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Comparative Assessment of Fischer–Tropsch and Methanol Synthesis Pathways for Resilient Fuel Production from Sustainable CO₂ Sources

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The Fischer–Tropsch synthesis and methanol-to-jet (MtJ) pathways are of strategic importance for resilient energy systems because they enable the production of liquid fuels from a wide range of alternative carbon sources, including biomass, waste streams, captured CO₂, and renewable hydrogen. Unlike conventional fossil-based refining, these technologies reduce dependence on crude oil imports and diversify fuel supply chains, thereby increasing energy security in times of geopolitical instability and market disruptions. In particular, they support the domestic production of sustainable aviation fuels and chemical feedstocks, helping to establish more flexible, decentralized, and climate-compatible energy infrastructures.

Both routes, Fischer–Tropsch synthesis and methanol-to-jet synthesis represent key technologies for transforming synthesis gas into liquid energy carriers and chemical intermediates. This study presents a comparative assessment of both pathways in terms of process efficiency, carbon utilization, and flexibility in handling fluctuations in renewable-energy supply and upstream operation. Process simulation models are developed to evaluate system performance under fluctuating operating conditions and different integration scenarios, including DAC-based CO₂ supply.

The analysis focuses on identifying key performance indicators such as carbon efficiency, energy demand, and process robustness. Particular attention is given to the integration of renewable hydrogen. Results will be presented and discussed with regard to the suitability of Fischer–Tropsch and methanol to jet synthesis for resilient and sustainable fuel production systems. The findings are expected to provide insights into optimal process configurations and their role in future circular carbon economies.