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Spatio-temporal potential profiles for building, land and water-bound photovoltaic installations for future Dutch energy transition scenarios

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We construct a geodatabase of spatially resolved PV supply profiles for building, land and water-bound installations under typical meteorological circumstances. This is done for three 2050 energy transition scenarios, which are all in line with the Dutch Climate Agreement, but differ from each other regarding the degree of decentralization of electricity demand and supply.

Hourly global horizontal irradiation (GHI) measurements by 33 Dutch ground observation stations are gathered and linearly interpolated to obtain a raster dataset with a resolution of 25 km. GHI is converted to global tilted irradiation (GTI) for a multitude of slope and azimuth combinations by subsequently applying the Erbs diffuse fraction and Perez transposition models, thus generating a GTI lookup table.

By combining building polygons and a high-density LiDAR height point cloud, roof surface polygons characterized by a slope and azimuth are identified for all buildings in the Netherlands. Using the GTI lookup table, the solar resource on each of the roof surfaces is determined. Scenario-specific national PV capacities for residential and utility buildings are then distributed over neighborhoods proportional to the total yearly solar resource on their corresponding roof surfaces. The resulting neighborhood capacities are sub-distributed over slope-azimuth-positions by applying distribution ratios found in a large dataset on registered Dutch PV systems.

Scenario-dependent national capacities for field-bound PV (agriculture, roadside and dike) and inland water-bound PV are distributed over municipalities proportional to their corresponding suitable land use areas. Offshore PV capacity is kept on national level. All neighborhood and municipality capacities are converted to GTI. The building-bound profiles are then translated to PV supply by applying solar elevation angle dependent performance ratios and an assumed panel efficiency of 20%. The same is done for the land and water-bound profiles, only now assuming a constant performance ratio of 90%. Residential building-bound PV is fully allocated to the low voltage distribution grid. For the utility variant, the portion allocated to low voltage level is equal to the neighborhood floorspace share of utility buildings estimated to have a grid connection capacity of less than 300kW. The remainder is assigned to mid voltage level. Water and land-bound PV supply is apportioned to mid and high voltage level with a 3:1 ratio, except for the

offshore category, which is fully allocated to high voltage level.

Research results will be presented in the form of a country map and a cumulative distribution function (CDF) graph for; low voltage PV supply; mid voltage PV supply, low voltage self-sufficiency, and mid voltage self-sufficiency. All maps and CDF graphs provide information for all three 2050 scenarios, a 2030 scenario and the present situation.

The PV supply calculation module described above is part of our Advanced Scenario Management model. This model consists of a number of supply and demand modules (traditional building demand, heat pump demand, electric vehicle demand, PV supply and wind turbine supply), each producing low voltage (neighborhood), mid voltage (municipality) and high voltage (country) level electricity profiles. Together, they allow for supply-demand system analysis for multiple voltage levels and energy transition scenarios.