1st Energy Informatics.Academy Conference Aisa

Technical program

Energy Informatics.Academy
The global community for energy informatics

SDC
The university partnership
Denmark – China

Table of Contents

Preface

The 1st Energy Informatics.Academy Conference Asia (EI.A Asia 2021) has collected great contributions from researchers and practitioners in various scientific, technological, engineering and social fields to disseminate original research on the application of digital technology and information management theory and practice to facilitate the global transition towards sustainable and resilient energy systems.

With the whole technical program committee's effort, in total twenty-five (25) high-quality papers (including full papers and poster papers) are accepted and will be presented at the conference.

With the SDC Sustainable Energy's sponsor, three best papers and one best presentation will be awarded at the conference. Furthermore, thanks again for SDC Sustainable Energy's sponsor for the publication for researchers from Danish universities and the Chinese Academy of Science (UCAS & CAS).

Sincerely,

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Jong-Bae Park, Konkuk University, South Korea
Gang Qu, University of Maryland, USA
Danda Rawat, Howard University, USA
Hamid Reza Shaker, University of Southern Denmark, Denmark
Athila Santos, University of Southern Denmark, Denmark
Bo Sheng, University of Massachusetts Boston, USA
Dong-Joon Shin, Hanyang University, South Kores, South Korea
Chuanwang Sun, Xiamen University, China

Program

Activity	Saturday 29 May 2021 Topic	Presenter	Central EU. Time Start	 End	Beijing Time Start	 End
Conference opening Dean of Sino-Danish College, Prof. Hong Zhao EI.A Asia 2021 co-chairs of Prof. Bo Nørregaard Jørgensen, Prof. Guangchao Chen, Dr. Birte Holst Jørgensen			8.30	9.00	14.30	15.00
Keynote speech	International research collaboration – a stepping stone for the green transition	Dr. Thomas Trøst Hansen	9.00	9.35	15.00	15.35
	Coffee break		9.35	9.40	15.35	15.40
Paper session **Energy systems**	A Scoping Review of Deep Neural Networks for Electric Load Forecasting	Nicolai Bo Vanting	9.40	10.40	15.40	16.40
	FlexChain - Blockchain-induced activation of small flexibility potentials in the low-voltage grid	Shari Alt				
	Advanced Voltage Control Method for Improving the Voltage Quality of Low-Voltage Distribution Networks with Photovoltaic Penetrations	Marika Nakamura				
	Coffee break		10.40	10.45	16.40	16.45
Keynote speech	Cybersecurity for the future power system	Prof. Ming Ni	10.45	11.20	16.45	17.20
Paper session **Energy policy and regulation**	How to Design a Dynamic Feed-in-Tariffs Mechanism with a Renewable Energy Target Capacity	Junqi Liu	11.20	12.20	17.20	18.20
	Evaluating the CO2 abatement effects of low-carbon city policy in China: A quasi-natural experiment	Mian Yang				
	Digitalisation Potentials in the Electricity Ecosystem: Lesson learnt from the Comparison between Germany and Denmark	Thorsten Hack				
	Lunch/dinner break		12.20	13.00	18.20	19.00
Keynote speech	Vehicle-to-grid and blockchain application	Dr. Ye Yang	13.00	13.35	19.00	19.35
Paper session **Energy communities**	Software toolchain to enhance the management and integration of a sustainable campus model	Athila Quaresma Santos	13.35	14.35	19.35	20.35
	Web-based platform for the management of citizen energy communities and their members	Helder Pereira				
	An Overview of Digitalization for the Building-to-Grid Ecosystem	Bo Nørregaard Jørgensen				
	Coffee break		14.35	14.40	20.35	20.40
Paper session **Electric Vehicles**	Joint Optimal Allocation of Electric Vehicle Charging Stations and Renewable Energy Sources Including CO2 Emissions	João Soares	14.40	16.00	20.40	22.00
	A generic agent-based framework for modeling business ecosystems: a case study of electric vehicle home charging	Magnus Værbak				
	Electric Vehicles as Distribution Grid Batteries:A Reality Check	Prasad Prakash Malya				
	Methodology for identifying technical details of Smart Energy Solutions and Research Gaps in Smart Grid: An Example of Electric Vehicles in the energy system	Kristoffer Christensen				

Sunday 30 May 2021			Central EU. Time		Beijing Time	
Activity	**Topic**	**Presenter**	Start	End	Start	End
Keynote speech	General, powerful, and scalable management of energy flexibility with FlexOffers	Prof. Torben Bach Pedersen	8.30	9.05	14.30	15.05
Paper session **Energy markets**	Local Energy Markets - An IT-architecture Design Industrial consumers' electricity market participation options: A case study of an industrial cooling process in Denmark Analysis and forecasting of crude oil price based on the variable selection-LSTM integrated model	Bent Richter Nicolas Fatras Quanying Lu	9.05	10.05	15.05	16.05
	Coffee break		10.05	10.10	16.05	16.10
Keynote speech	Application of Digital Twin technology in intelligent buildings	Prof. Xiaoyu Zhao	10.10	10.45	16.10	16.45
Paper session **Energy in buildings**	Climatization and Luminosity Optimization of Buildings Using Genetic Algorithm, Random Forest, and Regression Models A QR code based framework for auto-configuration of IoT sensor networks in buildings A Practical Data-Driven Condition Indicator for Room-Level Building Diagnostics A Digital Twin Framework for Improving Energy Efficiency and Occupant Comfort in Public and Commercial Buildings	Luis Gomes Simon Soele Madsen Hamid Reza Shaker Anders Clausen	10.45	12.05	16.45	18.05
	Lunch/dinner break		12.05	12.45	18.05	18.45
Keynote speech	The future directions of energy informatics	Prof. Rick Watson	12.45	13.20	18.45	19.20
Paper session **Energy in industry**	Greenhouse Industry 4.0 – Digital Twin Technology for Commercial Greenhouses A Multi-objective Optimization Platform for Artificial Lighting System in Commercial Greenhouses Agent Based Coordination Protocol for System of Cyber-Physical Systems	Daniel Anthony Howard Ying Qu Aisha Umair	13.20	14.20	19.20	20.20
Coffee break	Coffee break		14.20	14.25	20.20	20.25
Paper session **Energy systems**	Optimization of district heating production with thermal storage using mixed-integer nonlinear programming with a new initialization approach Fake Reference Approach: D-STATCOM Control Using Reinforcement Learning	Jakob Bjørnskov Jong Ha Woo	14.25	15.05	20.25	21.05
Best papers and presentation awards and closing			15.05	15.35	21.05	21.35

Keynote speakers

International research collaboration – a stepping stone for the green transition

Dr. Thomas Trøst Hansen
Innovation Center Denmark Shanghai, China

Science Attaché at the Innovation Centre Denmark Shanghai and consul for higher education and research at the Consulate General of Denmark. Previously, he has held various positions in the Danish Ministry of Higher Education and Science, where he has worked on research and innovation policy intended to underpin the green transition. He holds a PhD in Science Studies from the University of Aalborg and a MSc from the University of Copenhagen.
Innovation Center Denmark (ICDK) has 7 centers strategically located in innovative hotspots around the world. ICDK assists the Danish triple-helix model by promoting access to international knowledge, networks, innovation, capital and markets. Innovation Centre Denmark (ICDK) in Shanghai supports Danish companies and higher education institutions in exploring opportunities to expand or establish activities in China.

Cybersecurity for the future power system

Prof. Ming Ni 倪明
NARI Technology Inc
国电南瑞科技股份有限公司

Chief Expert of Power System Planning and Analysis in NARI Technology Inc, and Special Expert of State Grid Corporation of China. He is a professional engineer of State Ohio. His research interests are: power system security and stability analysis and control, power system planning, power market, cyber physical power system, etc.

Vehicle-to-grid and blockchain application

Dr. Ye Yang 杨烨
State Grid Electric Vehicle Charging Service Corporation
国网电动汽车服务有限公司

Senior power system R&D Engineer of State Grid Electric Vehicle Service Co., Ltd. His research interests include grid vehicle integration, renewable energy integration, smart grid control, and applying AI, block-chain technologies in power systems, etc.

General, powerful, and scalable management of energy flexibility with FlexOffers

Prof. Torben Bach Pedersen
Aalborg University, Denmark

Full professor of computer science at Aalborg University, Denmark, and co-founder of FlexShape, focusing on Big Data Analytics with applications in digitalization of the energy sector. He has published more than 300 peer-reviewed papers which received more than 7100 citations on Google Scholar, yielding an h-index of 48. He serves on the PCs of the top conferences in (big) data management (SIGMOD, PVLDB, ICDE, CIKM, and EDBT) and digital energy (ACM e-Energy). He is an ACM Distinguished Scientist, a Senior Member of the IEEE, and Member of the Danish Academy of Technical Sciences.

He received the Best Paper Award at ACM e-Energy in 2017 and an Honorary Doctorate from TU Dresden in 2020 for his work on managing energy flexibility using FlexOffers, which are used in more than a dozen International and national research projects with more than a thousand prosumers and 7+ commercial products.

Smart buildings and energy efficiency

Prof. Xiaoyu Zhao 赵晓宇
Tongfang Technovator International Limited Corp
同方智慧城市研究院

Vice Chief Engineer of Tongfang Technovator International （Beijing） Limited Corporation. She is a professional engineer and chief editor of the standards of building automation system and intelligent building systems. Her research interests are: automatic control of HVAC system, building automation system, building energy saving, etc.

The Origins of Energy Informatics & Future Directions

Prof. Rick Watson
University of Georgia

Rick Watson is a Regents Professor and the J. Rex Fuqua Distinguished Chair for Internet Strategy in the Terry College of Business at the University of Georgia. He is a former President of the Association for Information Systems. In 2011, he received the Association for Information Systems' LEO award, which is given for exceptional lifetime achievement in Information Systems. The University of Liechtenstein has established with government support a Consortium for Digital Capital Creation based on the ideas in his recent book, Capital, Systems, and Objects. For about a decade, he was Research Director for the Advanced Practices Council of the Society of Information Management and a visiting researcher at the Research Institute of Sweden (RISE) in Gothenburg.

Paper themes

Theme	Paper title
Energy systems	A Scoping Review of Deep Neural Networks for Electric Load Forecasting FlexChain - Blockchain-induced activation of small flexibility potentials in the low-voltage grid Advanced Voltage Control Method for Improving the Voltage Quality of Low-Voltage Distribution Networks with Photovoltaic Penetrations Optimization of district heating production with thermal storage using mixed-integer nonlinear programming with a new initialization approach Fake Reference Approach: D-STATCOM Control Using Reinforcement Learning
Energy in buildings	Climatization and Luminosity Optimization of Buildings Using Genetic Algorithm, Random Forest, and Regression Models A QR code based framework for auto-configuration of IoT sensor networks in buildings A Practical Data-Driven Condition Indicator for Room-Level Building Diagnostics A Digital Twin Framework for Improving Energy Efficiency and Occupant Comfort in Public and Commercial Buildings
Energy communities	Software toolchain to enhance the management and integration of a sustainable campus model Web-based platform for the management of citizen energy communities and their members An Overview of Digitalization for the Building-to-Grid Ecosystem
Electric Vehicles	Joint Optimal Allocation of Electric Vehicle Charging Stations and Renewable Energy Sources Including CO_2 Emissions A generic agent-based framework for modeling business ecosystems: a case study of electric vehicle home charging Electric Vehicles as Distribution Grid Batteries: A Reality Check Methodology for identifying technical details of Smart Energy Solutions and Research Gaps in Smart Grid: An Example of Electric Vehicles in the energy system
Energy in industry	Greenhouse Industry 4.0 – Digital Twin Technology for Commercial Greenhouses A Multi-objective Optimization Platform for Artificial Lighting System in Commercial Greenhouses Agent Based Coordination Protocol for System of Cyber-Physical Systems
Energy markets	Local Energy Markets - An IT-architecture Design Industrial consumers' electricity market participation options: A case study of an industrial cooling process in Denmark Analysis and forecasting of crude oil price based on the variable selection-LSTM integrated model
Energy policy & regulation	How to Design a Dynamic Feed-in-Tariffs Mechanism with a Renewable Energy Target Capacity Evaluating the CO2 abatement effects of low-carbon city policy in China: A quasi-natural experiment Digitalisation Potentials in the Electricity Ecosystem: Lesson learnt from the Comparison between Germany and Denmark

Paper abstracts

Note: the order of the paper abstracts follows the paper theme.

A Scoping Review of Deep Neural Networks for Electric Load Forecasting

Authors: Nicolai Bo Vanting[1], Zheng Ma[2], Bo Nørregaard Jørgensen[2]
Affiliations: [1]Department of Mathematics and Computer Science, University of Southern Denmark, Denmark
[2]The Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Denmark

Abstract: The increasing dependency on electricity and demand for renewable energy sources means that distributed system operators face new challenges in their grid. Accurate forecasts of electric load can solve these challenges. In recent years deep neural networks have become increasingly popular in research, and researchers have carried out many experiments to create the most accurate deep learning models. Players in the energy sector can exploit the increasing amount of energy-related data collected from smart meters to improve the grid's operating quality. This review investigates state-of-the-art methodologies relating to energy load forecasting using deep neural networks. A thorough literature search is conducted, which outlines and analyses essential aspects regarding deep learning load forecasts in the energy domain. The literature suggests two main perspectives: demand-side management and grid control on the supply side. Each perspective has multiple applications with its challenges to achieve accurate forecasts; households, buildings, and grids. This paper recommends using a hybrid deep learning multivariate model consisting of a convolutional and recurrent neural network based on the scoping review. The suggested input variables should be historical consumption, weather, and day features. Combining the convolutional and recurrent networks ensures that the model learns as many repeating patterns and features in the data as possible.

Presenter: Nicolai Bo Vanting is an MSc Data Science student at the University of Southern Denmark currently writing his thesis on load forecasting using deep neural networks. While studying, he works as a Data Scientist at Center Denmark. This non-profit company supports the danish energy sector with data-driven solutions and infrastructure to accelerate the green transition and energy flexibility. Furthermore, he holds a BA in Business, Language, and Culture at the University of Southern Denmark.

FlexChain - Blockchain-induced activation of small flexibility potentials in the low-voltage grid

Authors: Sassan Torabi-Goudarzi; Shari Alt; Dr. Dirk Werth
Affiliations: August-Wilhelm Scheer Institut, Germany

Abstract: The activation of flexibility potentials and using them for stabilizing the power grid is a crucial component to overcome the challenges of the energy transition. Flexibility potentials are not only provided by centralized, large-scaled traditional power plants but also by private households. The increasing availability of electric-powered vehicles, photovoltaic systems, and energy storage systems in private households make such flexibilities even more available and increases the importance of private households. The role of households, therefore, changes from pure consumers to consumers and producers of electric power. These households are called prosumers. The activation of small prosumer flexibilities can thereby make a decisive contribution to the systematic stabilization of local power grids. FlexChain research project goals are developing an easy-to-use, decentralized efficient trading platform and generating incentives for private households to provide their prosumer flexibility to stabilize their local power grid.

Presenter: Shari Alt is Digitization Associate at the August-Wilhelm Scheer Institute, a private research institution. Her research focuses on smart energy, sustainability and green technologies. She is currently actively involved in the role of project manager in the FlexChain research project, which aims to intelligently activate prosumers to stabilize the low-voltage grid. Ms. Alt holds a master´s degree in industrial engineering.

Advanced Voltage Control Method for Improving the Voltage Quality of Low-Voltage Distribution Networks with Photovoltaic Penetrations

Authors Marika Nakamura[1], Shinya Yoshizawa[2], Hideo Ishii[2], Yasuhiro Hayashi[1]
Affiliations
[1] Department of Electrical Engineering and Bioscience, Waseda University, Japan
[2] Advanced Collaborative Research Organization for Smart Society, Waseda University, Japan

Abstract: As the number of photovoltaic (PV) power generators connected to the distribution grid increases, applications of on-load tap changers (OLTCs), power conditioning systems, and static reactive power compensators are being considered to mitigate the problem of voltage violation in low voltage distribution systems. The reactive power control by power conditioning systems and static reactive power compensators can mitigate steep voltage fluctuations. However, it creates losses in generation opportunities. On the other hand, OLTCs are installed at the bases of distribution lines and can collectively manage the entire system. However, the conventional voltage control method, i.e., the line drop compensation (LDC) method, is not designed for the case in which a large number of PV systems are installed in the distribution network, which results in voltage violations above the limit of the acceptable range. This study proposes a method to determine the optimal LDC control parameters of the voltage regulator, considering the power factor of PV systems to minimize the magnitude of voltage violations based on the voltage profile analysis of low-voltage (LV) distribution networks. Specifically, during a measurement period of several days, the voltages at some LV consumers and pole transformers were measured, and the optimal parameters were determined by analyzing the collected data. The effectiveness of the proposed method was verified through a numerical simulation study using the actual distribution system model under several scenarios of PV penetration rates. Additionally, the difference in the effectiveness of voltage violation reduction was verified in the case where all the LV consumer's consumer voltage data measured per minute were used as well as in the case where only the maximum and minimum values of the data within the measurement period were used. The results reveal that the proposed method, which operates within the parameters determined by the voltage analysis of the LV distribution network, is superior to the conventional method. Furthermore, it was found that even if only the maximum and minimum values of the measurement data were used, an effective voltage violation reduction could be expected.

Presenter: Marika Nakamura received the B.E. degree from the Department of Electrical Engineering and Bioscience, Waseda University, Tokyo, Japan, in 2020, where she is currently working toward the M.E. degree at the Department of Electrical Engineering and Bioscience. Her current research interests include voltage control in distribution systems

Optimization of district heating production with thermal storage using mixed-integer nonlinear programming with a new initialization approach

Authors: Jakob Bjørnskov, Lasse Kappel Mortensen, Konstantin Filonenko, Hamid Reza Shaker, Muhyiddine Jradi, Christian Veje
Affiliations: Center for Energy Informatics, University of Southern Denmark, Denmark

Abstract: Non-convex scheduling of energy production allows for more complex models that better describe the physical nature of the energy production system. Solutions to non-convex optimization problems can only be guaranteed to be local optima. For this reason, there is a need for methodologies that consistently provide low-cost solutions to the non-convex optimal scheduling problem. In this study, a novel Monte Carlo Tree Search initialization method for branch and bound solvers is proposed for the production planning of a combined heat and power unit with thermal heat storage in a district heating system. The optimization problem is formulated as a non-convex mixed-integer program, which is incorporated in a sliding time window framework. Here, the proposed initialization method offers lower-cost production planning compared to random initialization for larger time windows. For the test case, the proposed method lowers the yearly operational cost by more than 2,000,000 DKK per year. The method is one step in the direction of more reliable non-convex optimization that allows for more complex models of energy systems.

Presenter: Jakob Bjørnskov is a Ph.d.-student at Center for Energy Informatics, University of Southern Denmark. His research focuses on data-driven energy modeling of buildings to identify and utilize demand-side flexibility.

Fake Reference Approach: D-STATCOM Control Using Reinforcement Learning

Authors Jong Ha Woo, Chaewoon Park, Jae Hyung Roh, Jong-Bae Park
Affiliations Dept. of Electrical and Electronics Engineering, Konkuk University, South Korea

Abstract: The increased use of intermittent renewable source in large power system, and more harmonics infused into distribution system; both prompt high distortion level in the power system. This paper analyzes electric power quality by applying D-STATCOM, one of the Flexible AC Transmission System (FACTS) devices, into 4.16kV distribution system. The new control method, named 'fake reference approach', coordinates with reinforcement learning; especially, Deep Deterministic Policy Gradient (DDPG) algorithm. The action vector from the reinforcement learning creates a new fake reference applying to the voltage control. The real time simulations confirm that the system voltage is more stable with D-STATCOM. As a final outcome, the proposed model is compared with the conventional control method.

Presenter: Jong Ha Woo
Current job title: Master's degree in electrical engineering, Konkuk University, Seoul, South Korea
Hometown: Seoul, South Korea
Research Interests: Reinforcement learning, Smart grid, and power system operation.

Climatization and Luminosity Optimization of Buildings Using Genetic Algorithm, Random Forest, and Regression Models

Authors Affiliations
Bruno Mota [1,2], Miguel Albergaria [1], Helder Pereira [1,2], José Silva [1], Luis Gomes [1,2], Zita Vale [1], Carlos Ramos [1,2]
[1] Institute of Engineering - Polytechnic of Porto, Portugal
[2] GECAD – Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development, Portugal

Abstract: With the rise in popularity of artificial intelligence, coupled with the growing concern over the environment, there has been a surge in the use of intelligent energy management systems. Additionally, as more buildings transition into the smart grid and, consequently, more energy and environmental data is gathered, there has been a significant increase in the number of data-driven approaches for building management systems. This paper proposes a methodology that aims to optimize the climatization and luminosity inside a building, using a genetic algorithm, a random forest, and two polynomial models. The proposed methodology enables the real-time management of the building taking into account the user needs and preferences. Air conditioner units and light systems are optimized to minimize energy costs, while also improving the air quality and considering the users' temperature and luminosity preferences. This paper shows the results achieved, by the proposed solution, in an office building case study. The promising results demonstrate the possibility of minimizing energy costs while maximizing the users' comfort.

Presenter: Luis Gomes got his PhD in 2020 in Computer Engineering at the University of Salamanca, Spain. He has two MSc degrees, one in multimedia from the University of Porto (2020) and one in computer engineering from the Engineering School of Polytechnic Institute of Porto (2013). He has published more than 60 papers, 16 of each in international journals and book chapters. He has been working and involved in more than 14 national and international R&D projects. His main skills are related to the application of Optimization and Artificial Intelligence Techniques to Power Systems.

A QR code based framework for auto-configuration of IoT sensor networks in buildings

Authors Simon Soele Madsen, Athila Quaresma Santos and Bo Nørregaard Jørgensen
Affiliations
Center for Energy Informatics, University of Southern Denmark, Denmark.

Abstract: Worldwide buildings are responsible for about 40% of the overall consumption and contribute to an average of 30% percent of the global carbon emissions. Nevertheless, most current buildings lack efficient energy management systems because such solutions are very expensive, especially when necessary instrumentation needs to be installed after the building's construction. As an alternative, we purpose the use of IoT sensor networks to retrofit existing medium and large-sized buildings to provide energy management capabilities in a cost-effective way. An IoT network auto-configuration platform for building energy management was developed. In order to efficiently manage metadata related to location and devices, a database using dynamic QR codes was created. Furthermore, we discuss the potential and shortcomings of different sensor-gateway pairing strategies that are applicable to an auto-configuring system. Lastly, we share our implementation of these concepts and demonstrate their use in a medium-sized building case study. The results show a trade-off between optimal configuration and total configuration time with a focus on the quality of the communication signal strength. The proposal provided the necessary automation for a cost-effective energy management system that can be deployed in both new constructions and existing buildings.

Presenter: Simon Soele Madsen is a Student Developer at the Center for Energy Informatics, Maersk Mc-Kinney Møller Institute, University of Southern Denmark (SDU), Denmark. Simon Soele Madsen is an inquisitive full-stack and app developer assisting in the exploration of automating IoT. The concept of controlling embedded devices is fascinating. He is finishing his bachelor's degree in software Engineering this summer with the thesis titled "Large-scale Deployment and Maintenance of IoT Sensor Networks", which overlaps with the presented paper. Other than being a Student and Student Developer he tutors young aspiring engineers in the discipline of Database Management and develops a cross platform app at a startup company.

A Practical Data-Driven Condition Indicator for Room-Level Building Diagnostics

Authors Hamid Reza Shaker, Athila Quaresma Santos, Bo Nørregaard Jørgensen
Affiliations Center for Energy Informatics, University of Southern Denmark, Denmark

Abstract: Faults and anomalies in buildings are among the main causes of occupant discomforts or energy inefficiencies. Therefore, early fault and anomaly detection are important for improving buildings operation. A statistical process monitoring measure for room-level condition monitoring of the building is proposed in this paper. The proposed measure uses multivariate statistics to detect faults and anomalies and therefore helps to improve the performance of the smart buildings. This method firstly employs principal component analysis for dimensionality reduction. After the projection of the observations into a principal component subspace, the method uses Hotelling's T squared statistics to detect deviations in the principal component subspace. The approach has been tested on the real building which is located in Odense, Denmark and the results are presented. The results have shown that the method could detect faults and anomalies successfully without requiring sophisticated and computationally expensive training. The method is scalable, adjustable, and implementation-wise simple. Therefore, it is potentially suitable for wide adoption in practice.

Presenter: Hamid Reza Shaker received a Ph.D. degree from Aalborg University, Denmark, in 2010. He was a Visiting Researcher at MIT, a Post-Doctoral Researcher, and an Assistant Professor at Aalborg University from 2009 to 2013, and an Associate Professor at the Norwegian University of Science and Technology, Norway, from 2013 to 2014. He is currently an Associate Professor at the Center for Energy Informatics, University of Southern Denmark. He is a senior member of IEEE. His research interests are Fault detection and diagnosis, Prognostics, Proactive and Predictive Maintenance within Energy Technology.

A Digital Twin Framework for Improving Energy Efficiency and Occupant Comfort in Public and Commercial Buildings

Authors Anders Clausen, Krzysztof Arendt, Aslak Johansen, Fisayo Sangogboye, Mikkel Baun Kjærgaard, Christian T. Veje and Bo Nørregaard Jørgensen
Affiliations Center for Energy Informatics, University of Southern Denmark, Denmark

Abstract: Model Predictive Control (MPC) can be used in the context of building automation to improve energy efficiency and occupant comfort.
Ideally, the MPC algorithm should consider current- and planned usage of the controlled environment along with initial state and weather forecast to plan for optimal comfort and energy efficiency.
This implies the need for an MPC application which 1) considers multiple objectives, 2) can draw on multiple data sources, and 3) provides an approach to effectively integrate against heterogeneous building automation systems to make the approach reusable across different installations.
To this end, this paper presents a design and implementation of a framework for digital twins for buildings in which the controlled environments are represented as digital entities. In this framework, digital twins constitute parametrized models which are integrated into a generic control algorithm that uses data on weather forecasts, current- and planned occupancy as well as the current state of the controlled environment to perform MPC. This data is accessed through a generic data layer to enable uniform data access. This enables the framework to switch seamlessly between simulation and real-life applications and reduces the barrier towards reusing the application in a different control environment.
We demonstrate an application of the digital twin framework on a case study at the University of Southern Denmark where a digital twin has been used to control heating and ventilation.
From the case study, we observe that we can switch from rule-based control to model predictive control with no immediate adverse effects towards comfort or energy consumption. We also identify the potential for an increase in energy efficiency, as well as introduce the possibility of planning energy consumption against local electricity production or market conditions, while maintaining occupant comfort.

Presenter: Anders Clausen, PhD, is an Assistant Professor at the Center for Energy Informatics at the University of Southern Denmark. He does research in the software aspects of grid integration, energy efficiency, demand response through utilization of demand-side resources and aggregation of distributed energy resources in virtual power plants. The technical aspects of his research involves genetic algorithms, neural networks as well as software- and system architecture.

Software toolchain to enhance the management and integration of a sustainable campus model

Authors Affiliations

Luiz C.P. da Silva[1], Paulo C.M. Meira[1], João G.I. Cypriano[1], Hader A.D. Azzini[1] and Athila Q. Santos[2]

[1]University of Campinas, Brazil.

[2]Center for Energy Informatics, University of Southern Denmark, Denmark.

Abstract: The aim of this article is to describe a novel ICT-centred methodology and software toolchain to enhance the management of a Smart Campus. The project will be implemented at the University of Campinas through a partnership between UNICAMP, CPFL (local Utility Distribution Company) and the University of Southern Denmark. This project was recently submitted to a strategic and priority call from the Brazilian Regulatory Agency (National Electric Energy Agency – ANEEL, acronym in Portuguese). The project integrates energy efficiency with research and development in distributed generation with an innovative IoT-based DMS energy management tool. These actions comply with the ISCN/GULF Sustainable Campus Chapter policies, signed by UNICAMP a few years ago. This paper is important because it will result in a replicable model for sustainable campuses, with a detailed step-by-step procedure covering local mini-grid EMS, IoT DMS, Mobility, real-time retrofitted efficiency and institutional energy governance.

Presenter: Athila Quaresma Santos is an Assistant Professor at the Center for Energy Informatics, Maersk Mc-Kinney Møller Institute, University of Southern Denmark (SDU), Denmark. Athila Santos is an IoT and a Smart Grids enthusiast. His area of expertise area: (1) Technology development for electric grid applications with focus on Microgrids; and (2) Large-scale deployment of IoT solutions on the building sector. Before joining SDU, Athila finished his PhD in the Electrical Engineering field, researching Information and Communication Technologies (ICT) applied to transmission systems.

Web-based platform for the management of citizen energy communities and their members

Authors Helder Pereira [1,2], Luis Gomes [1,2], Pedro Faria [1,2], Zita Vale [2], Carlos Coelho [1,2]
Affiliations
[1] GECAD – Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development, Portugal
[2] Institute of Engineering - Polytechnic of Porto, Portugal

Abstract: The appearance of citizen energy communities demands the conception, development, and testing of new management models for the community and its end-users. Citizen energy communities promote the active participation of end-users, including them in the management of the community. End-users are incentivized to participate in demand response programs and share their energy among peers, enabling a decrease in their energy costs. In this paper, it is proposed a platform for the management of citizen energy communities. The paper focuses and presents four services related to energy tariffs, end-users' aggregation, price elasticity, and load response. The services are based on historical data and enable deep analysis of end-users' energy profiles. As the platform allows the upload of different scenarios, it is possible to test and validate management models in multiple energy communities and scenarios and study their impact in different conditions. The paper presents a case study, where all the services are applied to a community with 996 end-users.

Presenter: Helder Pereira is graduated in Computer Engineering and is currently a student in the Polytechnic of Porto, in the Masters of Artificial Intelligence Engineering. Besides that, he currently has a research scholarship in GECAD, an innovation and research group affiliated with the Polytechnic of Porto. His research till today focuses on integrating artificial intelligence algorithms and models, more specifically machine learning, decision support and optimization, into energy systems, but his interests relate to the whole artificial intelligence areas and their possible applications.

An Overview of Digitalization for the Building-to-Grid Ecosystem

Authors Zheng Ma[1], Anders Clausen[1], Yun Lin[2], Bo Nørregaard Jørgensen[1]
Affiliations [1]The Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Denmark
[2]College of Information and Communication Engineering, Harbin Engineering University, China

Abstract: Digitalization is playing an important role in the emerging practice of Building-to-Grid (B2G). However, the majority of the literature only covers either the grid side, the demand side, or the technical aspect of B2G integration, and an overview of the digitalization in B2G and the involved stakeholders is missing. To fill these gaps, this paper proposes a definition of the B2G ecosystem and provides an overview of the digitalization of the B2G ecosystem with six aspects (B2G goals and themes, B2G technologies, B2G data sources and data management, and B2G related stakeholders). This paper also discusses five emerging technologies (5G, IoT, big data, artificial intelligence, and blockchain) and three main challenges of the applications of the emerging technologies in the B2G ecosystem (Security and privacy, interoperability and scalability, coordination, and dysfunctional emerging behaviors of collective intelligent controls). Lastly, this paper recommends future research directions in the Building-to-Grid ecosystem (especially ecosystem modeling and simulation), B2G's role in smart cities, sustainability, resilience, and harmonization of the B2G ecosystem, and other emerging technologies in B2G.

Presenter: Professor, Dr. Bo Nørregaard Jørgensen is founder and head of Center for Energy Informatics at the University of Southern Denmark. Center for Energy Informatics is an interdisciplinary research center focusing on digital solutions for facilitating the transition towards a sustainable energy system. The center's research is conducted in close collaboration with industrial partners, public bodies, and government agencies. As head of center, Dr. Jørgensen represent University of Denmark at national and international events, in advisory boards and government reference committees. He is appointed member of the Danish Academy of Technical Science. Dr. Jørgensen research focuses on digital solutions for integration of the demand-side with the supply-side in the energy sector, from the technology and business perspectives. He holds a Ph.D. in Computer Science from the University of Southern Denmark, a M.Sc. and a B.Sc. in Computer System Engineering from Odense University, Denmark.

Joint Optimal Allocation of Electric Vehicle Charging Stations and Renewable Energy Sources Including CO_2 Emissions

Authors Affiliations
Tayenne Dias de Lima[1], John F. Franco[2], Fernando Lezama[3], João Soares[3], Zita Vale[4]

[1]Dep. of Electrical Engineering, São Paulo State University, Brazil
[2]School of Energy Engineering, São Paulo State University, Brazil
[3]GECAD, Polytechnic of Porto, Portugal
[4]Polytechnic of Porto, Portugal

Abstract: Several transformations in the transport sector are expected in the coming years, associated with the increase in electric vehicles (EVs). These changes directly impact electrical distribution systems (EDSs), introducing new challenges in their planning and operation. One way to assist in integrating this technology is to allocate EV charging stations (EVCSs). Efforts have been made towards the development of EVCSs, with the ability to recharge the vehicle at a similar time as conventional vehicle filling stations. Besides, EVs can bring environmental benefits by reducing greenhouse gas emissions. However, depending on the energy matrix of the country in which the EVs fleet circulates, there may be indirect emissions of polluting gases. Therefore, the development of this technology must be combined with the growth of renewable generation. Thus, this proposal aims to develop a mathematical model that includes EVs integration in the distribution system. To this end, a mixed-integer linear programming (MILP) model is proposed to solve the allocation problem of EVCSs including renewable energy sources. The model addresses the environmental impact and uncertainties associated with demand (conventional and EVs) and renewable generation. Moreover, an EV charging forecast method is proposed, subject to the uncertainties related to the driver's behavior, the energy required by these vehicles, and the state of charge of the EVs. The proposed model was implemented in the AMPL modelling language and solved via the commercial solver CPLEX. Tests with a 24-node system allow evaluating the proposed method application.

Presenter: João Soares has a BSc in computer science and a master in Electrical Engineering in Portugal, namely Polytechnic of Porto. He attained his PhD degree in Electrical and Computer Engineering at UTAD university. He is a researcher at GECAD – Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development. His research interests include optimization in power and energy systems, including heuristic, hybrid and classical optimization. He is currently the co-chair of IEEE Task Force 3 – Computational Intelligence in the Energy Domain.

A generic agent-based framework for modeling business ecosystems: a case study of electric vehicle home charging

Authors Magnus Værbak[1], Zheng Ma[2], Yves Demazeau[3], Bo N. Jørgensen[1]
Affiliations [1]Center for Energy Informatics, University of Southern Denmark, Denmark
[2]Center for Health Informatics and Technology, University of Southern Denmark, Denmark
[3]Laboratoire d'Informatique de Grenoble, CNRS, France

Abstract: Modeling and simulation have been popularly used for system investigation and evaluation. With proper evaluation, distribution system operators can decide on a reasonable course of action for encouraging energy flexibility and make predictions on the recommended timing and magnitude of system updates under different scenarios. However, there is no efficient tool for system operators to quickly set up and perform simulations of alternative scenarios for system updates before planning their course of action, without much experience with programming or system modeling. This paper proposes an agent-based modeling framework for developing agent-based simulation models of business ecosystems that can be applied to multiple evaluation scenarios by simple configuration of agents and roles. There are two steps in this proposed framework: Step 1 – Interface and role interactions design and Step 2 – Agent architecture and connections design. In addition, the framework depends on a pre-step that covers mapping and architecture development of the business ecosystem to be modeled. The framework is demonstrated with a case study of an energy business ecosystem consisting of an electricity distribution grid with 137 connected domestic consumers. The case study shows that the proposed agent-based modeling framework supports the development of agent-based models for simulating energy business ecosystems. To verify the behavior of the developed agent-based simulation models, a verification procedure of the agent models is briefly discussed, which includes unit, integration, and system testing approaches similar to the ones used in software testing.

Presenter: Magnus Værbak is a Ph.D. fellow at Center for Energy Informatics at the University of Southern Denmark (SDU). He has a background in energy technology engineering, having attained experience in analysis and planning of energy systems in the transition towards a smarter and greener energy sector. Building further upon this knowledge, his Ph.D. research concerns development of agent-based simulation frameworks for investigating and evaluating the impact from future distributed energy resources in the electricity sector.

Electric Vehicles as Distribution Grid Batteries: A Reality Check

Authors Affiliations
Prasad Prakash Malya[1], Laura Fiorini[2], Mohammadhadi Rouhani[3] , Marco Aiello[1]
[1]Department of Service Computing IAAS, University of Stuttgart, Germany.
[2]Bernoulli Institute, University of Groningen, The Netherlands.
[3]University of Alberta, Canada.

Abstract: The current transition towards electric mobility implies that a significant portion of electricity is drawn by and stored in the electric vehicle's (EV) batteries. Vehicle-to-grid (V2G) technologies can potentially give distribution system operators access to such energy to provide ancillary services, while remunerating the vehicle owners for their availability to participate. Although the benefits of stabilization and grid efficiency improvements are clear, is it appealing and lucrative for the vehicle owners to participate in such services? In this work, we answer this question by modelling the V2G system and performing economic projections of the possible benefits for EV owners. In particular, we present a novel way of parametrizing the electric vehicle driving profile and the V2G energy transfer to compute battery degradation costs. A profit model is developed to evaluate the profit earned by the vehicle owners offering their batteries. The profit is estimated on the basis of the owner's inclination to buy and sell energy from the grid based on the electricity price. Using data of the German electricity market, we estimate a profit of 662 €/EV/Year for a vehicle with 100 kWh capacity, 95% battery round trip efficiency and driving 52 km per day. The remuneration is meaningful and can have the potential to encourage EV owners to participate in V2G service.

Presenter: Prasad is an alumnus of the University of Stuttgart and holds a master's degree in Information technology specialized in embedded systems. He has more than 5 years of work experience as an embedded software developer with different reputed industries in India and Germany. The major fields of his research are software development for embedded systems and energy systems. Currently, he is working as a software developer for AKKA Technologies, Stuttgart.

Methodology for identifying technical details of Smart Energy Solutions and Research Gaps in Smart Grid: An Example of Electric Vehicles in the energy system

Authors Kristoffer Christensen[1]*, Zheng Ma[2], Yves Demazeau[3], Bo Nørregaard Jørgensen[1]
Affiliations
[1]Center for Energy Informatics, University of Southern Denmark, Denmark.
[2]SDU Health Informatics, University of Southern Denmark, Denmark.
[3]Laboratoire d'Informatique de Grenoble, CNRS, France.

Abstract: Simulations, especially agent-based simulation, are able to facilitate the investigation of smart energy solutions and business models, and their impacts on the energy system and involved stakeholders. Technical details, alternatives, and multiple options for what-if scenarios influence simulation quality, but no methodology available to support the investigation. This paper proposes a method for identifying technical details of smart energy solutions in the energy system and identifying research gaps in the smart grid context with EV solutions as an example. The method includes the investigation of the state-of-the-art EV solutions by scoping review and the allocation of the scoping review results into the Smart Grid Architecture Model framework with three dimensions (Domains, Zones, and interoperability layers). The quantitative scoping review results in a total number of 240 references and 10 references match the criteria based on the qualitative scoping review. The results show that the most popular EV use case within the targeted scope is the V2G concept, and 6 out of the 10 references discuss the EVs' potentials to work as energy storage. 17 features are identified by mapping the EV use cases (solutions and business models) into the three dimensions (domain, zone, and interoperability layers) of the SGAM framework. The process at the Zone layer is the most popularly covered (mentioned 64 times), and enterprise at the Zone layer and communication in the interoperability layer are the least covered (mentioned 4 times each).

Presenter: Kristoffer Christensen is a Danish Ph.D. fellow in the Center for Energy Informatics at the University of Southern Denmark. He has a background in energy technology engineering giving him fundamental insight into the energy system, its green transition, and its challenges. This knowledge is applied to his Ph.D. research, developing frameworks for evaluating energy flexibility solutions and adoption strategies in the energy ecosystem using agent-based simulation.

Greenhouse Industry 4.0 – Digital Twin Technology for Commercial Greenhouses

Authors Affiliations
Daniel Anthony Howard[1]*, Zheng Ma[2], Christian Veje[1], Anders Clausen[1], Jesper Mazanti Aaslyng[3], Bo Nørregaard Jørgensen[1]
[1]Center for Energy Informatics, University of Southern Denmark, Denmark.
[2]SDU Health Informatics, University of Southern Denmark, Denmark.
[3]Danish Technological Institute, Denmark.

Abstract: The project aims to create a Greenhouse Industry 4.0 Digital Twin software platform for combining the Industry 4.0 technologies (IoT, AI, Big Data, cloud computing, and Digital Twins) as integrated parts of the greenhouse production systems. The integration provides a new disruptive approach for vertical integration and optimization of the greenhouse production processes to improve energy efficiency, production throughput, and productivity without compromising product quality or sustainability. Applying the Industry 4.0 Digital Twin concept to the Danish horticulture greenhouse industry provides digital models for simulating and evaluating the physical greenhouse facility's performance. A Digital Twin combines modeling, AI, and Big Data analytics with IoT and traditional sensor data from the production and cloud-based enterprise data to predict how the physical twin will perform under varying operational conditions. The Digital Twins support the co-optimization of the production schedule, energy consumption, and labor cost by considering influential factors, including production deadlines, quality grading, heating, artificial lighting, energy prices (gas and electricity), and weather forecasts. The ecosystem of digital twins extends the state-of-the-art by adopting a scalable distributed approach of "system of systems" that interconnects Digital Twins in a production facility. A collection of specialized Digital Twins are linked together to describe and simulate all aspects of the production chain, such as overall production capacity, energy consumption, delivery dates, and supply processes. The contribution of this project is to develop an ecosystem of digital twins that collectively capture the behavior of an industrial greenhouse facility. The ecosystem will enable the industrial greenhouse facilities to become increasingly active participants in the electricity grid.

Presenter: Daniel Anthony Howard is a Ph.D. fellow from the Center for Energy Informatics at the SDU Mærsk Mc-Kinney Møller Institute. His research is centered around energy flexibility potentials established through a Multi-Agent-based System framework for Digital Twin solutions in the production flow process. He has collaborated with multiple industrial facilities through his research combining detailed knowledge of production processes with modeling and simulation to evaluate the impact of energy flexibility on the process flow. He holds an M.Sc. Eng. In Energy Technology from the University of Southern Denmark.

A Multi-objective Optimization Platform for Artificial Lighting System in Commercial Greenhouses

Authors Ying Qu, Anders Clausen, Bo Nørregaard Jørgensen
Affiliations The Maersk Mc-Kinney Moller Institute, University of Southern Denmark

Abstract: Limited natural daylight in Nordic Countries means artificial lighting is a critical factor in industrial plant production. The electricity cost of artificial lights accounts for a large percentage of the overall cost of plant production. The optimal use of artificial lighting in plant production can be formulated as a multi-objective problem (MOP) to achieve optimal plant growth while minimizing electricity cost. In previous work, for solving this MOP, a Genetic Algorithm (GA) was used to create a Pareto Frontier (PF), which contains solutions representing a trade-off for using artificial lighting against plant production objectives. The PF was updated immediately once a non-dominated child-solution was found by comparing the dominance with solutions in the PF. Besides, in addition to the PF, the initial random population is also reused as a parent source in the evolution process. When the genetic evolution process terminated, a priority-based selection mechanism was used to select a final solution from the PF. In this paper, an alternative evolution strategy is proposed and compared with the previous GA evolution strategy. By this alternative strategy, all child-solutions are only compared with their parents during the evolution process, and the non-dominated child-solutions are collected into a candidate list. The PF is then updated at the end of each generation by comparing solutions on the PF with the collected candidate solutions. In this alternative strategy, the PF is the only source of parent-solution during the evolution process. In addition, a posterior normalization is implemented in the dominance evaluation, and social welfare metrics (SWs) are applied as an alternative to the priority-based selection mechanism to avoid the explicit ranking of objectives. The experimental results show that the proposed alternative evolution strategy outperforms the previous strategy on dramatically avoiding local minima.

Presenter: Ying Qu is a PhD student in the Center for Energy Informatics at the University of Southern Denmark. She received her Bachelor's and Master's degrees in Electronic Engineering at Harbin Engineering University, China. Her research focuses on using AI methods to solve engineering problems. For her PhD project, she applies Deep Learning and Genetic Algorithm to solve the multi-objective optimization problems of climate control in commercial greenhouses. It aims to optimize the artificial light-plan to reduce the electricity cost without compromising the quality of productions. In addition, she is also skilled in the areas of Robotics and Electronics Engineering.

Agent Based Coordination Protocol for System of Cyber-Physical Systems

Authors Affiliations

Aisha Umair[1], Anders Clausen[1], Yves Demazeau[2], Bo Nørregaard Jørgensen[1]

[1]University of Southern Denmark, Denmark

[2]Laboratoire d'Informatique de Grenoble, Centre National de la Recherche Scientifique, France

Abstract: Nowadays, society and business rely heavily on Information and Communication Technology (ICT) systems, which are progressing faster than ever. To stay on pace with them, focus is shifted towards integration of individual ICT systems into complex systems, which offers more functionality than simply the sum of individual systems. In this regard, Cyber-Physical Systems (CPSs) have gained significant importance and System-of-Systems (SoS) approach has been suggested for modeling complex CPSs to achieve a higher level goal, by dynamically building a large system with existing autonomous, and heterogeneous constituent systems (CSs). An important challenge in a system of Cyber-Physical Systems (SoCPSs) is to develop seamless collaboration between autonomous constituent-CPSs (CCPSs) to coordinate their operations. In this paper, we propose an agent-based coordination mechanism to coordinate resource allocation and demand in SoCPSs. The approach models each CCPS as an agent and describes how multiple autonomous CCPSs, i.e., Virtual Power Plant (VPP), Commercial Greenhouse Growers (CGGs), communicate and collaborate with each other asynchronously through negotiation and how potential conflicts between CCPSs with conflicting goals are resolved. The efficacy of the proposed mechanism is validated through simulation of different real-world acyclic SoCPSs topologies. The results show that proposed approach is able to balance the individual requirements of multiple connected CPSs while achieving SoCPSs' mission.

Presenter: Aisha Umair joined University of Southern Denmark (SDU) as a Full Time Lecturer in the Department of Software Engineering in 2020. Prior to that, she was a Research Assistant in Center for Energy Informatics, SDU Denmark. She holds B.S. degree in Software Engineering from Fatima Jinnah Women University, Pakistan, M.S. degree in Software Engineering from National University of Science and Technology, Pakistan and PhD in Software Engineering from SDU Denmark. Aisha has 10+ years experience in research and teaching in academia. She has held academic and research positions in various educational institutions. Her research interests include Cyber-Physical Systems, Multi Agent Systems and Multi Objective Optimization. She is the author of 8 technical papers and is the recipient of Outstanding Paper Award by International Conference on Intelligent Systems and Agents 2015, IADIS.

Local Energy Markets - An IT-architecture Design

Authors Affiliations
Bent Richter[1], Armin Golla[1], Klaus Welle[2], Philipp Staudt[1], Christof Weinhardt[1]
[1]Karlsruher Institute of Technology,Germany
[2]Selfbits GmbH, Germany

Abstract: In recent years, local energy markets have become an important concept in more decentralized energy systems. Implementations in pilot projects provide first insights into different hypotheses and approaches. From a technical perspective, the requirements for the IT infrastructure of a local energy market are diverse, and a holistic view of its architecture is therefore necessary. This article presents an IT-architecture, which enables all basic local energy market functionalities, processes and modules based on the available literature. The proposed IT-architecture can serve as a blueprint for future local market projects as it covers the basic processes and is at the same time extendable. Furthermore, we give a detailed description of a real-world implementation of a local energy market using the described IT-architecture and discuss the advantages and disadvantages of the utilized technologies along with this case study.

Presenter: Bent Richter is a Ph.D. student at the Karlsruhe Institute of Technology (KIT), Germany. He holds a Master's degree in Economics from the University of Freiburg, Germany, and is currently working in the Department of Economics at the Institute of Information System and Marketing (IISM). His research focuses on the implementation and operation of local energy markets. Based on the Landau Microgrid Project (LAMP), he analyzes the different aspects of an implemented local energy market from conception to operation. The main focus of his work is the design of the market mechanism, the analysis of the user behavior, as well as the identification of the challenges of a concrete technical implementation. He also investigates the interaction of users with the information system in order to identify basic design principles using design science research and analyzes the effects of automated agents acting on the local market by using machine learning techniques.

Industrial consumers' electricity market participation options: A case study of an industrial cooling process in Denmark

Authors: Nicolas Fatras[1,2], Zheng Ma[3], Bo Nørregaard Jørgensen[1]

Affiliations:
[1]Center for Energy Informatics, University of Southern Denmark, Denmark
[2]Sino-Danish Center for Education and Research,University of Chinese Academy of Sciences, China
[3]Center for Health Informatics, University of Southern Denmark, Denmark

Abstract: In a deregulated market context, industrial consumers often have multiple market participation options available to bid their flexible consumption in electricity markets and thereby reduce their electricity bill. Yet most participation strategies for demand response are developed in a fixed and predefined set of submarkets. Meanwhile, little literature has compared multiple market options for market participants. Therefore, this paper proposes a comparative approach between available market options to evaluate savings from different market participation options. More specifically, this study implements an optimisation program in Python to investigate the impacts of changes in an industrial process' flexibility on savings with different market participation options. The optimisation program is tested with a case study of an industrial cooling process in three Danish submarkets (day-ahead, intraday, and regulating power markets). The market participation options are formed by different combinations of these three submarkets, and the type and amount of process flexibility are varied by changing time and load constraints in the optimisation program. The results show that bidding in market options with multiple submarkets yields higher savings than single-market bidding, but that increases in available flexibility impact savings in each market option differently. Increased flexibility will only bring additional savings if it allows to take further advantage of price variations in a market option. Additionally, increases in savings with flexibility depend on the considered type of flexibility. These changes in relative savings between market options at each flexibility level imply that the optimal market option is not a static choice for a process with variable operating conditions. The optimal market option for an industrial consumer depends not only on market price signals, but also on the type and amount of available flexibility.

Presenter: Nicolas Fatras is a PhD student at the SDU Center for Energy Informatics and the Sino-Danish Center for Education and Research at the University of Chinese Academy of Sciences, through the Sino-Danish Center (SDC) PhD scholarship program. His thesis focuses on the development of a digital twin framework for energy markets, applied to industrial consumers providing demand response in the Danish and Chinese electricity markets. He holds an MEng in Civil Engineering (University of Bristol) and an MPhil in Energy Technologies (University of Cambridge).

Analysis and forecasting of crude oil price based on the variable selection-LSTM integrated model

Authors Quanying Lu[1], Shaolong Sun[2], Hongbo Duan[3], Shouyang Wang[1,3]
Affiliations [1]Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China
[2]The School of Management, Xi'an Jiaotong University, China
[3]School of Economics and Management, University of Chinese Academy of Sciences, China

Abstract : In recent years, the crude oil market has entered a new period of development and the core influence factors of crude oil have also been a change. Thus, we develop a new research framework for core influence factors selection and forecasting. Firstly, this paper assesses and selects core influence factors with the elastic-net regularized generalized linear Model (GLMNET), spike-slab lasso method, and Bayesian model average (BMA). Secondly, the new machine learning method long short-term Memory Network (LSTM) is developed for crude oil price forecasting. Then six different forecasting techniques, random walk (RW), autoregressive integrated moving average models (ARMA), elman neural Networks (ENN), ELM Neural Networks (EL), walvet neural networks and generalized regression neural network Models (GRNN) were used to forecast the price. Finally, we compare and analyze the different results with root mean squared error (RMSE), mean absolute percentage error (MAPE), directional symmetry (DS). Our empirical results show that the variable selection-LSTM method outperforms the benchmark methods in both level and directional forecasting accuracy.

Presenter: Dr. Quanying Lu is a Special Research Assistant (Postdoctor) at the Institute of Mathematics and Systems Science, Chinese Academy of Sciences. Her research interests are in Energy Finance, Energy Economics, Energy-Environment-Policy Analysis and Management, Green Transportation, Macroeconomic Analysis, Bayesian Econometrics, Machine Learning, Economic and Financial Forecasting. She has published more than 10 papers in important international academic journals, including *Nature Communications*, *Energy Economics*, *Energy Policy*, *Technological Forecasting & Social Change*、*Transportation Research Part D: Transport & Environment*, etc. In addition, she published two academic monographs.

How to Design a Dynamic Feed-in-Tariffs Mechanism with a Renewable Energy Target Capacity

Authors: Junqi Liu[1], Lei Zhu[1], Wei Zhang[2], Beilin Xiao[3]
Affiliations: [1]School of Economics and Management, Beihang University, China
[2]School of Management, Zhejiang University, China
[3]School of Economics and Management, Beihang University, China

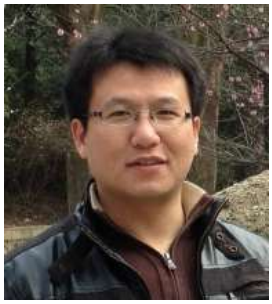
Abstract: Feed-in tariffs (FITs) are among the most favoured policies with which to drive the deployment of renewable energy. This paper offers insights into quantifying dynamic FITs to realize the expected installed capacity target with minimum policy cost under uncertainties of renewable intermittence and technology learning. We use stochastic dynamic programming to model the strategic behaviour between policy-maker and investor and extend the one-time investment decision to multiple-period decisions. China's offshore wind power investment is used as a case study to investigate the relationships among the optimal dynamic FITs level, the total policy cost, and the expected capacity target. The simulation results demonstrate that our proposed dynamic FITs can track the changes in technology learning well and that they can avoid the inefficiency of fixed FITs in stimulating technology adoption in the initial periods, along with overpayment by the policy-maker.

Presenter: Junqi Liu is a PHD student at School of Economics and Management of Beihang University, his research interests include energy investment evaluation, low-carbon policy research and operations research methods.

Evaluating the CO_2 abatement effects of low-carbon city policy in China: A quasi-natural experiment

Authors Qiangyi Li [1], Mian Yang [2], Fei Xu[3], Fuxia Yang[4], Xiaojian Xiang[1]
Affiliations [1]School of Economics and Management, Guangxi Normal University, China
[2]Economics and Management School, Wuhan University, China
[3]School of Economics and Management, Anhui Normal University, China
[4]College of Economics & Management, Huazhong Agricultural University, China

Abstract: The formulation and implementation of Low-Carbon City Policy (LCCP) is an essential initiative for China to build its low-carbon society. Based on the panel data of 282 prefecture-level cities in China from 2003 to 2016, this study evaluates the effects of LCCP implementation on pilot cities' carbon emission performance using difference-in-differences method, and then the mechanism has also been examined with a mediating effect model. The results show that: first, the LCCP implementation has increased the carbon emission performance of the pilot cities significantly, indicating that it is an effective way to promote the low-carbon transformation of Chinese cities. Second, the positive effects in CO_2 performance resulting from LCCP demonstrate significant heterogeneity: in general, the cities in east China, with higher economic development level and in a larger size, achieve more significant CO_2 emission reduction than their respective counterparts. The results on the mechanism test imply that the LCCP helps improve pilot cities' carbon emission performance in three ways, including reducing energy consumption, updating the industrial structure, and promoting technological progress. Finally, some useful policy recommendations are put forward to promote China's low-carbon city construction.



Presenter: Mian Yang is currently working as a full professor at the Economics and Management School, Wuhan University, China. He has been devoting his endeavor to the area of design on the long-term mechanism for energy conservation and emissions reduction. Up to now, he has published nearly 50 peer-reviewed articles (including the forthcoming ones) including in some top field journals such as EJOR, and Energy Economics, acting as the first and/or corresponding author. Moreover, Mian has presided over 3 academic projects funded by the National Natural Science Foundation of China.

Digitalisation Potentials in the Electricity Ecosystem: Lesson learnt from the Comparison between Germany and Denmark

Authors: Thorsten Hack[1], Zheng Ma[2], Bo Nørregaard Jørgensen[1]
Affiliations: [1]Centre for Energy Informatics, University of Southern Denmark, Denmark
[2]Centre for Health Informatics and Technology, University of Southern Denmark, Denmark

Abstract: Digitalisation potentials in the electricity sector are frequently discussed around the world, especially in Europe which has the largest interconnected continental electricity grid in the world. The analysis and comparison of electricity ecosystems between countries can help to enhance international understanding and cooperation. It can also enable businesses to expand. However, little literature has covered the cross-national comparisons of digitalisation potentials in the electricity sector. This paper uses the business ecosystem architecture development methodology to identify commonalities and differences between two electricity ecosystems: Germany and Denmark. The result shows that there are many similarities between the two countries, but the roles of market framework provider, market supervision, and metering point operator are performed by different actors. By comparing the value chain segments, the main differences between Denmark and Germany are the share of renewable energy generation, the organisation of the transmission system, smart meter installation & operations, and the national electricity data hub. Based on the comparisons, six recommendations for the digitalisation of the electricity ecosystem are proposed: digitalisation for enabling more renewable energy resources for electricity generation, digitalisation in the electricity grids, digitalisation in the electricity markets, digitalisation on the demand side, especially the transport sector, and regulation-driven digitalisation of the electricity ecosystem.

Presenter: Thorsten Hack is a master student in Energy Management and Informatics at FH Aachen in Germany. He is writing his thesis about predicting the heat demand of greenhouses at the Mærsk Mc-Kinney Moller Institute within the University of Southern Denmark in Odense. He has a computer science background and worked in mobile app and web development before switching focus to machine learning and the energy sector.