Energy policy: Demand-side policies can significantly reduce emissions from energy use in buildings and transport

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Standfirst

Large emission reductions in buildings and transport are possible by integrating demand-side strategies to electrify energy use, improve technological efficiency, and reduce or shift patterns of activity. With enabling policies and infrastructures, final energy users can make significant contributions to climate goals, particularly through widespread deployment of heat pumps and electric vehicles.

Based on van Heerden et al. (2025), Demand-side strategies enable rapid and deep cuts in buildings and transport emissions to 2050. Nat Energy [DOI]

Messages for Policy

- Developing targets and corresponding policies to increase the share of electricity and sustainable fuels in energy-using sectors globally will yield significant emission reductions, especially in the medium term.
- Adopting a mix of policy measures, including both technological solutions and in support of behavioral changes, can alleviate the burden of mitigation on energy supply and infrastructure.
- End-use policies, such as efficiency improvements and promoting electrification, mostly interact synergistically with minimal trade-offs. A coordinated mix of these policies accelerates decarbonization.
- Transformative changes in buildings and transport can significantly reduce emissions. Key actions include electrification, smarter use of space, better insulation, enhanced vehicle efficiency, less driving, more biking, and better public transport.

The policy problem

The Paris Agreement sets a goal to keep global warming well below 2 °C. However, model projections show that this goal is unlikely to be met with current climate policies and actions, indicating a need for additional strategies to further reduce greenhouse gas (GHG) emissions. Alongside technological supply-side solutions to transition away from fossil fuels, for example with the adoption of renewable energy sources in electricity generation, demand-side strategies involving energy users in sectors like buildings and transport can contribute significantly to emission reductions. Direct emissions from energy use in buildings and transport account for over 20% of global GHG emissions. In buildings, measures such as electrifying energy use through heat pumps, improving insulation, and reducing energy demand through behavioral shifts can significantly lower emissions. Similarly, in transport, electrifying vehicles, enhancing efficiency, and promoting mode shifts to public transit or active modes like cycling can drastically reduce emissions. Determining the most cost-optimal and effective policy mix is a complex systems problem.

The findings

Our analysis shows that a comprehensive set of measures involving end users can reduce sectoral CO_2 emissions by 51-85% in buildings and 37-91% in transport by 2050, compared to a scenario based on current policies (Fig 1). Electrifying energy end-use and switching to alternative fuels delivers the largest emission reductions, though also lead to increases in electricity demand. Reducing or changing energy-using activities including travel distances and mode choices can reduce energy demand and ease pressure on the electricity supply. So too can using more efficient technologies. The combination of all measures leads to significant further emission reductions,

despite some offsetting interactions such as the reduced emission-reduction potentials of heat pumps when homes are better insulated. It is important to note, however, that the successful implementation of these policies depends on multiple conditions, such as broader societal support, which was not explicitly considered in this study.

The study

Our study uses quantitative scenarios generated with global Integrated Assessment Models (IAMs) which are specifically designed to capture the interactions within and between the energy system, the economy, and the environment. We developed three scenarios that each capture the impact of a specific strategy targeting energy use. In the first scenario end users reduce or change energy-using activities, in the second they adopt more efficient technologies, and in the third they switch to electrification or alternative energy carriers as substitute to fossil fuels. Using a structured questionnaire, we also gathered inputs from policymakers and experts in demand sectors to refine the scenarios. We quantitatively interpreted and quantified the scenarios through 2050 using seven IAMs. Finally, we compared the resulting emission reductions per strategy across the set of models and scenarios and analyzed the results to better understand the main factors driving these reductions.

Further Reading

IPCC, ed. in Climate Change 2022 - Mitigation of Climate Change Ch. 5 (Demand, Services and Social Aspects of Mitigation), 503-612 (Cambridge University Press, 2023).
https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-5/
This chapter provides an extensive literature overview of demand-side mitigation measures and their estimated impact.

Creutzig, F. et al. Demand-side solutions to climate change mitigation consistent with high levels of well-being. Nature Climate Change 12, 36-46 (2022).
https://doi.org/10.1038/s41558-021-01219-y
This article shows that demand-side mitigation options can reduce emissions while simultaneously improving well-being.

Hill, G., Heidrich, O., Creutzig, F. & Blythe, P. The role of electric vehicles in near-term mitigation pathways and achieving the UK's carbon budget. Applied Energy 251, 113111 (2019).
https://doi.org/10.1016/j.apenergy.2019.04.107
This article demonstrates that accelerating electric vehicle uptake in passenger transport is important to achieve climate targets after 2030 in the UK.

Padovani, F., Sommerfeldt, N., Longobardi, F. & Pearce, J. M. Decarbonizing rural residential buildings in cold climates: A techno-economic analysis of heating electrification. Energy and Buildings 250, 111284 (2021).
https://doi.org/10.1016/j.enbuild.2021.111284
This article demonstrates that sustainable heating electrification is techno-economically viable in rural, residential buildings in cold climates.

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Competing interests

The authors declare no competing interests.

Figure

Figure 1: ***Change in global final energy use and direct CO_2 emissions from fuel combustion in the buildings and transport sectors. a-b****, Final energy use in buildings (**a**) and transport (**b**).* ***c-d****, CO_2 emissions from buildings (**c**) and transport (**d**). The figure shows model results for five scenarios: a business-as-usual reference (REF), reducing or changing energy-using activities (ACT), adopting more efficient technologies (TEC), switching to electrification or alternative energy carriers as substitute to fossil fuels (ELE), and a combined scenario (ALL) integrating ACT, TEC, and ELE. All scenarios have current policies implemented. Markers indicate individual model results and bars depict the model ranges. Figure is adapted with permission from Nat. Energy.*

