Abstract

**System efficiency of US wind power generation is declining - A decomposition of historical wind power generation data**

US Wind power generation has grown significantly over the last decades, mostly driven by more and larger turbines being installed. While growth of wind power generation is necessary to build an energy system with high shares of renewables, the technology also causes negative externalities. The installation of more and larger turbines can, for example, negatively affect wild life and humans.

In theory, technological progress could lead to an increase of system efficiency, i.e. to higher electricity generation in relation to kinetic power in wind at turbine locations, thus reducing impacts by generated unit of power. We therefore assess for the US, which has one of the largest wind power fleets globally, how system efficiency has changed in the period 2010-2019.

For that purpose, we combine wind power generation time series, data on installed wind turbines and wind speed time series from the ERA5 reanalysis to decompose the growth of US wind power generation into its driving factors. These include the number of installed turbines, average rotor swept area, system efficiency, location choice, and hub height. In total, less electric power was extracted by rotor swept area in 2019 than 10 years before. This is caused by a declining system efficiency, which can be largely explained by a decrease in the specific power of wind turbines. At the same time, wind power developers were able to increase the power available in wind per unit of rotor swept area, as turbines with larger hub heights and in windier locations have been built, offsetting to some extent the reductions in system efficiency.