Methane from renewable energies for the transportation sector – an environmental analysis of the crucial value chain

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Background and objectives

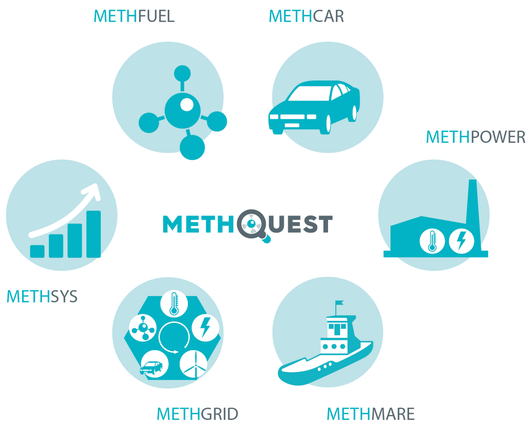

Figure 1: Layout of the project MethQuest

The ongoing energy transition needs to progress hand in hand with a transition of the mobility sector to enhance defossilisation and to counter climate change. One approach offering reduction perspectives for both sectors are Power-to-Gas technologies (PtG). The project MethQuest, funded by the German Federal Ministry for Economic Affairs and Energy, tries to support and investigate large scale introduction of renewable methane.

Next to technology development environmental analyses are crucial in order to avoid misdevelopments and to identify optimal pathways. Those analyses aim to figure out the overall impact of the production phase of facilities and its potential changes over unit size and years, as well as the relevance of life spans and auxiliary plant components.

More information on the project MethQuest can be found on https://www.methquest.de/

Method

Life Cycle Assessment is used as evaluation tool.

Goal and Scope definition:

- Evaluated system: Power-to-Gas facilities from 1 to 100 MW for different years (2020, 2030, 2040 and 2050)
- Functional Unit: Production of 1MJ methane (LHV)
- System boundary: CO_2 from biogas free of burden (Cut-Off), for biomass gasification feedstock production is included. All production chains include production of the facility itself
- Impact Assessment Category and Method used: Global warming potential (GWP), Environmental Footprint 3.0
- Software: GaBi v10

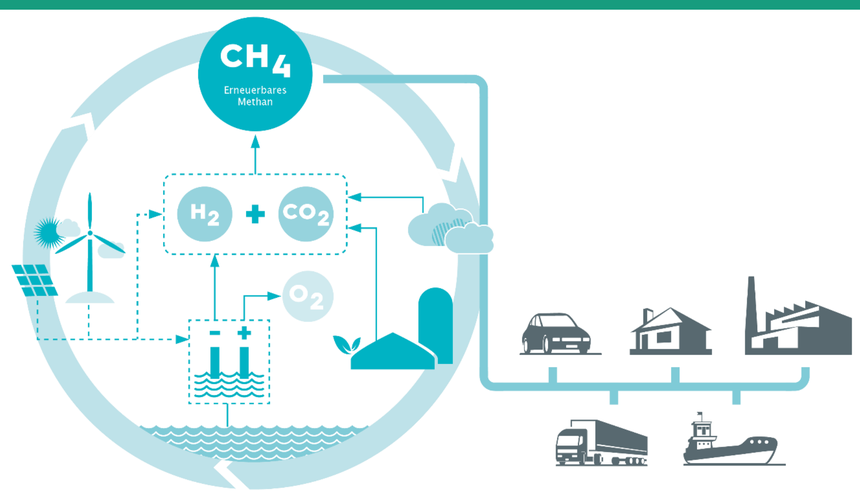

Figure 2: Methane from renewable sources for various applications

Results

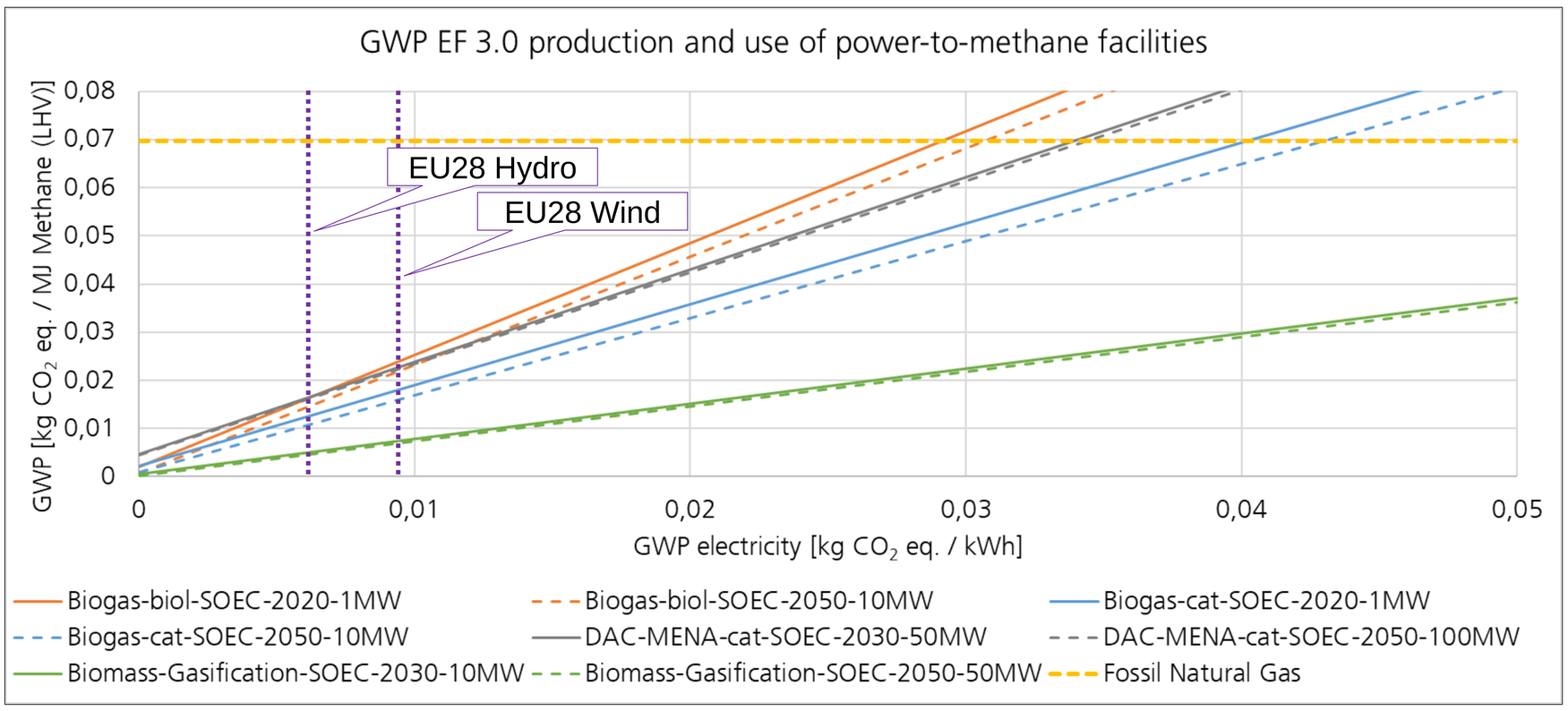

Figure 3: LCA results for the 8 evaluated process chains in best case parameter settings

Only some of the evaluated routes are shown in Figure 3

The considered process chains vary in the following parameters:

Source of Carbon / Production technology

- Biogas / biologic methanisation
- Biogas / catalytic methanisation
- Direct air capture (DAC) in MENA region / catalytic methanisation
- Biomass gasification

Unit Size

- 1 to 100 MW (depending on route)

Type of electrolyser technology

- Solid oxide electrolyser cell (SOEC)

Year of production

- 2020 to 2050 (depending on route)

Figure 3 shows the resulting GWP per produced MJ methane (LHV) depending on the GWP of the available electricity:

- The yellow dashed horizontal line shows fossil natural gas including combustion and indicates the potential break-even
- A (very) high renewable share is needed to have a lower GWP compared to fossil natural gas
- Biomass gasification has the lowest impact as biomass is an energy rich feedstock compared to CO_2
- DAC needs more energy to capture CO_2 compared to burden free CO_2 from Biogas. Also liquefaction for transport is included in the electricity demand. But a location in the MENA region offers potentially high amounts of low GWP and low cost renewable electricity
- The lines do not start at 0 (y-axis) as the production of the facility is included. In the case of DAC MENA with catalytic methanisation and wind power as electricity source more than 20% of the total impact are related to the production of the facility

Conclusion and Outlook

These results represent an extract of the study only. They are illustrating findings for exemplary PtG production pathways. On one hand renewables are necessary for a climate friendly PtG production, on the other hand renewables can be used directly as decentral production is possible with small installed capacity. Especially if renewables are used the production of the facility should be accounted for, because its relevance increases.

Within the project additional evaluations have been conducted to assess the whole value chain. For example the use of the renewable methane can be shown by a well-to-wheel analysis of the German vehicle fleet including an agent based modelling of the gradual exchange of powertrains over the years.

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