EGU General Assembly 2024

EGU24-5238, updated on 24 Mar 2025
https://doi.org/10.5194/egusphere-egu24-5238
EGU General Assembly 2024

High spatiotemporal resolution mapping of rooftop solar technical and deployment potential in China

Mai Shi and Xi Lu

Rooftop solar photovoltaics (RSPV) play a pivotal role in enabling countries and cities to transit to renewable energy and achieve net-zero emissions. Effective RSPV deployment hinges on understanding its spatiotemporal patterns and a city's capacity to integrate it, considering the challenges of supply-demand inconsistency and grid security. Despite its importance, there is a lack of high-resolution data on RSPV in terms of both power generation and accommodation potential.

From the perspective of RSPV technical potential, its assessment has much larger complexity than utility-scale PV systems, as individual rooftop rather than a large site serves as the smallest unit for the assessment. Given the difficulty in mapping rooftop and its available space for RSPV installation, high resolution mapping of RSPV technical potential of an entire large country remains challenging. Current literatures on this topic reach a spatial resolution on 10-100 km^2 scale, which is still hard to demonstrate details within cities, and fail to account rooftop availability for each individual pixel. From the perspective of RSPV deployment potential, current literatures tend to aggregate total RSPV supply with grid demand. As different types of buildings have different load intensity and patterns, such simplification would underestimate the variability of load-accommodation ability for RSPV.

To tackle these challenges, we develop an integrated framework that combines high-resolution RSPV potential assessment with consumption optimization based on building-related loads. For the technical potential evaluation, we employ a machine learning model, which integrates ~30 variables from different remote sensing images and spatial explanatory data, to quantify building rooftop area and height distribution on 1 km^2 scale. A rooftop availability analysis is then applied for each 1 km^2 pixel based on its building density, height and property. The RSPV capacity and hourly electricity potential are then calculated through combining available rooftop and radiation modelling. For the consumption analysis model, we first use building simulation to model the hourly power demand for different buildings (urban residential, public, industry and rural) in different cities. Combining hourly RSPV potential and building-related loads, we then optimize the RSPV deployment by profit maximization, with the constraint of a series grid-accommodation scenarios. Specifically, the grid-accommodation scenarios include minimum self-consumption and

maximum peak-valley difference.

We apply our framework to China as a case, with a potential mapping for 3,596,668 1*1km^2 pixels and deployment analysis for 369 prefecture-city for each kind of buildings. The results show that the total RSPV potential in mainland China amounts to 2785 GW, with 4631 TWh annual electricity potential. Urban residential, public, industry and rural buildings respectively takes up 7.6%、7.0%、24.9% and 60.5% for total potential. We quantify the deployable RSPV capacity under various local consumption and peak-valley difference constraints, ranking different building types in different cities based on levelized cost of energy (LCOE), value of solar (VOS), and emission reduction potential. The study concludes by discussing pathways to achieve renewable energy targets based on these findings.