Renewable energy and CCS in German and European power sector decarbonization scenarios

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Summary

In order to avoid unmanageable impacts of anthropogenic climate change, it is necessary to achieve substantial CO2 emission reductions in all energy sectors. Due to salient decarbonization options such as renewable energy technologies and carbon capture and storage (CCS), the power sector plays a major role in climate change mitigation strategies. However, these options come with a set of challenges: the output of wind and solar energy varies in time and space and CCS faces technical challenges and public acceptance problems.

This thesis develops power sector decarbonization scenarios for the EU and Germany while taking into account both the interplay of renewable energy technologies and CCS as mitigation options as well as the technical challenges of renewable energy integration. More specifically, a series of model based studies address the respective roles of CCS and renewable energy technologies in emission reduction strategies while evaluating technical integration options such as transmission, storage and balancing technologies.

Results show that large-scale expansion of renewable energies will play the main role in power sector decarbonization scenarios, but the availability of CCS could lead to lower total costs and easier reaching of emission reduction targets through compensation of emissions generated by balancing technologies. Long-distance transmission enables better siting of renewable energy and thus higher achievable renewable shares in power generation and higher capacity factors. These indirect effects of delayed expansions induce additional power system costs, which are high relative to investment costs for new transmission lines. Results also reveal a preference for flexible technologies in combination with high shares of renewables for balancing purposes rather than inflexible baseload plants. The case studies presented for the German and European power sectors show that a large-scale decarbonization is achievable through large shares of renewable energy technologies for electricity generation. CCS is not a prerequisite for successful CO2 emission strategies in neither area, but allows reaching mitigation targets at a lower cost. A portfolio of renewable energy integration options is essential to manage temporal and spatial fluctuations; the optimal technology mix is determined by the underlying power system.