ECONOMIC AND ENVIRONMENTAL ASPECTS OF BIOMASS-BASED GASES FOR THE TRANSPORT AND ENERGY SECTORS IN THE EUROPEAN UNION

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Overview

Natural gas is an important energy carrier in the EU (Billig and Thraen, 2017) and used for various applications like electricity production, synthesis of chemicals, transport, etc. Figure 1 shows the increasing consumption from about 313 million m³ in 1990 to around 410 million m³ in 2019. However, the consumption of fossil fuels like natural gas leads to increasing CO2 concentrations in the atmosphere and rise of global average temperatures. As part of the European Green Deal, the EU aims also to decarbonize the gas sector. For this reason, a new framework for low emission hydrogen (H2) and methane production was proposed in December 2021.

Hydrogen is besides methane another important energy carrier (Ajanovic and Haas, 2021). The global demand has grown by around 50% in the period from 2000-2020, but 96% of hydrogen is currently produced from fossil fuels (IEA, 2021) with accordingly high emissions of 9-11 kg CO2 per kg H2 produced (Salkuyeh et al., 2018). Alternatives to natural gas and fossil fuel-based hydrogen can be produced from biomass via different process routes, e.g. biogas technology or thermochemical conversion.

The core objectives of this paper are economic, environmental and policy assessments of biomass-based gases for the energy sector.

Methods

In this paper, production costs of biomass-based gases are analyzed as well as corresponding emissions.

(i) Production costs are obtained using following equations:

$$CRF = \frac{(1+r)^n r}{(1+r)^n - 1} \quad (1)$$

$$C_{fuel} = I_C * \frac{CRF}{FLH} + p_{Biomass} * \frac{z}{LHV} + c_{var} \quad (2)$$

(ii) A comparison for specific GHG emissions along the production chain is given in a cradle-to-gate approach, which means that consumption of the energy carriers is not considered, see Figure 2. Therefore, the uptake of CO_2 by crops or trees was also not considered, as it makes more sense to incorporate it into the calculation when the whole life cycle is analyzed. Data for emissions were obtained from GEMIS, ProBas databases as well as literature. (iii) Furthermore, a literature review of EU policies regarding the deployment and support of green gases in the EU was conducted considering their impact on economics and environmental prospects of biomass-based gases.

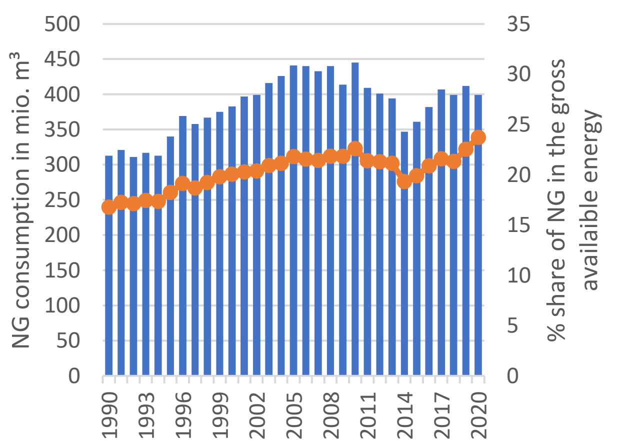

Fig. 1. Natural gas consumption in the EU in mio. m³ (left axist) and % share of natural gas in EUs gross available energy. Source: Eurostat

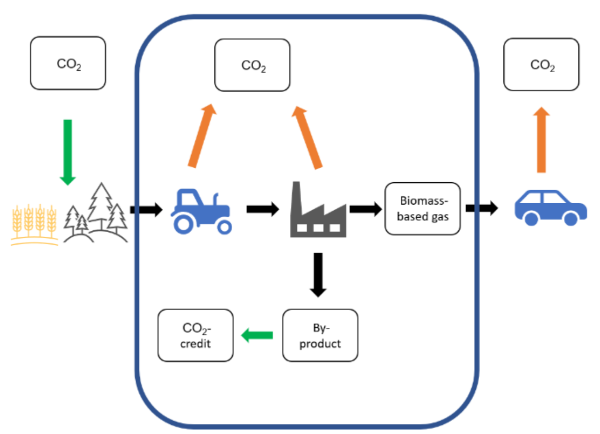

Fig. 2. Boundaries of environmental assessment of biomass-based gas production technologies.

Results

Production costs for biogas and biomethane are in most cases lower than for synthesis gas and SNG, seen in Figure 3. However, the scale has an influence on the overall production cost, because unit production costs decrease at a larger scale. A 20 MWth plant shows approximately 2 to 2.5 times higher overall production costs than a 200 MWth plant. The environmental performance of the thermochemical pathway, on the contrary, can be better because of higher carbon utilization. The type of feedstock has also a substantial influence too on the environmental analysis, as shown in Figure 4. Crop cultivation has a strong impact on the feedstock related emissions. Therefore, the utilization of residues is more environmentally friendly than of energy crops.

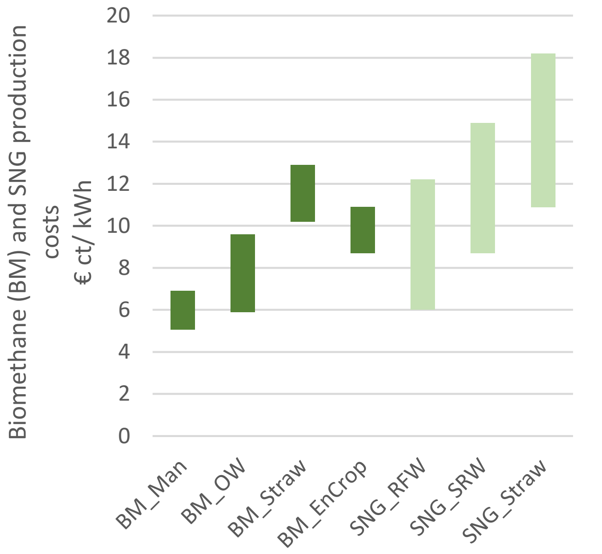

Fig. 3. Production costs for biomethane (BM) and SNG via anaerobic digestion and thermochemical conversion of biomass depending on the utilized feedstock. Sources: (Billig and Thraen, 2017; Millinger et al., 2017; Rotunno et al., 2017)

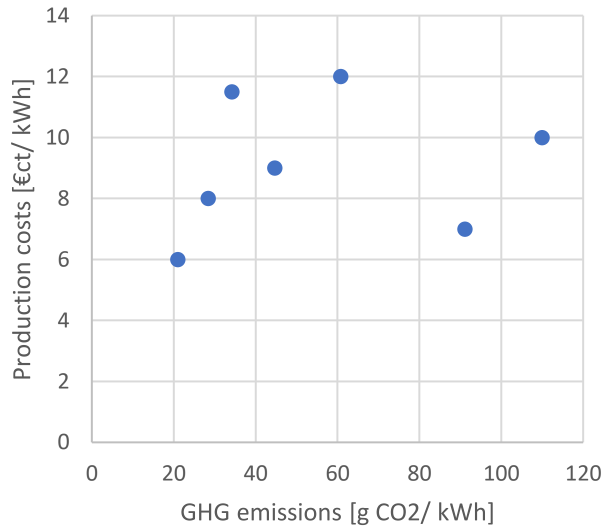

Fig. 4. Differences in production costs and GHG emissions of biomass to gas conversion technologies and various feedstocks utilized. Source: ProBas database, (Ajanovic et al., 2012)

Conclusions

Biomass-based gases can contribute to reach the GHG emission reduction goals. The analysis in this paper shows that there is a broad range of production costs of the gases as well as of the potential CO2-savings. The deployment should be promoted by using appropriate policies, because in most cases the production costs are higher than for natural gas and fossil fuel-based H2. (to be completed for the final presentation)

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