ECONOMIC ASSESSMENT OF CO_2 UTILIZATION FOR WASTE BIOMASS CONVERSION INTO TRANSPORT FUELS

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Overview

The European Commission adopted a new circular economy action plan in 2020 to create sustainable growth and protect biodiversity (European Commission 2020). Biomass is used in many regions of the world as feedstock for green gas or liquid fuel production. However, it must be considered that this resource has limitations and conflicts with other sectors can arise [1]. A conflict for the use for food, feed and fuel production of agricultural land exists already and this competition will likely get even stronger [2]. In years with low agricultural yields, the chance of increasing crop prices through biofuel production is higher [3].
The transport sector is a major contributor to greenhouse gas (GHG) emissions in Austria and the EU. **Figure 1** shows GHG emissions in Austria from 1990-2019 in kt CO_2 eq. per sector. The emissions in the transport sector strongly increased by around 75%, in the EU by around 25%. The utilization of biowastes and lignocellulosic biomass for conversion into energy carriers is proposed to contribute to the decarbonization of the energy system and progress towards a circular economy [4]. These kinds of feedstocks gained more attention in recent years, because the EU restricts the use of food crops for biofuel production to 7% of all renewable fuels (Renewable Energy Directive, EU 2018). Lignocellulosic biomass has a greater potential than energy crops towards a decrease of GHG emissions, because biomass cultivation, harvesting and transport have a substantial influence on environmental impact. The usage of local biomass is suggested to be the most environmentally friendly and economically feasible way of producing biofuels [5].

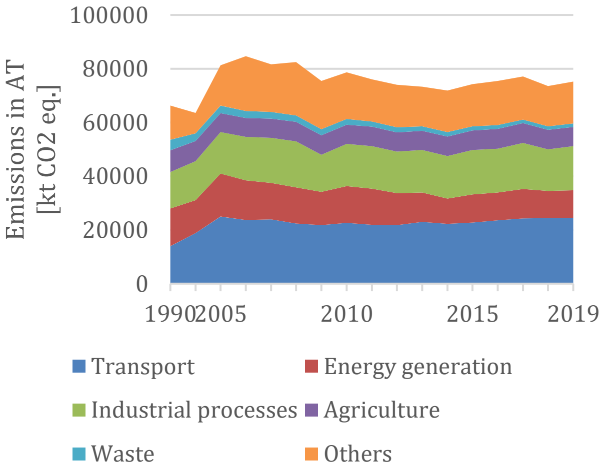

Figure 1. Sectoral emssions in Austria from 1990-2019, source: Umweltbundesamt

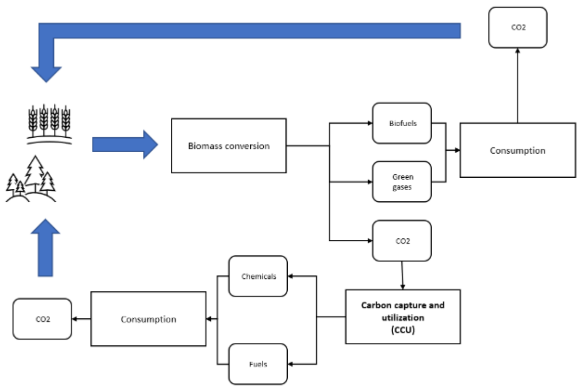

Figure 2. Scheme of biomass conversion and carbon capture and utilization (CCU) to produce CO2-derived products

The core objective of this paper is an economic assessment of biomass conversion with CO_2. The usage of CO_2 as a renewable carbon source is an innovative approach in recent years. CO_2 can be utilized via conversion or non-conversion, e.g. as a solvent or for material processing (Jeffry et al. 2021). In carbon capture and utilization (CCU) as seen in **Figure 2**, CO_2 becomes converted into valuable products for

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example fuels, chemicals, etc. One possible conversion method is realized in the dual fluidized bed gasification reactor with CO_2 as gasifying agent [6]. An important reaction in this process is the Boudouard-reaction: $CO_2 + C \leftrightarrow 2\ CO$, $\Delta H = + 172{,}5$ kJ/ mol. The reaction of gaseous CO_2 with solid C from biomass is supposed to form carbon monoxide (CO), which is more favorable in the synthesis gas for upgrading into fuels, e.g. synthetic natural gas (SNG).

Methods

Our approach is based on: (i) an extensive literature research of state-of-the-art technologies for CO_2 utilization and biomass conversion; (ii) an assessment of feedstock potentials with a focus on Europe; (iii) an economic discussion regarding production cost of renewable fuels compared to fossil fuels; (iv) an outlook for innovative CO_2 utilization methods under research.
Production costs were calculated based on feedstock prices from Statistik Austria for 2020 and values for conversion efficiencies and specific investment costs from ALTETRÄ [7].
Total fuel production costs were calculated with following formula:

$$C_{fuel} = I_C * \ CRF + p_{Biomass} * z + c_{var}$$

C_{fuel}= fuel production cost, I_C= specific investment cost [€/ t fuel], CRF = capital return factor, $p_{Biomass}$= price [€/ t feedstock], z = conversion factor [t feedstock/ t fuel], c_{var}= variable cost including: operating and maintenance (O&M), heat & electricity, labor, transport, CO_2 price [€/ t fuel]

Preliminary results and discussion

Energy crops are currently widely used for biofuel production in Europe. However, conversion of residues and waste streams should be promoted in the future, because of conflicts with agricultural land and material utilization. Furthermore, it is also expected that fuels derived from waste streams will earlier reach economic competitiveness with fossil fuels than fuels from energy crops.
Feedstock prices and conversion efficiencies have a strong influence on the overall production cost of SNG from biomass. Production costs for biomass gasification of spruce or pine fiber wood are approximately 7.5 €ct/ kWh and for straw 8.9 €ct/ kWh. Feedstock price of straw accounts for 34.9% of total production cost, whereas in the case of spruce fiber wood for only 21.5%.
Only a few pilot plants for carbon capture are in operation worldwide. Prices per ton CO_2 avoided are very different depending on the technology. For market penetration of CO_2-derived fuels, high concentrated CO_2 streams for example from biogas upgrading with low capture cost are preferred.
The preliminary calculations lead to the conclusion that biomass conversion with CO_2 is currently not cost-competitive to fossil fuels and support schemes will be important for market deployment.

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