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Estimating maximum global wind power availability and associated climatic consequences

Lee Miller, Fabian Gans, and Axel Kleidon
Max Planck Insitute for Biogeochemistry, Jena, Germany (lmiller@bgc-jena.mpg.de)

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Wind speed reflects the continuous generation of kinetic energy and its dissipation, primarily in the atmospheric boundary layer. When wind turbines extract kinetic wind energy, less kinetic energy remains in the atmosphere in the mean state. While this effect does not play a significant role for a single turbine, it becomes a critical factor for the estimation of large-scale wind power availability. This extraction of kinetic energy by turbines also competes with the natural processes of kinetic energy dissipation, thus setting fundamental limits on extractability that are not considered in previous large-scale studies [1,2,3].

Our simple momentum balance model using ECMWF climate data illustrates a fundamental limit to global wind power extractability and thereby electricity potential (93TW). This is independent of engineering advances in turbine design and wind farm layout. These results are supported by similar results using a global climate model of intermediate complexity. Varying the surface drag coefficient with different simulations allows us to directly relate changes in atmospheric and boundary layer dissipation with resulting climate indices and wind power potential.

These new estimates of the maximum power generation by wind turbines are well above the currently installed capacity. Hence, present day installations are unlikely to have a global impact. However, when compared to the current human energy demand of 17TW combined with plans by the US and EU to drastically increase onshore and offshore wind turbine installations [4,5,6], understanding the climatic response and ultimate limitations of wind power as a large-scale renewable energy source is critical.

[1] Archer, C., and M.Z. Jacobson, (2005) Evaluation of global wind power, J. Geophys. Res. 110:D12110.
[2] Lu, X., M.B. McElroy, and J. Kiviluoma, (2009) Global potential for wind-generated electricity, Proc Natl Acad Sci, 106.
[3] Liu, W.T., W. Tang, and X. Xie, (2008) Wind power distribution over the ocean, Geophys. Res. Lett., 35 L13808.
[4] IPCC, (2008) IPCC scoping meeting on renewable energy sources - proceedings, Intergovernmental Panel on Climate Change
[5] U.S. Department of Energy, (2008) 20% wind energy by 2030: increasing wind energy's contribution to U.S. electricity supply, U.S. Dept. of Energy - Energy Information Administration.
[6] EEA, (2009) Europe's onshore and offshore wind energy potential, European Environment Agency, ISSN 1725-2237.