Economic and ecologic analysis of biomass-based energy carriers in Austria – contribution to decarbonizing the energy sector by 2040

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Introduction & Motivation I

- Decarbonization of and transition to a sustainable energy system (e.g. COP21, Austrian government's climate neutrality by 2040 mandate)

- Important role of biomass as GHG- and CO_2-neutral energy carrier in this context

- Globally, Biomass is the energy carrier with the longest historical significance
  - In the year 2019, it represented approximately 18% of the primary energy within Austria's overall energy mix.
  - Criticism of certain biomass fractions from an ecological standpoint

- Analysis of selected energy carriers (solid, liquid, gaseous biomass fractions) from an economic & ecologic standpoint.
  → derive optimal stragtegies for the use of different biomass fractions in Austria from an energy economics viewpoint & to highlight the role of biomass within *the climate neutrality by 2040* mandate

Objective

(1) To determine and compare the present[1] **economic** and **environmental** performance of the following eight Biomass-to-Energy Carrier chains and their conventional alternatives:

(a) Forest residue & wheat straw pellets-to-FT Diesel

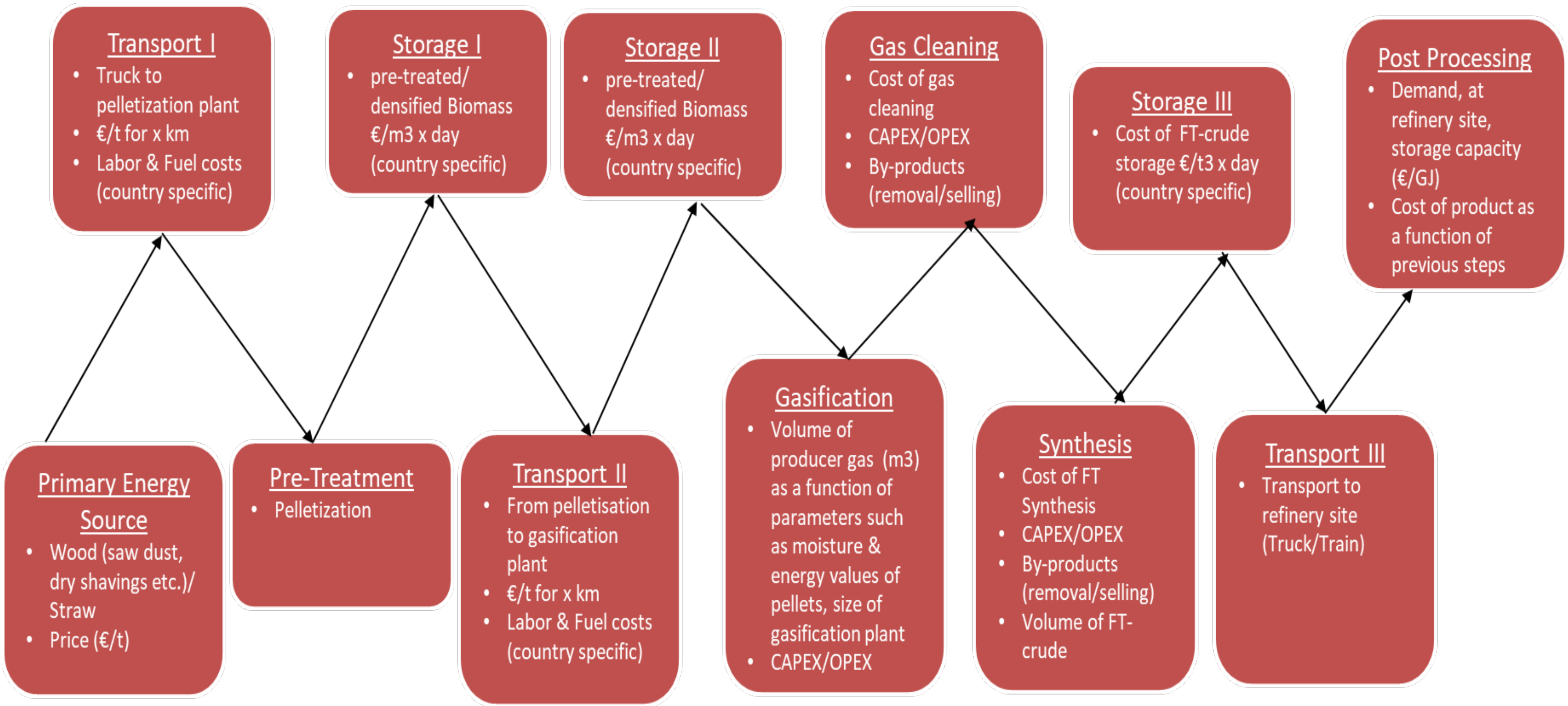
(b) Wood chips → local heat, electricity, (SNG)

(c) Sawmill-by-products → local heat (from boilers), electricity, (SNG)

Diesel, electricity, heat & gas based on conventional (fossil) fuels

(2) To provide an outlook for the expected economic and environmental performances of the above mentioned Biomass-to-Energy Carrier chains and their conventional alternatives for 2030 and 2050

Generic BtL fuel process chain for CLARA*



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Method of Approach

Economic analysis:

where:

EC……Energy content [kWh/ton FS]

FS…. Feedstock

P_{FS}……price FS [€/ton FS]

IC……investment costs [€/kW]

n……..efficiency of refinery

$C_{O\&M}$…..∑operation & maintenance, transport, labor, electricity, heat etc. [€/Kw]

R_{SP}…. Revenues side-products

T…. full load hours [h/yr]

Environmental analysis:

where:

η_{FS}……Feedstock 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 ($credit_{by\text{-}products}$, pressing, BF conv., other WTT, $transp._{fill.\ stat.,}$ TTW) [kg CO_2/kg BF]

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

Economic Assessment, Forest residue & wheat straw pellets → FT-Diesel

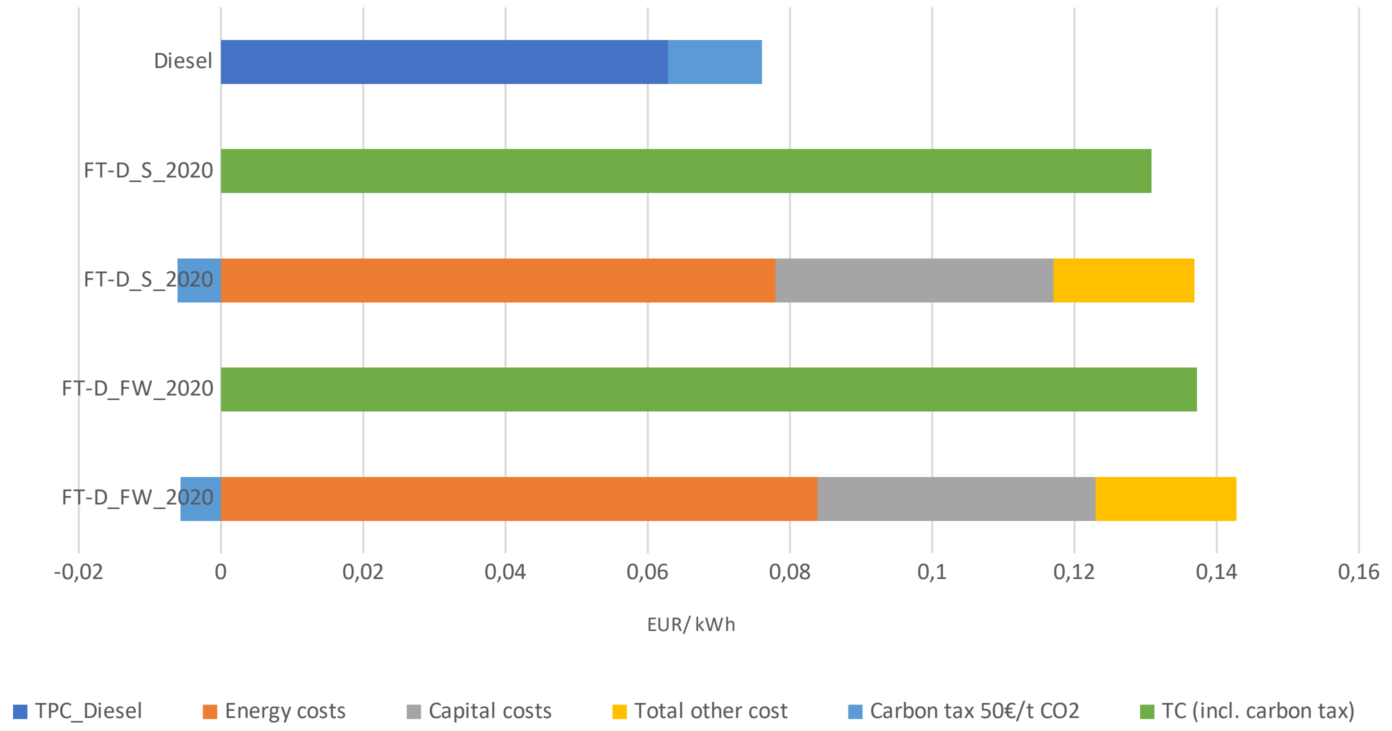

Fig. 1. Segmented total production costs for forest wood-to-FT diesel & straw –> FT diesel chains incl. CO_2 taxes for 2020

*for the year 2020
Abbreviations:
TPC… total production cost, FT-D_FW…FT-diesel produced from forest wood, FT-D_S… FT-diesel produced from straw

Economic Assessment, Wood chips → local heat, electricity & (SNG)

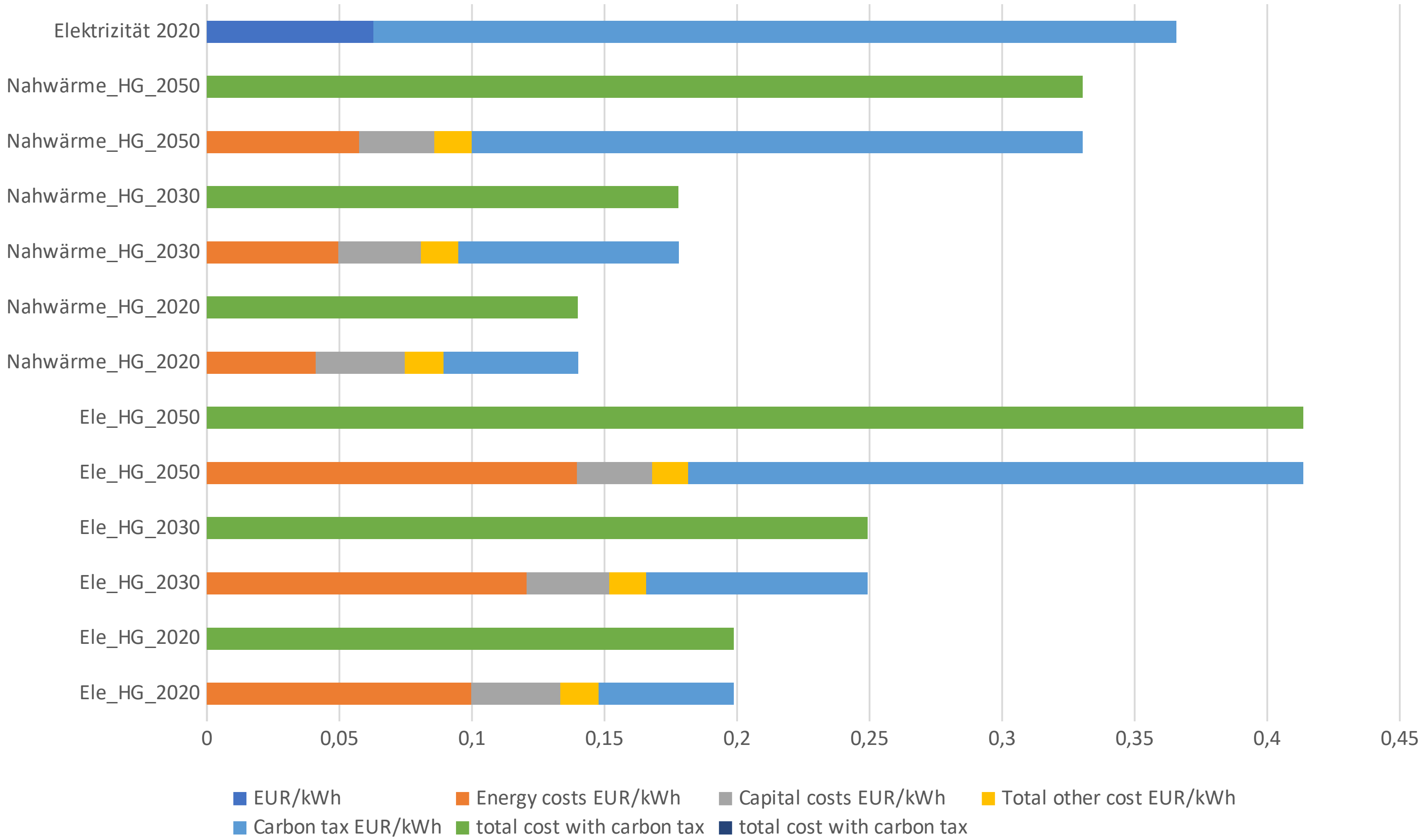

Fig. 2. Segmented total production costs for wood chips → local heat & electricity chains incl. CO_2 taxes compared to corresponding electricity price (€/kWh) for the EU

Abbreviations:
TPC… total production cost, FT-D_WS…FT-diesel produced from wheat straw, FT-D_PFR… FT-diesel produced from pine forest residues

Economic Assessment, Sawmill-by-products → local heat (from boilers), electricity & (SNG)

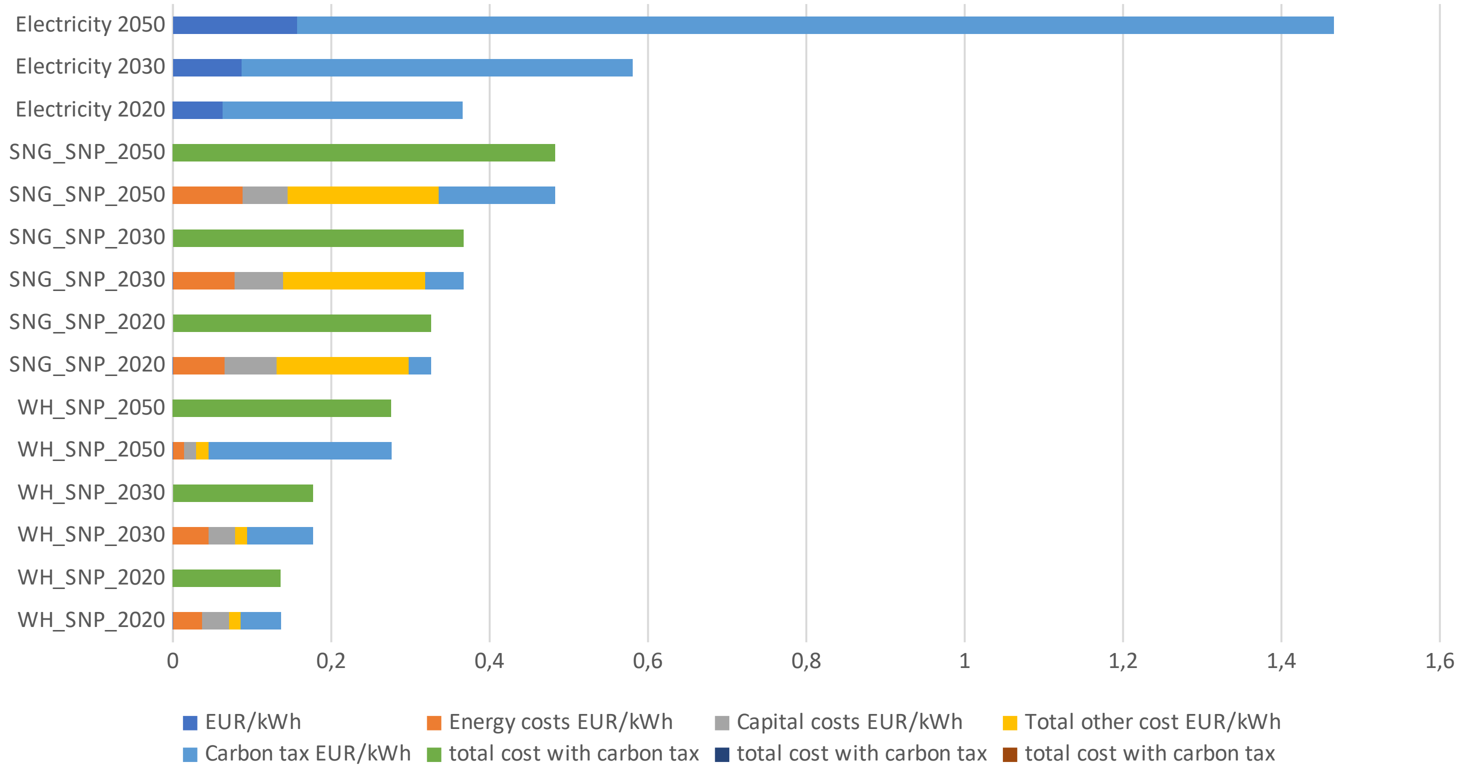

Fig. 3. Segmented total production costs scenarios for Sawmill-by-products → local heat & electricity chains incl. CO_2 taxes for 2030 and 2050 compared to corresponding Electricity prices (EUR/kWh) for the EU

Where FT-D_S and FT-D_FW signify FT diesel obtained from straw and forest wood, respectively, * Ajanovic et al (2012)

Environmental Assessment, FT- Diesel example

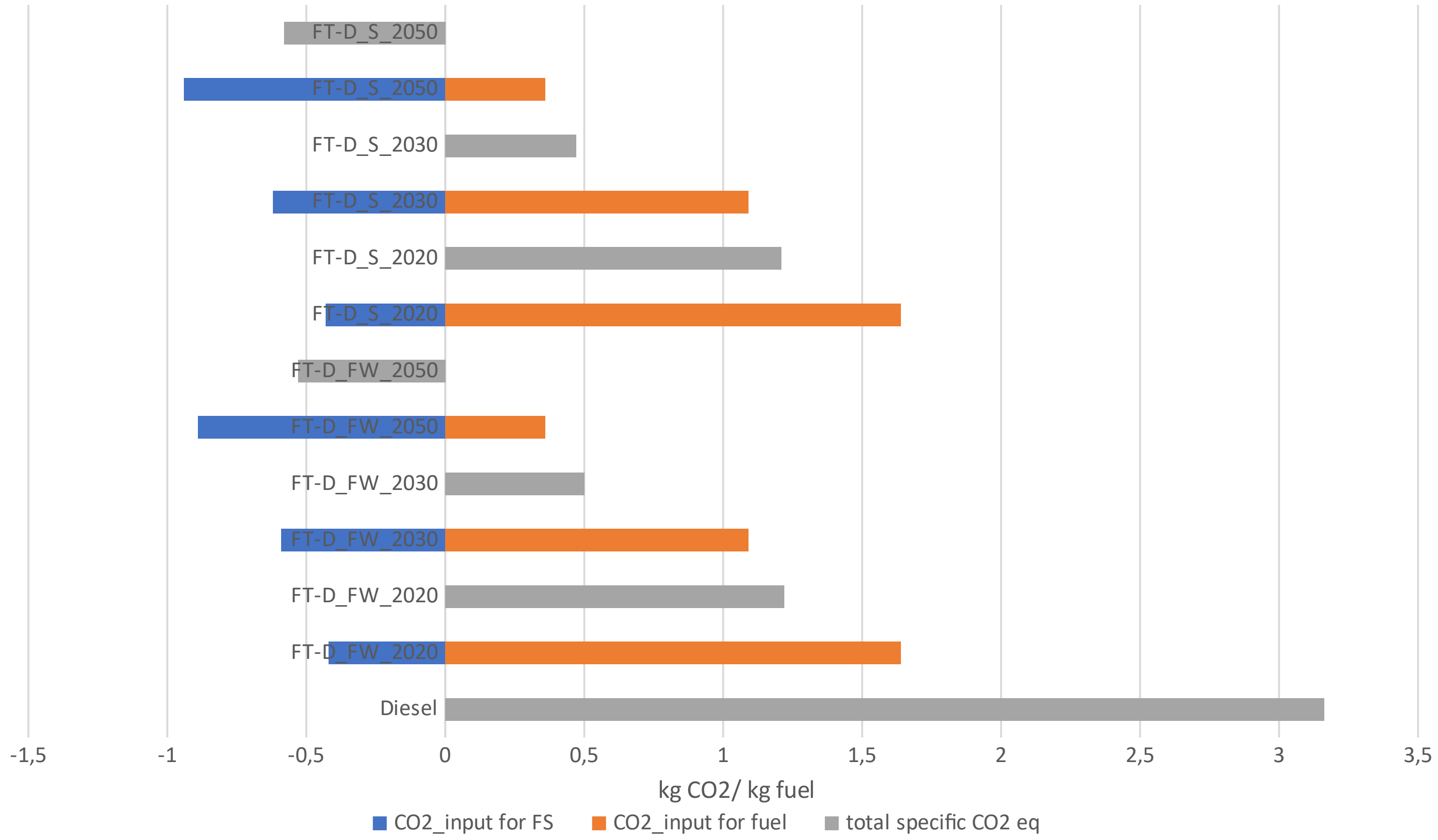

Fig. 4. CO_2 balances for forest wood-to-FT diesel & straw-to-FT diesel chains for 2020, 2030 and 2050 compared to corresponding Diesel CO_2 (TTW emissions) for the EU

Where FT-D_S and FT-D_FW signify FT diesel obtained from straw and forest wood, respectively, * Ajanovic et al (2012)

Conculsions (selected results)

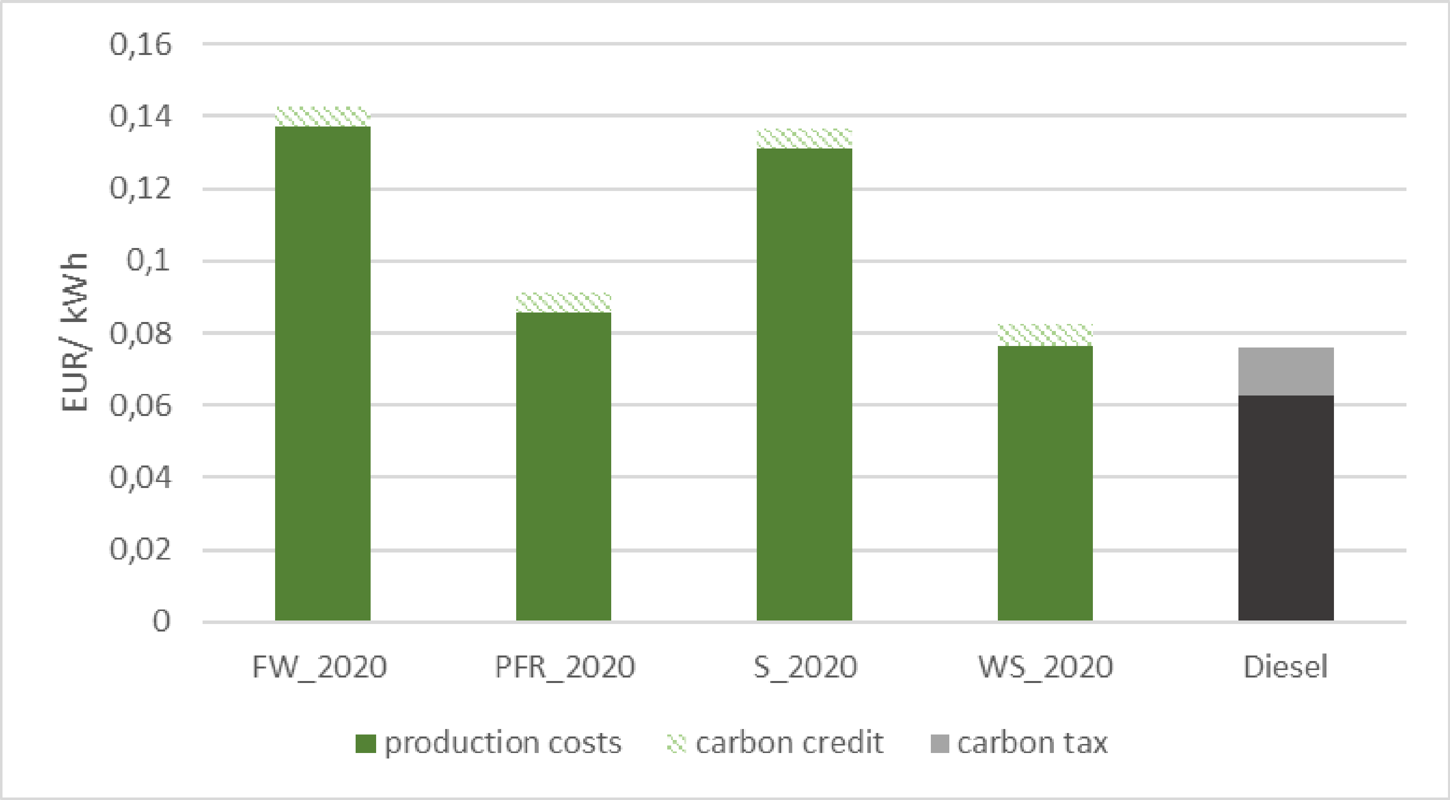

Fig. 5. Total production cost scenarios for forest wood-to-FT diesel (a), pine forest residue-to-FT diesel (c), straw-to-FT diesel (b) and wheat straw-to-FT diesel (d) chains incl. CO_2 taxes for 2020 (based on Ajanovic et al. 2012 & CLARA project) compared to corresponding Diesel prices (EUR/kWh) for the EU

Conclusions

(i) For an increased share of green alternatives to conventional fuels in the overall energy mix rigorous policy measures are needed (e.g. regulations for min. share of renewable fuels in total energy mix)

(ii) For green alternatives to play a significant role in the energy transition a proper mix of CO_2-taxes & intensified R&D to improve the conversion efficiency from feedstock to fuel (leading to lower feedstock cost & improved ecological performance) are needed

(iii) Increase in TPC & CO_2 taxes of conventional alternatives, combined with the increase in ecologic and economic performance of green energy sources, is highly likely to cause the latter to supersede conventional energy sources by 2030, if not earlier.

Insights:

- Recent FS cost data for wheat straw & pine forest residue* suggest that these are significantly lower (36 €/ ton wheat straw & 50 €/ ton pine forest residue) than previous estimates cited in literature (e.g. Ajanovic et al. 2012, (119 €/ ton for straw & 129 €/ ton forest wood) for the year 2020
- FS cost (€/ton) seems to have a significant effect on the TPC of full biomass-to energy carrier chains
  - Low FS costs combined with CO_2 taxes could lead to FT diesel production from wheat straw being economically feasible earlier than expected and approximately equal to conventional diesel in 2020
- Labour costs have been significantly higher for specific biomass-to-energy carrier chains than other especially e.g. in wood and straw pellet → SNG chains

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