

2021 IEEE International Conference on Energy Internet (ICEI 2021)

**Southampton, United Kingdom
27 – 29 September 2021**



**IEEE Catalog Number: CFP21D74-POD
ISBN: 978-1-6654-0735-9**

**Copyright © 2021 by the Institute of Electrical and Electronics Engineers, Inc.
All Rights Reserved**

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

****** This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP21D74-POD
ISBN (Print-On-Demand):	978-1-6654-0735-9
ISBN (Online):	978-1-6654-0734-2

Additional Copies of This Publication Are Available From:

Curran Associates, Inc
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: (845) 758-0400
Fax: (845) 758-2633
E-mail: curran@proceedings.com
Web: www.proceedings.com

CURRAN ASSOCIATES INC.
proceedings
.com

2021 IEEE International Conference on Energy Internet (ICEI) **ICEI 2021**

Table of Contents

Message from the Chairs	xiii
Conference Organization	xiv

Complementary Scheduling and Optimization of Multiple Energy Flows

Configuration of Storage Battery Cooperating with Pumped Storage Units for wind and Photovoltaic Power Fluctuation Smoothing	1
<i>Chuangxin Fang (Hubei Bailianhe Pumped Storage Company Ltd., China), Zhiping Hu (Hubei Bailianhe Pumped Storage Company Ltd., China), Chuanlin Xia (Hohai University, China), Linjun Shi (Hohai University, China), Feng Wu (Hohai University, China), and Yang Li (Hohai University, China)</i>	
Electricity-Heat Collaborative Optimization Strategy in Microgrid using Deep Reinforcement Learning	6
<i>Hanmei Ma (State Grid Corporation of China, China), Mingyue Sun (State Grid Corporation of China, China), Yanhong Jian (State Grid Corporation of China, China), Qian Wang (State Grid Corporation of China, China), and Yirong Wang (State Grid Corporation of China, China)</i>	
Does Explicit Prediction Matter in Deep Reinforcement Learning-Based Energy Management?	13
<i>Zhaoming Qin (Tsinghua University, China), Huaying Zhang (China Southern Power Grid, China), Yuzhou Zhao (China Southern Power Grid, China), Hong Xie (China Southern Power Grid, China), and Junwei Cao (Tsinghua University, China)</i>	
A Technology Platform and Its Applications of a Metering Operating System for the Energy Internet	20
<i>Xiangcheng Zhang (Hangzhou Vango Technologies, Inc., China), Zhouqiang Qu (Hangzhou Vango Technologies, Inc., China), Yu Fang (Hangzhou Vango Technologies, Inc., China), Zhengming Lu (Hangzhou Vango Technologies, Inc., China), and Bo Liu (Hangzhou Vango Technologies, Inc., China)</i>	
Robust Controller Design for the Emergency Response Module of Energy Router	28
<i>Miao Jia (Hohai University, China), Xinyu Luo (Hohai University, China), Jiaye Tuo (Hohai University, China), Haochen Hua (Hohai University, China), and Xingying Chen (Hohai University, China)</i>	

Analysis of Distribution Network Safety Margin Index Under Multivariate Uncertain Scenes	34
<i>Nan Hu (State Grid Nantong Power Supply Company, China), Ting Huang (State Grid Nantong Power Supply Company, China), Geliang Chen (State Grid Nantong Power Supply Company, China), Liyuan Dai (State Grid Nantong Power Supply Company, China), Jiaye Tuo (Hohai University, China), and Miao Jia (Hohai University, China)</i>	

Power System & Power Quality

Probabilistic Power Flow Calculation of Microgrid Based on ℓ_1 -Minimization	40
<i>Hong Liang (Tsinghua University, China), Tonghe Wang (Tsinghua University, China), Jian Guo (Tsinghua University, China), and Junwei Cao (Tsinghua University, China)</i>	
Classification Method of Voltage Sag Sources in Station Area Based on Edge Computing	47
<i>Yonggui Wang (State Grid Information & Telecommunication Group Co., Ltd, China), Zhu Liu (State Grid Information & Telecommunication Group Co., Ltd, China), Lvchao Huang (State Grid Information & Telecommunication Group Co., Ltd, China), Shuai Zhang (State Grid Information & Telecommunication Group Co., Ltd, China), Zhi Li (State Grid Information & Telecommunication Group Co., Ltd, China), and Siyang Deng (State Grid Information & Telecommunication Group Co., Ltd, China)</i>	
Resampled Data Splicing Method Based on Continuous Single-Cycle used in Power Quality Analysis	52
<i>Siyang Deng (State Grid Information & Telecommunication Group Co., Ltd, China), Zhu Liu (State Grid Information & Telecommunication Group Co., Ltd, China), Lvchao Huang (State Grid Information & Telecommunication Group Co., Ltd, China), Yonggui Wang (State Grid Information & Telecommunication Group Co., Ltd, China), and Kaiming Chen (State Grid Information & Telecommunication Group Co., Ltd, China)</i>	
Research on Power Quality Monitoring Method of Distribution Network Based on Intelligent Fusion Terminal	56
<i>Yue Du (The State Grid Corp. of China, China), Zhu Liu (The State Grid Corp. of China, China), Limin Wang (The State Grid Corp. of China, China), Lvchao Huang (The State Grid Corp. of China, China), Jinguo Fang (The State Grid Corp. of China, China), and Shuai Zhang (The State Grid Corp. of China, China)</i>	
Robust Frequency Regulation for Islanded Scenic Spot Considering Flexible Loads	62
<i>Wenting Huang (Hohai University, China), Jiaye Tuo (Hohai University, China), Xinyu Luo (Hohai University, China), Haochen Hua (Hohai University, China), and Xingying Chen (Hohai University, China)</i>	

Propagation Characteristics Analysis of Fault Transient Voltage Traveling Wave in GIL Considering External Connection	68
<i>Lei Mao (State Grid Nantong Power Supply Company, China), Jianhua Yu (State Grid Nantong Power Supply Company, China), Yanfang Mao (State Grid Nantong Power Supply Company, China), Ziwei Zhang (Tsinghua University, China), Dengwei Ding (Tsinghua University, China), Qian Wang (State Grid Nantong Power Supply Company, China), Yayang Lin (State Grid Nantong Power Supply Company, China), and Chunfeng Lu (State Grid Nantong Power Supply Company, China)</i>	

Demand Side Management and Response (I)

Short-Term Load Forecasting Based on Hierarchical Clustering and ISA-LSSVM Model	73
<i>Bin Yang (State Grid Jiangsu Electric Power Co., Ltd., China), Xuesong Shao (State Grid Jiangsu Electric Power Co., Ltd., China), and Le Zheng (Southeast University, China)</i>	
A Novel Forecasting Method for Short-Term Load Based on TCN-GRU Model	79
<i>Xiaoyan Hu (Economic and Technical Research Institute of State Grid Jiangsu Electric Power Company, China), Bingjie Li (Economic and Technical Research Institute of State Grid Jiangsu Electric Power Company, China), Jing Shi (Economic and Technical Research Institute of State Grid Jiangsu Electric Power Company, China), Hu Li (Economic and Technical Research Institute of State Grid Jiangsu Electric Power Company, China), and Guojing Liu (Economic and Technical Research Institute of State Grid Jiangsu Electric Power Company, China)</i>	

Demand Side Management and Response (II)

Short-Term load Forecasting Based on DenseNet-LSTM Fusion Model	84
<i>Liyun Pan (Beijing Zhongdian Puhua Information Technology Co., Ltd., China), Wenjun Zhu (Beijing Zhongdian Puhua Information Technology Co., Ltd., China), Sining Wang (Beijing Zhongdian Puhua Information Technology Co., Ltd., China), and Lu Han (Information and Communication Branch of State Grid Corporation of China, China)</i>	
Robust Optimization Strategy for Residential User's Electricity Price Score Coefficient Considering Response Uncertainty	90
<i>Yujiang Chen (Hohai University, China), Kun Yu (Hohai University, China), Xingying Chen (Hohai University, China), and Lei Gan (Hohai University, China)</i>	
Benefits Allocation Method for Demand Response in Smart Distribution Network with High PV Penetration	96
<i>Xiuming Tang (Hohai University, China), Kun Yu (Hohai University, China), Xingying Chen (Hohai University, China), Lei Gan (Hohai University, China), and Haochen Hua (Hohai University, China)</i>	

Network and Wireless Communication

State Estimation of Energy Internet using SCADA and PMU Data Based on Graph Convolutional Networks	102
<i>Xian Wu (New Smart City High-quality Power Supply, Joint Laboratory of China Southern Power Grid, Shenzhen Power Supply Co., Ltd, China), Huaying Zhang (New Smart City High-quality Power Supply, Joint Laboratory of China Southern Power Grid, Shenzhen Power Supply Co., Ltd, China), Sheng Guo (Tsinghua University, China), and Junwei Cao (Tsinghua University, China)</i>	
Research of Terminal Access and Monitoring of Energy Internet	107
<i>Jing Ma (State Grid Cyber Security Technology(Beijing) Co., Ltd, China), Yonggang Xu (State Grid Cyber Security Technology(Beijing) Co., Ltd, China), Zengming Liu (State Grid Cyber Security Technology(Beijing) Co., Ltd, China), Huinan Wang (State Grid Shanxi Marketing Service Center Taiyuan, China), and Xuelu Cui (State Grid Cyber Security Technology(Beijing) Co., Ltd, China)</i>	
A Flexible SoC Subsystem for Harmonic Measurement and Metering	114
<i>Xiaohui Xiao (Zhejiang University, China), Chunguang Lu (Marketing Service Center, State Grid Zhejiang Electric Power Co., Ltd., China), Nianxiong Tan (Zhejiang University, China), Jie Cao (Hangzhou Vango Technologies, Inc., China), Hengzhi Hu (Hangzhou Vango Technologies, Inc., China), and Aijun Wang (Hangzhou Vango Technologies, Inc., China)</i>	
Evolve from Traditional Power Grid Network to Blockchain and IoT Integrated Network	119
<i>Qiaoyin Yang (Tsinghua University, China), Dengke Zhou (Science and Technology Research Institute China, Three Gorges Corporation), Yiheng Chen (Guangdong Power Grid Co Maoming Power Supply Bureau, China Southern Power Grid, China), Xianfeng Zhang (Science and Technology Research Institute, China Three Gorges Corporation, China), and Yibo Su (Science and Technology Research Institute, China Three Gorges Corporation)</i>	
Improving Physical Layer Security using Multi-UAVs-Enabled Mobile Relaying	125
<i>Tianyu Lan (Hubei University, China), Zhiqun Hu (Hubei University, China), and Yujing Zhang (Beijing University of Posts and Telecommunications, China)</i>	

Energy Related Information Technology

- A New Security Authentication Method for Master Station and Terminal 131
Fan He (*Zhongguancun Xinhaizyou Technology Co. LTD, China*), Zhengquan Ang (*Beijing aerospace flight control center, China*), Qingqin Fu (*Zhongguancun Xinhaizyou Technology Co. LTD, China*), Guanglun Yang (*Zhongguancun Xinhaizyou Technology Co. LTD, China*), Pingjiang Xu (*Beijing SmartChip Microelectronics Technology Co., Ltd., Key Lab of Power Grid Design and Analysis, State Grid Corporation of China, China*), Jia Liu (*Beijing SmartChip Microelectronics Technology Co., Ltd., Key Lab of Power Grid Design and Analysis, State Grid Corporation of China, China*), Ling Yi (*Beijing SmartChip Microelectronics Technology Co., Ltd., Key Lab of Power Grid Design and Analysis, State Grid Corporation of China, China*), Changsheng Niu (*Beijing SmartChip Microelectronics Technology Co., Ltd., Key Lab of Power Grid Design and Analysis, State Grid Corporation of China, China*), Jiankui Liu (*Zhongguancun Xinhaizyou Technology Co. LTD, China*), and Yuqiang Jiang (*Zhongguancun Xinhaizyou Technology Co. LTD, China*)
- Design and Implementation of High-Precision Timing Module for NR Terminals Based on FPGA . 136
Zhihui Wang (*China Electric Power Research Institute, China*), Yue Hu (*China Electric Power Research Institute, China*), Jiuxin Gong (*China Electric Power Research Institute, China*), Shen Jin (*State Grid Jibei Electric Power Company Limited, China*), Sachula Meng (*China Electric Power Research Institute, China*), Delong Yang (*China Electric Power Research Institute, China*), Baojuan Ma (*China Electric Power Research Institute, China*), Jinxia Han (*China Electric Power Research Institute, China*), Sicheng Zhu (*China Electric Power Research Institute, China*), Sai Wu (*China Electric Power Research Institute, China*), Heng Liu (*China Electric Power Research Institute, China*), and Junbao Duan (*China Electric Power Research Institute, China*)
- Efficient Privacy-Preserving Federated Learning For Electricity Data 143
Xiaohui Wang (*Artificial Intelligence on Electric Power System State Grid Corporation Joint Laboratory, China; Global Energy Interconnection Research Institute co.Ltd, China*), Xiao Liang (*Artificial Intelligence on Electric Power System State Grid Corporation Joint Laboratory, China; Global Energy Interconnection Research Institute co.Ltd, China*), and Xiaokun Zheng (*Artificial Intelligence on Electric Power System State Grid Corporation Joint Laboratory, China; Global Energy Interconnection Research Institute co.Ltd, China*)
- CPS Modeling and Analysis Method of Power Grid Based on Graph Computing 149
Mingyue Wei (*Global Energy Enterconnection Research Institute co.Ltd, China*), Bo Chai (*Global Energy Enterconnection Research Institute co.Ltd, China*), Siyan Liu (*Global Energy Enterconnection Research Institute co.Ltd, China*), Shaopeng Quan (*Global Energy Enterconnection Research Institute co.Ltd, China*), Zikai Zhu (*Global Energy Enterconnection Research Institute co.Ltd, China*), and Wei Li (*The University of Sydney, Australia*)

Fuzzy Test Guidance Technology for Power Internet of Things Firmware Vulnerability Detection	157
<i>Bo Zhang (State Grid Key Laboratory of Information & Network Security, Global Energy Internet Research Institute, China), Zesheng Xi (State Grid Key Laboratory of Information & Network Security, Global Energy Internet Research Institute, China), and Kunlun Gao (State Grid Key Laboratory of Information & Network Security, Global Energy Internet Research Institute, China)</i>	

A Risk-Sensitive Control Strategy for Frequency Stability of Edge Data Center	164
<i>Nan Hu (State Grid Nantong Power Supply Company, China), Ting Huang (State Grid Nantong Power Supply Company, China), Geliang Chen (State Grid Nantong Power Supply Company, China), Liyuan Dai (State Grid Nantong Power Supply Company, China), Wenting Huang (Hohai University, China), Miao Jia (Hohai University, China), Xinyu Luo (Hohai University, China), and Jiaye Tuo (Hohai University, China)</i>	

Energy Market & Trading

A Distributed Point-to-Point Energy Trading System Based on Blockchain Privacy Protection	170
<i>Xiaoyun Kuang (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China), Yixin Jiang (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China), Peiming Xu (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China), Baorong Zhou (Electric Power Research Institute, China Southern Power Grid, China), Pingping Xie (Electric Power Research Institute, China Southern Power Grid, China), and Yunan Zhang (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China)</i>	

A Design of Electricity Trading System Based on Blockchain Technology	178
<i>Yixin Jiang (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China), Peiming Xu (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China), Xiaoyun Kuang (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China), Baorong Zhou (Electric Power Research Institute, China Southern Power Grid, China), Pingping Xie (Electric Power Research Institute, China Southern Power Grid, China), and Yunan Zhang (Guangdong Provincial Key Laboratory of Power System Network Security, Electric Power Research Institute, China Southern Power Grid, China)</i>	

An Outlook of Flexibility Aggregation of Distributed Energy Sources over a Blockchain-Enabled Energy Internet	185
<i>Qiaoyin Yang (Tsinghua University, China), Zhengyun Sun (State Grid Corporation of China, China), Sheng Chen (Tsinghua University, China), Haiwang Zhong (Tsinghua University, China), and Haochen Hua (Hohai University, China)</i>	

PBFT-Based Regional Energy Internet Blockchain Transaction Consensus	191
<i>Dong Wang (State Grid Blockchain Technology (Beijing) Co., Ltd., China; State Grid Electronic Commerce Co., Ltd., China), Hejian Wang (State Grid Blockchain Technology (Beijing) Co., Ltd., China; State Grid Electronic Commerce Co., Ltd., China), Zhenhua Yan (State Grid Ningxia Electric Power Co., Ltd., China), Junwei Ma (State Grid Shanxi Electric Power Company, China), Yongliang Li (State Grid Ningxia Electric Power Co., Ltd., China), Songpu Ai (Tsinghua University, China), and Junwei Cao (Tsinghua University, China)</i>	
Blockchain-Based Distributed Reputation for a Cap-and-Trade Carbon Emission System	197
<i>Dong Wang (State Grid Electronic Commerce Co., Ltd., State Grid Blockchain Technology (Beijing) Co., Ltd. \ P.R. China), Da Li (State Grid Electronic Commerce Co., Ltd., State Grid Blockchain Technology (Beijing) Co., Ltd. \ P.R. China), Junwei Ma (State Grid Shanxi Electric Power Co., Ltd. \ P.R. China), Zhenhua Yan (State Grid Ningxia Electric Power Company, P.R. China), Yongliang Li (State Grid Ningxia Electric Power Company, P.R. China), Tonghe Wang (Tsinghua University, P.R. China), Songpu Ai (Tsinghua University, P.R. China), and Junwei Cao (Tsinghua University, P.R. China)</i>	
Optimal Bidding Strategy of Load Aggregators for the Auxiliary Service Market of Peak Shaving and Valley Filling	205
<i>Jinkun Liu (Hohai University, China), Xingying Chen (Hohai University, China), Hantao Liu (Hohai University, China), Kun Yu (Hohai University, China), Lei Gan (Hohai University, China), and Haochen Hua (Hohai University, China)</i>	
Analysis of Energy Internet Business Model Considering Carbon Trading	211
<i>Nan Hu (State Grid Nantong Power Supply Company, China), Ting Huang (State Grid Nantong Power Supply Company, China), Geliang Chen (State Grid Nantong Power Supply Company, China), Liyuan Dai (State Grid Nantong Power Supply Company, China), Xinyu Luo (Hohai University, China), and Wenting Huang (Hohai University, China)</i>	

Fault Diagnosis

Fault Prediction Technology of Power Communication Field Based on Fuzzy Petri Net	217
<i>Shidanjie Dong (State Grid Information and Communication Industry Group Co., Ltd., Beijing), Yan Jiang (Beijing CLP Flying Communications Co., Ltd, Beijing), Yongqing Liu (State Grid Information and Communication Industry Group Co., Ltd., Beijing), and Chao Yang (State Grid Liaoning Electric Power Company Information and Communication Branch, Liaoning)</i>	
Research on Fault Early Warning Technology of Key Operation Nodes in Power Communication Network	223
<i>Shidanjie Dong (State Grid Information and Communication Industry Group Co., Ltd., Beijing), Yongsheng Zhao (State Grid Information and Communication Industry Group Co., Ltd., Beijing), Yan Jiang (Beijing CLP Flying Communications Co., Ltd, Beijing), and Chao Yang (State Grid Liaoning Electric Power Company Information and Communication Branch, Liaoning)</i>	

Research on Insulating Oil Gas Analysis and Fault Prediction Based on the Edge Computing Platform of the Internet of Things	229
<i>Jingwen Lin (State Grid Information & Telecommunication Group Co., Ltd., China), Wenjing Guo (State Grid Information & Telecommunication Group Co., Ltd., China), Rundong Liu (State Grid Information & Telecommunication Branch Beijing, China), Wenjing Li (State Grid Information & Telecommunication Group Co., Ltd., China), Zhi Li (State Grid Information & Telecommunication Group Co., Ltd., China), and Xiaochuan Liang (State Grid Information & Telecommunication Branch Beijing, China)</i>	
Research on Single-Terminal Fault Location Method Based on CWT Cumulative Coefficient of Traveling Wave for GIL	236
<i>Lei Mao (State Grid Nantong Power Supply Company, China), Qian Wang (State Grid Nantong Power Supply Company, China), Yanfang Mao (State Grid Nantong Power Supply Company, China), Ziwei Zhang (Tsinghua University, China), Dengwei Ding (Tsinghua University, China), Zhong Yu (State Grid Nantong Power Supply Company, China), Jianhua Yu (State Grid Nantong Power Supply Company, China), and Yayang Lin (State Grid Nantong Power Supply Company, China)</i>	
Author Index	241