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Mapping minimum technical requirements for electricity self-sufficiency of single family houses using regional reanalysis data and satellite imagery derived data

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Decreasing prices of photovoltaic (PV) and electricity storage systems have popularized the idea of independency from the grid among household's owners. The basic idea is simple: on the one side, PV installations can easily fit in building's roof-tops while producing more energy per year than a household would require; on the other side, the temporal mismatch between energy generated by the PV system and the electricity consumed by the household can be corrected with storage systems. In theory, this basic concept would require the examination of long time series of weather data and an optimization model in order to find a system configuration that actually fulfils the requirements of a household in a particular location. In practice, such detailed studies would be too expensive for small-scale installations and contractors take system sizing decisions based on empirical values or general sizing guidelines. Motivated by the project CrossEnergy, a research project that studies the future of the energy system in rural areas at the border between Germany and Czech Republic, and by the publication of the COSMO-REA high resolution regional reanalysis data sets for Europe in 2017, this study presents a methodology to generate maps indicating minimum battery and PV sizes for self-sufficient single family houses (SFHs). The methodology consist of three parts. First, settlement data extracted from the LUISA Territorial Modelling platform of the European Commission is used together with standard load profiles to generate spatiotemporal data sets of electricity demand for rural and low density urban areas. Second, spatiotemporal data sets of PV potential are generated based on a) a technical PV model, b) instantaneous solar irradiance and temperature data from the COSMO-REA regional reanalysis data, and c) snow cover data from the Land Surface Analysis Satellite Applications Facility. Third, a linear optimization model, relying on the data sets of the two previous parts, serves to define PV and battery systems sizes and to generate the corresponding maps. The resulting maps cover Germany and Czech Republic and are generated for multiple technical and weather dependent scenarios. The results show how complicated it could be to achieve a complete independence from the grid in certain locations and offer a scientifically based source of information for sizing PV-battery systems in the two countries. An outlook how to apply the methodology to the whole CORDEX Euro area and for future work is provided.