IEEE IAS IEEE Industry Applications Society UCET IUB Student Chapter — Linking Research to Practice

IEEE

IEEE I&CPS Asia 2024

ABSTRACT BOOK

2024 IEEE IAS Industrial and Commercial Power System Asia

CARBON NEUTRALITY FOR FUTURE POWER AND ENERGY SYSTEMS

PATTAYA, THAILAND

JULY 9-12, 2024

IEEE I&CPS Asia 2024

2024 IEEE IAS Industrial and Commercial Power System Asia

IEEE IAS IEEE INDUSTRY APPLICATIONS SOCIETY Linking Research to Practice SCHOOL OF ENGINEERING KMITL EEAAT

CONTENT

MESSAGE FROM GENERAL CHAIR

It is with great honor and pleasure that extend a warm invitation to you all for the upcoming 2024 IEEE IAS Industrial and Commercial Power System Asia (IEEE I&CPS Asia 2024). I am glad that the IEEE I&CPS Asia 2024 will be held here in Pattaya, Thailand from July 9th to July 12th, 2024. This Pattaya conference is the first IEEE I&CPS Asia held in a city outside China. I hope this memorable conference will be a successful and fruitful one.

Under the theme of "Carbon Neutrality for Future Power and Energy Systems," our conference aims to provide participants with a high-quality experience. Keynote sessions and a special panel session will offer numerous opportunities for productive exchanges and the establishment of future partnerships.

This event will focus on a wide range of topics, including power systems, energy systems, smart grids, renewable energy integration, Energy storage technologies, Electric Vehicles Applications, Carbon Neutrality in Power and Energy Systems, and Other Relevant Topics. In addition, there will be exciting activities such as IAS committee meetings, a welcome reception, and a banquet dinner. We eagerly anticipate your active participation in these events.

We extend our deepest gratitude to our esteemed keynote speaker, Prof.Dr.Wei-Jen Lee from The University of Texas at Arlington, Prof.Dr.Ming Yang from Shandong University, and Prof.Dr.Issarachai Ngamroo from King Mongkut's Institute of Technology Ladkrabang. We are also delighted to welcome Assoc.Prof.Dr.Somyot Kaitwanidvilai Dean of School of Engineering from KMITL and Assoc.Prof.Dr.Athikom Roeksabutr Association President of EEAAT, who will provide a warm welcome at the opening ceremony.

In conclusion, I would like to express our gratitude to all the participants and wish each of you a productive and enjoyable conference experience in the beautiful city of Pattaya, Thailand.

Thank you for being so cooperative.

Asst.Prof.Dr.Chai Chompoo-inwai
General Chair of LOCs, IEEE I&CPS Asia 2024

MESSAGE FROM CHAIRPERSON

It is my great honor to welcome all participants to 2024 IEEE IAS Industrial and Commercial Power System Asia (IEEE I&CPS Asia 2024) in the wonderful, bustling city of Pattaya, Thailand. We truly hope that this event will provide a unique platform for all participants to exchange ideas, discover novel opportunities, reacquaint themselves with colleagues, meet new friends, and broaden their knowledge.

The technical program of IEEE I&CPS Asia 2024 will be four days long, starting from June 9th to 12th, 2024. In addition, we are pleased to have Prof.Dr.Wei-Jen Lee (The University of Texas at Arlington, United States) Prof.Dr.Ming Yang (Shandong University, China) and Prof.Dr.Issarachai Ngamroo (King Mongkut's Institute of Technology Ladkrabang, Thailand) as the keynote speakers. Again, we are hoping that the technical demonstrations will facilitate the exchange of useful information and experiences as well as stimulate future research in this area.

The success of this conference required significant effort and dedication on the part of many people who have worked with us in planning and organizing. We would like to express special thanks to the organizing committee, the IEEE I&CPS Asia committee, keynote speakers, and authors for supporting the conference.

We would like to encourage all participants to spend some time off from the main event exploring the city to experience the culture, the people, and most important of all, have fun.

Assoc.Prof.Dr.Athikom Roeksabutr
Chairperson of IEEE I&CPS Asia 2024
President of EEAAT

MESSAGE FROM ADVISORY COMMITTEE

It is my great pleasure to have a chance to deliver a message of congratulation. Of every alternative year that IEEE I&CPS Asia 2024 has been organized, this year the 5th event has achieved another wonderful success. It can have almost 160 papers submitted. The authors are from more than 17 countries worldwide. This is also the first time that IEEE I&CPS Asia is organized in Thailand. Pattaya is a world-recognized tourist sport. It holds ideal islands, seas, and beaches. IEEE I&CPS Asia 2024 is also one of the few remarkable conferences hosted or co-hosted by the EEAAT Association. Every year the association hosts several conferences, both domestic and international.

As a co-host of the IEEE I&CPS Asia 2024 conference, I, the Dean of the School of Engineering, King Mongkut's Institute of Technology Ladkrabang would like to certainly welcome all participants and foreign committee members to Thailand. Apart from the conference program that will be conveyed nicely and successfully, I hope you will not miss the outside atmosphere. Among several things you can do during your visit, you should enjoy Thai and local food and culture.

Ladies and gentlemen, the continuous success of IEEE I&CPS Asia 2024 can never happen without the serious purpose of all parties, steering committee, local committee, technical program committee, authors, reviewers, and sponsors. IEEE I&CPS Asia 2024, likewise, can achieve that so. I would like to take this opportunity to express my sincere thanks to the steering committee members, our co-host (EEAAT), local committee, and arrangement staff for their tireless work to get the best outcome. My thanks are also extended to the authors and reviewers who did a hard job of getting meaningful papers to be presented at this conference. I wish you all a fruitful conference participation as well as a safe journey back home.

Assoc. Prof. Dr.Somyot Kaitwanidvilai
Advisory Committee of IEEE I&CPS Asia 2024
Dean, School of Engineering, KMITL, Thailand

COMMITTEES

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- Chairperson: **Piampoom Sarikprueck**, *KMITL, Thailand*
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LOCAL ORGANIZING COMMITTEE

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- **Nattapon Marukatat**, *KMITL, Thailand*
- **Orathai Kruthun**, *KMITL, Thailand*

I&CPS ASIA OPERATING COMMITTEE

- Resheek Rifaat
- Yuan-Kang Wu
- Zhenyuan Zhang
- Chengxiong Mao
- Jie Shi
- Zhaohao Ding

Organized by

- School of Engineering, King Mongkut's Institute of Technology Ladkrabang, Thailand
- Electrical Engineering Academic Association (Thailand)
- IEEE I&CPS Asia 2024 Local Organizing Committee

Full Sponsored by

- IEEE Industry Application Society (IAS)

Conference Office Address

IEEE I&CPS Asia 2024 Office,
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GENERAL INFORMATION

General Information

The 2024 IEEE IAS Industrial and Commercial Power System Asia (IEEE I&CPS Asia 2024) provides a good opportunity to present and discuss the latest findings in the field of Industrial and Commercial Power Systems. The 2024 IEEE IAS Industrial and Commercial Power System Asia in Pattaya, Thailand will continue along the lines of the previous conferences, which were held in Weihai (2020), Chengdu (2021), Shanghai (2022), and Chongqing (2023).

The conference is organized by King Mongkut's Institute of Technology Ladkrabang, EEAAT, and IEEE I&CPS Asia 2024 Local Organizing Committee.

Scope

The 2024 IEEE IAS Industrial and Commercial Power System Asia, IEEE I&CPS Asia 2024, Pattaya, Chonburi provides an excellent opportunity for scientists, engineers, designers, and users of Industrial and Commercial Power Systems, from a wide range of universities and industrial companies, to present and discuss the latest scientific result and share their practical experience in the field of Industrial and Commercial Power Systems technology. This conference is focused on the following subject.

1. Power Systems
2. Energy Systems
3. Smart Grids
4. Renewable Energy Integration
5. Energy storage technologies
6. Electric Vehicles Applications
7. Carbon Neutrality in Power and Energy Systems
8. Other Relevant Topics

Conference Venue

The venue of IEEE I&CPS Asia 2024 will be in Pattaya City, Chonburi, which is a popular beach resort city located on the eastern coast of the Gulf of Thailand.

It is approximately 150 kilometers southeast of Bangkok, making it a well-known destination for both local and international tourists. Pattaya is famous for its vibrant nightlife, beautiful beaches, water sports, shopping, and entertainment options.

Address: 240 Moo 5, Pattaya Beach Road Pattaya 20150, Thailand.

Website: https://www.amari.com/pattaya

How to get to Pattaya

By Air:

When you exit the arrivals hall at Suvarnabhumi Airport, you'll be approached by numerous touts offering to transport you anywhere in Thailand, usually in a minivan or a limousine. Touted limos and minivans are rather pricey, even when factoring in the fact that they might hold more people. You can opt for an airport limousine service for privacy. Book one in advance or upon arrival at the service counter on the 2nd floor of Suvarnabhumi Airport.

A more affordable option is taking a bus from the airport's Transport Centre. Buses leave every 2 hours and take about 1.5 hours to reach Pattaya. These air-conditioned vehicles stop at the North Pattaya Road Bus Station, where you will need additional transport to get to your hotel.

By Car Rentals:

Renting a car is a great way of getting to Pattaya from Bangkok. Those arriving at Suvarnabhumi Airport can find booths of major car rental companies like Budget, Hertz and Avis. The airport is around 120 km northwest of Pattaya, and you don't need to drive through Bangkok to reach the seaside resort.

By Bus:

Bangkok residents often get to Pattaya by bus. Some of the most frequent departures are from the Eastern Bus Terminal, adjacent to the Ekkamai BTS Station on Sukhumvit Road at Soi 63 (Soi Ekkamai).

Air-conditioned buses leave approximately every 30 minutes between 5 am and 11.30 pm each day. Buses also leave the Northern Bus Terminal (Mochit) between 5.30 am and 8 pm. If you are near the Southern Bus Terminal (Sai Tai Mai), buses leave at 5.30 am, 8.30 am, 10 am, noon, 2 pm, 4 pm, and 6.30 pm. This terminal is the easiest to access from Khao San Road – take the bus no. 511 on Rachdamnoen Road and get off at the end of the line.

Trips to Pattaya usually take about 2 hours, though times vary considerably depending on traffic. Travel agencies and hotels around Bangkok, particularly in Khao San Road, offer minivan services. Another 'door-to-door' option is taking a taxi, but the price is significantly higher.

Pattaya and its history

Pattaya is a city in Eastern Thailand, the second-largest city in Chonburi province and the eighth-largest city in Thailand. It is on the east coast of the Gulf of Thailand, about 100 kilometers southeast of Bangkok, and has a population of 328,961 as of 2021.

Pattaya City is a self-governing municipal area within, but not part of, Bang Lamung district and has a population of 119,532. It covers the tambons of Nong Prue and Na Klua and parts of Huai Yai and Nong Pla Lai. Although the municipal area is not part of Bang Lamung district, Pattaya City has grown into all adjacent sub-districts and accounts for the largest population percentage in the district, making it de facto a part of the "Pattaya-Bang Lamung-Jomtien" area, otherwise known as "Greater Pattaya".

The city is in the industrial Eastern seaboard zone, along with Si Racha, Laem Chabang, and Chonburi. Pattaya is at the center of the Pattaya-Chonburi Metropolitan Area (a conurbation in Chonburi Province with a population of 1,000,000), which forms the third largest metropolitan area in Thailand.

The name Pattaya evolved from the march of Phraya Tak (later King Taksin) and his army from Ayutthaya to Chanthaburi, which took place before the fall of the former capital to Burmese invaders in 1767. When his army arrived in the vicinity of what is now Pattaya, Phraya Tak encountered the troops of a local leader named Nai Klom, who tried to intercept him. When the two met faces to face, Nai Klom was impressed by Phraya Tak's dignified manner and his army's strict discipline. He surrendered without a fight and joined his forces.

The place the armies confronted each other was thereafter known as "Thap Phraya", which means the "army of the Phraya". Thap Phraya was later changed to Pattaya, which means 'the wind blowing from the southwest to the northeast at the beginning of the rainy season'.

The main sweep of the bay area is divided into two principal beachfronts. Pattaya Beach lies parallel to the city center and runs about 2.7 km long from North Pattaya south along the coast to South Pattaya which is the entrance to Walking Street. The beach, which used to be 35 m. wide, suffers from erosion, and in some places was reduced to a width of only two to three meters. A 429-million-baht beach restoration scheme was implemented in 2018. It will take 360,000 m^3 of sand from Ko Rang Kwian offshore to increase the beach width to 50 m.

Access Map

Currency

The official currency in Thailand is the Thai Baht (THB), however, most foreign currencies are easily exchanged at banks and hotels. A passport may be required for currency exchange services.

Registration Desk

The IEEE I&CPS Asia 2024 registration desk is in the foyer in front of the Grand Ballroom of Amari Pattaya Resort. All attendees must register upon arrival and receive a badge to participate in conference activities. The registration desk opens in the following hours:

- Tuesday, 9 July 2024 13:00 – 18:00
- Wednesday, 10 July 2024 08:30 – 16:00
- Thursday, 11 July 2024 08:30 – 16:00

Conference Proceedings

Each registrant will receive the conference proceedings in a USB memory device in a badge.

Papers

The paper will be presented and discussed in oral sessions. All orally presented papers shall be presented exclusively through a computer projector system. Microsoft Powerpoint (Microsoft 365) or PDF File will be available. A PC will be available in each conference room.

If you have any questions, please contact the local organizing committee.

Presentation Guideline

Introduction

Firstly, we would like to, once again, express our appreciation for your contributions to the IEEE I&CPS Asia 2024. Regarding your presentation, please kindly find the presentation instructions and other detailed information prepared for you.

Time Allocation for Presentations

Oral presentations are allocated 15 minutes. A typical presentation includes one minute for preparation and introduction of the speaker by the chairperson, and 10 to 12 minutes for the main presentation, including approximately 3 to 5 minutes of Q&A/discussion. The session times of the presentations are listed in the program book.

Speakers should note the following:

1. Oral presenters are required to show up to the session chairs 15 minutes before each session starts and check their presentation files with the provided conference computers.
2. When your turn is next, go to the next speaker's seat in the front row of the session room.
3. When it is your turn, go to the podium and start your presentation after being introduced by the chairperson.

Presentation Check

We strongly recommend that the presenter should check the presentations in the session room during the break time before your presentation.

Working language

The working language of the conference is English and will be used for all printed matters.

Lunches

Daily lunches are provided by the conference.

Changes to the conference program

The program of the conference will be subject to change. In the event of cancellations by registrants or others, no refund of the registration fee can be made.

Liability

The 2024 IEEE IAS Industrial and Commercial Power System Asia (IEEE I&CPS Asia 2024) organizing committee shall not be liable for any loss, damage, expenditure or inconvenience caused because of alteration or cancellation of the conference program for any reason beyond its control. The organizers cannot be held responsible for accidents to IEEE I&CPS Asia 2024 participants for damage or loss of their properties. Participants should therefore make their own insurance arrangements.

IEEE I&CPS Asia 2024 Welcome Reception

Tuesday, July 9, 2024, 18:00 – 22:00 at Grand Ballroom, Amari Pattaya.

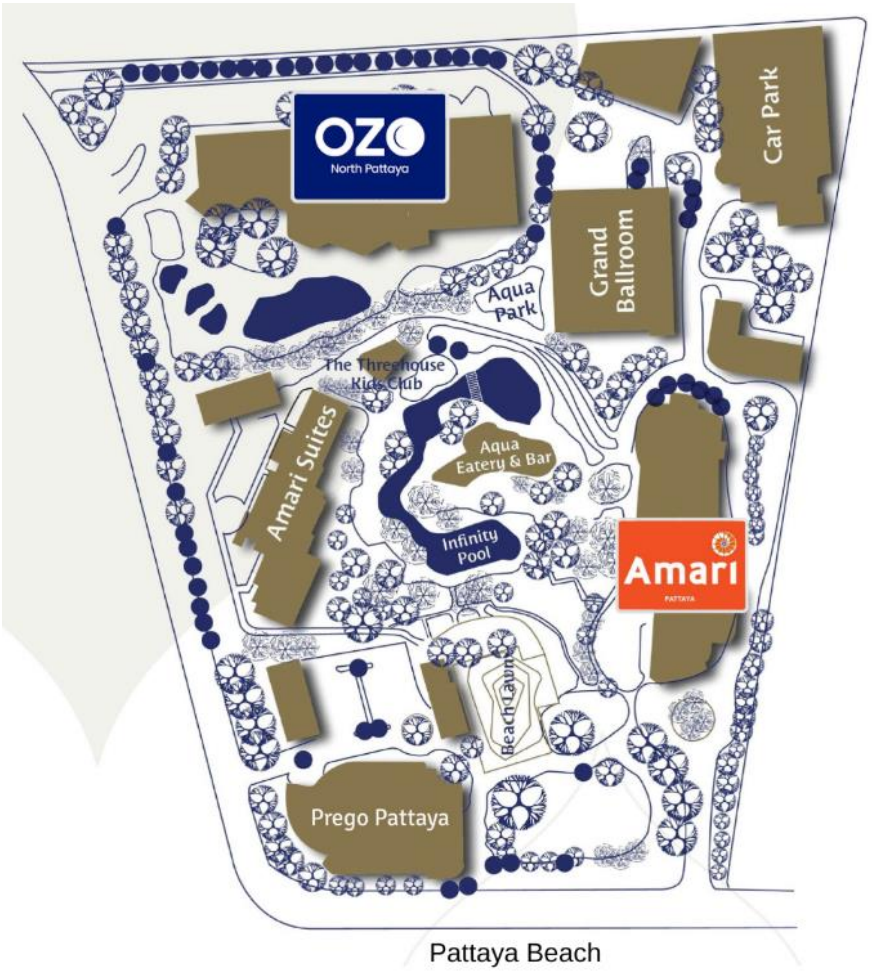
The Welcome Reception will be held at the Grand Ballroom, Amari Pattaya (Please refer to the layout of the conference area). The Welcome Dinner is open to all IEEE I&CPS Asia 2024 attendees and registered accompanying persons.

IEEE I&CPS Asia 2024 Conference Banquet

Thursday, July 11, 2024, 18:30 – 22:00 at Beach Lawn, Amari Pattaya.

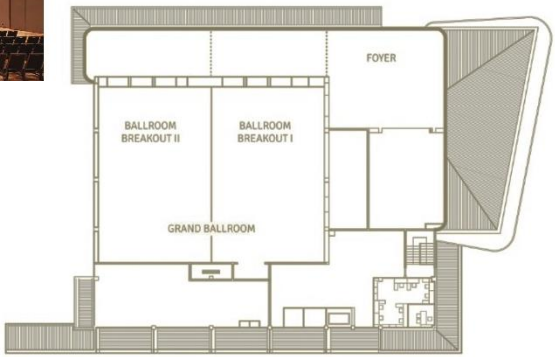
The Conference Banquet will be held at The Beach Lawn close to the beach. The Conference Banquet is open to all IEEE I&CPS Asia 2024 attendees and registered accompanying persons. You will encounter a variety of foods in Thai Traditional style.

Layout of Conference Area



Conference Room

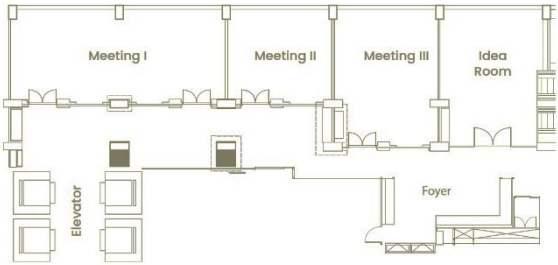
- *Grand Ballroom*



- Meeting rooms @ Amari Tower

MEETING I

IDEA ROOM



IEEE I&CPS Asia 2024 - Program

Time	9 July 2024
09.00 - 13.00	Group meetings, i.e. KMITL Staff, and so on
13.00 - 18.00	Registration *(pick up conference materials)*
18.00 - 22.00	IEEE I&CPS Asia 2024 Welcome Reception at Grand Ballroom

Time	10 July 2024
09.00 - 09.30	**Open Ceremony** *(Grand Ballroom)*
09.30 - 10.45	**Invited Speaker** *(Grand Ballroom)* **Keynote Speech 1 : "Energy Transition for Low Carbon Emission Future"** *Prof.Dr.Wei-Jen Lee*, The University of Texas at Arlington, United States of America **Keynote Speech 2 : "Energy Meteorology for the New Electric Power System"** *Prof.Dr.Ming Yang* , Shandong University, China **Keynote Speech 3 : "Stability Issues and Control Challenges for Carbon-Neutral Power Systems"** *Prof.Dr.Issarachai Ngamroo*, King Mongkut's Institute of Technology Ladkrabang, Thailand
10.45 - 11.00	**Coffee Break**
11.00 - 12.00	**Panel Discussion : "Carbon Neutrality for Future Power and Energy Systems"** *(Grand Ballroom)* *Mr.Warit Rattanachuen* , Assistant Governor - Electricity Generating Authority of Thailand (EGAT), Thailand *Mr.Pongsakorn Yuthagovit* , Assistant Governor - Provincial Electricity Authority (PEA), Thailand *Dr.Adisorn Tuantranont* , Assistant Director - National Science and Technology Development Agency (NSTDA), Thailand *Dr.Werachet Khan-ngern* , Chief Innovation Officer - Kumwell Corporation Public Company Limited, Thailand Moderator: ***Asst. Prof. Dr. Supattana Nirukkanaporn*** , Rungsit University
12.00 - 13.00	**Lunch**
13.00 - 15.00	**Oral Presentation**

Registration	Room	Grand Ballroom	Meeting 1	Meeting 3	IDEA room
	Session	*Power System - 1*	*Smart Grid - 1*	*Smart Grid & Renewable Energy*	*Power System and Smart Grid - 1*
	Paper ID	***P04789, P04892, P04912, P05140, P05331***	***P04743, P05164, P05171 P05223, P05224***	***P05584, P05125, P05174, P05342, P05634, P05248, P05593, P05108***	***P05506, P05043, P05048 P05058, P04787***
	Session Chair	**Assoc.Prof.Dr.Anantawat Kunakorn** *KMITL, Thailand*	**Asst.Prof.Dr.Bo Jie** *The University of Tokyo, Japan*	**Asst.Prof.Dr.Piampoom Sarikprueck** *KMITL, Thailand*	**Prof.Dr. Zhenyuan Zhang** *University of Electronic Science and Technology of China, China*
	15.00 - 15.15	**Coffee Break**			
	15.15 - 17.15	**Oral Presentation**			
	Room	Grand Ballroom	Meeting 1	Meeting 3	IDEA room
	Session	*Power System - 2*	*Electric Vehicles Applications*	*Energy System - 1*	*Renewable Energy - 1*
	Paper ID	***P05011, P05147, P05191, P05240, P05387***	***P05068, P05243, P05601, P05626, P05779***	***P05170, P05241, P05418, P05574, P05774, P04999***	***P04782, P04820, P05098, P05150, P05169***
	Session Chair	**Dr.Thongchart Kerdphol** *Kasetsart University,Thailand*	**Assoc.Prof.Dr.Chanin Bunlaksananusorn** *KMITL, Thailand*	**Asst.Prof.Dr.Chai Chompoo-inwai** *KMITL, Thailand*	**Assoc.Prof.Dr.Sambasivam Sangaraju** *United Arab Emirates University, U.A.E*

IEEE I&CPS Asia 2024 - Program

Time		11 July 2024			
08.30 - 10.10		Oral Presentation			
Room		Ballroom 1	Ballroom 2	Meeting 1	Meeting 3
Session		*Power System - 3*	*Energy System - 2*	*Power System & Smart Grid - 2*	*Renewable Energy - 2*
Paper ID		***P05196, P05205, P05229, P05333, P05741***	***P05184, P05190, P05385, P05408, P05863***	***P05410, P05415, P05620, P05621, P05668,***	***P05185, P05363, P05405, P05630, P05744***
Session Chair		**Assoc.Prof.Dr.Chow Chompoo-inwai** *KMITL, Thailand*	**Prof. Dr. DONG-HEE LEE** *Kyungsung University, Korea*	**Prof.Dr. Zhenyuan Zhang** *University of Electronic Science and Technology of China, China*	**Dr. Le-Ren Chang-Chien** *National Cheng Kung University, Taiwan*
10.10 - 10.25		Coffee Break			
10.25 - 12.05		Oral Presentation			
Room		Ballroom 1	Ballroom 2	Meeting 1	Meeting 3
Session		*Power System - 4*	*Energy System - 3*	*Carbon Neutrality*	*Other Relevant Topics - 1*
Paper ID		***P05211, P05231, P05232, P05238, P05419***	***P05183, P05193, P05227, P05236, P05388***	***P05239, P05360, P05389 P05413, P05645***	***P05247, P05317, P05373, P05854, P05181***
Session Chair	Registration	**Dr. Dawei Chen** *Shanghai Jiao Tong University, China*	**Assoc.Prof.Dr.Chanin Bunlaksananusorn** *KMITL, Thailand*	**Asst.Prof.Dr. Kamon Thinsurat** *Walailuk University, Thailand*	**Dr. Bamrung Tausiesakul** *Mahidol University, Thailand*
12.05 - 13.00		Lunch			
13.00 - 14.40		Oral Presentation			
Room		Ballroom 1	Ballroom 2	Meeting 1	Meeting 3
Session		*Power System - 5*	*Energy Storage*	*Renewable Energy - 3*	*Energy System - 4*
Paper ID		***P05221, P05242, P05383, P05396, P05631***	***P05167, P05177, P05197, P05417***	***P05384, P05403, P05414, P05608, P05609***	***P05237, P05864, P05865, P05736, P05866***
Session Chair		**Assoc.Prof.Dr.Suratsavadee K. Korkua** *Walailuk University, Thailand*	**Assoc. Prof. Dr. Theerayod Wiangtong** *KMITL, Thailand*	**Dr.Sompob Polmai** *KMITL, Thailand*	**Assoc.Prof.Dr.Anantawat Kunakorn** *KMITL, Thailand*
14.40 - 14.55		Coffee Break			
14.55 - 16.35		Oral Presentation			
Room		Ballroom 1	Ballroom 2	Meeting 1	Meeting 3
Session		*Power System - 6*	*Energy Storage & Electric Vehicles*	*Renewable Energy - 4*	*Energy System & Smart Grid*
Paper ID		***P05404, P05421, P05618, P05619, P05851***	***P04711, P04764, P05623, P05390, P05411***	***P05606, P05612, P05359, P05633, P05636***	***P05028, P05234, P05585, P05599, P05613, P05862***
Session Chair		**Assoc.Prof.Dr.Yanhui Gao** *Oita University, Japan*	**Assoc.Prof.Dr.Keerati Chayakulkheeree** *SUT, Thailand*	***Asst.Prof.Dr.Poom Konghuayrob KMITL, Thailand***	**Prof. Dr. Vijit Kinnares** *KMITL, Thailand*
17.45 - 18.30		Break			
18.30 - 22.00		*IEEE I&CPS Asia 2024 Conference Banquet at Beach Lawn (Amari Pattaya)*			

IEEE I&CPS Asia 2024 - Program

Time	12 July 2024			
08.30 - 10.10	Oral Presentation			
Room	Ballroom 1	Ballroom 2	Meeting 1	Meeting 3
Session	*Smart Grid - 2*	*Other Relevant Topics - 2*		
Paper ID	***P05572, P05776, P05622, P05624, P05393***	***P05214, P05235, P05364, P05379, P05773***		
Session Chair	**Assoc.Prof.Dr.Jie Shi** *University of Jinan, China*	**Asst.Prof.Dr.Sommart Sang-Ngern** *Naresuan University, Thailand*		
10.10 - 10.25	Coffee Break			
10.25 - 12.05	Oral Presentation			
Room	Ballroom 1	Ballroom 2	Meeting 1	Meeting 3
Session	*Renewable Energy - 5*	*Power System - 7*		
Paper ID	***P04929, P05369, P05210 P05409, P05473, P05654***	***P05375, P05189, P05372, P05374, P05377, P05707***		
Session Chair	**Asst.Prof.Dr.Chai Chompoo-inwai** *KMITL, Thailand*	**Asst.Prof.Dr.Piampoom Sarikprueck** *KMITL, Thailand*		
12.05 - 13.00	Lunch			
13.00 - 16.30	Technical and Culture Tour			

Note: 10 to 15 mins. for presentation and 5 mins. forQ&A (the total time of each paper is 15 mins.)

SESSION CHARIS

Session	Chairs
Power System - 1	**Assoc.Prof.Dr.Anantawat Kunakorn** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Power System - 2	**Dr.Thongchart Kerdphol** *Kasetsart University,Thailand*
Power System - 3	**Assoc.Prof.Dr.Chow Chompoo-inwai** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Power System - 4	**Dr.Dawei Chen** *Shanghai Jiao Tong University, China*
Power System - 5	**Assoc.Prof.Dr.Suratsavadee K. Korkua** *Walailak University, Thailand*
Power System - 6	**Assoc.Prof.Dr.Yanhui Gao** *Oita University, Japan*
Power System - 7	**Asst.Prof.Dr.Piampoom Sarikprueck** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Energy System - 1	**Asst.Prof.Dr.Chai Chompoo-inwai** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Energy System - 2	**Prof.Dr.DONG-HEE LEE** *Kyungsung University, Republic of Korea*
Energy System - 3	**Assoc.Prof.Dr.Chanin Bunlaksananusorn** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Energy System - 4	**Assoc.Prof.Dr.Anantawat Kunakorn** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Renewable Energy - 1	**Assoc.Prof.Dr.Sambasivam Sangaraju** *United Arab Emirates University, United Arab Emirates*
Renewable Energy - 2	**Dr.Le-Ren Chang-Chien** *National Cheng Kung University, Taiwan*
Renewable Energy - 3	**Dr.Sompob Polmai** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Renewable Energy - 4	**Asst.Prof.Dr.Poom Konghuayrob** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Renewable Energy - 5	**Asst.Prof.Dr.Chai Chompoo-inwai** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Smart Grid - 1	**Asst.Prof.Dr.Bo Jie** *The University of Tokyo, Japan*
Smart Grid - 2	**Assoc.Prof.Dr.Jie Shi** *University of Jinan, China*

Session	Chairs
Electric Vehicles Applications	**Assoc.Prof.Dr.Chanin Bunlaksananusorn** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Smart Grid & Renewable Energy	**Asst.Prof.Dr.Piampoom Sarikprueck** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Energy Storage & Electric Vehicles	**Assoc.Prof.Dr.Keerati Chayakulkheeree** *Suranaree University of Technology, Thailand*
Energy System & Smart Grid	**Prof. Dr. Vijit Kinnares** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Energy Storage	**Assoc. Prof. Dr. Theerayod Wiangtong** *King Mongkut's Institute of Technology Ladkrabang, Thailand*
Carbon Neutrality	**Asst.Prof.Dr. Kamon Thinsurat** *Walailak University, Thailand*
Power Systems & Smart Grid – 1	**Prof.Dr.Zhenyuan Zhang** *University of Electronic Science and Technology of China, China*
Power Systems & Smart Grid – 2	**Prof.Dr.Zhenyuan Zhang** *University of Electronic Science and Technology of China, China*
Other Relevant Topics - 1	**Dr. Bamrung Tausiesakul** *Mahidol University, Thailand*
Other Relevant Topics - 2	**Asst.Prof.Dr.Sommart Sang-Ngern** *Naresuan University, Thailand*

KEYNOTES SPEAKER I

" Energy Transition for Low Carbon Emission Future "

Prof.Dr. Wei-Jen Lee, IEEE Fellow
Professor and Chair
University of Texas at Arlington
United States of America

Professor Lee received the B.S. and M.S. degrees from National Taiwan University, Taipei, Taiwan., and the Ph.D. 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 and the chair of the Electrical Engineering Department.

He has been involved in the revision of IEEE Std. 141, 339, 551, 739, 1584, 1584.1, 1584.2 3002.8, and 3002.9 development. He is the past president of IEEE Industry Applications Society (1/2021-12/2022), past chair of IEEE TAB (Technical Activity Board) Climate Change Program (3/2022-12/2023), past project manager of IEEE/NFPA Arc Flash Phenomena Collaborative Research Project (9/2008-12/2022), co-chair of IEEE Sustainable Development Ad Hoc Committee, member of IEEE TAB Hall of Honor, chair of IEEE Smart Grid Program, and a member of United Nations Council of Engineers for the Energy Transition (CEET).

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 two hundred and twenty journal papers and three hundred and ten conference proceedings. He has provided on-site training courses for power engineers in Panama, China, Taiwan, Korea, Saudi Arabia, Thailand, and Singapore. He has referred to numerous technical papers for IEEE, IET, and other professional organizations.

Prof. Lee is a Fellow of IEEE, International Artificial Intelligence Industry Alliance, and Asia-Pacific Artificial Intelligence Association, member of National Academy of Inventors, and registered Professional Engineer in the State of Texas.

Abstract

The 2018 Intergovernmental Panel on Climate Change (IPCC) Report highlighted that achieving the 1.5°C goal would necessitate the world reaching net zero carbon emissions by 2050. Following COP26, nearly 200 countries reached consensus on the Glasgow Climate Pact, aimed at constraining the global temperature rise to 1.5°C and finalizing key aspects of the Paris Agreement. At the onset of COP27, a year later, UN Climate Change Executive Secretary Simon Stiell urged the alignment of "every facet of human endeavor" with the 1.5°C objective, emphasizing the progression from agreement in Paris to planning in Katowice and Glasgow, with implementation now shifting to Sharm El Sheikh. During COP28, UN Secretary General Antonio Guterres asserted that achieving the 1.5°C limit hinges on ultimately ceasing the combustion of all fossil fuels, rather than merely reducing or mitigating emissions, but by phasing them out within a clear timeframe in alignment with the 1.5°C target.

Numerous industries are taking significant steps to achieve this objective. For instance, Apple has pledged to achieve 100 percent carbon neutrality for its supply chain and products by 2030, while other manufacturers have set similar targets. These initiatives are poised to revolutionize society as a whole.

According to the March 2023 IEA Flagship Report on CO2 Emissions in 2022, the power and heat sector contributed to over 42% of the global CO2 emissions. To decarbonize this sector, developers must evaluate their approaches for smooth transition. While planning for large-scale renewable energy projects, it is difficult to maintain stability and resilience of the power systems with phase out and replacement alone of traditional fossil fuel generation.

This presentation discusses the options of orderly transition from fossil fuel to low carbon emission energy resources future.

KEYNOTES SPEAKER II

"Energy Meteorology for the New Electric Power System"

Prof.Dr. Ming Yang
Shandong University,
China

Ming Yang is a Professor with Shandong University and "Taishan Scholar" Distinguished Professor of Shandong Province, China. He was selected as the World's Top 2% Scientists of 2022/2023 released by Stanford University. He received the B.S. and Ph.D. degrees from School of Electrical Engineering, Shandong University, Jinan, China, in 2003 and 2009, respectively. From 2006 to 2007, he was an exchange Ph.D. student with Energy System Research Center, University of Texas at Arlington, Arlington, TX, USA. From 2015 to 2016, he was a Visiting Scholar with the Energy Systems Division, Argonne National Laboratory, Argonne, IL, USA. His major research interests include power system operation and scheduling, new energy generation forecasting. In the past 15 year, he has worked on more than 30 projects to solve the problems of the optimal integration of renewable energy into power systems, which are supported by the government, domestic and international companies. He has published four books and more than 150 peer-reviewed papers (with more 100 journal papers) that have more than 3800 citations. He won several prizes awarded by the People's Government of Shandong Province, Chinese Electrotechnical Society, etc. He serves as an associate editor/editor of IEEE Transactions on Power Systems/Power Engineering Letters/Industry Applications, Protection and Control of Modern Power Systems, IET Renewable Power Generation. He is the co-chair of IEEE IAS I&CPS Asia Operation Committee, founding chair of IEEE I&CPS ASIA, member of Grid Integration of Renewable Energy Generation Subcommittee of IEC (IEC SC8A), Deputy Director of National IOT Information Technology and Systems Engineering Experimental Teaching Center of China, and executive member of Intelligent Energy Standards Committee of Chinese Electrotechnical Society.

Abstract

The main task of the new power system is to build a high proportion of renewable energy supply and consumption system, the operation law of its source, network, load and storage is closely related to meteorological changes.

The operation and scheduling, planning and design, disaster prevention and reduction, and other aspects of the power grid all need to consider the influence of weather. The integration and development of the two disciplines of electricity and meteorology have become inevitable. We summarize the key technologies of numerical weather prediction from four aspects: meteorological observation, quality control, data assimilation, and numerical modeling. Meanwhile, typical application scenarios and methods of numerical meteorology are summarized from three aspects: source load power prediction, wind and solar resource assessment, and power grid disaster warning.

In addition, the unique requirements of the new power system for the accuracy, timeliness, and precision of numerical weather prediction are analyzed.

The key research directions for the integration and development of electricity and meteorology disciplines in the future are discussed in terms of data, mode, and platform construction, in order to provide reference for relevant theoretical research and practical applications.

KEYNOTES SPEAKER III

"Stability Issues and Control Challenges for Carbon-Neutral Power Systems"

Prof.Dr. Issarachai Ngamroo
School of Engineering
King Mongkut's Institute of Technology Ladkrabang,
Thailand

Issarachai Ngamroo received the B.Eng. degree in Electrical Engineering from King Mongkut's University of Technology Ladkrabang (KMITL), Bangkok, Thailand, in 1992. He received M.Eng and Ph.D. degrees in Electrical Engineering from Osaka University, Osaka, Japan in 1997 and 2000, respectively, under the Japanese Government Scholarship. He worked at Sirindhorn International Institute of Technology, Thammasat University, Thailand in 2000 until 2006. In 2007, he joined the Department of Electrical Engineering, School of Engineering, KMITL and was appointed Professor of Electrical Engineering in 2012. His research interests include power system stability, dynamics, and control. From his research contributions, he was conferred the KMITL Award for Outstanding Research 2015, KMITL Engineering Outstanding Alumni Award 2018, Senior Research Scholar Fellowship from the National Research Council of Thailand 2020, and World Ranking of Top 2% Most-Cited KMITL Engineering School Researchers 2023. He was the leader of the Senior Research Scholar Project of "Intelligent control-based smart renewables for power system stability enhancement" from 2020-2023 granted by the National Research Council of Thailand. He is a Senior Member of the IEEE.

Abstract

The devastating impacts of climate change force many countries to reach carbon-neutrality in 2050. Since the energy sector is one of the main sources of carbon emissions, renewable energy (RE) sources, electric vehicles (EVs) etc., have been significantly installed in electric power systems to lower the emissions. However, the high penetration of inverter-based RE such as wind and solar, as well as EVs causes adverse effects on power system stability. This presentation focuses on the stability issues and control challenges due to inverter-based resources for carbon-neutral power systems. Three main parts will be presented as follows. The first part introduces Thailand's carbon neutrality pathway. The target, national energy plan, RE and EV situations, and stability issues will be clarified. Next, the power oscillations problem is provided as the second part. The wide area monitoring system by micro-phasor measurement units (μPMU) and power oscillation damping control will be proposed. Lastly, the third part presents a low system inertia problem and intelligent control of grid forming inverters.

ORAL PRESENTATION

Session: Power System – 1 (Wednesday, July 10, 2024)
Chair : Assoc.Prof.Dr.Anantawat Kunakorn
Room : Grand Ballroom
Time : 1.00 PM – 3.00 PM

P04789	**Techno-Economic Assessment for First Submarine Cable Project in Oman** *Amjed Al Rumedhi, Ahmed Al Omairi, Mohammed Al Hasni, Afara AL Qataiti, Musabah Al Siyabi, and Hisham Al Riyami*
P04892	**Energy Conserving in Power Plant: A Case Study of Practical Demand Cutting in Power Station Service System** *K. Pingyos, N. Jirasuwankul, and S. Chandee*
P04912	**Voltage Stability and Transfer Limit Analysis in Bhutan Power System using P-V Curve Approach** *Samten, Ugyen Chophel, Dawa Gyeltshen, and Sherub*
P05140	**Short-term Power Load Forecasting based on Light GBM-VMD-SE and Inception-BiGRU-Attention** *Jingqi Xu, Hui Hou, Tian Ni, Chao Luo, Lingyun Chen, Yi Kang, Wenjie Wu, and Bozheng Li*
P05331	**Optimal Design of PSS-FACTS Using Craziness Particle Swarm Optimization in SMIB System** *Muhammad Ruswandi Djalal, Makmur Saini, and A.M. Shiddiq Yunus*

Session: Smart Grid – 1 (Wednesday, July 10, 2024)
Chair : Asst.Prof.Dr.Bo Jie
Room : Meeting 1
Time : 1.00 PM – 3.00 PM

P04743	**Design of Transmission Line Lightning Monitoring System based on LoRa Technology** *Xiaomin MA, Xi Liu, Songhai Fan, Li Chen, and Zhiling Chen*
P05164	**Characterization of Energy Sharing Potential of Prosumers based on Evolutionary Game on Social Network** *Hongli Wang, Jun Yang, Fengran Liao, Legang Jia, Nianjiang Du, and Tianhui Li*
P05171	**Cyber Attacks Detection Using Deep Learning Methods for Resilient Operation in DC Shipboard Microgrids** *Zulfiqar Ali, Tahir Hussain, Chun-Lien Su, Anca Delia Jurcut, Shazia Baloch, and Muhammad Sadiq*
P05223	**A Novel FCL based on Continuous Current Commutation for LVDC Distribution Network** *Hongyuan Wu, Jinyi Deng, Yong Chen, Peitao Wang, Xingyu Pei, Qi Xiong, and Huan Guo**
P05224	**Parameter Comprehensive Optimization of a Fast DC Fault Current Limiter** *Hongyuan, Yubo Zhong, Yong Chen, Zhi Chen, Xingyu Pei, Yufei Zhang, and Huan Guo*

Session: Smart Grid & Renewable Energy (Wednesday, July 10, 2024)
Chair : Asst.Prof.Dr.Piampoom Sarikprueck
Room : Meeting 3
Time : 1.00 PM – 3.00 PM

P05584	**A Voltage Security Boundary Computation Method for New Type Power Systems based on Dynamic Dimensionality Reduction Equivalence** *Lin Xue, Tao Niu, Sidun Fang, Hung Dinh Nguyen, and Guanhong Chen*
P05125	**Enabling Forecasting-aided State Estimation in Active Distribution Networks via GRformer-Driven Pseudo-Measurement Modeling** *Yue Yu, and Yue Wang*
P05174	**A Remedial Action Scheme Against False Data Injection Cyberattacks Targeting ULTC Transformers in Smart Distribution Systems** *Zulfiqar Ali, Arash Asrari, and Poria Fajri*
P05342	**State-Space Modeling and Transient Stability Analysis of the Paralleled SG-VSG System Coupled to Weak Grid** *Lei Chen, Shencong Zheng, Yuqi Jiang, Jingguang Tang, Yifei Li, and Hongkun Chen*
P05634	**Maximizing Wind Power Injection by Transmission Switching and DLR with Voltage Stability Constraints** *Ke Wu, Lei Wang, Hengxu Ha, and Mei Zhang*
P05248	**Planning for Hybrid Refueling Stations with PV Power in Highway Networks based on Traffic Equilibrium and Price Response** *Yiming Xian, Mingchao Xia, Qifang Chen, Fangjian Chen, Jichen Wang, and Jichen Wang*
P05593	**Real-Time Energy Management for Hybrid AC/DC Microgrids with Adjustable Bus Voltage** *Kai Li, Xuan Liu, Xiao Qi, Huashuo Zhuo, and Tianyang Zhao*
P05108	**Wind Power Fluctuation Smoothing Strategy based on Variational Modal Decomposition and Model Predictive Control** *Zhao Jiang, Shangqing Song, Hao Cheng, Zhencheng Shi, Wang, and Xiaodong Yu*

Session: Power System & Smart Grid – 1 (Wednesday, July 10, 2024)
Chair : Prof.Dr. Zhenyuan Zhang
Room : Idea room
Time : 1.00 PM – 3.00 PM

P05506	**PPO-based Satellite Terminal and UAV Nest Location Scheme for Space-Air-Ground Integrated Power Line Inspection** *Keren He, Quan Zhou, Yang Shen, Chenhao Sun, and Zhikang Shuai*
P05043	**Performance Analysis of Multi-Area AGC Control of Interconnected Power System with Renewable Energy Sources (RESs) and Energy Storage System (ESS)** *Om Rishi*, Tapan Garg, Gaurav Kumar, Rishabh Verma, and Diljinder Singh*
P05048	***A Sequential Power Flow Analysis of the Radial Hybrid AC/DC Distribution Network with Aggregated EV load*** *Gaurav Kumar, Rishabh Verma, and Diljinder Singh*
P05058	**Nonparametric Probabilistic Forecasting of Regional Photovoltaic Power based on Spatial Clustering and Combining Quantile Regression** *Zhiqiang He, Yan Peng, Can Wan, Hao Sun, Chengyu Lu, and Wenjin Chen*
P04787	**Configuration and Operation Model for Integrated Energy Power Stations with Concentrated Solar Power Plants** *Qingxin L, Ming Shi, Linfeng Zheng, and Sijie Chen*

Session: Power System – 2 (Wednesday, July 10, 2024)
Chair : Dr.Thongchart Kerdphol
Room : Grand Ballroom
Time : 3.15 PM – 5.15 PM

P05011	**China Southern Power Grid Fault Analysis under 2023 Typhoon Haikui Disaster** *Wenjie Wu, Hui Hou, Ruizeng Wei, Huan He, Lei Wang, and Yongchao Liang*
P05147	**Operational Planning to Enhance Bhutan Power Grid Resilience against Cascading Failures in Interconnected Systems** *Kelzangla, Naebboon Hoonchareon, and Wijarn Wangdee*
P05191	**Two-stage Voltage Control Strategy for Distribution Networks with Multi-Microgrids Considering Reactive Power Incentive** *Keyu Zhang, Jian Chen, Xianglong Qi, Yang Chen, Zihan Sun, and Meijia Wei*
P05240	**Operating Experience and Suggestions for Reliability and Resilience Indices – A Study in Taiwan** *Yuan-Kang Wu, Quoc-Thang Phan, and Duc-Tung Trinh*
P05387	**Sample-based Conservative Bias Linear Power Flow Approximations** *Paprapee Buason, Sidhant Misra, and Daniel K. Molzahn*

Session: Electric Vehicles Applications (Wednesday, July 10, 2024)
Chair : Assoc.Prof.Dr.Chanin Bunlaksananusorn
Room : Meeting 1
Time : 3.15 PM – 5.15 PM

P05068	**A Experimental study of Used Battery Energy Storage System Control Concept with Swappable Battery Packs for Electric Vehicle** *InJae Kwak, SilLo.Jin, HyeongTae.Noh, SangHoon.Kim, and JaeIn.Kim*
P05243	**Hamiltonian Control for CC-CV Primary-side Buck Converter of Inductive Wireless EV Charging** *Thanet Sriprom, Jutturit Thongpron, Uthen Kamnarn, Anon Namin, Noureddine Takorabet, Serge Pierfederici, Babak Nahid-Mobarakeh, Burin Yodwong, Phatiphat Thounthong, and Nicu Bizon*
P05601	**Electric Vehicle Potential to Reduce Overvoltage-Induced Photovoltaic Energy Curtailment in Distribution Networks** *Chaowanan Jamroen, Dulpichet Rerkpreedapong, and Sanchai Dechanupaprittha*
P05626	**An Optimization Method of Motor Topology based on Analysis of Coefficient of Prognosi** *Yuan Mao, Yuanzhi Wang, Yun Yang, and Youbing Zhang*
P05779	**Comparative Analysis of Electrification Technologies in Heavy-Duty Vehicles: A Case Study of Thailand** *Nitikorn Junhuathon, and Keerati Chayakulkheeree*

Session: Energy System – 1 (Wednesday, July 10, 2024)
Chair : Asst.Prof.Dr.Chai Chompoo-inwai
Room : Meeting 3
Time : 3.15 PM – 5.15 PM

P05170	**Multi-objective Reinforcement Learning for Optimal Scheduling of Electricity-Hydrogen-Thermal Multi-Energy Microgrids** *Chen Liu, Yu Wang, and Kaigui Xie*
P05241	**TSO-DSO Coordination to Effectively Integrate DER Flexibility into the Balancing Market** *Hang Nguyen, Trung Thai Tran, Kha T. Nguyen, Koen Kok, and Phuong H. Nguyen*
P05418	**Soft Starting Comparison of Single-Phase Capacitor Start Capacitor Run Induction Machine between Motoring and Generating Operation using Asynchronous PWM AC Chopper** *Nuttapong Prapurt, Vijit Kinnares, and Sakdawut Boontua*
P05574	**Wind-sensitive Energy-transport Scheduling Method for Electric Transfer Vehicles in Seaports** *Ying Lu, Ailing Xing, Sidun Fang, Tao Niu, Guanhong Chen, and Ruijin Liao*
P05774	**Enhancing Energy Efficiency in Rubberwood Drying Kilns by Optimizing Air Velocity for Sustainable Production** *Choosak Rittiphet, Siraporn Sakphrom, Krit Funsian, Kamon Thinsurat, Charenkiat Pochaiya, and Suratsavadee K.Korkua*
P04999	**Accurate Loss Tangent Determination in Damped Alternating Voltage Tests** *Peerawut Yutthagowith, Punyavee Chaisiri*, and Busayapol Paophan*

Session: Renewable Energy – 1 (Wednesday, July 10, 2024)
Chair : Assoc.Prof.Dr.Sambasivam Sangaraju
Room : IDEA room
Time : 3.15 PM – 5.15 PM

P04782	**A High-Precision Parameter Identification Method based on Improved DFT for Sub-Super Synchronous Oscillations** *Feiyu Sun, Dongsheng Cai, Zhengyuan Zhang, and Qi Huang*
P04820	**Data-Driven PID Controller of Wind Turbine Systems Using Memory-based Smoothed Functional Algorithm** *Muhammad Ikram Mohd Rashid, Mohd Ashraf Ahmad, Mok Ren Hao, Mohd Helmi Suid, and Mohd Zaidi Mohd Tumari*
P05098	**Solar Power Plant Capacity Monitoring using Random Forest Machine Learning Algorithm** *Emmanuel Ede Ogar, Surachai Chaitusaney, and Watit Benjapolakul*
P05150	**Seamless Electro-mechanical Energy Release for Frequency Response Under Optimal Wind Power Production** *Le-Ren Chang-Chien, Dinh Minh Duc Truong, and Wang-Rong Ni*
P05169	**Comparative Optical Performance Analysis of Cross Linear System with Parabolic Trough and Linear Fresnel System at Latitudes Above 30° N.** *Akash Patel, Archana Soni, and Prashant Baredar*

Session: Power System – 3 (Thursday, July 11, 2024)
Chair : Assoc.Prof.Dr.Chow Chompoo-inwai
Room : Ballroom 1
Time : 8.30 AM – 10.10 AM

P05196	**A Universal Method for Suppressing Transient DC-bias in Triple-Active-Bridge Converters based on Superposition analysis** *Xu Han , Huiqing Wen , Zhichen Feng , Guangyu Wang , Yiwang wang, and Jose Rodriguez*
P05205	**Design of Flexible Ramping Product Coupled with Spinning Reserve** *Haoxuan Chen , Lizi Zhang, and Siyu Hao*
P05229	**Synthetic Inertia-Power Sharing in High Renewable Power Grids Through Vehicle-to-Grid Topology** *Thongchart Kerdphol , Tossaporn Surinkaew, and Issarachai Ngamroo*
P05333	**FACTS: SVC Optimization for Optimal Power Flow Using Craziness Particle Swarm Optimization In Sulselrabar System** *Makmur Saini , Muhammad Ruswandi Djalal, and A.M. Shiddiq Yunus*
P05741	**A Simple Generator Reduction Method by Using a Power System Reproduction Model** *Jae-Pil Seo , Yoon-Seong Choi , Sangsoo Seo , Jaesik Kang, Seongmin Pyo, and Dongho Lee*

Session: Energy System - 2 (Thursday, July 11, 2024)
Chair : Prof. Dr. DONG-HEE LEE
Room : Ballroom 2
Time : 8.30 AM – 10.10 AM

P05184	**Regional Frequency Stability Constrained Resilience Enhancement Strategies for Distribution Systems with Flexible Energy Resources** *YANG Hongkun , WANG Xu , JIANG Chuanwen , WANG Yushan , CHEN Qizhen, and WU Hanxiao*
P05190	**Multi-timescale Optimal Scheduling of an Electricity-Hydrogen Integrated Energy System based on Deep Deterministic Policy Gradient** *Meijia Wei , Jian Chen , Zhencheng Shi , Yang Chen , Keyu Zhang, and Zihan Sun*
P05385	**Influence of Waste Composition and Air Speed on Waste Incineration Energy System** *Jinlong Yang , Aidan Lee , Seungwoon Park, and Chul-Hee Lee*
P05408	**Day-Ahead Scenario Generation Model of Multiple Wind Farm Output based on GCN and TimeGAN** *Jiangchun Yu , Diansheng Luo , Wenju Liang , Fangyu Fu , Hongying He, and Tianguang Lu*
P05863	**Multi-Service Provision Oriented Data Center Job Scheduling Scheme** *Shijie Chen, Yimeng Sun, Yehan Wang, and Zhaohao Ding**

Session: Power System & Smart Grid – 2 (Thursday, July 11, 2024)
Chair : Prof.Dr. Zhenyuan Zhang
Room : Meeting 1
Time : 8.30 AM – 10.10 AM

P05410	**Day-ahead Demand Response Potential Forecasting Method for Data Centers based on Federated Learning** *Shuya Lei , Xuwei Xia, and Jiangbo Sha*
P05415	**Application Analysis and Prospect of GPT-enabled Digital Transformation of Power Systems** *Lu Gan , Peng Wang , Di Zhang , Yiqun Cao , Liwan Zhou, and Yongjun Zhang*
P05620	**Arc Extinction and Control Strategy for Hybrid Grounding System Considering Line Impedance and Load in Distribution Networks** *Zitong Wang , Kangli Liu , Jianfeng Zhao , Wanglong Ding , Cheng Jin , Yu Zhou, and Anlong Zhang*
P05621	**Satellite-Terrestrial Data Fusion-based Geological Disaster Risk Prediction Method for Power Substations** *Jiyang Liu , Quan Zhou , Chenhao Sun , Jiawei Zhou, and Yang Shen*
P05668	**Space-Air-Ground Integrated Framework Augmented with Multimodal Information Fusion for Substation Fault Prediction** *Yao Wen , Quan Zhou , Shiyuan Qiu , Keren He, and Chenhao Sun*

Session: Renewable Energy - 2 (Thursday, July 11, 2024)
Chair : Dr. Le-Ren Chang-Chien
Room : Meeting 3
Time : 8.30 AM – 10.10 AM

P05185	**Short-term Wind Power Prediction based on Variational Mode Decomposition and Improved LSTM** *Shangqing Song , Zhao Jiang , Zhencheng Shi , Hao Cheng , Heng Wang, and Xiaodong Yu*
P05363	**A Network Utilization Pricing Mechanism Considering Network Constraints in Peer-to-Peer Energy Trading** *Yunqiang Gao , Yun Liu, and Chao Sun*
P05405	**Stand-alone Offshore Wind Farm for Green Hydrogen Production with Technical Feasibility** *Trung Thai Tran , Minh-Duc Ngo , Kha T. Nguyen, and Phuong H. Nguyen*
P05630	**Building Integrated Photovoltaic Thermal (BIPVT) technology and the results of MATLAB calculations of power generation in cold climate conditions** *Mungunshagai Gansukh, Ochirbat Tsetsgee, Mand-Uugan. M, Tugsbus. G, Mikhaylov. A, and Gankhuleg. M*
P05744	**Control of a 3-Phase 12/8 Switched Reluctance Generator for Future Energy System Applications** *Phop Chancharoensook*

Session: Power System - 4 (Thursday, July 11, 2024)
Chair : Dr. Dawei Chen
Room : Ballroom 1
Time : 10.25 AM – 12.05 PM

P05211	**Mathematical Models of The Flexible Ramping Market Demand Curve Adapted to China's Electricity Market** *Xianglin Ren, Xianchao Huang, Dan Luo, Muyao Han, and Haoxuan Chen*
P05231	**Technical Feasibility Study of Utility Microgrid Pilot Project at Rubesa, Bhutan.** *Karma Chheki, and Naebboon Hoonchareon*
P05232	**Medium Term Load Forecasting for an Industrial Factory Using Bi-LSTM** *Muhammad Hammad Hassan, and Channarong Banmongkol*
P05238	**Stability Analysis and Optimization of DC Circuit Breakers with Single Gate Drive Scheme for Power System Protection** *Ningyu Luo, Yang Xu, Miaoran Zhang, Peichao Xu, Huiqing Wen, Guabgda Xu, and Xinran Liang*
P05419	**Protecting Sensor Data Confidentiality in WAN-Enabled Power Systems: A Framework Utilising Image Encoding and Machine Learning Regression** *Siddhartha Deb Roy, Sanjoy Debbarma, Kingshuk Roy, and Liza Debbarma*

Session: Energy System - 3 (Thursday, July 11, 2024)
Chair : Assoc.Prof.Dr.Chanin Bunlaksananusorn
Room : Ballroom 2
Time : 10.25 AM – 12.05 PM

P05183	**Electrochemical-Thermodynamic Coupling Modeling of Solid Oxide Fuel Cells for Integrated Energy System Optimization Scheduling** *Boyi Yin, Can Wang, and Xuewei Pan*
P05193	**Two-layer Optimal Planning for Hybrid Electricity Hydrogen Energy Storage of Integrated Energy System Considering the Extreme Weather Scenario** *Zihan Sun, Jian Chen, Yang Chen, Meijia Wei, Keyu Zhang, and Wen Zhang*
P05227	**Optimizing Hydrogen Highway Planning Model Considering Hydrogen Cost and Vehicle Flow Effects** *Yan Zhang, Yong Lv, Yanming Wan, Yuxin Sun, Xian Zhang, Guibin Wang, Yifeng Wu, and Chang Liu*
P05236	**MVDC Converter Station Optimizing Site Selection Method in Urban Power Grids for Enhancing Grid Support** *Mingyang Li, Kaiqi Sun, Ke-jun Li, Yuanyuan Sun, Yang Liu, and Jie Liu*
P05388	**Compliant Parallel Beam Piezoelectric Array Energy Harvester based on Non-contact Rotating Magnetic Excitation** *Yi-He Zhang, Aidan Lee, Seungwoon Park, and Chul-Hee Lee*

Session: Carbon Neutrality (Thursday, July 11, 2024)
Chair : Asst.Prof.Dr. Kamon Thinsurat
Room : Meeting 1
Time : 10.25 AM – 12.05 PM

P05239	**Multiple industrial parks electric-carbon collaborative optimization operation method considering carbon emission flows** *Jizhong Zhu, Jialin Zhou, Di Zhang, Qingju Luo, and Ziyu Chen*
P05360	**A Continuous Double Auction Mechanism for Joint Trading of Carbon Allowance and Reduction: A China's Carbon Market Study** *Fangxuan Pei, Yun Liu, Jizhong Zhu, and Ziyu Chen*
P05389	**An Improved Convolutional Networks model for Carbon Emission Prediction in Power Systems** *Dongsheng Cai, Caroline Acen, Chiagoziem C. Ukwuoma, Nan Zhang, Wei Liu, Zhenyuan Zhang, and Qi Huang*
P05413	**Low-carbon and Economic Scheduling Strategy for Virtual Power Plant based on Complementary Characteristics and Aggregation Model of DER** *Zheng Jia, Qinfei Sun, Liyong Wang, Songsong Chen, Taorong Gong, Xinxin Ge, Fei Wang, and Qinggui Chen*
P05645	**Carbon-Accounted Optimal Power Dispatch and Spot Pricing** *Prakaipetch Muangkhiew, and Keerati Chayakulkheeree*

Session: Other Relevant Topics - 1 (Thursday, July 11, 2024)
Chair : Dr. Bamrung Tausiesakul
Room : Meeting 3
Time : 10.25 AM – 12.05 PM

P05247	**Lifetime Extension Strategy for IEEE 802.15.4 DSME-based Wireless Powered Sensor Networks** *Jung-Hyok Kwon and Eui-Jik Kim*
P05317	**Dynamic Loss Simulation Considering Domain Wall Movements of GO Silicon Steels with Finite Element Method** *Shengze Gao, Xiaojun Zhao, Weimin Guan, Yanhui Gao, and Yanhui Gao*
P05373	**Development of a Simple Dielectric Equivalent Circuit Model from Polarization and Depolarization Current Measurements** *Peerawut Yutthagowith*, Phethai Nimsanong, and Yoshihiro Baba*
P05854	**Environmental Impact Assessment of Lead-Acid and Lithium-ion Battery Waste Management in Thailand** *Nattaya Morawan, Issariya Mungkhala, Chodchanok Attaphong*, John Katers, and Piampoom Sarikprueck*
P05181	**Edge-Based Anomaly Detection in AIoT Using a Hybrid CNN and Logistic Regression Approach** *Brij B. Gupta*, Akshat Gaurav, Varsha Arya, Kwok Tai Chui*

Session: Power System – 5 (Thursday July 11, 2024)
Chair : Assoc.Prof.Dr.Suratsavadee K. Korkua
Room : Ballroom 1
Time : 1.00 PM – 2.40 PM

P05221	**Analysis and Reliability Assessment for a Bidirectional Single-Stage DAB-based Three-port Photovoltaic Energy Storage Inverter** *Guangyu Wang, Huiqing Wen, Xu Han, Zhichen Feng, Peichao Xu, and Xue Wang*
P05242	**State Estimation in Power System under Deterministic False Data Injection Attack Using Minimization of Nuclear Norm and ℓ_1 Norm with Noisy Constraint Substitution** *Bamrung Tausiesakul, Krissada Asavaskulkiet, Chuttchaval Jeraputra, Ittiphong Leevongwat, Thamvarit Singhavilai, and Supun Tiptipakorn*
P05383	**Nodal Price Forecasting based on Spatiotemporal Transformer** *Shijie Ji, Junkang Chen, Wen Xie, Feng Gao, Guannan He, Zhenghao Yang, and Wanli Hu*
P05396	**Dynamic Assessment of Thailand's Available Transfer Capability for Third-Party Access** *Dhamrongsak Khakkharho, Thanakorn Sutheerawut, Thongchart Kerdphol, Noppada Teera-achariyakul, Tossaporn Surinkaew, and Watcharakorn Pinthurat*
P05631	**A Multi-Agent Reinforcement Learning based Approach for Frequency Regulation of Power System Penetrated with Dynamic RTEM and Microgrids** *Liza Debbarma, Sanjoy Debbarma, Kingshuk Roy, Siddhartha Deb Roy, and Piyush Pratap Singh*

Session: Energy Storage (Thursday, July 11, 2024)
Chair : Assoc.Prof.Dr.Theerayod Wiangtong
Room : Ballroom 2
Time : 1.00 PM – 2.40 PM

P05167	**Optimal Control of a Battery Storage on the Energy Market** *Stephan Schlüter, Abhinav Das, and Matthew Davison*
P05177	**Lessons Learned from the Operating Experience of Battery Energy Storage Systems in the World** *Yuan-Kang Wu, Quoc-Thang Phan, and Duc-Tung Trinh*
P05197	**Tuning the Intercalation Redox Mechanism in 2D Ti3C2Tx by Incorporating Cr2O3 Nanoparticles for Supercapacitor Applications** *Maheshwaran Girirajan, Ali H. Al-Marzouqi, Fathy M. Hassan, Soorathep Kheawhom, Saifudeen Kabeer, and Sambasivam Sangaraju*
P05417	**Benefits of Adjustable-Speed Pumped Hydro Units Running in Turbine Mode for Wide Water Head Variation Reservoir** *Vijay Mohale, and Madhukar Waware*

Session: Renewable Energy – 3 (Thursday, July 11, 2024)
Chair : Dr.Sompob Polmai
Room : Meeting 1
Time : 1.00 PM – 2.40 PM

P05384	**Enhancing Solar Forecasting Accuracy: A Fusion of Sky Images and Meteorological Data with Channel-wise Attention** *ANTO LEOBA Jonathan, Dongsheng Cai, Olusola Bamisile, Joseph Junior NKOU NKOU, Harriet AGOBAH, and Qi Huang*
P05403	**Short-Term Wind Power Prediction based on TCN-Transformer and STL Error Correction** *Xin Li and Yingying Zheng*
P05414	**New Energy Consumption Capacity Evaluation Method for Isolated Industrial Park Considering Flexible Load Regulation Ability** *Nan Li, Hui Xu, Zhenlong Tan, Haonan Dai, Zhibao Zheng, Ling Hao, Fei Xu, Lei Chen, and Zihao Tong*
P05608	**Single Control Angle based Power Regulation in Modified Single-Pulse-Operated Switched Reluctance Generator** *Anupam Verma and G. Narayanan*
P05609	**Improved Small-Signal Model of Single-Pulse Operated Switched Reluctance Generator** *Anupam Verma and G. Narayanan*

Session: Energy System– 4 (Thursday, July 11, 2024)
Chair : Assoc.Prof.Dr.Anantawat Kunakorn
Room : Meeting 3
Time : 1.00 PM – 2.40 PM

P05237	**Data Pre-possessing Method for Distribution Networks based on the CNN-LSTM Considering the Spatial Properties** *Yiming Wang, Kaiqi Sun, Yuanyuan Sun, Wei Qiu, Yidian Gao, Guabgda Xu, Zhengxuan Cao, and Mingyang Li*
P05864	**Online Job Scheduling for Energy Cost Optimization in Geo-Distributed Data Centers Considering Data Locality: A Multi-Agent Reinforcement Learning Approach** *Junyi Lang, Xiaokang Zheng, Yimeng Sun, and Zhaohao Ding**
P05865	**Temporal Forecasting for IT Power Demand of Data Center** *Yehan Wang, Yuejun Yan, Wenyu Liu, Shijie Chen, Zhaoyang Wang, and Zhaohao Ding**
P05736	**Potential Assessment of Photovoltaic Power Generation in China Based on High Temporal Resolution Scale** *Xi Huang, Jiaxing Wang, Jie Shi, Yan Li, Yuming Wang*
P05866	**Flexibility Quantification for Energy-aware Data Center Job Scheduling: A Chance Constrained Bi-Level Model** *Wenyu Liu, Yuejun Yan, Peng Wang*, Zhaoyang Wang, and Zhaohao Ding*

Session: Power System – 6 (Thursday, July 11, 2024)
Chair : Assoc.Prof.Dr.Yanhui Gao
Room : Ballroom 1
Time : 2.55 PM – 4.35 PM

P05404	**Efficacy of Piezoelectric Transducer Placement in Enhancing Ultrasonic Cleaning Efficiency** *K. Punyatip, S. Samreong, J. Pakprom, W. Charoensiri, P. Janpangngern, T. Thosdeekoraphat, N. Santalunai, S. Santhalunai, and C. Thongsopa*
P05421	**An Encoder-Decoder-based Generation Command Dispatch for AGC of a Multi-Area Grid** *Kingshuk Roy, Sanjoy Debbarma, Siddhartha Deb Roy, and Liza Debbarma*
P05618	**Fault Current Calculation for DFIGs Under Complete Fault-Ride Through Strategies** *Dawei Chen, Canbing Li, Sheng Liu, Xubin Liu, Jianzhe Liu, Feilong Fan, and Juan Wei*
P05619	**Single-Phase Grounding Fault Line Selection Method based on VMD and Multi-Fault Feature Fusion in 10kV Distribution Networks** *Yuchen Yao, Kangli Liu, Jianfeng Zhao, Cheng Jin, Yu Zhou, and Zhengfei Lu*
P05851	**High Precision Lightning Warning System based on Combination of Electric Field Data and Magnetic Field Data** *Adisit Opachat, Kittinont Mokopen, Pawarut Kongsombatsuk, Somboon Manuch, Wiroj Tangtheerajaroonwong, Promsak Apirattakul, Nuttawut Chaiwongwan, Heinz Zenkner, Werachet Khanngern, and Boonsak Kiatjaroonlert*

Session: Energy Storage & Electric Vehicles (Thursday, July 11, 2024)
Chair : Assoc.Prof.Dr.Keerati Chayakulkheeree
Room : Ballroom 2
Time : 2.55 PM – 4.35 PM

P04711	**An Improved Sensorless Control of BLDC Motor using 1-Shunt Current Sensor for HVAC of EV** *Dong-Hee Lee*
P04764	**Thermal Characterization of Automotive Power Modules with an Embeddable BCI-ROM** *JungKyun Kim*
P05623	**A Novel Battery Temperature Prediction Method with High Adaptability** *Junting Bao, Youbing Zhang, Yun Yang, and Yuan Mao*
P05390	**Knowledge Distillation-CNN-BiLSTM based Lifelong Learning Model for Fault Diagnosis of Power Converters under Multi-condition** *Tao Li, Enyu Wang, Jiawei Yang, Chenxi Li, Guoyou Liu, Rongjun Ding, and Jun Yang*
P05411	**EV Scheduling Model in DR based on DRL with Prediction Accuracy as the Optimization Objective** *Shiyuan Yu, Bingfang Xu, Xinxin Ge, Fei Wang, and Qinggui Chen*

Session: Renewable Energy – 4 (Thursday, July 11, 2024)
Chair : Asst.Prof.Dr.Poom Konghuayrob
Room : Meeting 1
Time : 2.55 PM – 4.35 PM

P05606	**Spatio-Temporal-Transformation-based Method for Hour-Ahead Wind Power Forecasting** *Chunyang Pan, Sheng Jiang, Shuli Wen, Miao Zhu, and Yaoran Chen*
P05612	**Estimation of Effective Air-gap in a Switched Reluctance Machine from Measured Aligned Inductance Using a Flux-Tube-based Approach** *Samrat Das, and G. Narayanan*
P05359	**Day-ahead Photovoltaic Output Prediction based on Similar Days and IAdam-GNN** *Hongying He, Wei-Jen Lee, Runli Hong, Diansheng Luo, and Wenju Liang*
P05633	**A Novel Levy-Flight Arithmetic Optimizer for Security Constrained Unit Commitment Problem in Renewable Hybrid Power System for Reliability** *Pravin G. Dhawale,a, Vijay Mohale, Vikram Kumar Kamboj, and Chaman Verma*
P05636	**Frequency-Dependent Model and Improved Controller Design of an Axial Electromagnetic Bearing** *Aditya Raj, Kamisetti N V Prasad, and G. Narayanan*

Session: Energy System & Smart Grid (Thursday, July 11, 2024)
Chair : Prof. Dr. Vijit Kinnares
Room : Meeting 3
Time : 2.55 PM – 4.35 PM

P05028	**Long-cycle Electricity Market Simulation Study of Power Planning for Multiple Power Source Varieties in Electricity Market Environment** Chaoying Li and Yun Zhou
P05234	**Identification of Key Parameters Influencing Load Progression During Startup in Combined Cycle Power Plants (CCPP): Implications for Smart Grids** *Mogana Vadhna Suntrakumar, Sharifah Sakinah Binti Syed Ahmad, Mohamad Lutfi Samsudin, and Muhamad Ridzhuan Othman*
P05585	**Threshold Method Incorporated CNN based Non-Invasive Load Behavior Identification** *Zheng Wang, Zhenyuan Zhang, Yuqi Wang, Sihai Wen, Ying Liu, and Binxie Ren*
P05599	**A Comprehensive Recognition Framework for Three-Phase Power Quality Events based on Frame Frequency Attention** *Zhiwen Jiang, Hao Bai, Yanzhang Gu, Ziji Ma, Quan Zhou, and Zhikang Shuai*
P05613	**An Ant Colony Optimization-Enhanced LightGBM Algorithm** *Yuqi Wang, Zhenyuan Zhang, Zheng Wang, and Yuesheng Xian*
P05862	**Optimization Study of Alumina Industrial Process Based on Multi-Objective Dynamic Demand Response and K-Medoids Clustering** *Baoyong Liu, Shenglong Fan*, Jiakun Cao, Xiaochen Wang, Jie Gao, Liang Tang, Jie Shi*

Session: Smart Grid – 2 (Friday, July 12, 2024)
Chair : Assoc.Prof.Dr.Jie Shi
Room : Ballroom 1
Time : 8.30AM – 10.10AM

P05572	**Domain of Attraction Estimation and Control of DC Microgrids Considering Power Characterization of Energy Storage System** *Litao Zheng, Yingbing Luo, Sidun Fang, Tao Niu, Guanhong Chen, and Ruijin Liao*
P05776	**Real-Time Algorithm-based Power Management for a PV/Battery/FC Standalone Microgrid** *Harin M. Mohan, Suratsavadee K. Korkua, Ching-Ming Lai, Santanu Kumar Dash, Kamon Thinsura, and Saichol Chudjuarjeen*
P05622	**Zero-Sequence Voltage Suppression and Fault Arc Extinction Considering Three-Phase Parameter Asymmetry for Hybrid Grounding System** *Wanglong Ding, Kangli Liu, Jianfeng Zhao, Zitong Wang Cheng Jin, Yu Zhou, and Longxing Jin*
P05624	**Hybrid Current Balance Strategy for Multi-Phase Interleaved LLC Resonant Converter** *Tianao Xiao, Kangli Liu, Jianfeng Zhao, Jingyang Zhou, Cheng Jin, Xiaogang Pan, and Peng Chen*
P05393	**Life-cycle Operational Management for Electrochemical Energy Storage** *Zhang Qi, Yang Luye, He Xuan, Li Xiaojing, Wen Haoran, and Gong Qihang*

Session: Other Relevant Topics – 2 (Friday, July 12, 2024)
Chair : Asst.Prof.Dr.Sommart Sang-Ngern
Room : Ballroom 2
Time : 8.30AM – 10.10AM

P05214	**Towards Carbon Neutrality Using Green Digital Twins for Industrial Energy Systems** *David Wagstyl, Marius Syberg, Jan Niklas Büscher, Philipp Schlunder, Josef Kimberger, René Wöstmann, Nicolas Wolf, Lukas Schulte, and Jochen Deuse*
P05235	**Study of The Relationship Between The Occasion of Lightning Strikes and The Critical Breakdown Voltage According to ANSI/NEMA C29.11-2012 in Crown, D-cup, and Blunt Lightning Rods.** *K. Kitwattana, J.Pinit , and T.Apichart*
P05364	**Transient Analysis of Micro Grid-Integrated EV Charging Station with Hybrid Energy Storage System** *Prabhakaran Koothu Kesavan, Nirmal Mukundan C M, Umashankar Subramaniam, and Dhafer Almakhles*
P05379	**Design and Implementation of a Novel Power Converter based on Input-Output Transfer Function** *Yu-Kai Chen and Jin-Yi Liang*
P05773	**Revolutionizing Quality Control of Boron in Rubberwood Industry by Using MATLAB Driven RGB Imaging** *Suratsavadee K. Korkua, Siraporn Sakphrom, Krit Funsian, Pannipa Chaowana, Santanu Kumar Dash, and Kamon Thinsurat*

Session: Renewable Energy – 5 (Friday, July 12, 2024)
Chair : Asst.Prof.Dr.Chai Chompoo-inwai
Room : Ballroom 1
Time : 10.25AM – 12.05PM

P04929	**One hour a-head PV power forecasting with a Neural Network dynamic time series model** *Thatree Mamee, Usa Boonbumrung, Netithorn Ditnin, Patamaporn Sripadungtham, and Nitikorn Nanthawirojsiri*
P05369	**A Forecast Error Correction Method based on Seq2Seq and Auto Encoder for Short-term Wind Power Forecast Enhancement** *Haoyu Ma, Ming Yang, Zifen Han, Bo Wang, Jianfeng Che, and Menglin Li*
P05210	**Fault Tolerant Differential Power Processing Scheme for Parallel Photovoltaic Modules** *Xue Wang, Huiqing Wen, Zhichen Feng, Guangyu Wang, Peichao Xu, and Xu Han*
P05409	**Ultra-Short-Term Power Forecasting for Distributed PV based on Multi-Source Remote Sensing Information and Adaptive Feature Extraction** *Boyu Liu, Ziqi Liu, Yuqing Wang, Zhao Zhen, Fei Wang, and Zihao Tong*
P05473	**A Wind Power Ramp Events Detection Method based on Improved SDA and Endpoint Correction** *Shuaijie Shan, Ming Yang, Lidanlan Tao, Menglin L, Chuanqi Wang, and Yixiao Yu*
P05654	**Power Climbing Extremes Two Stage Forecast based on Auto Encoder and Bi-LSTM** *Chuanqi Wang, Ming Yang*, Yixiao Yu, Menglin Li, Shuaijie Shan, and Yuanhe Zhang*

Session: Power System – 7 (Friday, July 12, 2024)
Chair : Asst.Prof.Dr.Piampoom Sarikprueck
Room : Ballroom 2
Time : 10.25AM – 12.05PM

P05375	**Enhanced Robust Scheduling Approach Considering Dynamic Flexibility Support from District Heating Systems** Wenzhang Zheng, Peng Li, and Ming Yang
P05189	**Probabilistic Equivalence of Distribution Network Considering Characteristic of PV Power Forecast Error** *Shaoling Wang and Zhenyuan Zhang*
P05372	**A High-dimensional Spatio-temporal Feature Extraction Method of Distributed PV and Load** *Lidanlan Tao, Ming Yang, Shuaijie Shan, Xian Wang, Yao Wang, Huiwen Zhang, and Donglei Sun*
P05374	**Mid-long Term Photovoltaic Power Forecasting Method Considering Periodicity Characterization** *Minyi Zhuo, Ming Yang, Peng Li, Yi Sun, Rui Liu, Zhijie Zheng, and Bingke Shi*
P05377	**Distributed Photovoltaic Power Forecasting Method based on AP Clustering and Transfer Learning** *Baolong Yang, Ming Yang, Qiangsheng Bu, Chuanqi Wang, Yuanhe Zhang, Haoyang Zho, and Fei Luo*
P05707	**Preventive Strategy against Cascading Failures Triggered by N-k Contingencies in Power Systems** *Haipeng Kang, Heng Zhang, Haozhong Cheng, Gengfeng Li, Zhaohong Bie, and Xiaolong Jin*

ABSTRACT

PAPER ID: P04711

An Improved Sensorless Control of BLDC Motor using 1-Shunt Current Sensor for HVAC of EV

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Abstract:
In this paper, a novel 3-phase current sensing and reconstruction method using a current ratio function at a single-shunt current sensing structure is presented. A single-shunt resistor is an attractive current sensing method due to its low cost and reduced size. But it has current non-detectable regions when the PWM(Pulse Width Modulation) duty ratios of each phase are close to each other. For continuous current sensing at every PWM period, the actual PWM times of two effective voltage vectors have to be longer than the required current detection time. Consequently, the limited PWM duration causes additional current distortion with reduced control performance. In the proposed method, the current ratio between the detectable phase current and the non-detectable medium phase current of the 3-phase BLDC (brushless DC) motor is derived to estimate the medium phase current. Then, the other phase current is calculated by multiplying the detected phase current by the estimated medium phase current. The proposed method doesn't limit the PWM duty ratio to avoid a shorter duration than the required sensing time. Then, the sinusoidal phase current with reduced distortion can be implemented with improved control performance. Furthermore, a complex mathematical model with parameter dependencies is not used. Only a simple derived current relation function according to the rotor position is used to calculate the non-detectable phase current. The proposed method is tested and verified in the simulation and experiments of sensorless control of fan blower BLDC motors for electric vehicles. In the simulation and compared experiments, the proposed method shows advanced current sensing with improved sensorless control performance.

Keywords:
Single-shunt resistor, Current Sensing, Non-detectable region, Current ratio, Sensorless, BLDC motor

PAPER ID: P04743

Design of Transmission Line Lightning Monitoring System Based on LoRa Technology

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Abstract:
For the lightning monitoring system of transmission lines, the issue of significant energy waste and reduced sensor lifespan arises from the continuous 24-hour operation of monitoring equipment. Additionally, due to China's transmission lines spanning many remote mountainous areas, there are challenges related to long transmission distances and poor signal quality. This paper proposes a design method for transmission line lightning monitoring system based on Long Range Radio (LoRa) wireless technology. This method aims to extend the data transmission distance in remote areas and reduce data transmission power consumption, while also modifying the working mechanisms of monitoring equipment and sensors to significantly lower power consumption. Experimental results demonstrate that this design scheme substantially reduces power consumption of the lightning monitoring system. While ensuring data accuracy, it also significantly enhances the data transmission distance.

Keywords:
LoRa, Communication transmission, Lightning monitoring system, Transmission line

PAPER ID: P04764

Thermal Characterization of Automotive Power Modules with an Embeddable BCI-ROM

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Abstract:
This paper introduces a novel thermal characterization approach for automotive power modules with an embeddable boundary condition independent reduces-order model (BCI-ROM) technology. The thermal transient measurement method, thermal simulation modeling, its calibration procedures, and an embeddable BCI-ROM are employed in this study. This model represents a significant enhancement to the exchange of package models within the automotive supply chain. The results of the BCI-ROM are in high agreement with the detailed Flotherm thermal model. Furthermore, an embeddable BCI-ROM is developed for automotive drive cycles, which are obtained from a calibrated thermal model.

Keywords:
Embeddable Boundary Condition Independent Reduces Order Model (BCI-ROM), Thermal transient measurement, Structure Function, Thermal model calibration

PAPER ID: P04782

A High-Precision Parameter Identification Method Based on Improved DFT for Sub-Super Synchronous Oscillations

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Qi Huang
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Abstract:
Wind energy has been employed extensively as a renewable energy source with the aim of carbon neutrality. The power system also makes extensive use of power electronic properties and lead to the sub/super-synchronous oscillation (Sub/Sup-SO) issue, which damages equipment and jeopardizes the power system's ability to operate safely and steadily. To improve the frequency band estimation range to 100 Hz, this research use Phasor Measurement Unit (PMU) instantaneous value data to determine the Sub/Sup-SO associated characteristics. To reduce the influence of spectral leakage and the fence effect, as well as to improve the identification accuracy of the related parameters, this paper adopts the RV self-convolutional window based Discrete Fourier Transform (DFT) and the Hanning double-window based all-phase Fast Fourier Transform (apFFT) hybrid algorithm to identify the Sub/Sup-SO modal parameters. We take into account the identification accuracy in complex cases, such as non-nominal frequencies, with noise effects and multiple Sub/Sup-SO modes. The simulation results show that the proposed method has high discrimination bandwidth, high discrimination accuracy and strong flexibility.

Keywords:
All-phase Fast Fourier Transform; Parameter Identification; RV Self-convolution Window; Sub/super-Synchronous Oscillation; Three-point Interpolation

PAPER ID: P04787

Configuration and operation model for integrated energy power stations with concentrated solar power plants

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Abstract:
The large-scale integration of renewable energy sources leads to large power output fluctuations, which brings challenges to the stable operation of the power grid. Considering the unique thermal storage technology of concentrated solar power (CSP) plants, the configuration of integrated energy power stations considering CSP has become a solution for integration of renewable energy. This paper first analyzes the technical features of CSP generation and establishes the energy flow model of wind-photovoltaic-CSP-storage integrated power station. Secondly, it analyzes the costs and benefits of the integrated power station, and establishes an optimization model for the configuration and operation of the station. Finally, an example simulation is set up with electricity market data from Northwest China, and the calculation results show that the integrated power station with a CSP plant outperforms that with an energy storage facility.

Keywords:
renewable energy, concentrated solar power, configuration, operation strategy, power market

PAPER ID: P04789

Techno-Economic Assessment for First Submarine Cable Project in Oman

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Oman Electricity Transmission Company, Oman
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Abstract:

Masirah Island is located in the Eastern part of oman and currently is supplied by Distribution System from the local existing diesel generation plant. In addition, there is no transmission system that exists in Masirah Island up to date. Supplying Masirah Island via Diesel generation is not a feasible long-term solution financially due to Capital (Capex) and Operational (Opex) Costs. In addition, as the demand growth increases in Masirah, the diesel consumption cost will increase as well as a huge amount of harmful emissions is released to the air. Hence, Masirah Island system is required to be connected to Transmission System to overcome these issues. OETC is in progress to connect Masirah Island via Subsea Cable from the MIS. Integration of Masirah Island will have many advantages such as saving Capex and Opex, displacing the diesel generation at the Masirah Island and subsequently reducing harmful emissions such as CO2. In addition, Enhancing system security and reliability at Mairah Island, Integration of spinning reserve requirements. Moreover, Economic Analysis has been assessed which includes Cost Estimation and Net Present Value (NPV) analysis of Masirah Island connection. It's found that integrating Masirah Island to MIS via 132kV HV submarine cable is the optimum solution to address the above issue. To implement this solution the results performed in the year 2026 show there is a need to add a shunt reactor for both ends for reactive power compensation. In addition, the load flow studies indicate there are no risks associated with TSS compliance. Circuit loadings and busbar voltages are all acceptable for the scenarios considered. The calculated short circuit levels in the network are within allowed limits.

Keywords:

Subsea cable, Reactive Power Compensation, Transmission System

PAPER ID: P04820

Data-Driven PID Controller of Wind Turbine Systems Using Memory-based Smoothed Functional Algorithm

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Abstract:
Stochastic nature of wind speed and turbulence generated between turbines are commone factors that cause stress in wind turbine. Hence, it is important to regulate the rotor speed of wind turbine based on the desired reference speed. Consequently, employing a PID-based controller is crucial for maintaining wind turbine system performance. Recently, there has been a growing interest in utilizing better optimization tools to tune the PID control parameters, providing an advantage in enhancing wind turbine system output response while maintaining the robustness and simplicity of PID controller. However, existing optimization tools for tuning PID controllers, particularly those based on multi-agent optimization, often involve a large number of function evaluations (NFE), resulting in high computational burdens. This study introduces a novel approach using a memory-based smoothed functional algorithm (MSFA) to tune the PID controller in wind turbine systems. The MSFA, which is in the class of single-agent based optimization techniques, requires fewer number of function evaluations per iteration, addressing the computational burden issue. Simulation analyses, encompassing the fitness function convergence curve, step response time specification analysis, Bode plot stability analysis, and computational effort analysis based on NFE, are performed to evaluate the effectiveness of the suggested PID controller for wind turbine systems based on MSFA. The results indicate that the proposed MSFA-based PID controller is highly effective in producing better integral absolute error (IAE) with less values of NFE in comparison with other existing based methods.

Keywords:
PID tuning, computational effort, single-agent optimizer, high control accuracy.

PAPER ID: P04892

Energy Conserving in Power Plant: A Case Study of Practical Demand Cutting in Power Station Service System

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Abstract:
This paper proposes an energy conserving practice in gas turbine and combined cycle power plant (GTCC) during the plant operating in reserve shutdown mode. By using demand cutting in plant station services system, which was a case study of one unit combined cycle system of the twos in Wang-Noi power plant block-4, EGAT-Thailand. The results from the field data illustrated that, among available technical possibilities during the plant operating in reserve shutdown mode, demand cutting in circulating and cooling water pump system (CWP), by redirecting and replacing the large, conventional circulating water circuit, with the new one of fractional flow capacity and the driven motor, was the promised and effective approach. The best practice on energy conserving of the CWP system during the post commissioning period, was recorded as much as 50% in averaged of demand reduction when compared to the base case of the pre-commissioning period. It finally turned out to be approximately 556 MWh of the expected energy conserving per year.

Keywords:
Energy conserving, Demand cutting, Power plant, GTCC, Circulating water system.

PAPER ID: P04912

Voltage Stability and Transfer Limit Analysis in Bhutan Power System using P-V Curve Approach

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Bhutan Power System Operator, Bhutan
Sherub
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Abstract:
Maintaining voltage stability is essential for the smooth operation of a power system, ensuring a reliable supply of electricity at acceptable voltage limit. Disturbances, such as sudden changes in load and generation can disrupt the balance between power supply and demand, resulting in voltage fluctuations. Failure to manage these fluctuations effectively can result in voltage collapse, triggering widespread blackouts. In this study, the P-V curve approach in PSSE version 35 was employed to examine voltage stability and its corresponding power transfer capability for Bhutan power system network. By analyzing it, areas of weakness in the network are identified under various conditions. Subsequently, the employment of appropriate reactive power compensation were simulated and observed improvement in the stability performance of the Bhutan power system.

Keywords:
Bhutan network, voltage stability, P-V curves, PSSE

PAPER ID: P04929

One hour a-head PV power forecasting with a Neural Network dynamic time series model

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Abstract:
Currently, short-term PV power forecasting has been one of the important parts of optimizing the operation of PV power in both off-grid and grid-connected systems. Forecasting of PV power allows the PV system to manage energy usage and improve the performance of the PV system. This paper presented the comparison of different PV power forecasting models: nonlinear Autoregressive (NAR), nonlinear Input-Output (NIO), and nonlinear Autoregressive with External (Exogenous) Input (NARX) for a grid-connected PV system. A 23.1 kWp PV system was installed in Bangkok Thailand. The primary input data to model consist of solar irradiance value and temperature from 1 to 6 hours prior to the actual time. The training process uses one year of data (2019) to compute in the learning model. The data from January 2020 to April 2020 were used for testing the model to compare the accuracy for each condition. This paper reported the optimized time series, number of neural (NN) and accuracy indicator were MAPE, and R^2 for evaluating the model. Found that first model, NAR under the time series of 4 hours and number of neurons is 100, performances are MAPE=9.03% and R^2=0.97. Second, NIO model under a time series of 3 hours, number of neurons 50, the performances are MAPE=7.3477%, and R^2=0.98. Third, NARX model, under a time series delay 3 hours, with 50 neurons, the performances are MAPE 6.84%, and R^2=0.9.

Keywords:
Irradiance forecasting, Neural network, Solar cell

PAPER ID: P04999

Accurate Loss Tangent Determination in Damped Alternating Voltage Tests

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Abstract:
Underground cables are crucial for sustainable energy systems due to their minimal visual impact, reliability, and resilience against weather-related disruptions. As reliance on renewable energy sources rises, their importance grows. Regular evaluation of these cables is essential for ensuring safety, reliability, and resilience of electricity networks. By promptly identifying risks like insulation degradation, utilities can optimize maintenance, prioritize repairs, and bolster the integration of renewables, enhancing overall infrastructure performance. Loss tangent is the most significant value used for evaluation of the cable condition. This paper presents an alternative method for estimation of loss tangent in comparison with a conventional approach in damped alternating current voltage (DACV) tests. In the loss tangent estimation, the equivalent circuit of the DACV test system and a damping factor of the measured test voltage are utilized in the loss tangent estimation. From simulation experimental results, it is found that the conventional method is not accurate in loss tangent estimation in cases of low loss tangent measurement in the range of 0.1% which is a typical value of the new and used underground power cables. However, the accuracy of the proposed method is still in the acceptable range for estimation of the loss tangent in the range of 0.1%

Keywords:
damped alternating voltages, equivalent circuit, loss tangent, on-site tests, underground power cable.

PAPER ID: P05011

China Southern Power Grid Fault Analysis under 2023 Typhoon Haikui Disaster

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Abstract:
Typhoon disasters bring huge losses to power grid every year. How to reduce typhoon's impact on power grid is an important issue. Typhoon Haikui (2023) had characteristics of a long-life course, multiple landings and residual vortex retention. The disasters like strong wind, heavy rainfall, flooding and debris flow caused by it brought great challenges to power grid operation. Based on the summary of typhoon Haikui's meteorological characteristics, this paper makes a statistical analysis of the damage to transmission, transformer and distribution facilities in China Southern Power Grid. The advanced power grid hardening methods and emergency repair strategies under typhoon disasters are also discussed. The real data of typhoon Haikui (2023) is taken as an example to analyze its particularity and puts forward some problems that have not been considered in previous studies.

Keywords:
Typhoon Haikui (2023), secondary disaster, disaster defense, power grid blackout, power grid facilities

PAPER ID: P05028

Long-cycle Electricity Market Simulation Study of Power Planning for Multiple Power Source Varieties in Electricity Market Environment

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Abstract:
In order to investigate the impact of China's national unified electricity market construction on the power system planning scheme, this study establishes a electricity market long-cycle simulation program considering the operation of the power system for multiple power source varieties of wind, PV, hydro, thermal power, and storage. Based on the market simulation analysis of a clean energy province's target grid network in the planning year, the study compares different planning scenarios to provide a reference for promoting the comprehensive upgrading of the new power system planning system.

Keywords:
electricity market, power planning, market simulation, new energy consumption

PAPER ID: P05043

Performance Analysis of Multi-Area AGC Control of Interconnected Power System with Renewable Energy Sources (RESs) and Energy Storage System (ESS)

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Abstract:
Electricity grid consists of various types of power generation plants these plants present different dynamic characteristics for sudden load change. Recent trends of utilizing renewable energy resource and aggregated e-mobility load add further complexity in grid dynamic characteristics. Tackling these disturbances requires controller to be tuned optimally. This study presents a two-area multiunit hydrothermal plant dynamic characteristic in presence of sudden load change and aggregated EVs load. Enhancing system dynamic characteristic requires energy storage system, consist of flywheel energy storage system and battery energy storage system are integrated. The controller are optimized using established heuristic genetic algorithm approach. Improved dynamic characteristics of the system is presented in form of frequency and tie-line power deviation. The results are presented in both pictorial additionally in numerical form for comparison purposes. The proposed optimized controller coupled with energy storage presents improved dynamic stability of the system.

Keywords:
Automatic Generation Control (AGC), Renewable Energy Source (RES), Hydro- thermal, Genetic Algorithm, Energy Storage System, Aggregated Plug-in Electric Vehicle Load, Power System, Interconnected.

PAPER ID: P05048

A Sequential Power Flow Analysis of the Radial Hybrid AC/DC Distribution Network with Aggregated EV load

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Abstract:
The conventional AC system is required to consist of power converters with Distributed Generation to integrate into the AC system and other converters at the utilization end. To convert the conventional AC system into the hybrid AC/DC system is becoming more acceptable, and cost-efficient for increased integration of DG, i.e., appropriate for the increasing growth of DC loads. This neoteric hybrid AC/DC system avoids the excessive use of the conversion stages results in the reduction of cost and better quality of power supply and increases the reliability of power supply. In this paper, a hybrid AC/DC distribution system is conceptualized for the design of the low-voltage and medium-voltage power feeder routing to each load end. A power flow algorithm is introduced for the solution of the AC-DC hybrid system, considering the voltage deviation and phase angle deviation. The converter is designed to be used as a phase controller for the forward sweep, while it is employed as an inverter for the backward sweep for the power flow solution. The existing backward-forward sweep, based on the graphical search method, is modified for the AC-DC distribution system due to presence of the power converter in the system. The 15-bus AC system is modified as the hybrid 15-bus AC/DC distribution for the analysis of the system using the proposed method.

Keywords:
Power flow analysis, Renewable energy source, Distributed generation, Distribution system, AC-DC distribution system, Power System, Low Voltage (LV), Medium Voltage (MV), Distributed Energy Resources (DERs).

PAPER ID: P05058

Nonparametric Probabilistic Forecasting of Regional Photovoltaic Power Based on Spatial Clustering and Combining Quantile Regression

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Abstract:
As the share of distributed photovoltaic power generation increases rapidly, accurate and reliable regional photovoltaic power uncertainty quantifying becomes crucial to the economic and secure operation of power systems. This paper proposes a novel nonparametric probabilistic forecasting method for regional photovoltaic power to tackle the challenge induced by massive meteorological data and distributed power data. Firstly, distributed meteorological stations are divided into different clusters by the generalized spatial clustering algorithm considering geographic distance and meteorological conditions simultaneously to reduce data dimensions. Then, non-crossing quantile regression for regional photovoltaic power is elaborately devised by introducing deep learning techniques with patterns from clusters as input. Besides, the model performance is enhanced by ensembling multiple quantiles produced by different networks using the quantile regression combination. Finally, sufficient experiments of day-ahead regional photovoltaic power forecasting are carried out to verify the prominent performance of the proposed nonparametric probabilistic forecasting based on spatial clustering and combining quantile regression.

Keywords:
Probabilistic forecasting, regional photovoltaic power, quantile regression, spatial clustering, deep learning

PAPER ID: P05068

A Experimental Study of Used Battery Energy Storage System Control Concept with Swappable Battery Packs for Electric Vehicle

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Abstract:
Electric two and three wheelers are gradually gaining popularity in terms of zero emission vehicles in motorcycle market to protect environment pollutions. On the other hands, they have pain points of a short driving range and long charging time same as electric four wheeler. These drawbacks can be completely overcome by applying a swappable battery pack with Battery Swapping Stations. This pack can be applied to various type of vehicles with series and parallel connection to make enough in various supply system voltage and energy capacity. The choice of battery pack configuration for electric vehicles depends on numerous factors, system voltage, current consumption, pack lifespan, and system complexity. The parallel configuration offers a longer pack lifespan but requires additional hardware configuration to control equivalent electric power. The series configuration provides higher system efficiency but can have a negative impact on pack lifespan due to high power consumption. The proposed system in this study utilizes a series and parallel configuration to achieve high system efficiency but also high capacity while minimizing the need for additional system configuration. In accordance with this study, swappable battery pack can also be applied to Energy Storage System as a perspective for the battery total life cycle management.

Keywords:
BEV (Battery Electric Vehicle), ESS (Energy Storage System), BSS (Battery Swapping Station), VCU (Vehicle Control Unit), MCU (Motor Control Unit), BMS (Battery Management System), SOC (State of Charge), SOH (State of Health), EOL (End of Life), UBESS (Used Battery Energy Storage System)

PAPER ID: P05098

Solar Power Plant Capacity Monitoring using Random Forest Machine Learning Algorithm

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Abstract:

The natural abundance of solar energy and its favorable environmental impacts have led to growing acceptance and utilization as the world transitions from a fossil fuel-based economy to a cleaner, more sustainable, and ecologically friendly alternative. An increasing number of solar photovoltaic projects have emerged to capitalize on these benefits. However, factors such as weather conditions, exposure to natural elements, device deterioration, improper installations, and maintenance concerns can eventually compromise these systems' power-generating performance and dependability over time. This study demonstrates how the random forest machine learning classifier can be used to monitor and categorize the performance of solar PV plants to ensure their reliability and efficiency. The study collected and preprocessed a field dataset containing various environmental and electrical parameters. These parameters include plant capacity, active power, generating capacity, ambient temperature, global radiation, and module temperature. This data was used to train a random forest machine learning algorithm to categorize the operational condition of the solar power plant. The results demonstrate that the model efficiently classified the operational condition of the solar power plant by effectively identifying conditions such as optimal mode, moderate sub-optimal mode, severe sub-optimal mode, critical mode, emergency mode, and offline mode, achieving 99.92% accuracy on the test set. The proposed method provides an effective technique for estimating and monitoring the generating capacity and operational condition of solar power plants in near real time, thereby serving as a distinctive instrument for boosting the efficiency and reliability of solar power generation.

Keywords:

Solar cell, Capacity monitoring, Machine learning, Artificial Intelligence, Random Forest algorithm.

PAPER ID: P05108

Wind power fluctuation smoothing strategy based on variational modal decomposition and model predictive control

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Abstract:
In order to make the wind power fluctuation comply with the national standard of grid-connected fluctuation, and further reduce the average fluctuation of wind power, and at the same time reduce the required storage power rating and the total charge/discharge power of energy storage, this paper proposes a control method based on variational modal decomposition and model predictive control (VMD-MPC). In this method, the original power sequence is firstly subjected to variational modal decomposition, and then the decomposed sequence is Fourier transformed to obtain the center frequency of each sequence, and the sequence is reconstructed into low-frequency and high-frequency components according to the center frequency. Then, the high-frequency components are smoothed using a model predictive control method to reduce the power fluctuations while decreasing the energy storage power rating. In order to verify the feasibility of the VMD-MPC control method, this paper simulates the actual power data of a wind farm and compares it with the minimum energy storage rated power required to satisfy the grid-connected fluctuation requirements obtained under the uncontrolled method, the VMD-uncontrolled method, and the MPC control method with the average fluctuation value of the final grid-connected power after smoothing. The experimental results show that the method proposed in this paper reduces the minimum energy storage rating by 1.88 MW and the smoothed average fluctuation value by 0.39 MW compared to the uncontrolled method, and the total charging and discharging of the supercapacitor is reduced by 81.21 MW compared to the VMD-uncontrolled method, while satisfying the grid-connection criteria.

Keywords:
wind power fluctuation, energy storage, variational modal decomposition, model predictive control

PAPER ID: P05125

Enabling Forecasting-aided State Estimation in Active Distribution Networks via GRformer-Driven Pseudo-Measurement Modeling

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Abstract:
To address the issues of insufficient real-time measurements after large-scale integration of distributed generation (DG) into the grid and limited estimation accuracy of traditional forecasting-aided state estimation (FASE), this paper proposes a FASE for active distribution networks based on pseudo-measurement construction by GRformer. Firstly, a GRformer model is established based on historical operation data of active distribution networks. This model incorporates a generalized robust principal component analysis (GRPCA) layer into Crossformer to reduce the impact of non-Gaussian noise on prediction results. Then, the GRformer is utilized for ultra-short-term load forecasting, and bus pseudo-measurements are obtained through power flow calculation to supplement missing data when measurements are insufficient. Finally, adaptive interpolation strong tracking extended Kalman filter (AISTEKF) is employed for state estimation. Simulation tests on the IEEE 33-bus test system demonstrate the advantages in estimation accuracy and robustness of proposed method.

Keywords:
AISTEKF, Crossformer, FASE, GRPCA, pseudo-peasurement construction

PAPER ID: P05140

Short-term Power Load Forecasting based on LightGBM-VMD-SE and Inception-BiGRU-Attention

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Abstract:

With the development of the new power system, the electricity spot market demands an increasing level of accuracy in short-term power load forecasting. A short-term power load forecasting method based on LightGBM-VMD-SE and Inception-BiGRU-Attention is proposed. Firstly, the LightGBM algorithm is used to calculate the feature importance scores of various factors influencing power load and select the highly important ones, thus reducing the impact of non-significant features on prediction accuracy. Secondly, in order to mitigate the influence of non-stationarity in power load time series, the variational mode decomposition technique is employed to decompose the original load sequence into a set of stationary intrinsic mode functions. Then, the sample entropy is utilized to analyze the complexity of each stationary intrinsic mode function, and the high-frequency and low-frequency components are reconstructed to reduce computational complexity. Finally, an Inception-BiGRU-Attention model with convolutional kernels of different scales is constructed to separately predict the high-frequency and

low-frequency components, and their predictions are combined to obtain the final forecasted value. The proposed method is validated using actual load data from Hubei Province, China. Simulation results demonstrate that compared to the VMD-SE-CNN-BiGRU-Attention model, the VMD-SE-Inception-LSTM-Attention model, the VMD-SE-Inception-BiGRU model and the Inception-BiGRU-Attention model, the proposed model improves the prediction accuracy by 8.0%, 9.1%, 11.9%, and 13.3% respectively, thus affirming its effectiveness in shor-term power load forecasting.

Keywords:
short-term power load forecasting, LightGBM, VMD, SE, Inception

PAPER ID: P05147

Operational Planning to Enhance Bhutan Power Grid Resilience against Cascading Failures in Interconnected Systems

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Abstract:
This research addresses the imminent challenges faced by the Bhutan power grid due to cascading failures in interconnected systems. An Intentional Controlled Islanding (ICI) scheme is introduced as a last-resort corrective action to prevent potential blackouts. The study thoroughly explores three pivotal aspects for appropriate islanding solutions: the appropriate time (When), boundary (Where), and execution method (How). The methodology strategically separates the system into a sustainable island based on dynamic performance analysis deriving from expected real-time measurement information gathered from Phasor Measurement Units (PMUs). An application of this ICI methodology is demonstrated using the real-life Bhutan power grid modeled in PowerWorld Simulator.

Keywords:
Blackouts, cascading failures, grid stability, intentional controlled islanding (ICI), interconnected systems,

PAPER ID: P05150

Seamless Electro-mechanical Energy Release for Frequency Response Under Optimal Wind Power Production

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Abstract:
The high penetration of wind power plants (WPPs) into the power system necessitates the provision of frequency response to ensure frequency stability. However, in current practice, WPPs typically operate in Maximum Power Point Tracking (MPPT) mode to optimize returns for investors, often at the expense of not delivering inertial or primary response akin to traditional generators. As grid codes increasingly demand frequency support from WPPs, there is a growing need to strike a better balance between maximizing wind production and providing frequency support. This paper outlines a novel wind turbine control strategy to ensure seamless electro-mechanical response for frequency support without compromising turbine stability. The operational concept and proposed control strategy were validated using MATLAB/ Simulink software. Simulation results demonstrate the capability of the wind farm to achieve a mutually beneficial operation.

Keywords:
Frequency regulation, inertial control, speed droop control, wake effect, wind farm.

PAPER ID: P05164

Characterization of Energy Sharing Potential of Prosumers Based on Evolutionary Game on Social Network

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Abstract:
Widespread access to renewable energy has led to the emergence of a large number of prosumers with both production and consumption capacities. Localized energy sharing market provides new ideas for the full utilization of prosumers' resources. However, the overall sharing potential of prosumers guided only by price is difficult to quantify. An evolutionary game model among social network is proposed to characterize the sharing potential of the prosumers group. First, a social network of prosumers based on scale-free community network and is established. Second, an evolutionary game model based on the utility model of prosumers is proposed. Finally, an optimal response learning algorithm is proposed to characterize the response of prosumers to prices. Simulation results verify that the proposed method can accurately and quickly characterize the overall sharing potential of prosumers and provide boundary parameters for prosumer aggregators to participate in the sharing market.

Keywords:
energy sharing, prosumer, social network, evolutionary game

PAPER ID: P05167

Optimal Control of a Battery Storage On the Energy Market

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Abstract:
Electricity storage is crucial for a successful transition towards carbon-neutral energy production. Despite considerable research and a number of promising future alternatives such as hydrogen, battery storages currently remain the first choice. However, costs remain high and it remains to be shown whether an investment can be profitable. This article addresses this question by modelling a battery storage operating in the German power market. We consider two periods with very distinct price dynamics, namely a calm year (2020) and a turbulent year (2023). It shows that even for low battery costs a 2020 style price environment does not allow for profitable battery operation, whereas current market conditions allow for positive payoffs.

Keywords:
optimal control, battery, energy markets

PAPER ID: P05169

Comparative optical performance analysis of cross linear system with parabolic trough and linear fresnel system at latitudes above 30 °N.

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Abstract:

Higher latitude regions of the world have high solar radiation intensity, cloud-free dry climate, abundant barren land, and low ambient temperature, making them suitable for concentrated solar thermal systems. The challenge with CSP technology is to accurately track the movement of the sun, especially in the region of higher latitudes. In this paper, the Indian states of Ladakh situated at latitudes above 30 °N have been chosen to evaluate the performance of the newly developed cross-linear (CL) system. In this study, the performance based on the cosine effect (ζ_{θ}) is carried out for the CL system and compared with the existing parabolic trough concentrator (PTC) and linear fresnel reflector (LFR). The two cases have been considered to study the CL system, first is the receiver height (H) and second is the receiver position. Analysis has been carried out with three different heights of a receiver (10m, 12m, and 15m) and with three different positions between the heliostats in a North-south direction. The monthly average year cosine effect ($\zeta_{\theta,M.avg}$) and hourly average seasonal cosine effect ($\zeta_{\theta,h.avg}$) are evaluated and a comparative analysis has been performed. The simulation was performed using Engineering Equation Solver (EES) and Python programming to determine the average cosine effect. The results show that the CL system outperforms the PTC and LFR in terms of the Cosine Effect and heat flux generation capacity throughout the winter season. The study further suggests that a yearly average cosine effect of over 0.8 could be maintained for a 4-hour period between 10 a.m. and 2 p.m. when solar radiation is maximum using the CL system in higher latitude regions such as Ladakh, India, which is not possible with PTC or LFR.

Keywords:

Concentrated solar power; High latitude; Cross Linear; Ladakh, Solar radiation; Cosine Effect.

PAPER ID: P05170

Multi-objective Reinforcement Learning for Optimal Scheduling of Electricity-Hydrogen-Thermal Multi-Energy Microgrids

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Abstract:
The multi-energy microgrid (MEMG) has attracted extensive attention due to its advantages in economic and environmental benefits. The MEMG should manage its coupled energy subsystems while interact with the external systems in a coordinated way. This paper introduces a multi-objective reinforcement learning approach for energy management of electricity-hydrogen-thermal coupled MEMG (EHT-MEMG) system, aiming to minimize operational costs, CO2 emissions, and energy consumption. To validate the effectiveness of this method, it is compared with other candidate algorithms in an EHT-MEMG model. Through experimental comparison, the effectiveness of the proposed method is confirmed.

Keywords:
Multi-energy microgrid, Multi-objective reinforcement learning, Optimal scheduling, Pareto optimization.

PAPER ID: P05171

Cyber Attacks Detection Using Deep Learning Methods for Resilient Operation in DC Shipboard Microgrids

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Abstract:
Cyber resilience has become paramount as a transition of maritime systems towards digitization, particularly within DC shipboard microgrids (SMGs). Adopting innovative communication technologies can enhance the resilience of SMGs for stable operation. However, challenges like false data injection and Man-in-The-Middle attacks pose significant threats to SMG operations when integrating these technologies into ship intelligent grids. In this regard, this paper proposes a reliable deep learning (DL) method, especially an Artificial neural network (ANN) with a deep encoder-decoder architecture, for the detection of cyber-intrusions and mitigating their effects, ensuring system control and stability for resilient operation of SMG. Detecting malicious data intrusions is crucial for maintaining optimal grid conditions and preventing disruptions in load dispatch. The proposed method utilizes a fusion of current and voltage data features for comprehensive DL model training, resulting in an adequate level of detection accuracy and providing cybersecurity analysis for SMGs, addressing component-level attacks, and devising defense strategies from aspects of detection, mitigation, and prevention. Furthermore, the deep ANN is fine-tuned with optimal hyperparameters to effectively counter cyberattacks, achieving an enhanced accuracy rate of 97.51% and minimal loss of 0.101%, surpassing conventional machine learning approaches. Rigorous test scenarios are performed to validate the robustness of the proposed method, emphasizing the cyber resilience of DC SMGs for enhanced security and operational integrity.

Keywords:
Attack detection, Artificial neural network, Cyber-security, Deep Learning, DC shipboard microgrid.

PAPER ID: P05174

A Remedial Action Scheme Against False Data Injection Cyberattacks Targeting ULTC Transformers in Smart Distribution Systems

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Abstract:
This paper proposes an on-line remedial action scheme (OLRAS) in order to mitigate the voltage violations caused by false data injection attacks (FDIAs) targeting under load tap changing (ULTC) transformers in smart distribution systems. The FDIA framework contains two different phases. In the attack phase, distribution system operator (DSO), being in attacker's shoe, considers cyberattack scenarios through compromising the results of volt-var optimization problem in a radial distribution grid modified with distributed energy resources (DERs) such as photovoltaic (PV) units and wind turbines (WTs). The outcome of the attack phase will be the compromised voltage profile of the distribution grid showing different rates of voltage violations. In the reaction phase, the DSO rapidly identifies a customized distribution feeder reconfiguration (CDFR) in order to update the flows of active and reactive power throughout the targeted distribution system and recover the voltage profile. The objective functions of the proposed CDFR are defined to minimize the impacts of such cyberattacks targeting ULTCs within distribution grids. This will empower DSOs to react to severe cyberattacks, bypassing the detection stage, and address the voltage violations in a timely manner. The effectiveness of the proposed OLRAS is validated on an IEEE test system.

Keywords:
Customized distribution feeder reconfiguration (CDFR), false data injection attack (FDIA), on-line remedial action scheme (OLRAS), overvoltage, undervoltage, voltage violation.

PAPER ID: P05177

Lessons Learned from the Operating Experience of Battery Energy Storage Systems in the World

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Abstract:
With the development of renewable power generation, more battery energy storage systems (BESS) have been installed in power grids, especially for large-scale BESS systems. It is crucial to survey the functions and benefits of these installed storage systems. In this study, numerous large-scale BESS projects, including utility-scale BESSs, were investigated. These battery storage systems were built in America, Asia, Europe and Australia. Each BESS project has its main target and the corresponding operating functions. These functions mainly cover frequency regulation, voltage support, peak shaving, power reliability and resilience enhancement, transmission congestion relief, line upgrade deferral and black start. Additionally, several new trends for BESS developments have been observed. For instance, BESSs are combined with hydrogen power plants to store excess renewable energy; advanced AI software will be applied to real-time trading and control for BESSs by controlling the state-of-charge; the technologies of grid forming for BESSs becomes important; second-life BESSs would be widely utilized in power industry, and dual-battery designs have been proposed to obtain optimal operational strategies. After a complete survey, the results of this study provide important references to the applications of BESSs on power systems.

Keywords:
battery energy storage systems (BESS), power grid, frequency regulation, voltage support, peak shaving, black start, grid forming

PAPER ID: P05181

Edge-Based Anomaly Detection in AIoT Using a Hybrid CNN and Logistic Regression Approach

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Abstract:
This study presented an edge-based anomaly detection model for AIoT environments using hybrid CNN and Logistic Regression. The model has been evaluated against KDD dataset, and it can be found that it can differentiate DDoS attack traffic from normal traffic with 94% accuracy. In addition, it can be noted that the developed model demonstrates the level of performance, which can be considered as satisfactory, since it has the precision of 0.94, the recall of 0.94, and f1-score of 0.94. Thus, it can be stated that the developed edge-based anomaly detection model can be successfully implemented for ensuring the real-time network security and detecting, and preventing the anomalies in the various smart home applications based on its high potential.

Keywords:
CNN, AIoT, LR, Deep Learning, Edge Computing

PAPER ID: P05183

Electrochemical-Thermodynamic Coupling Modeling of Solid Oxide Fuel Cells for Integrated Energy System Optimization Scheduling

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Abstract:
Solid oxide fuel cell (SOFC) is recognized as a pivotal technological component in the utilization of hydrogen energy, drawing extensive interest due to their high operating temperatures, high efficiency, low emissions, and cost-effectiveness. This study introduces an electrochemical-thermodynamic coupling (ETC) modeling approach suitable for the optimized scheduling of integrated energy system (IES). Initially, a semiempirical formulation is employed to derive a bivariate non-linear relationship between the output power of SOFC, their operating temperature, and hydrogen consumption rate. Subsequently, the thermodynamic process of SOFC equipped with waste heat recovery systems is modeled to determine the temperature dynamics process of the SOFC. The ETC model of the SOFC is then segmented and linearized, and the resulting linear model is integrated into the IES optimization scheduling framework. Finally, a case study based on an industrial park in South China is conducted to simulate and validate the proposed method. The simulation utilizes Matlab and Cplex to solve the optimization problem, confirming the feasibility and superiority of the method in guiding SOFC participation in IES scheduling, reducing operational costs, and actively engaging in the hydrogen energy market.

Keywords:
Solid oxide fuel cell, Hydrogen, integratedenergy system, electrochemical-thermodynamic coupling model, thermodynamic process

PAPER ID: P05184

Regional Frequency Stability Constrained Resilience Enhancement Strategies for Distribution Systems with Flexible Energy Resources

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Abstract:
Extreme weather can easily trigger emergency faults in distribution networks, which in turn can have a significant impact on the frequency within the region, compromising the stable and reliable operation of the power grid during disasters. Traditional resilient distribution networks' flexible energy resource (FERs) allocation and scheduling strategies primarily focus on the steady-state operation before and after faults, with little consideration for the impact of unbalanced currents on regional frequency during the dynamic process when lines are disconnected, leading to potential frequency violations. this paper proposes a resilience enhancement strategy for distribution network systems with FERs that incorporates regional frequency stability constraints. With the dual objectives of optimizing resilience enhancement and minimizing economic costs, the distribution network system is strategically employed to regulate the mobility scheduling of FERs, thus establishing a comprehensive resilience enhancement model. By harnessing the capabilities of numerical simulation techniques, a linear representation of the Rate of Change of Frequency (ROCOF) and the frequency nadir in regions affected by faults is achieved, which significantly reduces the complexity of model resolution and aids in the formulation of a resilience enhancement strategy for distribution network flexible resources, taking into account constraints associated with regional frequency stability. The efficacy of the proposed method is corroborated through its application to the IEEE 33-node distribution network system.

Keywords:
resilience enhancement, flexible energy resources, Mobile Energy Storage Systems, frequency constrain

PAPER ID: P05185

Short-term wind power prediction based on variational mode decomposition and improved LSTM

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Abstract:
This paper proposes the integration of variational modal decomposition (VMD), sparrow search algorithm (SSA), and long-short-term memory neural network (LSTM) with sample entropy (SE) to establish a wind power prediction model (VMD-SE-SSA-LSTM) about the goal of improving wind power prediction accuracy. Firstly, the original wind power data undergoes VMD decomposition and subsequent reconstruction based on sample entropy. Subsequently, the LSTM model hyperparameters are fine-tuned utilizing SSA, and the reconstructed components are fed into the LSTM neural network to derive the predicted values for each component. And finally, the predicted values of each component are aggregated to obtain the final wind power prediction. Several models LSTM, VMD-LSTM, VMD-SSA-LSTM and VMD-SE-SSA-LSTM are validated against historical wind farm data. Results indicate that compared to traditional LSTM predictions, the proposed VMD-SE-SSA-LSTM model reduces mean absolute error (MAE) by 1.14, root mean square error (RMSE) by 1.72, mean absolute percentage error (MAPE) by 2.04, and improves the coefficient of determination (R2) by 0.02. These findings demonstrate the superior predictive accuracy of the proposed model, offering a new approach for wind power prediction.

Keywords:
wind power prediction, variational modal decomposition, sample entropy, sparrow search algorithm, long- and short-term memory networks

PAPER ID: P05189

Probabilistic Equivalence of Distribution Network Considering Characteristic of PV Power Forecast Error

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Abstract:
The uncertainty of photovoltaic (PV) changes the characteristics of the distribution network, making it more random and complex. Therefore, an equivalence of distribution network that can accurately characterize the uncertainty of PV is essential. This paper proposes a probabilistic equivalence modeling method for distribution networks considering the characteristics of PV power forecast error. First, model distributions of PV output forecast error. Forecast error is related to forecast time and value, so a two-layer modeling framework is proposed, in which forecast error distributions are first clustered based on forecast time and then classified based on forecast value. The distributions are modeled by kernel density estimation via diffusion (KDED). Then, the equivalent model is established, and parameters of equivalence are identified online based on the hybrid grey wolf optimization-particle swam optimization (GWO-PSO) algorithm. Finally, a modified IEEE33-bus distribution network is used to verify the accuracy of the proposed equivalence.

Keywords:
probabilistic equivalence, distribution network, distributed PV, distribution of PV power forecast error

PAPER ID: P05190

Multi-timescale Optimal Scheduling of an Electricity-Hydrogen Integrated Energy System Based on Deep Deterministic Policy Gradient

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Abstract:
The variability in the time scales of electric and hydrogen energy scheduling of an electricity-hydrogen integrated energy system (EH-IES) poses many challenges to the efficient and economic management. To this end, the paper presents a multi-timescale optimal scheduling approach of the EH-IES based on deep deterministic policy gradient (DDPG) algorithm. Firstly, the EH-IES model is introduced, focusing on the hydrogen storage model, the electricity storage model and gas turbines operation model. Secondly, the EH-IES two-layer optimal scheduling model with multi-timescale is established. The upper layer is the storage and usage scheduling of hydrogen energy for 7 days on the long time scales, and the lower layer is the charging and discharging scheduling of electric energy for 24 hours on the short time scales. Then the DDPG algorithm is adopted and the two-layer optimal scheduling model is solved to achieve the dynamic scheduling of the EH-IES. Lastly, analysis of a case is executed to confirm the effectiveness of the proposed method.

Keywords:
electricity-hydrogen integrated energy system, deep deterministic policy gradient, multi-timescale optimal scheduling

PAPER ID: P05191

Two-stage Voltage Control Strategy for Distribution Networks with Multi-Microgrids Considering Reactive Power Incentive

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Abstract:
Microgrids (MGs) are extensively incorporated into the distribution system as a very efficient means of utilizing renewable energy sources. While MGs generally aim at maximizing economic benefits in grid-connected operation, and distributed power output has volatility and uncertainty, so issues with voltage violation and the distribution networks (DNs)' voltage level may arise from the higher generation of its internal DGs. In this regard, this study proposes a two-stage voltage control method that takes reactive power incentive into account for DN with multi-microgrids. In the first stage, the MGs are optimized with the objective of economic optimality to acquire the power interaction value with the DNs. In the second stage, distribution networks conduct voltage verification, when voltage violation occurs, the optimal power flow is solved for voltage control, and reactive power can be supplied by photovoltaics (PVs) and energy storage systems (ESSs) in microgrids to control voltage. Finally, the case analysis is performed using the modified IEEE 33-node architecture. Compared with the scheme of using traditional regulation equipment for regulation of voltage in the DNs, the outcomes show that the reactive voltage regulation with MGs can realize the secure control of the voltage of each node in a more economical way, which verifies that the control approach proposed in this paper is valid.

Keywords:
multi-microgrids, distribution networks, voltage control, reactive power incentive

PAPER ID: P05193

Two-layer Optimal Planning for Hybrid Electricity-Hydrogen Energy Storage of Integrated Energy System Considering the Extreme Weather Scenario

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Abstract:
The extreme weather with continuous low output of renewable energy such as photovoltaic (PV) raises the pressure on long-term supply-demand balance of integrated energy system (IES). This paper proposes a two-layer optimal planning method for hybrid electricity-hydrogen energy storage of IES considering the extreme weather scenario. Firstly, the electricity and hydrogen energy storage equipment models are established by taking into account various energy storage forms and operation cycles. Secondly, the hybrid electricity-hydrogen energy storage planning framework considering extreme weather and aims at economic optimization is proposed. Then the enhanced particle swarm optimization algorithm (PSOA) is utilized for solving the typical weeks of normal and extreme weather scenarios with the goal of achieving optimal system economy. Results indicate that the proposed approach may lessen the impact of PV continuous low output harsh weather on the system's dependable operation, hence improving its economy.

Keywords:
Extreme weather, hybrid electricity-hydrogen energy storage planning, integrated electric-thermal-hydrogen energy systems component.

PAPER ID: P05196

A Universal Method for Suppressing Transient DC-bias in Triple-Active-Bridge Converters Based on Superposition analysis

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Abstract:
Triple-active-bridge (TAB) converter has attracted considerable attention due to its commendable electrical isolation, high energy density, and bidirectional energy transmission capabilities. Nevertheless, dynamic variations in the TAB converter can disrupt the volt-second balance, leading to the generation of dc-bias current, which may result in increased current stresses, causing magnetic saturation of the converter and posing a risk of damage to power electronics components. Addressing the analytical complexity stemming from the threewinding transformer in the TAB converter, this work conducts an analysis of the equivalent model based on superposition theorem, effectively reducing control complexity. Additionally, a universal modulation strategy is proposed to eliminate dc-bias current. The strength of this method lies in its versatility across various modulation techniques and its effectiveness in addressing diverse dynamic scenarios, encompassing load changes, fluctuations in power magnitude, power reversal, and start-up processes, among others. Finally, a TAB experimental prototype is constructed to validate the feasibility of the proposed method.

Keywords:
Triple-active-bridge, dc-bias current, universal mode, superposition theorem

PAPER ID: P05197

Tuning the Intercalation Redox Mechanism in 2D Ti3C2Tx by Incorporating Cr2O3 Nanoparticles in Aqueous electrolytes for Supercapacitor Applications

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Abstract:
The development of high-energy electrodes for supercapacitors has been thoroughly explored for use in electronics and technological applications. In this research, we synthesized a Ti3C2Tx-Cr2O3 composite through an etching process followed by a hydrothermal method. Cyclic voltammetry (CV) results showed that the Ti3C2Tx-Cr2O3 nanocomposite (NC) achieved a high specific capacity of 315 C/g at a sweep rate of about 10 mV/s. The electrochemical impedance spectroscopy (EIS) study revealed that the Ti3C2Tx-Cr2O3 NC had solution impedance (Rs) and charge transport impedance (Rct) values of 0.8 Ω and 1.3 Ω, correspondingly. The galvanostatic charge and discharge (GCD) tests confirmed long charge and discharge times and excellent rate capability for the Ti3C2Tx-Cr2O3 NC, with a specific capacity of approximately 622 C/g. Additionally, cyclic stability tests indicated that the Ti3C2Tx-Cr2O3 NC retained 90.6% of its capacitive performance even after 3000 cycles.

Keywords:
Supercapacitor; Ti3C2Tx MXene; Cr2O3; Specific capacity; Cyclic stability

PAPER ID: P05205

Design of Flexible Ramping Product Coupled with Spinning Reserve

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Abstract:

In order to solve the problem of short-term strong gradient changes in net load caused by the high proportion of renewable energy integration, flexible ramping products have been applied in many regions. However, most of the existing ramping products rely on the abundant local power regulation capabilities, which aim to optimize the resource allocation of rapid units, while ignoring the full release of the regulation capabilities of slow units. In most power systems of China, where renewable energy accounts for a high proportion and coal power is the main regulatory resource, the high proportion of wind power and photovoltaic integration generate a huge demand for flexible ramping, while the slow regulating rate of coal power causes the overall ramping rate to be scarce. In addition, a large amount of intra-day regulation space of coal power units has been occupied by spinning reserve products. The simple application of existing flexible ramping products will encounter serious shortages on the supply side and make the prices of flexible ramping products remain high, as well as increase the risk of massive load loss in the system. To cope with the challenges faced by such systems that are short in regulation capabilities, this paper designs a flexible ramping product coupled with spinning reserve product. By replacing the rapid coal power units which winning the bid in the day-ahead spinning reserve product with slow coal power units in intra-day stage, it fully releases the regulation capabilities of slow coal power units, so as to effectively reduce the procurement expenditures of system flexible ramping and the purchase costs in electric energy market. Meanwhile, massive abandoned wind-photovoltaic power or load loss due to insufficient flexible ramping capabilities of the system is also reduced. This paper verifies the effectiveness of the designed product through a simplified actual case study in Ningxia, China.

Keywords:

Electric power auxiliary services market, Flexible ramping products, Spinning reserve products, Power system flexibility, Coal power units, Wind power, Photovoltaics.

PAPER ID: P05210

Fault Tolerant Differential Power Processing Scheme for Parallel Photovoltaic Modules

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Abstract:
This paper proposes a fault tolerant differential power processing (DPP) scheme for parallel-connection photovoltaic (PV) modules. The proposed DPP utilizes two switches to achieve voltage balance and power balance under shadow faults. The switches are also connected with an LC resonant tank as
a resonant switched capacitor converter (RCSS) to confirm the DPP can operate properly under the open-circuit fault (OCF) and the short-circuit fault (SCF). The circuit is significantly simplified since only two switches are required while the number of submodules can be expanded in each module. A 320-W PV system containing four modules is built and tested with the power improvement of 18.36%.

Keywords:
Differential power processing, shadow fault detection, photovoltaic, voltage equalization.

PAPER ID: P05211

Mathematical Models of The Flexible Ramping Market Demand Curve Adapted to China's Electricity Market

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Abstract:
In the context of developing a new power system, utilizing the flexible ramping capacity of the power system is an effective approach to addressing the challenges associated with large-scale new energy grid connection. To better align with the current stage of China's power market development, this paper presents a mathematical model of the flexible ramping product (FRP) demand curve that is tailored to the specific circumstances of the Chinese market. Firstly, the composition of flexible ramping capacity is clarified, and the interval probability prediction results of ramping capacity at different confidence levels are transformed into probability density histograms on the basis of the probability prediction of ramping capacity demand. Secondly, the mathematical modelling of FRP demand curve is carried out, and single-segment and multi-segment stepped Mathematical models of FRP demand curves have been established to accommodate the various stages of the flexible ramping market's development. Finally, an illustrative analysis has been conducted using actual operational data from China's western power grid in 2020, which provides quantitative and pricing information for the flexible ramping market clearing.

Keywords:
high percentage of new energy, flexible ramping products, demand curves

PAPER ID: P05214

Towards Carbon Neutrality Using Green Digital Twins for Industrial Energy Systems

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Abstract:
The escalating climate crisis requires innovative strategies across industries to mitigate environmental impacts, particularly in energy-intensive sectors like the process industry. This paper introduces the concept of Green Digital Twins as an approach towards achieving carbon neutrality in industrial energy systems. By leveraging Digital Twin technology, the study outlines a concept for reducing carbon dioxide equivalent emissions through improved energy allocations. The proposed functional components are the basis for further development towards sustainable practices. The research is grounded in the Design Science Research approach and draws upon extensive literature review and industry insights to establish requirements for Green Digital Twins. The proposed conceptual model focuses on functional components for data-based representation and is validated through application in a cyber-physical brewhouse as a representative of the process industry. This case study demonstrates the potential of Green Digital Twins to integrate energy data with individual process steps, offering a novel pathway for industries

to contribute to climate change mitigation. This approach provides a foundation for future innovations in Green Digital Twin technology and contributes to the ongoing discourse on digital transformation and sustainability.

Keywords:
Digital Twin, manufacturing, energy system, process industry, requirements, sustainability

PAPER ID: P05221

Analysis and Reliability Assessment for a Bidirectional Single-Stage DAB-Based Three-port Photovoltaic energy storage inverter

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Abstract:
With the gradual popularization of the concept of carbon neutrality, more and more sustainable energy sources are being developed and applied. Corresponding photovoltaic (PV) systems that rely on batteries for stable output require three-port inverters with high stability and efficiency. Due to the lack of research on the PV energy storage inverter itself and its reliability, this paper first makes A theoretical analysis of a three-port converter based on bidirectional single-stage DAB. Secondly, the reliability and mean time to failure analysis of the proposed three-port topology under different working conditions are carried out. Finally, the paper gives the conditional parameters of theoretical analysis and simulation, and gives the simulation waveform of the proposed topology under different working conditions, proving the feasibility of the topology.

Keywords:
Three-pore inverter, Photovoltaic power system,
Reliability, Carbon neutrality

PAPER ID: P05223

A Novel FCL Based on Continuous Current Commutation for LVDC Distribution Network

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Abstract:
The importance of the DC Fault Current Limiter (FCL) cannot be overstated when it comes to ensuring the safety and stability of low-voltage DC distribution networks (LVDC). However, the problem of current-limiting inductor saturation has not been effectively solved in the typical FCLs, and improving the current-limiting capability can only increase the value of the current-limiting inductor. This paper introduces a current continuously commutated FCL topology aimed at addressing the limitations encountered in practical engineering applications of FCLs. The proposed topology effectively prevents saturation of the current-limiting inductor while maintaining the normal operation of the DC distribution network. This circuit consists of a nested double bridge, where the outer bridge circuit realizes bidirectional current flow, and the inner bridge circuit realizes the natural switching from the normal branch to the current limiting branch, and through the internal bridge circuit. The current flowing through the current-limiting inductor in the DC system undergoes conversion into high-frequency AC. This transformation enables continuous and efficient limitation of fault currents, effectively addressing the issue of inductor saturation in current limiters, and experimental tests are conducted to validate the operational principles and advantages of the proposed FCL.

Keywords:
Fault current limiter, low-voltage DC distribution network, inductor saturation, DC fault ride through.

PAPER ID: P05224

Parameter Comprehensive Optimization of A Fast DC Fault Current Limiter

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Abstract:
The DC fault current limiter (FCL) is significant to the safe and stable operation of the low-voltage DC distribution network (LVDC). The parameter design of the current limiter will affect its performance, as well as its cost, volume, and device energy consumption. However, the existing parameter optimization design methods have not comprehensively optimized the design cost, volume, and energy consumption. Therefore, a parameter optimization method for the current limiter is proposed, which includes building the device total cost model of the current limiter. The device volume model of the current limiter is constructed. According to the switching loss and commutating period of IGBT in the current limiting process, the heating power model of IGBT is built. The device cost, volume, and IGBT heating power models were normalized and weighted to get the objective function. According to the preset constraints and objective functions, the first parameter optimization model of the current limiter is constructed. The first parameter optimization model is iteratively optimized based on NSGA-II, and the optimal solution set of target parameters is obtained. It can be optimized for the current limiter parameters so that the current limiter can guarantee the current limiting performance while reducing cost, volume, and heating power.

Keywords:
Fault current limiter, low-voltage DC distribution network, Parameter comprehensive optimization, NSGA-II

PAPER ID: P05227

Optimizing Hydrogen Highway Planning Model Considering Hydrogen Cost and Vehicle Flow Effects

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Abstract:

In recent years, global governments have been actively advocating for the adoption of hydrogen fuel cell vehicles (HFCVs) as a means to foster a more sustainable future in transportation. However, the widespread integration of these vehicles necessitates robust hydrogenation infrastructure support. This paper presents a novel hydrogen highway optimization planning model tailored for the strategic placement of hydrogen refueling stations (HRSs) along highways. Based on the traditional HRS site selection models, this approach innovatively integrates factors encompassing hydrogen procurement, transportation, and utilization. The model optimizes the location, scale of the HRSs and quantity of hydrogen dispensers within each HRS, utilizing the minimum unit cost of hydrogen as the objective function. To verify the effectiveness, the proposed model is applied in the Beijing-Tianjin-Hebei (BTH) and Chongqing regions, conducting HRS location planning across both demonstration and promotion stages and the specific planning results are obtained. This study offers valuable insights into hydrogen infrastructure planning along highways, serving as a reference for future endeavors in this domain.

Keywords:

Hydrogen refueling station, Hydrogen highway planning, Hydrogen fuel cell vehicles, genetic algorithm

PAPER ID: P05229

Synthetic Inertia-Power Sharing in High Renewable Power Grids Through Vehicle-to-Grid Topology

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Abstract:
Power system total inertia is anticipated to relatively reduce with the increasing integration of renewable energy sources (RESs). The rest of total inertia is expected to regulate system frequency and limit its excessive rate of change. The utilization of dispatchable loads, such as electric vehicles (EVs), holds promise as a solution. This paper proposes the synchronized inertia support topology from a vehicle-to-grid (V2G) system corresponding to its bidirectional chargers. This concept can be constructed by cooperating with a large-scale energy storage system (ESS) from controllable EVs through the remodeling inertia emulation topology. The synthetic inertia control technique is modified by considering the EV customer's convenience and synchronized state of charge control (SOC), which can enable synchronized inertia power sharing, resulting in the expansion of the degree of freedom to the grid dynamic and resiliency. Simulation results show that the proposed technique seamlessly provides abrupt inertia support from the onboard ESS of EVs not only for the sake of frequency stability enhancement but also for the synchronism and robustness of grid operation.

Keywords:
Dynamic stability, Electric vehicle, Frequency control, Renewable energy, Synthetic inertia, Vehicle-to-grid

PAPER ID: P05231

Technical Feasibility Study of Utility Microgrid Pilot Project at Rubesa, Bhutan

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Abstract:
Over the years, Microgrid integration of hybrid renewable resources has emerged as a game-changing solution, significantly enhancing resilience and sustainability in the global energy landscape. This paper introduces both off-grid and grid-connected microgrid designs tailored to the context of Rubesa, a local community in the western part of Bhutan called Wangduephodrang district. Drawing upon hybrid solar and hydro resources to serve the local demand. The study emphasizes the study of technical feasibility using the Hybrid Optimization Multiple Energy Resources (HOMER Pro) software. By showcasing a utility microgrid pilot project, the research aims to demonstrate how a diversified mix of renewable energy sources can power Rubesa sustainably. Ultimately, this initiative strives to transform Rubesa into a model sustainable community, illustrating the potential of microgrids to drive local energy autonomy. The insights gained from this project could pave the way for similar initiatives elsewhere, to enhance power system reliability and resilience throughout the country.

Keywords:
Microgrid, DER application, HOMER Pro

PAPER ID: P05232

Medium Term Load Forecasting For an Industrial Factory Using Bi-LSTM

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Abstract:
This paper introduces an improved method of medium-term load forecasting in industrial factories, utilizing Bidirectional Long Short-Term Memory (Bi-LSTM) networks. While LSTM models are traditionally employed for time series prediction, this study highlights the superior accuracy of Bi-LSTM, which processes data sequences in both directions, capturing complex temporal relationships more effectively. Our methodology is validated through an empirical analysis based on actual load data from an industrial factory, showcasing significant improvements over conventional LSTM models. This breakthrough has substantial implications for energy management within industrial sectors, enabling more precise forecasting and, consequently, more efficient resource utilization and cost reduction. Although the use of Bi-LSTM is established in various domains, our study delineates specific adaptations and optimizations like hyperparameters tuning that amplify its efficacy in load forecasting. Moreover, results from proposed Bi-LSTM network are compared with LSTM network. The results show that Bi-LSTM predicts load with higher accuracy as compared to LSTM.

Keywords:
medium-term load forecasting, Bi-LSTM, recurrent neural networks, long short-term memory

PAPER ID: P05234

Identification of Key Parameters Influencing Load Progression During Startup in Combined Cycle Power Plants (CCPP): Implications for Smart Grids

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Abstract:
This paper investigates integrating advanced analytics techniques into smart grids to enhance energy system efficiency and reliability. It focuses on identifying key operational parameters influencing load progression during startup processes in combined cycle power plants (CCPPs). Using a dataset categorized into different startup classes (Hot, Warm 1, Warm 2, Cold), it employs feature selection techniques such as PCC, LASSO regularization, and RF-RFE to identify influential parameters. Predictive modeling evaluates each technique's efficiency in capturing system dynamics, revealing variations in predictive performance across startup classes. The study highlights crucial variables contributing significantly to load progression and discusses implications for smart grid applications like predictive maintenance and load prediction. It advances understanding of CCPP operation within smart grids, providing insights for enhancing energy system intelligence and resilience.

Keywords:
Smart Grid, CCPP, energy, power, predictive modeling, feature selection, key operational parameters.

PAPER ID: P05235

Study of the Relationship between the Occasion of Lightning Strikes and The Critical Breakdown Voltage According to ANSI/NEMA C29.11-2012 in Crown, D-cup, and Blunt Lightning Rods.

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Abstract:
This research studies the relationship between the occasion of lightning striking the lightning rod and the critical breakdown voltage according to ANSI/NEMA C29.11-2012 standards in 3 types of lightning rods: Crown type, Cup D type, and Blunt type. The test uses an Impulse generator rated at 800kV to test for the critical breakdown voltage using the Up and down method for each type of lightning rod. After that, a test was performed to compare the occasion of a breakdown using the Blunt lightning rod as a reference, using the Crown lightning rod and the Cup D lightning rod as comparisons. The Crown and Cup D lightning rods are available in sizes 6mm. and 10mm. But the Blunt type is only 6mm. From the test, the authors found that the critical impulse breakdown voltage of lightning rods of Blunt, Crown 6 mm., Crown 10 mm., Cup D 6 mm. and Cup D 10 mm. types is -427.38 kV, -437.0 kV, -434.01 kV, - 437.05 kV and -435.70 kV respectively. Testing the occasion of a breakdown at a voltage of -450kV, 80 centimeters of air gap, using a Blunt 6 mm. lightning rod as a reference. The occasion of breakdown of lightning rods of Crown 6 mm., Crown 10 mm., Cup D 6 mm. and Cup D 10 mm. is 25%, 35%, 25% and 30%. It can be concluded that the critical impulse breakdown voltage is statistically related to the occasion of a breakdown occurring in each lightning rod type. Therefore, the design of the lightning rod has a significant effect on protection and the occasion of lightning strikes.

Keywords:
lightning impulse, lightning rod, critical impulse breakdown voltage.

PAPER ID: P05236

MVDC Converter Station Optimizing Site Selection Method in Urban Power Grids for Enhancing Grid Support

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Abstract:

Due to the rapidly increasing integration of the distributed photovoltaic system and power electronic-based loads, reconstruction of some conventional AC interties to medium voltage DC (MVDC) intertie has become an irreversible trend in the urban power grid in order to reduce power transmission loss and improve control flexibility. However, the site selection method of the MVDC converter station has not received attention. There is no method that could provide optimal site selection for MVDC intertie, which could bring maximum benefits to the urban power grid. This paper proposes a site selection method for converter stations of MVDC intertie in the urban power grid to fill research gaps. Firstly, based on the operation requirements of the urban power grid under different operation conditions, the typical operation modes of the MVDC intertie are developed, and the site selection requirements of the MVDC intertie are summarized. Secondly, the voltage stability margin as a preliminary selecting index to identify critical nodes in the urban power grid, then the Euclidean distance and grey relational analysis are adopted in the site selection method to calculate the proximity coefficients for determining the optimal locations of the converter station. The coefficients adopted in the site selection method are also calculated using the analytic hierarchy process and rank entropy methods in order to improve the generality of the proposed site selection method. A case study based on an actual urban power grid

in China validates the proposed method, showing that the selected MVDC converter station sites could significantly improve grid stability and performance during normal and emergency operating conditions.

Keywords:
MVDC intertie, urban power grid, capacity enhancement, resilience enhancement.

PAPER ID: P05237

Data Pre-preprocessing Method for Distribution Networks based on the CNN-LSTM Considering the Spatial Properties

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Abstract:

Due to the explosive increase of renewable energy and power electronic-based devices, the complexity and volume of grid data have significantly increased in the distribution network, which challenges the process of data collection, transmission, storage, and usage. In addition, network issues, equipment failures, and adverse weather conditions further result in data loss and delays, compromising the reliability of grid data. Ensuring the dataset's accuracy while providing timely data exchange is crucial for the stability of the distribution system operation with highly proportional renewable energy integration. In order to fully consider the influence of a high proportion of renewable energy integration on distribution network data, a novel data preprocessing method based on CNN-LSTM is proposed. Compared to the traditional data preprocessing methods, the proposed method combines the advantages of time series and spatial characteristics of distribution network data. In addition, the proposed method uses the spatial layout of distribution network nodes and improves the accuracy of data preprocessing on time series. In order to verify the effectiveness of the proposed data preprocessing method, a real dataset measured in north China is adopted, which includes

8064 voltage data from 7 different nodes. The simulation results show that the proposed data preprocessing method significantly improves the accuracy of data filling and outlier detection results.

Keywords:
renewable energy, data preprocessing, distribution network, power grid data, CNN-LSTM.

PAPER ID: P05238

Stability Analysis and Optimization of DC Circuit Breakers with Single Gate Drive Scheme for Power System Protection

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Abstract:
This research presents an in-depth analysis of small signal Modelling for DC Circuit Breakers (DCCBs), highlighting its significance in power system protection. The study focuses on the stability assessment of DCCBs, particularly when driven by single-gate signals and tasked with managing a series of switch devices. The paper introduces a novel Single-Gate Drive (SGD) scheme, incorporating additional gate diodes to effectively mitigate unwanted voltage oscillations and suppress gate oscillation during the turn-off process. The impact of circuit parameters, such as parasitic inductances and capacitances, on the stability of DCCBs is thoroughly examined. Through simulations, the paper demonstrates that an increase in output capacitance can alter the system's frequency response characteristics while maintaining relative stability. Conversely, higher bus voltages lead to a decrease in the system's damping ratio, enhancing oscillatory tendencies. The findings underscore the necessity of striking an optimal balance between voltage levels and system stability to ensure the reliable operation of DCCBs in protecting power systems from fault currents.

Keywords:
DC Circuit Breakers, Stability Analysis, Single gate drivers.

PAPER ID: P05239

Multiple industrial parks electric-carbon collaborative optimization operation method considering carbon emission flows

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Abstract:
This paper proposes a bi-level optimization operation method for multiple industrial parks based on the carbon emission flow theory, where the upper model mainly implements the dispatch strategy of the distribution network and the calculation of the node carbon intensity, and the lower model introduces the ladder-type carbon trading mechanism and carries out the low carbon economic dispatch strategies with the dynamic carbon emission factors calculated by the upper model, to minimize the operation cost and trading cost of the parks. The optimal production and electric-carbon trading strategies for industrial parks are solved by iterative two-layer modeling, and the oscillation phenomenon is handled by a dichotomy-based heuristic method. The case results show that the proposed method can effectively reduce the carbon emissions generated by the production and operation of industrial parks while taking into account the economy.

Keywords:
carbon emission flow, ladder-type carbon trading mechanism, low-carbon economic dispatch.

PAPER ID: P05240

Operating Experience and Suggestions for Reliability and Resilience Indices – A Study in Taiwan

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Abstract:
This paper mainly focuses on the issue about reliability indices and the corresponding measured methods. These indices cover the operating aspects on distribution, transmission and generation systems. Additionally, this paper discussed about the reasons that affect reliability indices, including the effects of distribution automation on reliability. Moreover, the frequent occurrence of major accidents caused by natural disasters, especially typhoons and earthquakes, has highlighted the importance concerning about grid resilience, leading to a requirement to design appropriate resilience indices. By surveying various definitions and research works on grid resilience with related indicators, this paper provides feasible methods for calculating resilience indicators, thereby providing a tool for assessing whether the power grid resilience can be improved gradually.

Keywords:
reliability indices, distribution, transmission, generation, grid resilience.

PAPER ID: P05241

TSO-DSO coordination to effectively integrate DER flexibility into the balancing market

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Abstract:
Managing the power system in a high renewable energy penetration situation requires close interaction between the transmission system operator (TSO) and the distribution system operator (DSO). Enhancing the TSO-DSO coordination opens up opportunities for restraining congestion in the distribution grid caused by distributed energy resources (DERs) assets owners participating in the electricity market, especially when providing services to the TSO in the balancing market. Based on the current situation in the Netherlands, this study proposes a coordination scheme for TSO and DSO in the offering process to leverage the DER flexibility for providing balancing service to TSO, while accounting for congestion issues in the distribution network. A comparison between a scenario using only reserved capacity from large generators and a scenario with DER flexibility participants shows the cost benefits of using DER flexibility in balancing the market. Furthermore, based on the simulation results from the modified 34-node feeder network in Matpower, the coordination scenario outperforms the non-coordination scenario by effectively preventing congestion through cooperation. Additionally, a new approach for simulation based on model coupling shows the potential for extending and integrating other models in the future.

Keywords:
TSO-DSO coordination, DER flexibility, congestion management, balancing market, model coupling.

PAPER ID: P05242

State Estimation in Power System under Deterministic False Data Injection Attack Using Minimization of Nuclear Norm and ℓ1 Norm with Noisy Constraint Substitution

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Abstract:
This work considers a state estimation problem in the power system of a smart grid network. We propose an improved optimization technique for extracting the attack-free signal component from the attacked data obtained from the measurement and a concept of estimating the power system state vector from the extracted signal component. Numerical simulation is conducted to demonstrate the possible operation of the proposed concept and the numerical results indicate that our proposed technique for extracting the attack-free signal component consumes less computational time than the former work.

Keywords:
power system state estimation, false data attack, convex optimization.

PAPER ID: P05243

Hamiltonian Control for CC-CV Primary-side Buck Converter of Inductive Wireless EV Charging

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Abstract:
This study presents a Hamiltonian control law for constant current - constant voltage (CC-CV) inductive wireless charging. The novel control system design, simulation, and experimentation aimed to confirm the Hamiltonian controller is a superior choice. The wireless charging experiments tested the step-resistant battery simulator and the EV battery. Based on the findings, it is possible to run the Hamiltonian control law for continuous 10 A and 82 V charging while maintaining optimal response, stability, and realization. The charging system's maximum efficiency and power were 76.5% and 782 W.

Keywords:
inductive, wireless charging, electric vehicle, charging infrastructure, hamiltonian control law.

PAPER ID: P05247

Lifetime Extension Strategy for IEEE 802.15.4 DSME-based Wireless Powered Sensor Networks

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Abstract:
This paper presents a lifetime extension strategy for IEEE 802.15.4 deterministic synchronous multi-channel extension (DSME)-based wireless powered sensor networks (WPSNs). The proposed strategy aims to prevent energy depletion of the sensor devices by selectively conducting wireless energy transfer (WET) considering the amount of energy remaining in each sensor device. In the proposed strategy, the sensor devices request WET to a hybrid access point (HAP) only when the residual energy is insufficient for normal operation. In addition, the unused channel resource is utilized for WET to increase the amount of residual energy. The experimental simulation was conducted to evaluate the proposed strategy. The results showed that the proposed strategy obtained better performance compared to the existing strategy in terms of average residual energy and the number of energy-depleted sensor devices.

Keywords:
energy harvesting, IEEE 802.15.4 DSME, lifetime extension strategy, MAC protocol, WPSN.

PAPER ID: P05248

Planning for Hybrid Refueling Stations with PV Power in Highway Networks based on Traffic Equilibrium and Price Response

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Abstract:
The widespread application of new energy vehicles in highways requires the construction of sufficient hybrid refueling stations (HRSs). A reasonable planning method is one of the important links in promoting the construction of HRSs on highways. Therefore, this paper proposes a planning method for PV HRSs on highways based on traffic equilibrium and price response. Firstly, a simulation method for charging demand of HRSs on highways was proposed based on the traffic equilibrium. Then, based on electric-hydrogen conversion and hybrid energy storage, a planning model for HRSs with the goal of optimal economy was established. Finally, a price response mechanism for HRSs was proposed. Practical examples show that the method proposed in this paper reduces the power outage rate of the HRSs by 3.88% and the total cost by 11.64%.

Keywords:
new energy vehicles, hybrid refueling stations, photovoltaic, highway networks, traffic equilibrium.

PAPER ID: P05317

Dynamic Loss Simulation Considering Domain Wall Movements of GO Silicon Steels with Finite Element Method

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Abstract:
As the trend of the increasingly implementation of electrical devices with high power densities and frequencies, the excess eddy current loss is taking a larger proportion of iron losses in magnetic cores of devices, like electrical transformers, in the power system. This article proposed a numerical method for calculating the dynamic losses of grain-oriented (GO) silicon steel sheets considering the movement of the magnetic domain wall generating the excess eddy currents. First, according to the domain wall theory, the GO silicon steel sheets are simulated by the finite element (FE) method with the movable boundary conditions. Then, dynamic and the static hysteresis loops are measured for extracting the dynamic losses of the magnetic core sample. Compared to the measurement results, the proposed method has better accuracy than the conventional method on the loss simulation. Finally, the distributions of the eddy currents at specific time steps can be derived and compared to the conventional method for investigating the effects of the domain wall movements on the magnetic characteristics.

Keywords:
electromagnetic modeling, excess eddy currents, finite element method, high frequency devices, loss simulation.

PAPER ID: P05331

Optimal Design of PSS-FACTS Using Craziness Particle Swarm Optimization in SMIB System

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Abstract:
Changes in load cause oscillations in the generator, resulting in fluctuations in frequency and rotor angle. Additional control equipment is essential to enhance the stability of a generator, especially during load changes. While the Static Synchronous Series Compensator (SSSC) is a Flexible Alternating Current Transmission System (FACTS) power electronics device used to enhance power system stability and control, the Power System Stabilizer (PSS) is a controller that can supply additional damping signals to the generator. Proper coordination is crucial to achieve optimal performance from PSS and SSSC. In this research, we propose an artificial intelligence-based optimization method known as the Craziness Particle Swarm Optimization (CRPSO) method. The performance of CRPSO was evaluated using the Particle Swarm Optimization (PSO) method. Furthermore, the effectiveness of PSS-SSSC in this research was tested on a Single Machine Infinite Bus (SMIB) system. Analysis results indicate that implementing CRPSO-based PSS-SSSC provides optimal results for enhancing SMIB performance, particularly during load changes. Optimization results demonstrate that CRPSO outperforms conventional PSO, yielding a minimum fitness function of 0.01090 compared to PSO's 0.01117. The CRPSO computing process converges more quickly in optimizing PSS-SSSC parameters, determining optimal controller parameters in just 11 iterations, while PSO requires 24 iterations. The combination of PSS-SSSC controllers provides optimal stability to the SMIB system, effectively dampening overshoot oscillations that may occur during load changes.

Keywords:
PSS, SSSC, CRPSO, SMIB, Overshoot.

PAPER ID: P05333

FACTS: SVC Optimization for Optimal Power Flow Using Craziness Particle Swarm Optimization in Sulselrabar System

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Abstract:
This paper explores the influence of Flexible AC Transmission System (FACTS) devices on the optimization problem of Optimal Power Flow (OPF). It employs the Craziness Particle Swarm Optimization (CRPSO) technique to address the OPF problem and determine optimal parameter configurations and allocation of FACTS devices, focusing on optimizing bus voltages and minimizing power losses in transmission lines. To assess CRPSO's accuracy, a conventional PSO comparison method is utilized. The FACTS device examined in this study is the Static Var Compensator (SVC), applied to the Sulselrabar multimachine system. The analysis evaluates the enhancement of voltage profiles at each bus and the reduction of losses in transmission lines. Results from PSO optimization indicate optimal placement and sizing of the SVC at bus 31, with a rating of 40 MVar, while the proposed CRPSO method suggests a rating of 80 MVar. Optimization outcomes demonstrate that CRPSO outperforms conventional PSO, as evidenced by superior fitness function minimization and faster computation. Installing the SVC leads to improved voltage profiles and decreased power losses in transmission lines.

Keywords:
FACTS Devices, SVC, Sulselrabar, OPF, CRPSO.

PAPER ID: P05342

State-Space Modeling and Transient Stability Analysis of the Paralleled SG-VSG System Coupled to Weak Grid

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Abstract:
Concerning a paralleled synchronous generator (SG) and virtual synchronous generator (VSG) system, it is essential to pay more attention to the paralleled system's transient stability when it is linked to a weak grid, since the SG and VSG generally possess different governors. This paper investigates the transient stability characteristics of the paralleled system under different control parameters. Firstly, the paralleled SG-VSG system's topology and control strategy is presented. Then, a state-space model is constructed for the paralleled system, and the equal area criterion (EAC) method is applied to qualitatively probe the transient stability mechanism under typical fault scenarios. In light of the MATLAB platform, a detailed simulation model is created to imitate the paralleled system's dynamic response, and the simulation findings confirm the correctness and adaptability of the theoretical analysis.

Keywords:
Synchronous generator, virtual synchronous generator, transient stability, state-space model, weak grid.

PAPER ID: P05359

Day-ahead photovoltaic output prediction based on similar days and IAdam-GNN

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Abstract:

Aiming at higher accuracy of photovoltaic power prediction, a day-ahead prediction method based on similar days and improved Adam optimized graph neural network (IAdam-GNN) is proposed in this paper. The historical outputs and multiple meteorological information are fully utilized. In order to reduce the number of weather feature input parameters, the Maximum Relevance-Minimum Redundancy (mRMR) is employed to establish an optimal set of weather features which are strongly correlated with the photovoltaic power output with small redundancy. The similar days to be used to predict is obtained by an improved method by combining the grey correlation, cosine similarity and Euclidean distance. The output of the historical similar days and the meteorological information of the day to be predicted are used to construct a topology graph. Since graph neural network (GNN) has significant parallel processing ability on graph data, a GNN is designed to realize the full mining of the input characteristics and the correlation among the features by using the constructed graph as the input. To take advantage the Powerful time-frequency processing capability of wavelet neural network (WNN), an integrated WNN and GNN algorithm is employed for nodes and edges updating of the graph to obtain higher prediction accuracy. In order to enhance searching ability, the first moment estimation and second moment estimation of Adam are improved. The testing results show that the prediction accuracy of the proposed method is better than the Adam-BPNN, Adam-WNN, Adam-GRU, and Adam-GNN. Moreover, the computational burden is significantly reduced.

Keywords:

day-ahead photovoltaic output prediction, multiple meteorological information, similar days, the maximal relevance and minimal redundancy method (mRMR), feature topology graph, graph neural network, nodes and edges updating, improved ADAM algorithm.

PAPER ID: P05360

A Continuous Double Auction Mechanism for Joint Trading of Carbon Allowance and Reduction: A China's Carbon Market Study

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Abstract:
Global warming has become a major concern for the international community. Therefore, carbon emission allowance and reduction policies are proposed by some countries, such as China, to address climate change and further achieve carbon neutrality. Major transactive product in China's carbon market includes Chinese Certified Emission Reduction (CCER) and China Emission Allowance (CEA) but relevant market mechanisms for them are lacking in investigation. To this end, this paper developed a joint trading method for CEA and CCER based on continuous double auction market. Specifically, the bidding and asking behavior for buyer and seller are firstly formulated and the market is cleared when the bid and ask are matched. The objective function designs to maximize social welfare. Finally, simulation results verify that the proposed market mechanism of joint trading enjoys better economic benefits compared to existing trading mechanisms.

Keywords:
China's carbon market, carbon allowance, emission reduction, joint carbon trading, continuous double auction.

PAPER ID: P05363

A Network Utilization Pricing Mechanism Considering Network Constraints in Peer-to-Peer Energy Trading

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Abstract:
With the widespread adoption of distributed energy resources and rapid advancements in advanced information and communication technologies, peer-to-peer (P2P) energy trading has been primarily utilized in an active distribution network (ADN) to facilitate energy sharing among prosumers. While many studies have considered network utilization fees charged to prosumers in the P2P energy market, few have investigated the impact of network utilization price (NUP) on actual energy transfer. Therefore, this paper proposes a NUP-guided P2P energy trading mechanism considering network constraints to ensure the safe and stable operation of the ADN. Specifically, an interactive bilevel Stackelberg-generalized Nash equilibrium game is established among prosumers and the distribution network service provider (DNSP). Subsequently, in a multilateral environment, prosumers minimize their operational costs based on the NUP published by the DNSP to achieve a generalized Nash equilibrium. Then, the DNSP updates the NUP according to the ADN operating status, aiming to maximize its income. These two processes iteratively repeat until overall market equilibrium is reached. Finally, simulations are conducted on an IEEE 33-bus test feeder with 10 prosumers to validate the effectiveness and feasibility of the proposed method.

Keywords:
distribution network service provider, network physical constraints, network utilization price, peer-to-peer, prosumer.

PAPER ID: P05364

Transient Analysis of Micro Grid-Integrated EV Charging Station with Hybrid Energy Storage System

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Abstract:
Integrating electric vehicles (EVs) and renewable energy sources is becoming gradually popular to address the decreasing availability of fossil fuels and their negative impact on the environment. However, the adoption of EVs is challenged by high costs and a need for more sufficient charging stations. Microgrid technology has demand and generation imbalances due to the weather-dependent renewable energy system (RES) power generation. This paper presents a power configuration and control strategy for photovoltaic (PV)-powered grid-integrated charging stations. The proposed EV charging station consists of a high-gain power converter, a grid-integrating voltage source converter, and an energy storage system (ESS). The performance and efficacy of the proposed 3.5 kW system are studied under different test conditions, i.e., PV to grid, PV+EV to grid, and PV to grid and EV, using MATLAB/Simulink. Based on the results, the proposed configuration effectively maintains the total harmonic distortion (THD) of grid current below 5%, as specified by the IEEE 519-2022 standard.

Keywords:
electric vehicle, photovoltaic, MPPT, high-gain converter.

PAPER ID: P05369

A Forecast Error Correction Method Based on Seq2Seq and Auto Encoder for Short-term Wind Power Forecast Enhancement

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Abstract:
Accurate wind power forecast (WPF) is highly significant for the safe and economic operation of power systems, and implementing error correction is a common and effective manner to further enhance the forecasting performance. Nonetheless, existing error correction methods fail to consider temporal relationship and may inadvertently increase the error under certain circumstances, thereby compromising the local precision of forecast. In order to address these issues, this paper proposes an error correction model based on Seq2Seq and auto encoder (AE) to improve forecasting accuracy. Firstly, the seq2seq with attention mechanism is introduced to infer the probable error sequence through learning the temporal relationship between the numerical weather prediction sequence and the actual error sequence. Secondly, the samples that the seq2seq providing a positive error inference are collected and the AE model is employed to extract the meteorological features at these moments. Finally, on the basis of the above two models, the error correction method is constructed consisting of preliminary error inference and posterior correction determination. Using operational data from Ningxia province, the proposed method is validated for its remarkable superiority based on the evaluation metrics.

Keywords:
Attention mechanism, auto encoder, wind power forecast, error correction, Seq2Seq.

PAPER ID: P05372

A High-dimensional spatio-temporal Feature Extraction Method of Distributed PV and Load

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Abstract:
Distributed PV and load are closely related, in order to better achieve the balance and stable operation of the grid, in the daytime peak electricity consumption hours, the power generation of PV sites can provide additional power supply, thereby reducing the load pressure of the grid. However, there is a lack of effective methods to evaluate the relationship between regional PV and load. In order to achieve source-load feature matching, this paper presents a method of source-load feature matching. Initially, this paper identifies the wave characteristics of the curve through Fourier decomposition and constructs a spatial-temporal feature matrix, incorporating various additional features. Subsequently, it employs the combination of K-medoids clustering and the elbow method to categorize photovoltaic sites based on their distinctive traits, resulting in output curves that encapsulate a wide range of characteristics. Concludingly, the paper leverages derivative dynamic time warping (DDTW) for feature matching, determining the similarity between distributed photovoltaic output curves and load power curves by identifying the shortest path. The effectiveness of this feature matching approach is validated using actual data from photovoltaic sites and load, based on the aforementioned algorithmic model.

Keywords:
distributed PV, feature extraction, Fourier decomposition, K-medoids clustering, similarity analysis.

PAPER ID: P05373

Development of a Simple Dielectric Equivalent Circuit Model from Polarization and Depolarization Current Measurements

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Abstract:
Assessing insulation performance is vital for sustainable energy systems, which aim to minimize visual impact while ensuring reliability and resilience against weather-related disruptions. With increasing reliance on renewable energy sources, the importance of insulation performance becomes even more pronounced. Regular evaluations of insulation performance are critical for maintaining the safety, reliability, and resilience of electricity networks. By promptly identifying risks such as insulation degradation, utilities can improve maintenance practices, prioritize repairs, and enhance the integration of renewables, thereby boosting overall infrastructure performance. This paper introduces a straightforward and precise technique for determining the equivalent circuit parameters of insulation systems in high-voltage equipment. The proposed method facilitates the accurate determination of the dielectric loss factor from the equivalent circuit. To validate this approach, test cases were utilized to demonstrate its effectiveness. The results obtained through this method were then compared with those obtained using commercial software. The comparison reveals that the proposed approach results in a lower number of depolarization current branches compared to the commercial software. Also, it provides almost the same relative root mean square error and the lower root mean square relative error of the depolarization current. These findings underscore the appeal and effectiveness of the proposed method for determining the equivalent circuit of the dielectric model.

Keywords:
damped alternating voltages, equivalent circuit, loss tangent, on-site tests, underground power cable.

PAPER ID: P05374

Mid-long term photovoltaic power forecasting method considering periodicity characterization

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Abstract:
Accurate forecasting of mid-long term photovoltaic power plays a key role in site planning, operation scheduling and mid-long term plan development for new power system. Meanwhile, the uncertainty in solar power generation is a key factor influencing the precision of its forecasting. This paper proposes a mid-long term PV power forecasting method considering periodic characterization, which first obtains the key meteorological factors through the maximal information coefficient, and extracts the timing features through ARIMA model for mid-long term PV power periodic component prediction. Then the results obtained from above are inputted to the LSTM model, which is trained using raw data to obtain the final PV power prediction results with high accuracy. Validation is carried out through the model's RMSE, MAE and MAPE metrics and the comparison of the model's forecasting results with traditional GRU model.

Keywords:
mid-long term photovoltaic power prediction, periodicity characterization, LSTM.

PAPER ID: P05375

Enhanced Robust Scheduling Approach Considering Dynamic Flexibility Support from District Heating Systems

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Abstract:
Apart from flexibility resources, e.g., thermal generators and battery energy storage system in electrical power system, dynamic heating networks and flexible heat loads in district heating systems could also provide reserve capacity support for electrical power system. To accurately quantify the reserve support capacity, two operating periods of district heating systems, i.e., reserve capacity support providing period (RCPP) and reserve capacity support recovery period are designed in the paper. Since reserve capacity support from district heating systems are unavailable during RCRP, a novel dynamic flexibility support interaction mechanism among multiple district heating systems is presented, and a new scheduling strategy is proposed to coordinate electrical power system and district heating systems, where the concept of allowable regulating capacity exchange interval is introduced to make full use of reserve capacity in DHS. And then, an enhanced robust scheduling model is developed for electrical power systems, where both of the wind power allowable region and operational costs are involved. To make the resulting model tractable, a well-tailored reformulation approach is designed to transform the proposed model into a deterministic and robust optimization model with a priority objective function. Case studies demonstrate the proposed method effectively tackles the flexibility coordination between electrical power system and multiple district heating systems and then improves the operational economy and renewable energy integration level.

Keywords:
robust dispatch, district heating network, dynamic flexibility support, interaction mechanism, reserve capacity support recovery.

PAPER ID: P05377

Distributed photovoltaic power forecast method based on AP clustering and Transfer learning

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Abstract:
Highly accurate photovoltaic (PV) power forecast technology can provide a scientific basis for grid planning to ensure safe, economical, and efficient grid operation. The investment cost for a specialized power prediction system for each PV plant is high. Consequently, a distributed PV (DPV) power forecast method based on affinity propagation (AP) clustering and transfer learning is proposed in this paper. First, the dynamic time warping (DTW) algorithm determines the similarity of power curves between DPV plants; on this basis, multiple DPV power plants in the area to be forecasted are divided into station clusters by using AP clustering; and the PV power plants in each station cluster are divided into source and target domain by transfer learning, combined with long-short term memory (LSTM) network, the power forecasting model is established, and enabling transfer of power models from source to target domain. Finally, data from 20 DPV plants in China are used to demonstrate the effectiveness of the approach. Compared to separate modeling, the proposed method reduces the average training time by 58% while maintaining the forecasting accuracy.

Keywords:
distributed photovoltaic power plant clusters, AP clustering, transfer learning, LSTM.

PAPER ID: P05379

Design and Implementation of a Novel Power Converter Based on Input-Output Transfer Function

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Abstract:
This paper develops a power converter capable of both positive and negative gains. Based on the input-output transfer function, a novel converter applicable to both DC and AC power sources is proposed to achieve voltage regulation. The primary approach entails developing a power topology for a simple buck or boost voltage converter, employing techniques like capacitor DC offset biasing, feedback, and feedforward theories. The proposed converter topology consists of only two bidirectional switches, two capacitors, and two inductors. The driving waveforms for the bi-directional switches are implemented using the Renesas microprocessor. Finally, the simulation and experimental results are presented to validate the correctness and feasibility of the proposed converter.

Keywords:
positive and negative gains, feedback system, PWM.

PAPER ID: P05383

Nodal Price Forecasting Based on Spatiotemporal Transformer

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Abstract:
Nodal price forecasting is crucial for market participants like generators, traders, and consumers to make informed decisions. With the history information of nodal price of neighbors, the prediction can be more precise. In this paper, to predict nodal price, we proposed a Spatiotemporal Transformer (ST Transformer), which extracts both spatial and temporal information through a series of spatiotemporal Transformer blocks. A spatiotemporal transformer block consists of a spatial transformer and a temporal transformer. Experiments show that compared with some well-known time series forecasting machine learning and deep learning methods, our model has a better performance on prediction errors, especially at the peak hours of electricity price.

Keywords:
nodal price forecasting, spatiotemporal prediction, spatiotemporal dependency, transformer.

PAPER ID: P05384

Enhancing Solar Forecasting Accuracy: A Fusion of Sky Images and Meteorological Data with Channel-wise Attention

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Abstract:
Accurate solar forecasting is crucial for efficient integration of solar power into the electricity grid. While sky image based methods are introduced to overcome the low capability of numerical data to capture some features, enhancing forecasting accuracy remains an active area of research. In this paper, we combine numerical data and sky images to improve the accuracy of solar forecasting. A new framework is proposed based on a convolutional neural network model with a channel-wise attention mechanism for 10 minutes ahead solar forecasting using sky images and meteorological data. The model utilizes a series of convolutional blocks to extract spatial features from input sky images, followed by channel-wise attention layers to focus on the most salient features. Numerical data such as historical irradiance value, time, Tower Dry Bulb Temperature (TDBT), Total Cloud Cover (TCC), Average Wind Speed (AWGS) are also incorporated through a separate extraction branch. The extracted sky image features and numerical representations are fused and fed into the model to forecast the global horizontal irradiance (GHI). An evaluation of real-world datasets demonstrates the effectiveness of the proposed method. The channel-wise attention mechanism helps improve model interpretability by highlighting influential image regions. Compared to benchmark persistence and CNN models, the proposed approach achieves 8% lower error in 10 minutes ahead of forecasts. An error analysis indicates its superior performance under abrupt cloud conditions that are difficult to predict.

Keywords:
GHI, numerical data, sky images, channel wise attention, CNN, solar forecasting, deep learning.

PAPER ID: P05385

Influence of Waste Composition and Air Speed on Waste Incineration Energy System

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Abstract:
CFD (Computational Fluid Dynamics) was employed to simulate the combustion process in a waste incinerator and evaluate the effects of different variables on combustion. The research compared the distribution of furnace temperature and oxygen mass fraction at inlet air speeds of 5.36 m/s and 2.62 m/s. The results demonstrated that higher inlet air speed resulted in increased furnace temperature, reaching a maximum of 1719.4 K. Furthermore, the study investigated the impact of raising non-combustible substances to 50.2% on combustible substances during full combustion. The findings indicated that the presence of non-combustible substances reduced the maximum furnace temperature by 149.1K, diminished the high-temperature zone, impeded combustion efficiency and the decomposition of harmful substances, leading to higher emissions of harmful gases. The analysis suggested that optimizing waste incinerator performance could be accomplished by raising the inlet air speed appropriately and reducing the proportion of non-combustible substances, thereby enhancing furnace temperature and combustion efficiency.

Keywords:
waste incinerator, inlet air speed, non-flammable substances, CFD.

PAPER ID: P05387

Sample-Based Conservative Bias Linear Power Flow Approximations

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Abstract:
The power flow equations are central to many problems in power system planning, analysis, and control. However, their inherent non-linearity and non-convexity present substantial challenges during problem-solving processes, especially for optimization problems. Accordingly, linear approximations are commonly employed to streamline computations, although this can often entail compromises in accuracy and feasibility. This paper proposes an approach termed Conservative Bias Linear Approximations (CBLA) for addressing these limitations. By minimizing approximation errors across a specified operating range while incorporating conservativeness (over- or under-estimating quantities of interest), CBLA strikes a balance between accuracy and tractability by maintaining linear constraints. By allowing users to design loss functions tailored to the specific approximated function, the bias approximation approach significantly enhances approximation accuracy. We illustrate the effectiveness of our proposed approach through several test cases.

Keywords:
conservative bias linear approximation, power flow approximation.

PAPER ID: P05388

Compliant parallel beam piezoelectric array energy harvester based on non-contact rotating magnetic excitation

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Abstract:
Smart wearable systems have revolutionized the way humans interact with technology, providing functions ranging from fitness tracking to medical assistance. However, the sustainability of these systems relies heavily on efficient energy supply mechanisms. To address this challenge, energy harvesting technology has received attention. Among them, rotary piezoelectric energy harvesters have emerged as a promising solution for harnessing human body motion to generate electricity. In this study, we propose a non-contact rotating magnetic excitation energy harvester and test the dynamic response of the harvester. The test results show that the energy harvester has a good working bandwidth and can achieve uninterrupted energy harvesting under low-frequency excitation and high-frequency excitation.

Keywords:
energy harvester, piezoelectric, magnetic, rotational excitation.

PAPER ID: P05389

An Improved Convolutional Networks model for Carbon Emission Prediction in Power Systems

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Abstract:
In response to the imperative need for carbon reduction, tracking the carbon footprint of power systems has emerged as a critical concern. Traditional methods have struggled to accurately capture the nuances of carbon emissions, necessitating a fresh approach. To address this gap, the study introduces a pioneering deep learning-based model. We contend that the rapid advancement of deep learning offers a solution by harnessing neural network models, particularly the temporal convolutional networks (TCN) and gated recurrent units (GRU). These models are adept at handling the intricate patterns and dependencies inherent in carbon emission data, which exhibit both short-term fluctuations and long-term trends. Sequel to that, we propose a novel TCN-GRU-ATT neural network model designed explicitly for carbon footprint data. This innovative model combines TCN, GRU, and attention mechanisms to comprehensively capture both short-term variations and long-term dependencies within carbon emission patterns. Using power generation data from a gas-fired unit within the power grid as a foundation, the model calculates carbon emissions across various time intervals. Results demonstrate the model's exceptional performance, with a low Mean Absolute Percentage Error (MAPE) of 1.7123%, a Root Mean Square Error (RMSE) of 8.8436 kg/CO2, and a high Coefficient of Determination R^2 of 0.9802.

Keywords:
power system, carbon emission prediction, convolutional networks, TCN-GRU-ATT.

PAPER ID: P05390

Knowledge Distillation-CNN-BiLSTM Based Lifelong Learning Model for Fault Diagnosis of Power Converters under Multi-condition

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Abstract:

The power converter of electric vehicle's electric drive operates under conditions such as inversion and rectification. When it malfunctions, it poses a significant risk to the safe operation of electric vehicles. Current research mainly focuses on improving the fault diagnosis accuracy of power converters under a single condition. However, the issue of fault diagnosis when conditions vary continuously remains to be addressed. This paper proposes a knowledge distillation-convolutional neural network-bidirectional long short-term memory (CNN-BiLSTM) based lifelong learning model for fault diagnosis of power converters under multi-condition. Initially, a CNN-BiLSTM neural network based on knowledge distillation is established to extract and identify the fault features of power converters. The network's learning of key fault features during training is continuously reinforced through knowledge distillation. Subsequently, utilizing a replay-based lifelong learning framework enables the network to further develop the ability to learn continuously under different conditions, constantly reinforcing the memory of all previously learned tasks, thereby achieving fault diagnosis of power converters under various operating conditions. Finally, through simulation experiments, the model is trained onthree-phase AC current signal fault datasets of power converters operating under inversion and rectification conditions.

The experimental results demonstrate the model's accurate diagnosis of power converter faults under different operating conditions on the test set. The proposed model holds significant engineering significance in enhancing the reliability of electric vehicle electric drive systems and the intelligence of their maintenance.

Keywords:
lifelong learning, fault diagnosis, power converter, knowledge distillation-CNN-BiLSTM, Insulated Gate Bipolar Transistor.

PAPER ID: P05393

Life-cycle operational management for electrochemical energy storage

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Abstract:
In recent years, the economics of electrochemical energy storage (EES) technology with high energy conversion efficiency has gradually come to the fore, and the application of energy storage technology is gradually shifting from project demonstration to commercial operation. However, making decisions and determining the valuation of EES over the long term still present significant challenges for operators. Battery life, including economic life and physical life, is a key factor in the planning, operation and economic evaluation of EES systems. In this study, we develop the full life-cycle decision-making model. For evaluating the full life-cycle revenues and optimal marginal degradation costs (MDC) of EES. A lithium-ion EES arbitrage case study in the California energy market shows that for distributed/residential EES systems, the end of economic life may occur earlier than the end of physical life.

Keywords:
energy arbitrage, economic end of life, life-cycle decision-making model, electrochemical energy storage, battery degradation.

PAPER ID: P05396

Dynamic Assessment of Thailand's Available Transfer Capability for Third-Party Access

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Abstract:
Thailand is experiencing significant growth in renewable energy sources, such as solar power and wind power. This growth is leading to an increase in independent electricity trading across public, private, and household sectors, making Thailand the origin of third-party access to electricity in the country. However, the current transmission infrastructure is struggling to keep pace with this development, making it challenging to assess regional transmission capabilities accurately. Furthermore, the rapid urban and industrial growth has also resulted in a significant increase in electricity demand, emphasizing the urgent need for a robust transmission and distribution network. To address these challenges, a paper is currently underway to model the remaining transmission capacity in Thailand's regions using real data and sophisticated electrical engineering software. This analysis primarily concentrates on Available Transfer Capability known as ATC, which draws insights from various methods used in the Indian case study. The goal is to enhance the utilization of the transmission system, support independent electricity trading, and guarantee the stability, security, and reliability of the power system in line with the changing electricity market.

Keywords:
available transfer capability, third-party access, renewable energy, system stability.

PAPER ID: P05403

Short-Term Wind Power Prediction Based on TCN-Transformer and STL Error Correction

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Abstract:
Wind power prediction has a profound impact on the power system in determining the optimal combination of unit outputs and developing the intra-day scheduling plan. The wind power prediction model needs to consider both the nonlinear relationship between numerical weather prediction (NWP) data and wind power and the time-series dynamic characteristics of the data. In this paper, a novel wind power prediction method based on TCN-Transformer model and seasonal and trend decomposition using loess (STL) error correction is proposed. In the first part, the feature dimensionality reduction is carried out through the minimal redundancy maximal relevance (mRMR) principle; in the second part, the temporal convolutional networks (TCN) network is used to capture the time-series dynamic features of the low-dimensional data, and the attention mechanism of the Transformer is used to the second part uses TCN to capture the dynamic features of the low-dimensional data, and the attention mechanism of Transformer is used to model the dependencies between different positions in the time-series data to obtain the baseline prediction; in the third part, the error series of the validation set is decomposed into the trend, seasonal, and residual components by the STL algorithm, and the high correlation components are selected to train the TCN-Transformer model to perform the error prediction. The high correlation components are selected to train the TCN-Transformer model for error prediction, and the baseline prediction and error prediction results are superimposed to obtain the final prediction results. The simulation results verify the effectiveness of the method.

Keywords:
short-term wind power forecasts, transformer, temporal convolutional networks (TCN), seasonal and trend decomposition using loess (STL), error correction.

PAPER ID: P05404

Optimal Piezoelectric Transducer Placement for High Efficiency in Ultrasonic Cleaning Systems

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Abstract:
This research examines the installation methods of piezoelectric transducers in ultrasonic cleaning systems and their impact on cleaning efficiency. Harmonic response analysis and sound pressure testing were employed to evaluate the forces generating cavities within the cleaning tank. Measurements of ultrasonic pressure at various tank locations were taken using a cavitation intensity meter and were further validated through corrosion tests on aluminum foil. The findings indicate that although increasing the power supplied to the transducer leads to heightened sound pressure, it does not correspondingly improve cleaning effectiveness. Instead, optimal cleaning efficiency is achieved through precise adjustments in the frequency and positioning of the transducers, with a configuration of four piezoelectric transducers spaced 20 cm apart proving most effective. The study underscores the necessity of appropriate transducer spacing and frequency tuning to maximize ultrasonic cleaning efficiency.

Keywords:
Ultrasonic cleaning, piezoelectric transducer, cavitation intensity, ultrasonic frequency.

PAPER ID: P05405

Stand-alone Offshore Wind Farm for Green Hydrogen Production with Technical Feasibility

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Abstract:
This study investigates the technical feasibility of utilizing stand-alone offshore wind farms for the production of green hydrogen using a centralized electrolyser, contributing to global decarbonization initiatives. The wind farm is equipped with PMSG Wind Turbine Generators (WTGs). These generators operate in a grid-forming mode (GFM) using droop control, ensuring regulation of the point of common coupling (PCC) voltage magnitude and frequency. The system's design comprises multiple interconnected subsystems: WTGs organized in arrays, rectifiers, DC/DC converter, a Battery Energy Storage System (BESS), and a centralized electrolyser. Some challenges related to designing the offshore system like black-start capability, synchronization, and power generation-load balance are investigated. Simulation results validate the system's capability to consistently power the electrolyser for green hydrogen generation, given that the wind farm receives sufficient wind. In situations where wind power is insufficient, the system will shut down, only to restart when wind speeds rise above a set threshold, determined by both wind speed data and system reaction times.

Keywords:
battery energy storage system, black-start, centralized electrolyser, hydrogen, grid forming, power management, wind turbine generator.

PAPER ID: P05408

Day-Ahead Scenario Generation Model of Multiple Wind Farm Output Based on GCN and TimeGAN

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Abstract:
Aiming at the uncertainty of the wind power output, this paper proposes a multiple wind farm output scenario generation method considering the temporal and the spatial correlation characteristics of the wind power output, which consists of a Graph Convolutional Network (GCN) and a Time-series Generative Adversarial Network (TimeGAN). Initially, the method employs the Spearman correlation coefficient to calculate the correlations between the outputs of multiple wind farms, constructing topological graph data. The GCN is then utilized to extract the spatial correlation features among the outputs of multiple wind farms. Subsequently, the TimeGAN is employed to extract the temporal correlation features of the wind farm output timing information that integrates the spatial correlation information of multiple wind farm outputs, generating the output scenarios of multiple wind farms. The effectiveness and accuracy of the proposed method are validated through comparative analysis using real-world data. The experimental results demonstrate that, compared to the TimeGAN method and the CGAN method, the proposed method effectively characterize the temporal and the spatial correlation among the outputs of multiple wind farms, and the scenario set generated by the proposed method is able to more accurately and reliably predict the fluctuation range of the wind output.

Keywords:
generation of wind power output scenarios, multiple wind farms, graph convolutional network, time-series generative adversarial network, spatial correlation characteristics.

PAPER ID: P05409

Ultra-Short-Term Power Forecasting for Distributed PV based on Multi-Source Remote Sensing Information and Adaptive Feature Extraction

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Abstract:

The lack of meteorological data for distributed photovoltaic (DPV) makes it impossible to incorporate meteorological information sources highly related to PV output into power forecasting model, which limits the further improvement of forecasting accuracy. Therefore, this study employs satellite cloud image data, including Cloud Fraction Rate (CFR), Cloud Top Height (CTH), and Surface Solar Irradiance (SSI), for research purposes. The multi-source satellite remote sensing information describes the distribution of solar irradiance from different angles, which provides a powerful data support for the forecasting of PV power generation. However, existing forecasting methods that rely on satellite cloud images face a problem where convolutional autoencoder (CAE) used to extract features from these images may inadvertently discard some critical attributes, which can negatively impact the final power forecasting results. Therefore, this study proposes a novel ultra-short-term power forecasting method for regional DPV systems using multi-source remote sensing information and adaptive feature extraction techniques. The process begins with preprocessing both satellite cloud image data and PV power generation data. Building upon this foundation, the proposed approach harnesses the spatial feature capturing capabilities of a Convolutional Neural Network-Long Short-Term Memory Network (CNN-LSTM) network to identify and extract the correlation between

the multi-source remote sensing information and the PV power output, thus compensating for the dearth of meteorological information in distributed PV power forecasting and enhancing its ultra-short-term forecasting accuracy. Finally, the effectiveness of the proposed methodology is validated through practical application to DPV power generation data.

Keywords:
Distributed photovoltaics, Ultra-short-term power forecasting, Multi-source remote sensing information, Adaptive feature extraction, CNN-LSTM.

PAPER ID: P05410

Day-ahead Demand Response Potential Forecasting Method for Data Centers Based on Federated Learning

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Abstract:
The unique nature of data center workloads determines a considerable adjustable potential in their power demand at different times and locations. Fully exploring and utilizing this potential is crucial for devising strategies for power load shifting, participating in demand response (DR) or electricity markets, and effectively reducing the operational costs of data centers. However, current research in demand response forecasting often inadequately considers the spatiotemporal correlation of data centers and potential privacy issues during the sample training process, limiting the accuracy and reliability of forecasting models. To address the challenges posed by this phenomenon, this paper first estimates the demand response potential of ten data centers under central server using the load elasticity coefficient method with a sliding window. Subsequently, parameter weights are assigned based on actual geographical conditions, and a federated learning algorithm based on Long Short-Term Memory (LSTM) is employed to forecast the demand response potential. Finally, the effectiveness of this method is validated using load data provided by the National Renewable Energy Laboratory (NREL).

Keywords:
data center, demand response potential, spatiotemporal correlation, federated learning, load elasticity coefficient method.

PAPER ID: P05411

EV Scheduling Model in DR Based on DRL with Prediction Accuracy as the Optimization Objective

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Abstract:
Electric vehicle (EV) possesses both load and storage characteristics, which is highly flexible demand-side resource, offering significant potential for temporal and spatial shifting. Traditional optimization scheduling strategies for EV charging behavior primarily rely on operations research or evolutionary algorithms, which do not meet current needs. Recently, the advantages of deep reinforcement learning (DRL) technology have become increasingly apparent. For the day-ahead invitation-based demand response (DR) scenario, the accuracy of the response volume forecast is particularly important. However, current optimization scheduling based on DRL often targets response volume or fluctuation mitigation without considering forecasting issues. Therefore, this paper proposes an EV charging strategy model based on DRL, aimed at optimizing the accuracy of the day-ahead DR potential prediction for EVs. This method simulates and estimates the charging power of EVs based on partial information, employs DRL algorithm to formulate real-time EV charging strategies, and uses LSTM-DNN architecture to predict response capacity. By improving the accuracy of day-ahead DR potential prediction while ensuring response volume, the final results show a 17.56% improvement over traditional scheduling methods.

Keywords:
deep reinforcement learning, demand response, long and short-term memory neural network, charging strategies.

PAPER ID: P05413

Low-carbon and Economic Scheduling Strategy for Virtual Power Plant Based on Complementary Characteristics and Aggregation Model of DER

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Abstract:

Virtual power plants (VPP) aggregate dispersed resources into a whole to participate in power market transactions and improve the scheduling capabilities of resources and the economics of operation. The challenges faced by VPP are that there are too few types of aggregated resources, the modeling is not precise enough, and there is a lack of more practical and rich application scenarios. Therefore, this paper proposes a low-carbon economic operation scheduling optimization method for VPP considering multiple heterogeneous resource aggregation. Firstly, the model of 8 kinds of resources is established, and scenario generation and reduction methods are used to reduce the uncertainty of photovoltaic (PV) and wind power (WP), and Minkowski theory is used to establish an accurate aggregation model for electric vehicles (EV). Secondly, carbon emission factors are introduced to calculate the carbon emissions of VPP, and the heat load is considered to establish a combined heat and power (CHP) model, and then the sum of the operating cost and carbon emission cost of VPP is minimized to realize its low-carbon economic operation. Finally, the scheduling strategy of VPP every 15 minutes is formulated through an illustration, which shows the flexibility of

VPP power regulation, and the impact of carbon emission on the overall output of VPP is verified through sensitivity analysis, which solves the problem of optimal scheduling of VPP with multiple heterogeneous resources of counting grade in an economic and low-carbon way, and promotes its development in a low-carbon context.

Keywords:
virtual power plant, dispatching mode, low carbon economy, power regulation curve.

PAPER ID: P05414

New Energy Consumption Capacity Evaluation Method for Isolated Industrial Park Considering Flexible Load Regulation Ability

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Abstract:

In the context of the global energy transition, China is promoting the synergistic integration of energy sources, grids, loads and storage through national strategic policies. This paper examines the challenges of integrating volatile new energy sources, such as wind and solar, into the grids of isolated industrial parks (IIPs). It proposes a model to assess and optimize the consumption capacity of these resources to balance energy production with grid demand effectively. Initially, a "resource-power" conversion model is developed to simulate the potential output of wind and solar installations, given the absence of direct connectivity to the grid in newly established IIPs. Then, with the optimization objective of minimizing the overall cost of isolated grid operation, the new energy consumption capacity of IIPs is evaluated, taking into account the actual operating constraints of thermal power units, the maximum new energy consumption that can be technically achieved, and the regulation potential of flexible load participation response to mitigate the impacts caused by fluctuations in new energy sources. Finally, based on

the analysis of the actual operation data of the IIPs, the simulation results show that the IIP can be guided by adjusting the installed capacity parameters for planning the installed size of wind and solar in the IIP before connecting to wind and PV. Moreover, fully exploiting flexible load regulation ability can effectively improve the IIP's wind power consumption capacity, which can provide theoretical guidance for optimizing the IIP's scheduling and promoting new energy consumption.

Keywords:
New energy consumption capacity evaluation, isolated industrial parks (IIPs), flexible load regulation potential, robust energy optimization.

PAPER ID: P05415

Application Analysis and Prospect of GPT-enabled Digital Transformation of Power Systems

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Abstract:
The rapid development of Generative Pre-trained Transformer (GPT) models brings both opportunities and challenges to power system digital and intelligence transformation. Starting with the summarization of the concept and technical architecture of GPT models, four kinds of potential application scenarios in new power systems related to GPT models are presented. Then, the integration of GPT models with several typical digital technologies in new power systems are reviewed, such as computer vision, human-computer interaction, knowledge graph, Internet of Things, and Blockchain. Finally, the challenge and development direction of GPT models for new power systems are prospected. The comprehensive analysis could provide theoretical and application guidance for the development of GPT-enabled models in new power systems.

Keywords:
New power system, digital transformation, large language model, GPT model, application scenarios.

PAPER ID: P05417

Benefits of Adjustable-Speed Pumped Hydro Units Running in Turbine Mode for Wide Water Head Variation Reservoir

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Abstract:
Renewable energy resources including solar photovoltaic and wind power, are gradually associated with the power system to cope with the demand for power generation. Nevertheless, power systems are having issues with increased DERs due to the impact of fluctuations in power generation due to their intermittent nature. Therefore, variable speed pumped storage units are gaining attention among the grid authorities in view of power balancing, maximizing electricity revenue, and higher dynamic response. This paper provides the expected aids of adjustable speed pumped storage hydro unit (PSHU) operating at generation/turbine mode in Indian power scenario. A case study of 310 MVA doubly fed induction machine (DFIM) fed adjustable speed PSHU is investigated. Further, it provides the detailed comparison of constant and adjustable speed PSHU based on the real time implementation. A 310 MVA MATLAB/Simulink model is created for both fixed and variable speed PSHU for analyzing the different kinds of control. The findings showed that, compared to a fixed-speed PSHU, the adjustable-speed PSHU generates an extra 6.82% of electrical power.

Keywords:
Adjustable speed pumped hydro unit, doubly fed induction machine, synchronous machine, generation mode, higher water head range.

PAPER ID: P05418

Soft Starting Comparison of Single-Phase Capacitor Start Capacitor Run Induction Machine between Motoring and Generating Operation using Asynchronous PWM AC Chopper

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Abstract:
This paper presents a soft starting comparison of a single-phase, 1 hp, 220 V, 4.8 A, four-pole capacitor-start capacitor-run induction machine between motoring and generating mode of operation when connected to a grid using single-phase PWM AC chopper. An asynchronous PWM strategy is used for controlling the machine voltage with the AC chopper during soft start with a reason of simplicity. The PWM AC chopper offers some advantages over a conventional ac voltage controller using phase control in terms of harmonic reduction and linear relationship between fundamental voltage and duty ratio. The comparison of waveforms of starting currents, voltages, instantaneous power under direct on line and soft connection conditions is given when the machine operates as a generator and a motor during startup. According to experimental results, it is found that when starting the connection, the generator offers lower starting current compared to the motor and the soft starter can reduce starting current to one fifth when compared to direct on line start.

Keywords:
soft starting, capacitor-start capacitor-run induction machine, PWM AC chopper.

PAPER ID: P05419

Protecting Sensor Data Confidentiality in WAN- Enabled Power Systems: A Framework Utilising Image Encoding and Machine Learning Regression

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Abstract:
Effective grid management in power systems relies on transmitting sensor signals from remote substations to the control center, facilitating real-time monitoring and controls. Wide area networks (WAN) enhance grid resilience and enable advanced automation. However, WAN adoption introduces cybersecurity risks, including sensor data eavesdropping. While methods exist to detect False Data Injection Attacks, there is a notable absence of approaches addressing eavesdropping and data confidentiality protection. Sophisticated attacks, such as Stealthy and Imposter attacks, threaten power system stability by exploiting real-time sensor data acquired through eavesdropping. Our study focuses on ensuring data confidentiality to eliminate such threats. Encoding time series data into grayscale images obscures sensitive information, impeding unauthorised access. Machine learning regression algorithms reconstruct original sensor data from encoded images, ensuring system operation continuity while preserving confidentiality. Demonstrated in Automatic Generation Control systems, our framework showcases the effectiveness of the Gramian Angular Summation Field algorithm paired with Gaussian Process Regression in safeguarding sensor data confidentiality. Through this approach, we mitigate cybersecurity risks and enhance the resilience of power systems against intelligent attacks.

Keywords:
Eavesdropping, Gramian Angular Field, Markov Transition Field, AGC, Data confidentiality, False data injection attacks.

PAPER ID: P05421

An Encoder-Decoder-Based Generation Command Dispatch for AGC of a Multi-Area Grid

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Abstract:
The inclusion of mileage settlement within the frequency regulation market has encouraged fast-acting units (FAUs) to take part in active power balancing through automatic generation control (AGC). Traditional generation command dispatch (GCD) schemes struggle to handle the increasing variability of FAUs and lack sufficient incentives for FAUs. In view of this, an attention-embedded encoder-decoder-based GCD framework has been developed for a multi-area power system consisting of FAUs under the performance-based frequency regulation market. The model employs stack-long short-term memory (LSTM) layers at both encoder and decoder blocks. The LSTM layers can successfully collect the temporal information from the input dataset, whereas the attention mechanism gives more weightage to the crucial information. The LSTM layers at the decoder model predict the final output based on the weightage-based information from the attention layer. This proposed GCD framework optimally distributes the generation command among various AGC units with different regulation characteristics. The efficacy of the proposed GCD framework is also evaluated, considering the realistic cyber-physical layer within the existing AGC infrastructure accounting for communication delay. Finally, the assessment of the proposed framework is done considering variation in AGC unit configuration, and noise in the data-acquisition environment.

Keywords:
Automatic Generation Control, Generation Command Dispatch, Converter Interface Generator, Encoder-Decoder, Regulation Mileage Payment.

PAPER ID: P05473

A Wind Power Ramp Events Detection Method Based on Improved SDA and Endpoint Correction

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Abstract:
To improve the wind power ramping event detection accuracy, this paper presents a method for the detection of wind power ramping events by adopting adaptive gate width parameters, trend merging and ramping event's endpoint modification. First, the unique parameter ε of the swinging door algorithm (SDA) is obtained by calculating the average absolute value of the difference of the initial data (AAVD), the detected SDA compression segments are screened for extreme values, and the trend segments to be measured are obtained by merging the endpoint of the compression segment with the extreme value. Second, with the bump event detection definition and trend merge rules, the set of ramping events is preliminarily determined. Finally, in accordance with the established definition of a ramp, the endpoints of each of the above sets of ramping events have been modified. The inherent defects of traditional SDA detection methods are solved, and the optimal ramping events are obtained. The results demonstrate that, in comparison to the two control detection methods, the proposed detection scheme is capable of both adaptive acquisition of the SDA's ε in accordance with the data characteristics and the detection of the endpoints of ramp events with high precision.

Keywords:
ramping events detection, improved SDA, neighbor trend segment merging, endpoints correction.

PAPER ID: P05506

PPO-based Satellite Terminal and UAV Nest Location Scheme for Space-Air-Ground Integrated Power Line Inspection

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Abstract:
Intelligent unmanned inspection is emerging as the future trend for power line maintenance, yet comprehensive communication coverage as a necessary condition presents significant challenges in this context. This paper introduces a space-air-ground integrated inspection architecture to address the communication coverage issues inherent in intelligent unmanned inspections. A novel location scheme based on Proximal Policy Optimization (PPO) for satellite terminals and Unmanned Aerial Vehicle (UAV) nests is proposed, significantly enhancing the efficiency and cost-effectiveness of communication and inspection tasks. Simulation results demonstrate the superiority of the proposed method over conventional approaches, highlighting its potential to improve operational capabilities in wide-area intelligent unmanned inspection environments, thereby advancing the reliability and functionality of smart grids.

Keywords:
Resilience, power line inspection, UAV, area covering problem, satellite internet.

PAPER ID: P05572

Domain of Attraction Estimation and Control of DC Microgrids Considering Power Characterization of Energy Storage Systems

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Abstract:
The energy storage systems (ESSs) are integrated on DC microgrids to resolve the power mismatch and voltage instability. This article proposes domain of attraction (DOA) estimation and control of DC microgrids considering power
characterization of ESS. Firstly, a novel full-order model of DC microgrid system with power characteristics of ESS is proposed. The power characterization of ESS is analysed based on previous work. Then, a dynamic current droop control based on state of charge (SOC) limitation is proposed to prevent battery overcharging and overdischarging. By using Takagi–Sugeno fuzzy model (TSFM), stability conditions with characterization constraints of battery are obtained. Finally, the analysis results of DOA are presented in detail to reveal influences of the battery dynamics on stability of the system.

Keywords:
DC microgrids, Energy storage systems, Power characterization, Domain of attraction, Stability analysis.

PAPER ID: P05574

Wind-sensitive Energy-transport Scheduling Method for Electric Transfer Vehicles in Seaports

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Abstract:
This paper proposes a wind-aware energy-transport management method for electric transfer vehicles (ETVs) in seaports, aiming to improve energy efficiency and operational performance. It integrates actual wind data into scheduling algorithms to adapt vehicle movements and energy usage to varying wind conditions. By optimizing route scheduling and time management based on wind effects, the strategy maximizes wind utilization, potentially reducing energy costs and enhancing operational responsiveness. To address the challenge of low solution efficiency due to extensive variable space, a Markov decision process framework coupled with a hybrid actor-critic algorithm is proposed. Case studies demonstrate significant improvements in energy utilization efficiency, cost reduction, and route optimization, enhancing overall operational responsiveness and efficiency.

Keywords:
Energy-transport management, seaport, Electric transfer vehicles, Wind conditions, Markov decision processes.

PAPER ID: P05584

A Voltage Security Boundary Computation Method for New Type Power Systems Based on Dynamic Dimensionality Reduction Equivalence

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Abstract:
With the increasing penetration of new energies in new type power system, the voltage security issues are accelerated to hundreds of milliseconds-level and easier to spread from local areas to the whole system, resulting in prominent potential power outages. Fast and accurately determines the voltage security boundary is a crucial way to guaranteeing the secure system operation. However, current methods mostly focus on the static characteristics of power systems, insufficiently considering the dynamic characteristics of the system, and failing to achieve an effective balance between computational speed and accuracy. To this end, this paper proposes a voltage security boundary computation method for new type power systems based on dynamic dimensionality reduction equivalence. Firstly, dimensionality reduction processing is conducted separately from the fault dimension and the Var/voltage dimension, simplifying the original large-scale system into a small-scale system to reduce the computational burden. Then, for the differential equation constraints in the system, a piecewise trajectory sensitivity method is used to transform them into algebraic equations, and error analysis is performed to ensure computational accuracy. Finally, the accuracy and effectiveness of the proposed method are verified using test systems of different scales.

Keywords:
dynamic dimensionality reduction equivalence, new type power systems, voltage security boundary.

PAPER ID: P05585

Threshold method incorporated CNN based Non Invasive Load behavior identification

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Abstract:
Non-invasive load monitoring (NILM) technology has increasingly become a core aspect of the smart grid infrastructure. The characteristics of electrical appliances serve as a crucial foundation for the non-invasive identification of appliance status, and the extraction of these characteristics depends on the detection of changes in the appliance's state. This paper presents a multi-scale recognition model based on sliding window thresholding techniques and neural network algorithms. The model employs an improved thresholding method to preliminarily identify potential change points in the load device from the AMPds dataset within time series data, tagging them appropriately for use as a training dataset for Convolutional Neural Networks (CNNs). Test results indicate that the proposed algorithmic model processes data at high speeds, capable of handling millions of records in a short time frame, while also precisely detecting changes in the status of electrical devices and pinpointing the moments of these state changes. This paves the way for the extraction of transient characteristics of the appliances.

Keywords:
Non-Invasive Load Monitoring, Electricity Consumption Equipment, Neural Networks, State Identification.

PAPER ID: P05593

Real-Time Energy Management for Hybrid AC/DC Microgrids with Adjustable Bus Voltage

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Abstract:
Studies on dynamic voltage adjustment at the power electronics level within DC microgrids are prevalent, yet there is a scarcity of research on corresponding energy management strategies. This article introduces a novel approach that integrates DC bus voltage as an adjustable variable within the dispatch model, which incorporates a DC/DC and DC/AC converters power loss model. This model is real-time solved using the Deep Deterministic Policy Gradient (DDPG) algorithm, enhanced with a corrector. The strategy enables dynamic adjustment of the low-voltage DC bus in AC-DC microgrids, significantly reducing losses in DC/DC and DC/AC converters, thereby lowering operational costs. Simulations conducted in Python validate the effectiveness of this method, demonstrating its potential to improve energy management in microgrids.

Keywords:
Microgrid, Energy management strategy, Deep reinforcement learning.

PAPER ID: P05599

A Comprehensive Recognition Framework for Three-Phase Power Quality Events Based on Frame Frequency Attention

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Abstract:
Analyzing the operational status of the power grid through the quality of electrical energy holds significant develop mental and strategic importance. To enhance the granularity and efficiency in recognizing electrical energy events across the three phases, this research proposes the integration of tri-phase time-series power quality data (PQD) into a single two-dimensional three-channel RGB spectrogram. Based on the premise that the rows and columns of pixels in the two-dimensional feature map have local and holistic representational meanings, a Frame Frequency Attention Mechanism is further introduced, enabling efficient capture of frequency variation information at different temporal nodes of the electrical energy signal. Experimental results on two datasets (with classification numbers reaching 216 and 1001, respectively) demonstrate that the proposed method outperforms other attention networks with the same number of layers. Finally, testing with real-time data collected from the RT-Lab platform yields promising results

Keywords:
power quality recognition, three-phase un-balance, three-channel spectrogram, neural network, attention mechanism.

PAPER ID: P05601

Electric Vehicle Potential to Reduce Overvoltage-Induced Photovoltaic Energy Curtailment in Distribution Networks

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Abstract:
Overvoltage frequently occurs in low-voltage (LV) distribution networks due to significantly increased photovoltaic (PV) penetration. Active power curtailment is integrated into a smart inverter to mitigate overvoltage. However, this power curtailment leads to substantial waste in PV energy generation. Therefore, this study proposes a potential solution for reducing overvoltage-induced PV energy curtailment by employing an electric vehicle (EV). A smart EV charging approach is developed in the grid-to-vehicle mode incorporating overvoltage-induced curtailment. The proposed approach is validated using a simplified LV distribution network to investigate its efficacy. Four scenarios are compared to explore the benefits and limitations of the proposed approach from both the system operator and EV owner aspects. Simulation results reveal that the proposed approach could mitigate overvoltage effectively. Notably, this approach could significantly reduce the curtailed energy by 88.22%. Simultaneously, the EV was fully charged, as the state-of-charge reached the maximum level without the need for charging from the network.

Keywords:
electric vehicle, voltage regulation, distribution networks, state-of-charge.

PAPER ID: P05606

Spatio-Temporal-Transformation-based Method for Hour-Ahead Wind Power Forecasting

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Abstract:
Wind power forecasting (WPF) is crucial for integrating renewable energy into power grids efficiently, tackling the variability of wind energy production. This study addresses significant spatial-temporal challenges in WPF for large-scale turbine clusters, which are not effectively managed by traditional methods such as point prediction and statistical upscaling. In this paper, we introduce a novel spatio-temporal-transformation-based (STT) method incorporated with a multi-head residual LSTM network (MRLSTM), aimed at significantly improving forecasting accuracy by effectively coupling spatial and temporal dynamics across wind turbines. Comprehensive evaluations on a public dataset confirm that the STT-MRLSTM framework outperforms both conventional forecasting framework as the statistical upscaling method, and other forecasting models as LSTM, GRU and Transformer in hour-ahead forecasting accuracy.

Keywords:
hour ahead forecasting, wind power forecasting, long short-term memory, clustering algorithm, spatio-temporal- transformation.

PAPER ID: P05608

Single Control Angle Based Power Regulation in Modified Single-Pulse-Operated Switched Reluctance Generator

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Abstract:
A switched reluctance generator (SRG) is a good choice in power generation applications. The SRG can be operated in modified single-pulse mode (MSPM) close to and above its base speed. In MSPM, three control angles decide the output of SRG. Multiple optimal methods exist to select these control angles for a given output power. All these methods rely on extensive simulation of the SRG system and optimization; therefore, they are computationally intensive and time-consuming. This article proposes three simple methods to determine the control angles for a given output power. The proposed simple methods use a few simulations and do not require any optimization. The proposed simple methods are validated through simulations and experiments in terms of rms phase current, rms capacitor current, power loss, and efficiency of SRG drive. A laboratory prototype of 4-kW, 4-phase, 280-V, and 1500-rpm SRG is utilized for experimental results. A reasonably good agreement between the simulation and measured result is found.

Keywords:
switched reluctance generator, modified single-pulse mode, control angles, simple method, one angle control.

PAPER ID: P05609

Improved Small-Signal Model of Single-Pulse Operated Switched Reluctance Generator

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Abstract:
A switched reluctance generator (SRG) operates in single-pulse mode close to or above its base speed. In single-pulse mode, the generated current depends on two control angles. The partial differentiation of generated current with each control angle is defined as the small-signal model of single-pulse operated SRG. The existing small-signal analysis ignores the effect of magnetic core saturation and winding resistance drop. This paper improves the existing small-signal analysis by incorporating the effect of magnetic core saturation. The improved mathematical expressions of partial differentiation are derived in the paper. These partial differentiations depend on the current derivative of inductance. Therefore, a method to determine the current derivative of inductance using measured flux-linkage characteristics is also discussed in the paper. The results of the improved small-signal model are validated through simulation and experiment at multiple operating points. An improvement in the proposed model compared to the existing model is demonstrated. The proposed small-signal model is useful in real-time control of single-pulse operated SRG.

Keywords:
switched reluctance generator, single-pulse mode, small-signal model, and core saturation effect.

PAPER ID: P05612

Estimation of Effective Air-gap in a Switched Reluctance Machine from Measured Aligned Inductance Using a Flux-Tube-Based Approach

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Abstract:
Due to the manufacturing processes, the air-gap length may significantly alter in a switched reluctance machine (SRM). This paper proposes an analytical method to estimate the uncertain air-gap length of a manufactured SRM with a given dimension and material's relative permeability. The work can be broadly classified into three major steps. Firstly, an analytical expression of aligned inductance is derived using a flux-tube-based method, assuming the magnetic material to be infinitely permeable. An approximate estimate of air-gap length is obtained by equating the inductance expression with the measured aligned inductance. In the second step, the aligned inductance is expressed as a function of the air-gap and the material's relative permeability. A corrected estimate of effective air-gap length is obtained by incorporating the effect of iron magneto-motive-force (MMF) drop. Finally, the accuracy of the analytical method is validated by results obtained from extensive FEA simulations. All the measurements and FEA simulations pertaining to the proposed approach are carried out on a 7.5 kW, 30,000 rpm, 6/4-pole, 3-phase SRM.

Keywords:
Effective air-gap, flux-tube, analytical method, switched reluctance machine.

PAPER ID: P05613

An Ant Colony Optimization-Enhanced LightGBM Algorithm

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Abstract:
In recent years, the application of machine learning in non-intrusive load monitoring (NILM) for load identification has become increasingly widespread. Current research primarily employs traditional machine learning algorithms for load identification, such as Random Forest, Bayesian methods, and Deep Forest. However, these approaches often lack precision. The LightGBM (Light Gradient Boosting Machine) algorithm is known for its low memory consumption and computational complexity, yet it falls short in accuracy. To enhance the precision of machine learning in load identification, this paper introduces an improved LightGBM algorithm based on Ant Colony Optimization (ACO), termed ACO-LightGBM. Comparative experiments with other models demonstrate that the ACO-LightGBM algorithm achieves higher accuracy.

Keywords:
LightGBM, ACO, load identification.

PAPER ID: P05618

Fault Current Calculation for DFIGs Under Complete Fault-Ride Through Strategies

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Abstract:
The fault current characteristic of doubly fed induction generators (DFIGs) is determined by both the external grid voltage and the internal rotor voltage. However, there are multiple fault-ride through strategies employed by DFIGs. In this paper, a fault current calculation method for DFIGs under complete fault-ride through strategies is proposed. The transient behavior of the DFIG is described by the state space model in which the stator voltage and rotor voltage are selected as input signals. The internal dynamics of the DFIG is modeled by the rotor voltage which is controlled by multiple strategies in sequence. Comparative case studies are carried out to demonstrate the accuracy of the proposed method.

Keywords:
Doubly fed induction generator, fault current calculation, FRT control strategy, weak grid.

PAPER ID: P05619

Single-Phase Grounding Fault Line Selection Method Based on VMD and Multi-Fault Feature Fusion in 10kV Distribution Networks

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Abstract:
The reliable isolation of single-phase grounding faults is related to the safe and stable operation of the 10kV distribution network. And the identification of fault lines plays an important role in the entire protection system. However, the traditional fault line selection method has the problems of low accuracy and difficulty in selecting high-resistance grounding fault lines. In this paper, an improved grounding fault line selection method based on variational mode decomposition and multi-fault feature fusion is proposed. Firstly, the characteristics of the zero-sequence current of each line in single-phase grounding fault are analyzed. Then, the zero-sequence current signals are decomposed by variational mode decomposition, and the correlation coefficient, polarity, and energy entropy are extracted as three criteria. Finally, the fuzzy theory is applied to realize the fusion of three criteria, and the line with the largest fault measure is judged as the fault line. The simulation results show that the proposed method can be applied to accurately identify lines under various fault conditions, especially for high resistance grounding fault, and can be effectively used to traditional resonant grounding systems or hybrid grounding systems.

Keywords:
Fault line selection, grounding fault, variational mode decomposition, multiple fault characteristics, fuzzy theory

PAPER ID: P05620

Arc Extinction and Control Strategy for Hybrid Grounding System Considering Line Impedance and Load in Distribution Networks

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Abstract:
To improve the security and reliability of distribution networks when addressing single-phase ground faults, this paper presents a complete control strategy for hybrid grounding system (HGS). Firstly, the study begins by introducing the structure of HGS and conventional arc extinction principle. Considering the impact of line impedance and load, an improved arc extinction principle involving calculating accurate reference voltage of the inverter is further proposed. In addition, to achieve precise tracking of the reference voltage, a dual-loop control strategy is employed, with the addition of a lead correction stage to enhance the system stability. And a coordinated control strategy for HGS is proposed, which can deal with all types of single-phase ground faults by setting three-level thresholds for zero-sequence current. Finally, MATLAB simulation results verify the rationality and effectiveness of the proposed arc extinction method and control strategy for HGS.

Keywords:
hybrid grounding system, grounding fault, arc extinction, coordinated control

PAPER ID: P05621

Satellite-Terrestrial Data Fusion-based Geological Disaster Risk Prediction Method for Power Substations

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Abstract:
Power substations are often situated in remote regions vulnerable to geological disasters, requiring precise prediction of geological disaster risks to prevent severe and intolerable consequences caused by disaster-induced shutdowns. However, challenges arise from the incomplete collection and diversity of disaster impact factors, complicating accurate risk predictions. Accordingly, this paper proposes a satellite-terrestrial data fusion-based geological disaster risk prediction (SDFGDRP) method for accurately predicting potential power substation disasters. It integrates geological data from remote sensing satellites and ground sensors, utilizes a network transmission mechanism assisted by satellite internet, and employs the RF-KFIST risk prediction algorithm, combining Random Forest (RF), K-Means clustering, and Fuzzy Inference System Tree (FIST). The proposed SDFGDRP method ensures extensive coverage in geological feature collection and real-time prediction capabilities. Simulation results demonstrate that the method effectively consolidates multi-source data to precisely predict power substations geological disaster risks, offering reliable decision support for proactive engineering actions and adjustments in grid operational strategies.

Keywords:
Risk prediction, satellite internet, multi-source data fusion.

PAPER ID: P05622

Zero-Sequence Voltage Suppression and Fault Arc Extinction Considering Three-Phase Parameter Asymmetry for Hybrid Grounding System

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Abstract:
To address the challenge of low fault identification in low-resistance grounding system during single-phase high-resistance ground faults, a hybrid grounding system combining flexible device with low resistance is applied. In scenarios of three-phase parameter asymmetry, the zero-sequence voltage generated under normal operational conditions adversely affects fault detection in low-resistance grounding method. Moreover, traditional methods of current injection for arc extinguishing leave residual voltage, leading to incomplete fault clearance. Therefore, strategies for suppressing zero-sequence voltage due to three-phase parameter asymmetry and for extinguishing single-phase ground faults are introduced based on the hybrid grounding system. By injecting the appropriate current through an inverter, this approach not only ensures the rapidity of low-resistance grounding fault detection under normal conditions but also achieves complete arc extinction in the event of high-resistance grounding faults, thereby enhancing the power supply reliability of the distribution network. The simulation and HIL-based results validated the effectiveness of the proposed method.

Keywords:
Risk prediction, satellite internet, multi-source data fusion.

PAPER ID: P05623

A Novel Battery Temperature Prediction Method with High Adaptability

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Abstract:
The temperature change of the battery during operation is an important parameter to ensure the safe operation of the battery. Most battery failures are thermal runaway accidents due to high battery temperature, which can be avoided if the battery temperature can be monitored in real-time. In this paper, a joint VWF-VFFRLS and MSFUKF temperature prediction model is proposed to reduce the complexity of the model to estimate different battery temperatures. The proposed model is accurate, and reliable and requires only one parameter identification for the same battery model. The models were derived and then experimentally confirmed with commercial batteries of different aging conditions. The verification results show that the proposed method can well predict the temperature change of the battery. Under different SOH conditions, the maximum error RMSE of temperature prediction is only 0.449.

Keywords:
VWF-VFFRLS, MSFUKF, battery, temperature.

PAPER ID: P05624

Hybrid Current Balance Strategy for Multi-Phase Interleaved LLC Resonant Converter

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Abstract:
In interleaved LLC resonant converters system, the component parameter tolerance of the resonant tanks will lead to discrepancies in voltage gain, resulting in uneven current distribution among phases, making it difficult to achieve uniform power distribution. To address this problem, in this paper, based on the analysis for the difficulty of achieving current balance in multi-phase full-bridge LLC resonant converters alone with the switch-controlled capacitor, and the adverse effects of using phase shift modulation alone, a hybrid control method based on switch-controlled capacitor and phase shift modulation is proposed. The main idea is to initially increase the gains of light loaded phases with switch-controlled capacitor. And for gains with heavy loads, the phase shift modulation is used for suppressing gains to avoid control instability caused by the introduction of switch-controlled capacitor. The simulation and HIL-based results validate the correctness of the proposed method and analysis.

Keywords:
LLC resonant converter, current balance, switch- controlled capacitor, phase shift modulation

PAPER ID: P05626

An Optimization Method of Motor Topology Based on Analysis of Coefficient of Prognosis

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Abstract:
This paper presents a method for optimizing motor topology based on the analysis of the Coefficient of Prognosis (CoP). The CoP is evaluated by scanning the space of input variables and corresponding responses, i.e., the relevant dimensions of the motor topology, based on Latin Hypercube Sampling (LHS). The metamodel of the motor can be derived by establishing corresponding variable space for each approximate response model by the Moving Least Squares (MLS) approximation. Therefore the multi-objective optimization problem with constrains is conducted by using the approximate metamodel. By means of the analysis of the CoP, one can improve the sampling efficiency and minimize the the sampling point correlation, which makes process in optimization more reasonable.

Keywords:
Coefficient of Prognosis, finite element analysis, Latin Hypercube Sampling, Moving Least Squares

PAPER ID: P05630

Building Integrated Photovoltaic Thermal (BIPVT) technology and the results of MATLAB calculations of power generation in cold climate conditions

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Abstract:
This study introduces the fundamental properties and recent developments of building integrated photovoltaic thermal (BIPVT) technology, emphasizing its dual role in enhancing building aesthetics while serving as an electrical and heat energy provider. BIPVT holds significant promise economically and technologically, particularly in the pursuit of zero-emission buildings. The paper provides an overview of current BIPVT products, highlighting standardization efforts and lifetime assessment considerations. To assess the performance of BIPVT systems, the study conducts calculations incorporating thermal accessory systems, using measured data from Mongolia. Through comprehensive analysis and simulation, the research aim to deeply understand the potential and efficacy of BIPVT technology in addressing energy consumption challenges and advancing sustainable building practices. Based on our studies, BIPVT technology has the potential to supply 51.5% of the electrical and thermal energy needs for a rooftop BIPVT house in Ulaanbaatar, known as the coldest capital in the world.

Keywords:
Photovoltaic (PV), building integrated photovoltaic (BIPV), Photovoltaic thermal, cold climate

PAPER ID: P05631

A Multi-Agent Reinforcement Learning Based Approach for Frequency Regulation of Power System Penetrated with Dynamic RTEM and Microgrids

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Abstract:
Due to the widespread adoption of renewable energy sources (RES), power systems have become more complex and uncertain with increasing risk on traditional control methods. This paper proposes an advanced controller i.e., a multi-agent reinforcement learning (MARL) approach for frequency regulation of a RES-integrated power system considering dynamic real-time electricity market (RTEM) and microgrids. To support frequency regulation, the RTEM is dispatching energy every five minutes in addition to the contribution from conventional AGC systems. Further, to manage local disturbances, microgrids consisting of several distributed energy resources (DERs) contribute to the grid. Within microgrids, energy transactions are through peer-topeer trading. In addressing the MARL, a derivative agent known as a multi-agent Deep Deterministic Policy Gradient (DDPG) is formulated. Critical examination is conducted on the three-area following load and generation uncertainties. The results indicate that the proposed controller exhibits superior control performance.

Keywords:
Automatic Generation Control, Multi-Agent Reinforcement Learning, Real-Time Energy Market, Microgrid, P2P Trading.

PAPER ID: P05633

A Novel Levy-Flight Arithmetic Optimizer for Security Constrained Unit Commitment Problem in Renewable Hybrid Power System for Reliability

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Abstract:
The power system security has been extensively important in renewable hybrid energy system due to its various benefits. This research article introduced a new system for the integration of renewable power generation, conventional power generation, and plug-in electric vehicles for the fulfillment of the increasing power demand of the system. To fulfill this demand the integration of a renewable hybrid power system for security-constrained unit commitment problems with a novel levy-flight arithmetic optimizer has been used. The primary contribution of this paper lies in the application of the Levy-Flight Arithmetic Optimization algorithm (LFAOA) to solve SCUC problem. Results from testing on 10, 20, and 40-unit systems showcase a substantial reduction in operating costs. The percentage cost savings are 0.1363% and 0.076390% in comparison to the BAT and BAT-GA algorithms, respectively, using the LFAOA method. The best values for the 10, 20, and 40-unit systems configurations using LFAOA are $479,205.8, $529,223.7, and $2,155,661. The paper thoroughly investigates various parameters, including power demand, mean, standard deviation, peak value, scheduled units, convergence curve, and median. In the result section, a comparative analysis with the existing ones has been done and it is observed that the proposed system gives expected results.

Keywords:
Security Constraint Unit Commitment (SCUC), Levy-Flight Arithmetic Optimization Algorithm (LFAOA), Renewable Energy, Plug-in electric Vehicles (PEVs)

PAPER ID: P05634

Maximizing Wind Power Injection by Transmission Switching and DLR with Voltage Stability Constraints

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Abstract:
This paper proposes a maximum wind power injection (MVPI) problem under the engineering operation requirements of modern power systems and voltage stability constraints. To dig the access capacity of power grid for wind power, dynamic line rating (DLR) and optimal transmission switching (OTS) are jointly co-optimized to provide flexible operation of power systems. A novel DLR technique independent ambient parameter is proposed with the line parameter correction. The proposed problem is a mix-integer nonlinear programming problem that is hard to solve directly. Hence, a three-stage methodology is developed, which has been applied on the IEEE 24-bus RTS system, the IEEE 118-bus power system. The computational results show the effectiveness of the conducted model in maximizing the usage of wind power.

Keywords:
Maximizing wind power injection, DLR, voltage stability, transmission switching

PAPER ID: P05636

Frequency-Dependent Model and Improved Controller Design of an Axial Electromagnetic Bearing

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Abstract:

To Axial electromagnetc bearings (EMBs) are used to support high-speed rotors against axial forces. This paper develops a frequency dependent model for an axial EMB which is typically made up of solid core. The non-laminated structure results in significant eddy currents inside the core, which adversely affects the performance of axial EMB. In this paper, the 2D Finite Element (FE) analysis shows that there can be significant magnetic flux-density inside the core due to eddy currents, even when the air gap flux density is zero. The fluxlinkage gets attenuated and lags behind the control current at higher frequencies. The resulting reduction in the air-gap flux density reduces the force density and leads to an overall reduced axial force. A small-signal model is developed through current perturbation about the bias point using FE analysis. The control current and control force are no longer instantaneous. The reduction in control force and its phase lag from the control current are captured as a complex coefficient. This results in degraded stability margins of position control loop if the position controller design does not include the eddy effect. An improved controller is designed to consider the effect of eddy currents. The improved controller performance is shown as improved stability margins, fast rejection of step disturbance force and better rejection of sinusoidal disturbance force

Keywords:

Terms—Active magnetic bearing, axial electromagnetic bearing, eddy current effect, dynamic stiffness, thrust active magnetic bearings

PAPER ID: P05645

Carbon-Accounted Optimal Power Dispatch and Spot Pricing

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Abstract:
In this paper, the proposed carbon-accounted optimal power dispatch and spot pricing model is implemented using particle swarm optimization techniques and assessed on the IEEE 30-bus system. The proposed method assesses the impact of incorporating carbon emission costs into the optimal power dispatch problem and electricity spot pricing. Comprehensive models that account for carbon emissions under both single-side and double-side auction schemes are investigated. The results demonstrate that integrating carbon accounting into the dispatch and pricing mechanism can substantially reduce overall carbon emissions. Regarding consumer payments, decoupling carbon emission costs from spot prices results in higher total consumer costs than integrating the costs directly into electricity prices. Furthermore, the carbon-accounted double-sided auction framework effectively reduces carbon emissions and, meanwhile, improves the overall social welfare.

Keywords:
spot pricing, electricity markets, social welfare maximization, carbon pricing, optimal power dispatch

PAPER ID: P05654

Power Climbing Extremes Two Stage Forecast based on Auto Encoder and Bi-LSTM

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Abstract:
Power climb period is one of the periods with the largest error of renewable power forecast. The deviation in the forecast of the time and value of the start-end points will lead to a significant forecast error to the whole climbing process. Therefore, accurate power climbing forecast can effectively improve the renewable power forecast accuracy. In this paper, stacked denoising auto encoder (SDAE) is applied on encoding the meteorological features of the power climbing process. Then, the coded part is spliced with a classifier and fine-tuned, promote the output with clear category identity. Finally, the coding is fed into a bidirectional neural network to forecast the power at the start-end points. After testing, the proposed method in this paper demonstrated an improvement in the accuracy of extreme forecast of start-end points power by 4.94% in comparison to the climbing recognition method based on power forecast results.

Keywords:
self-encoding, power climbing, climbing forecast, renewable power forecast

PAPER ID: P05668

Space-Air-Ground Integrated Framework Augmented with Multimodal Information Fusion for Substation Fault Prediction

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Abstract:

Substations are a critical component of the power system, their safe and stable operation is essential for ensuring the reliability of the power supply. With the rapid advancement in the automation of substation systems and the extensive use of new information technologies, the equipment data mining inside and outside the substation is directly related to the reliability, stability and safety of the substation. In this paper, under the background of Satellite-Terrestrial fusion, based on the application architecture of sky-earth synergy, and based on the method of considering rare causes of failures, the accuracy of substation risk prediction is improved through the integration of multimodal data, and a substation risk prediction method under the Space-AirGround integrated framework is proposed to provide a synergistic, efficient and safe approach to substation monitoring and application in a wide spatial range by utilizing the multimodal data from satellites in different orbits, unmanned aerial vehicles (UAVs), and ground-based sensors and other equipments. The traditional form of the importance diagnostic criterion score calculation method is improved based on the distribution of rare elements in each fault characteristic, enabling the design of a different score calculation method for

rare elements from that for common elements, so that the influence of rare fault elements continues to be taken into account in the from rare variables. The validity of this paper's method to improve model predictions is demonstrated through a real-world substation simulation.

Keywords:
Space-Air-Ground integrated, fault prediction, multi-modal data fusion.

PAPER ID: P05707

Preventive Strategy against Cascading Failures Triggered by N-k Contingencies in Power Systems

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Abstract:
Cascading failures (CFs) in power grids are frequently initiated by multiple (N-k) contingencies during extreme weather conditions, leading to blackouts with enormous economic loss and adverse social impact. To this end, this paper proposes a novel preventive method against various severe CFs after exit of unexpected k components. Firstly, a screening method based on random chemistry algorithm is presented for minimal N-k induced cascading contingencies bringing out serious load loss. The preventive model is then proposed, where serious scenarios corresponding to various N-k induced cascading contingencies are transformed into constraints, to mitigate and eliminate potential CFs. Finally, the effectiveness of the proposed method is verified by numerical simulation on the IEEE 39-bus system.

Keywords:
cascading failure, N-k contingency, random chemistry algorithm, preventive strategy, power system

PAPER ID: P05736

Potential Assessment of Photovoltaic Power Generation in China Based on High Temporal Resolution Scale

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Abstract:

Photovoltaic (PV) power generation in China has experienced promising growth and will further become a significant sector of the power system in the near future. To further utilize the variable uncertain PV resources, the PV power generation resource assessment focusing on a high temporal resolution would greatly assist China in achieving its dramatic solar development goals. In this paper, the installed PV potential of every province in China is measured by the Energy Research Institute of the National Development and Reform Commission based on the radiation intensity and temperature data with a time step of 15 minutes. Thus the real-time PV power output of 31 provinces, along with the assessment results show that China's PV power potential is 4567.0 TWh/year, which is approximately equivalent to 60% of the total social electricity consumption in 2019; as for the spatial distribution, Inner Mongolia, Xinjiang, and Tibet possess the largest PV potential in China, with power generation potential of 1281.6 TWh/year, 576.0 TWh/year, and 394.3 TWh/year, respectively; there are large quarterly and monthly varieties in the availability of PV power generation in each province. There are large monthly and quarterly differences in the temporal availability of PV power generation in each province, with the difference between the highest availability month and the lowest availability month in every province generally being larger than 150%, and the PV output also fluctuates considerably during the day in different seasons in each province.

Keywords:

solar energy, PV power potential assessment, temporal availability, spatial availability, potential density

PAPER ID: P05741

A Simple Generator Reduction Method by Using a Power System Reproduction Model

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Abstract:
The increasing penetration of inverter-based power facilities has raised concerns about power system stability. Conventional simulation-based stability analysis methods become computationally expensive and time-consuming as the system size grows. To address this challenge, equivalent reduction models are employed to reduce the number of variables while preserving the dynamic response characteristics of the power system. This paper proposes a simplified reduction method that utilizes a power system reproduction model to aggregate generators and employs damping adjustment to minimize errors. The effectiveness of the proposed method is demonstrated by dynamically reducing 10 generators to 1 generator in a portion of a large-scale power system and comparing the pre- and post-reduction response
characteristics.

Keywords:
reduction, power system, stability, generator, simulation

PAPER ID: P05744

Control of a 3-Phase 12/8 Switched Reluctance Generator for Future Energy System Applications

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Abstract:
This paper presents implementation of a control system for a 3-phase 12/8 switched reluctance generator (SRG). The study has confirmed the potential of switched reluctance machines to be decent alternatives in renewable energy applications, energy storage systems and electrified transportation systems. Initially, a dynamic model of the SRG was created in MATLAB/Simulink environment to achieve useful preliminary results from computer simulation. Next, in hardware realization, the proposed system employed a standard asymmetric half-bridge (AHB) converter to generate a voltage of 200 V at the DC-link. Optimal turn-on and turn-off angles of phase current waveforms were used through commutation signals generated by a simple and inexpensive opto-interrupter rotor position sensor. There were two closed-loop controls involved in the system. The outer loop was for DC-link voltage control using PI controller while the inner loop was for phase current control using soft chopping hysteresis control technique. Finally, real-time control was implemented using an economical dsPIC30F4011 microcontroller. Experimental results have shown acceptable performance of the proposed SRG control system in various conditions, including normal operation, speed change and step reference voltage change. The DC-link voltage can be satisfactorily regulated when subjected to those conditions.

Keywords:
switched reluctance generator, switched reluctance machine, SRG control, renewable energy applications.

PAPER ID: P05773

Revolutionizing Quality Control of Boron in Rubberwood Industry by Using MATLAB Driven RGB Imaging

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Abstract:
This paper proposes a fast, convenient, and effective technique to detect the percentage of boric acid equivalent in rubberwood which may significantly reduce cost in wood industries when a conventional observing method requiring an expert is unnecessary. Color thresholds was constructed to identify digital images using MATLAB to process the RGB color ratio from boron testing performed on timber samples. Photographed boron treated timber samples was infiltrated with curcumin reagent then the RGB color ratio was calculated to show the percentage of boric acid equivalent. The G to R and B to G ratios were presented and the proposed algorithm was used for processing colors to determine the percentage of boric acid equivalent. The results showed that the algorithm is promising with high accuracy when the percentage of boric acid equivalent of real samples from the factory were detected with no error although color classification error to determine the percentage of boric acid equivalent using the G to R and B to G ratio algorithm is presented.

Keywords:
rubberwood, digital image processing, percent boric acid equivalent, boron detection

PAPER ID: P05774

Enhancing Energy Efficiency in Rubberwood Drying Kilns by Optimizing Air Velocity for Sustainable Production

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Abstract:

This study investigates the air velocity to enhance energy efficiency in the drying process of 75 mm thick rubberwood lumber under controlled laboratory-scale kiln drying conditions. Drying experiments were conducted at a constant dry-bulb temperature of 75°C and a wet-bulb temperature of 50°C, employing two distinct air velocities: 1 m/s and 3 m/s, consecutively. The drying process was maintained until a final wood moisture content of 10% was achieved. The analysis focuses on the impact of air velocity on the drying rate, duration, and overall energy consumption. From the findings, we propose a two-stage drying process for rubberwood drying. Starting with an initial phase with higher air velocity, this stage significantly accelerates the drying rate and then followed by the secondary stage, the air velocity will be diminished as the drying rate decreases. Notably, adjusting the air velocity from 3 m/s to 1 m/s when the moisture content falls below 40% resulted in a substantial 59% reduction in energy consumption, primarily by decreasing the speed of the induction three-phase motor. These insights underscore

the high potential for substantial energy savings through strategic air velocity adjustments during the critical phases of wood drying, contributing to more sustainable production practices in the rubberwood timber industry.

Keywords:
Rubberwood lumber, Rubberwood drying, Air velocity, Energy saving

PAPER ID: P05776

Real-Time Algorithm-Based Power Management for a PV/Battery/FC Standalone Microgrid

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Abstract:
The growing need for clean energy sources in power grids creates issues in effectively regulating fluctuations in power output which will disturb the system stability. The study involves a metaheuristic algorithm, namely the Horse Herd Algorithm (HOA), to maximize the distribution of power among the distributed energy sources. The optimization capabilities of the HOA along with a DNN based MPPT efficiently handle the challenges related to changing solar irradiation, battery state of charge (SOC), and shifting load needs. The effectiveness of the suggested PMS is analyzed using simulations. These simulations entail the comparison of DC bus voltage management with the conventional PMS techniques found in the literature. Moreover, the proposed technique with DNN-MPPT is validated by conducting real-time verification of the results using the OPAL-RT simulator. The DNN-MPPT-HOA-based PMS is highly effective in optimizing power sharing, leading to substantial improvements in microgrid efficiency, stability, and overall performance.

Keywords:
Microgrid, Optimization, Renewable energy

PAPER ID: P05779

Comparative Analysis of Electrification Technologies in Heavy-Duty Vehicles: A Case Study of Thailand

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Abstract:
This study presents a comprehensive evaluation of three potential electrification technologies for Heavy-Duty Vehicles (HDVs) in Thailand: charging, battery swapping, and hydrogen fuel cells. The research began by developing an energy consumption model for heavy-duty vehicles (HDVs) and their corresponding electrification stations. A scenario was then created using parameters associated with a commonly used HDV route in Thailand. The goal was to minimize the number of stations, ensuring that a charger would be available for any HDV upon reaching its destination. The simulation results reveal the energy consumption patterns of HDVs along this route, the scheduling for various types of HDVs, and a cost analysis highlighting both advantages and disadvantages.

Keywords:
battery electric trucks, battery swapping, fuel cell, charging infrastructure, total cost of ownership.

PAPER ID: P05851

High Precision Lightning Warning System Based on Combination of Electric Field Data and Magnetic Field Data

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Abstract:
The Development of a lightning warning system based on comparing the performance of lightning alerts from lightning detection devices from various sources. To develop a lightning alert system with the best alert performance based on the IEC62793 standard, lightning alert data collection was carried out using only electric field data. The use of network lightning data for notification only and the use of network lightning data and electric field data (M-field + E-field) are analysed and processed together. Therefore, the efficiency of lightning warning using networked lightning data and electric field data (M-Field + E-Field) combine to give good results with EAR values up to 95%. The FAR value is 0%.

Keywords:
Lightning warning system, electric field data, magnetic field data

PAPER ID: P05854

Environmental Impact Assessment of Lead-Acid and Lithium-ion Battery Waste Management in Thailand

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Abstract:
This study used material flow analysis and life cycle impact assessment to evaluate the waste management of lead-acid and lithium-ion batteries in Thailand in 2022. Four scenarios were designed, employing two methods: landfill and waste utilization. Landfilling lead-acid and lithium-ion battery waste showed significant negative environmental impacts. Lead recovery for lead-acid battery waste also had negative impacts due to slag generation. However, metal recovery of lithium-ion battery waste, which recovered lithium carbonate and cobalt carbonate, demonstrated positive environmental outcomes. When comparing the two methods, landfilling was preferable for lead-acid batteries, whereas metal recovery was better for lithium-ion batteries. These findings provide essential information for battery waste management guidelines in Thailand and indicate that future research should explore additional methods and their economic aspect.

Keywords:
lead-acid battery, lithium-ion battery, sustainability, waste management, landfill, life cycle assessment

PAPER ID: P05862

Optimization Study of Alumina Industrial Process Based on Multi-Objective Dynamic Demand Response and K-Medoids Clustering

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Abstract:

Industrial processes are prone to emitting large amounts of carbon dioxide, and electricity substitution is considered a strategic decision to promote the green and low- carbon transformation of energy sources, contributing to achieving "dual carbon" goals. However, practical issues such as unstable steam consumption, unreliable load assessment, and inaccurate selection of typical days are always encountered. Additionally, dynamic issues such as power uncertainty and volatility frequently arise when new energy sources are utilized as primary power supplies. Process optimization in the alumina industry model has been constructed to address these challenges based on multi-objective dynamic demand response and K- Medoids clustering. Firstly, to achieve the goal of green power supply, wind farms have been planned to supply power to the industrial process. A multi-objective demand response model has been developed for the electricity consumption of alumina production, and the model has been solved using the Normal Boundary Intersection (NBI) algorithm. Based on the multi- objective demand response model results, typical days for each of the four seasons have been selected using the K-Medoids clustering method. Subsequently, the time consumption of production processes and interval times have been analyzed for the selected typical days of the four seasons. Combining this analysis with

the daily electricity price fluctuations, an optimization plan for the alumina industry process has been proposed. This plan aims to achieve energy savings and emission reductions while minimizing costs and ensuring the plant's productivity meets expectations. Through case analysis, it has been demonstrated that using the NBI algorithm for optimized scheduling in alumina production can reduce the electricity cost per ton of alumina by 35% to 75%, with a maximum reduction of 9% in wind and solar curtailment rates

Keywords:
Process Optimization, Alumina Industry, Electricity Substitution, Multi-Objective Demand Response, K-Medoids Clustering

PAPER ID: P05863

Multi-Service Provision Oriented Data Center Job Scheduling Scheme

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Abstract:
With the development of artificial intelligence, data centers consume a considerable amount of energy and costs. Due to the unique characteristics of computing jobs, the data center can schedule jobs by adjusting execution times to gain temporal flexibility in energy consumption. Data centers can utilize the flexibility to actively participate in real-time energy markets, frequency regulation, and reserve markets. However, the different time scales of prices and targets pose challenges to the coordinated optimization of job scheduling strategies in data centers. In this paper, we establish a collaborative model for data center bidding in multiple markets and job scheduling to improve data center economic return. First, we model the data center job scheduling and participation in multiple markets bidding as Markov processes. Then, we build a multi-time scale optimization model based on hierarchical reinforcement learning to support multi-market bidding and job scheduling strategies of the data center. Next, we utilize the Deep Deterministic Policy Gradient and Double Deep Q-Network algorithms to derive the bidding and scheduling strategies. Finally, we validate the effectiveness of the model through numerical experiments and analysis.

Keywords:
Job scheduling, Participate in multi-market, Time-division multiplexing, Hierarchical reinforcement learning

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Online Job Scheduling for Energy Cost Optimization in Geo-Distributed Data Centers Considering Data Locality: A Multi-Agent Reinforcement Learning Approach

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Abstract:
With the rapid growth of cloud computing, geo-distributed data centers are becoming more energy-intensive. Given the unique characteristics of computing jobs, they can be executed across data centers in different geographic locations to better utilize lower electricity prices. However, data locality is a crucial factor to be considered in this process, as it is a precondition for the execution of jobs. In this paper, we propose a multi-agent deep reinforcement learning-based job scheduling algorithm that addresses constraints such as data locality and job deadlines to achieve real-time scheduling of jobs and data across data centers to optimize energy costs. First, we formulate the data locality-aware job scheduling problem across geo-distributed data centers as a Markov Decision Process (MDP). Then, we develop a multi-agent system where agents handle job scheduling and data transfer respectively. The job scheduling agent needs to consider data transfer conditions when taking actions, as the necessary data for job execution must be available before executing. These agents collaborate by sharing the reward function to optimize the scheduling strategy, reducing the overall energy costs of job execution and data transfer. Finally, we conduct numerical experiments to validate the effectiveness of our proposed scheduling method in reducing data center energy costs while maintaining high service quality.

Keywords:
Geo-distributed data centers, Power consumption, Reinforcement learning, Data locality, Job scheduling

PAPER ID: P05865

Temporal Forecasting for IT Power Demand of Data Center

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Abstract:
As the critical infrastructure in the digital era, data center sector is playing a more and more important role in power demand. Generally speaking, the power consumption of IT equipment, which is closely related to the computing task scheduling and resource management, composes a significant part of the overall energy consumption of data centers. Capturing its temporal pattern can benefit the understanding of data center power demand and enhancing its capability to be deployed as a demand side resource. Therefore, we investigate the temporal characteristics of IT power demand of data center and provide forecasting scheme. To improve the accuracy of IT power prediction, we first adopt an energy-centric approach to analyzing the impact of computing tasks and other environmental factors. By studying the relationship between IT power consumption and various factors, we observe that computing workloads and IT power demand exhibit similar periodicity. However, the latter demonstrates a certain degree of seasonal variation trend due to the influence of other environmental factors. Based on these findings, we present a novel Decomposition-TimesNet model for predicting IT power demand of data center. Our approach combines the modules of seasonal decomposition and pattern capturing within and outside variable cycles from TimesNet blocks and forms an end-to-end model. This integration enables us to overcome the inherent limitation of the original TimesNet model in accurately capturing trend variations. Experimental results using real-world datasets demonstrate our approach improves the accuracy of IT equipment power prediction across different time scales.

Keywords:
Data center, IT power demand, Load forecasting, Load modeling, Energy management

PAPER ID: P05866

Flexibility Quantification for Energy-aware Data Center Job Scheduling: A Chance Constrained Bi-Level Model

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Abstract:
Due to their fast-growing energy consumption and unique power flexibility, data centers are potential demand-side resources in power systems. A data center can flexibly adjust its power load by altering the scheduling of computing jobs. However, most existing flexibility quantification models oversimplify the job scheduling process or are scenario-specific. This paper proposes a chance-constrained bi-level model to quantify the power flexibility of job scheduling in data centers. The upper level model determines the lower limit of data center power in each time interval according to the given Service Level Agreement (SLA) constraints, while the lower level makes specific job scheduling decisions. We model the SLA requirements as chance constraints and reformulate them to ensure that the probability of job deadline violations does not exceed a certain value. Then, the power flexibility of data center job scheduling that ensures SLA requirements for a given computing job trace can be solved through iteration. Case studies validate the effectiveness of the proposed method.

Keywords:
Data center, Demand-side resource, Flexibility quantification, Job scheduling

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