

Integrated model for assessing the dual role of biomass in energy transition and forest carbon dynamics

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Abstract

Biomass is a widely available renewable energy source, yet its complex role in decarbonization across various sectors remains insufficiently explored. This paper presents a comprehensive analysis of the role of biomass in Romania’s decarbonization trajectory, focusing on its implications for energy consumption, emissions reduction, and

environmental sustainability. Utilizing three scenarios—NECP, Medium Ambition, and High Ambition—this paper examines the potential outcomes of reduced biomass utilization in heating and cooling sectors, as well as electricity and heat production, until 2050. Through a combination of historical data analysis and scenario modeling using the Low Emissions Analysis Platform (LEAP) software, key findings arise regarding primary and final energy consumption trends, biomass consumption patterns, CO₂ emissions, and local pollution levels. The results indicate that ambitious biomass reduction targets, particularly in the high ambition scenario, can lead to significant reductions in primary energy consumption and net emissions, with notable improvements in air quality. The pivotal role of the Land Use, Land-Use Change, and Forestry (LULUCF) sector in achieving carbon neutrality is underscored. This paper contributes to the scientific understanding of biomass's role in decarbonization efforts across all sectors and provides valuable insights for policymakers seeking to promote sustainable energy practices.

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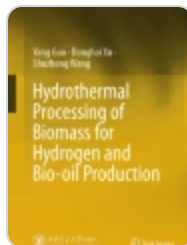
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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to institutional and project-level confidentiality agreements but are available from the corresponding author on reasonable request. The LEAP energy system model used in the analysis is a nationally developed and customized tool that integrates proprietary and public data sources. Access to the model or detailed outputs can be provided upon justified request, subject to data sharing policies and confidentiality agreements.

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Contributions

The first and the second author conceptualized the study, led the development of the methodology, and coordinated the overall research process, including data analysis, model design and validation, interpretation of results, literature review, and drafting of the manuscript. The third and the fourth author contributed to the input data for the local pollution component of the model and provided input for the literature review. All authors reviewed and approved the final manuscript.

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Ethics declarations

Human participants and/or animals

This study did not involve any experiments with human participants or animals performed by any of the authors.

Informed consent

Not applicable. This research did not involve human participants.

Conflict of interest

The authors confirm that there is no conflict of interest for this paper submission.

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