POWER SECTOR DECARBONIZATION – WHICH TECHNOLOGIES MATTER?

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Overview

A number of studies agree that power sector decarbonization is a low-hanging fruit on the way to stringent climate targets (Luderer et al 2012, Krey et al 2014), but countries differ strongly in which technologies they put their hopes on. We here analyze which technologies can be expected to contribute most to the cost-efficient decarbonization of the power sector, given that an overall stringent climate target is to be met. This discussion can help policy-makers to prioritize research and regulation needs for the most relevant technologies, and to better understand the basic technology characteristics required by future power systems. The current study provides new insights because the power sector is embedded in an intertemporal model with full energy system representation. Therefore, all relevant interactions between the different energy sectors like resource scarcities, capital requirements, or deployment bottlenecks, are endogenously included in the model.

Methods

We employ the hybrid energy-economy model REMIND (Leimbach et al 2010) to analyze cost-optimal long-term climate mitigation scenarios for 11 world regions. ReMIND calculates amount and timing of investments in different energy technologies by intertemporally optimizing utility under the constraint of a maximum global mean temperature increase of 2°C until 2100. The model includes a wide range of energy technologies, and explicitly models technology development through endogenous learning-by-doing via learning curves.

To analyze the relevance of different technologies for the decarbonization of the power sector, we run a number of scenarios in which we exclude certain technologies, and observe how these technology exclusions influence future electricity prices. We also discuss limiting factors to deployment for the different technologies, and investigate how the interaction with the rest of the energy system prevents some technologies from assuming a major role in future electricity sectors.

Results

According to preliminary results, excluding the variable renewable energy (VRE) technologies PV, CSP and wind increases long-term power prices by a staggering 600% over 2010 values. In contrast, excluding CCS or nuclear only increases long-term prices by about 100%, which is comparable to prices in mitigation scenarios with all technologies available. The limited power sector reaction to the exclusion of CCS can be explained by the substantial competition for carbon sequestration sites from the rest of the energy sector, namely industry, residential, and transport energy demand. Among the VRE technologies, it is crucial to have at least one solar technology available and deployed at large scale to keep electricity prices from rising substantially. The main challenge for the wide-spread use of variable renewable energies is the availability of flexibility options like storage, demand-side response or improved connections between the power sector and other parts of the energy system, which should therefore also remain

Conclusions

If a stringent climate target of 2°C is to be met, the VRE technologies PV, CSP and wind are the most relevant technologies for reducing power sector emissions. While biomass and CCS are expected to be crucial for the cost-efficient decarbonization of heat and liquid fuel supply, both technologies do not seem to play a significant role for the power sector. It might thus be advisable to shift the focus of research and regulation from CCS for power plants to CCS in combination with biofuel production.

References

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