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Editorial

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Modeling and control of multimodal and hybrid energy systems

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The ongoing transition of the entire power system has led to the need of new concepts for operation and control. The integration of renewable sources, the fade-out of conventional and nuclear energy sources and the growing cross-border internal European energy market have evoked several changes in the behavior of the system. First of all, the utilization of the grid has changed due to higher energy transmission amounts and longer distances between generation and consumption. Secondly, the replacement of rotating masses by power electronic driven generation reduces time constants and leads to a faster and more dynamic system. Finally, new players, e. g., electric vehicles, large-scale battery energy storage systems and Power2X, enter the market.

On the other hand, these new players and the flexibility provided by power electronics offer new parameters to securely operate the system and increase system stability and resilience. Together with the ongoing digitalization of the energy supply system new possibilities arise. Especially flow controlling assets like HVDC and sector-coupled systems are considered promising to reach the desired goals. New concepts of grid planning and operation are needed to efficiently integrate these new assets into the existing AC system.

Therefore, in 2017, DFG has published a call for proposals for a special priority program entitled “Hybrid and multimodal energy systems: System theoretical methods for the transformation and operation of complex networks (SPP 1984)”. The projects started in 2018 and now – about one year after the launch – first results are available.

This special issue provides insight into a choice of SPP 1984 projects and other topic-related research projects with similar goals.

The first article is provided by the energy informatics group of the Leibniz University Hannover. It is a sweeping statement about the modelling of multimodal energy systems and considers ICT as well as Power2X and CHP. It gives an overview on a simulation and controller framework to model and operate multimodal energy systems. The general idea is to separate the component and the control layer.

The second article is provided by the institute of automation technology of the University Bremen. The authors describe a multidimensional control concept for distribution systems to coordinate adjacent distributed generation under consideration of voltage bounds and active and reactive power exchange at the handover-point to the overlaying grid.

The next article as well deals with multi-objective optimization of system operation but in contrast focusses on the transmission system and HVDC line integration. The leading author is member of the electric energy supply research group at TU Ilmenau. The article describes strategies how HVDC lines can actively support the AC system in critical situations by providing reactive power and influencing the active power flow in the AC system by applying optimal power flow calculations.

Usually, a sensitivity analysis is the basis for optimization and control strategies and is applied in the previous two approaches. Therefore, this article presented by the Control methods and robotics team of the TU Darmstadt deals with distributed, constrained gradient approach to optimize energy management problems. The authors describe and compare two different strategies: on the one hand a decoupling approach based on Lagrange and on the other hand a penalty-term approach using the push-sum-consensus.

The final “Methods” paper is presented by the Electric Power Engineering Section of the Leibniz University Hannover. The authors describe a standardized environment to design and evaluate multilevel control strategies for inverter-dominated grids. Furthermore, the authors deal with aspects of ICT and the stability of converter clusters in large-scale energy systems.

The “Application” section of this journal consists of one paper provided by the Institute of Electric Power Systems of the Otto-von-Guericke University Magdeburg.

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The authors come back to the topic of the first article and present a mixed-integer optimization framework for sector-coupled systems. Thereby, the energy hub approach is considered. The focus of this work is the description of a systematic modelling and simulation framework to easily configure and optimize sector-coupled systems of different size.

Finally, in the "Tools" section the authors of the Institute for Automation and Applied Informatics of the Karlsruhe Institute of Technology propose distributed co-simulation technologies to combine existing single-domain simulations into one large integrated energy system simulation. In this context, a new distributed co-simulation architecture for multi-physics based energy systems integration is introduced.

It is evident, that all articles deal with urgent challenges of the energy system and provide interesting and promising solutions. The editors hope that the reader will enjoy this special issue. Furthermore, the editors want to thank the authors and the reviewers for their respective contributions.

Bionotes

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