SOE 18: Energy Networks (joint SOE/DY) (joint session SOE/DY)

Time: Thursday 11:30–12:30 Location: H17

SOE 18.1 Thu 11:30 H17

Principal flow patterns across renewable electricity networks

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Using Principal Component Analysis (PCA), the nodal injection and line flow patterns in a network model of a future highly renewable European electricity system are investigated. Remarkably, the application of PCA to the transmission line power flow statistics shows that irrespectively of the spatial scale of the system representation a very low number of only 8 principal flow patterns is sufficient to capture 95% of the corresponding spatio-temporal variance. This result can be theoretically explained by a particular alignment of some principal injection patterns with topological patterns inherent to the network structure of the European transmission system. By connecting these insights to a spectral clustering method it is shown how through topological changes the flow patterns on the network can be controlled.

SOE 18.2 Thu 11:45 H17

Flow Redistribution after Link Failures in Linear Flow Networks

— •Franz Kaiser[1,2], Julius Strake[1,2], Henrik Ronellenfitsch[3], and Dirk Witthaut[1,2] — [1]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE) — [2]University of Cologne, Institute for Theoretical Physics — [3]Department of Mathematics, Massachusetts Institute of Technology

Failing links can degrade the operation of a supply network up to the point of complete collapse. Yet, the interplay between network topology and locality of the response to such damage is poorly understood. Here, we study the role of topology for the redistribution of flow after the failure of links in linear flow networks with a special focus on power grids. In particular, we analyze the decay of flow changes with distance after a link failure and examine the interplay of multiple lines failing at the same time. In addition to that, we introduce a rerouting distance to predict this decay for real-world networks and use this tool for describing the interaction of multiple outages. Our results show that it is possible to forecast flow rerouting after link failures to a large extent based on purely topological measures and that these effects generally decay with distance from the failing link.

SOE 18.3 Thu 12:00 H17

Understanding power-grid-frequency dynamics with stochastic modelling: The influence of the electricity market

— •Leonardo Rydin Gorjão[1,2], Mehrnaz Anvari[3], Holger Kantz[3], Marc Timme[4,5], Benjamin Schäfer[4,5], and Dirk Witthaut[1,2] — [1]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), 52428 Jülich, Germany — [2]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — [3]Max–Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [4]Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed) and Institute for Theoretical Physics, Technical University of Dresden, 01062 Dresden, Germany — [5]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany

The ongoing energy transition transforms the power system by introducing additional fluctuations via intermittent renewable energy generation To evaluate the various proposed strategies of implementation of renewable energy generation and the impact of market design on the power grid's stability, a solid understanding of the power grid dynamics, specifically its frequency, is necessary. A pure empirical study on existing power grids is limited due to their small number, limited available data and high costs of implementing control and market schemes in real grids. Our model allows predictions of the frequency statistics for diverse power grids and ultimately enables us to quantify the impact of control proposals and market designs.

SOE 18.4 Thu 12:15 H17

Effects of time delay on the control of synchronous electricity grids

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In the course of the 'Energiewende', highly volatile energy sources (i.e. wind and photovoltaics) will be introduced to a system built with conventional energy sources in mind. Removing conventional energy sources and replacing them with fluctuating renewable generation that does not provide inertia could make the system vulnerable to disturbances. Control mechanisms can only be employed by accurately measuring the system state (i.e. frequencies and load flows) and correctly communicating theses values. The delay associated with the measurement, communication and deployment of control might play an increasingly important role in a system that relies on strongly fluctuating feed-in.

The control mechanisms used at the moment are integrated into a model of coupled oscillators which resembles the second order Kuramoto model. This model is used to investigate the behavior of the interconnected electricity grid. To identify regions in parameter space that make stable grid operation possible, the linearized system is analyzed to create the system's stability chart. The influence of the control parameters, the underlying network topology and the delay on the grid frequency is of special interest.