

Supporting Information for Requirement on the Capacity of Energy Storage to Meet the 2 °C Goal

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Supporting Figures

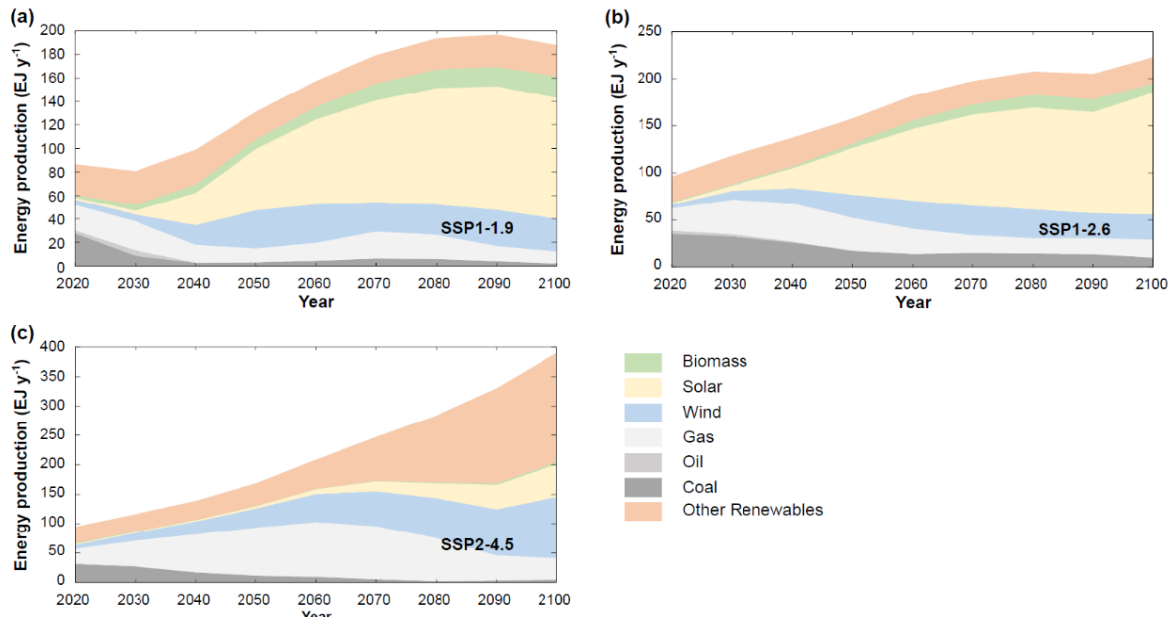


Figure S1. Projection of energy production in three Shared Socioeconomic Pathway (SSP) scenarios. The energy production by energy source during 2020–2100 is predicted under the scenarios of SSP1-1.9 (a), SSP1-2.6 (b) and SSP2-4.5 (c).

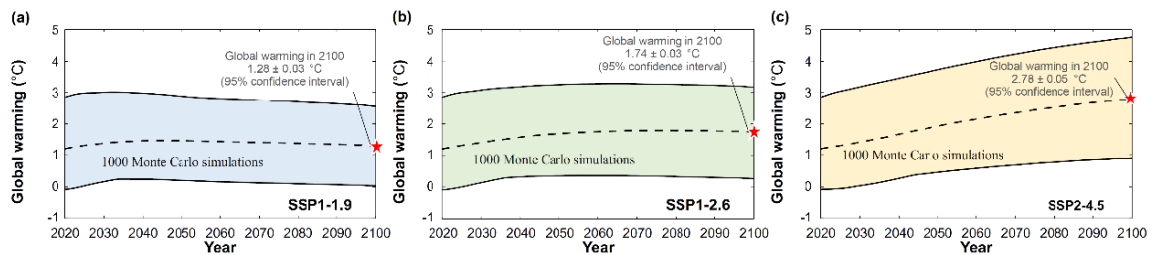


Figure S2. Projection of global warming in three Shared Socioeconomic Pathway (SSP) scenarios. The average estimate (dotted line) and the range (the shaded area) of global warming during 2020–2100 are predicted under the scenarios of SSP1-1.9 (a), SSP1-2.6 (b) and SSP2-4.5 (c) by running Monte Carlo simulations 1,000 times with the OSCAR model.

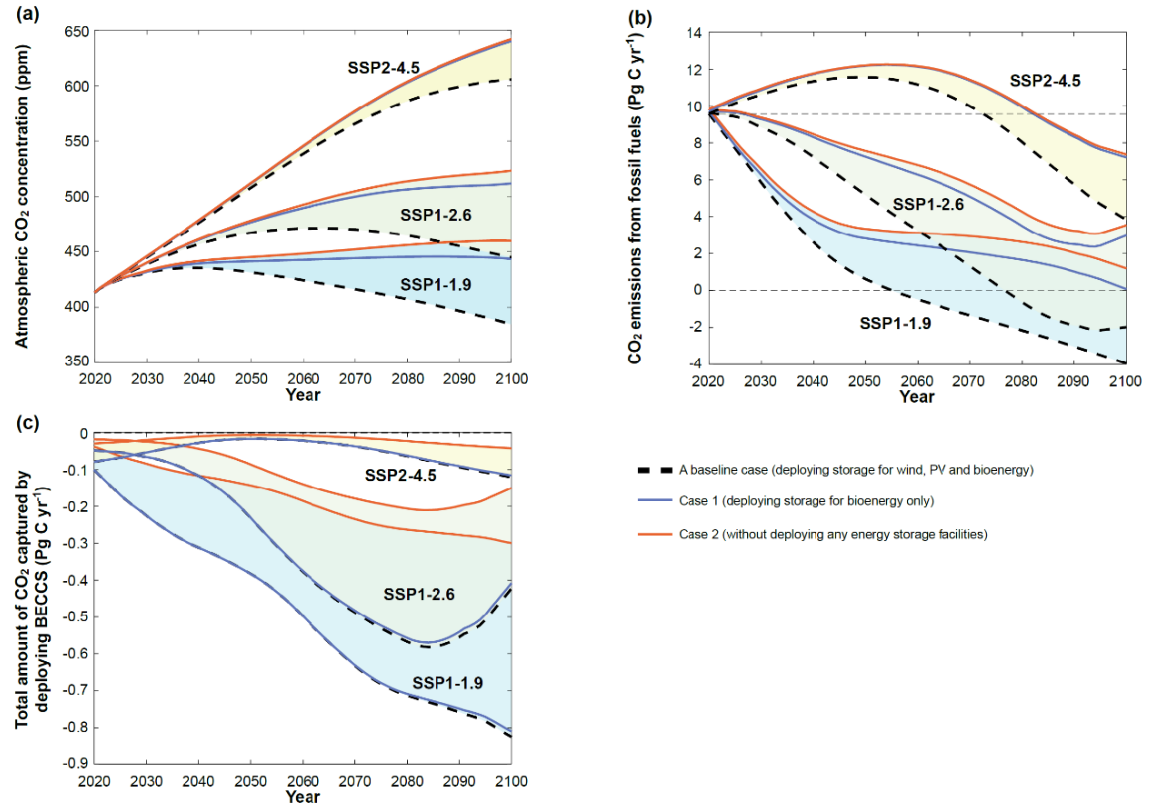


Figure S3. Projection of atmospheric CO₂ concentration and CO₂ emissions in three Shared Socioeconomic Pathway (SSP) scenarios. Atmospheric CO₂ concentration (a), fossil fuel emissions (b) and the amount of CO₂ captured by deploying BECCS (c) during 2020–2100 are predicted under the scenarios of SSP1-1.9, SSP1-2.6 and SSP2-4.5. The dotted black line denotes a baseline case fulfilling the demand for energy storage of wind, PV and bioenergy, while the blue line denotes a case satisfying the demand for storage of bioenergy only (Case 1). The red line denotes a case without deploying any energy storage facilities (Case 2).

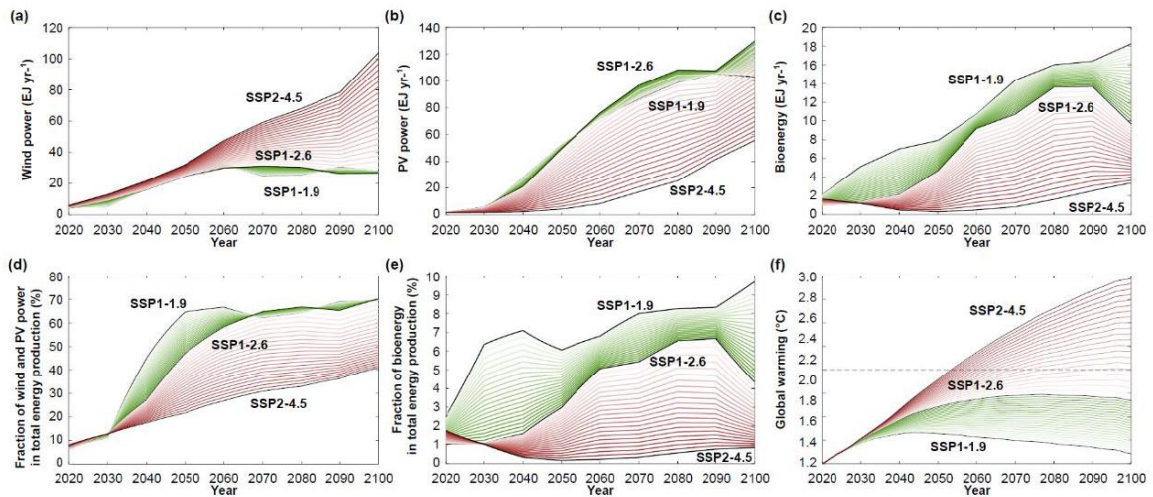


Figure S4. Interpolation of wind, PV and bioenergy between any two neighboring Shared Socioeconomic Pathway (SSP) scenarios. Wind (a), PV (b), bioenergy (c), the fraction of wind and PV power in total energy production (d), the fraction of bioenergy in total energy production (e), and global warming (f) during 2020–2100 are predicted by applying a simple interpolation between SSP1-1.9 and SSP1-2.6 (green lines) and between SSP1-2.6 and SSP2-4.5 (red lines).

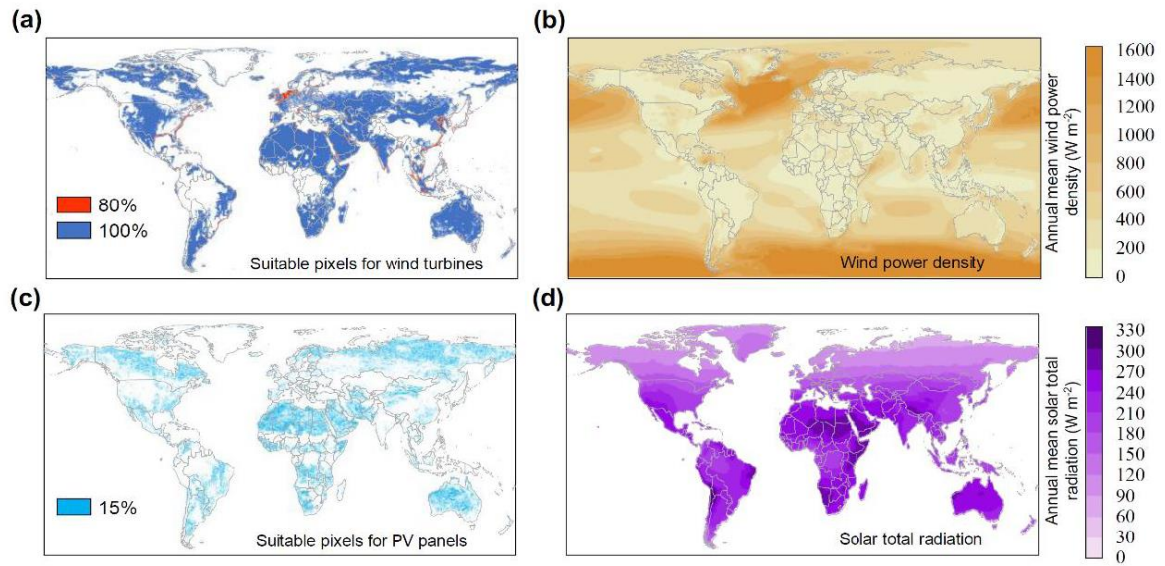


Figure S5. Global distribution of wind and solar resources. (a) Pixels that are suitable for installing onshore or offshore wind turbines. (b) Annual mean wind power density during 1981–2020 at a spatial resolution of $0.5^\circ \times 0.625^\circ$. (c) Pixels that are suitable for installing PV panels. (d) Annual mean solar total radiation during 1981–2020 at a resolution of $0.5^\circ \times 0.625^\circ$.

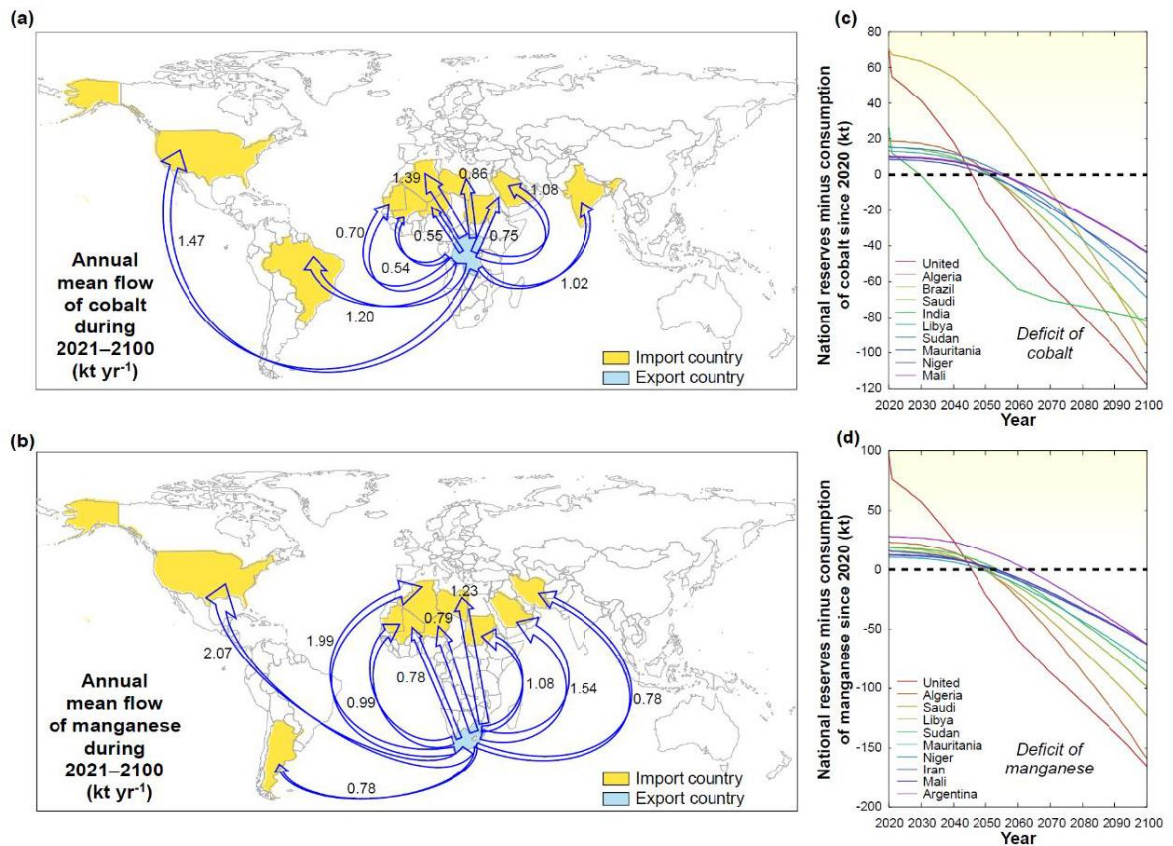


Figure S6. International trade of cobalt and manganese in the 2°C case under the SSP1-2.6 scenario. (a, b) Annual mean flows of cobalt (a) and manganese (b) during 2021–2100 from the country with the highest reserve to ten countries with the largest consumption minus reserve. (c, d) Reserve minus consumption of cobalt (c) and manganese (d) in ten countries with the largest consumption minus reserve.

Supporting Tables

Table S1. Thresholds of screening pixels that are suitable for installing wind turbines and PV panels.

Variables		PV panels	Onshore wind turbines	Offshore wind turbines
Suitability factor (%)	Forest	0	0	0
	Closed Shrubland	0	0	0
	Open Shrubland	15	100	0
	Woody savanna	15	100	0
	Savanna	15	100	0
	Grassland	0	100	0
	Wetland	0	0	0
	Croplands	0	100	0
	Urban	0	0	0
	Vegetation mosaics	0	100	0
	Snow, ice	0	0	0
	Deserts	15	100	0
	Water bodies	0	0	100
	Slope (%)	<5	<20	—
Aspect (°)	in the Northern Hemisphere	90°–270°	—	—
	in the Southern Hemisphere	0°–90° or 270°–360°	—	—
Solar radiation (hour d ⁻¹)		>4.2	—	—
Annual average capacity factor (%)		—	>20	—
Surface air temperature (°C)		> 0	—	—
Altitude above sea level (meter)		—	<3000	—
Water depth in the ocean (meter)		—	—	≤60
Fraction of electricity loss in the transmission from offshore wind turbines to onshore stations (%)		—	—	<10
Natural reserve		Excluding terrestrial and marine reserve		
Mask of territorial seas		—	—	Within Exclusive Economic Zone
Shipping routes		—	—	Excluding 20% area of pixels with SO ₂ emission rate > 10 ⁻¹¹ kg m ⁻² s ⁻¹