ECONOMIC AND ENVIRONMENTAL ASSESSMENT OF CO2 UTILIZATION FROM BIOMETHANE PRODUCTION

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Overview

The European Commission adopted a new circular economy action plan in 2020 to create sustainable growth and protect biodiversity [1]. The utilization of biowastes and lignocellulosic biomass for conversion into biomethane can contribute to the decarbonization of the energy system and progress toward a circular economy [2]. Biomass is used in many regions of the world as feedstock for biomethane production. However, it must be considered that this resource has limitations, and conflicts with other sectors can arise [3].

The biomass conversion also causes biogenic CO_2 emissions. CO_2 utilization can be used to enhance the amount of biogenic carbon, which is converted to the valuable product, biomethane, in this work.

This work investigates the production costs and emission avoidances of biomethane from biomass feedstocks with additional hydrogen input enhancing the production output.

Methods

Our approach is based on: (i) an extensive literature research on the investment and operating costs of biomethane production, (ii) an assessment of possible CO_2 utilization routes, (iii) an economic analysis regarding the production cost of enhanced biomethane output. Hydrogen and renewable electricity are required to enhance the output and utilize the CO_2.

Total biomethane production costs were calculated with the following formula:

$$c_{gas} = \frac{CRF * IC + C_{O\&M} + C_{misc}}{FLH} + \frac{P_B}{LHV * \eta} + c_{var}$$

with: C_{gas}= production costs of biomethane [EUR/MWh], IC = investment costs [EUR/ kW], CRF = capital recovery factor, p_B= biomass costs [EUR/ t], C_{misc} = other capacity related costs (EUR/MW), FLH = operational full-load hours (h), LHV = lower heating value (MWh/ ton), η = conversion efficiency (%) and c_{var} = variable costs, including electricity, chemicals, etc. (EUR/MWh).

The environmental analysis in this study accounts for all relevant greenhouse gas emissions along the process chain until the final product. The data is derived from the literature and the ProBas database of the German environment agency. The analysis also considers emissions from consumption as this is appropriate for the comparison with fossil references. However, no specific use case was investigated.

Preliminary results and discussion

The production costs of biomethane are the lowest per MWh for biowaste conversion. The production costs based on energy crops of 90-114 EUR/ MWh are 50-100% higher than for biowaste utilization. The utilization of low-cost biomass residues can show economic feasibility. However, the utilization of CO_2 from these processes will remain challenging as the costs increase significantly.

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The environmental analysis of the base case without hydrogen showed that the feedstock-related emissions have the highest impact on the results. The embedded emissions for the biomethane plants account for only a minor share of the total emissions. The extent of emission reductions depends on the electricity source and biomass feedstock.

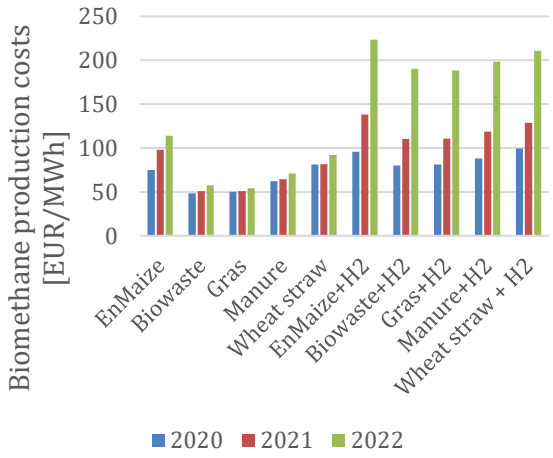

Figure 1. Production costs of biomethane in the base case and for CO_2 utilization by adding hydrogen addition.

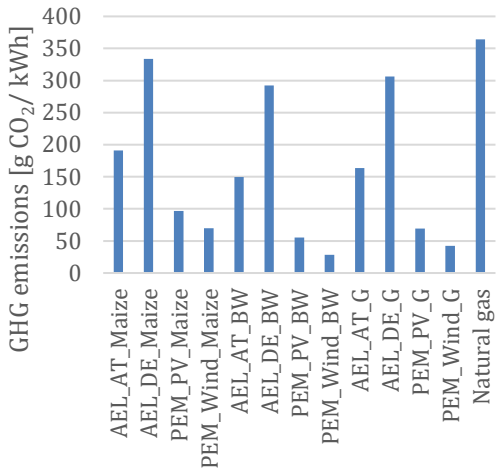

Figure 2. Greenhouse gas emissions of enhanced biomethane production. AEL = alkaline electrolysis, AT = Austrian electricity mix, DE= German electricity mix, BW = biowaste, PV = photovoltaics, G = grass, PEM = proton exchange membrane electrolysis.

References

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