WHAT FUTURE FOR ELECTROFUELS? – ANALYSIS OF COST-COMPETITIVENESS OF ELECTROFUELS FOR TRANSPORT IN GLOBAL CLIMATE MITIGATION

Mariliis Lehtveer, Selma Brynolf, Maria Grahn
Chalmers University of Technology
Electrofuels

- Carbon-based fuels produced from carbon dioxide and water (hydrogen), with electricity as the primary source of energy.
- Also known as power-to-gas/liquids/fuels, e-fuels, or synthetic fuels.
- Many different fuels can be produced (methane, methanol, gasoline etc.)
- Using biogenic CO$_2$ makes electrofuels potentially climate neutral.
Production of electrofuels

Brynolf et al. 2017
Motivations: variation management for VRE

- Absorbing excess electricity at windy and/or sunny times when the price of electricity is low.
- Making room for dispatchable generation so it can run for more hours and thus at lower cost.
Motivations: limited biomass

- Biomass may be more needed in other sectors.
- Adding hydrogen to biogas production can increase the yield.
- Reduces transport sectors reliance on biofuels.
Motivations: Hydrogen is difficult to handle

• Hydrogen needs investment in infrastructure to be used in transport.
• It may be difficult to use hydrogen for some modes (aviation, shipping).
Production cost of different electrofuels

Cost of electricity and electrolysers identified as main contributors to the fuel production cost.

Brynolf et al. 2017
Aim of the study:

To investigate under what conditions can electrofuels be a part of a cost-effective solution for mitigating climate change?
Global Energy Transition (GET) Model

- A cost minimizing systems engineering model of the global energy system
- Set up as a linear programming problem
- Five end use sectors: electricity, transport, feedstock, residential–commercial heat and industrial process heat
- Global carbon budget
- Resource based slicing used to capture intermittency of variable renewables
- Used to study mitigation scenarios up till 2100
Carbon flows in GET

- **Atmosphere**
  - Atmospheric CO₂ concentration
  - Carbon cycle model

- **CO₂**
  - From Biomass
  - From Carbon based fossil energy sources (coal, oil, natural gas)
  - From CO₂ storage from fossil fuels, biomass and air

- **Societal energy conversion and CO₂ capture**
  - CO₂ from Biomass
  - CO₂ from captured CO₂

- **Captured CO₂**
  - CO₂ to Carbon based fossil energy sources (coal, oil, natural gas)
  - CO₂ to CO₂ storage from fossil fuels, biomass and air
Cases studied:

- Base case – 450 ppm and 550 ppm CO2
- VRE case – 50% cheaper wind and solar
- Low bio case – 50% less biomass available
- No storage case – No carbon storage available
- No H₂ in transport case
Results: Global H₂ production from electricity 2070

450ppm

550ppm
Results: Global methanol production from H₂ 2070

450ppm

550ppm
Results: Global potential for electrofuels in transport 2070

450ppm

550ppm
Monte Carlo: electrofuels vs electrolyser cost

Cost of electrolyser in USD2010/kW

Amount of electrofuels in the system in EJ

$R^2 = 0.0003$
Monte Carlo: electrofuels vs relative cost of VRE

![Graph showing the relationship between the amount of electrofuels in the system (in EJ) and the relative cost of VRE, with an R² value of 0.0046.](image-url)

- Amount of electrofuels in the system in EJ
- Relative Cost of VRE
- R² = 0.0046
Monte Carlo: electrofuels vs biomass availability

\[ R^2 = 0.0024 \]
Monte Carlo: electrofuels vs carbon storage

\[ R^2 = 0.6755 \]
Conclusions:

• The potential for electrofuels in transport is very limited or non-existent in most cases.

• Cost of electrolyser and variable renewables will not be determining factor of whether electrofuels enter the transport system.

• There is a strong correlation between availability of carbon storage and the potential for electrofuels in the system. However, if the global carbon storage potential exceeds 750 GtCO₂, electrofuels will not be cost competitive.

• In case of 450 ppm climate target and no carbon storage available, electrofuels have a potential of ca 23 EJ globally at 2070, providing for ca 14% of transport energy demand.