Paper 225

The Role of Bioenergy in Achieving Net-Zero Emissions: Opportunities and Challenges

In response to the escalating threat of climate change, an increasing number of countries have announced commitments to achieving net-zero emissions, aiming to balance greenhouse gas emissions and removals by a specific target date. Within the broader context of global energy transition and decarbonization strategies, bioenergy has emerged as a key component due to its renewable nature, carbon neutrality, and diverse application pathways. Bioenergy, produced from biomass combustion, biofuels, and biogas, can be utilized across multiple sectors including transportation, industry, power generation, and heating—providing a practical alternative to fossil fuels.

Compared to other renewable energy sources such as wind and solar, bioenergy offers the advantage of high storability and dispatchability, making it particularly valuable in hard-to-electrify sectors such as aviation, maritime transport, and high-temperature industrial processes. Moreover, the bioenergy industry has the potential to stimulate rural economic development and promote circular use of agricultural and forestry residues. However, the large-scale deployment of bioenergy also faces significant challenges. Issues such as land-use competition, food security concerns, biodiversity impacts, and the effectiveness of emission reductions over the entire life cycle can undermine its sustainability and actual contribution to net-zero targets.

This study aims to systematically examine the role of bioenergy in achieving net-zero emissions from policy, technological, and environmental perspectives. It evaluates both the potential and limitations of bioenergy development in various national and regional contexts. By combining comparative case studies and life cycle assessment (LCA) methodologies, this research will propose strategic recommendations for the sustainable development of bioenergy, ensuring it contributes meaningfully to climate goals without compromising food security or ecological integrity. The ultimate objective is to support the formulation of more inclusive and effective pathways toward carbon neutrality.