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Technology Competition and Policy Design for Cost-Effective Aviation Decarbonization

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Extended Abstract

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Abstract Summary

Aviation decarbonization is uniquely difficult. Unlike other sectors, no low-cost alternative to fossil jet fuel exists. Biofuel-based SAF, power-to-liquid eSAF, and DAC-based pathways each face distinct trade-offs across affordability and sustinabilty. Volatile fossil fuel prices and competing technologies at different maturity stages further complicate the policy landscape, situating aviation at the heart of the energy trilemma.

To address this, we develop a system dynamics model projecting technology competition under various policy scenarios. Unlike existing models, our model endogenizes cost trajectories via experience curves, models technology choice, and captures global spillovers from regional policies. Uncertainty in initial costs and learning rates is handled through quasi-Monte Carlo and Sobol sensitivity analysis, generating ensembles of plausible futures evaluated across policy scenarios including ReFuelEU mandates, EU ETS, contracts-for-difference, and subsidies.

Three preliminary findings stand out. First, no alternative closes the cost gap to fossil jet fuel even under optimistic assumptions. Second, existing mandates drive some adoption but are insufficient to stabilize emissions if demand grows as projected. Third, early policy choices strongly shape long-run outcomes: delayed action risks lock-in to biofuels or continued fossil dependence, while front-loaded support for eSAF triggers learning dynamics that substantially reduce long-run costs.

The core policy implication is that no single instrument suffices. Coordinated mixes of demand-pull and revenue certainty mechanisms are necessary. The long-run cost burden is itself a policy choice determined by today's deployment decisions, making early intervention critical. Large-scale eSAF and DAC deployment also carry significant implications for energy systems planning, requiring substantial build-out of low-carbon electricity, renewables, and storage.

Presenting Author Biography

Yash is a PhD Researcher at the Energy and Technology Policy Group of ETH Zürich, pursuing his doctoral research in the computation modelling of industries such as aviation and chemicals.