Climate change resilient future energy systems: assessing the impact of heatwaves in Germany

Madhura Yeligeti[1], Hans Christian Gils[1], Shima Sasanpour[1]

1. Institute of Networked Energy Systems, German Aerospace Center (DLR), Stuttgart, Baden Wuerttemberg, Germany

Objective & Background

As climate-induced risks become more prominent, the design of energy systems of the future must account for resilience to sudden and extreme events. Heatwaves, unlike earthquakes and floods offer near-foreseeability and tend to be less catastrophic. However long spans of extreme heat can seriously damage energy system components and test the endurance of the energy system and society at large.

Method

To address this risk to security of energy supply, we investigate the possible effects of a heatwave on the energy system. The major effects of a heatwave manifest in the form of higher electricity demand for cooling, limited power transmission and overtime outages due to transformer failures. In extreme cases, heatwaves can cause shutting down of large power plants and industries due to lack of cooling water. A heatwave is parameterized from literature and using available data from real heatwaves in the past e.g. the Arizona heatwave in the United States in 2016. The non-linear relationship between the climatic conditions during the heatwave and electricity demand is captured with Machine Learning regression. We apply this extreme event on different configurations of a future energy system for Germany and its neighbouring countries for the year 2050. Using an energy system optimization model, we analyse the optimal performance of the system in response to the heatwave. The drop in performance is indicative of the unmet energy demand which should be minimal for a resilient system response.

Principal Findings and Conclusion

The correlation between extreme heatwave temperatures and power demand enables us to generate several heatwave scenarios at high spatial resolution. By testing several stress cases i.e. combinations of time, duration, intensity of the heatwave, it is possible to identify critical systemic conditions for a heatwave to occur. More importantly, the comparison of different energy system designs is valuable to identify better performing technologies and scenarios to realise energy systems with high resilience to heatwaves in the future.