Horizon 2020
European Union Funding
for Research & Innovation

MefCO$_2$ - Methanol fuel from CO$_2$

Synthesis of methanol from captured carbon dioxide using surplus electricity

Brussels, 13 September 2018

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MefCO$_2$ at a glance

Our project:

MefCO$_2$ (Methanol fuel from CO$_2$) aims to demonstrate the **economic feasibility** of valorising captured CO$_2$ by turning it into a versatile platform chemical and renewable fuel such as methanol using hydrogen produced from renewable energy.

Our team:

MefCO2 is a joint effort of multinational companies, SMEs and research centers from 7 countries

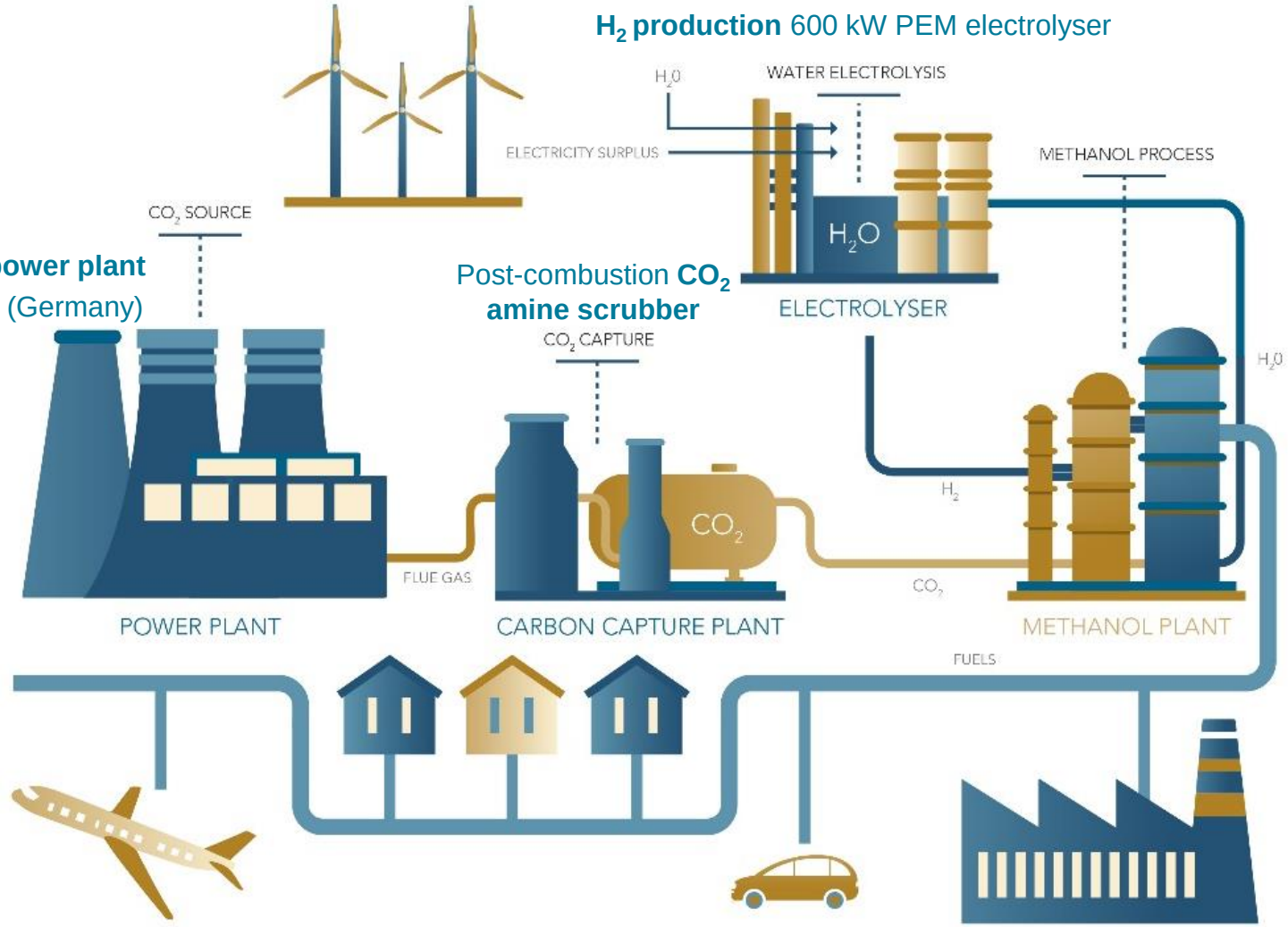
- **i-deals** (Spain) → Coordination, dissemination & exploitation
- **National Institute of Chemistry Slovenia** (Slovenia) → Catalysis and reaction engineering
- **Mitsubishi Hitachi Power Systems Europe** (Germany) → System integrator
- **RWE** (Germany) → Power plant owner
- **Cardiff Catalysis Institute** (UK) → Research in catalyst synthesis
- **Carbon Recycling International** (Iceland) → CO$_2$ to methanol technology developer
- **DIME - University of Genoa** (Italy) → Thermo-economic analysis and process optimisation
- **Hydrogenics Europe** (Belgium) → Electrolyser technology developer
- **University of Duisburg Essen** (Germany) → CO$_2$ capture technology provider

MefCO_2 Concept

H_2 production 600 kW PEM electrolyser

Lignite fired power plant
Niederaussem (Germany)

Post-combustion **CO_2 amine scrubber**



MeOH plant
Max MeOH output
1000 kg/day
Max CO_2 input
1500 kg/day

Our approach: MefCO$_2$

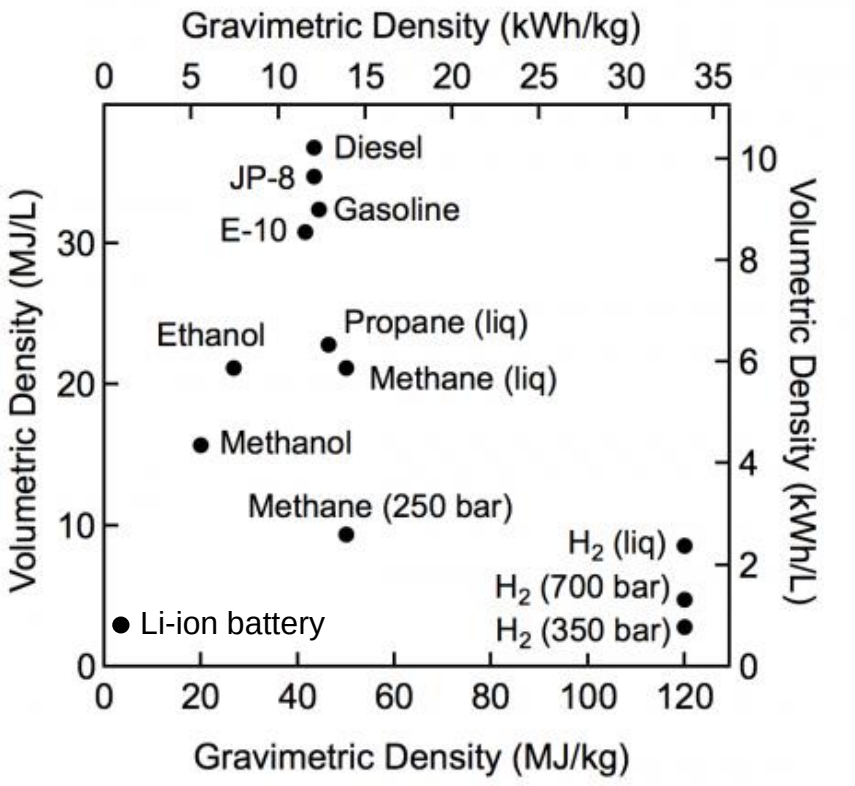
Chemical energy storage

What is MefCO2

- Is a demonstration low carbon methanol production route which can be transformed into other high volume base chemicals
- Is an indirect electrification route of road and maritime transport which can be deployed using existing ICEs with no or small modifications.
- Is a test bench for the provision of grid services using flexible electrolysers
- MefCO2 is aimed at improving the business case for CCS by using part of captured CO_2 and turning it into a revenue generation source.

What is not MefCO2:

- Is not a solution aimed at long term storage of captured CO_2. However it reduces fuel carbon footprint of transportation fuels since it substitutes fossil fuels.



Our approach. MefCO_2

Why methanol?

Current situation

Current MeOH production capacity of 100 MMT/year and projected demand (BAU) of 109 MMT/year in 2023 with growth coming from fuel blends and olefins.

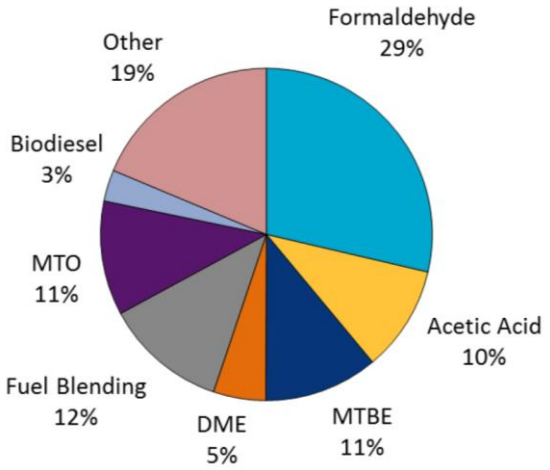
Nearly all MeOH produced is made from **fossil fuel feedstock** (natural gas and coal) while **low carbon MeOH** is limited to pilot tests and small scale production plants.

Biggest growth in MeOH demand has occurred in China mainly in MTO, DME synthesis and direct blending with gasoline.

New opportunities

Direct blending of methanol with gasoline is a relevant **growth opportunity**. Blending in the EU is well below the **3% v/v** limit set on the FQD directive in standard ICEs. The limit could be increased further for flexifuel vehicles.

IMO regulations mandate a reduction on Sulphur content of marine fuels and place tighter restrictions in ECA (Emission Control Areas) for SOx, NOx and PM. Methanol can be used as marine fuel and is Sulphur free burning cleanly without any PM and low NOx emissions.



Methanol Usage

Source: Methanex

Our approach: MefCO$_2$

From geothermal to other renewable energy sources

Reference plant

- Industrial plant located in Svartsengi (Iceland)
- CO_2 from gas separator in Svartsengi geothermal power plant
- Steady H_2 generation using alkaline electrolysers
- MeOH output 4000 ton/a, CO_2 input 5,500 ton/a
- Power consumption approx. 5 MWel (including gas compression)

MefCO$_2$ pilot plant

- Pilot plant located in Niederaussem (Germany)
- Postcombustion capture of CO_2 from flue gases in a lignite fired plant
- H_2 generation in 600 kW PEM electrolyser
- MeOH max output 1 ton/day / CO_2 input 1,5 ton/day

The EC effort towards climate change mitigation

The EU has recently reinforced its goals in terms of energy and climate change and mitigation with the RED II:

	2020	2030	2050
GHG reduction*	20%	min 40% (>45% possible)	80-95%
Renewable energy share	20%	32%**	-
Renewable energy in transport	10%	14%**	-
Efficiency increase	20%	32.5%	-

*From 1990 levels
** An upwards revission clause in 2023 is considered

Sector coupling can play a major role in the EU decarbonisation by direct or indirect electrification in sectors such as steel or chemicals. MefCO2 contributes to this decarbonisation effort in three ways:

- Facilitating CCS adoption in emission intensive industries
- Providing a production route for a versatile chemical such as methanol without consuming fossil fuel feedstock (olefins, formaldhyde, formic acid, etc.)
- Substituting fossil fuels in transport applications by low carbon methanol in multiple ways (direct blending with gasoline, in biodiesel production, oxygenate production, DME, MTG, etc.)

Legal framework for low carbon methanol production

Renewable Energy Directive II

Low carbon methanol can be considered a **Renewable Fuel of Non-Biological Origin (RFNBO)** or a **recycled carbon fuel**:

- 'Recycled carbon fuels' means liquid and gaseous fuels that are produced from solid waste and waste processing gases and exhaust gases of non-renewable origin which are produced as an **unavoidable and not intentional** consequence of the production process in [ ] industrial installations.
- 'Renewable liquid and gaseous transport fuels of non-biological origin' are liquid or gaseous fuels used in transport whose **energy content comes from renewable energy sources** other than biomass.

The **Renewable Energy Directive (RED II)** sets the framework for the deployment of these fuels:

- RFNBO and recycled carbon fuels are **eligible to meet the targets for renewable fuels**. However, MS may exempt fuel suppliers supplying RFNBO's from complying with the minimum share of advanced fuels.
- It is needed to prove that electricity taken from the grid is renewable is needed. **Guarantees of origin or acceptance of bi-lateral contracts can be explored as potential solutions**.

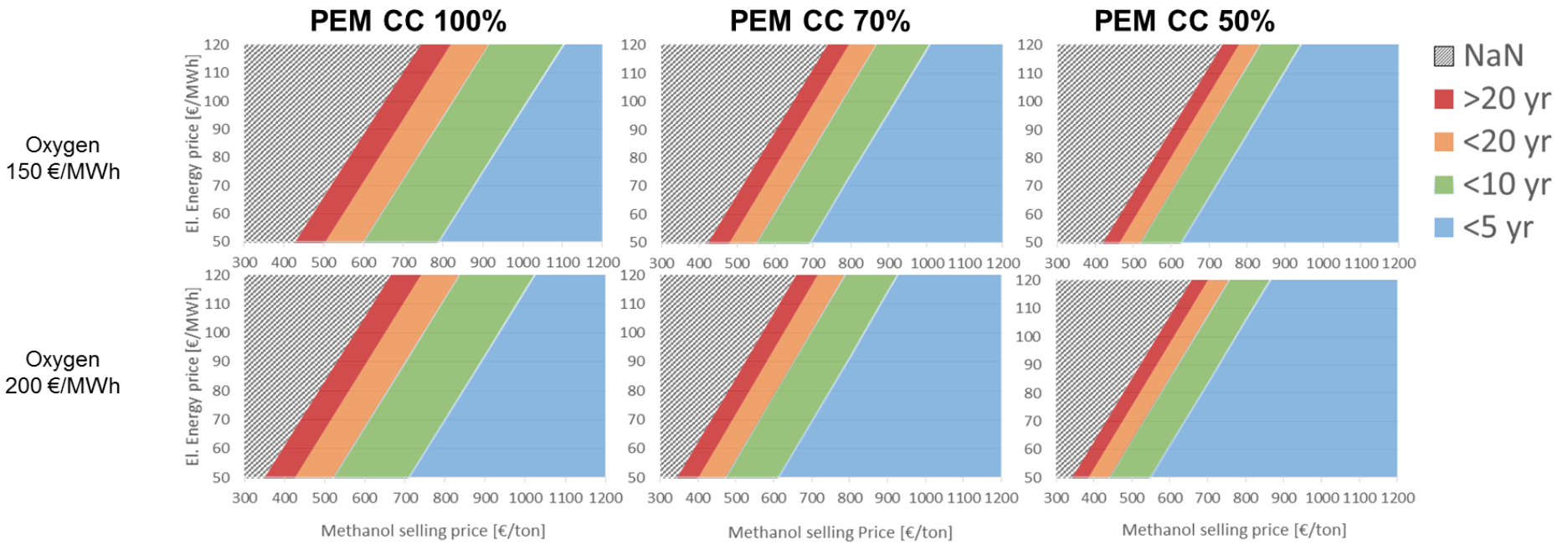
  > "In addition, [ ] electricity that has been imported from the grid [ ] may be counted as fully renewable if the electricity is produced exclusively from renewable energy sources [ ] and: The renewable properties and any other appropriate criteria [ ] have been demonstrated, ensuring that the renewable properties of this electricity are claimed only once and only in one end-use sector."

- The contribution of fuels supplied in the aviation and **maritime sector** shall be considered to be 2 times and **1.2 times** their energy content respectively.
- RED I included in Annex IX both RFNBO and recycled carbon fuels as advanced fuels and their renewable energy content could be double counted towards advanced fuel content target. Unofficial **RED II documents excludes them from Annex IX.**

There are **no incentives** for low carbon **methanol use as a chemical**.

Our approach: MefCO_2

Some basic figures



- Electricity is the main cost driver for methanol production costs. **PPA and bilateral contracts** between wind power operators and methanol producers can provide a win-win situation for both parties.
- Electrolysis unit represents 85% of plant CAPEX but **costs and efficiency are projected to improve** in the mid-long term providing a more advantageous business case.
- **Monetisation of secondary revenue sources** such as oxygen and grid services can further reduce methanol production costs.
- **Methanol can be sold at a premium price** as it is considered a renewable fuel and complies with the advanced fuel requirements unless a ME requests an exemption.

FReSMe

From Residual Steel gases to Methanol

Topic: Topic: Utilisation of captured CO_2 as feedstock for the process industry (LCE-25-2016)

FReSME aims to demonstrate the feasibility of valorising CO_2 and H_2 captured from blast furnace gases (BFG) by turning them into methanol

i-deals (ES)

Carbon Recycling International (IS)

National Institute of Chemistry Slovenia (SI)

Stichting Energieonderzoek Centrum (NL)

Swerea MEFOS (SE)

Kisuma Chemicals BV (NL)

Tata Steel BV (NL)

SSAB AB (SE)

Array Industries BV (NL)

Politecnico de Milano (IT)

Stena Rederi AB (SE)

Conclusions

So far…

- MefCO$_2$ results can contribute to improving the business case for **CCU+CCS**.
- MefCO2 technology is **highly flexible and** can be deployed in emission intensive sectors such as fossil fuel power generation, steel sector or cement production.
- Methanol is a **versatile feedstock** with a consolidated market that is expected to grow mainly due to its use as renewable fuel and as a basic chemical.
- Wind power can contribute to the deployment of Low Carbon methanol production by setting a **minimum price for electricity** in bilateral contracts with methanol producers**.**
- The use of flexible electrolysers for H_2 production can contribute to grid stability and earn additional revenue by **providing ancillary services** to the grid operator.
- MefCO$_2$ low carbon fuels can significantly contribute to ECs 14% **renewable energy content in transportation fuels** and voluntary **advanced fuels** content targets. However, **the legal framework must create the appropriate incentives for long term investment.**

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