

DY 46: Energy Networks (joint SOE/DY) (joint session SOE/DY)

Time: Thursday 11:30–12:30

Location: H17

DY 46.1 Thu 11:30 H17

Principal flow patterns across renewable electricity networks

— •MIRKO SCHÄFER¹, FABIAN HOFMANN², JOHANNES KRUSE³, TOM BROWN^{4,2}, JONAS HÖRSCH^{4,2}, STEFAN SCHRAMM², and MARTIN GREINER³ — ¹Department of Sustainable Systems Engineering (INATECH), Albert-Ludwigs-Universität Freiburg — ²Frankfurt Institute for Advanced Studies — ³Department of Engineering, Aarhus University, Denmark — ⁴Institute for Automation and Applied Informatics, Karlsruhe Institute of Technology

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.

DY 46.2 Thu 11:45 H17

Flow Redistribution after Link Failures in Linear Flow Networks

— •FRANZ KAISER^{1,2}, JULIUS STRAKE^{1,2}, HENRIK RONELLENFITSCH³, and DIRK WITTHAUT^{1,2} — ¹Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE) — ²University of Cologne, Institute for Theoretical Physics — ³Department 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.

DY 46.3 Thu 12:00 H17

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

— •LEONARDO RYDIN GORJÃO^{1,2}, MEHRNAZ ANVARI³, HOLGER KANTZ³, MARC TIMME^{4,5}, BENJAMIN SCHÄFER^{4,5}, and DIRK

WITTHAUT^{1,2} — ¹Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), 52428 Jülich, Germany — ²Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — ³Max-Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — ⁴Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed) and Institute for Theoretical Physics, Technical University of Dresden, 01062 Dresden, Germany — ⁵Network 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.

DY 46.4 Thu 12:15 H17

Effects of time delay on the control of synchronous electricity grids

— •PHILIPP C. BÖTTCHER¹, ANDREAS OTTO², and STEFAN KETTEMANN³ — ¹DLR-Institut für Vernetzte Energiesysteme, Oldenburg — ²Institute of Physics, TU Chemnitz, Chemnitz — ³Department of Physics and Earth Sciences, Jacobs University, Bremen

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 these 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.