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Early policies can close the gap to 1.5°C

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We compare five integrated assessment models that have been improved in a number of aspects to analyze the effects of early climate policies targeting production and energy supply, consumption and energy demand, and the land sector. We find that the combination of these early policies can close the gap between well-below 2°C and 1.5°C pathways using the same carbon price trajectory. While production and energy supply policies are necessary to decarbonize the energy sector in the long run, consumption and demand-side transformations can reduce emissions especially in the short-term, thus enabling lower cumulative emissions leading to lower peak temperature. Additional land policies can not only reduce CO₂ emissions further, but also target non-CO₂ emissions.

Introduction: Current climate policies are not consistent with the 1.5°C limit in almost all countries. If carbon prices are implemented at all, they are too low and there seems to be reluctance to increase carbon prices to levels that would lead to a 1.5°C pathway. Yet early and rapid emissions reductions as mandated by the Paris Agreement and national and regional targets as the EU Green Deal require to draw on advanced emission reduction measures across the board. In this study, we investigate how early policies leveraging advanced emissions reduction measures on the producer and consumer side as well as in the land sector can close the gap between well below 2°C and 1.5°C pathways without increasing the carbon price. For our analysis we use a comparison of five integrated assessment models (IAMs) that have been improved in a number of aspects within the Horizon 2020 funded project NAVIGATE, including enhanced sector representation, updated GDP and population projections, or new marginal abatement cost curves (MACCs) for non-CO₂ greenhouse gas (GHG) emissions.

Methods: For this study, we focus on three dimensions of advanced emission reduction measures as early policy entry points: advanced consumption and demand transformation in the energy system

(AdvCD), advanced production and energy supply transformation (AdvPE), and advanced mitigation measures in the land sector, including both production and consumption measures.

On the demand side, these emission reduction measures include consumer-facing measures relating to both efficiency improvements and behavioral changes towards lower energy demand, e.g. faster buildings renovation and better insulation for new constructions, efficiency improvements in the transport sector, but also reduced passenger and freight transport, transport modal shifts (e.g. bicycle, public transport), lower floorspace per capita, and a shift in setpoint temperatures. On the production and energy supply side, the measures include a rapid decarbonization of electricity generation, a push for more direct and indirect electrification in all sectors, and significant deployment of carbon capture and storage (CCS). Though electrification in the buildings and transport sector ultimately requires changes in consumer behavior, it can also be seen as change in energy technologies and also requires the adoption of new technologies. We therefore include electrification measures in the production and energy supply side. Finally, measures in the land-use sector range from advanced measures in reducing non-CO₂ GHG emissions modelled via more optimistic MACCs and inclusion of peatland protection and restoration as well as additional land-sharing carbon dioxide removal (CDR) methods to dietary changes and reduced food waste both at household levels and farms or processing retail.

We combine these three dimensions to five scenarios (see Tab. 1): a “Default” without any advanced mitigation measures, advanced consumption and demand transformation in the energy system (AdvCD), advanced transformation of production and energy supply (AdvPE), the combination of both (AdvEn), and the combination plus advanced transformation in the land sector (AdvEnL). All scenarios follow the same carbon price trajectory, which is defined by the “Default” scenario with a carbon budget of 900 GtCO₂ from 2020 on that is not to be exceeded at any point in time. This corresponds to a high probability (>80%) of remaining below 2°C^{1,2}.

	Default Production & Energy	Advanced Production & Energy	Advanced Production Energy & Land
Default Consumption & Demand	Default	AdvPE	
Advanced Consumption & Demand Transformation in the Energy System	AdvCD	AdvEn	
Advanced Consumption & Demand in Energy and Land			AdvEnL

Table 1: Scenario design.

Results: We find that an advanced transformation of production and energy supply (AdvPE) reduces global CO₂ emissions in 2050 stronger than an advanced transformation of consumption and demand in the energy system (AdvCD), and already to levels comparable to the combination of both (AdvEn) (Fig. 1a). However, the energy demand reductions associated with the AdvCD scenario make a notable effect in 2030, when the energy system is not yet decarbonized. Therefore, AdvCD and AdvPE complement each other in 2030, with the combination enabling lower short-term targets than AdvPE alone which translate to lower cumulative emissions (Fig 1b) and therefore lower peak temperature. Both, producer-facing and consumer-facing policies are therefore needed to reduce the peak budget to a level almost compatible with the 1.5°C budget. Additional land policies (AdvEnL) can reduce emissions further and close the remaining gap of the CO₂ budget to 1.5°C. In addition, non-CO₂ greenhouse gas (GHG) emissions are reduced below the levels of all other scenarios, leading to a further reduction of peak temperature.

As expected, the AdvPE scenario targets mainly emission intensity by reducing fossil energy and increasing the expansion of renewable energy and electrification. The AdvCD scenario on the other hand reduces energy intensity, in particular in the buildings and residential sector.

When looking into the demand sectors, we see that in contrast to total CO₂ emissions, the AdvCD scenario reduces emissions in 2030 in the buildings and transport sectors to a comparable level as AdvPE and AllEn (Fig. 2), with significant effects still visible in 2050. Unsurprisingly, there are hardly

any effects in the industry sector, which could only be affected via reduced material demands, but these effects are beyond this study.

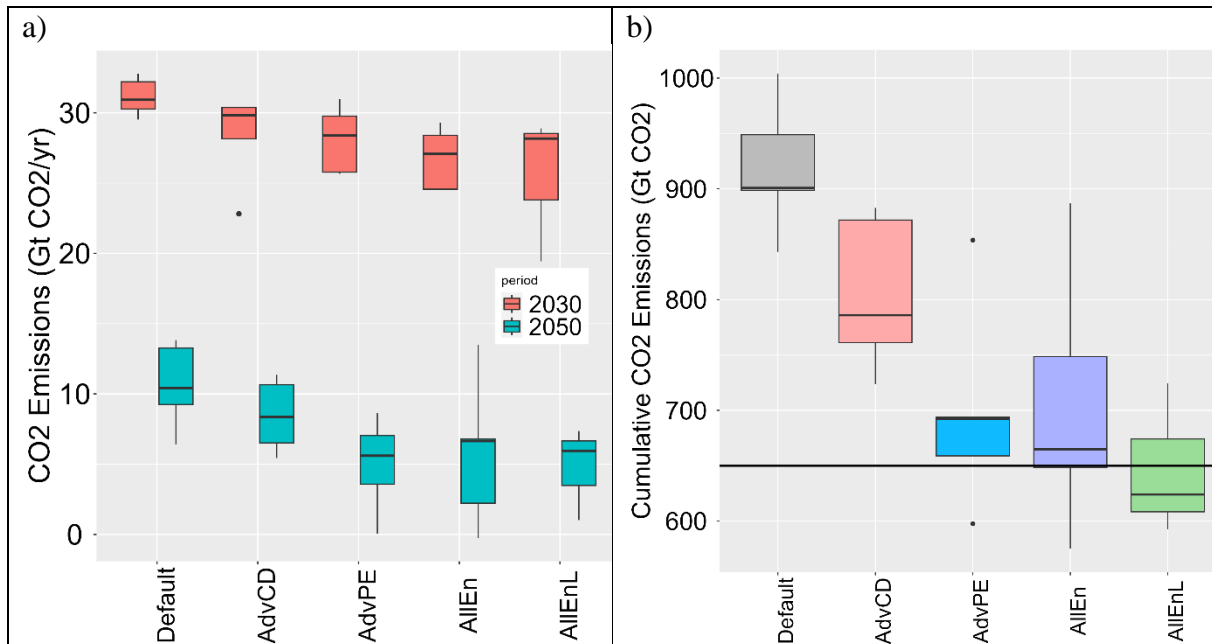


Figure 1: a) Global annual CO₂ emissions in 2030 (orange) and 2050 (blue) and b) global cumulative CO₂ peak budget from 2020 onwards for a well-below 2°C scenario (Default), and four scenarios following the same carbon price, but adding policies to enhance decarbonization of production and the energy supply side (AdvPE), for advancing consumption and demand transformation (AdvCD), a combination of both (AllEn), and with additional land policies (AllEnL). The black line indicates the global CO₂ peak budget consistent with 1.5°C with low overshoot (650 GtCO₂).

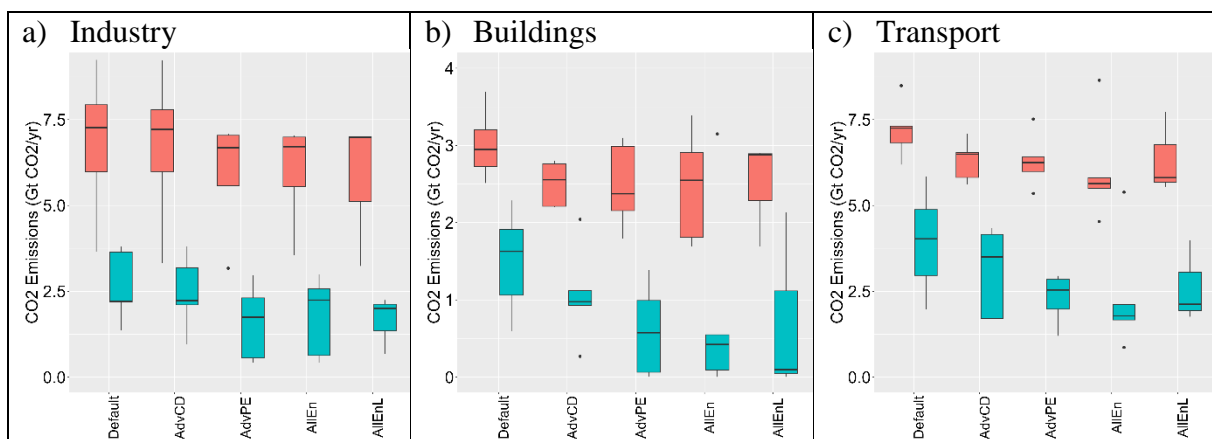


Fig. 2: Global CO₂ emissions in 2030 (orange) and 2050 (blue) for all scenarios for a) industry, b) buildings, c) transport.

Discussion and conclusion: Early policies targeting production and energy supply as well as consumption and demand transformation can close the gap between a pathway on track for well-below 2°C and a pathway compatible with reaching 1.5°C. Both dimensions are needed, as the production and supply side transformation is indispensable to reach the industry sector and to decarbonize all sectors in the long run. Energy demand reductions can reduce emissions especially in the short term, when the energy system is not yet decarbonized and therefore allow for lower short-term targets and lead to lower cumulative emissions and thus lower temperature. However, the fast energy demand reductions observed in the scenarios may be hard to achieve in the real world as

behavior can be very inert and changes don't happen by themselves. Additional agriculture and land use policies can have a large impact not only on CO₂ emissions, but also on CH₄ and N₂O, leading to a further reduction of global mean temperature.

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