PRODUCING SYNFUELS FROM CO2, BIOMASS AND HYDROGEN RESOURCES, ROUTES, EMISSIONS AND ECONOMICS: A EUROPEAN OVERVIEW

Guillaume Boissonnet, +33 4.38.78.30.62, CEA I-Tésé, Saclay – Grenoble, France, mail: guillaume.boissonnet@cea.fr

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Overview

We live in a fossil carbon society, for energy chemistry, health or materials. Resource depletion and greenhouse gas issues are driving changes. Reducing the part of fossils in energy and CO2 emissions is then a major concern. Finding renewable carbon resources is also essential. A new green deal was established for Europe in 2019.

How will we do that? Doing without carbon? Substituting it? In the field of energy, especially in the field of transport, guidelines are being developed for renewable energy and electricity (for the moment the final energy dedicated to mobility stands for about 30-40%). In the past decades, biofuels or hydrogen used as energy carriers were envisaged as a solution to replace fossils fuels. If using electricity and batteries for road mobility, especially for short distance makes sense, liquid or gaseous fuel should be more appropriate for longer distances. In the same way, replacing liquid fuels carriers in the aviation sector by other carriers seems highly improbable.

The present study try to clarify to the issue of non-carbon fossil energies and renewable carbon resources. The only non-fossil carbon resources are biomass and CO2. Their use leads to very different situations in terms of conversion routes, global energy consumption and systems efficiencies. Let us look at the impacts of energy and carbon resources on systems performances. A specific objective of this study is **to highlight the specific constraints in terms of resource availability, infrastructures, economics and regulation**.

Methods

The present study is based on overall analysis of:

- Resources (potential assessment of biomass, usable CO2 and electricity to produce carbon-free hydrogen)
- Fuels types and fuels demand and supply (overall production routes balances). With A specific application to transport
- CO2 emissions (comparing the use of carbon free electricity - from renewable or nuclear or the use of electricity from the present European mix)
- Economics in terms of production cos (LCOE) in a first approach

Results are based on process multi-objective optimisation (Pareto frontiers calculations), followed by mass and energy balances, leading to process performances and CO2 emissions. The economic calculation are based on CAPEX and OPEX assessments and production cost (LCO) calculations.

Results

In terms of resources, the final energy provided by fossils fuels is about 75% of the 1640 Mtoe/y in the European energy mix. Biomass count for approximately 10%, mainly used for biomass energy (heat and electricity) and for biofuels in the road sector. The additional biomass potential ranges from 200 to 350 Mtoe, which must be compared to 540 Mtoe for transports. Even if decarbonisation of industry is forecasted, the concentrated CO2 potential is sufficient to provide complementary amount of e-synfuels. The total amount of e-fuels coming from CO2 (recycled C) and biomass (renewable C) combined with hydrogen from carbon-free electricity. This take into account the fact that direct electricity use (batteries) is implemented to perform 70% of the total amount of kilometres, in the individual road transport sector.

Thus, we can demonstrate that **all liquid fossil fuels could be replaced with electricity-assisted hydrocarbon biofuels plus CO2 synfuels.** This mean a specific massive deployment of free carbon electricity means of production. This requires a certain amount of carbon-free electricity to produce hydrogen, necessary to be injected in synthesis processes, whether the resource is biomass or CO2 (see figure 1a). CO2 emissions in the transport sector are reduced by a factor of 1.5 to 5, depending of e-synfuel route and electricity origin (see figure 1b).

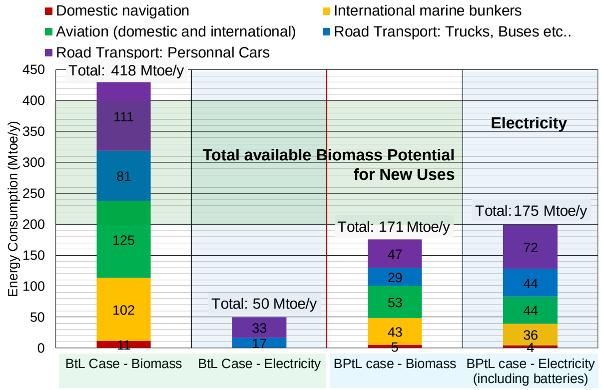

Figure 1a: Energy consumption for e-synfuels

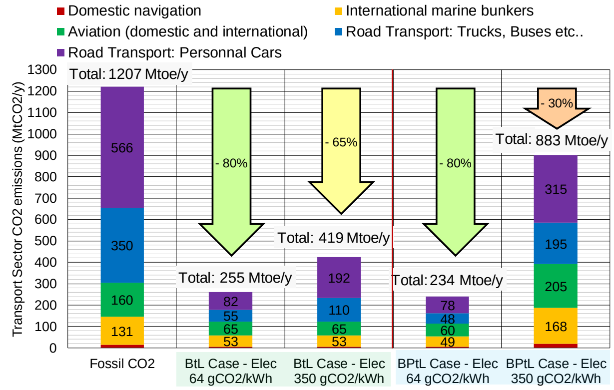

Figure 1b: Reduction of CO2 emissions for transport sector

In terms of economics, For 200 $MW_{biomass}$ input plant capacities, production costs are in the range of 1.0-1.4 €/l for technologies producing up to about 0.5 $kJ_{fuel}/kJ_{biomass}$ and close to being neutral in terms of electricity balance. For technologies using hydrogen from electrolysis the conversion can increase to 0.8 $kJ_{fuel}/kJ_{biomass}$ with production costs of 1.8 €/l. The electricity storage capacity, in this case, is of 0.5 $kJ_e/kJ_{fuel.}$, corresponding to a net electricity requirement of about 0.4 $kJ_e/kJ_{biomass}$(Peduzzi et al. 2018). The production cost comparison is provided in figure 2.

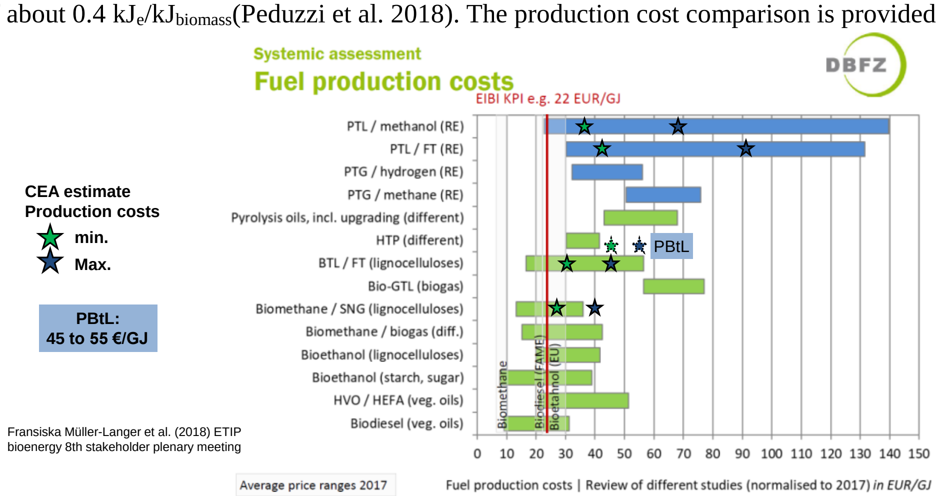

Figure 2: E-synfuels and biofuels production cost (synthetic figure)

Conclusions

The main conclusion are as follows

- Producing biofuels, synthesis fuels from CO2 or electric-assisted hydrocarbon biofuels is technically feasible. Technology or R&D does not limit deployment.
- Good trade-offs exist between biomass use, CO2 use and hydrogen use (produced by carbon free electricity) to optimise the overall fuels energy mix.
- When based on liquid fuels or methane-based gas, infrastructures will not be a major concern in term of deployment, as liquid fuels and natural gas infrastructures already exists.
- As conversion technologies already exist (motor engines for road or aviation, gas turbine, gas heater) the final user technology developments are not real obstacles.
- The highest limitation is the access to resources: biomass, concentred CO_2 or electricity. This will require specific industrial facilities (power plants, CO_2 capture) and specific infrastructures and supply chains.
- Of course, renewable fuels production costs are higher than fossil fuels production cost. However, when considering every aspect of the problem (infrastructure, CO2 and other pollutants' emission, taxes, energy independency…), renewable fuels become quite competitive.
- For the moment, regulations are not adapted to the objectives. Even if EU regulations such as RED2 or EU Taxonomy have defined a way forward, specific regulations in terms of renewable fuels definition, biomass resource access and exploitation or biodiversity protection must be adapted to reach the goal.

References

Peduzzi, Emanuela, Guillaume Boissonnet, Geert Haarlemmer, and François Maréchal. 2018. 'Thermo-Economic Analysis and Multi-Objective Optimisation of Lignocellulosic Biomass Conversion to Fischer–Tropsch Fuels'. *Sustainable Energy & Fuels*. https://doi.org/10.1039/C7SE00468K.