module hot spot, and realize automatic alarm and location investigation of complex hot spot.
Coffee Break		

Session 27: S3. Energy Systems>c. Distributed Energy Resources Session Chair: Dr. Tengfei Ma, Chinese Academy of Science Venue: Xiangtai Hall@2F 祥泰厅@2 楼 Time: 10:30-12:00		
Time	**Paper ID**	**Title & Author**
10:30-10:45	S0105	Data-Driven Distributionally Robust Model for Trading Strategy of Energy Retailers Considering Distributed Generation and Interruptible Load **Presenter: Meng Yang** *Xi'an JiaoTong University* Abstract: Marketing methods are urgently needed to accommodate distributed energy resources9 rapid development. When large-scale renewable energy enters the energy market, the uncertainties of renewable energy output and pool price are main factors that energy retailers must take into account when making trading strategy. Traditionally, both of robust optimization and stochastic optimization have some limitations when handling the uncertainties associated with the renewable energy output or pool price. Besides, energy retailers have more options with the advancement of controllable distributed generation, energy storage system and adjustable load. Therefore, a two-stage trading strategy model considering distributed generation and interruptible load based on data-driven distributionally robust approach is firstly proposed in the paper. The first stage decides how much to purchase from forward contracts, and then the next stage decides the specific operation scheme. The model is solved by classical CCG algorithm. A numerical example is designed to verify the effectiveness of the proposed approach.
10:45-11:00	S1013	The Energy Management Strategies of Residential Integrated Energy System Considering Integrated Demand Response **Presenter: Tengfei Ma** *Institute of electrical engineering Chinese Academy of Science* Abstract: In this paper, a novel residential integrated demand response model is proposed, which enables residential consumers to participate in demand response programs not only by shifting appliances, but also through changing energy types they consumed. The integrated demand response is modeled from three levels, namely the interactions with utility grids, the flexibilities of power, cooling and heating demands and the optimal operation of smart energy hub. In order to demonstrate the effectives and advantages of integrated demand response, four contrastive cases are studied, and simulation results show that the integrated demand response can bring better economic and environmental benefits. Furthermore, a new evaluation index: electricity substitute ratio is also proposed to evaluate the integrated demand response capacity and potential.
11:00-11:15	S0124	A Data-Driven Multi-Agent PHEVs Collaborative Charging Scheme Based on

		Deep Reinforcement Learning **Presenter: Shiying Huang** *Shandong University* Abstract: This paper investigates the collaborative charging problem of plug-in hybrid electric vehicles(PHEVs)in a residential area charging station(CS)under an interaction mechanism. The target is to coordinate the charging strategies of all PHEVs to minimize charging cost of PHEVs on the one hand, and avoid the load peak of CS formed by charging behavior of PHEVs on the other hand. At the same time, the usage habits of PHEV owners, the uncertainty of time-varying electricity price in power market, and operation constraints of PHEVs and CS are also taken into account in this paper. To this end, this paper proposes a data-driven multi-agent PHEVs collaborative charging scheme based on deep reinforcement learning(DRL)method. Firstly, PHEVs are respectively constructed as agents. The interaction among PHEVs in the CS are formulated as a Markov Game. Then, a multi-agent PHEVs charging scheduling algorithm based on a multi-agent deep deterministic policy gradient(MADDPG)method is developed, in which each agent(i.e., PHEV)expects to minimize its cost by choosing the optimal charging strategy during the charging horizon. The proposed method can learn from data mining and gradually grasp the system operation rules by input and output data. Simulations are presented at last to validate the effectiveness of the proposed method.
11:15-11:30	S0014	On-line Evaluation Method of Operating State of Distributed Photovoltaic Power Generation System for Multi Time Scale Characteristics **Presenter: Guanglei Li** *State Grid Shandong Electric Power Electric Power Research Institute* Abstract: It is of great significance to master the operating state of distributed photovoltaic power generation system(DPPGS)to ensure the safety and stability of grid connected operation of the system. This paper constructed a multidimensional index evaluation system suitable for DPPGS, and proposed the calculation method of corresponding index weight. The dual data queue algorithm based on time window was used to solve the problem of multi-time scale of monitoring data in DPPGS. On this basis, the operating state of DPPGS was divided into “excellent'', “good'', “qualified'' and “warning". Through the correlative coefficient method, the operating state of DPPGS can be evaluated online, which can reflect the operating state of DPPGS in real time and accurately. According to the evaluation results, a report was issued, which can provide reference for maintenance and dispatching of operation and maintenance personnel.
1130-11:45	S1008	Exploring Integrated Demand Elasticity for Market Power Mitigation **Presenter: Qi An** *North China Electric Power University*

		Abstract: In the deregulated markets across the world, the marginal pricing(MP)mechanism is widely adopted. However, this mechanism is known to lose market efficiency when units exercise market power to earn more profits. Most of the existing *literature* focuses on the design of incentive-compatible market mechanism or market regulation policy to mitigate market power for generation. In this paper, we first explore the role of integrated demand elasticity for market power mitigation. A bi-level optimization framework of integrated demand response(IDR)is developed considering the complementary of energy conversion. On the first level, an economic dispatch model is formulated aiming to minimize the total costs of electric power system operation. On the second level, an IDR model is developed, which enables energy users to flexibly switch the source of consumed energy, including natural gas and hydrogen, etc. We propose a solution algorithm that converts the bi-level model into a single-level optimization model by using Karush-Kuhn-Tucker(KKT)conditions. Then the mixed-integer linear programming model can be embedded in the economic dispatch model. Case studies based on the IEEE 30-bus system demonstrate that IDR can significantly improve demand elasticity, and thus effectively mitigate the strategic incentive of thermal generators.
11:45-12:00	S1019	Competition-Oriented Demand Response Strategic Bidding Model for Retailers Considering Backup Scheme **Presenter: Zihan Chen** *University of Electronic Science and Technology of China* Abstract: With the fierce competition of electricity market, demand response(DR)amount is also traded in day-ahead market. From the perspective of retailers, just considering its inside customers' characteristic is not enough, the competitiveness of DR bidding also matters, because it depends on the qualification of participating in DR market. Thus, this paper constructs a complicated DR strategic bidding model. Firstly, based on managed residential customers' DR feature, optimize bidding considering competitors' risk preference with deep reinforcement learning approach and guarantee the probability of winning DR bid as much as possible. Secondly, in the actual quotation process, the inaccuracy DR declaration amount or retailers' personal bidding preference, aggressive or moderate style, leads to DR vacancy punishment or overage waste, so that produce the loss of income. Based on previous bidding model, design backup schemes for different types of retailers in advance to reduce loss. Then utilize real case to verify the effectiveness of proposed DR bidding models.
Lunch Time		***Xiangjing Hall祥景厅/2nd Floor 2楼***

Session 28: S2. Power System Protection>c. High Voltage Protection Session Chair: Dr. Hongying He, Hunan University Venue: Yuchun Hall Room I@2F 玉春堂 1 号厅@2 楼 Time: 13:30-15:00		
Time	**Paper ID**	**Title & Author**
13:30-13:45	S1014	Prediction for Dissolved Gas in Power Transformer Oil Based on Temporal Convolutional and Graph Convolutional Network **Presenter: Hongying He** *Hunan University* Abstract: Dissolved Gas Analysis(DGA)is an important method to identify internal faults of transformers. A novel predictive method for dissolved gas content in transformer oil based on temporal convolutional network(TCN)and graph convolutional network(GCN)is proposed in this paper. First, a Temporal Convolutional Network based on dilated causal convolution algorithm is designed to extract feature information from both current data and historical data of each gas content's time sequences. Since the correlation coefficients among different gases may affect the accuracy of the prediction, a topological structure diagram is constructed to describe the relationship among different gases. Then, a GCN is designed to predict the gas contents in the desired time horizon by using the information obtained from the topological structure diagram. The elements in the adjacency matrix of GCN are replaced by Pearson correlation coefficients to improve the accuracy of the prediction. The test results show that the proposed method in this paper achieves high accuracy for the prediction of dissolved gas content in transformer oil. The Mean Absolute Error(MAE)of the predicted gas content by the proposed method is reduced by 11.18%compared with the Long Short-Term Memory(LSTM)network and 12.23%compared with the traditional Back Propagation Neural Network(BPNN).
13:45-14:00	S0011	Research on Transient Protection of HVDC Transmission Line Based on Wavelet Energy **Presenter: Tengyue Zhang** *Guangxi University* Abstract: The DC line fault signal contains rich transient information. Aiming at the problems of poor reliability and insufficient sensitivity of single-ended protection of traditional DC transmission lines, a protection principle that uses only transient currents to achieve full-line rapid operation of DC transmission lines is proposed. The influence of the HVDC transmission line and the constructed boundary model on the fault transient signal is analyzed, and the multi-resolution wavelet is used to analyze the fault current signal and obtain the corresponding wavelet energy. The bipolar DC transmission system model based on the CIGRE model was built on PSCAD and simulated. The results show that the method can accurately determine the fault within and

		outside the fault zone, and is not affected by the transition resistance and line length, and has high accuracy.
14:00-14:15	S0023	Reliability Evaluation Method of Power Grid Security and Stability Control System Based on Survival Theory and Deep Learning **Presenter: Hourui Liu** *CYG Sunri Co. LTD* Abstract: The research on the reliability evaluation of the Power Grid Security and Stability Control System(PGSSCS)is the basis for the design of the system, which is also an important guarantee for the normal operation of the power system. Traditional complex mathematical modeling methods do not match the real-time requirements in analysis. Firstly, the research results of reliability evaluation indicators and reliability evaluation modeling methods of PGSSCS have been analyzed. Secondly, the reliability evaluation methods of the PGSSCS based on survival theory and convolutional neural network, which can accurately and quickly realize reliability evaluation, are respectively analyzed. Then, the above two reliability modeling methods were used to analyze PGSSCS with two-layer dual-redundant, and the reliability indexes were calculated respectively. Finally, the training set error and the test set error in the training process are calculated by the two modeling methods respectively. The size of the error between the two different methods and the pros and cons of the training time were compared and analyzed.
14:15-14:30	S0046	Recovery Strategy of Pole-to-Pole Short-Circuit Fault with Backup Automatic Switch in DC Distribution Network **Presenter: Yi Jiang** *Sichuan Aerospace Liaoyuan Science and Technology Co. , Ltd.* Abstract: Aiming at the DC distribution network failure, combined with the two-supply and one-backup topology, a strategy for recovering pole-to-pole short-circuit faults in DC distribution network with backup automatic switch(BAS)is proposed. By changing the logic of BAS operation, the influence of distributed generation(DG)on BAS is eliminated. Considering the wide use of DC circuit breakers, a fault recovery strategy based on DC circuit breaker and BAS is proposed. This strategy uses a DC circuit breaker to cut off transient faults, and when the permanent faults occur, it uses BAS to restore the power supply in the non-fault isolation area. The faults at different locations of the DC line are partitioned to ensure the stability of the power supply to the load terminal. In order to verify the feasibility of the scheme, a two-supply and one-backup DC distribution network model is established through MATLAB/Simulink. Simulation results proved the effectiveness of the proposed method.
14:30-14:45	S0104	Simulation Analysis of DC Arc Extinguishing Characteristics of Arcing Horn **Presenter: Qin Deng** *Southwest Jiaotong University*

		Abstract: Due to Direct Current(DC)has no periodic zero crossing, the arc is difficult to extinguish by itself. To prevent grounding insulator surface flashover, a protective gap is set on the grounding insulator. The Claw arcing horns are one of the protection gap devices and produce DC arc. In this study, the simulation model of Claw arcing horns is established, based on the Magneto Hydro Dynamics(MHD)theory. The arc development characteristics are analyzed, which is of maximum temperature and the corresponding time. The simulation results show that the minimum distance of its installation gap and the material of its electrode have a great influence on the DC arc. When the gap minimum distance between the gaps of its electrodes increases, the temperature of arc changes regularly. The minimum gap distance for this model is 3. 5 mm. And the Claw arcing horns are made of copper, which is conducive to arc extinguishing. This study has guiding significance for the structural design and material selection of the arc extinguishing horn in DC grounding system.
14:45-15:00	S1015	Study on Entropy Characteristics of Buck-Boost Converter with Switched Capacitor Network **Presenter: Cheng Lin** *State Grid Shaanxi Electric Power Research Institute of Electric Power* Abstract: Switched capacitor network has been widely used in power electronic circuits. Under the same input voltage and switch duty cycle, buck-boost converter with switched capacitor network can achieve better voltage-drop effect. Based on peak current controlled buck-boost converter with switched capacitor network, a model of discrete iterative mapping, this paper studies the entropy characteristics to analyze the nonlinear dynamic behavior of the converter. First, two-dimensional entropy of the converter is obtained, which reflects the overall statistical characteristics. Then, the numerical sequence distributions of buck-boost converter with switching capacitor network are also analyzed under different load resistors. Finally, the nonlinear dynamical analysis for the converter is verified by experimental results.

Session 29. Energy Systems>a. Energy Efficiency Session Chair: Dr. Yan Gong, University of Electronic Science and Technology of China Venue: Yuchun Hall Room II@2F 玉春堂 2 号厅@2 楼 Time: 13:30-15:00		
Time	**Paper ID**	**Title & Author**
13:30-13:45	S0317	A Novel Magnetic Integrated Boost-forward Converter **Presenter: Yu Gu** *Harbin Insititute of Technology Shenzhen* Abstract: In this paper, a novel magnetic integrated Boost-forward converter based on Boost and Forward topology is proposed. This topology not only eliminates the right half plane zero point and input current ripple, but also reduces the volume and weight of the converter. The converter uses magnetic integration technology to increase power density. The magnetic integrated module includes an input inductor, an auxiliary inductor and a ripple cancellation inductor. The three inductors are coupled to the same magnetic core to achieve the purpose of magnetic integration. The proposed converter has the same voltage gain as the boost converter, but has no input current ripple and right half plane zero, which benefits from its special structure. Moreover, a prototype with an input of 60V and an output of 100V has been built and tested. Experimental results show that the proposed topology achieves right half plane zero point elimination and extremely low input current ripple. The simulation and experimental results demonstrated the effectiveness of the proposed converter.
13:45-14:00	S0226	Optimal Scheduling Strategy of Charging Station Considering Reactive Power of Electric Vehicle Charging Pile **Presenter: Zhongyu Zhao** *Shandong University* Abstract: With the popularity of electric vehicles, the impact of large-scale electric vehicle access to the distribution network has become more obvious. In this context, a real-time rolling optimization scheduling strategy for charging stations that takes into account the reactive power response of electric vehicle charging piles is proposed, fully considering the space-time distribution characteristics of electric vehicles and the active and reactive interaction capabilities between charging stations and the grid. Establish a two-layer model to optimize the scheduling of the active and reactive power of the charging station in time and space. The quadratic programming and the second-order cone programming are used to solve the upper and lower models respectively. Finally, the improved IEEE33 node distribution network system is used for simulation. The simulation results show that the strategy can effectively reduce the system load peak-valley difference and reduce the system network loss, improve system voltage level, etc.
14:00-14:15	S0271	A Constraint Equivalent Model of Heat Network with Heat Storage

		Presenter: Zining Liu *Guangxi University* Abstract: Optimal co-operation of the combined heat and power systems(CHP)can achieve the high energy efficiency with detailed information of both the power and heat network. Nevertheless, sharing detailed data is challenge because power and heat networks are owned by different companies. In this paper, a constraint equivalent model is proposed to represent the influence of the heat network on the power network while protecting data privacy. By using this model, the feasible region for power output of CHP units can be approximately captured considering the operational constraints of heat network. Meanwhile, the impact of heat storage as a flexible resource on power output feasible region of CHP units is analyzed. The constraint equivalent model can replace detailed information of heat network and can be provided to power systems without data leakage. The simulation of a modified 6-node heat network shows the effectiveness of the proposed method.
14:15-14:30	S1003	Pollution Reduction Effect of Rural Integrated Energy System Oriented to Low-Carbon Transformation **Presenter: Zhixia Zhang** *Shandong Agriculeture and Engineering University* Abstract: With the gradual decline of environmental air quality in China, the traditional way of energy use in rural areas has been gradually outlawed due to low energy consumption and high pollution. It is urgent to find a low-carbon and environmentally friendly energy supply method suitable for rural areas. Based on low carbon environmental protection as the goal, this paper analyzed the natural resources in the rural areas and proposed a comprehensive energy system suitable to rural area, which composed of the photo voltaic, wind power, ground source heat pump, straw curing fuel for rural energy, can make full use of abundant biomass and idle land in rural area and satisfy rural residents' demand for cold, heat, electricity. With the pollution emission factor model as the main calculation reference, this paper studies the pollution emission of energy system, and initially adopts the full life cycle method to calculate the pollution emission of photo voltaic and wind power equipment. Considering the flexible consumption of users and the initiative of operators, the capacity of energy supply equipment is selected with the goal of low carbon emission reduction and considering economic constraints. Taking full account of regional differences, the low-carbon emission reduction effects of three different energy supply modes are compared. Taking a rural area in shandong province as an example, the proportion of CO2, SO2, NOX, PM 2.5 that can reduce emission is 95.41%, 97.51%, 90.31%and 97.40%, respectively. The emission reduction effect is remarkable.

14:30-14:45	S0320	Adjustability Analysis of Variable-speed Technology for Hydropower Unit Using Converter **Presenter: He Wang** *China Institute of Water Resources and Hydropower Reasearch* Abstract: This paper introduces the application of variable-speed technology based on the decoupling control strategy of the converter in hydropower units. It can solve several defects of conventional pumped storage units such as long-term partial operation in generating mode and the inability of adjusting the input power in pumping mode. The converter element, which is widely used in wind and photovoltaic power systems with high mobility, is applied to the hydropower unit as an actuator to achieve electricity transmission and stable output. The main effects of the regulation parameters on the response time of the guide vane and the adjustable performance of pump-turbine are analyzed. The simulation analysis of the regulation process of electrical signals including synchronous machine and converter is carried out to obtain the rapidity and accuracy of the adjustable capability. The results indicate that the variable-speed technology can make greater use of the potential regulation of hydropower units and thus better cope with the potential risks that may arise in the power system.
14:45-15:00	S1006	An Integrated Energy Storage Configuration Method for Integrated Energy Service Providers Considering Return on Investment and Medium-and Long-Term Demand Response **Presenter: Donglou Fan** *Nanjing TECH University* Abstract: How to accurately calculate the return on investment(ROI)of integrated energy service providers(IESPs)is an urgent problem to improve the efficiency of energy storage allocation and operation economy. In this paper, an integrated energy storage configuration method for IESP considering ROI and medium-and long-term demand response(MLTDR)is proposed. It is applied to electricity, gas, and heat multi-type energy storage configuration of IESP with integrated energy distribution network. Firstly, the basic operation structure and energy storage configuration principle of IESP are given, and the calculation method of ROI and MLTDR is put forward. Secondly, an integrated energy storage configuration model considering ROI and MLTDR is established to realize the location and capacity of electricity, gas and heat multi-type energy storage. The configuration scheme and operation mode of integrated energy storage are given to improve the efficiency of energy storage configuration. Finally, the results of calculation simulation show that the proposed method improves 43. 75%ROI under the condition of ensuring the same operating income increment. The effectiveness of the proposed method is verified.

Session 30: S3. Energy Systems>b. Microgrid Session Chair: Dr. Rui Yan, Hohai university Venue: Xiangqing Hall@2F 祥庆厅@2 楼 Time: 13:30-14:30		
Time	**Paper ID**	**Title & Author**
13:30-13:45	S0038	Research on Photovoltaic Power Plant Participating in Primary Frequency Regulation of Power Grid with Variable Control Gain Based on Describing Function Method **Presenter: Rui Yan** *Hohai University* Abstract: With the increasing proportion of photovoltaic and other new energy in the power grid operation, the overall frequency modulation ability and inertia level of the system decline, so it is urgent for new energy to participate in the primary frequency modulation of the power grid. The gain of frequency regulation control(the reciprocal of the regulation coefficient)is the key parameter of the primary frequency regulation control system, a frequency regulation system can run with smaller control gain under small disturbance, when the frequency deviation in power grid is large due to the large load disturbance in the system, if the original control gain is switched to the greater control gain, it is excepted to bring better control effect of frequency regulation. So the use of variable gain control is a subject worth studying. For this reason, this paper studies the variable gain control problem of photovoltaic power plant participating in primary frequency modulation. Firstly, the primary frequency modulation control analysis model of photovoltaic power plant is established. What's more, the value of original control gain is given referring to the actual operation experience of the power system. Then based on the nonlinear Nyquist stability criterion, the range of control gain can be obtained that ensure the stability of the system. Finally, the optimal control gain is obtained by using Particle Swarm Optimization(PSO). Simulation results show the effectiveness of the proposed method.
13:45-14:00	S0107	The Impact of Industrial Structure Adjustment on Economic Growth under the Background of Energy Internet **Presenter: Chuanzheng Gong** *North China Electric Power University Energy Internet Research Center* Abstract: This paper explores the impact of the global energy Internet on the energy industrial structure and then on the industrial structure, establishes a dynamic relationship model between industrial structure adjustment and economic development, and analyzes the promoting effect of industrial development on economic growth. The results show that the output value of the tertiary industry has the strongest pulling effect on the economy, followed by the primary industry, and the first industry is the weakest Economic development is affected by industrial structure. Global energy Internet can

		promote industrial upgrading, adjust industrial structure, and realize economic benefits.
14:00-14:15	S0195	Energy Trading among Multiple Microgrids Considering Adjustable Potential **Presenter: Songli Fan** *Suzhou University of Science and Technology* Abstract: Interconnected microgrids(MGs)system is regarded as one of the future power system configurations, where individual MGs can support each other through interchanging energy. Specifically, MGs with surplus power can trade with those with deficit power. This paper presents a two-level hierarchical structure to manage the energy trading among MGs and also with the main grid. In lower level, individual MGs would operate as self-controlled entities; in upper level, an independent and nonprofit third party would coordinate the energy transaction among different MGs. To guarantee the fairness and autonomy, a local energy exchange market is established, in the presence of the main grid. Apart from the surplus or deficit energy, adjustable power is also incorporated in the individual MGs' bidding strategies. The local trading prices are determined via the market clearing. We analyze the economic benefits of such an energy trading mechanism and also the value of adjustable power originally hidden in MGs. Numerical results demonstrate the effectiveness of the proposed framework for the energy trading among multiple MGs system.
14:15-14:30	S0224	Optimal Operation of Isolated CCHP System Considering Time-varying Weighting Factors **Presenter: Ke Duan** *Nanjing Normal University* Abstract: Nowadays, comprehensive utilization of multiple forms of energy to improve energy efficiency is popularly concerned. To this end, an isolated combined cooling, heating and power(CCHP)system is deeply explored in this paper. Aiming for further optimization of the system according to characteristics of island operation mode, two integrated energy system(IES)evaluation indexes are taken as the objective function. Furthermore, a time-varying weight factor is proposed to calculate multi-objective function and optimize the system scheduling. Case study results demonstrate that the potential benefits of the proposed optimization strategy in terms of operation economics, energy utilization, as well as the load balancing of isolated system.

Session 31: S5. Smart Grid Technology & Application>a. Real-time Grids Monitoring and Security Assessment
Session Chair: Dr. Zhenyuan Zhang, University of Electronic Science and Technology of China
Venue: Xiangtai Hall@2F 祥泰厅@2 楼
Time: 13:30-15:15

Time	Paper ID	Title & Author
13:30-13:45	S0026	Power System Transient Stability Control Method Based on Deep Learning Hybrid Model **Presenter: Sajia Lin** *CYG Sunri Co. LTD* Abstract: The deep adjustment of power grid structure puts forward new requirements for power system emergency control technology. Aiming at the problem that traditional transient stability control methods only consider power angle stability constraints, resulting in low control accuracy and unable to guarantee the transient voltage stability of power grid, a hybrid model based on deep learning is proposed for power system emergency control. Firstly, the power system emergency control margin model of random forest is established to accurately judge the stability of the system and avoid improper decision-making due to the failure of the model. Secondly, the long short-term memory network is used for real-time power curve prediction to provide accurate implementation scheme of machine and load shedding, so as to realize the stable operation of power system. Finally, simulation analysis is carried out in IEEE 16 machine 68 bus interconnected system. The results show that our method has better system stability judgment accuracy than the comparison method, and the emergency control method can effectively ensure the stable operation of the system after failure.
13:45-14:00	S0144	A FP-growth Algorithm Based Fault Analysis Method for Distribution Terminal Unit **Presenter: Xuecen Zhang** *Southeast University* Abstract: Distribution terminal unit(DTU)is an indispensable device that monitors and controls other secondary-side devices in distribution network. With the large-scale integration of DTU into power system, limited numbers of maintenance engineers can hardly cope with the pressure brought about by the massive increment of DTU devices. Fault of DTU may lead to severe impact on normal operation of distribution network and power system. Therefore, researching DTU fault mechanisms and taking measures to lower fault incidence are crucial for ensuring the stable and safe operation of distribution network. In this paper, we proposed a FP-growth algorithm-based fault analysis method for DTU. Firstly, different possible factors that lead to DTU fault are analyzed, fault types are also introduced. Then the main idea of FP-growth algorithm is illustrated. Afterwards, a DTU fault analysis method

		based on FP-growth algorithm is put forward. Experiment is conducted on realistic DTU fault database to prove the practicality of this method.
14:00-14:15	S0179	A Transfer Algorithm for Dynamic Security Region under Maintenance Operation **Presenter: Kun Ma** *Tsinghua University* Abstract: With the energy transition development, power systems have continuously increasing complexity in their structure, planning and operation. To quickly and accurately assess the dynamic security region(DSR)of power system, there are prominent problems with traditional analysis method, i.e., the rules' roughness and low calculation efficiency, while data mining provides a new approach to get around such problems. In addition, for a case of maintenance, i.e., N-1 operation mode, the DSR of pre-maintenance is no longer suitable, and a resources consumption to re-tag data and train algorithm can be undoubtedly huge. Therefore, a DSR transfer algorithm for maintenance mode is proposed in this paper. With a limited structural change from pre-maintenance to maintenance system, this paper assumes that there is a certain connection between DSRs of two systems. With fully using the existing DSR knowledge of the pre-maintenance system, the algorithm adds a small number of maintenance samples to achieve better performance. The transfer algorithm is verified by a test case.
14:15-14:30	S0145	Convolutional Neural Network and Data Augmentation Method for Electricity Theft Detection **Presenter: Xuecen Zhang** *Southeast University* Abstract: Electricity theft is a severe issue that causes huge revenue loss for utility companies and influences stable operation of power system. With the development of big data analysis, electricity theft detection(ETD)based on data-driven method has received massive attention. However, since available data in low-voltage(LV)network is usually sparse and imbalanced, most of the existing data-driven ETD methods are not applicable to residential customers. In light of this issue, we proposed a convolution neural network(CNN)and data augmentation method for ETD. This method applies kernel density estimator(KDE)and monte carlo method to expand dataset. Then CNN model is implemented on the dataset for classification. Experiment using realistic electricity usage data has been conducted to verify the effectiveness of this method, results show that this method can achieve high performance in terms of different metrics.
14:30-14:45	S0198	An Abnormal Electrical Phenomena Detection Method for Vehicle-Grid Monitoring and Evaluation Framework P**resenter: Feifan Liu** *Southwest Jiaotong University*

		Abstract: In this paper, a monitoring and evaluation framework for vehicle-grid electrical coupling system(VGECS)in electrified railway is proposed. The framework consists of monitoring block, analysis block and evaluation block and the key part is the analysis block. To effectively process the massive monitoring data in VGECS, two strategies based on convolutional neural network(CNN)and long short term memory network(LSTM)are designed to identify the abnormal electrical phenomena(AEP)in VGECS. The proposed method can identify typical AEP in VGECS, including inrush current, low frequency oscillation, harmonic resonance and short circuit in a rapid manner based on voltage and current signals. The effectiveness of the proposed method is validated by experimental tests with measured data.
14:45-15:00	S0236	Research on Virtual Inertia of AC/DC Hybrid Microgrids Based on the Firework Algorithm **Presenter: Qingsong Zhao** *Shenyang University of Technology, School of Electrical Engineering* Abstract: This paper presents an improved firework algorithm to efficiently configure the virtual inertia for AC/DC hybrid microgrids with distributed energy and high penetration, which can solve the problem of efficient utilization of virtual inertia resources in hybrid microgrid. Firstly, the virtual inertia configuration evaluation model of hybrid microgrids is derived and established. Additionally, To reduce the difficulty of inertia optimization configuration, this paper converts the inertia configuration optimization problem from non-convex to convex optimization. Thirdly, this paper mainly optimizes the particle selection method of the firework algorithm, and introduces the vector optimization domain to directionally select the particles in the optimal domain. Finally, Compared with the traditional firework algorithm, the simulation results of the improved firework algorithm has stronger ability to find optimized areas and more accurate performances.
15:00-15:15	S0316	A Novel Non-Contact Measurement Method for Current Positioning Based on Magnetic Sensors **Presenter: Haoyang Fan** *University of Electronic Science and Technology of China* Abstract: With the intelligent and distributed development of the power grid, the demand for the security of power systems is increasing. As an essential part of energy transportation in power systems, transmission lines have arc sags and wind-induced swings that can lead to serious safety incidents, so more and more researchers are studying the spatial condition monitoring of transmission lines. The existing methods usually use intrusive sensors, such as temperature sensors, or need photographic image analysis. Nevertheless, the intrusive sensors may increase safety risk, and the image analysis can be affected by extreme weather conditions. This paper proposes a novel

		non-contact method for current measurement and spatial positioning based on magnetic field sensors. In this method, two sensors are combined as a probe. By analyzing the magnetic field at different distances, the space position of the conductor and the target current can be calculated. Since the measurement results of this method are unstable when the target current is close to 0, this paper proposes an optimized method by using a limiter and digital low-pass filter to process the distance values, which effectively improves the measurement stability and accuracy. In experiments, the average error of distance is about 1%, and the error of the current RMS is about 2%.

Poster Sessions

2021 7/19 MON

Poster Session 1 Venue: lobby@2F 2 楼大厅 Time: 15:00-17:00	
Paper ID	**Title & Author**
S0094	Simulation on Evaporation of Copper Droplet in Vacuum **Presenter: Yujie Gong** *Xi'an Jiaotong University* Abstract: Evaporation of droplets in vacuum circuit breaker has impact on dielectric strength recovery and breaking ability. In this paper, we use simulation to study impact of different parameters on evaporation. We found that the evaporation process can be separated into two parts, fast evaporation and stable evaporation. This difference is caused by the saturated vapor pressure and it restrains the evaporation. By changing initial speed, temperature, angle and number of droplets, evaporation process shows different pictures.
S0029	Simulation of No-load Medium Recovery Characteristics of CO2 Circuit Breaker **Presenter: Muxin Diao** *Xi'an Jiaotong University* Abstract: CO2 is considered as one of the most potential SF6 substitute gases due to its good arc quenching performance, low global warming potential(GWP), stable physical and chemical properties and low price. Gas medium recovery characteristics largely determine the interruption performance of high voltage circuit breakers. Therefore, it has great significance to research the medium recovery characteristics of CO2 circuit breaker for guiding the design of the circuit breaker. In this paper, a CO2 circuit breaker model is established based on a 40. 5kV SF6 circuit breaker. The no-load flow field of the CO2 circuit breaker is analyzed by Fluent software. The pressure distribution of CO2 is obtained under different contact gap, and the influencing factors are analyzed. The electric field of the circuit breaker is analyzed by An soft Maxwell software, and the distribution of electric field strength and potential is obtained under different stroke. On this basis, the no-load medium recovery characteristics of CO2 circuit breaker are calculated by streamer theory.
S0297	A Novel Hilbert Transform Based Accurate Phasor Estimation Method of PMU for the Power System Out-of-step Oscillation Situation **Presenter: Shuai Zhang** *Shandong University*

	Abstract: Out-of-step oscillation is a serious physical phenomenon in the power system, which needs timely control and protection. However, this process requires accurate wide-area measurement information from PMU as a guarantee. This article firstly analyzes and illustrates the fact that the great and rapid amplitude and frequency fluctuation of bus voltage and system current during the out-of-step oscillation process brings great challenge on the phasor measurement, and points out the urgent demand to develop a novel phasor measurement method to suit for this condition. Then this article takes advantage of the 90 degree non-attenuation rotation characteristic of Hilbert transform, analyzes the error caused by discrete Hilbert transform, and gives the corresponding error elimination scheme to form a novel Hilbert transform based phasor measurement method. Through verification, its advantages over the traditional phasor measurement methods are described. It can be taken as an important supplement to the PMU, which could provide the necessary accurate measurement information for the out-of-step protection and control.
S0129	Frequency Characteristics of Southwest Power Grid and Scheme of Over-frequency Generator Tripping **Presenter: ZhenLin Ni** *NARI Group Corporation* Abstract: Based on the single machine model, the key factors affecting the frequency response of the system are studied, the expressions of the initial frequency change rate and the maximum frequency deviation after large disturbance are derived, and the mechanism of improving the frequency stability of conventional units and new energy frequency response, DC frequency modulation, load frequency response, emergency control and other factors is analyzed. According to the frequency response characteristics of Southwest Power Grid, the over-frequency generator tripping scheme is designed from the aspects of high frequency generator tripping object, starting threshold, generator tripping capacity, etc. , and the coordination principle of high cycle generator tripping, generator overspeed protection and low frequency load shedding is proposed. The effectiveness of the proposed scheme is verified by practical examples.
S0113	Failure Probability Model of Distribution Network Equipment Based on Improved Age-reduction Model and Factor Correction **Presenter: Ting Zhang** *North China Electric Power University* Abstract: Equipment outage is the root cause of power system failure, and the establishment of equipment failure rate model is the basis for system reliability analysis. Based on data-driven and fuzzy theory, a time-varying failure rate model of equipment was proposed. Firstly, double Weibull distribution was used to describe the aging failure. For the risk factors such as operating environment, internal health, external condition and meteorological environment, the equipment state was evaluated by subjective and objective comprehensive weight. The exposed equipment adopted the dual-condition cloud model, and the distribution of cloud drops was used to describe the impact factor. The enclosed equipment adopted the proportional hazard model and used comprehensive health index as the covariate. Secondly, considering repair fatigue, an improved

	age-reduction model was applied to calculate the equivalent age. Thirdly, using Levenberg Marquardt method to estimate the parameters of the model. Finally, the typical scenarios were extracted based on the improved k-means to calculate the reliability of a microgrid. The results show that the model can better simulate the actual situation of system operation, reflect the temporal and spatial differences of equipment failure, and improve the accuracy of reliability calculation.
S0062	Peak Load Regulation Compensation Based Energy Management Strategy Considering New Energy Power Output Randomness **Presenter: Qian Yang** *Sichuan University* Abstract: This paper addresses a stochastic energy bidding problem for multiple wind farms belonging to different entities. Considering competitive relationship among wind farms, a Cournot game based pricing function is introduced to describe dynamic market prices and the amount of energy bids from wind farms in day-ahead(DA)electricity market. Furthermore, the output power of wind power generations is modeled by stochastic scenarios and the Conditional Value-at-Risk(CVaR)method is applied to measure the cost of energy bids under uncertainty. Especially, a CVaR based risk term is added into the objective function to obtain trade-off bidding decisions between expected profits and financial risks. By the case study, the effectiveness and feasibility of the proposed Cournot stochastic game based bidding strategy are verified.
S0266	Partial Discharge and Its Influence in Oil-Paper Insulated Needle Plate Systems under Combined AC-DC Voltage **Presenter: Hanliang Lin** *Shandong University* Abstract: As an important part of the ultra-high voltage direct current(UHVDC)transmission system, the safety of the oil-paper insulation at the rectifying valve side of the converter transformer is extremely important. This kind of insulation is mainly dealing with combined AC-DC voltages, therefore, further studies about the partial discharge(PD)and its influence on the rectifying valve side need to be carried out. In this study, experimental platform including a high-speed camera was used to obtain photos of the experimental phenomenon, herein the PD process and its influence can be observed and analyzed. Experimental results show that the aging of oil-paper insulation system is closely relevant to the PD phenomenon. This study reveals the relationship between the PD process and the electrical aging, which can help to protect the oil-paper insulation system at the rectifying valve side of the converter transformer.
S0254	VSG Integrated Control Strategy Based on Hamilton Theory **Presenter: Jifeng Liang** *State Grid Hebei Electric Power Co. , Ltd. Electric Power Research Institute* Abstract: As the penetration rate of new energy generation continues to grow, the weak inertia and underdamping characteristics of the traditional power electronic converter interface will have a negative impact on the stable operation of the power grid. To solve

	this problem, firstly, a third-order VSG control model considering excitation control is established, and the control law is obtained based on the dissipative Hamilton system method to improve the stability of the system while preserving the nonlinearity of the system. At the same time, a comprehensive adaptive control strategy for the moment of inertia and damping coefficient is proposed, which makes full use of the flexible and adjustable technical advantages of the VSG to suppress the power oscillation of the power system. Finally, using MATLAB/Simulink and DIgSILENT software simulation analysis and verification of the effectiveness and robustness of the designed control strategy.
S0181	The Optimization for Voltage and Reactive Power Control of Distribution Network Considering Equipment Operation Loss **Presenter: Rui Zhang** *State Grid Hebei Electric Power Research Institute* Abstract: Voltage and reactive power control is an important task to ensure the economic and safe operation of the distribution network. Coordinating multiple adjustment methods can improve the operation efficiency of the distribution network. In this paper, voltage and reactive power control devices are considered, such as on load tap changer(OLTC), voltage regulators(VR), capacitor bank(CB)and distributed generation(DG). And the optimization is proposed to solve the meaningless action in existing Volt control. Firstly, the voltage and reactive power optimization model of distribution network is established based on the branch power flow equation, which is relaxed to the mixed integer second-order cone programming(MISOCP). At the same time, considering the action cost of the devices, a rolling optimization mode based on model predictive control(MPC)is proposed. Finally, the effectiveness of the proposed strategy is verified based on the improved IEEE-33 bus test system.
S0164	A Loss Modeling Method of Buck Converter with Different Control Methods **Presenter: Zheng Zhi** *Xi'an Jiaotong University* Abstract: As one of the core devices of DC power grid, the performance of DC transformer will have a great impact on the application effect of DC power grid. At present, in order to adapt to the high-power and high-frequency conditions of DC transformer application, scholars have carried out a lot of research on topology optimization and control methods of DC transformer. In order to provide theoretical basis for device selection, topology selection and control optimization of DC transformer, it is necessary to study the loss modeling method. This paper first introduces the topology of buck converter circuit. The operation mode and advantages and disadvantages of the low current and high current ripple control methods are described in detail. Based on the above analysis, the loss causes and modeling methods of the circuit are studied, the loss models of the two control methods are established, and the LTSPICE simulation model is built to verify the theoretical results. Finally, the experimental verification of the above theoretical model is completed, and the effectiveness of the control method and theoretical modeling is verified by the measured waveform and efficiency.

S1004	The Simulation of Kunliulong Flexible DC Project with Single Station Operation and Out of Operation **Presenter: Hongbin Wu** *Shandong University* Abstract: The hybrid DC transmission technology which fully combines the economic and technological advantages of LCC(Line Commutated Converter)and MMC(Modular Multilevel Converter)has developed rapidly due to its large transmission capacity and no commutation failure, etc. This paper takes Kunliulong hybrid three-terminal DC transmission project with conventional UHV converter station at the sending end and hybrid valve flexible UHV converter station at the receiving end as an example, analyzing the operation mechanism of hybrid three-terminal HVDC system. In this paper, a simulation model of hybrid three-terminal DC transmission system is established and a controller of hybrid three-terminal DC transmission system is designed by using simulation software based on line topology and parameters. The Kunliulong project is qualitatively analyzed under normal operation, single station operation and out of operation conditions, which provides reference and basis for the reconstruction and expansion of Kunliulong UHV multi-terminal Hybrid DC transmission project and other DC projects.
S0132	A Supplementary Frequency-voltage Controller for Improving the Stability of MMC-HVDC Connected Weak Receiving Power Grid **Presenter: Yansheng Zou** *Maintenance Test Center EHV Company of CSG* Abstract: The active power and reactive power of modular multilevel converter based HVDC(MMC-HVDC)can be decoupled independently, and can be rapidly controlled. Based on this characteristic, a supplementary frequency-voltage controller(SFVC)is designed to improve the frequency and voltage stability of MMC-HVDC connected to the weak receiving system. A detailed electromagnetic transient model is built in PSCAD. The simulation results of different disturbance locations and time durations show that the SFVC can quickly restore the frequency and voltage stability of the receiving system. The effectiveness and superiority of the proposed SFVC are proved.
S1005	Optimal Control Time of Emergency Control to Damp Power System Low-frequency **Presenter: Chenghao Li** *Grid Technology Center* *Electric Power Research Institute of State Grid Henan Electric Power Corporation* Abstract: When the low-frequency power oscillation occurs in the power system, dispatchers often adopt the emergency control method of reducing output and load to suppress the oscillation as soon as possible, so as to maintain the stability of the system. This paper proposes and studies the optimal control time of the emergency control. The importance of controlling time selection to suppress oscillation is proposed and demonstrated when emergency control is applied. This paper presents an algorithm for calculating the optimal emergency control time, calculates the optimal emergency control time of the demonstration example, finds the relation between the optimal emergency

	control time and the time when the line power oscillation reaches the maximum and minimum amplitude, and explains the observed rule by using the Equal Area Criterion, and deduces the conclusion. Finally, through an example of a complex multi-machine power system, the results of the optimal emergency control time calculation and the nonlinear simulation verify the conclusion of the relationship between the optimal emergency control time and the maximum and minimum amplitude time of power oscillation.
S0067	Research on the Influencing Mechanism of SV Message Transmission Process on the Accuracy of Digital Measurement System **Presenter: Fuchao Li** *State Grid Sichuan Electric Power Corporation Metering Center* Abstract: This paper studied the influence mechanism of sampled value(SV)message transmission process on the accuracy of digital measurement system in smart substations. The influence factors of SV message transmission process are analyzed firstly. Furthermore, a test device for time characteristics of SV message is developed which used to do Change of Absolute Delay of SV Messages The delay introduced by transformers, merging units and ethernet switches in the SV message transmission process is shown in Fig. 1. x1 x2 x3 experimental verification. Based on the research results, an effective test scheme and a corresponding technical standard is proposed.
S0022	Summary of Research on Intelligent Alarm Technology of Substation **Presenter: Fang Chen** *Univeristy of JiNan* Abstract: Alarm is one of the important application scenarios of intelligent technology in the operation of substations. The study of intelligent technologies such as expert systems, Petri nets, fuzzy set theory, and machine learning has great significance to promote the development of intelligent substations. This article briefly explains the basic concepts of the above-mentioned intelligent technology, introduces the research results of intelligent technology in the field of substation alarm and fault diagnosis, points out the problems in the current research institute and looks forward to the future development direction of this field.
S1010	Integrated Charging Facility and Fleet Planning for Shared Mobility-on-Demand System **Presenter: Min Tian** *North China Electric Power University* Abstract: Electric vehicle(EV)based shared Mobility-on-Demand(MoD)system plays an important role in energy saving, environmental protection and high quality of people travel. In this paper, a two-stage programming model is presented to determine the optimal size for the charging facility and fleet. The first stage of the programming model is planning the optimal size by minimizing the investment and operation cost of the city planners. Moreover, the second stage of the programming model optimizes charging scheduling, order dispatching, and vehicle rebalancing by minimizing the cost of MoD system and power system. The second stage problem is formulated as a linear programming(LP)model and solved by Gurobi solver. The first stage solves planning variables and the operation

	variables are determined by the second stage. Consequently, a simple iteration optimization method is applied since part of the parameters in the second stage are obtained from the planning variables. The numerical simulation experiments in case study are performed to demonstrate the effectiveness of this proposed integrated planning model.
S0027	Partition Method of Power System State Estimation Parallel Computing Based on Substations **Presenter: Fang Chen** *University of Jinan* Abstract: For distributed and parallel power systems state estimation, a partition method is proposed with the goal of minimizing the total computation time. Firstly, the structure of the gain matrix in the Weighted Least Squares(WLS)is analyzed. Secondly, in the processing of substations data based on sparse matrix technique, the calculating path is analyzed; According to the path set of calculation and the location of substations, a time-consuming model of distributed and parallel state estimation is established. Taking into account the balance of computational burden, time consumption and resource allocation, the method presented in this paper can give a better partition scheme, and simulation results turn out it is practical and easy to implement.
S0159	Fully Distributed Energy and Reserve Scheduling for Hybrid AC/DC Systems **Presenter: Rui Chen** *Wuhan University* Abstract: Purchasing reserve power in advance is an efficient approach to address intermittency of renewable energy. To promote renewables penetration level and increase cost-efficiency of bulk power system, a novel coordinated dispatch model for both energy and reserve based on conditional value-of-risk for hybrid AC/DC system is proposed in this paper. In addition, renewable generation and load centers locate separately in a large spatial range and usually are managed by different system operator. A fully distributed framework based on alternating direction method of multipliers(ADMM)is proposed in this paper to solve the schedule model in a decomposed manner, which guarantees low calculation burden and the privacy information of each sub system. Moreover, a dynamic penalty factor accelerated algorithm is proposed in this paper to enhance the decomposition method convergence and efficiency property. The effectiveness and robustness of proposed model and algorithm are validated through case studies based on a 2-area 6-bus system.
S1023	Hybrid Deep Learning Gaussian Process for Deterministic and Probabilistic Load Forecasting **Presenter: Pengfei Zhao** *University of Electronic Science and Technology of China* Abstract: Various hybrid load forecasting models have been proposed in recent years, but they generally assign weights to individual forecasting models for optimal combinations and without taking full advantage of the strengths of each model. In this paper, a hybrid

	Deep Learning Gaussian Process(HDLGP)model for short-term deterministic and probabilistic load forecasting(DLF and PLF)is proposed. This model merges the predictive power of artificial neural networks(ANN)and the ability to handle uncertainty of Gaussian Process(GP)by a composite kernel. Firstly, we design a multi-layer perception(MLP)neural network to learn high fluctuating load data. Then a GP with a composite kernel is incorporated to capture the residuals based on MLP so that further boost accuracy of DLF, meanwhile performing high-quality probability density estimation. Our model guarantees both reliability and sharpness of the PLF. Verifying our proposed model based on the realistically available data, it indicates that our model outperforms the other list approaches both in DLF and PLF.
S0217	Research on the development path and analysis method of electric energy substitution for the global energy interconnection **Presenter:Wei Wang** *State Grid Corporation of China* Abstract: Under the background of global energy interconnection, predicting and analyzing the development path of electric energy substitution has important theoretical and practical significance for the further promotion of electric energy substitution globally and the promotion of global electrification. This paper analyzes the influencing factors that affect the proportion of electric energy in the final energy and uses the combination method to predict and analyze the global electric energy alternative development route. First, in the context of the rapid development of a variety of renewable energy sources, electrical energy and hydrogen energy are analyzed and compared in terms of production, storage, transportation, and safety. Secondly, use factors such as GDP, economic structure, energy utilization efficiency, and total population level that may affect the proportion of electricity to construct a co-integration model of the proportion of electricity. Finally, according to the factors that influence the proportion of electric energy, multiple linear regression and trend analysis methods that have better effects in mid-term and long-term demand forecasting are selected for analysis, and combined with the variance-covariance (MV) method to construct a combined forecasting model to obtain a global electric energy alternative development route forecast figure, illustrating the development trend of the proportion of power terminals, and then uses the scenario analysis method to further analyze the proportion of power terminals in 2050.

Poster Sessions

2021 7/20 TUE

Poster Session 2 Venue: lobby@2F 2 楼大厅 Time: 10:00-12:00	
Paper ID	**Title & Author**
S0306	Energy Storage Allocation and Control Strategy for Fast Frequency Regulation of Regional Grid with High-Penetration Renewable Energy **Presenter: Jie Chen** *State Grid Huai'an power supply company* Abstract: Under the goal of peaking carbon dioxide emissions and achieving carbon neutrality, energy structure has advanced from traditional energy to renewable energy, but the inertia response and primary frequency regulation ability of the power system could be reduced by the high-penetration of renewable energy. The renewable energy unit requires the ability of primary frequency regulation, and energy storage is increasingly widely used in the power system containing renewable energy units. In order to solve the frequency regulation problem caused by high-penetration renewable energy, an Energy storage allocation and Control strategy suitable for fast frequency regulation of regional grid with high-penetration renewable energy is proposed by the paper. Firstly, frequency response characteristics of the power system under different permeability of renewable energy are analyzed. Secondly, an energy storage capacity allocation method based on the mean value method considering confidence is proposed. Thirdly, based on the proposed control strategy of high-penetration of renewable energy power system containing wind/solar/storage, the design of parameters such as frequency regulation dead zone is detailed. Finally, the model of renewable energy participating in primary frequency regulation response is built in Matlab/Simulink, and the performance index of primary frequency regulation is proposed. By analyzing the results, the conclusion is drawn that the renewable energy unit could quickly respond to the frequency fluctuation of the power system and the first "defense line"of the frequency regulation of the power system could be consolidated.
S1017	Cross-product Manipulation Model Considering Financial Transmission Rights and Virtual Bidding in Electricity Market **Presenter: Kaiyuan Yu** *North China Electric Power University* Abstract: Virtual biddings are financial positions which enables market participants to arbitrage by using the expected price difference between day-ahead price and real-time

	price. Due to the interaction between virtual bidding and other financial factors, some market participants may gain improper profits in other related markets by manipulating virtual bidding positions. Therefore, virtual bidding is not only an important market design, but also a risk that regulators need to face. Considering the relationship between virtual bidding and financial transmission rights, we establish a bi-level model of cross-product manipulation in two-settlement energy market. Karush Kuhn Tucker condition, dual condition and large-M method are used to transform the model into mixed integer linear programming model. Finally, the effectiveness of the model is verified by the simulation on a five bus system.
S1018	EV Fleet Charging Management Method Considering the Uncertainty of Passenger Travel Choice **Presenter: Jinran Guo** *North China Electric Power University* Abstract: Given that many countries have issued a series of policies to promote the development of electric vehicles(EVs), the amount of EVs is growing rapidly around the world. The charging behaviour of EVs is related to the transportation system, powergrid and passenger travel. Considering the uncertainty of passenger travel choice, we establish a EV fleet charging management method in this paper to optimize the dispatch of EV fleet and minimize the total system cost. On the one hand, we design the EV routing mechanism and charging scheduling strategy based on the traffic condition and the limit of charging stations. On the other hand, the uncertainty of passenger travel choice resulted from the consumer preference is also proposed in this model, which greatly affect the operation condition of EVs. In addition, a numerical case study is utilized to verify the effectiveness of the proposed model.
S0309	Research on Line Loss Improvement of Station Area in Distribution Network by Modular Photovoltaic Energy Storage System **Presenter: Kai Liu** *NARI Group Corporation* Abstract: Under the background of "carbon peak and carbon neutral", it is the general trend to promote the transformation of energy structure. The new energy power generation system represented by photovoltaic is developing rapidly. The mismatch between photovoltaic output and line load power will inevitably lead to the increase of line loss. The energy storage system that has both rapid power regulation and energy storage capacity is one of the effective means to improve the increase of line loss caused by photovoltaic access. Based on the in-depth analysis of the influence of photovoltaic system access on the line loss of the station area of distribution network, a modular photovoltaic energy storage system to improve the line loss of the station area in distribution network was constructed, and the research on the capacity configuration and coordinated control of the modular photovoltaic energy storage system was carried out in this paper. Finally, a typical line model of photovoltaic access station is constructed to verify the improvement effect of the modular photovoltaic energy storage system proposed in this paper on the line loss of station area in distribution network.

S0001	A Load Aggregator Management Information System for Energy Internet: Design and Application **Presenter: Lijuan Duan** *Tsinghua University* Abstract: Green development and efficient development will become the future direction of China's energy system construction, and a large number of new energy sources are connected to the power grid, which brings great challenges to the power grid dispatching. Resource aggregation is an important technical means to tap the flexible adjustment ability of urban integrated energy system resources to deal with the uncertainty of new energy output. Load aggregator is an important branch of integrated energy services of Energy Internet. Based on the analysis of the relationship between Load aggregator and other entities, the main business and user objects of La, this paper puts forward the typical architecture and core function design of LAMIS, which provides a reference for the construction of Load aggregator application system.
S1001	A Measuring Device for Energy Efficiency of Fan Unit Based on Wireless Data Transmission in Real-time **Presenter: Naili Guo** *National Institute of Measurement and Testing Technology* Abstract: Due to the limited range of application and low efficiency of the existing professional measuring devices for energy efficiency of fan unit, a new-type device to measure the energy efficiency of fan unit has been developed with real-time wireless data transmission for every measurement point. It has a main control computer and three assistant microcomputers as control and processing cores. Data acquisition equipments are composed of electrical power quality analyzer, air pressure sensors, temperature and humidity sensors and atmospheric pressure sensor, and data transmission relies on 485 communication and Zigbee wireless modules to solve the inconvenience of wired data transmission caused by long distance between power distribution cabinet and fan unit. Moreover, working statuses of fan unit and motor are respectively shown on two operation interfaces of upper computer, achieving dual purpose. The practical application in industrial enterprise has demonstrated its accuracy, stability and reliability. In addition, it can improve the testing efficiency.
S0066	A Peer-to-Peer Transaction Method for Clean Energy Considering Dynamic Network Fees and Safe Power Supply Capability **Presenter: Zhiguo Wu** *Sichuan University* Abstract: With the development of clean energy including hydropower, photovoltaics, pumped storage power stations, etc. , various power generation entities participate in the sale of electricity in the distribution network. Also, users are gradually diversified, forming a multi-buyer and multi-seller trading market. However, designing the network fee to support the grid recovery costs and a reasonable transaction model is a critical issue. This article discusses a peer-to-peer transaction method that considers dynamic network fees

	and safe power supply capability. First, a dynamic network fee model based on the power transmission distribution factor is established. Furthermore, proposing two continuous double auctions multi-round transaction mechanisms considering the dynamic network fee are proposed. The mechanism includes a real-time rolling network verification method and real-time calculation of safe power supply capability, as well as an update strategy based on the improved disappointment-regret avoidance theory. Finally, through data simulation, multilateral bidding transactions considering dynamic network fees can be effectively realized.
S0197	Clean Energy Included Transmission Price Determination Based on Bi-Level Optimization in Power Spot Market **Presenter: Wenqiao Xiao** *Sichuan University* Abstract: With the development of power transmission functions, the traditional method of establishing single electricity price based on the operating period method is challenging to adapt to the competitive market environment and affect the competitive efficiency in the future. Therefore, a bi-level optimization model for the two-part transmission price of dedicated project in the power spot market is introduced in this paper. The upper model is based on dedicated project and determines the highest energy price under the lowest level of the usage cost in the spot market. The energy price decision plan of the upper model passes to the lower model. The lower model is based on the power spot market. An optimal power allocation model is established to optimize the declared power of the sending end's unit participating in the power spot market of the receiving end. A clearing model that considers risk is established considering the transmission price at the receiving end and determine the output plan and clearing price of each unit and pass it to the upper model. In this way, the optimal structure of the two-part transmission price for the dedicated project is determined. The simulation results confirm that the proposed model can effectively intensify the operating efficiency of the power spot market and fair sharing of transmission costs.
S0012	Quantification Calculation Methods of Inertia Support Provided by New Energy Units **Presenter: Mengjun Wang** *China Electric Power Research Institute* Abstract: With the rapid development of new energy in the future, wind power and photovoltaics are introduced to replace the synchronous generators on the power generation side, which will bring great challenges to the security and stability of the power system. In this paper, two modes of providing inertia support for the power grid by new energy units are introduced firstly. Then the quantitative calculation method of the inertia provided in virtual inertia mode is proposed. Finally, the validity of the calculation method is verified in the IEEE 9-bus system, and the parameter sensitivities are analyzed at the same time. According to the proposed calculation method of inertia, the minimum equivalent moment of inertia that the new energy units need to have under different conditions can be clarified, which provides theoretical support for the arrangement of operation modes of the power grid.

S0230	Probability Prediction of Short-term Wind Power Based on Quantile Regression Forest and Variable Bandwidth **Presenter: Kunpeng Shi** *Beijing Jiaotong University* Abstract: Electric vehicles(EVs)can be used as load-side mobile energy storage resources to control the balance of power system supply and demand, so it is particularly important to evaluate the regulation capability of electric vehicle clusters. Firstly, this paper establishes an evaluation model for theregulation capability of EV clusters based on EV battery capacity limitations and user charging requirements. Secondly, after dispatching instructions from the power grid, the status of the electric vehicles at the station is classified. Thirdly, the time margin and the state-of-charge(SOC)margin are comprehensively considered to make dispatching plans for different status types of EVs. The regulation capability is dynamically updated in real time while tracking the dispatching instructions issued by the power grid. Finally, a simulation case of an EV cluster in an office area verifies the effectiveness of the EV cluster regulation capability evaluation model and grid dispatching strategy proposed in this paper.
S0241	Frequency Regulation of Thermal Power Units assisted by Battery Energy Storage System **Presenter: Qingsong Wang** *Southeast University* Abstract: At present, more and more renewable energy power are injected to the grid, as the main means of grid frequency regulation, the thermal power units(TPU)are facing severe challenges. Because the battery energy storage system(BESS)is very responsive, it can be used to assist the frequency regulation of TPU to reduce the pressure of TPU. In this paper, a novel operation principle is proposed, which uses the deep-seated cause of grid frequency fluctuation, the mismatch between load power and system output power, as the input signal of BESS. This signal has a quantitative relationship with the expected output of the d-axis current of the power conversion system. As a result, it's output power can be directly controlled to achieve the purpose of compensating the system power deviation and stabilizing the grid frequency.
S0243	Modeling and Stability Analysis of Multi-Parallel Grid-connected PCSs **Presenter: Qingsong Wang** *Southeast University* Abstract: Aiming at the resonant issue of multi-parallel grid-connected power conversion systems(PCSs), a method to suppress resonance spikes of the system is proposed, and the stability of the parallel system is studied. Firstly, the resonance characteristic of a single LCL-type PCS is analyzed, accordingly, the passive damping strategy with filter capacitor series resistor is introduced, and the stability of a single PCS based on the current control loop is studied. Then, the mathematical model of multi-parallel grid-connected PCSs system under the influence of grid impedance is established, and the amplitude-frequency characteristic curves are used to verify that the passive damping method can effectively restrain the resonant spikes generated by the coupling of multiple PCSs and enhance the

	stability of the system. Finally, by utilizing simulation, it is verified that the passive damping method has the characteristics of high reliability and strong ability to suppress resonance spikes.
S0244	Analysis of the Influence of Distributed Photovoltaic on Automatic Reclosing **Presenter: Qingsong Wang** *State Grid Hebei Electric Power Research Institute* Abstract: In order to study the influence of distributed photovoltaic on the automatic reclosing of the line, this paper analyzes the transient process and distributed photovoltaic output characteristics of the inverter during the reclosing action from the dynamic characteristics of the distributed PV phase-locked loop during the reclosing operation. Then according to the different matching degree of PV capacity and local load and different fault locations, the effects of PV access on reclosing are discussed respectively. Finally, the reclosing configuration method considering distributed PV access is given. The island protection action and the time when the circuit breaker is completely disconnected are considered in the reclosing time setting.
S0208	Review on Probabilistic Short-term Power Forecast **Presenter: Wenli Zhu** *Shanghai University of Electric Power* Abstract: Wind power, photovoltaic(PV)generation and loads are influenced by lots of factors, which causes different levels of errors existed in their forecast results. Compared with traditional point forecast methods, probabilistic forecast methods can quantize uncertainties in the process of forecast, provide more comprehensive and valuable probability distribution information for power system operation and control. To obtain a clearer development venation, this paper makes a unified review of wind power, PV generation and load power probabilistic forecast methods. Firstly, this paper analyzes the causes of forecast uncertainties, then summarizes the merits, demerits and applicable conditions of some probabilistic forecast processes and the common used models. After that this paper collects the popular evaluation indexes and existing evaluation mechanism. At the end, the future development directions of wind power, PV generation and load power probabilistic forecast is prospected.
S0261	Research on Big Data Query Optimization Method of Power System Substation Equipment Condition Monitoring **Presenter: Lixia Wang** *State Grid Liaoning Electric Power Co. , LTD.* Abstract: Power Internet of things is the application of Internet of things in smart grid, which will effectively integrate communication infrastructure resources and power system infrastructure resources, and provide important technical support for power grid generation, transmission, transformation, distribution, power consumption and other links. However, the existing scheduling algorithm has the problem that the node information level is not clear, which leads to the task span is too long. Therefore, a resource balancing scheduling algorithm of power Internet of things node based on big data is designed. Get

	the edge coefficient of power Internet of things node, release different degrees of pheromone according to the size of fitness function, extract resource scheduling characteristics, clarify the constraints between resources, sort the node information priority by big data, improve the task grouping scheduling strategy, set resource balanced scheduling module management function, and realize the algorithm design. Experimental results: compared with the other two existing scheduling algorithms, the average task span time-consuming of the designed scheduling algorithm is 83. 390s, 123. 300s and 124. 952s respectively, which proves that the scheduling algorithm integrated with big data technology has more perfect performance.
S0050	Research and Analysis on the Influence of Environmental Factors on the Leakage Current of CVT **Presenter: Sujie Liu** *State Grid Sichuan Electric Power Corporation Metering Center* Abstract: As an important primary equipment of the power system, the capacitive voltage transformer(CVT)directly affects the safe operation of the power grid and the fairness and justice of electricity measurement. Leakage current is an important parameter reflecting the insulation status of CVT. Due to the particularity of its structure, environmental factors will affect its insulation aging, which will lead to faults and defects. Based on the structure and working principle of CVT, this paper conducts a theoretical analysis of CVT leakage current generation principle and environmental influence factors, builds a simulation circuit diagram in Simulink, and deeply studies the influence of various environmental factors on CVT leakage current.
S0207	Research on Economic Dispatch of Intelligent Community to Promote New Energy Consumption **Presenter: Wenli Zhu** *State Grid Materials Co. Ltd.* Abstract: New energy generation forecasting, grid connection, consumption and other issues have become the development and research focus of the new energy industry. In order to study the comprehensive benefits of improving the capacity of new energy consumption in regional power grids, this paper explores the modes of different forms of load participation in demand response, establishes a demand response mechanism of power load, and puts forward the economic dispatch optimization model to promote the new energy consumption. The model takes into account the impact of the injection of new energy sources such as photovoltaics and wind power, with the goal of minimizing the total operating cost in order to achieve the goal of economic optimization. At the same time, on this basis, the safe consumption of new energy has been achieved.
S0218	Research on Maintenance Efficiency Optimization for the Catenary System of Electrified Railways **Presenter: Ding Feng** *Southwest Jiaotong University* Abstract: Traditional preventive maintenance schemes for catenary systems of electrified

	railways are mainly formulated by on-site managers with reference to previous maintenance records and experience. With the increase of the maintenance workload of catenary systems, traditional maintenance schemes have been unable to meet the highly efficient requirements for on-site maintenance strategies. In view of this, a maintenance efficiency optimization method is proposed. According to the sequence of maintenance work of catenary systems, the workflow model of catenary maintenance work is established. Then, by taking the maintenance resources as constraints and the shortest completion time of maintenance tasks as the optimization objective, the optimal allocation model of catenary system maintenance resources is established. Finally, the differential evolution algorithm is used to obtain the optimal maintenance scheme. Based on the field data of a railway bureau in China, the maintenance scheme of the catenary systems is optimized. The results show that this method can greatly improve the maintenance efficiency of the catenary systems compared with the on-site maintenance scheme, and can provide decision support for the formulation of the catenary system maintenance scheme.
S1020	Coordinated Optimal Operation for Building Microgrid Considering Hybrid Storage and Demand Response **Presenter: Lanxin Shao** *Zhejiang University* Abstract—The integration of photovoltaics(PVs)and hybrid energy storage system(HESS)in building microgrid has provided potential benefit for residents and system operator. However, the economic and reliable operation of building microgrid needs to consider the randomness and intermittent nature of PVs and loads. This paper proposes a two-level model predictive control energy management system(EMS)consider-ing HESS and demand response. The upper level problem aims at minimizing operational cost of building microgrid, and the lower level problem aims at eliminating power fluctuations. In addition, real-time energy price and demand charging costs are also included in the EMS issue. Simulation studies demonstrate the effectiveness of the proposed method.
S0240	Research on the Development of UHV DC Technology Standardization for Global Energy Interconnection **Presenter: Yu Zhang** *Global Energy Interconnection Development and Cooperation Organization (GEIDCO)* Abstract: The goal of global energy interconnection (GEI) is to construct a worldwide interconnected power grid, by which integrated clean and sustainable energy can be dispatched and distributed all over the world. More specifically, GEI aims to build a globally interconnected power grid for dispatching electricity generated by renewable energy worldwide. This goal has become a significant motivation for the academic and industrial fields of electrical and power engineering. An ultra-high-voltage (UHV) direct current (DC) technique is expected to play the most important role in creating the backbone for GEI and for performing considerable functions for long-range, high-capacity, and high-voltage transmission. The UHV DC approach has also significantly promoted development progress in regards to insulation, power electronics, communications, control, automation, etc. With

	the rapid progress made so far, an increasing number of urgent demands have emerged for the standardization of technologies. The present study provides explorations of the UHV DC standards and their systems. First, the background of this research is presented in the introduction. Then, the simultaneous progress in technology standards is discussed. Moreover, the demands for UHV DC standards, especially for the fast development of the GEI, are investigated. Subsequently, a future standard system is proposed, considering overall planning, facilities and examination, buildings, and maintenance. Finally, a feasible roadmap is provided.

Poster Sessions

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Poster Session 3 Venue: lobby@2F 2 楼大厅 Time: 15:00-17:00	
Paper ID	**Title & Author**
S0187	Locational Price Driven Electric Bus Fleet Operation and Charging Demand Management **Presenter: Shanyu Chen** *North China Electric Power University* Abstract: This paper studies the route assignments and charging scheduling of electric bus fleet under centralized control. Specifically, we optimize the charging scheduling decisions for the electric bus fleet to minimize the daily scheduling cost which includes the deadheading travel cost and charging cost. The charging cost is characterized by a time-varying locational pricing scheme. A mixed integer linear programing(MILP)model is formulated to efficiently solve the proposed fleet management and charging scheduling problem. Also, we provide a numerical case study based a real-world dataset to illustrate the effectiveness of the proposed model.
S0303	Multi-agent based Stochastic Programming for Planning of Fast Charging Station Integrated with Photovoltaic and Energy Storage System **Presenter: Jianzhou Feng** *Tsinghua University* Abstract: The rapid growth of electric vehicles(EVs)and the deployment of fast charging infrastructures bring considerable impacts on the planning and operation of power systems. Integrating the photovoltaic(PV)and energy storage system(ESS)with the fast charging station can alleviate the negative impacts and bring benefits to the power system and the charging service provider. In this paper, a planning method of fast charging station integrated with PV and ESS in urban area is proposed, while taking the influence of competitors, EV users' decision-making psychology, and the uncertainties of charging demand and PV power output into consideration. Firstly, a charging demand estimation method based on the average driving speeds and multi-agent simulation is proposed, considering the decision-making psychology and preferences of different consumers along with the competition of adjacent charging stations. Secondly, in order to deal with the uncertainties, a distributionally robust optimization(DRO)planning model based on the Wasserstein-metric is built to determine the capacities of PV and ESS. Finally, the proposed method is tested using real traffic data of Shenzhen City. Simulation results verify the effectiveness of the proposed method.

S0305	Cooperative Operation of Electric Power and Truck-Based Battery Transportation System with Electric Vehicles **Presenter: Wenjing Dong** *Xi'an Jiaotong University* Abstract: Electric vehicle(EV)shows great potential in promoting the renewable power integration and urban mobility decarbonization. The cleanliness of battery power supply side and the convenience of EV battery demand side are issues worthy of consideration. This paper proposes a cooperative operation method of electric power system(EPS)and truck-based battery transportation system(BTS)with EVs. The battery transportation problem is modeled with the battery delivery trucks(BTs)routing and loading with the transportation network considered. On this basis, the cooperative optimal operation model is formulated, in which, 1)depleted batteries can be centrally charged in charging stations(CSs)connected to the relatively clean energy generation, and 2)charged batteries can be transported to battery swapping stations(BSSs)located in the urban via BTs. EPS and BTS are coupled by the battery power and the collaborative optimization is established as a nonlinear mixed integer programming problem. The case studies have verified the effectiveness of the proposed model and demonstrated that the cooperation of battery charging and transportation has economic and sustainable benefits.
S0276	Short-Term Power Load Forecasting Based on HFEMD and GALSTM **Presenter: Ji Jin** *Wuhan University of Science and Technology* Abstract: To better capture the variation characteristics of short-term power load, a power load prediction method based on High Frequency Empirical Mode Decomposition(HFEMD)and Long Short Memory network optimized by Genetic Algorithm(GALSTM)is proposed. For non-stationary characteristics of short-term power load, HFEMD is employed to decompose the load sequence in a high precision, and the selection to frequency and amplitude of high frequency inharmonic signal for HFEMD is researched. Then GA is adopted to optimize the structure parameters of LSTM model. The experiments of one-step and multi-step prediction on actual load data in some area in US is executed. HFEMD can effectively improve the mode mixing problem of EMD and avoid the unnecessary components of EEMD caused by assisted white noise. Meanwhile, the proposed model can better excavate the variation characteristics of power load and enhance the forecasting accuracy for short term power load.
S0259	Noise Cancellation of a Train Electric Traction System Fan Based on a Fractional-Order Variable Step Size Active Noise Control Algorithm **Presenter: Gang Xiao** *Jiangxi University of Applied Science* Abstract: To improve the convergence performance of an integer-order active noise control algorithm and achieve the noise cancellation of a train electric traction system fan, in this research, an active noise control algorithm based on a fractional-order variable step size was proposed. This algorithm introduced fractional calculus to control the iteration of the

	filter weights and to optimize the variable step size in order to improve the algorithm convergence process. The simulation results showed that the algorithm was superior to the conventional algorithm in terms of the performance of the convergence speed, steady-state error, and error attenuation. Consistent with the simulation results, this algorithm showed good performance in the half physical simulation. The results showed that this algorithm had a good noise-cancellation effect on the fan noise of the train electric traction system.
S0115	Fast AC Loss Calculation for Superconducting High Capacity Power Transmission Line **Presenter: Wenbo Xue** *Shanghai Jiao Tong University* Abstract: The high temperature superconductor(HTS)CORC cable shows a great advantage on high-capacity power transmission. AC loss in HTS can considerably affect the efficiency of HTS cable during operation, which has to be calculated accurately in the cable design. The high capacity CORC cable often has dozens of HTS tape in parallel, which leads to a great challenge for the 3D electromagnetic modeling. This study is to conduct a fast AC loss calculation on the CORC cable by applying simplified 2D models, meanwhile, the results have enough accuracy for engineering applications. Two 2D simplified electromagnetic models based on H-formulation is developed for the AC loss calculation of CORC cable. Their accuracy is studied in detail by comparing with 3D models. The results show that air gap is the most important factor in the magnification loss calculation of CORC cable. In the simplified 2D models, the air gap should be the same with the physical one, which can significantly reduce the discrepancy. The 2D models are more accurate at high applied magnetic fields, and the discrepancy increased rapidly with decrease of applied fields. This study is useful for the fast and accurate AC loss calculation of high capacity HTS CORC cables.
S0174	Research on ELM-Based Fault Diagnosis of AC Filter Circuit Breaker in Converter Station **Presenter: Jiayu Kang** *Shanghai Jiao Tong University* Abstract: In the high-voltage DC transmission system, the converter station is a site established to complete the conversion of AC and DC power. Whether the AC filter can operate stably will directly affect the reliability of the DC transmission system. At the same time, AC filter also have higher fault rate than other circuit breakers in the converter station. If the operating conditions of the AC filter can be predicted to a certain extent and hidden dangers can be removed in advance, serious accidents such as fault trips can be avoided to a large extent. This paper proposes a fault early warning method of AC filter circuit breaker based on the extreme learning machine(ELM). Taking a converter station in Northwest China as the background, analyze the recorded waveform of the AC filter. The opening and closing current of the circuit breaker and the corresponding operating conditions when the AC filter is switched on and off are extracted, establishing a learning training library and verifying its effectiveness. The influence of different activation functions and the number of hidden layer nodes on this method is discussed. Finally, the fault diagnosis performance of intelligent learning methods such as BP neural network, RBF neural network and genetic RBF network is compared.

S1012	Diagnosis Method of AC Filter Circuit Breaker in Converter Station Based on RBF Neural Network and Expert Experience Method **Presenter: Shenxi Zhang** *Shanghai Jiao Tong University* Abstract: In the DC transmission system, due to the limitations of technology, a large number of harmonics will be generated and reactive power will be consumed when the converter performs current conversion. In order not to burden the power grid, each converter station will automatically put in the corresponding AC filter bank on the AC side according to the transmission power during operation. To analyze the fault information of the circuit breaker in time, this paper proposes a fault diagnosis method for the AC filter circuit breaker of the converter station based on the combination of RBF neural network and expert experience method. For fault diagnosis based on RBF neural network, the recorded waveform of AC filter circuit breaker is used as input, and the judgement of whether the waveform is abnormal is used as output. For fault diagnosis based on expert experience method, an expert experience library is established, and the waveform of the AC filter circuit breaker is also used as the expert diagnosis input, whether the waveform is abnormal is used as the output. It is mainly based on the threshold of the current difference, the failure threshold of the closing resistance, etc. to determine whether the AC filter circuit breaker has a potential fault. The example results show that this method can find the potential fault information of the AC filter circuit breaker and issue an early warning before the protection device operates.
S0077	Research and Application of Diamond Distribution Network Self-healing System **Presenter: Yuanbing Xiao** *Shanghai Municipal Electric Power* Abstract: A self-healing system based on double-loop network connection mode is proposed in order to further improve the power supply reliability of 10kV distribution network. The model has good distributed generation(DG)access and low-carbon environmental characteristics. Firstly, this study analyzes the advantages of diamond distribution network, focuses on the structure and configuration of self-healing system. Moreover, expounds its principle from the aspects of protection action strategy, device function development and cooperation with original protection. The reliability and accuracy of the self-healing system are verified by dynamic model test and on-site joint adjustment results. Finally, as a consequence, some problems and solutions encountered in the process of installation, commissioning and operation and maintenance are summarized, which can provide some reference for the promotion and application in the future.
S0205	Optimal Electric Bus Fleet Charging Scheduling Considering Passenger Flow **Presenter: Jinran Guo** *North China Electric Power University* Abstract: Transportation electrification has played an important role in reducing CO2 emissions and mitigating environmental problems. Meanwhile, battery electric buses(BEBs)are growing rapidly due to their energy conservation and quietness. This

	paper presents a battery electric bus fleet charging scheduling method to optimize the operation of BEBs. According to the total cost minimization of BEB fleets, a charging load management method is proposed to optimize the spatial-temporal distribution of BEB charging load. Besides, we consider the influence of passenger flow and road condition on the power and transportation system, which greatly affect the real travel and charging behavior of BEBs. In addition, several cases are designed to estimate the performance of BEB charging scheduling model. The results verify the effectiveness of BEB fleet charging management scheme.
S0220	Method Development for Electric Vehicle-based Virtual Power Plant to Provide Secondary Frequency Control **Presenter: Xinhui Lai** *North China Electric Power University* Abstract: At present, virtual power plant has been widely proposed to provide the frequency modulation service in power systems. Therefore, it is necessary to develop a method of secondary frequency modulation by virtual power plant. Firstly, the framework of the virtual power plant participates in the system frequency modulation is introduced. Secondly, the allocation strategy of the frequency modulation capacity considering the state of charge of each electric vehicle in the virtual power plant is proposed. Finally, the effectiveness of the control strategy is verified by MATLAB/Simulink simulation, which shows that the proposed strategy can guarantee the system frequency fluctuation less than 0. 1Hz.
S0119	Analysis of AC/DC Side Harmonic Interaction of Back-to-back VSC Based SNOP **Presenter: Kang Fu** *Xi'an Jiaotong University* Abstract: Soft normally open point(SNOP)is power electronic device installed in place of normally-open point(NOP)in electrical power distribution networks. The application of SNOP has the potential to improve the power supply reliability and power quality of distribution network. Background harmonics in the distribution network will cause abnormal fluctuations in voltage and current. Based on the working mechanism of SNOP, this paper analyzes the generation process injection of harmonics will cause fluctuations in grid voltage and current, which will have a great impact on the SNOP control loop. Therefore, studying the mutual influence of harmonics on the AC side and DC side of SNOP is of great significance for selecting suitable filtering measures. of harmonics on the AC and DC side of SNOP. The correctness of the proposed analysis is demonstrated through simulation results.
S0139	A Novel ISOP SCDAB-CLLLC Hybrid Bidirectional DC-DC Converter for Renewable Energy DC Grid **Presenter: Yichen Wang** *Xi'an Jiaotong University* Abstract: In this paper, a novel ISOP(input series and output parallel)hybrid DC-DC converter is proposed for renewable energy grid, which consists of a CLLLC resonant

	converter and a switched capacitor dual active bridge(SCDAB). This paper analyzes the power characteristics, steady-state operation and average model of the proposed converter. The parameter calculation method of this converter is also presented. Moreover, the proposed converter adopts a hybrid control scheme of pulse frequency modulation control and single-phase-shift control. To verify the effectiveness of the proposed converter and control scheme, a simulation prototype of this converter is built up in PLECS.
S0140	Research on High Efficiency and High Power Density Power Electronic Transformers Based on Sic Devices **Presenter: Yichu Li** *Xi'an Jiaotong University* Abstract: The high-voltage isolation bidirectional DC/DC converter module is the main link in the voltage isolation and conversion of power electronic transformers. In order to reduce module switching losses, improve system efficiency, reduce the footprint and control complexity of the power conversion part, an LC series resonance topology based on SiC mosfet is used to design power electronic transformer power modules. The gain characteristics of the LC series resonance structure are analyzed, the main parameters in the circuit are designed, and the prototype design is completed based on the SiC power device, and finally the simulation verification is carried out. The simulation results show that the operating characteristics of the LC series resonant DC/DC converter based on SiC mosfet are consistent with the traditional full-bridge bidirectional DC/DC converter, and the mosfet loss accounts for only 8. 2%, which effectively reduces the switching loss of the module.
S0141	A Novel Asymmetric Duty Modulation Control of Dual-Active-Bridge for LVDC Applications **Presenter: Xinyu Cui** *Xi'an Jiaotong University* Abstract: As a traditional dual-active-bridge(DAB)converter control strategy, phase-shift(PS)control has some defects, including the large root-mean-square(RMS)value of current stress when the voltageson both sides mismatch. Therefore, asymmetric duty modulation(ADM)control is introduced, which can effectively reduce the(RMS)current and improve the efficiency of DAB. However, the influence of the backflow power is seldom considered in the research of ADM control. Subsequently, in this paper, compared with the conventional ADM control, a novel ADM control scheme is proposed, where the backflow power grows down substantially. In the meanwhile, there exists tremendous RMS value of current stress in DAB when operating under EPS control. Aforementioned modified ADM control can retard the RMS value of current stress gradually. Finally, the effectiveness of the proposed control scheme is verified by simulation results.
S0142	A Novel Topology of Three-Port DC-DC Converter with Improved Carrier Phase-Shifted Control for MVDC Applictions **Presenter: Ruixin Xu** *State Grid Shanxi Electric Power Company* Abstract: With the advancement of DC/DC power transmission technology, various DC/DC

	topologies are proposed, promoting the efficiency in power delivery and energy conversion dramatically, for example, Dual-Active-Bridge(DAB)converter. Aiming at the MVDC applications, this paper proposes a novel topology of DC/DC converter which consists of modular multilevel converter on the primary side and double full bridges on the secondary side. Based on carrier phase-shift modulation, the primary side produces a five-level waveform to decrease the instant voltage impact on switches and realize the stable power transmission. In order to retard the losses brought by circulating current, the individual capacitor voltage is chosen for outer loop to produce reference value. Eventually, the effectiveness and correctness of this topology and corresponding control methods are verified by the results in MATLAB/Simulink.
S0161	Auction Based Distributed and Optimal Trading Mechanism in Electricity Markets under Blockchains **Presenter: Yu Fu** *Beijing Institute of Technology* Abstract: Auction mechanisms have been widely applied in the electricity market for determining the market price and energy trading. Those who take demand response into consideration are promising to enable interaction of end-users with the grid. In addition, blockchain is an effective way to secure the energy trading in the electricity market. In this paper, a new pricing mechanism based on auction is proposed to induce users to participate actively with the goal of social welfare maximization and to reduce the storage burden of blockchains. In this mechanism, each user submits individual bids to the system/auctioneer. The auctioneer makes optimal allocation with respect to the submitted bidding profile and broadcasts the market price to all the participants. To obtain the optimal trading strategy, an energy distribution algorithm is proposed. In this algorithm, each individual user updates its best response with respect to the market price, which is determined by the set of previous bidding curves. The expected system price determines the user's best response while the resulting load pattern will change this price reversely.
S0162	Design of a Dual Channel High Current Silicon Carbide MOSFET Driver **Presenter: Zheng Zhi** *Xi'an Jiaotong University* Abstract: In recent years, the technology of wide bandgap devices has developed rapidly, and its utilization rate in various power electronic devices is also higher and higher. Among them, SiC MOSFET has the advantages of high temperature resistance, high voltage resistance and fast switching, so it has been widely used in various topologies. However, higher switching frequency and various driving interference factors make the driver module of SiC MOSFET need higher quality. In order to make better use of SiC MOSFET and ensure that it can switch stably in the circuit, it is necessary to study the design method of SiC MOSFET Driver. This paper presents a design scheme of SiC MOSFET driver module which is suitable for dual channel high current condition. The driver has DC/DC isolated power supply, under voltage protection and short circuit protection. It provides+15V/-5V driving voltage, dual channel output, switching delay time of about 50ns and peak current of 14A. The schematic diagram of driving and main circuit is drawn, the experimental

	platform is built, and the effectiveness of the design scheme is verified by experiments.
S0177	A DC Fluctuation Suppression Control Strategy for Isolated DC Microgrids Based on Linear Active Disturbance Rejection Control(LADRC) **Presenter: Haoyu Wang** *Xi'an Jiao Tong university* Abstract: This paper introduce a control strategy based on liner active disturbance rejection control to reduce the DC fluctuation in DC microgrid. A brief introduction of DC microgrid is presented, and the advantage of isolated storage port is claimed. Later, this paper explains the small signal model of dual active port. The basic working principle of LADRC is analyzed, the mathematical expression of extended state observer(ESO)is explained. Combining the small signal model of DAB, a simulation in Matlab/Simulink verifies the advantage of the proposed control strategy.
S0315	Research on Loop-closing Strategy of Two-way Active Distribution Network Based on Power Flow Controller **Presenter: Can Su** *State Grid Hebei Electric Power Research Institute* Abstract: The distribution network in China is mainly closed-loop designed and open-loop operated. Loop-closing operation is often taken to improve the reliability of power supply. However, due to different line lengths and loads on both sides of the circuit, the amplitude and phase of voltages at both ends would be different. The accompanying short-term power outages, circulating currents, and transient processes may cause unnecessary shocks to the system. To solve this problem, a loop-closing control strategy based on power flow controller is proposed in this article. Simulation results show that the proposed control strategy can effectively reduce the loop closing current.

Poster Sessions

2021 7/21 WED

Poster Session 4 Venue: lobby@2F 2 楼大厅 Time: 10:00-12:00	
Paper ID	**Title & Author**
S0312	Research on Double-Layer Coupling Voltage Regulation Strategy for Distribution Network Containing High Permeability Distributed Generation **Presenter: Shaobo Yang** *State Grid Hebei Electric Power Research Institute* Abstract: The penetration rate of distributed power sources in the distribution network continues to increase, and the problem of voltage limit violations in the distribution network has gradually become prominent. This paper combines the linearization method and the voltage sensitivity to propose a two-stage linearization voltage regulation strategy. In the first stage, the optimal voltage regulation model is established. Aiming at the problem that the traditional model is difficult to solve by non-convex and nonlinearity, this paper analyzes the influence of transformer taps and distributed power reactive power on network loss and node voltage, and constructs linearized voltage regulation. The model effectively reduces the calculation complexity and calculation time of the optimization problem. In the second stage, in view of the uncertain factors in actual operation, an in-situ compensation based on droop characteristics and a comprehensive voltage adjustment strategy based on voltage sensitivity are proposed. Based on the linearized scheduling results of the first stage, the output of photovoltaic power is reproduced. The regulation ensures the robustness of the voltage regulation algorithm, and the effectiveness of the method proposed in this paper is verified through case analysis.
S0015	Optimal Operation Method of Virtual Power Plant Considering Power Deviation Rate **Presenter: Kailing Chen** *State Grid Shanghai Economic Research Institute* Abstract: Due to the difference and uncontrollability of distributed energy, it has become an important challenge for virtual power plant to achieve low power deviation rate as conventional power plant. Therefore, starting from the specific connotation of the power deviation rate of virtual power plant, the objective power curve and power baseline are described in detail. Additionally, taking into account the power deviation rate, economy and environmental protection of the virtual power plant, a multi-objective virtual power plant optimal scheduling model is constructed with consideration of the operation constraints of wind power, photovoltaic, energy storage, electric vehicles and other distributed generation

	and their complementary relationship. In view of the complexity of the model, the linearized model is transformed into a mixed integer linear single objective optimization model, which is solved by GAMS. The results show that the capacity and charge discharge rate of the energy storage system are the main factors affecting the power deviation rate of the virtual power plant. Considering the power deviation rate in the optimal operation can give full play to the role of peak shaving and valley filling of the virtual power plant, and realize the friendly grid connection of the distributed power sources.
S0202	An IGDT-based Day-ahead Optimal Energy Scheduling Strategy in a Virtual Power Plant **Presenter: Xingyu Yan** *Southeast University* Abstract: As grid-connected variable renewable energy(VRE)increases, especially in the distribution network, dealing with the uncertainty, variability, and consequently flexibility requirements is becoming an urgent challenge to the power system operators. Virtual power plant(VPP)can group different kinds of small-scale distributed energy resources(DERs), which are usually unseen by the system operators, as a single unit to participate in energy markets and system management. Therefore, an optimal energy management problem of a VPP is addressed in this paper for energy and operating reserve(OR)scheduling. The studied VPP is a cluster of dispersed generating units(including dispatchable and stochastic power), flexible loads, as well as storage units. Since the uncertainty could come from the stochastic power production, load demand, and electricity price, information gap decision theory(IGDT)is applied in the unit commitment procedures to minimize the VPP operating cost to deal with price uncertainty, while both power production and load forecasting uncertainties are covered by OR services. Finally, the proposed method is applied with a case study, and optimal decisions are investigated.

Online Sessions

2021 7/20 TUE

Online Session 1: S2. Power System Protection
Session Chair: Dr. Peng Wang, University of Electronic Science and Technology of China
Room ID: 97564318768
Zoom Link: [https://zoom.com.cn/j/97564318768] Password:ICPS2021
Time: 09:30-12:15

Time	Paper ID	Title & Author
9:30-9:45	S0044	Power Restoration Method of Distribution Network with ESS and DG **Presenter: Shoujing Sun** *Shandong University* Abstract: A restoration method of distributed power supply in power grid with energy storage system is proposed. First, it introduces the principle of distributed access and operation constraints of ESS and DG in the distribution network. Utilizing the parallel coordination and information interaction between independent and peer intelligent terminals in the distribution network, the power restoration method is adopted, which mainly includes two parts: distributed network topology search and expression and calculation of constraints on power restoration. It not only exerts the advantages of ESS in power restoration, but also avoids the problems of large amount of information collection and large amount of calculation in the centralized power restoration method in the distribution network. At the same time, consider the ESS power control adjustment strategy to achieve reasonable power support for the distribution network to expand the scope of power restoration in the power outage area. The simulation results of the IEEE33-bus system example verify the flexibility and effectiveness of the proposed method.
9:45-10:00	S0219	Transient Overvoltage Analysis of Wind Farm PCC Caused by HVDC Commutation Failure under Different Faults **Presenter: Lin Pei** *North China Electric Power University* Abstract: Commutation failure is one of the most common events in line-commutated converter high voltage direct current (LCC-HVDC) transmission systems. During the commutation failure period, an transient overvoltage will be generated in the sending AC system, posing a serious

		threat to the stable operation of the new energy power grid. Aiming at this problem, this paper uses the PSCAD platform to establish an electromagnetic model of the power system including DC transmission lines and doubly-fed wind turbines. Under the same fault location, by applying three-phase fault and single- phase fault at different times, the transient overvoltage peak value at the wind turbine port during the commutation failure period is compared. The simulation results found that the peak value of transient overvoltage is related to the moment of fault occurrence, and when a fault occurs at some point in a system cycle, the transient overvoltage peak caused by the single-phase fault is more serious than that caused by the three-phase fault. According to the analysis of the simulation results, this phenomenon has a great relationship with the transient reactive power characteristics of the rectifier during commutation failure.
10:00-10:15	S0085	Non-intrusive Load Event Detection and Identification Algorithm for Concealed Power Consumption of Railway Signal Power System **Presenter: Shuangqing Lu** *Shandong University* Abstract: Railway signal power system supplies power to all kinds of signal equipment, which belongs to the first level power load and requires high reliability and continuity of power supply. In view of the potential hidden power consumption problems, non-intrusive load monitoring (NILM) can realize the identification of illegal electrical appliances. This paper uses an improved bilateral CUSUM event detection algorithm based on sliding window, In variable length transient event detection and recognition window Wdr the minimum interval variance algorithm is used to determine the start and end points of the event, and the method of determining the threshold is improved, the multi start process of the event is considered as well. Then SVM model after second order particle swarm optimization is used to identify the load of switching events. Finally, compared with other event detection and load identification algorithms, this algorithm has higher detection and identification accuracy, stronger stability, and is more suitable for railway concealed power monitoring.
10:15-10:30	S0058	Fault Detection Method for Intelligent Distribution Network Based on Protected Element Model **Presenter: Zeqian Wang** *Shandong University* Abstract: The intelligent distribution network allows a large number of DGs to access. Under the influence of complex fault characteristics of DG and its control strategy, it is difficult for longitudinal comparison principle protection based on fault direction to reliably judge the fault sections. A fault detection method based on protected element model is proposed. This method no longer starts with analyzing the fault characteristics of DG, but takes the

		mathematical model of the protected object as the breakthrough point. Firstly, an appropriate physical quantity can be defined based on the mathematical constraints of the model. Then, by analyzing the variation law of the defined physical quantity under both the internal and the external fault of the model, the integrity of the model can be judged, which can be used as the basic information for pilot protection to constitute the corresponding fault judgment method. In this paper, the operation voltage is taken as the physical quantity to judge whether the model is intact, and the setting principles of the impedance in operation voltage method is analyzed in detail, so that the method proposed can adapt to the operating characteristics of intelligent distribution network. Simulation results show that the method proposed in this paper is basically not affected by the fault characteristics of DGs, and the comparison of the longitudinal logical results can accurately identify the fault section.
10:30-10:45	S0072	Prediction of Power Grid Emergency Material Resources under Meteorological Disasters **Presenter: Liangping Hu** *Shandong University* Abstract: Power Grid accidents caused by sudden natural meteorological disasters have the characteristics of suddenness, complexity and uncertainty. In order to improve the efficiency of power grid emergency repairs, a method for predicting emergency material resources under the conditions of power grid meteorological disasters combining case-based reasoning, deep belief network and deep learning is proposed. This method is based on meteorological data, power grid maintenance data and geographic environment data. At the same time, the method uses case-based reasoning to determine the appropriate input and output structure of the prediction model, and uses different methods to process and quantify according to the characteristics of disagreeing input factors. Use deep belief networks to complete case adaptation, and integrate accident scale information to establish a dynamic power grid emergency material resources prediction model. The analysis result shows that the emergency material resources prediction method proposed in this paper can analyze various characteristic factors comprehensively, and combine the scale of the accident to establish the relationship between the emergency material resources demand of the power grid, and accurately predict the material demand for the emergency response of the power grid under the weather disaster, and provide a scientific reference for emergency response of power grid.
10:45-11:00	S0065	Longitudinal Protection Method for AC/DC Hybrid System Based on Measuring Current Similarity **Presenter: Hongzhe Zhang** *Shandong University*

		Abstract: When a fault occurred on the tie line of the AC/DC hybrid system, the change rule of the current on the DC side is different from that of the traditional infinite AC power source. Traditional relay protection methods may meet the problem of low sensitivity and reliability. A longitudinal protection method for AC/DC hybrid system based on measuring current similarity is proposed. The method bases on the conclusion that the waveform characteristics of the measuring current at both sides of the line are different in the case of internal and external faults, determine the fault location through the Bhattacharyya distance method. The simulation results of PSCAD model show that the scheme in this paper can accurately identify the fault of the tie line of the AC/DC hybrid system, and has high reliability and good applicability.
11:00-11:15	S0076	Power Supply Network Topology Identification Based on Smart Meter Data **Presenter: Xuanzheng Hu** *Shandong University* Abstract: In this paper, a method of power supply network topology identification based on iterative principal component analysis (IPCA) and voltage correlation analysis (VCA) is proposed. This method is based on the principle of conservation of electric energy, that is, the electric energy measured by the superior electric meter is equal to the sum of the electric energy measured by the subordinate electric meters connected below it, and the topology of the power supply network is modeled as a linear model among the electric energy of each electric meter. IPCA is used to estimate the model constraint matrix and calculate the error covariance matrix of the electric energy measurement value. The error covariance is used to modify the model constraint matrix. Finally, the regression matrix is obtained according to the model constraint matrix, and then the correlation matrix is obtained to identify the low-voltage power supply network topology.
11:15-11:30	S0078	New Protection Method for High-voltage Transmission Lines Based on Traveling Wave Energy Comparison **Presenter: Hao Kong** *Shandong University* Abstract: To improve the reliability of conventional protection using fault travelling wave, a new method based on the energy comparison of fault voltage direction traveling wave is proposed. The high frequency band energy of voltage travelling wave is obtained based on S-transform after the occurrence of the fault. The ratio of the backward travelling wave energy and the forward travelling wave energy on the same side of transmission line is used to construct the protection judgment. For the external fault, the energy ratio of the side close to the fault is less than 1, and the energy ratio of the side far away from the fault is greater than 1. For the internal fault, the energy ratio on both sides is greater than 1. Then the external and the internal fault

		can be identified obviously. Using PSCAD/EMTDC for simulation verification, the results show that the proposed method has good adaptability, fast operation speed and high reliability. Its performances are immune to fault location, fault inception angles and grounding resistance.
11:30-11:45	S0061	Fault Component Differential Protection of DC Bus in Flexible DC Distribution Network **Presenter: Hao Guo** *University of Jinan* Abstract: At present, the bus protection of the flexible DC distribution network refers to the AC protection scheme basically, and the existing bus protection methods cannot remove the fault quickly and accurately. In order to achieve reliable and fast protection of bus fault in flexible DC distribution system, the fault characteristics of the DC bus in the flexible DC distribution network are analyzed firstly, and then the principle of fault component differential protection is studied, and a fault component differential protection of DC bus in flexible DC distribution network is proposed. The effectiveness of the proposed scheme is verified by PSCAD/EMTDC simulation. The simulation results show that the proposed protection scheme has excellent performance of fast operating and against transition resistance.
11:45-12:00	S0007	A Combination Method for PV Output Prediction using Artificial Neural Network **Presenter: Xi Wang** *Shandong University* Abstract: Photovoltaic power generation and grid-connected technologies are being used more and more widely. The accurate prediction of photovoltaic power generation can be beneficial to the stable operation of the power grid. An improved method for predicting the output characteristics of photovoltaic cells based on the combination of BP neural network and Elman neural network in different weather is proposed. Compared with the traditional BP network, a context layer is added to Elman, thereby reducing the number of iterations and reducing the amount of calculation. According to the method of using artificial intelligence in irradiance, the weather is divided into two categories. The first category is that the irradiance fluctuates more severely, and the second category is that the irradiance is relatively flat. According to the experiment, the prediction errors of the two neural networks are analyzed using the error function. In the weather with severe irradiance fluctuations, the prediction results of the BP neural network are more accurate, and in the weather with lower irradiance, using ELMAN neural network is more accurate. This paper proposes that the combined model based on different weather can be more reliable and accurate, and accurately predict the output characteristics of the photovoltaic system, which is very helpful for improving the security and stability of the power grid.

12:00-12:15	S0200	A BCS-GDE Algorithm for Multi-objective Optimization of Combined Cooling, Heating and Power Model **Presenter: Jiahui Deng** *Northwest University* Abstract: District energy systems can not only reduce energy consumption but also set energy supply dispatching schemes according to demand. In this paper, the combined cooling heating and power economic emission dispatch (CCHPEED) model is established with the objective of economic cost, primary energy consumption, and pollutant emissions, as well as three decision-making strategies, are proposed to meet the demand for energy supply. Besides, a generalized differential evolution with the best compromise solution processing mechanism (BCS-GDE) is proposed to solve the model, also, the best compromise solution processing mechanism is put forward in the algorithm. In the simulation, the resource dispatching is performed according to the different energy demands of hotels, offices, and residential buildings on the whole day. The simulation results show that the model established in this paper can reduce the economic cost, energy consumption, and pollutant emission, in which the maximum reduction rate of economic cost is 72%, the maximum reduction rate of primary energy consumption is 73%, and the maximum reduction rate of pollutant emission is 88%. Concurrently, BCS- GDE also has better convergence and diversity than the classic algorithms.
Lunch Time		

Online Session 2:S6. Special Session>a. Emerging Power Electronics&b. Planning and Management of Flexible Resources
Session Chairs: Dr. Sidun Fang, The Chinese University of Hong Kong
Dr. Minghao Wang, The Hong Kong Polytechnic University
Room ID: 94976900821
Zoom Link: [https://zoom.com.cn/j/94976900821] Password:ICPS2021
Time: 09:00-10:30

Time	Paper ID	Title & Author
9:00-9:15	S0083	Distributed Optimal Dispatch of Regional Integrated Energy System Considering Electricity-Gas-Heating **Presenter: Wenzhao Nie** *Jinan Power Supply Company, Shandong Electric Power Company* Abstract: Taking account of day-ahead dispatch of electricity-gas-heating regional integrated energy system, the active power flow model of distribution network, heating network transmission equation and natural gas network model with the consideration of dynamic characteristics of natural gas are first established. Then, a day-ahead dispatch model is established aiming at minimizing the system economic cost. Considering the privacy and opacity of information between electricity-gas-heating entities, based on improved alternating direction multiplier method, a distributed optimization scheduling method is proposed. The augmented Lagrange function of the whole system is decomposed into three sub-problems of electricity, natural gas and heating for iterative solution. Finally, case study verified the effectiveness and validity of the proposed model and optimization method.
9:15-9:30	S0137	Uncertainty Quantification of Loads and Correlated PVs on Power System Dynamic Simulations **Presenter: Ketian Ye** *Mississippi State University* Abstract: This paper proposes a copula-based polynomial chaos expansion(PCE)framework for quantifying correlated uncertain PVs and loads on power system dynamic simulations. The correlations among uncertain PVs are first extracted by copula statistics and further included into the revised PCE formulation. The PCE allows us to conveniently estimate the confidence intervals of system dynamic responses. The effects of different dependence structures of PVs and the number of uncertain sources are investigated using the modified IEEE 39-bus system. Comparison results with other methods show that the proposed method is able to accurately quantify the uncertain dynamic simulations while being computationally efficient.
9:30-9:45	S0172	Research on Accommodation Method of High-Proportion Distributed Photovoltaic Based on Energy Storage Management **Presenter: Huang Wandi**

		The Chinese University of Hong Kong Abstract: With the continuous increase of photovoltaic(PV)penetration rate in the distribution network, the safety and economic capacity of the distribution network have been weakened by the intermittent, random and volatility of PV output. The use of battery energy storage(BES)can alleviate those above-mentioned adverse effects to a certain extent. This paper proposes an accommodation method of high-proportion distributed photovoltaic based on energy storage management. Firstly, based on the historical data of PV output, using K-means clustering method to generate typical scenarios of PV output. Secondly, take the conditional value at risk (CVaR) of the solar power curtailment value as the objective function to establish a PV accommodation promoting model based on energy storage management. Constraints mainly include power flow, branch power load, nodal voltage, branch current and limits of BES. By linearizing the objective function and transforming the second-order cone of the power flow equation, the model can be directly solved based on the commercial solver Gurobi. In this paper, a modified IEEE 33-bus system example is used to verify the feasibility and effectiveness of the proposed method.
9:45-10:00	S0084	Optimal Utilization Strategy of Integrated Energy for Commercial Users Based on CCHP Coupling **Presenter: Encheng Dong** *Shandong University* Abstract: Aiming at the optimal utilization problem of integrated energy for commercial users, the stepped utilization of energy was firstly analyzed in typical combined cooling, heating and power(CCHP)systems. Secondly, considering the coupling structure of the system and energy utilization characteristics of commercial users, a physical framework of integrated energy system(IES)was set up for multi-energy optimal utilization. Devices of energy production, conversion and storage was modelled on the source side, and meanwhile, on end-user side, load models were built according to space cooling, space heating, hot water and electric. Then, taking into account the time-of-use and costs of operation and maintenance, a mathematical model of IES optimal utilization was established, which was solved by YALMIP/Gurobi. Finally, Case study proves the economy and effectiveness of the proposed optimization strategy.
10:00-10:15	S0169	State-of-Charge Balance Control of Distributed Battery Systems with Distinct State-of-Health in DC Microgrids **Presenter: Yun Yang** *The Hong Kong Polytechnic University* Abstract: This paper presents a three-layer hierarchical control scheme that can balance the state-of-charge(SoC)of distributed battery systems(DBS)with

		distinct state-of-health(SoH)in DC microgrids under the conditions of load variations and cyber attacks. The tertiary control is a consensus control that provides SoC references for the secondary control. The secondary control is an adaptive droop control that provides output voltage deviation reference for the primary control. The primary control is a local proportional-integral(PI)control that tracks the output voltage reference of DBS via the regulation of the grid-connected converter. The effectiveness of the proposed control scheme is validated via a 100 kW photovoltaic(PV)-battery system comprising one new battery and two aged batteries installed on a 380 V DC bus.
10:15-10:30	S0318	Probabilistic Power Flow of Distribution System Based on a Graph-Aware Deep Learning Network **Presenter: Huayi Wu** *The Hong Kong Polytechnic University* Abstract: Quantifying the uncertainties in the distribution system is critical for economic load dispatch yet of great challenge. To address this issue, a graph-aware deep learning network(GADLN)for probabilistic power flow(PPF)calculation is proposed considering the unknown correlation distribution pattern among the wind and solar power generation. By fully utilizing the convolutional operation to aggregate the correlation among nodal active and reactive power injections, the distribution features of the distribution system state variables brought by uncertain wind, solar power, and load demand can be well captured. In this regard, the proposed GADLN can achieve enhanced effectiveness and efficiency without prior knowledge about the correlation of wind and solar power profiles. The case studies are carried out and compared with the state-of-art based on IEEE 33-node system. Simulation results show that the proposed model outperforms the state-of-art in terms of PPF calculation efficiency and accuracy.
Break Time		

Online Session 3: S1. Power System Engineering Session Chair: Dr. Peng Wang, University of Electronic Science and Technology of China Room ID: 97564318768 Zoom Link: [https://zoom.com.cn/j/97564318768] Password:ICPS2021 Time: 13:30-15:45		
Time	**Paper ID**	**Title & Author**
13:30-13:45	S0136	Design of Provincial Bilateral Electricity Spot Market in China under High New Energy Penetration **Presenter: Zan Yang** *Beijing TsIntergy Technology Co. , Ltd.* Abstract: As it is a severe challenge to accommodate the increasing new energy generation integrated to the power grid, electricity spot market can serve to address this issue by producing real-time time-of-use price signals and guiding consumers to adjust their electricity consumption behaviors. To resolve the dilemma of new energy consumption, this paper first designed a provincial bilateral electricity spot market, and put forward the trading mechanism considering both power plants and consumers. Then, a comparative analysis was conducted on the bilateral market clearing results and the unilateral market clearing results considering only power plants through case study. The results show that integrating consumers in the spot market can help to encourage them to consume new energy in an active manner. The bilateral electricity spot market proposed in this paper can provide a reference for improving the new energy consumption in regions with high new energy penetration.
13:45-14;00	S0133	Regional Short Term Load Forecasting Model Considering Dynamic Participation of Multiple Users **Presenter: Chan Wu** *North China Electric Power University* Abstract: Accurate short-term load forecasting results can effectively guarantee the safe dispatch and stable operation of power system. However, with the popularization of distributed generation and the increase of user-side flexible resource, the load characteristics of users have changed, which has a certain impact on the accuracy of short-term load forecasting. Therefore, a regional short-term load forecasting model considering dynamic participation of multiple users is proposed in this paper. Firstly, the quantitative indexes of price-based demand response are extracted according to the characteristics of load-to-price, and the incentive-based demand response resources are divided into three categories: curtailment load(CL), transferable load(TL)and optical storage system(OSS). The quantitative models are established respectively considering the uncertainty and diversity of users' response, which are represented by Monte Carlo simulation sampling method. Then, GORUBI solver is used to obtain the results after

		combining all kinds of resources. After that, on the basis of the historical load data, the above two kinds of indexes are introduced into the multivariate long-short term memory(LSTM)network model. Finally, a case study is carried out to evaluate the performance of the proposed model. The results demonstrate that the short-term load forecasting model with user-side factors can effectively reduce the prediction errors and further improve the prediction accuracy.
14:00-14:15	S0068	Bi-level Programming of AC/DC Hybrid Distribution System **Presenter: Zhendong Xu** *Shandong University of Science and Technology* Abstract: With the wide application of distributed generation and advanced power electronic technology, AC/DC hybrid distribution network provides a new idea for the development of distribution network. Therefore, the AC-DC hybrid distribution network planning is of great significance. This paper presents a bi-level programming model of AC/DC distribution network considering the randomness of DC type of bus and connecting line. The model uses Monte Carlo method to simulate the uncertain output curve of load demand and photovoltaic distributed generation, and divides the planning scheme into upper planning model and lower optimization model: the upper planning model uses genetic membrane algorithm, with the lowest grid construction cost and operation cost as the objective function; the lower optimization model uses interior point method, with the lowest operation cost as the objective function. The upper and lower layer models are solved alternately to obtain the optimal network configuration.
14:15-14:30	S0079	Research on Maximum Power Point Tracking Strategy for Partially Shaded PV System based on Improved Firefly Algorithm **Presenter: Shoukun Zhang** *Shandong University* Abstract: When photovoltaic(PV)arrays operate under the partial shadow, the output characteristic curve has multiple peaks, and it is difficult for traditional algorithms to track the global maximum power point(GMPP). To solve this problem, this paper proposes an improved firefly algorithm(IFA), which introduces an adaptive step size based on the traditional firefly algorithm(FA). In the early stage of algorithm operation, the larger step size is adopted, in the later stage of the algorithm operation, the smaller step size is taken, so that the algorithm can quickly and accurately realize the PV global maximum power point tracking(GMPPT). A simulation model is built in Matlab/Simulink, the results under static and dynamic conditions prove the effectiveness of the improved algorithm.
14:30-14:45	S0099	Pre-Processing of Power Measurements Data at Substations Based On Lagrange Interpolation **Presenter: Yujie Shi**

		Tsinghua-Berkeley Shenzhen Institute Abstract: Power system's data transmission between different information systems are becoming more and more common these days, while some of the data could be missing or wrong due to cyber security and communication issues. In this regard, this paper proposes a pre-processing method for substation-level active and reactive measurement data obtained from the "big data platform" built by the information center in utilities to collect and store the data, which is originally from EMS in distribution system operation center. Firstly, we use Lagrange's interpolation method to deal with the missing data of power substations, and then, the abnormal data of the substation is detected based on whether it's fixed for too many time slots, or, fluctuates with abnormal speed. The completeness and accuracy of substation data after pre-processing have been effectively improved, and the characteristics of data become obvious, which can be used for further data mining and analysis.
14:45-15:00	S0047	Reactive Power Optimization and Reconstruction of Distribution Network Based on Improved GSA Algorithm **Presenter: Xiuqing Yi** *Shandong University* Abstract: Reactive power optimization and distribution network reconstruction are both important means of distribution network optimization. First, the principles of series compensation and parallel compensation are analyzed, and a reactive power compensation site selection method based on the optimization effect is proposed. A multi-objective comprehensive optimization model with the goals of network loss, voltage improvement and the number of voltage limit violations is established. Secondly, the shortcomings of gravitational search algorithm(GSA)are analyzed, and two improvement measures about speed adjustment and range testing are proposed to improve the optimization accuracy and speed of the algorithm. Finally, the effectiveness of the optimization method and the improved algorithm proposed in this paper is verified by simulation examples.
15:00-15:15	S0108	Load Elasticity-based reallocation of Energy in a Peer-to-Peer Electricity market considering Consumers' Willingness **Presenter: Syed Adrees Ahmed** *University of Electronic Science and Technology of China* Abstract: P2P electricity market is a source of high pleasure in today's era that achieves a higher level of satisfaction for the participants involved in the P2P electricity market. However, uncertainty and intermittency of renewable energy resources(RERs)may become the reason for dissatisfaction for some participants at some time slots of the day in terms of energy supply which is considered a challenging task to fulfill energy demand. Considering this, this

		study distinguishes the consumers into two types: based on their willingness and load elasticity and proposes a load-reallocation algorithm for consumers who are willing to shift their price elastic load. This method differentiates the consumers by assessing the consumers' requirements and increasing their social welfare by reallocation policy. Simulation results show that the adopted approach reduces the consumer energy cost and addresses consumer preference by adding the willingness factor to shift and reallocate the load to another slot in the P2P electricity market
15:15-15:30	S0210	On-line Identification of Equivalent Inertia for DFIG Wind Turbines Based on Extended Kalman Filters **Presenter: Qipeng Xing** *North China Electric Power University* Abstract: This paper proposes an identification method of the equivalent inertia for doubly fed induction generator(DFIG)wind turbines. Firstly, a simplified model of DFIG incorporating phase-locked loop(PLL)and virtual inertia control is developed based on the analysis of mathematical model and control strategy of DFIG. On the basis, the equivalent motion equation of DFIG similar to the rotor motion equation of synchronous generators(SGs)is derived considering the dynamic characteristics of PLL and active power control model. According to the equivalent motion equation, the mathematical expression of equivalent inertia of DFIG wind turbines is derived. And then, an extended Kalman filter(EKF)based identification method for the controller parameters in the expression of equivalent inertial is proposed to quantitatively characterize the equivalent inertia of DFIG wind turbines. Finally, the effectiveness and accuracy of the proposed method is verified on a modified 4-machine 2-area system.
15:30-15:45	S0291	A Voltage Sensor Fault Diagnosis Method Based on Long Short-Term Memory Neural Networks for Battery Energy Storage Systems **Presenter: Quanqing Yu** *Harbin Institute of Technology, Weihai* Abstract: The safety of energy storage systems with lithium-ion batteries as the main energy storage component is a current research hotspot. Various battery system fault diagnosis strategies are based on the accurate assumptions of sensor data collection, and there are few studies on fault diagnosis of battery system data collection sensors, especially voltage sensors. This study proposes a method to detect and classify typical fault modes of voltage sensor in energy storage systems. Generate voltage sensor data with three typical fault modes, and inject them into the actual measurement data of the voltage sensor to form a dataset. The voltage sensor fault diagnosis model is constructed through a four-layer Long Short-Term Memory(LSTM)recurrent neural network(RNN)with three dense layers architecture. After training and testing, the ability of LSTM in processing timing information on voltage sensor

		diagnosis is preliminarily proved, which provides a reference for battery system sensor fault diagnosis.
Break Time		

Online Session 4: S6. Special Session>e. Future RE100-compliant Smart Power Distribution Networks with High Penetrations of Power Electronics
Session Chair: Dr. Yun Yang, The Hong Kong Polytechnic University
Room ID: 94976900821
Zoom Link: [https://zoom.com.cn/j/94976900821] Password:ICPS2021
Time: 11:00-12:15

Time	Paper ID	Title & Author
11:00-11:15	S0191	Lagrange Multiplier-Based Optimization Control for Distribution Power Loss Minimization of Islanded Three-Phase AC Microgrids **Presenter: Yajie Jiang** *The University of Hong Kong* Abstract: In this paper, the distribution power loss of islanded three-phase AC microgrids comprising both line loss and power converter loss is modelled as a quadratic function of current allocation coefficients, which is a convex function with constraints. On basis of convex optimization theory, the optimal current allocation coefficients of distributed energy resources (DERs) for distribution loss minimization are on-line calculated by Lagrange multiplier method. By adopting the average reactive power sharing scheme, the proposed control strategy is can obtain the optimal power allocation coefficients for minimizing the distribution power loss of AC microgrids in real time. Then, an improved adaptive droop control strategy is proposed to allocate output active power and reactive power of DERs for achieving the given current-sharing rate. In this way, the real-time efficiency optimization control of AC microgrid can be realized, regardless of line resistance and load variations. The effectiveness of the proposed control strategy is validated by simulation-based case studies.
11:15-11;30	S0156	Meta Ensemble Learning with Acoustic Spectrum Analysis for Intelligent Diagnosis of Direct-buried Transformer Substations **Presenter: Yang He** *Hunan University* Abstract: This paper proposes a meta ensemble learning method to extract multiple electrical and non-electrical features, including acoustic signal, voltage, current and temperature, etc., for the status monitoring and fault diagnosis of direct-buried transformer substation (DBTS). The proposed method consists of a meta learning model and a sub-classifier model. In the meta learning model, a multi-input and multi-output back propagation neural network (BPNN) with multiple hidden layers is utilized to dynamically update

		the integrated weight coefficients of sub classifiers based on the extracted multiple features of DBTS for accuracy improvements. The sub-classifier model involves four pre-trained classifiers using XGBoost for the fault type classification. Consequently, the fault type can be identified by weighted summation of integrated weights and classification results from the sub-classifier model. Comparative studies have been investigated to demonstrate the superior performance of the proposed meta ensemble learning method in improving the accuracy of DBTS fault diagnosis.
11:30-11:45	S0192	Power Loss Mitigation of Parallel-Connected Distributed Energy Resources in DC Microgrids using a Dual-Ascent Hierarchical Control **Presenter: Yajie Jiang** *The University of Hong Kong* Abstract: In this paper, the distribution power loss of DC microgrids comprising both line loss and converter loss is modelled as a quadratic function of current allocation coefficients, which is a convex function with constraints. On basis of convex optimization theory, the optimal current allocation coefficients are on-line calculated by dual ascent method. In the centralized iterative approach, the incremental of current allocation coefficients are moved in the direction of minimizing the augmented loss function. Then, an adaptive droop control is proposed to achieve the given current-sharing rate. In the proposed control, the current-sharing error generates additional adaptive bus voltage term. By sharing one common bus, the function between reference voltages and output currents of DERs can be obtained by ohm's law. By sampling data of two control periods, the line resistance can be identified in real time. In this way, the real-time efficiency optimization control of DC microgrid can be realized, regardless of line resistance variations. The effectiveness of the proposed control strategy is validated by simulation studies.
11:45-12:00	S0274	Economic Enhancement of Smart Homes using Electric Spring-Based Power Flow Routers **Presenter: Kaiyuan Wang** *Hong Kong Polytechnic University* Abstract: High penetrations of intermittent renewable energy sources (RES) in smart homes necessitate the power flow management. The recently proposed electric springs (ES), as alternatives to the conventional energy storage systems (ESS), can regulate the power flow with smaller battery capacities as compared to that of the ESS. This greatly increases the economic value of smart homes, as batteries of the domestic ESS are quite expensive. In this paper, a concept of having the ES equipped with communicate ports that connect with a home user's portable devices, hereon known as ES-based power flow routers (PFR), to mitigate the distribution line power loss, is proposed. By raising the power utilization, the economic value

		can be further enhanced. Case studies are carried out in MATLAB/SIMULINK to verify the effectiveness of ES in stabilizing a five-bus home microgrid, instead of using the conventional ESS. Besides, it is validated that the ES-based PFR can save substantial payments of electricity bills through the reduction of the distribution power loss.
12:00-12:15	S0273	Lifetime Modelling of Power Electronics for Power Electronic Based Power System—a Case for Microgrids **Presenter: Chendan Li** *Norwegian University of Science and Technology* Abstract: Lifetime is an important indicator of system reliability. With the paradigm power system evolves into a power electronics-based power system, lifetime modelling method for power electronics need to be revisited and perspective for modelling power electronics lifetime for system planning and operation usage is worth looking at. In this paper, the existent methods for modelling lifetime for power electronic system are reviewed and classified. The purpose is to detect the future research need and direction for lifetime model needed in reliability assessment for power electronics-based power system. Therefore, an outlook of lifetime modelling to this aim is envisaged.
Lunch Time		

Online Session 5: S1. Power System Engineering
Session Chair: Dr. Peng Wang, University of Electronic Science and Technology of China
Room ID: 97564318768
Zoom Link: [https://zoom.com.cn/j/97564318768] Password:ICPS2021
Time: 16:00-17:30

Time	Paper ID	Title & Author
16:00-16:15	S0255	Virtual Synchronous Generator Based on Type-IV Wind Turbine with Supercapacitor as Storage **Presenter: Liang Chen** *Aalborg University* Abstract: With the help of supercapacitor as energy storage, the type-IV wind turbine(WT)can be controlled as virtual synchronous generator(VSG). The virtual inertia provided by the grid-forming strategy can enable the grid frequency support function of WT, which is beneficial for the frequency stability of the power system confronting the increasing penetration of renewable energy. In this paper, a grid-forming WT solution based on supercapacitor connected to the DC-link via a DC/DC converter is proposed. The VSG controller which does not need frequency curtailed mode operation of WT is investigated. The virtual capacitor strategy of DC/DC converter is proposed to regulate the power flow of the supercapacitor. The supercapacitor capacity is also analyzed. The effectiveness of the proposed strategy is verified by the simulation.
16:15-16:30	S0281	A Side-effect-free Method of Capacitance Requirement Reduction for Modular Multilevel Converters with STATCOM Functionality **Presenter: Zhijie Liu** *Shandong University* Abstract: This paper found that the maximum capacitor voltage of Modular Multilevel Converters(MMC)can obviously increase when the MMC operates in the STATCOM mode. This can increase not only the capacitance requirement but also the overvoltage risk of IGBTs. The conventional methods of maximum capacitor voltage reduction(MCVR)can have side effects, such as power loss increment and main circuit modification. These side effects limit their applications in practice. Thus, a side-effect-free maximum capacitor voltage reduction method is proposed for the MMC with STATCOM functionality. The proposed method is realized based on three inherent MMC characteristics, and both the mechanism and realization approach are presented. The simulation results show that the maximum capacitor voltage can be effectively reduced without side effects when the proposed method is used.
16:30-16:45	S0030	Distributed Voltage Control in Distribution Network with Area Partition **Presenter: Zhengfa Zhang** *Aalborg University*

		Abstract: The deployment of distributed generations(DGs)poses increasing burden to sensing and communication in cen¬tralized voltage control. To address this issue, a distributed voltage control method is proposed in this paper. In the proposed method, the whole distribution network is separated into several areas and each area is equipped with a sub-controller. The idea of alternating direction on multipliers(ADMM)is used for the distributed voltage control design by exchanging information of boundary variables between two adjacent areas. In this way, the requirements for data collection and communication is reduced. Case studies on a modified IEEE 33 bus system with three area partition demonstrate the performance of the proposed distributed voltage control method.
16:45-17:00	S0035	Fault Modeling of Grid-forming Converters using Dynamic Phasor Theory **Presenter: Qi Zhang** *Aalborg University* Abstract: It has been pointed out in recent years that grid following and grid-supporting converters are harmful to the stability of the power system, and grid-forming converters(GFM)are becoming to be the most promising grid-connected converters for the integration of renewable energy. Nevertheless, the development of GFM converters challenges the fault analysis of the power system because GFM converters have a totally different fault response with that of the grid-supporting, grid-following converter, and the synchronous generator. The fault modeling of GFM converters is a foundation to overcome this issue, so it should be investigated firstly. However, this topic is rarely discussed in the previous literature. In order to fill this research gap, this paper proposes a fault modelling method for GFM converters based on the dynamic phasor theory. The dynamic phasor model of GFM converters can provide an effective interface to the power system analysis. Thus, the proposed model is outstanding because of its ability to analyze the interaction between converters and the power system in the fault analysis. To verify the correctness of the proposed model, a 12 MVA grid-forming converter is established in MATLAB/Simulink. The simulation results show that the proposed model can almost perfectly handle the fault analysis of the grid-forming converter.
17:00-17:15	S0049	Power System Video Encryption Scheme Based on Chaotic System **Presenter: Xiuqing Yi** *Shandong University* Abstract: A power system video encryption scheme based on chaotic systems has been developed in this paper. This scheme uses 2D sine Logistic modulation mapping to scramble pixels in video frames. Then the image is divided into three layers, and diffused by a new chaotic system. Ciphertext image is added in the diffusion to enhance the security of the algorithm.

		Finally, the algorithm is simulated in MATLAB. By analyzing the simulation results, it is proved that the video encryption algorithm in this paper has good encryption effect and has important application value in the information transmission of power system. Finally, the application of this algorithm in video transmission of power system is expounded.
17:15-17:30	S0163	PSO-MSVR Based Prediction Approach for Unstable Equilibrium Points of Disturbed Power System **Presenter: Guangmeng Liu** *North China Electric Power University* Abstract: With expansion of power system and continuous proliferation of renewable energy generation, the transient stability characteristics of power system become more complicated, and online transient stability assessment faces severe challenges. The calculation of unstable equilibrium point(UEP)is a critical step in the direct method of power system transient stability assessment. This paper presents a new method for predicting transient UEPs of power systems based on PSO-MSVR. Instead of complicated calculation, UEPs can be obtained by steady state measurement date. Firstly, UEPs are calculated by BCU method under different operating conditions of the system to provide sample data for the prediction model. Then the voltage amplitude and phase angle of the steady state operating conditions are taken as the sample characteristics, and the mapping relationship between the measured data and UEPs is constructed by multi support vector regression(MSVR). In the meantime, the penalty and kernel parameters in MSVR are optimized by particle swarm optimization(PSO)algorithm. Finally, fast prediction of the transient UEPs based on the steady state operating information of the system is achieved. Case study on IEEE 9-bus system shows that the proposed approach has high prediction accuracy through a small amount of training data.