Climate Action Programme
for the Chemical Industry

International PtX Hub

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GREEN METHANOL

Factsheet

Background

Methanol is a widely used solvent, energy source and raw material for the chemical industry. It is an organic chemical, which is colourless, flammable and toxic. Methanol can be mixed in various ratios with water and many organic solvents. Inorganic salts can also be dissolved in methanol. Along with ammonia, propylene, and ethylene, methanol is one of the most widely produced basic chemicals in the world. [1] Methanol is used in a variety of applications. including fuel and fuel additives, wastewater denitrification, chemical feedstock, and hydrogen carrier. [2]

Methanol is relevant for our daily lives. The primary uses involve the conversion into formal-dehyde, which is then processed to create resins, adhesives, and assorted plastics. Additionally, it is utilised in the manufacturing of acetic acid, primarily employed in producing polyester fibers and PET plastics, as well as in the automotive manufacturing and medical equipment. [3]

The synthesis of methanol is described with the following chemical equation:

$$\text{(1)}\quad CO\,(g) + 2\,H_2\,(g) \rightleftharpoons CH_3OH + Q$$

$$\text{(2)}\quad CO_2(g) + 3\,H_2(g) \rightleftharpoons CH_3OH + H_2O + Q$$

g gaseous
Q thermal energy

Over its life cycle, methanol produced from fossil feedstocks such as natural gas, or coal accounts for about 10% (0.3 gigatonnes) of the chemical sector's total annual CO_2eq emissions. According to International Renewable Energy Agency's (IRENA) Transformation Energy Scenario it is expected that the methanol demand will reach more than 120 Mt by 2025 and could rise to 500 Mt per annum by 2050. [1] This would mean that if methanol were produced from fossil feedstocks, emissions would increase to 1.5 Gt of CO_2 per year.

Methanol Fast Facts [1]

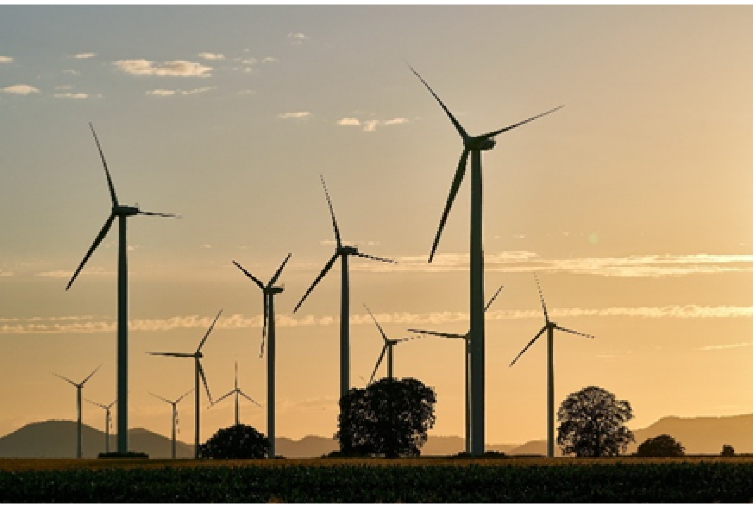
- Worldwide annual production: 98 Mt (2019)
- Most of the growth until 2028 is expected from China to produce olefins
- Renewable methanol production: less than 2 Mt annually
- Methanol from renewable sources cuts CO_2 emissions by up to 95% compared to conventional fuels

To reduce the carbon intensity of related value chains, the production of basic chemicals such as methanol needs to be progressively defossilised, which can eventually lead to net zero emissions. [1] Several alternative processes or pathways are available that do not rely on fossil resources or that make the methanol production less carbon intensive or even net carbon neutral.

Green methanol

There are two main cases in which methanol can be considered as ‘green’, although a combination of both is also possible: Bio-methanol derived from biomass feedstocks and e-methanol from renewable electricity, water, and pre-captured CO_2

Green methanol can be produced from renewable sources such as carbon-based feedstocks. Within this production several production routes are available e. g. pyrolysis, gasification, biosynthesis, electrolysis, or electrochemical processes. [4]



The catalytic production of green methanol requires hydrogen which is produced in electrolysers with renewable energy.

Bio-methanol

To refer to methanol as ‘bio’, it needs to be renewable. This means the utilised biomass stems from e. g. agricultural residues, forestry or organic waste. Depending on the scale of production, different technologies can apply.Pyrolysis is a commonly applied technology to realise a large-scale production of bio-methanol which finds application in diesel engines. During pyrolysis, biomass is broken down into its components in the absence of oxygen and then converted into bio-methanol as a syngas in a further step. In contrast, methanol can be produced directly during gasification. This process takes place under air and has economic advantages. However, the treatment of the bio-methanol produced in this way is more complex, as more by-products are produced. Gasification processes present a shows an economical advantage in cost effectiveness, way to produce gaseous fuel, compared to pyrolysis. [4]

E-methanol

The term e-methanol applies if the reactants comprise of pre-captured CO_2 and green hydrogen. The production for e-methanol involves but is not limited to catalysis and electrochemical processes. Here the core process comprises of the reaction between CO_2 and hydrogen. E-methanol is a promising building block for the further production of liquid fuels e. g. gasoline. [5]

Obstacles

Challenges for the production of bio-methanol, result from limited resources in suitable biomass, and a still limited number of producers worldwide. When using biomass, it is also important to note that it could compete with food production and have a negative impact on agricultural land use. A main barrier to the production of e-methanol are the high costs due to the energy-intensive production of hydrogen and renewable carbon sources, e.g. from Carbon Capture and Utilisation (CCU). According to the International Renewable Energy Agency (IRENA), around 50 MWh of electrical power are required to produce one tonne of hydrogen via electrolysis. [1] Due to high energy costs, green methanol, is more expensive than conventionally sourced fossil based methanol, which presents a major economical barrier. [6]

Utilisation options for methanol

It has been shown that green methanol as a feedstock can drastically reduce greenhouse gas emissions compared to gray (fossil-based with natural gas as a source) and blue (blue hydrogen in combination with captured CO_2) methanol. Specially in the case of e-methanol through the use of CO_2 capture and utilisation for the chemical production process, which is the main application of methanol. Methanol can be used as a hydrogen carrier. Methanol is easier to transport at room temperature due to its liquid state. For this reason, and due to the better logistics for methanol, transport is significantly cheaper than for hydrogen. Methanol can also be used as a fuel for ships, aircrafts, and cars, whether as a fuel or in a fuel cell. For example, there are already container ships powered by methanol. [3]

Outlook

The production of green methanol offers great opportunities to defossilise an important segment of chemical production and associated value chains.

Challenges such as lowering the costs of renewable electricity and securing financing for a successful market-launch, need to be overcome to sustainably integrate the production of green methanol. [1] It is therefore among those innovative technologies that are expected to gain ground and pave the way towards mitigating greenhoouse gas emissions and achieving national and international climate goals.

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