Policy Instruments for Carbon Dioxide Removal: A Modeling Approach in Europe

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Overview

This study examines policy instruments for enabling the large-scale deployment of carbon dioxide removal (CDR) technologies, specifically bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS). CDR technologies are critical for achieving global climate targets, including limiting global warming to 1.5°C above preindustrial levels (IPCC, 2022). Integrated Assessment Models project a need for 190 to 1,190 GtCO2 of cumulative removal by 2100 to meet these objectives (Huppmann et al., 2018; Rogelj et al., 2018). Among the leading options, BECCS and DACCS offer scalable pathways for negative emissions and are increasingly central to climate policies (Schenuit et al., 2021). However, their large-scale deployment presents critical challenges (Fuss et al., 2018; Heck et al., 2018). Emphasizing a critical importance of well-designed policies in fostering equitable and economically viable CDR investments (Jagu Schippers, 2022).

Methods

To address these challenges, we use a spatial and dynamic equilibrium model to evaluate the effectiveness of various policy mechanisms. Our analysis considers the interactions between key players in the CDR supply chain, including emitters, technology providers, and governments, as well as the influence of subsidies, carbon pricing mechanisms, and other incentives. By focusing on Europe from 2025 to 2050, our study provides a comprehensive understanding of how different policies and deployment strategies can support the adoption of BECCS and DACCS, while aligning with economic and environmental goals.

Results

The calibrated model provides detailed insights into the scale, geographic distribution, and timelines for deploying these technologies. Using policy instruments, such as subsidies and carbon pricing mechanisms, we assess their effectiveness in supporting CDR investments. Our findings also highlight the trade-offs between budget efficiency and sustainability goals, emphasizing the critical role of well-designed policies in achieving optimal outcomes. Finally, we propose a framework that combines budget efficiency and environmental actions.

Conclusions

This study shows the critical role of well-designed policy instruments in accelerating the deployment of novel CDR technologies. By addressing challenges related to economic viability, effective policies can foster scalable and equitable adoption of these technologies. Our findings highlight the importance of aligning policy goals with both budgetary efficiency and long-term climate objectives to achieve net-negative emissions. This research provides a foundation for policymakers to better understand different policy strategies while maximising the environmental and economic benefits of CDR investments.

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