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Are e-fuels worth it? Comparative TEA of Methanol & OMEs

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A major CO_2-utilising product group are fuels, also called electro fuels ('e-fuels'). E-fuels show three major benefits: Large-scale storage of fluctuating renewable energy, reduction of carbon intensity and reduction of pollutants for transport fuels (especially soot and NO_x).[1] E-fuels can become a major market with projected revenues of 10 - 250 billion USD in 2030, utilizing up to 2.1 Gt of CO_2.[2]

E-fuels R&D has progressed from lab-scale to pilot-scale and a range of industrial e-fuel projects dealing with methanol, ethanol and Fischer-Tropsch oil exist today.[2] But to replace diesel, methanol, ethanol and other alcohols are not suited due to too low cetane numbers.[1] Instead, Fischer-Tropsch diesel and oxymethylene ethers (OME) were identified as promising substitutes, especially dimethyl ethers (DME),[1] corresponding to "OME_0",[3] dimethoxymethane (DMM) corresponding to "OME_1",[4] and oligomeric OMEs with 3 to 5 repeating units ($OME_{3\text{-}5}$).[1]

While techno-economic (TEA) studies exist for CO_2 utilizing methanol, DME or FT-diesel, a detailed analysis of OME_1 and $OME_{3\text{-}5}$ from various CO_2 sources has not been performed. In this work, we present a TEA of the production of four e-fuels: Methanol, DME/OME_0, DMM/OME_1 and $OME_{3\text{-}5}$. Various production routes will be analyzed, combining different CO_2 emitters (ammonia plants, steel plants, and cement plants), and different electricity routes (natural gas, grid and wind). Regional scenarios reflecting the US and EU conditions are further included. The process design software Aspen Plus is used to develop process design flow sheets in order to calculate mass and energy balances, efficiencies and economics. For the commercialization of e-fuels, standardized and fair comparisons are necessary. This is why this assessment is based on a novel, standardized TEA framework developed in the TEA Guideline project, integrating concepts from TEA and LCA to make studies more transparent and comparable.

The main objective of this work is first to exemplify the TEA framework and second to identify promising e-fuel production options for CO_2 utilization in the processing industry. The study will outline future e-fuel production scenarios and focus points for the next steps in R&D.

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