HOW DOES INERTIA IN BUILDINGS ENERGY USE AFFECT THE ACHIEVABILITY OF AMBITIOUS CLIMATE TARGETS?

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Overview

Achieving ambitious climate targets requires full decarbonization of socio-economic systems by mid-century. In order to reach full decarbonization until that date, early and deep reductions of greenhouse gas emissions are crucial. However, concerns arise as for the economic, social and technical feasibility of such transitions. In particular, buildings' energy demand, which was responsible for approximately 20% of GHG emissions in 2010, might be difficult to reduce in the short-term because of the low turnover of the buildings stock. Improvement of insulation in dwellings and offices, installation of more efficient air conditioners and boilers happens as buildings are renovated with typical renovation rates of buildings of 1-3% per year.

One of the most important tools to assess the socio-economic achievability of stringent climate targets are Integrated Assessment Models (IAMs) which combine representations of energy systems, macro-economic dynamics and climate models. These models project pathways for energy systems which are compatible with climate targets at the least cost. While many IAMs take into account the path-dependencies in the energy production system, path-dependencies in energy demand systems, including buildings, are only rarely represented. By overlooking path-dependencies in this sector, IAMs might overestimate the short-term potential of energy demand reductions from buildings and thus underestimate the challenge ahead of full decarbonization.

In this study, we integrate path-dependency dynamics in buildings in an IAM model to better assess the potential of short term energy demand reductions from buildings, and the consequences for the achievability of stringent climate targets.

Methods

We use the model REMIND (Leimbach et al. 2010) to evaluate the achievability of the 1.5°C climate target in the presence of inertia in the buildings sector. REMIND is an integrated energy-economy general equilibrium model with a detailed representation of the energy supply system and a synthetic representation of energy demand sectors—buildings, industry and transports. REMIND computes GHG emissions from the energy system, the agricultural and land-use sectors.

Inertia in buildings' energy efficiency development is introduced through a putty-clay representation (Atkeson and Kehoe 1999). The model has the liberty to choose the level of energy efficiency investments in buildings' insulation for the building stock being built or renovated. The existing building stock which is not renovated keeps its past energy consumption properties. The model decides endogenously upon the optimal level of investments for the new or renovated building stock. The degree of inertia is represented explicitly through the renovation rate of the existing building stock.

In addition, the model REMIND represents crucial path-dependencies of the energy supply system through investment dynamics for individual conversion and distribution technologies, learning-by-doing cost curves, or constraints on ramp-up rates of innovative technologies. These path-dependencies are highly relevant for a realistic analysis of stringent climate targets, which require rapid transformations of energy systems to limit emissions. The model is linked to a reduced climate model, so that it is well suited for the investigation of energy demand and supply pathways consistent with specific climate targets (Luderer et al. 2013).

Results

Preliminary findings show that inertia in the buildings sector could limit the potential for rapid reductions in energy demand. When inertia in buildings is not taken into account, the model can achieve a short term reduction of demand of 20% compared to the baseline. When inertia in buildings is taken into account, this figure drops to 10%.

The model shows in addition that short term energy demand reductions are very sensitive to the assumption on the renovation rate. When doubling the renovation rate, the reductions increase by a factor of little less than two. In the long term however, the energy demand reduction is comparable across scenarios, irrelevant of the strength of inertia assumed. This comes from the similar elasticity of substitution between efficiency investments and energy consumption for renovated and new buildings.

Importantly, these results differ largely across regions. In developed countries where building stocks expand only moderately, energy characteristics of buildings can mainly be modified through renovations, which imply slow improvements due to long turnover cycles. In developing countries, where the buildings stock expands, inertia does not hamper strong modifications in energy characteristics of buildings. Developing countries conserve much of their potential to reduce energy demand compared to the case without inertia representation.

The cost of carbon, which measures the economic difficulty of achieving the 1.5°C climate target, increases however only moderately when the degree of inertia increases, meaning that other mitigation options can compensate for the lower energy demand reductions in buildings.

Conclusions

Rapid decarbonization of socio-economic systems is necessary to limit global warming to low levels. Socio-economic and technical barriers to rapid decarbonization are hence an important element to consider for the achievability of ambitious climate targets. In particular, the pace of buildings' energy demand reduction is constrained by the pace of renovation and construction of new buildings.

This study investigates the role of inertia in buildings for the achievability of ambitious climate targets. It uses the Integrated Assessment model REMIND and introduces a representation of path-dependencies in buildings.

We find that if we implement inertia in buildings' efficiency improvements according to rates observed in the past, this restricts energy demand reductions in the short term and raises the hurdle for achieving ambitious climate targets. Short-term energy demand reductions are a crucial element of climate policy as energy supply systems require time to decarbonize – which means that in the next decades, the carbon footprint of final energy will remain high and energy demand reductions will save high amounts of emissions. Early reductions of energy consumption therefore give more leeway to remain within the limits of tight carbon budgets.

We show that raising renovation rates constitutes a policy with high impact on the short-term potential for energy demand reductions in buildings, with reductions rising by a factor close to two when doubling the renovation rate.

These findings have important implications for policy-making. First, previous IAM scenarios may have been overly optimistic concerning short-term demand reductions in scenarios with ambitious climate targets. Second, increasing the refurbishment rates is a key priority for near-term policies.

References

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