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Desirable vs. likely: modeling feasible wind power potentials

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Assessments of the potential for wind turbine deployment have become a very active research field in spatial and temporal modeling. Initially, such studies assessed geographical, technical and wind resource potentials, with the objective to identify where wind turbines could in principle be erected. Together with further assumptions, for example on grid connection cost, this served as a prime input for power system models, which used results from studies of feasible potentials as upper limits on deployable capacities.

However, increasing opposition against new wind power projects has demonstrated the limitations of such assessments. In response, the research community developed novel methods to include social constraints in assessments of wind energy potentials. In many instances, this amounted to predicting whether wind turbines could be installed at a specific location, ultimately indicating the eligibility of a location for wind power by a binary categorization.

Another strand of literature sought to determine (socially) desirable allocations of wind turbines rather than predicting possible ones. While these attempts also respect binary geographical and technical constraints on wind power deployment, the desirability of a certain allocation of wind turbines results from the trade-off between corresponding benefits and (negative) impacts, assessed either implicitly in a welfare-framework or explicitly within a multi-criteria analysis.

We argue that predictive approaches are not suitable as a basis for further normative analysis in energy system models. Predictive analysis does not consider effects that are external to the modelled agents' decisions and is thus not compatible with weighing benefits and cost, arising for example from impacts on the environment, in a broader perspective.

To facilitate analysis, we see several avenues for improvement:

- Assessments should clearly state if they aim at predicting the spatial allocation of wind parks or if they model desirable allocations. If resulting wind potentials are used in energy system models, which are designed to model desirable future states of the energy system, we understand that predictive modeling on the side of spatial wind power allocations is incompatible with a general normative modeling approach.
- Binary land-eligibility studies may suffer from conceptual flaws if continuous measures are mapped to binary categorizations. We therefore propose to use binary indicators only in cases when wind turbine deployment is ruled out with high degrees of certainty (such as technical or

legal restrictions). This helps to decrease the computational complexity. To integrate trade-offs of different spatial allocations of wind parks in normative energy system models, continuous indicators such as wind resources or impacts of wind parks need to be assessed separately.

- Standard criteria for wind potential assessments should be amended by (i) largely neglected issues of human land-use and land-tenure, which are particularly important in countries where land tenure rights are insecure and different land use interests compete and (ii) assessments of wind park impacts on the quality of neighboring ecosystems. Integrating these insights into prospective modeling studies is of high relevance as climate change mitigation and biodiversity preservation should go hand in hand when modeling the energy transition.