

## Guest Editorial Special Section on Energy Internet

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# Guest Editorial for Special Section on Energy Internet

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AS one of current trends and developments the Internet of Things (IoT) is affecting and will shape the society and the world in all respects. IoT is defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where the virtual world of information technology integrates seamlessly with the real world of things. The integration of IoT and energy industry naturally brings the promise of Energy Internet round the corner to introduce significant advantages and opportunities: enhanced automation, controllability, deregulation, interoperability, energy efficiency, higher security and reliability, superior ecosystems, smarter energy management, advanced big data management capability, responsiveness, greater flexibility to accommodate various energy sources, better customer services and so on.

The key challenge for the researchers is to investigate and develop integrated and advanced solutions based on various backgrounds to deal with the comprehensive and cross-disciplinary research problems from theoretical foundations, infrastructure, control strategies, smart energy management to test-laboratories and applications for IoT integrated-smart energy networks.

The special section is a collection of new and original papers that cover different aspects from architecture, scheme design, control strategy, optimization, application and deployment of energy Internet systems. To sum up, the special section includes a various corpus of high-quality papers contributed by excellent researchers from interdisciplinary fields. There were total 8 manuscripts got final acceptances for the publication after strict peer-review processes.

The paper by Dongxu Yang et al. presents a framework for a virtual private cloud-based power-dispatching automation system (PDAS), which makes use of the following technologies, virtual private networks, virtual private clouds, https protocols, etc. Compared with the on-premise or public cloud hosted PDASs which are vulnerable and enslaved to blackouts under extreme situations, for instance, natural calamities or cyber attacks, the proposed framework can provide more stable and secure operation with extreme conditions, meanwhile, fulfill the power system reliability requirements.

The paper by Yining Liu et al. proposes a practical privacy-preserving data aggregation scheme without a trusted third

party, in which the users with some extent trust construct a virtual aggregation area to mask the single user's data. Meanwhile, the aggregation result almost has no effect for the data utility in large-scale applications. The reduced computation load and communication cost can effectively promote its practicability. Moreover, the proposed scheme is robust and efficient verified by the security analysis and performance evaluation.

The paper by Xinli Shi presents a hierarchical model predictive power dispatch and control strategy for a class of modern power systems with price-elastic controllable loads in energy Internet. Two case studies are performed on the IEEE 14- and 39-bus systems, respectively, which show that the system-frequency deviation and system cost are reduced significantly with the proposed methods.

The paper by Haochen Hua et al. proposes novel controllers for microturbines (MTs) and the energy routers, such that the following three criteria are concurrently fulfilled. Firstly, a bottom-up energy management approach is developed. Secondly, the operation cost for employing battery energy storage devices is minimized. Thirdly, the situation of overcontrol concerning MTs is effectively avoided. Additionally, a novel hybrid modeling method is developed combining both recurrent neural networks and Ornstein–Uhlenbeck process to achieve accurate power models for both photovoltaic panels and loads.

The paper by Bin Cao et al. investigates deployment issues of heterogeneous wireless directional sensor networks in 3-D smart cities. Based on 3-D urban terrain data, the deployment issue is converted to a multiobjective optimization problem, in which objectives of Coverage, Connectivity Quality, and Lifetime, as well as the Connectivity and Reliability constraints, are concurrently considered. A graph-based 3-D signal propagation model using the line-of-sight concept is employed to calculate the signal path loss. Novel distributed parallel multiobjective evolutionary algorithms are also proposed.

The paper by Kedi Zheng et al. proposes a novel data-driven approach which combines two novel data mining techniques. One is the maximum information coefficient (MIC) that can identify the correlations between the nontechnical loss and a certain electricity behavior pattern of the consumer. MIC can be employed to accurately detect thefts that appear normally in shapes. The other one is the clustering technique by fast search

and find of density peaks (CFSFDP). CFSFDP identifies the deviant users among thousands of load profiles, therefore highly appropriate for detecting electricity thefts with arbitrary shapes. A framework for integrating the strengths of these two techniques is also proposed.

The paper by Jinyu Hu et al. focuses on energy harvesting cooperative (EH) wireless sensor networks (EHC-WSNs) which is a new type of WSNs that combines EH and wireless energy transfer technologies to offer an uninterruptible and controllable energy supply. A graphene-grid deployment strategy is proposed to ensure energy coverage and network connectivity. A Graphene-based Energy Cooperation Management (GECM) mechanism is developed with the energy-neutral operation. Moreover, the GECM is separated into two stages, i.e., graphene-based energy cooperative charging strategy and graphene-based opportunistic cooperative routing algorithm, which are optimized in accordance with the graphene-grid structure.

The paper by Kai Ma et al. optimizes power and spectrum allocation simultaneously to improve the demand-side communication quality in smart grids and to further decrease the cost of utility companies. The electricity cost is first modeled based on regulation errors result from direct load control in the smart grid. Second, the subbands are allocated to different data aggregator units in accordance with the band confidence levels and the utility company's maximum cost. An algorithm is designed to optimize transmission power of the relays and refine the spectrum allocation to decrease utility cost.

These papers demonstrate a wide variety of approaches to harness the Energy Internet-enabled opportunities and to develop advanced solutions for the challenging problems in the Energy Internet field.

The section guest editors would like to thank the editorial board members for their valuable comments for preparing the special section of the *IEEE Transactions on Industrial Informatics*. Our gratefulness is also especially given to all of the authors who submitted papers, your papers contributed significantly to the challenges and issues by taking an exploratory role in the development of the Energy Internet field. Our sincere acknowledgment is also given to the reviewers for your time and your insightful comments that have been critical to enhance the quality of this special section. Last but not the least, we would like to give our sincere appreciation to Prof. Ren C. Luo, the Editor-in-Chief, and Miss Linda, the Secretary, for their thoughtful suggestions, great help and patient support in launching the Energy Internet Special Section of the *IEEE Transactions on Industrial Informatics*.

We sincerely expect that you think this Special Section interesting and helpful for your future research and development in the field. Thank you.



**Josep M. Guerrero** (S'01-M'04-SM'08-FM'15) received the B.S. degree in telecommunications engineering, the M.S. degree in electronics engineering, and the Ph.D. degree in power electronics from the Technical University of Catalonia, Barcelona, in 1997, 2000 and 2003, respectively. Since 2011, he has been a Full Professor with the Department of Energy Technology, Aalborg University, Denmark, where he is responsible for the Microgrid Research Program. From 2012 he is a guest Professor at the Chinese Academy of Science and the Nanjing University of Aeronautics and Astronautics; from 2014 he is chair Professor in Shandong University; and from 2015 he is a distinguished guest Professor in Hunan University.

His research interests are oriented to different microgrid aspects, including power electronics, distributed energy-storage systems, hierarchical and cooperative control, energy management systems, and optimization of microgrids and islanded minigrids. Prof. Guerrero is an Associate Editor for the *IEEE TRANSACTIONS ON POWER ELECTRONICS*, the *IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS*, and the *IEEE Industrial Electronics Magazine*, and an Editor for the *IEEE TRANSACTIONS ON SMART GRID* and *IEEE TRANSACTIONS ON ENERGY CONVERSION*. He has been Guest Editor of the *IEEE TRANSACTIONS ON POWER ELECTRONICS* Special Issues: Power Electronics for Wind Energy Conversion and Power Electronics for Microgrids; the *IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS* Special Sections: Uninterruptible Power Supplies systems, Renewable Energy Systems, Distributed Generation and Microgrids, and Industrial Applications and Implementation Issues of the Kalman Filter; and the *IEEE TRANSACTIONS ON SMART GRID* Special Issue on Smart DC Distribution Systems. He was the chair of the Renewable Energy Systems Technical Committee of the IEEE Industrial Electronics Society. In 2014 he was awarded by Thomson Reuters as Highly Cited Researcher, and in 2015 he was elevated as IEEE Fellow for his contributions on "distributed power systems and microgrids."



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Her research interests include microgrids, distributed generation systems, power converters for renewable energy generation systems, and energy Internet.



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His current research interests include operation, power management, hierarchical control, optimization and power quality applied to distributed generation and ac/dc microgrids. Dr. Vasquez is currently a member of the IEC System Evaluation Group SEG4 on LVDC Distribution and Safety for use in Developed and Developing Economies and the Renewable Energy Systems Technical Committee TC-RES in IEEE Industrial Electronics Society.



**Kai Sun** (M'12-SM'16) received the B.E., M.E., and Ph.D. degrees in electrical engineering from Tsinghua University, Beijing, China, in 2000, 2002, and 2006, respectively.

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