Scientists publish open resource to help design 'greener' energy systems

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Researchers have created a database of measurements from existing global power grid systems that will help develop new power systems capable of meeting changing demands, such as the move towards renewable energy sources.

The study, published in *Nature Communications*, is the first step towards

a more collaborative approach to energy research. It is hoped the publicly available data can be used worldwide to design and test new energy concepts in response to current and future challenges.

For the study, the researchers collected power grid data from 17 locations across three continents and covering 12 synchronous areas—regions containing different power plants and consumers that are connected and operate under the same frequency.

The research team, including scientists from Forschungszentrum Jülich, Queen Mary University of London, Karlsruhe Institute of Technology (KIT), Technical University Dresden and Istanbul University, were particularly interested in understanding changes in frequency, which highlight the balance between energy supply and demand.

Using a novel measurement device designed at KIT, the scientists were able to precisely capture differences in frequency between various synchronous areas by simply connecting it to a wall socket.

The researchers used their experimental recordings to test theoretical predictions on how the size of a synchrous area can influence its stability. They found that smaller areas tended to be much more volatile than larger areas in their fluctuations in frequency.

Dr. Benjamin Schäfer, a Marie Curie Research Fellow at the School of Mathematical Sciences at Queen Mary and lead author of the study, said: "The power grid in all European countries operates at a frequency of approximately 50 Hz and it is almost constant throughout a single synchronous area. If consumption rises, the frequency slightly drops, while a persistent burst of wind might increase the frequency as additional wind power generation is fed into the grid. The fluctuations of the frequency around the reference value tell us a lot about how a specific synchronous area is operated, including when trading takes

place, how large the grid is, how much control is enforced and more. In this study we confirm that size has an impact on the stability of frequencies, highlighting the need to consider size in the design and control of electricity grids, including microgrids"

By simultaneously measuring frequencies in several locations within a synchrous area the researchers also observed that whilst on longer time scales of minutes or more, the frequencies were identical everywhere, on a shorter time scale of seconds, substantial differences between locations were observed.

"We would assume that within a synchronous area, as the name suggests, the frequency would be identical everywhere. However when we conducted simultaneous measurements at several locations within the Continential European synchrous area we observed significant differences between frequencies on a timescale of seconds. The further away two locations are, the longer it takes for them to fully synchronize. In our article, we quantify this effect for the first time and measure how long this time-to-bulk is," added Dr. Schäfer.

The introduction of renewable energy sources to mitigate climate change is rapidly changing energy systems worldwide, and in particular, electricity grids. "Whilst new policies, technologies and business models are being implemented globally to meet these new requirements, it is also important for us to learn from the systems that have been implemented so far," said Professor Christian Beck, Professor of Applied Mathematics at Queen Mary.

"We believe this openly published data and their detailed statistical analysis provide a great source of information for those working on the control and design of power grids worldwide, providing empirical predictions for the future and helping us to better understand the complex dynamics of sustainable energy systems."

More information: 'Open data base analysis of scaling and spatio-temporal properties of power grid frequencies' Leonardo Rydin Gorjão, Richard Jumar, Heiko Maass, Veit Hagenmeyer, G.Cigdem Yalcin,Johannes Kruse, Marc Timme, Christian Beck, Dirk Witthaut and Benjamin Schäfer *Nature Communications*, DOI: 10.1038/s41467-020-19732-7

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