

Guest Editorial

Special Issue on Analysis, Control, and Optimization of Energy Networks

THE deployment of new technologies (e.g., renewable generation and electric vehicles) is rapidly transforming power networks by blurring the previously distinct spatiotemporal scales that many traditional approaches rely on for designing, analyzing, and operating power grids. Other energy systems, such as natural gas systems, are undergoing similar revolutionary transformations. This trend can be characterized as a disruptive surge in complexity that challenges design and operation, but also offers opportunities to deliver unprecedented efficiency and reliability.

The analysis, control, and optimization of energy networks are the most significant subjects underpinning the new technologies. For example, the central role of network control in power systems is to maintain desired operations while preventing contingency events involving voltage and/or frequency instability from developing into devastating cascades and blackouts. The rapid growth in renewable generation is displacing traditional forms of energy generation while increasing the need for controllable and flexible resources to balance fluctuations in load and generation. These fluctuations and frequent rearrangements of energy flows require new control mechanisms for the integrated energy infrastructures. Sensing and actuation technologies are also required for improving observability, hierarchical control, flexibility, and robustness. Additional emergency control systems need to be developed to monitor, verify, and act to guarantee that the system remains within operational limits during postcontingency dynamics.

This special issue of the IEEE TRANSACTIONS ON CONTROL OF NETWORK SYSTEMS (*TCNS*) contains original contributions which identify and solve the emerging challenges in power systems and, more generally, in complex energy networks. Thirty papers were selected with contributions in rigorous methods and algorithms as well as in computational heuristics which bridge the growing chasm between legacy energy systems and the future complex, math-validated, and physics-enabled engineered networks. The accepted papers address manifold of theoretical and computational challenges in network control, optimization, and big data of energy systems. The proposed solutions contain sound theory and

scalable algorithms and software implementable in practical systems.

Emerging theoretical and computational methods for the analysis, control, and optimization of energy systems, mainly power systems but also natural gas systems, are the main theme of papers in the special issue. The majority of accepted papers focus on methods which are informed by underlying physical flows, are aided by data, and mitigate increasing uncertainty. Topics covered in the special issue include:

- 1) tractable outer and inner approximations for feasible domains of network operations;
- 2) chance constrained and robust optimization and control of networks under uncertainty;
- 3) voltage and frequency stability and control of power systems at all levels;
- 4) worst-case, emergency analysis and control of power systems;
- 5) operation and uncertainty aware network expansion and asset-management methods;
- 6) co-operations and optimal design of energy markets (of power and natural gas networks);
- 7) joint statistical modeling and reconstruction of loads, renewable generation, components failures, and costs of service interruptions;
- 8) control and optimization for demand response technology;

We would like to mention that this special issue only provides a snapshot of the emerging field on energy systems modeling, optimization, and control. Due to standard page limits, we include a rather small number of papers. As a result, despite our best efforts, its coverage is by no means complete nor comprehensive. In particular, we were not able to identify solid contributions relevant specifically to such important components of energy systems as those related to district heating/cooling.

Finally, we would like to take this opportunity to thank all of the authors for their submissions and contributions. We would also like to thank many individuals who helped review the papers timely and professionally and provided many excellent suggestions. The Editorial Assistant M. Stanton provided valuable assistance. Last, but not least, we are grateful to the Editor-in-Chief, I. C. Paschalidis, for providing us this great opportunity to put together this special issue.

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Mihailo R. Jovanovic received the Dipl.Ing. and M.S. degrees from the University of Belgrade, Belgrade, Serbia, in 1995 and 1998, respectively, and the Ph.D. degree from the University of California, Santa Barbara, CA, USA, in 2004.

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of large dynamic networks, and dynamics/control of fluid flows.

Prof. Jovanovic is a fellow of APS. He received a CAREER Award from the National Science Foundation in 2007, the George S. Axelby Outstanding Paper Award from the IEEE Control Systems Society in 2013, the University of Minnesota Informatics Institute Transdisciplinary Research Fellowship in 2014, and the Distinguished Alumnus Award from the Department of Mechanical Engineering at UC Santa Barbara in 2014. His students' papers were finalists for the Best Student Paper Award at the American Control Conference in 2007 and 2014. He currently serves as a Guest Editor (of the Special Issue on Analysis, Control and Optimization of Energy System Networks in the IEEE TRANSACTIONS ON CONTROL OF NETWORK SYSTEMS) and as an Associate Editor of the IEEE TRANSACTIONS ON CONTROL OF NETWORK SYSTEMS, and had served as the Chair of the American Physical Society External Affairs Committee, a Program Vice-Chair of the 55th IEEE Conference on Decision and Control, an Associate Editor of the *SIAM Journal on Control and Optimization* (from 2014 to 2017), and an Associate Editor of the IEEE Control Systems Society Conference Editorial Board (from 2006 to 2010).



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Dr. Low was a co-recipient of IEEE best paper awards on the editorial boards of major journals in networks, power systems and control, and honorary/chair professors in Australia, China, and Taiwan. He was on the Technical Advisory Board of Southern California Edison and a member of the Networking and Information Technology Technical Advisory Group for the U.S. President's Council of Advisors on Science and Technology in 2006.



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