

Evaluating the potential of e-fuels for decarbonizing European truck transport: A techno-economic and life cycle approach

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Motivation

- Cement production emits unavoidable process-related CO₂
- Long-distance transport remains difficult to electrify
- PtL fuels may link both sectors through CO₂ utilization

Research Question

- How do e-methanol and FT-diesel compare in terms of technical, economic, and environmental performance?

Methodology

Case study

- Austrian cement plant emitting 750 kt of CO₂ per year [1]
- MEA-based CO₂ capture
- Alkaline electrolysis for H₂ production

Assessment framework

- Aspen Plus® process simulation for 2 e-fuel pathways
- Techno-economic assessment (TEA) with Aspen Process Economic Analyzer and an Excel-based model
- Life cycle assessment (LCA) with Cradle-to-wheel approach in SimaPro (Environmental Footprint 3.1)
- European electricity scenarios and different CO₂ sources

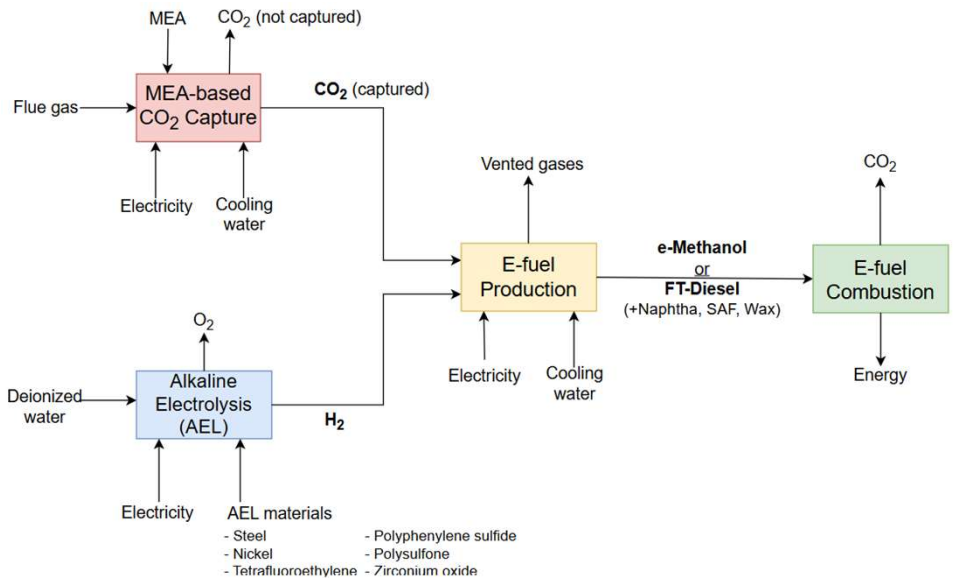


Figure 1: Scope of the study, consisting of four main blocks: (1) CO₂ capture from a cement plant; (2) H₂ production with alkaline electrolysis; (3) e-fuel production from CO₂ and H₂; and (4) e-fuel combustion

Pathways

- (i) e-methanol via direct CO₂ hydrogenation (3-stages) incl. upgrading (distillation)
- (ii) FT-diesel via reverse water gas shift reaction and Fischer-Tropsch synthesis (FTS) incl. upgrading (distillation and hydrocracking)

Results

Technical

- η_{global} : 45% (i) vs. 12% (ii)
- η_{carbon} : 81% (i) vs. 35% (ii)
- SEC: 12 kWh kg⁻¹ fuel (i) vs. 80 (ii) kWh kg⁻¹ fuel

Economic

- NPC_e: 250 EUR MWh⁻¹ fuel (i) vs. 590 EUR MWh⁻¹ fuel (ii)
- FT-diesel (ii) benefits from by-product revenues, but higher process complexity
- Electricity is the dominant cost driver

Country-specific electricity prices in EU (2025):

- e-Methanol: 300–700 EUR MWh⁻¹
- FT-diesel: 700–1,000 EUR MWh⁻¹
- Lowest production costs in Nordic countries (SE, FI, DK) and South-Western Europe (PT, ES)

Environmental

- Up to + 400 in CC compared to fossil diesel under carbon-intensive grids
- Up to – 50 % in CC in Austrian wind-based scenarios
- Biogenic CO₂ further improves environmental performance
- Electricity supply dominates climate performance

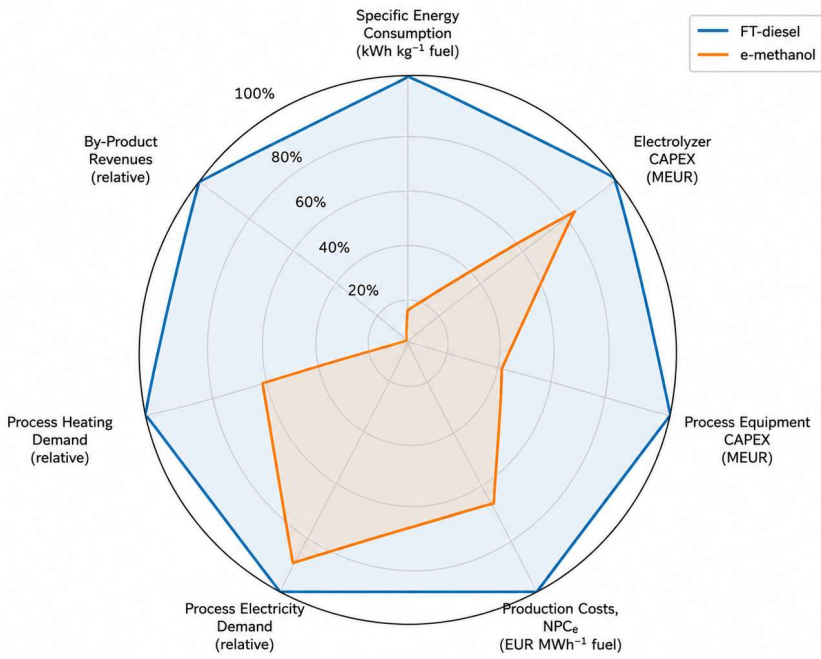


Figure 2: Normalized comparison of key techno economic indicators for FT-diesel (blue) and e-methanol (orange). 100% corresponds to the higher value for both pathways.

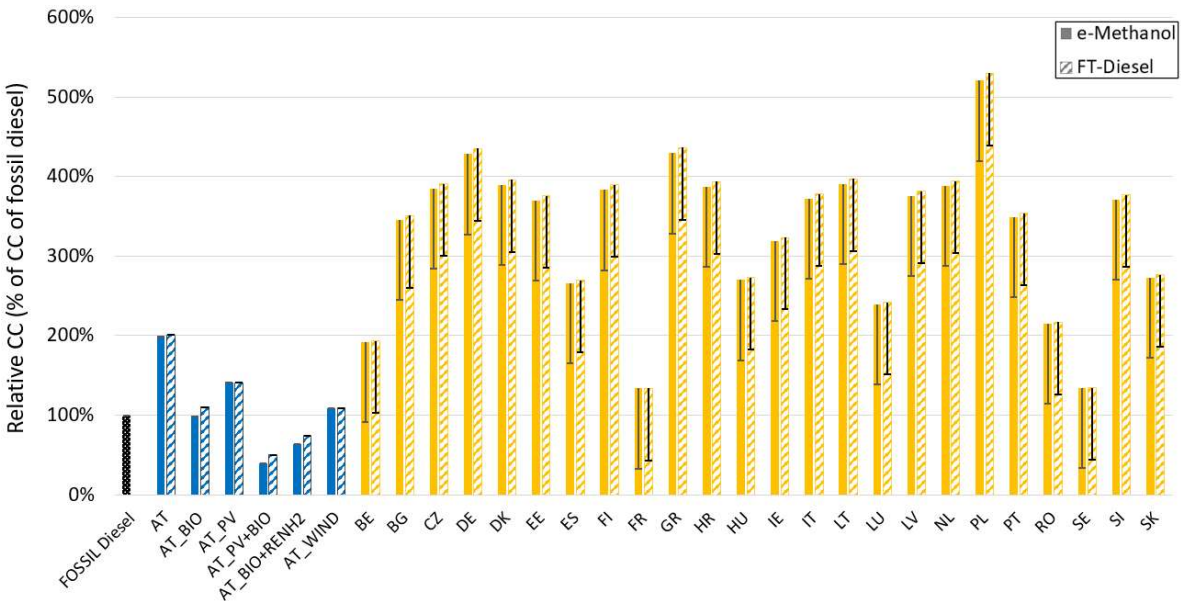


Figure 3: Damage assessment of climate change (CC) for e-methanol (solid bars) and FT-diesel (hatched bars) across Europe (fossil diesel = 100%), assessed using Environmental Footprint 3.1 method (v1.04).

E-methanol achieves higher efficiencies and lower production costs due to its simpler process configuration and substantially lower energy demand compared to FT-diesel.

Conclusion

- ✓ e-Methanol outperforms FT-diesel technically and economically
- ✓ Electricity supply is the dominant driver of both TEA and LCA results
- ✓ Low-carbon electricity is a prerequisite for meaningful GHG reductions
- ✓ Cement-based PtL pathways remain constrained by energy demand and production costs

[1] C. Markowitsch, M. Lehner, and M. Maly, "Comparison and techno-economic evaluation of process routes for lower olefin production via Fischer-Tropsch and methanol synthesis," *International Journal of Greenhouse Gas Control*, vol. 129, p. 103985, 2023, doi: 10.1016/j.ijggc.2023.103985.



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