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Forschungsinitiative der Bundesregierung

CoNDyNet

Principles and concepts for efficient, decentralised electricity grids

Project state Started

Theoretical and applied scientists and industrial partners are working closely together on developing basic criteria for the stability, reliability, risks and market access of future-proof electricity grids, whereby the focus in on the entire European region and a comprehensive supply with renewable energy sources. The transitional period, the grid modification with backup systems from conventional electricity generators and conversion scenarios are also being factored in.

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A reliable power supply and therefore a stable distribution of electrical energy are these days essential for all sectors of society. Conventional energy supply systems are organised centrally and are also largely controlled centrally. The restructuring of the electricity generation means that this functional principle is facing major challenges, since the integration of renewable energies entails small-scale, heterogeneous and decentralised generation that is also characterised by fluctuations and is only predictable to a limited extent. As the proportion of renewable primary energy sources increases, a system-wide consideration of the collective dynamics of the power grid will be essential that takes into account fluctuations and increased market access. In particular, repeated and simultaneously effective, non-linear feedbacks in the grid will have to be understood so that the grid is predictable and controllable.

In the joint CoNDyNet project (**Co**llective **N**onlinear **Dy**namics of complex **Net**works), the intention is to gain a comprehensive understanding of the dynamic phenomena in complex, decentralised electricity grids as well as to develop important cornerstones for new fundamental concepts for operating and expanding distribution and transmission grids from the regional to the pan-European level. To this end, the researchers are developing mathematical methods and expanding findings from nonlinear dynamics and statistical physics. They are combining these with modelling analyses and simulation studies of the electrical technology and are investigating critical grid conditions, risk scenarios and optimisation options. Finally, they will explore possibilities for implementing their results in order to achieve efficient grid expansion planning and robust grid control, including in collaboration with applied research institutions and industrial partners.

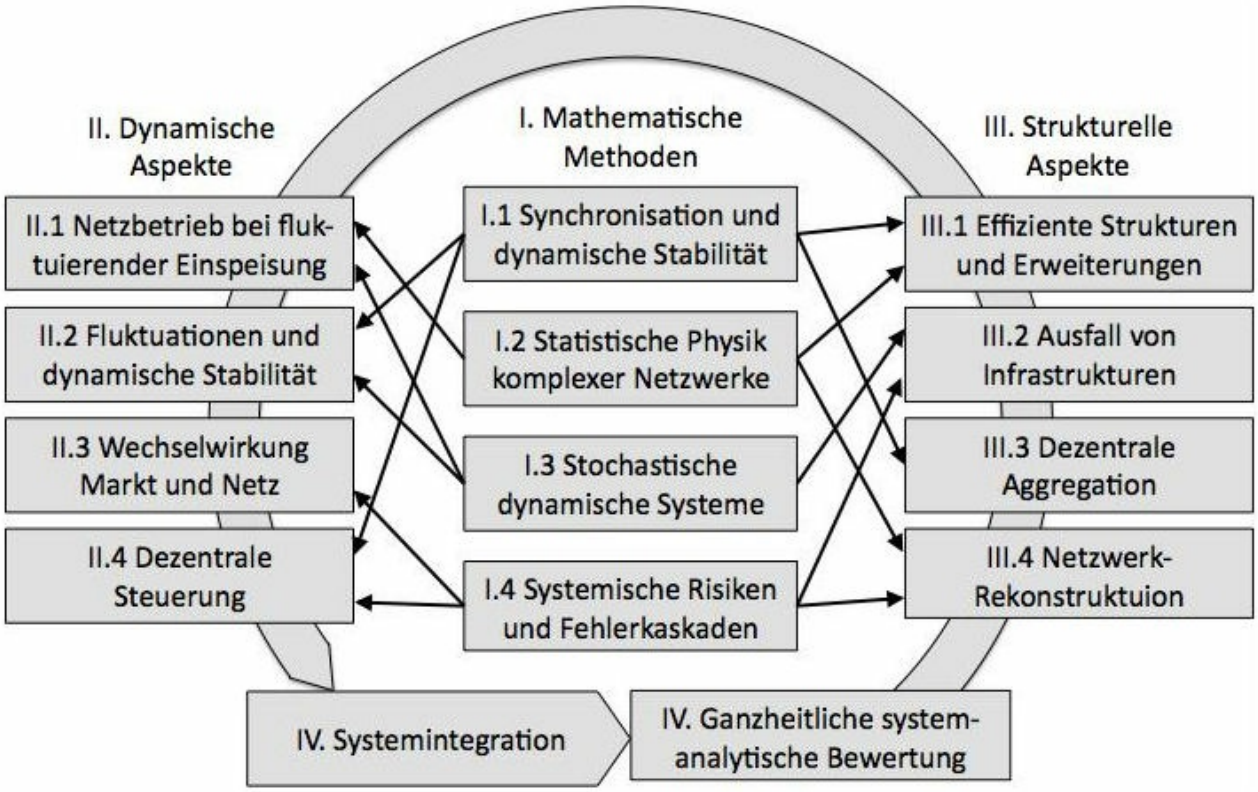
Hypothetical development of the European power grid from 2010 to 2050

The share of wind and solar power used to produce electricity in the individual German federal states is indicated by the node colour while the transmission capacities between the federal states are indicated by the type of line and width. This was calculated under the assumption that on average the same amount of energy will be generated from wind and solar power in 2050 as is consumed. The transmission line capacity is selected so that it reduces the energy required from controllable sources by 90% of the maximum amount possible through international transmission.
Bild: Sarah Becker

New models for complex electricity grids

The research partners in the consortium of applied and basic research institutes are seeking to gain a fundamental understanding of the collective dynamics of complex electricity grids in terms of possible applications aimed at ensuring the stability, robustness, efficiency and minimisation of risks in the grid operation as well as for use in the grid planning and market integration. For this purpose they are expanding and developing new physical and mathematical theories and models, as well as analysis methods and simulations, and are also considering aspects concerning the system integration and economic assessment.

An important overall objective is to combine engineering and physical concepts with the evolving theory of complex grids and to make the methods and findings available for applications in future-proof power grids. The consortium's scientific objectives are divided into four areas and various sub-areas:



Integration of the individual work areas.
Graphic: PIK-Potsdam

In **Part I** it is intended to develop the basic principles for mathematical models and theoretical concepts relating to the dynamics of complex power grids (i.e. decentralised, heterogeneous grids with fluctuating loads and generators that are also coupled via new market mechanisms).
Based on this, the researchers will investigate in **Part II** how the dynamics and operational management can be

designed in an efficiently and dynamically robust manner, even with large fluctuations and market access.
In **Part III**, the scientists will examine how grid structures can be efficiently designed, expanded and protected against risks. Finally in Part IV they will determine the system integration and economic aspects based on the methods and results of the other sub-areas.

The project milestones at a glance

- Fundamental collective and structural challenges, particularly with regard to decentralisation, risks caused by failures and fluctuations over short and long timescales
- Theoretical and conceptual foundations for a stable grid operation and its risks
- Dynamic instabilities in simple models and then in detailed standard applications
- Model enhancements in exchange with application partners with a view to specific practical problems (e.g. medium-voltage grids, measures for suppressing collective instabilities)
- Feedback on studies of simple models and the development of specific complex models
- Analysis of the system-based impacts of alternative grid expansion options on the energy system

Close collaboration between the research partners

Close collaboration is essential with all sub-projects, and shortly after the beginning of the research project there have already been several discussions about a wide variety of projects not just between the project partners themselves but also with application partners such as Easy Smart Grid GmbH and Aarhus University. The project partners – the Max Planck Institute for Dynamics and Self-Organisation (MPIDS), the Potsdam Institute for Climate Impact Research (PIK), the Research Centre Jülich (FZJ), the Frankfurt Institute for Advanced Studies (FIAS) and Jacobs University Bremen (JUB) GmbH – are international leaders in the basic research areas of nonlinear dynamics, statistical physics, complex systems, networks, mathematical modelling and their application in physical and technical systems. The research is focussing on trans-disciplinary applications for physical methods and the transformation of the energy supply (PIK), collective dynamics and the self-organisation of complex systems (MPIDS), statistical physics for sustainable and renewable energy grids (FIAS) and the transport and localisation in complex grids (JUB). With its Systems Analysis and Technology Development area, the FZJ is a global leader in the interdisciplinary analysis of energy systems taking into account technical, economic and ecological aspects and their interactions.

Project duration

09/2014 - 08/2017

Contact

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Links

Informationen on smart grids on the Max-Planck-Gesellschaft webseite
more... (http://www.mpg.de/8927460/electricity-intelligent-decentral-smart-grid)