Stochastic modelling of frequency fluctuations in power grids of the future

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Research Group: Dynamical Systems and Statistical Physics

Project description:

Building a sustainable energy system of the future is key to achieving the 2015 Paris goal of limiting global warming "well below 2°C". A sustainable future energy system requires electrified heating and transportation, powered by significantly more renewable energy sources. However, larger fractions of wind and solar generation introduce complex types of frequency fluctuations in power grids (small deviations around 50 Hz) which are dependent on the weather, as well as on demand fluctuations of consumers, market forces, and control actions. The larger fraction of renewables, and the lack of inertia, introduce significant spatio-temporal complexity in the power grid of the future which mathematically needs to be understood and modelled.

In this PhD project we will develop new mathematical models for spatio-temporal frequency fluctuations in power grids, and compare with recently obtained measured data [1,2]. The models will be based on stochastic differential equations with more complicated (non-Gaussian and correlated) noise sources and time-dependent volatility parameters. A detailed comparison with measured data of real systems will be performed, using superstatistical and multifractal data analysis techniques. The complex noise models will then be fed into other models and be used to make quantitative predictions for the behaviour of future power grid systems that will contain a higher fraction of renewables. A particular aspect of the PhD project will be to give quantitative predictions how batteries and storage solutions can smoothen the frequency fluctuations in the sustainable power grid of the future, using the above modelling approach.

The project is at the forefront of current research in the field and we encourage PhD student candidates with an excellent background in applied mathematics, physics, engineering or numerical computing to apply.

References

[1] B. Schaefer, C. Beck, K. Aihara, D. Witthaut, and M. Timme, Non-Gaussian power grid frequency fluctuations characterized by Levy-stable laws and superstatistics, Nature Energy 3, 119-126 (2018)

[2] L. Rydin Gorjao, R. Jumar, H. Maass, V. Hagenmeyer, G.C. Yalcin, J. Kruse, M. Timme, C. Beck, D. Witthaut, B. Schaefer, Open data base analysis of scaling and spatio-temporal properties of power grid frequencies, Nature Commun. 11, 6362 (2020)

Further information:

How to apply

Entry requirements

Fees and funding