MODELLING OF SOCIO-ECONOMIC IMPACTS AND MARKET DIFFUSION 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. Biomass gasification is one of the most promising routes for biofuel (e.g. Fischer Tropsch (FT) Diesel) production, which is a key element in reducing GHG emissions of the transport sector. While various process options have been investigated and implemented at different scales, most of these options currently lack economic competitiveness. Previous literature has suggested that 2nd generation biofuels, such as Fischer Tropsch (FT) diesel, will become economically competitive between 2020 and 2030 (e.g. Ajanovic et al., 2012). This paper aims to make use of recent data from the EU Horizon 2020 Project on the Chemical Looping Gasification for Sustainable Production of Biofuels (CLARA) (Dieringer et al., 2020; Atsonios et al.2020) in order to model potential socio-economic impacts and market diffusion of selected biomass-to-Fischer Tropsch (FT) Diesel chains in the EU.

Core objective

The core objective of this paper is to determine and compare the economic and environmental performance of (a) pine forest residue-to-FT diesel and (b) straw pellet-to-FT diesel chains (both feedstock types were chosen for the scope of the CLARA project) with conventional diesel under different boundary conditions for the EU, as well as to provide an outlook in of potential economic and environmental performances of the mentioned biomass-to-fuel chains and conventional diesel up to 2050 (scenarios) using Technological Learning approaches. The socio-economic and ecological viabilities of the examined constellations are estimated by comparison with costs, emissions, and jobs created from competitive biomass deployment for energetic and non-energetic use as well as from reference fossil fuel products. Finally, recommendations are drawn for policy makers and stakeholders about socio-economic and environmentally sound deployment strategies of bioenergy carriers based on chemical looping gasification of biogenic residues.

Method of approach

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.

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

where:

C_{energy}……energy costs [€/ton FS]
IC……investment costs [€/ton FS]
α capital recovery factor
C_{other} ∑transport, O&M, labour, electricity, heat [€/ tonne FS]

For the environmental analysis, we consider the CO_2 input and the conversion efficiency for the selected feedstock, as well as the CO_2 input of the final biofuel product.

$$CO_{2\_SP} = \eta_{feedstock}.CO_2\,input_{feedstock} + CO_2\,input_{biofuel} \qquad (2)$$

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where:
$\eta_{feedstock}$……FS conversion efficiency
CO_2 input feedstock……$\sum CO_2$ (passive/sink, fertilizer, $fuel_{feedstock}$, $fuel_{transport}$) [kg CO_2/ kg FS]
CO_2 input biofuel….$\sum CO_2$ ($credit_{by\text{-}products}$, pressing, BF conv., other WTT, $transp._{fill.\ stat.}$, TTW) [kg CO2/kg BF]
Abbreviations: WTT… well-to-tank, TTW…tank-to-wheel

Figure 1 represents the segmented total production cost for a forest-to-FT diesel and straw-to-FT diesel chain, including CO_2 taxes for 2020 (based on Ajanovic et al. 2012), compared to corresponding Diesel price (EUR/kWh) for the EU. It should be noted that this is a simplified graphical representation of the economic and environmental analysis of one possible biomass-to-liquid fuel chain and solely serves a representative purpose. The long version of the paper will include a more detailed and comprehensive analysis of different biomass fractions and energy carriers.

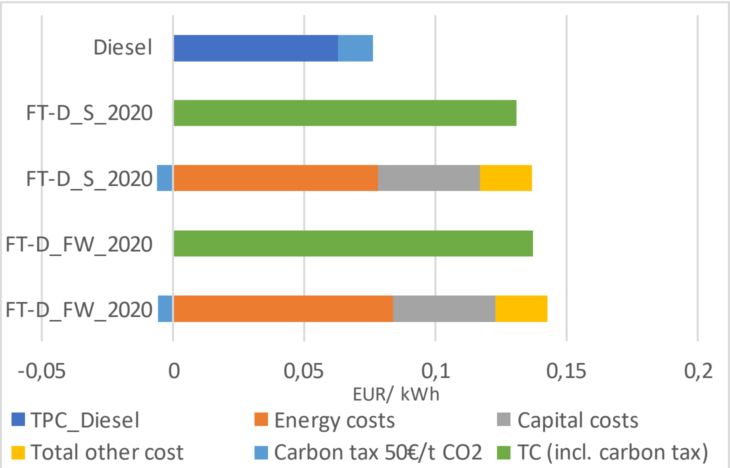

Fig. 1. Segmented total production costs for forest wood-to-FT diesel & straw-to-FT diesel chains incl. CO_2 taxes for 2020 (based on Ajanovic et al. 2012) compared to corresponding Diesel price (EUR/kWh) for the EU[2]

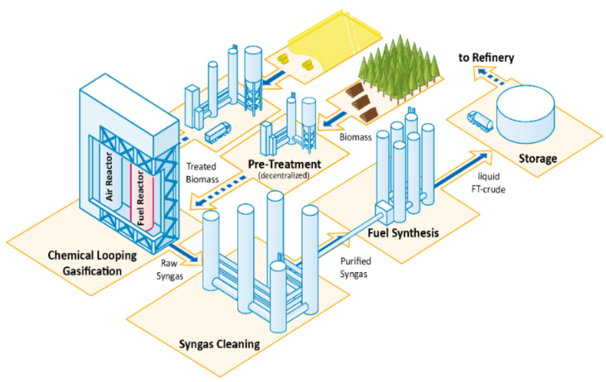

Fig. 2. Schematic overview of the biomass-to-FT-Diesel process chain of the EU Horizon 2020 CLARA project

Results[3]

The most important preliminary 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 CO_2 taxes are given. While we can see the advantages of CO_2 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 CO_2 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 CO_2 taxes of ~180 €/ t CO_2 are implemented. In 2050, both production costs as well as CO_2 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 CO_2 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 CO_2 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

[2] Abbreviations: TPC… total production cost, FT-D_FW…FT-diesel produced from forest wood, FT-D_S… FT-diesel produced from straw
[3] 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 a learning curve assessment.

in terms of negative lifecycle carbon emissions (kg CO_2/kg fuel) are expected to continuously increase until 2050 for both biomass-to- FT diesel chains under study.

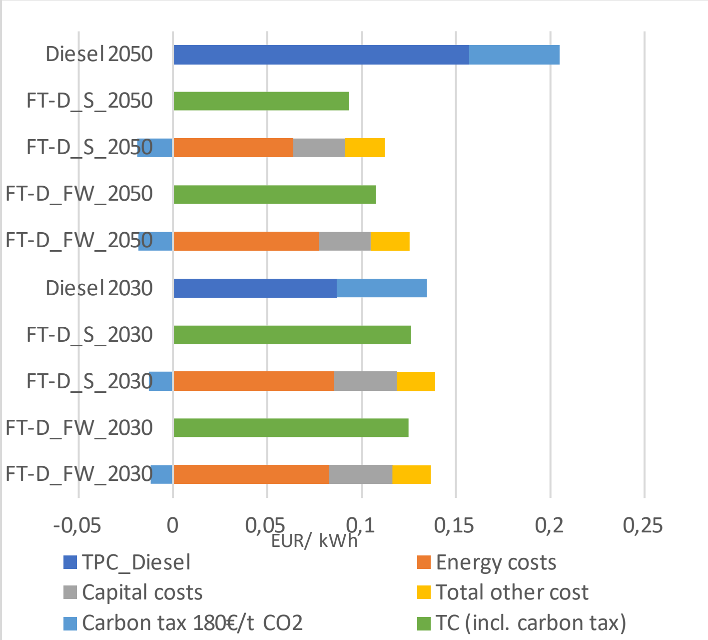

Fig. 3. Segmented total production costs scenarios for forest wood-to-FT diesel & straw-to-FT diesel chains incl. CO_2 taxes for 2030 and 2050 (based on Ajanovic et al. 2012) compared to corresponding Diesel prices (EUR/kWh) for the EU

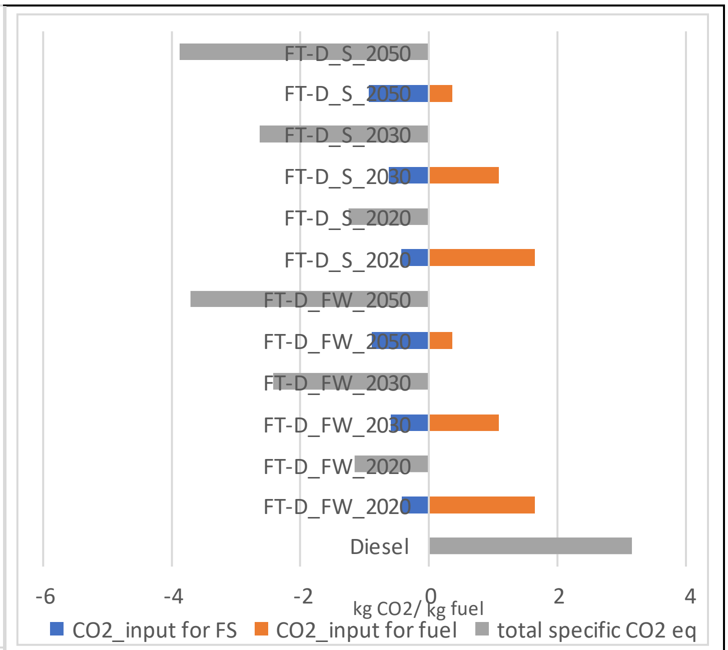

Fig. 4. CO_2 balances for forest wood-to-FT diesel & straw-to-FT diesel chains for 2020, 2030 and 2050 (based on Ajanovic et al. 2012) compared to corresponding Diesel CO_2 (TTW emissions) for the EU

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 CO_2-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 CO_2 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.

References

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