Republic of china solar energy research and development

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We estimated the marginal abatement cost (MAC) at the plant level, which varies from -$166 per tCO2 to $106 per tCO2 in 2060 in our optimal path (Fig. 2a). For example, 77% of PV and wind power could be competitive against nuclear power with a lower MAC1. The average abatement cost (-$4.5 per tCO2) for 9.5 PWh of power generation is lower than a previous estimate ($27 per tCO2) under an 80% renewable penetration in China6. The MAC increases as the capacity rises owing to techno-economic limits and differences in the prices of the substituted fossil fuel (Extended Data Fig. 6). Such behaviour of the MAC indicates an increase in the costs to install higher capacities of PV and wind power34, even by considering the benefits of technological improvements26.

We predicted that 183 of 3,844 plants will be built with capacity >10 GW. The average abatement cost will decrease from $62 to $6 per tCO2 as the limit of capacity for individual plants increases from 0.1 to 10 GW (Extended Data Fig. 7). The feasibility of building large power plants in China could be supported by commissions of the Jiuquan onshore wind power plant at 20 GW and the Yanchi PV power plant at 1 GW, but it entails high requirements on grid integration, electricity transmission and initial investment38. Non-economic factors such as ecological preservation, engineering feasibility and political impediment deserve attention.

The gap between current decarbonization rates and the levels required to achieve carbon neutrality remains substantial8,9,10. China has been at the forefront of PV deployment since 2009 (ref. 27), accompanied by an accelerated growth of wind power1. Despite these accomplishments, it remains challenging to achieve carbon neutrality by 2060. As fossil fuels continue to dominate energy-related investments12, renewable growth could slow down as subsidies for companies generating PV and wind power decline20,21. Unlike previous studies1,2,6,27,28,29, our research reveals greater potential for PV and wind power generation in China, alongside the need for larger investment in power-system upgrades.

We optimized the increase in power capacity at an interval of 10 years during 2021-2060 because it generally takes 10 to 20 years for new technologies to be widely applied52. Given the variation of renewable energy within a decade, we performed a sensitivity experiment by optimizing the model at an interval of 5 years, in which the installed PV and wind power capacity and total costs both change moderately (Extended Data Fig. 8). Nevertheless, simulating the penetration of renewable energy within a decade will be useful to improve the optimization model.

We sought the optimal system for storing energy when building a new power plant using either mechanical storage (pumped hydro) with a lifetime of 50 years and a round-trip efficiency of 70% or chemical storage (batteries) with a lifetime of 15 years and a round-trip efficiency of 85% (see the parameterization of two systems in Supplementary Table 5) to minimize the LCOE (Extended Data Fig. 9).

Last, xx is calculated as a function of the total capacity of installed PV or wind power (Supplementary Method 8) based on the measured rates of learning in China (Supplementary Table 1). We examined the sensitivity to adopting the international rates of learning in our model (Fig. 2c).

For a new PV or wind power plant x, the annual generation of power was calculated:

in which i is a pixel, j is the number of hours in a year and Wi,j is the hourly generation of power in a pixel installing PV panels (calculated in Supplementary Method 3), onshore wind turbines (calculated in Supplementary Method 4) or offshore wind turbines (calculated in Supplementary Method 5). The parameters used to estimate the projected PV and wind power generation are listed in Supplementary Table 6.

The investment cost of a new PV or onshore wind power plant x was calculated6:

in which i is a pixel, Pi is the installed capacity of PV panels (calculated in Supplementary Method 3) or onshore wind turbines (calculated in Supplementary Method 4), Si is the area of pixels installing PV panels or wind turbines, Pfix is the capacity of a voltage transformer (300 MW), mfix is unit capital costs, mland is unit cost of land acquisition, mline is unit cost of line connection and mtran is unit cost of voltage transformation.

The investment cost of an offshore wind power plant x was calculated on the basis of the distance of offshore wind turbines in this power plant to the onshore power station57: