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Widespread Irreversible Changes in Wind Energy Resources under Negative CO_2 Emission Scenarios

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Climate change affects both energy demand and renewable resources such as wind and solar power. A global climate model ensemble analysis indicates that up to ~40% of non-Antarctic land areas may face significant supply–demand match (SDM) reductions by century's end under intermediate emission scenarios. At northern mid-to-high latitudes, smaller and more variable renewable supply reduces SDM, though lower heating demand partly offsets this. At lower latitudes, rising cooling demand outweighs supply gains, causing major SDM losses. Long-term wind resources show strong hysteresis: about 59% of land areas fail to return to historical potential even if atmospheric CO_2returns to pre-industrial levels. This irreversibility is evident in the Central U.S., Argentina, South Australia, and Central Africa, while Western Europe and South Asia show weaker or opposite trends. These findings highlight climate-driven shifts in both supply and demand and the limited reversibility of wind, underscoring the urgent need for adaptive energy policy and infrastructure planning.

Keywords: Negative Co_2 emission, wind energy, supply-demand, wind speed.