

CASE STUDY: THE ECONOMIC AND ENVIRONMENTAL ASSESSMENT OF SELECTED BIOMASS-TO-FISCHER TROPSCH (FT) DIESEL CHAINS IN THE EU

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Motivation

In light of the European Green Deal's target to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels and to render Europe the world's first climate-neutral continent by 2050, it is crucial to increase the market share of renewable fuels. Previous literature has suggested that 2nd generation biofuels, such as Fischer Tropsch (FT) diesel, will become economically competitive between 2020 and 2030 (Ajanovic et al., 2012). This paper aims to make use of recent data on selected biomass-to-FT-Diesel chains from the EU Horizon 2020 CLARA project³ (Dieringer et al., 2020; Atsonios et al. 2020) to analyze and compare the ecological and economic performance of selected biomass-to-FT diesel chains. Further, this paper argues that selected biomass-to-FT diesel chains have a particularly high potential as alternative fuel due to increased ecological performance (lower life-cycle carbon emissions) and financial competitiveness due to an expected economies of scale effect, thus making a case for their contribution to achieving the European Green Deal's climate targets.

Core objective

The core objective of this paper is to determine and compare the present economic and environmental performance of (a) forestry wood-to-fischer-tropsch (FT) diesel, (b) straw-to-FT diesel, (c) pine forest residue-to-FT diesel, (d) straw pellet-to-FT diesel chains and conventional diesel for the EU, as well as to provide an outlook for the expected economic and environmental performances of the mentioned biomass-to-fuel chains and conventional diesel in 2030 and 2050.

Method of approach

While chain (a) and (b) will be based entirely on data from a previous study on the long-term prospects of biofuels in the EU-15 countries, see Ajanovic et al. (2012), chain (c) and (d) will be partially based on recent data from the EU Horizon 2020 CLARA project, as well as on Ajanovic et al. (2012).

For the economic analysis we consider energy costs, capital costs, as well as the following other costs: transport, operation & maintenance (O&M), labor, electricity and heat. The sum of these variables represent the total costs, C_{total} , for the production of a certain biofuel (BF) from a selected feedstock (FS) for a specific year.

$$C_{total} = C_{energy} + IC \cdot \alpha + C_{other} \quad [€/ \text{tonne FS}] \quad (1)$$

where:

C_{energy}energy costs [€/tonne FS]

ICinvestment costs [€/tonne FS]

αcapital recovery factor

C_{other} Σ transport, O&M, labour, electricity, heat [€/ tonne FS]

For the environmental analysis, we consider the CO₂ input and the conversion efficiency for the selected feedstock, as well as the CO₂ input of the final biofuel product.

$$CO_{2_SP} = \eta_{feedstock} \cdot CO_2 \text{ input}_{feedstock} + CO_2 \text{ input}_{biofuel} \quad (2)$$

where:

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$\eta_{\text{feedstock}} \dots \dots \text{FS conversion efficiency}$

$\text{CO}_2 \text{ input feedstock} \dots \dots \sum \text{CO}_2 \text{ (passive/sink, fertilizer, fuel}_{\text{feedstock}}, \text{fuel}_{\text{transport}}) \text{ [kg CO}_2\text{/ kg FS]}$

$\text{CO}_2 \text{ input biofuel} \dots \dots \sum \text{CO}_2 \text{ (credit}_{\text{by-products}}, \text{pressing, BF conv.}, \text{other WTT, transp.}_{\text{fill. stat.}}, \text{TTW}) \text{ [kg CO}_2\text{/kg BF]}$

Abbreviations: WTT... well-to-tank, TTW...tank-to-wheel

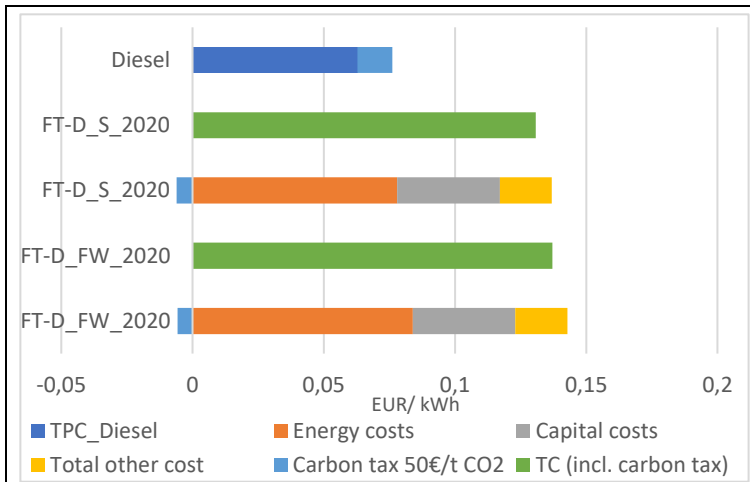


Fig. 1. Segmented total production costs for forest wood-to-FT diesel & straw-to-FT diesel chains incl. CO₂ taxes for 2020 (based on Ajanovic et al. 2012) compared to corresponding Diesel price (EUR/kWh) for the EU⁴

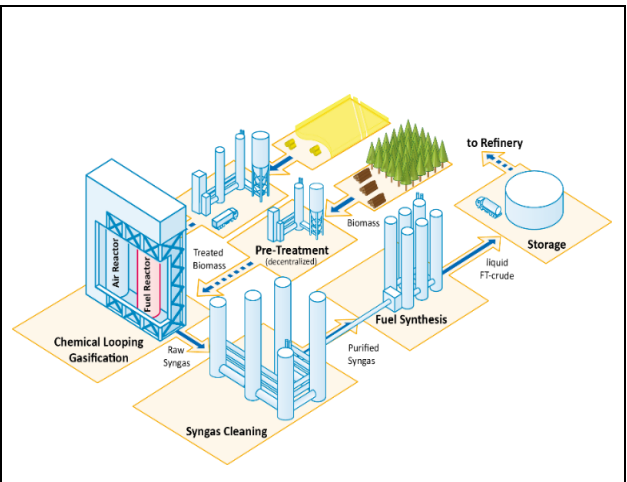


Fig. 2. Schematic overview of the biomass-to-FT-Diesel process chain of the EU Horizon 2020 CLARA project

Results⁵

The most important results are: (i) Fig. 1 describes the structure of the current total production cost of forest wood-to-FT diesel and straw-to-FT diesel chains and compares these with the corresponding total production cost of diesel for 2020 (€/kWh). Note, that for each biomass-to-fuel chain, next to the segmented production costs, the total production costs including CO₂ taxes are given. While we can see the advantages of CO₂ tax in its contribution to a decrease of the total costs / kWh of fuel for both FT diesel chains, in 2020 it is evidently more economically feasible to produce conventional diesel, including CO₂ taxes; ii) Fig. 3 depicts total production cost structure scenarios for 2030 and 2050 and compares these with the corresponding forecasts of total production costs of diesel (€/kWh). It is evident that already in 2030 the production of FT diesel could be economically feasible and lower than that of conventional diesel, given that CO₂ taxes of ~180 €/ t CO₂ are implemented. In 2050, both production costs as well as CO₂ taxes on conventional diesel are expected to increase, accompanied by a further decline of both costs for FT Diesel, thus rendering FT diesel a valuable alternative, both economically and environmentally; (iii) figure 4 depicts the CO₂ balances of forest wood-to-FT diesel and straw-to-FT diesel chains for the years 2020, 2030 and 2050 and compares these to the corresponding conventional diesel CO₂ balance. While it is evident that at present the ecologic performance of FT diesel is already superior to that of conventional diesel, the environmental benefits in terms of negative lifecycle carbon emissions (kg CO₂/kg fuel) are expected to continuously increase until 2050 for both biomass-to- FT diesel chains under study.

⁴ Abbreviations: TPC... total production cost, FT-D_FW...FT-diesel produced from forest wood, FT-D_S... FT-diesel produced from straw

⁵ It should be noted that, at this point, results from the CLARA project have no yet been included and that the preliminary findings presented in this abstract are solely based upon the previous study of Ajanovic et al. 2012. The long version of this paper aims to include recent data of the CLARA project and possibly a learning curve assessment.

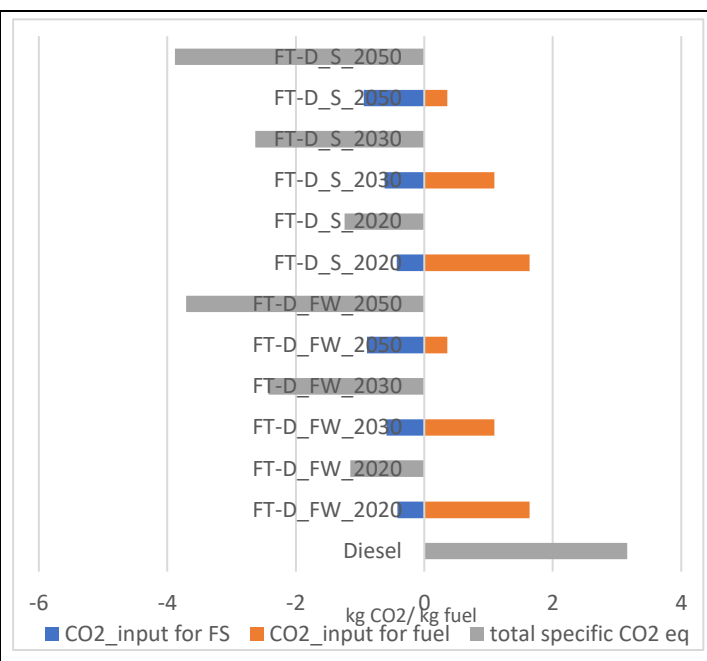
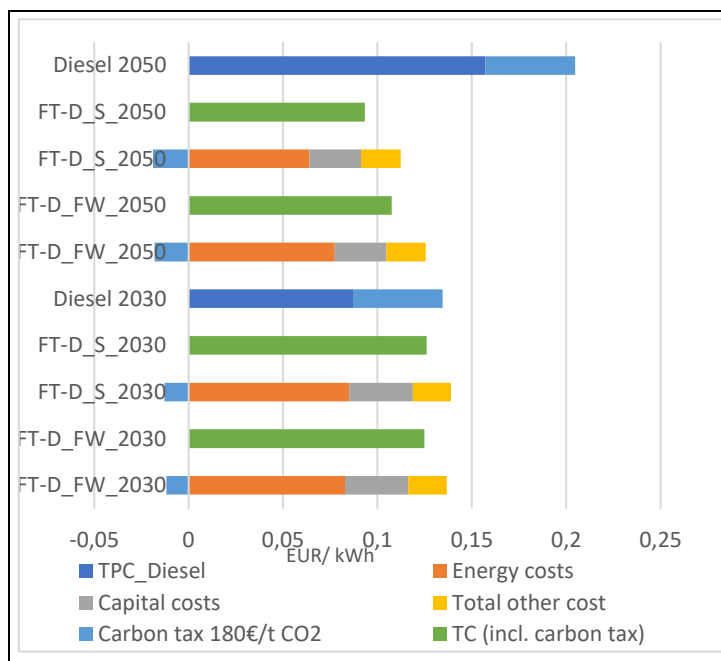


Fig. 3. Segmented total production costs scenarios for forest wood-to-FT diesel & straw-to-FT diesel chains incl. CO₂ taxes for 2030 and 2050 (based on Ajanovic et al. 2012) compared to corresponding Diesel prices (EUR/kWh) for the EU

Fig. 4. CO₂ balances for forest wood-to-FT diesel & straw-to-FT diesel chains for 2020, 2030 and 2050 (based on Ajanovic et al. 2012) compared to corresponding Diesel CO₂ (TTW emissions) for the EU

Conclusions

The major conclusions of this analysis are: (i) The way towards an increased share of 2nd generation biofuels, such as FT diesel, in the overall energy mix has to be accompanied by rigorous policy measures (e.g. regulations for min. share of renewable fuels in total energy mix); (ii) in order for 2nd generation biofuels to play a significant role in the energy transition a proper mix of CO₂-taxes and intensified R&D in order to improve the conversion efficiency from feedstock to fuel, thus leading to lower feedstock cost and improved ecological performance, are needed; (iii) the increase in production price and CO₂ taxes of conventional diesel, combined with the increase in ecologic and economic performance of 2nd generation biofuels, such as FT diesel, is highly likely to cause the latter to supersede conventional diesel as early as 2030.

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