Can Germany Move Towards 100% Renewables Without Major Problems?

A system dynamics modeling of the power generation in Germany during energy transformation

by

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Abstract

Germany has an ambitious program to move towards a 100% renewable energy on a sustainable manner. The country has a plan to phase out all nuclear and coal power plants by 2022 and 2038, respectively. One of the most important challenges for this ambitious energy transition is the need for the flexibility to balance the supply and demand in the electricity market since renewable energy resources are weather dependent and variable, and these variations generally do not always match with the fluctuations in demand. Along reviewing the main challenges in the energy transformation process, this study tries to address the question about how flexibility can be induced into an energy system which is mainly dependent on variable renewable resources. The study focuses on providing the most optimal capacity utilization for a variety of renewable and conventional resources until 2050 by considering economical and technical limitations.

With regards to the natural variations in the electricity demand and production, a system dynamics simulation model was developed in this study for the electricity market in Germany where electricity price, demand, and supply from different technologies were simulated hourly. The studied technologies included coal, gas, nuclear, onshore and offshore winds, solar, run-of-the-river, and hydro reservoirs. The model was calibrated recreate the historical data of supply, demand and price of electricity in Germany during 2019 with good accuracy.

With assumptions about technological development, CO_2 taxes and demand evolution, optimization results give different capacities for various resources in a 30-years vision. The optimizations show a system based on solar and wind power can be a cost-effective option for lower emissions. In accordance to these results, the need for natural gas as an energy carrier in the transition to a renewable society gets very limited. At the same time, with more contribution from renewable energies into the German grid and phasing out of coal and nuclear power plants in the future, volatility in the wholesale prices will increase. Therefore, an increasing need to provide flexibility via methods like flexible demand, storage capacity and an integrated electricity market should be evolved.