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Decarbonizing Construction Materials: Impacts of Carbon Policies on Energy Systems and Carbon Storage

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Extended Abstract

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Abstract Summary

Construction materials, particularly cement and steel, are major contributors to global greenhouse gas emissions and are increasingly targeted by carbon policies addressing embodied emissions. Achieving climate neutrality therefore requires integrating construction materials into decarbonization strategies. This study investigates how carbon policies affect material production, energy systems, and carbon storage, with a focus on costs, competitiveness, and resource constraints.

The analysis is based on a long-term prospective modeling framework using Integrated Assessment Modeling with the TIAM-FR model, representing the global energy system. The model includes detailed representations of cement and steel production pathways, including electrification, hydrogen-based processes, and carbon capture and storage. Material demand is treated exogenously following SSP2 assumptions under varying levels of climate policy stringency. Recycling is represented through alternative rates, particularly for steel scrap. Bio-based materials are included through engineered wood, with carbon storage accounted for in the built environment and deployment constrained by biomass availability informed by forest-sector outlooks. Carbon policies are implemented through carbon pricing, emissions caps, and embodied carbon requirements for construction materials.

Results show that embodied carbon policies significantly influence technology deployment and energy demand, notably through increased electrification of industrial processes. Bio-based materials contribute to emission reductions and carbon storage but remain constrained by resource availability, costs, and competing uses such as bioenergy. Cement and steel remain major sources of residual emissions, while carbon policies increase production costs and affect material competitiveness across regions.

The study highlights that carbon policies targeting construction materials can reshape energy systems and enable carbon storage, while revealing trade-offs between emissions, costs, and resource availability.

Presenting Author Biography

Sophie Chlela is a post-doctoral researcher at the Centre for Applied Mathematics, Mines Paris–PSL, France. Her research focuses on energy systems modeling using the TIAM-FR (TIMES Integrated Assessment Model), with an emphasis on land–energy interactions and climate policy analysis. She investigates decarbonization pathways and carbon dioxide removal strategies, providing insights into cost-effective and sustainable mitigation options. She holds a PhD and a Master's degree in Energy Systems Optimization from Mines Paris–PSL, a Master's degree in Renewable Energy from École Polytechnique, and a Bachelor's degree in Mechanical Engineering from Notre Dame University-Louaize.