SOE 14: Energy meets Economy: Dynamics and Statistics of Future Energy Systems (accompanying symposium SYEE joint with DY and jDPG)

Time: Wednesday 11:45–13:15 Location: GÖR 226

SOE 14.1 Wed 11:45 GÖR 226

Fluctuation analysis of high frequency electricity power load in the Czech Republic — •Hynek Lavicka[1,2] and Jiri Kracik[3] — [1]Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering, Department of Physics, Břehová 7, CZ-11519 Praha 1, Czech Republic — [2]Bogolyubov Laboratory of Theoretical Physics, Joint Institute of Nuclear Research, RU-141980 Dubna, Russia — [3]Charles University in Prague, Faculty of Social Sciences, Institute of Economic Studies, Opletalova 26. CZ-110 00 Prague 1, Czech Republic

We focus our analysis on data of electricity power loads in Czech Republic which exhibits seasonality and well as periodic trends typical for other European states. We separate the signal into two parts in Fourier picture where the data undergo power law with significant peaks. Deterministic part governs seasonal and periodic trends. While the latter part holds information on random fluctuations. To deeply analyze stochastic part we employ Multifractal Detrended Fluctuation Analysis (MF-DFA) to determine estimation of Hurst exponent and scaling exponent. Power law exponent of MF-DFA depends on parameter of analysis for stochastic and shuffled stochastic part. This behavior is typical for heavy-tailed distributions. Moreover we also determined properties of autocorrelation function and we found long-range correlation which depends on parameter of analysis.

SOE 14.2 Wed 12:00 GÖR 226

Large-deviation properties of power grids — •Timo Dewenter and Alexander K. Hartmann — Institut für Physik, Carl von Ossietzky Universität Oldenburg, 26111 Oldenburg

We study numerically a Kuramoto-like model [1,2] on different standard and spatial random graphs, which is used to describe the dynamical behavior of coupled mechanical rotators. Such a turbine is represented by a node in the graph, whereas edges stand for transmission lines which can transmit power up to a maximum capacity P^{MAX} between the machines. A machine can either produce (generator) or consume (motor) power. Here, we investigate the robustness of such networks of the random graph ensemble against transmission line failures, i.e. removal of edges. The measured histograms of the robustness certainly provide only information for the smallest probabilities being of order $1/N_{\mathrm{samp}}$, where N_{samp} is the number of samples used to generate the random graph ensemble. Therefore, we apply a large-deviation approach [3] to obtain the low-probability tails of the distribution, which allows us to gain insight in the topology of extreme robust and extreme vulnerable networks.

[1] G. Filatrella, A.H. Nielsen, N.F. Pedersen, Eur. Phys. J. B **61**, 485 (2008)
[2] M. Rohden, A. Sorge, M. Timme, D. Witthaut, PRL **109**, 064101 (2012)
[3] A.K. Hartmann, Eur. Phys. J. B **84**, 627 (2011)

SOE 14.3 Wed 12:15 GÖR 226

Extending electric grid physics to implement smart grid trading function — •Thomas Walter and Bernd Brunner — Wirsol Integrated PV Solutions

Renewable energy (RE) sources like solar and wind can now compete on generation cost with some fossil sources, but have the property of being volatile. Traditional concepts use storage of electric energy to compensate for this volatility. However, storage cost exceeds generation cost until major breakthroughs will be achieved. Electric grids in which reneable energies provide the larger share (RE dominated grids) therefore utilize the flexibility of decentral loads and generation units. If these are shifted suitably in time, they can utilize too high RE production, and supply energy when RE production is too low. The paper shows how the well known effect that grid freguency varies according to the balance of supply and demand can be utilized to build the basis of a smart grid. This system simplifies overall complexity and reduces cost by appropriate combination of physics and data based technologies.

SOE 14.4 Wed 12:30 GÖR 226

Imaginary Interest Rates and Complex Net Present Value Calculus in Energy Economics — •Gunnar Kaestle — Clausthal University of Technology, 38678 Clausthal-Zellerfeld, DE

A helpful instrument for evaluating the economic feasibility by integrating cash-flows is the Laplace transform [1], as it is an equivalent for net present value calculation. Mathematic rules known from control theory are able to simplify economic assessments. Introducing interest rates from the two-dimensional plane of comlex numbers expands their descriptive power from purely growth or decline to cyclical processes.

Besides discounting cash-flows, discounting energy flows is also a more general but very important assessment of investments in the energy sector. The limiting EROI-factor is gradually degrading in the fossil fuel sector due to the human nature to go for the low hanging fruits first. Severe long term economic implications have to be anticipated, due to the fact that energy is a very powerful production factor.

Therefore, a controlled transition towards non-exhaustive energy resources with a stable EROI has to be started when discretionary spending in learning investments and the deployment of new technology is still possible. The so called net energy cliff shall be avoided by following an exergy efficient transition pathway. Incentive schemes such as the self-adjusting feed-in tariff for German PV systems can be interpreted as supervisory economic control loops.

[1] Robert Grubbström: On the Application of the Laplace Transfrom to Certain Economic Problems; Management Science; Vol. 13; No. 7; 1967; pp. 558-567.

SOE 14.5 Wed 12:45 GÖR 226

Self-Organized Synchronization and Voltage Stability in Power Grids Modeled by Networks of Synchronous Machines — •Katrin Schmietendorf[1], Joachim Peinke[1], Oliver Kamps[2], and Rudolf Friedrich[3] — [1]Carl von Ossietzky Universität Oldenburg, Institut für Physik, ForWind — [2]CeNoS, Münster — [3]WWU Münster, Institut für Theoretische Physik

The energy transition is accompanied by grid decentralization and fluctuating power feed-in characteristics. Hence, with a view to future grids, power system stability and design are actual key issues.

We investigate power system stability in terms of self-organized synchronization aspects on the basis of a network of coupled synchronous machines. In recent years, a relationship between this approach and synchronization phenomena described by the well-known Kuramoto model (KM) has been uncovered. The KM models the dynamical behaviour of coupled oscillators displaying a phase transition from incoherent to partially synchronized states at a critical coupling value. In contrast to other attempts, our network model incorporates both rotor angle and voltage dynamics plus the feature of angle-voltage stability interplay. It can be shown to correspond to a novel version of the KM with time-varying coupling coefficients, which has not been investigated in the context of nonlinear dynamics yet.

We discuss the model's potential applications to modern power systems with a high percentage of renewable energy plants and present results concerning the stability properties of small two-machine units up to large networks.

SOE 14.6 Wed 13:00 GÖR 226

Power transmission in a renewable European future — •Sarah Becker[1], Rolando Rodriguez[2], Martin Greiner[2], and Stefan Schramm[1] — [1]FIAS Uni Frankfurt, Germany — [2]Uni Aarhus, Denmark

We investigate a renewable-based European electricity system, where wind and solar PV produce as much energy as is consumed. Since this generation flucuates with the weather, there will in general be a mismatch between load and generation in individual hours. We assume deficits to be covered by dispatchable power plants, while excesses are curtailed.

In this setting, we study different flow paradigms for inter-country power transmission, i.e. ways to share renewables and match deficits and excesses between the countries. Particular focus is placed on the effects on backup energy usage ("how much fuel is burned?"), backup capacity needs ("how many dispatchable plants need to be available?"), and transmission line investments. Furthermore, we examine different approaches to transmission grid strengthening and compare actual and optimized developments.