MODELLING GERMANIES ENERGY TRANSITION WITHIN A 1.5°C-CO2-BUDGET

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Overview

To restrict global warming to 1.5°C, greenhouse gas emissions must decline rapidly. The IPCC published remaining global CO2 budgets to limit global warming to a certain temperature increase. However, allocating national CO2 budgets is an open debate. Moreover, analysis of transition pathways using one integrated model that restricts national emissions to a 1.5°C budget are missing.

We discuss different approaches to derive a national CO2 budget for Germany. The energy system model REMod is used to model possible long-term transition pathways for Germany within its national 1.5°C-CO2-budget. Model results show that rapid action in all aspects of the energy system and fundamental changes in energy policy are needed to comply with the remaining CO2-budget: annual capacity additions of renewable energy sources (wind and solar) need to increase, direct electrification of all sectors needs to be accelareted by an exchange of technologies even before the end of their lifetime (e.g. gas boilers and ICE vehicles) and demand needs to decrease through behavioural changes in the society (sufficiency).

Methods

In this work the energy system model REMod is used to analyse long-term transition pathways of the German energy system. REMod simulates the energy system each year with an hourly resolution and uses an optimization algorithm to find the cost-optimal transformation path of a given scenario. The simulation includes all demand sectors (industry, transportation, buildings) as well as coupling of the sectors. The optimization determines yearly capacity additions for multiple power plant types and energy conversion technologies as well as exchange of technologies in the demand sectors. This approach of simultaneously optimizing all sectors of the energy system distinguishes REMod from other energy system models and makes it possible to analyse mutual influences of the different sectors.

Modelling of different scenarios is done by restricting CO2-emissions to a budget along the transition pathway. By setting further parameters like minimal and maximal yearly capacity additions in the supply sector and market shares in the demand sectors different technological foci or societal trends can be analysed.

Results

To restrict German CO2-emissions to a national CO2-budget that is in line with the 1.5°C-goal, rapid and unprecedented transformation in all aspects of the energy system is needed. This goes beyond recent studies that analyse the German energy transformation in line with its national CO2-reduction goals, i.e. with a larger CO2-budget. The current state of research outlines different scenarios with different transformation pathways where shortfalls in some aspects can be met by stronger efforts in other sectors, e.g. shortfalls in increase of wind power can be met by an increase of solar power and sufficiency measures can (optionally) support the transformation. A fundamental assumption in these scenarios is that technologies in the demand sectors are only exchanged at their end of lifetime.

Restricting national CO2-emissions to a 1.5°C-budget with equal per-capita emissions around the world lets the different scenarios collapse to one pathway: the addition of renewable energy capacities and exchange of technologies in the demand sectors need to reach an unprecedented pace where shortfalls in one technology cannot be met by further efforts in other aspects of the transformation. Moreover, in a 1.5°C-scenario fossil technologies like gas boilers in the building and industry sectors and ICE vehicles in the transportation sector need to be replaced by fossil-free technologies before their end of lifetime thus breaking the fundamental assumption in conventional scenarios. Additionally, a rapid decline in energy demand through sufficiency measures like reduction of private transport, reduction of living space per capita and creating a circular economy is inevitable.

Conclusions

While current analyses of transition pathways of the energy system focus on legal CO2-reduction targets, we model for the first time the transition given a national CO2-budget for Germany that is in line with restricting global warming to 1.5°C. As this target is much more ambitious, the transition is only possible if besides a massive increase of renewable energy capacities an accelerated exchange of technologies in the demand sectors is forced and the energy demand is reduced by behavioural changes in the society. This means a fundamental change not only in energy policy, but in all aspect of society and our daily life would be needed.

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