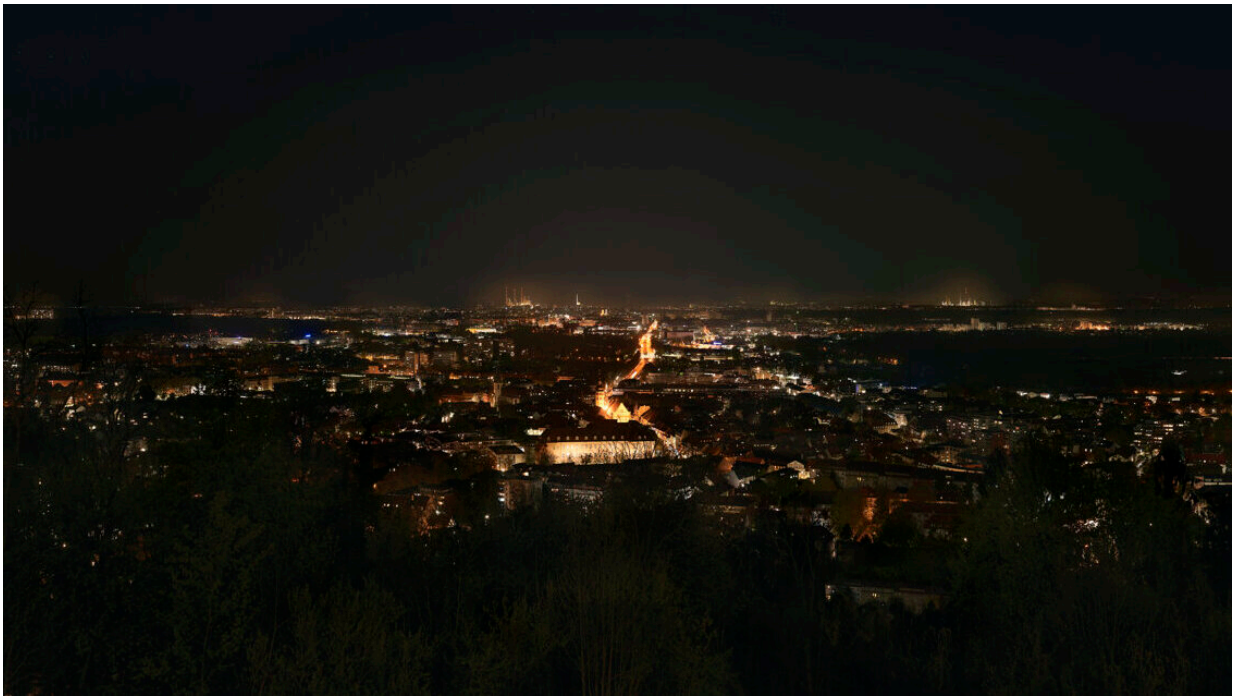
New microgrids model takes into account a fair design of decentralized energy systems

July 26 2024



Credit: Karlsruhe Institute of Technology

Local decentralized energy systems, known as microgrids, can make urban infrastructures more resilient and reduce risks for the population, for example, in large-scale power outages due to natural hazards or cyberattacks.

In *Nature Sustainability* researchers from Karlsruhe Institute of

Technology (KIT) present design criteria for microgrids that allow for fair treatment of different social groups alongside technical factors. The study shows how cities can shape the transformation towards a secure and more sustainable and equitable energy supply.

Climate change increases the probability of extreme events, as we have seen during the massive flooding of large parts of southern Germany in June. The question of how cities and municipalities can make power supply more resilient and more secure in the face of such crises is bringing so-called microgrids into focus.

Decentralized systems for generating, storing, and distributing energy, for example with networked photovoltaic power-generation systems and combined heat and power plants, are intended to make large-scale power outages in the entire urban area less likely and to ensure that critical infrastructures for the provision of public services will continue functioning.

A group of German and US researchers, led by Dr. Sadeeb Simon Ottenburger, Head of Department at the Institute for Thermal Energy Technology and Safety (ITES) at KIT, has developed a model for the spatial design of microgrids.

Their study provides urban planners with a template for a planning process that integrates various aspects—including socio-economic factors and issues related to societal participation in the planning process. Involved were employees of ITES, KIT's Institute for Technology Assessment and Systems Analysis (ITAS), and, in the U.S., the Energy Production and Infrastructure Center (EPIC) at the University of North Carolina and the National Renewable Energy Laboratory (NREL) in Colorado.

'Energy Gerrymandering': Who has access to the

energy supply?

"A special feature of our approach is that we do not consider technical parameters or cost issues as isolated factors, but rather look at the question of what role the design of microgrids plays in terms of a fair energy distribution," explains Ottenburger.

"Imagine the city as a jigsaw puzzle. The size and arrangement of its pieces can vary. The boundaries of energy networks are the result of deliberate decisions and have an impact on the population. In the event of a crisis, it makes a difference how the health, security, and food provision services are distributed within individual microgrids, but also throughout the entire urban area."

The study uses the term "degrees of freedom" to emphasize the importance of design flexibility. To refer to the potentially negative impact of districting that does not take social equity issues into account, the authors used the term "energy gerrymandering," akin to "political gerrymandering" known from the U.S., where electoral districts are divided to the advantage of certain groups.

Thus, microgrid districts might be defined in a way that creates an unfair distribution of resources and benefits. Strong and wealthy groups could be favored, while socially weaker and vulnerable groups could be left behind. "Resilience also includes a definition of how access is designed for different groups of the population," says Ottenburger.

Metrics for assessing well-being

The study focuses on the relationship between the different vulnerabilities of socio-economic groups and equitable access to energy and other services.

To this end, the researchers have developed metrics using existing vulnerability indices that describe the well-being of the population as a measurable variable and show how power disruptions affect socially and economically vulnerable groups, in particular: the sick or elderly, families with children, and low-income earners.

Data from case study after hurricane

The study evaluated data from a comprehensive case study conducted after the power outages caused by Hurricane Florence in New Hanover County, North Carolina, in September 2018.

The data was contributed by the US project partners. It allowed the researchers to analyze the critical infrastructure, its vulnerability in relation to the geographical distribution of socially disadvantaged households, and their access to basic services.

The project team used this data to develop a universal design that allows for a comprehensive assessment of urban resilience for each city and to generate proposals for the design of microgrids, taking technical and social aspects into account.

Multiple microgrids per city

One of the authors' specific recommendations is that a city should have not just one, but several microgrids to ensure a fair distribution and accessibility of critical services such as health and safety structures.

Concerning the districting of supply networks, city administrations should actively involve institutions in the areas of health care and security, representatives of different social groups, educational institutions, and social services in the planning and decision-making

processes to fairly consider the needs of all social groups.

"The search for optimized microgrid designs is highly complex and new algorithms are needed to develop viable models from the available data," says Ottenburger.

"The key point is that resilient solutions are not necessarily a question of more investment, but above all of sophisticated planning. We should make sure that all groups have a voice and can participate in these processes."

More information: Sadeeb S. Ottenburger et al, Sustainable urban transformations based on integrated microgrid designs, *Nature Sustainability* (2024). DOI: 10.1038/s41893-024-01395-7

Provided by Karlsruhe Institute of Technology