

Deep mitigation strategies for the European building sector

Abstract ECEMP2023 conference

Authors list:

Alessio, Mastrucci, IIASA
Bas, van Ruijven, IIASA
Francesco Pietro Colelli, CMCC
Vassilis Daioglou, PBL
Alice Di Bella, CMCC
Oreane Edelenbosch, Utrecht University
Johannes Emmerling, CMCC
Theofano Fotiou, E3 Modelling
Panagiotis Fragkos, E3 Modelling
Ramona Gulde, PIK
Robin Hasse, PIK
Elmar Kriegler, PIK
Florian Leblanc, CIRED
Thomas Le Gallic, SMASH-CIRED
Gunnar Luderer, PIK
Giacomo Marangoni, TU Delft
Stratos Mikropoulos, Utrecht University
Robert Pietzcker, PIK
Rik van Heerden, PBL
Detlef van Vuuren, PBL

Abstract

Buildings account for 36% of the energy-related greenhouse gas (GHG) emissions in the European Union (EU) ¹. The EU building sector will need to reduce its GHG by 60% by 2030 and fully decarbonize by 2050 ^{1,2} to achieve the EU climate targets ³. Integrated Assessment Models (IAMs) are commonly used to develop climate change mitigation scenarios. IAMs, however, have been mostly focusing on the energy supply-side system. Improved representation of end-use sectors, in particular buildings, is required to adequately assess demand-side interventions. Sectoral demand-side policies can make the climate transition faster and easier ⁴ and contribute to achieving ambitious climate targets.

In this multi-model study, we explore the CO₂ emission reduction potential for the building sector in the EU to support policy decisions towards carbon neutrality and intermediate targets for 2040. To this goal, we develop a set of scenarios combining sectoral demand-side interventions and different climate policies. We implement the scenarios in a series of IAMs with improved representation of the building sector, including residential and commercial buildings: Imaclim-R ^{5,6}, IMAGE ⁷, MESSAGEix ^{8,9}, PROMETHEUS ¹⁰, and REMIND ¹¹, and WITCH ¹².

The investigated building demand-side policies include: activity reduction and shifts (Activity), e.g. floorspace reduction, conservative temperature set-points; electrification and fuel shifts (Fuel shifts); technology improvements and energy efficiency (Technology), e.g. improved buildings energy efficiency, increased renovation rates; and a combination of all interventions (All). We also consider

two sets of climate policy scenarios: Current national policies with no stringent climate policies; and Stringent climate policies consistent with the 1.5°C target.

Under current national policies (Figure 1, top panels), the combination of all sectoral policies (All) provides the largest reduction of direct CO₂ emissions of 59% (69%) by 2040 (2050) compared to 2015 (averages across models). Combining sectoral policies with stringent climate policies results in more drastic CO₂ emission reductions, due to simultaneous decrease in energy demand and decarbonization of electricity and heat supply systems.

Combining all sectoral policies (All) and stringent climate policies (Figure 2, bottom panels) drives average reductions in direct CO₂ emissions up to 74% (90%) by 2040 (2050) compared to 2015 (averages across models). The residual CO₂ emissions are mostly due to residual fossil fuel use in space and water heating, requiring additional efforts for full decarbonization. Only one of the selected models was able to meet the 2050 net-zero GHG target of the EU under stringent climate policies, reaching 99% reduction of direct emissions in buildings with all sectoral policies implemented.

The results of this study show that, in order to reach the EU building sector targets, a combination of demand-side interventions and stringent climate policies is required. The investigated demand-side interventions are highly complementary and lead to the largest reduction potential when combined together. In addition to more widely investigated interventions on energy efficiency improvements and fuel switches, activity reductions and shifts have a significant mitigation potential and require further investigation. The results of this study can support decision making on the strategies for deep decarbonization of the European building sector and inform net-zero and intermediate emission targets.

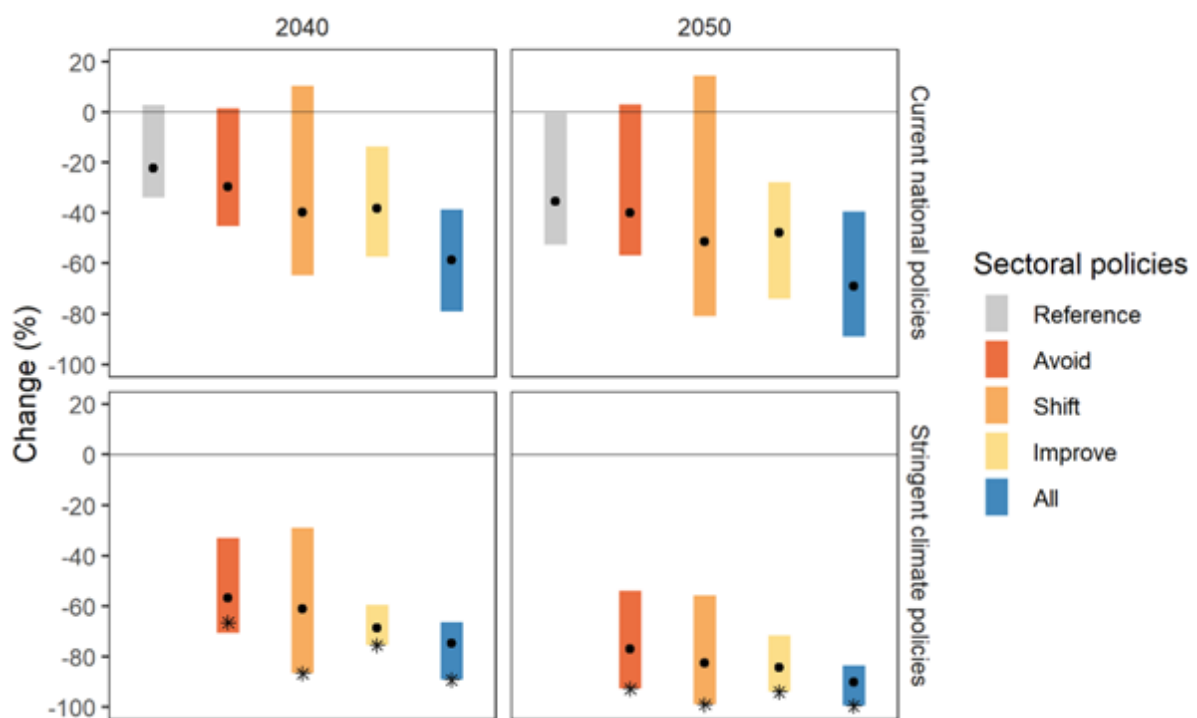


Figure 1 Change in direct CO₂ emissions in 2040 and 2050 compared to 2015 for the European residential and commercial sector under different scenarios including a set of sectoral policies and climate change mitigation policies. Coloured bars indicate the ranges covered by available model results, dots indicate the average, stars indicate the scenarios reaching net-zero Greenhouse Gas (GHG) targets for the European Union.

References

- (1) European Climate Foundation. *Renovating and Electrifying Buildings Strengthens Europe's Economy and Energy Security*; 2022. <https://europeanclimate.org/resources/renovating-and-and-electrifying-buildings-strengthens-europes-economy-and-energy-security/>.
- (2) European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Region. Stepping up Europe's 2030 Climate Ambition. Investing in a Climate-Neutral Future for the Benefit of Our People., 2020. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0562&qid=1629991001232>.
- (3) European Parliament and Council of the European Union. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), 2021. <http://data.europa.eu/eli/reg/2021/1119/oj>.
- (4) Creutzig, F.; Roy, J.; Devine-Wright, P.; Díaz-José, J.; Geels, F. W.; Grubler, A.; Maïzi, N.; Masanet, E.; Mulugetta, Y.; Onyige, C. D.; Perkins, P. E.; Sanches-Pereira, A.; Weber, E. U. Chapter 5: Demand, Services and Social Aspects of Mitigation. In *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*; IPCC, 2022.
- (5) CIRED/SMASH. Model Documentation - IMACLIM, 2016. https://www.iamcdocumentation.eu/index.php/Model_Documentation_-_IMACLIM.
- (6) Méjean, A.; Guivarch, C.; Lefèvre, J.; Hamdi-Cherif, M. The Transition in Energy Demand Sectors to Limit Global Warming to 1.5 °C. *Energy Efficiency* **2019**, *12* (2), 441–462. <https://doi.org/10.1007/s12053-018-9682-0>.
- (7) Daioglou, V.; Mikropoulos, E.; Gernaat, D.; van Vuuren, D. P. Efficiency Improvement and Technology Choice for Energy and Emission Reductions of the Residential Sector. *Energy* **2022**, *243*, 122994. <https://doi.org/10.1016/j.energy.2021.122994>.
- (8) Huppmann, D.; Gidden, M.; Fricko, O.; Kolp, P.; Orthofer, C.; Pimmer, M.; Kushin, N.; Vinca, A.; Mastrucci, A.; Riahi, K.; Krey, V. The MESSAGE Integrated Assessment Model and the Ix Modeling Platform (Ixm): An Open Framework for Integrated and Cross-Cutting Analysis of Energy, Climate, the Environment, and Sustainable Development. *Environmental Modelling & Software* **2019**, *112*, 143–156. <https://doi.org/10.1016/j.envsoft.2018.11.012>.
- (9) Mastrucci, A.; van Ruijven, B.; Byers, E.; Pobleto-Cazenave, M.; Pachauri, S. Global Scenarios of Residential Heating and Cooling Energy Demand and CO₂ Emissions. *Climatic Change* **2021**, *168* (3–4), 14. <https://doi.org/10.1007/s10584-021-03229-3>.
- (10) Fragkos, P.; Kouvaritakis, N. Model-Based Analysis of Intended Nationally Determined Contributions and 2 °C Pathways for Major Economies. *Energy* **2018**, *160*, 965–978. <https://doi.org/10.1016/j.energy.2018.07.030>.
- (11) Baumstark, L.; Bauer, N.; Benke, F.; Bertram, C.; Bi, S.; Gong, C. C.; Dietrich, J. P.; Dirnaichner, A.; Giannousakis, A.; Hilaire, J.; Klein, D.; Koch, J.; Leimbach, M.; Levesque, A.; Madeddu, S.; Malik, A.; Merfort, A.; Merfort, L.; Odenweller, A.; Pehl, M.; Pietzcker, R. C.; Piontek, F.; Rauner, S.; Rodrigues, R.; Rottoli, M.; Schreyer, F.; Schultes, A.; Soergel, B.; Soergel, D.; Strefler, J.; Ueckerdt, F.; Kriegler, E.; Luderer, G. REMIND2.1: Transformation and Innovation Dynamics of the Energy-Economic System within Climate and Sustainability Limits. *Geosci. Model Dev.* **2021**, *14* (10), 6571–6603. <https://doi.org/10.5194/gmd-14-6571-2021>.
- (12) CMCC. WITCH Documentation, 2019. <https://doc.witchmodel.org/>.