

Analysis of Steel Decarbonization Strategies and Supply Chain Integration

by

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Technical Summary

Industrial decarbonization is an obstacle as the global community focuses on climate change mitigation. Steel production is responsible for 7% of global emissions and faces unique challenges in reducing emissions in the ironmaking process. In order to evaluate potential solutions to the hard-to-abate industry, decarbonization strategies are modeled and analyzed from a plant and sector level.

First, India is examined as a critical case study given its role as an emerging economy that will undergo immense growth and high steel demand. Plant-level greenhouse gas emissions and costs are calculated for dominant and new steelmaking technologies to identify emission reduction potential. In addition, applying plant-level results at a sector level enables comparison of different demand scenarios for the Indian steel sector.

Next, an optimization model is developed to assess cost-optimal steel production for the United States with the application of policy, such as the IRA tax credits and emission goals. The production pathways are considered for 2022 to 2050, and an emission minimization case is also considered. With tax credits enabled, hydrogen-based steel production is favorable for primary (non-recycled) production.

Lastly, a model of hydrogen-based steel production is integrated into an existing hydrogen network model to assess supply chain needs and minimize costs. The combined model is applied to the United States in the Midwest, where coal-based production is predominantly located. By shifting to hydrogen-based production and considering different production settings, a range of greenfield system costs is identified, along with resource needs for regional steel production.

Overall, this thesis examines steel decarbonization options on an emission and cost basis, as well as the implications of optimizing on a sector and regional level with consideration of policy and resource needs.

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