ECONOMIC COMPARISON OF DIFFERENT ELECTROFUELS FOR ENERGY SCENARIOS IN 2035

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Overview

Electrofuels (e-fuels) enable CO_2-neutral mobility and are therefore an alternative to battery-powered electric vehicles. This paper compares the cost-effectiveness of Fischer-Tropsch diesel (FTD) methanol (MeOH) and hydrogen, which was temporarily bound to Liquid Organic Hydrogen Carriers (LOHC). The production cost of those fuels are to a large part driven by the energy-intensive electrolytic hydrogen production. Therefore, one focus of this paper is on the influence of electricity prices on the economic efficiency of the fuels.

Methods

In this paper, we use a multi-level electricity market model to calculate future hourly electricity prices for various electricity market designs (uniform prices an nodal prices regimes) in Germany for the year 2035. We then assess the economic efficiency of the different fuels under different future market conditions. In particular, we use the electricity price vectors as an input for a mathematical model of the entire process chain from hydrogen production and chemical bonding to the energetic utilization of the fuels in a vehicle. Within this model, we perform a sensitivity analysis to determine the parameters with the greatest influence on the fuel production cost.

Results

If a nodal price-based system is adopted, the e-fuels production cost drop by up to 40% at nodes with a large amount of renewable energies in the electricity mix. For other parts of the country, transporting e-fuels is the most economical option.

Also the investment cost for the electrolysis systems and the carbon dioxide purchase price have a strong influence on the production cost of e-fuels. If a uniform price market design is adopted, the electrolyzer's investment cost amount to about 10-15% of the total production cost. The share for the purchase of CO_2 is slightly above 10%.

The LOHC technology is the cheapest of the alternatives investigated. The fuel cost for 100 kilometres driven are about 1.90 € in a uniform price market design. MeOH and FTD are significantly higher at 2.50 €/100 km and 3.60 €/100 km respectively.

Conclusions

1) E-fuels can provide an economical alternative to conventional fuels. However, due to high losses during production FTD is less suitable than MeOH or hydrogen as a future fuel.
2) A major factor, influencing the production cost of fuels, are the electrolysis investment cost, the minimal partial load of the synthesis and the CO_2 procurement price.
3) Hydrogen production cost, which are also significantly driven by electricity prices, have the greatest influence on the economic efficiency of e-fuels. The design of the electricity market thus plays a decisive role in determining production cost. If a nodal price based system is assumed, the production cost will fall considerably by up to 40% for regions with a high rate of renewable energies. These favorable conditions also make it possible to transport the fuels to other parts of the country.