



Energy Internet

ICEI 2017

First IEEE International Conference on Energy Internet

17-21 April 2017, Beijing, China

Edited by Junwei Cao, Jiye Wang, Wenhua Liu, and Kai Xie



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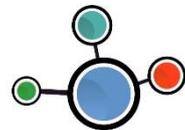
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Edited by
**Junwei Cao
Jiye Wang
Wenhua Liu
Kai Xie**



Los Alamitos, California
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First IEEE International Conference on Energy Internet

ICEI 2017

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Message from the ICEI 2017 Chairs

Welcome to the First IEEE International Conference on Energy Internet (ICEI 2017), held at Beijing, China, April 17–21, 2017.

Energy Internet is an Internet-style solution for bottom-up construction of energy infrastructure and applications. A key feature of Energy Internet is decentralized coordination of energy producing and consuming that enables open and peer-to-peer energy sharing. The ideal of Energy Internet is iterative balance among energy generation, storage and consumers in real time. By allowing high-level awareness and involvement in form of cooperation and interaction, secure and reliable delivery of energy is achieved by efficient scheduling, distribution and routing across peers of energy cells in Energy Internet.

IEEE ICEI 2017 focuses on related research areas such as architecture and design, energy switching and routing, information and communication technology, energy management systems, energy market and trading for Energy Internet. This conference provides a platform for researchers, academics and industries from multidisciplinary domains to share their knowledge, ideas and working experiences for Energy Internet. Hopefully, this event will promote more sophisticated technologies and appliances for the benefit of more economic and environment friendly energy utilization across the global.

There are totally 235 submissions, each receiving three reviews. Finally, only 62 papers are accepted, and the rate of paper acceptance is 26%. Regarding these accepted papers, there are totally 220 authors from 70 organizations contributing to this conference. On behalf of the whole conference committee, we would like to say thank you for all these dedicated works.

IEEE ICEI 2017 is co-sponsored by Research Institute of Information Technology, Tsinghua University, China; Tsinghua National Laboratory for Information Science and Technology; Beijing Smart China Energy Internet Research Institute; Technical Committee on Energy Internet, China Energy Research Society; Technical Committee on Energy Internet, Chinese Association of Automation; IEEE Computer Society; IEEE Computer Society Technical Committee on Internet. Their sponsorships support the success of conference.

IEEE ICEI 2017 would not have been successful without the support of many people and organizations. First and foremost, we would like to thank all the authors for submitting their papers to the conference, for their presentations and discussions during the conference. We would like to express our most sincere gratitude to Program Committee members and our professional reviewers, who carried out the most difficult work by carefully evaluating the submitted papers. We would like to give special thanks to the conference sponsors. Last but not least, we would like to thank all conference participants for their contribution and support. We hope that all participants can take this opportunity to share and exchange ideas with one another and enjoy IEEE ICEI 2017.

Junwei Cao, Tsinghua University, China

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ICEI 2017 Workshop Overviews

Workshop: Modelling, Control and Optimization of Energy Internet

Workshop Chair: Qiuye Sun, Northeastern University, China

Establishing low-carbon, efficient, safe and sustainable energy utilization mode to meet national economic and social development and environmental requirements is an important issue that should be solved urgently in China. From the perspective of energy source import, it's imperative to develop from traditional single energy structure to multi-energy structure containing a variety of energy structures. However, development of multi-energy system is facing unprecedented challenges that mainly stemming from increasing physical entities inside multi-energy system, addition of multi-energy transmission media and improvement in permeability of renewable energy sources as well as utilization of many cyber-physical fusion technologies. Consequently, resulted problems like more sophisticated system variables, more modals, stronger composition, higher dimension of schedule optimization, increasing network hidden security troubles as well as stronger discontinuity and uncertainty, etc., enhance difficulties in modelling and optimizing control on multi-energy system, restrict development of multi-energy system and bring a challenge to the existing advanced control theory.

Energy Internet as a multi-energy system with the largest coverage reflects features like non-linearity, random, multi-source big data and multi-scale dynamic, etc. A research emphasis and difficulty problem in Energy Internet is how to realize partial and global stability as well as optimum regulation of Energy Internet under a certain goal constraint through proposing effective and reasonable intelligent control methods.

Now, it is absolutely required for making a significant breakthrough on modelling and optimization control technology under the background of Energy Internet, so as to use new theory, new method and new technology to solve the present problems. Of which, problems like Energy Internet modelling and related Internet communication technology and system safety analysis, energy optimization of Energy Internet, control theory research on energy optimization, conversion and configuration, fault diagnosis and self-cure control research on Energy Internet, basic equipment research and hardware design on Energy Internet and new market trade mechanism and bidding strategy research, etc. are expected to become the research highlights. Discussion and research on these problems can play an important role in impelling settlement of the emphases and difficulties mentioned above in the field of Energy Internet. Thus, this workshop aims at timely dissemination of research in these areas. Possible topics include, but are not limited to:

- Architecture and basic theory of Energy Internet
- Planning, designing and operation of Energy Internet
- Trading patterns and market mechanism research of Energy Internet
- Intelligent control and optimization and its application case study in Energy Internet
- System security analysis, fault detection and information security
- Information collection, transmission, analysis and its communication technology
- Important infrastructure development and related hardware design
- Energy routers and energy hubs
- Energy management and control of multi-energy flow
- Energy quality and reliability of multi-energy flow
- Load forecasting model and demand response
- High-penetration renewable energies (especially the distributed generation)

Workshop: Energy Internet Demonstration Engineering and Applications

Workshop Chair: Dunnan Liu, North China Electric Power University, China

There will be national demonstration engineering projects in China in multiple areas related to Energy Internet, e.g., multi-energy complementation, Internet + smart energy, industrial power demand-side management, market trading for distributed generation, incremental power distribution networks, etc. In this workshop, we will invite experts and practitioners from these projects for demonstration engineering and applications to exchange their thoughts and experiences.

Workshop: Space Energy Internet & Energy Management

Workshop Chairs: Chunfeng Wang, Qian Xuesen Laboratory of Space Technology, China Aerospace Science and Technology Corporation, China; Fulu Li, Tsinghua University, China

In this workshop, we invite experts and practitioners from both academia and industry in the areas of Space Energy Internet to have extensive and in-depth discussions on the technical challenges and great opportunities on the road ahead toward efficient implementation of such a complex system for Space Energy Internet. We go through potentially disruptive technical innovations in the areas:

- Energy harvesting in space
- Emerging coding techniques that are suited for both information and energy data
- Renewable energy in space
- Intelligent Energy Internet diagnosis in space
- Energy transfer using wireless technologies
- Distributed energy storage in space

To the best of our knowledge, this is the first time such an exploration on Space Energy Internet has been presented. We hope that the discussions at this workshop by experts in the related fields yield a thorough, insightful and comprehensive blueprint for the development of Space Energy Internet for years ahead. At the end of this workshop, we will publish a formal Whitepaper on Space Energy Internet, in order to guide the development of this brand-new paradigm, which is essential for the peaceful and efficient usage of energy in space as well as the corresponding technologies.

Workshop: Advanced Wireless Communication and Networking for Energy Internet

Workshop Chair: Zhaoming Lu, Beijing University of Posts and Telecommunications, China

While traditional automation of the power grid makes use of wireline communications (copper, fiber), Energy Internet requires wide-area coverage with flexible and cost-efficient communications networks. Therefore, wireless communication and networking technologies will play an increasingly important role in future deployment scenarios. The investigated options range from 5G networks over satellite systems to wireless mesh networks. Particular challenges for wireless communication options include availability (with coverage down to the basement), real-time capabilities (for incident mitigation), resilience (after black-outs, against

jamming, etc.) and security (cyber-attacks). In the light of these recent developments, this workshop will focus on the following subjects of interest, as well as related issues:

- Architecture, performance and network planning of wireless networks for Energy Internet
- Resilient and low-latency wireless communication for Energy Internet
- Wireless networks for distributed generations
- Comparison of networking options for Smart Grids: e.g., wireline vs. wireless, mesh vs. cellular, satellite vs. terrestrial
- Energy Internet protocols (e.g., SCADA, WAMPAC) adapted to wireless networks
- Energy Internet specific wireless communication traffic models and channel models
- Low latency and high reliability technologies (e.g., M2M control and communications, mobile edge computing) in 5G
- New communication protocols and the exploitation of NFV/SDN for better communication and networking
- LPWAN communication and networking technologies (e.g., LoRa, Sigfox)
- Security and privacy concerns in wireless communication and networking for Energy Internet

Workshop – Energy Internet Application Development and Key Technologies

Workshop Chair: Shouzhen Zhu, Tsinghua University, China

Organizer: China Smart Power Technology Alliance & Beijing Smart China Energy Internet Research Institute

With announcement of National Demonstration Projects on Energy Internet by National Energy Administration, many projects will be launched in a couple of years on districted Energy Internet. This forum brings experts from different areas to address issues on project engineering, including application development and key technologies, e.g. multi-energy flow simulation, flexible DC networks, information and communication, energy management, energy trading, etc.