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Potential for deserts to supply reliable renewable electric power

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To avoid dangerous climate change, the electricity systems must be decarbonized by mid-century. The world has sufficient renewable electricity resources for complete power sector decarbonization, but an expansion of renewables poses several challenges for the electricity systems. First, wind and solar PV power are intermittent and supply-controlled, making it difficult to securely integrate this fluctuating generation into the power systems. Consequently, power sources that are both renewable and dispatchable, such as biomass, hydro and concentrating solar power (CSP), are particularly important. Second, renewable power has a low power density and needs vast areas of land, which is problematic both due to cost reasons and due to land-use conflicts, in particular with agriculture. Renewable and dispatchable technologies that can be built in sparsely inhabited regions or on land with low competition with agriculture would therefore be especially valuable; this land-use competition greatly limits the potential for hydro and biomass electricity. Deserts, however, are precisely such low-competition land, and are at the same time the most suited places for CSP generation, but this option would necessitate long transmission lines from remote places in the deserts to the demand centers such as big cities.

We therefore study the potential for fleets of CSP plants in the large deserts of the world to produce reliable and reasonable-cost renewable electricity for regions with high and/or rapidly increasing electricity demand and with a desert within or close to its borders. The regions in focus here are the European Union, North Africa and the Middle East, China and Australia. We conduct the analysis in three steps. First, we identify the best solar generation areas in the selected deserts using geographic information systems (GIS), and applying restrictions to minimize impact on biodiversity, soils, human heath, and land-use and land-cover change. Second, we identify transmission corridors from the generation areas to the demand centers in the target regions, using a GIS-based transmission algorithm that minimizes economic, social and environmental costs. Third, we use the multi-scale energy system model Calliope to specify the optimal configuration and operation of the CSP fleet to reliably follow the demand every hour of the year in the target regions, and to calculate the levelized cost of doing so, including both generation and transmission costs. The final output will show whether and how much reliable renewable electricity can be supplied from CSP fleets in deserts to demand centers in adjacent regions, at which costs this is possible, as well as a detailed description of the routes of HVDC transmission links. We expect to find that the potential for deserts to supply reliable CSP to the regions in focus is very large in all cases, despite the long distances.