ECOLOGIC AND ECONOMIC ASSESSMENT OF BIOMASS BASED ENERGY CARRIERS IN AUSTRIA – A DYNAMIC MODEL FOR THE OPTIMIZATION OF BIOMASS FOR ENERGETIC USE

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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. Especially in the context of the decarbonization of the energy system and its transition to a sustainable one, the future role of biomass as a largely GHG- and CO_2-neutral energy carrier plays a central role. However, in recent years certain biomass fractions have been increasingly criticized in terms of their economic and environmental performance.

Core objective

The core objective of this paper is to assess selected energy carriers of different states (solid, liquid and gaseous biomass fractions) from an economic, socio-economic and ecologic view point. Further, energy carriers will be assessed from an energy economics viewpoint with respect to the international biomass trade and in terms of their entire life-cycle in order to derive optimal strategies for the utilization and future research regarding different biomass fractions in Austria.

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), labour, 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 [€/ ton 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.

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

where:
$\eta_{feedstock}$……FS conversion efficiency
CO_2 *input* $_{feedstock}$……∑CO_2 (passive/sink, fertilizer, $fuel_{feedstock}$, $fuel_{transport}$) [kg CO_2/ kg FS]
CO_2 *input* $_{biofuel}$……∑CO_2 ($credit_{by-products}$, pressing, BF conversion, other WTT, $transport_{fill.\ stat.}$, TTW) [kg CO_2/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 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.

Results

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 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 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 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 drastically, 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 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. It should be noted that the long version of the paper will feature a more detailed and refined environmental analysis and that the method described here is meant to be a preliminary description.

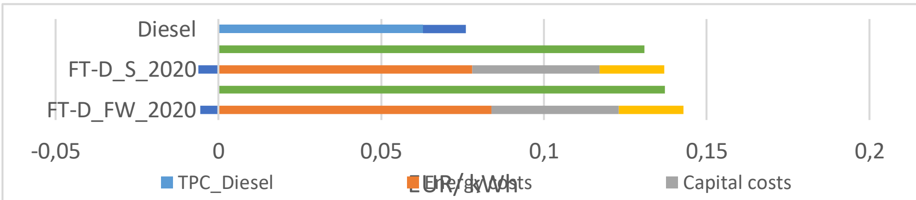

Fig. 1. Segmented total production costs for forest wood-to-FT diesel & straw-to-FT diesel chains incl. CO_2 taxes for 2020 (based on Ajanovic et al. 2012) compared to corresponding Diesel price (EUR/kWh) for the EU[1]

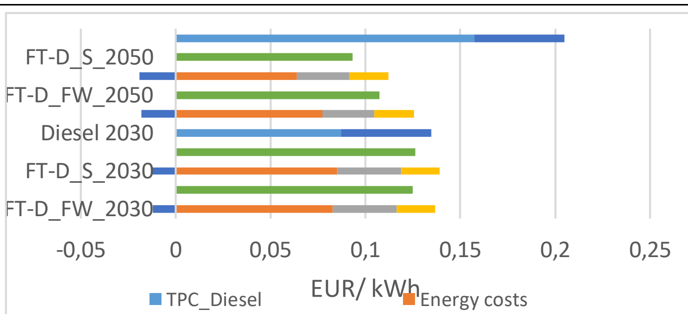

Fig. 2. Segmented total production costs scenarios for forest wood-to-FT diesel & straw-to-FT diesel chains incl. CO_2 taxes for 2030 and 2050 (based on Ajanovic et al. 2012) compared to corresponding Diesel prices (EUR/kWh) for the EU

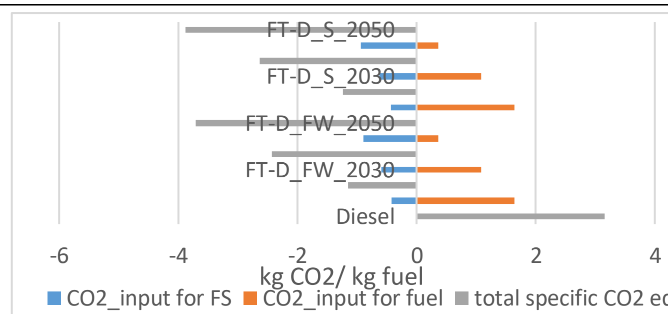

Fig. 3. Segmented total CO2 scenarios for forest wood-to-FT diesel & straw-to-FT diesel chains (based on Ajanovic et al. 2012) compared to corresponding Diesel prices (EUR/kWh) for the EU

Conclusions

The major, preliminary conclusions of this analysis are: (i) The way towards an increased share of biomass-based energy carriers, such as FT diesel, in the overall energy mix should be accompanied by rigorous policy measures; (ii) in order for biomass-based energy carriers 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 biomass-based energy carriers , such as FT diesel, is highly likely to cause the latter to supersede conventional diesel as early as 2030.

References

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[1] Abbreviations: TPC… total production cost, FT-D_FW…FT-diesel produced from forest wood, FT-D_S… FT-diesel produced from straw