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Using spatiotemporal data to evaluate renewable electricity self-sufficiency of municipalities and states in Bavaria and the Czech Republic

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Photovoltaics and wind power are the fastest growing and best established renewable energy technologies of today. Both are usually presented as the preferred option for energy systems to reach high shares of renewables but their integration is not an easy task due to their varying availability and its grid's feed-in. This work presents the likelihood of municipalities in Bavaria (Germany) and federal states in the Czech Republic to reach high penetration of photovoltaics and wind power until 2050 by taking into account demographic changes and alternative regulatory developments. To accomplish this, spatial development potential of wind power for three different sizes of turbines (10m, 50m and 137m) and free-standing photovoltaics are calculated for the whole study area using a mix of official and open data. Time series of electricity generation are constructed for every single potential area using physical models of the technologies. These models rely on solar radiation, temperature and wind speed time series from the COSMO-REA6 regional reanalysis as input data. Moreover, current total electricity demand per type of sector (residential, agricultural and industrial) is distributed in space using population and land use data from the LUISA territorial modelling platform of the European Commission. The population and land use forecast of the latter data set is utilized to estimate electricity demand per administrative unit for 2030 and 2050. The yearly values of electricity demand for each administrative unit are transformed into hourly electricity demand time series using German and Czech standard load profiles. Finally, an optimization model is employed to estimate if the local renewable potential per administrative unit together with storage systems are sufficient to cover the local demand under current and future conditions. Results are presented using maps covering the whole study area. These do not only show that massive storage systems would be required in order to supply electricity only based on photovoltaics and wind power, but also that the feasibility of achieving this could be considerably different between geographic and climatic areas with similar conditions.