Abstract

[Research Title]

Decarbonization transition: Multi-model assessment of innovation and lifestyle change

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We analyzed robust pathways for Japan's net-zero emissions goal by 2050 and the policy mix required to achieve such a target. We used a multi-model framework for scenario analysis and bridged it with the insights from sustainability transitions research.

Scenarios were developed to analyze uncertainties such as the rate of cost reduction of renewable energy, the cost of imported hydrogen and ammonia, and the scale of carbon dioxide removal (CDR) deployment. Scenario design was informed by an innovation database that collated wide-ranging future projections of energy technology costs. Results from five energy-economic and integrated assessment models were collected to create a scenario database. Model intercomparison revealed robust mitigation strategies, including economy-wide energy efficiency, decarbonization of power sources, end-use electrification, expansion of clean energy, and CDR. In particular, a significant scale of CDR (~ 100MtCO₂ or about 10% of the current emissions) was found to be important for economically efficient mitigation policies (Sugiyama et al., 2024a). We also identified power generation based on hydrogen and ammonia as an uncertain innovation.

To translate the modeling results into policy mixes, we conducted an extensive literature review on sustainability transitions research (e.g., Chen et al. 2022), particularly on multi-level perspectives and policy mixes. We developed a framework for analyzing policy mixes based on the phase of technology diffusion: niche support and research and development for the emergence phase, carbon pricing and deployment subsidies for the growth phase, and support for those sectors that may be negatively affected in the final reconfiguration phase. Focusing on CDR and hydrogen, we benchmarked Japan's policy with those of other regions, such as the United States. Our analysis showed that while important steps have been taken, the niche market creation programs are weak in Japan's policy mix, and subsidy or tax credit programs similar to the United States' Inflation Reduction Act are needed.

For lifestyle change, we conducted an extensive literature review (e.g., Sugiyama et al., 2024b) on how to

bridge model-based scenario analysis with transitions research. Focusing on food system transformation, the study found that Japan is at a pre-emergence stage and that basic policy actions, such as information dissemination, are needed. The study also identified the need to address the inequality-increasing (regressive) effects of strict carbon pricing on low-income households under a net-zero policy, as well as grid flexibility measures to enable high penetration of variable renewable energy sources such as solar and wind.

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