5th International Conference

TMFB Tailor-Made Fuels from Biomass

Separation Enhanced Dimethyl Ether (DME) Synthesis

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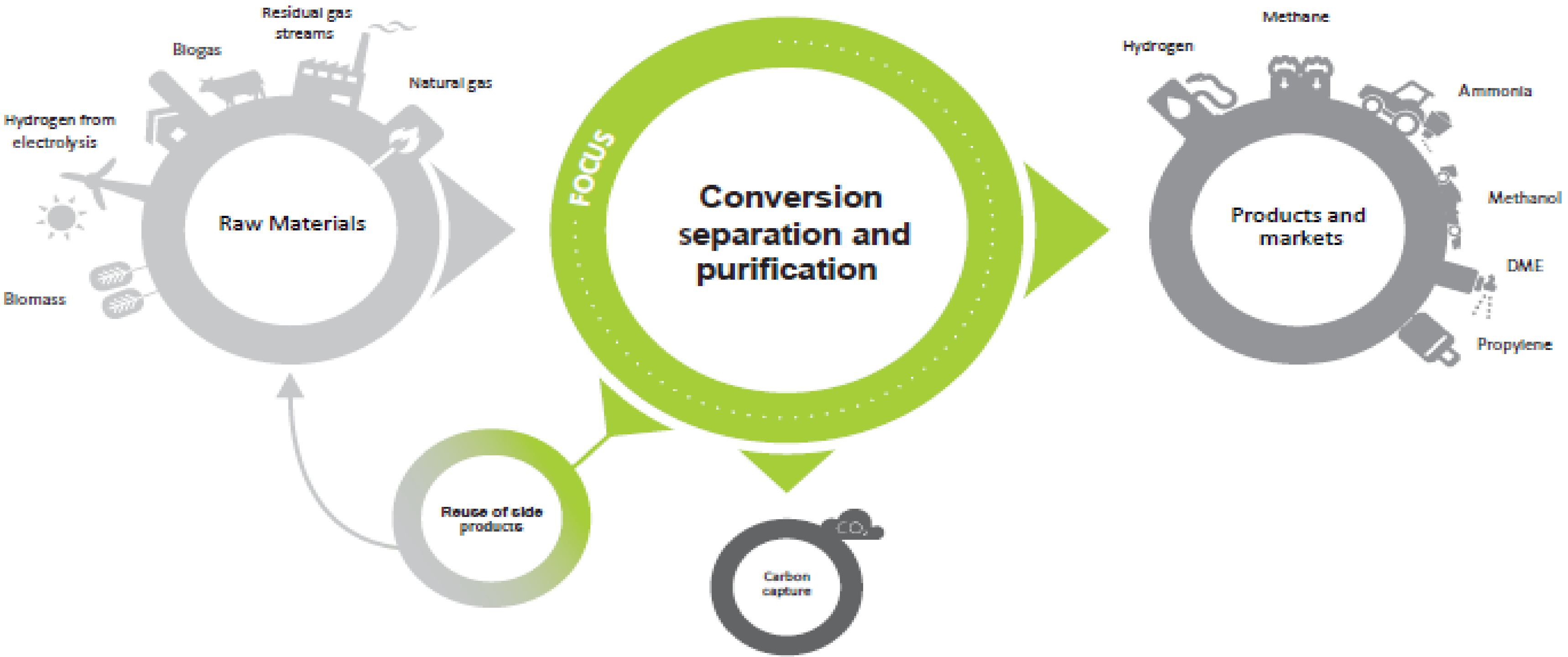
21 June 2017, Eurogress, Aachen

ECN

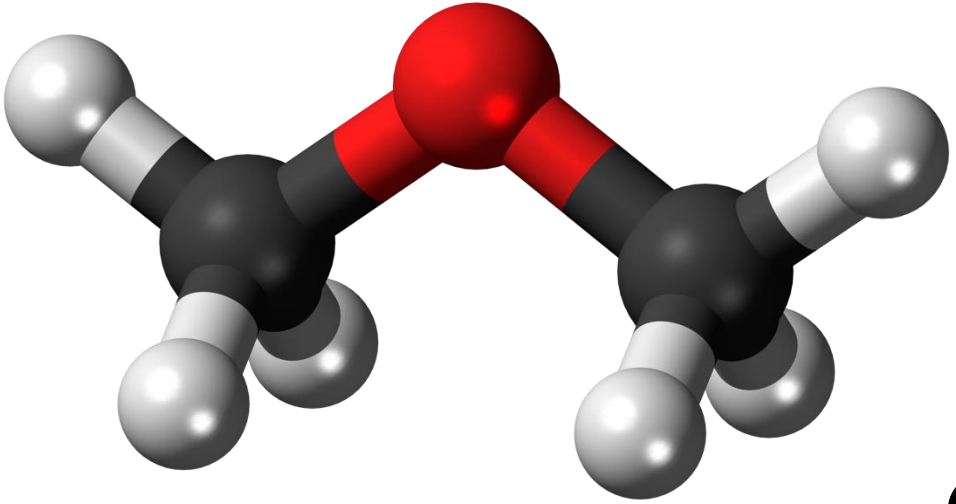
R&D Strategy ECN Energy & Industry Programme



Separation enhanced DME synthesis

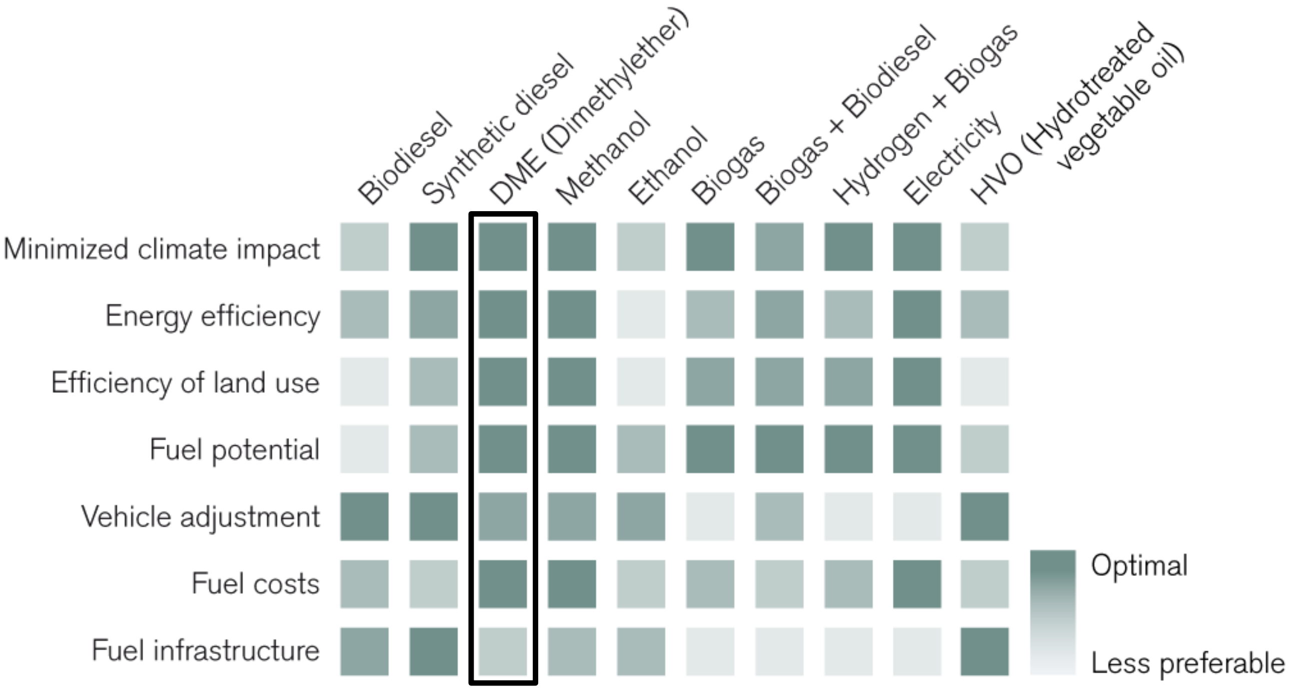
- DME: promising fuel for compression ignition vehicles
- Production of DME from biomass
- Conventional production of DME
- Separation enhanced DME synthesis
- Fledged: DME from biomass, renewable electricity

Dimethyl ether (DME)



C_2H_6O

DME: Fuel of choice



Volvo Sustainability report 2013

DME: Fuel of choice

- Promising in terms of GHG emissions, efficiency, economy
- Can be handled like LPG
- Behaves like diesel in a compression ignition engine
  without soot formation!

DME -

February 2017

SPECIAL FOCUS: CLEAN FUELS

DME as a diesel alternative in North America

Major trends in the global hydrocarbon processing industry include the regulatory-driven demand for clean, low-emissions fuels. Two decades of global efforts have shown that dimethyl ether (DME) can satisfy these drivers.

Sills, R. A., XTL & DME Institute

Major trends in the global hydrocarbon processing industry include the regulatory-driven demand for clean, low-emissions fuels. Two decades of global efforts have shown that dimethyl ether (DME) can satisfy these drivers.1 DME has been used for many years as an aerosol propellant in cosmetic and other personal and household products, but this represents a small market. DME was first commercialized as a fuel in China as a liquefied petroleum gas (LPG) blendstock for the domestic home cooking/heating market. As a result, it now represents about 5% of global methanol demand.2 This article focuses on the

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nstration of
Truck Begins in New

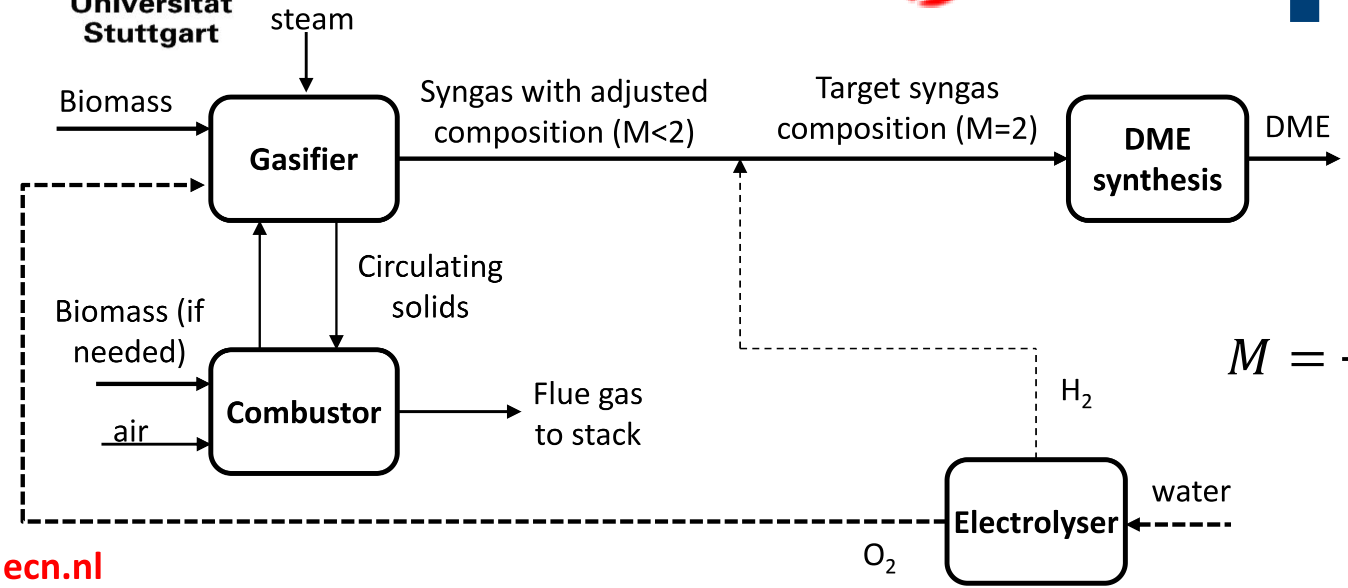
st step in the city's evaluation of
ME fuel in the city's waste
the largest in the world. "We
romise, and we are pleased to
ne customer DSNY to evaluate
ve to diesel" said Mack Trucks

ng in 2015.

Tom Berg

ecn.nl

Fledged: DME from biomass and hydrogen



$$M = \frac{[H_2] - [CO_2]}{[CO] + [CO_2]} = 2$$

2016-2020

Production of DME

Methanol synthesis

$$CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O$$

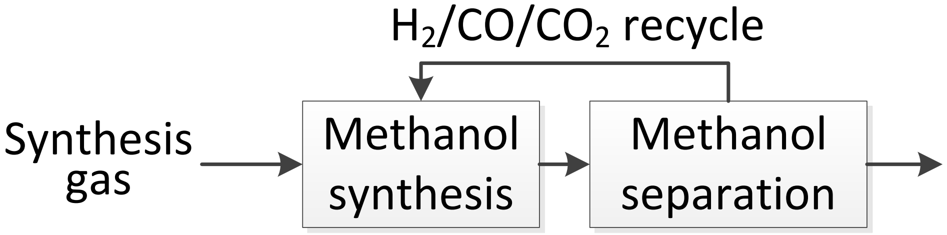
Water-gas shift (WGS)

$$CO + H_2O \rightleftharpoons H_2 + CO_2$$

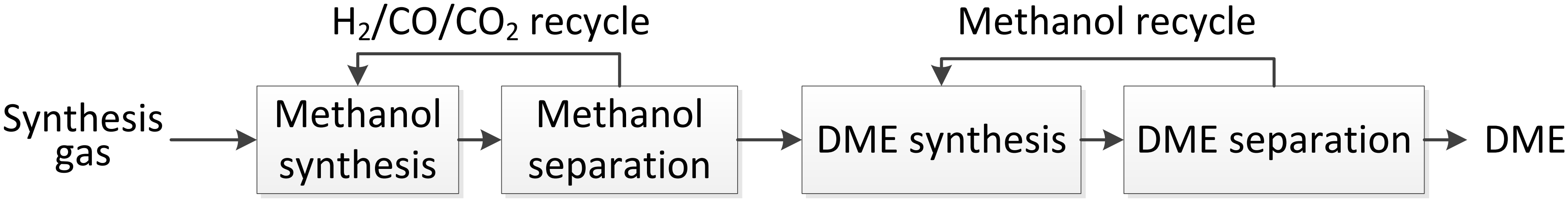
Methanol dehydration

$$2CH_3OH \rightleftharpoons CH_3OCH_3 + H_2O$$

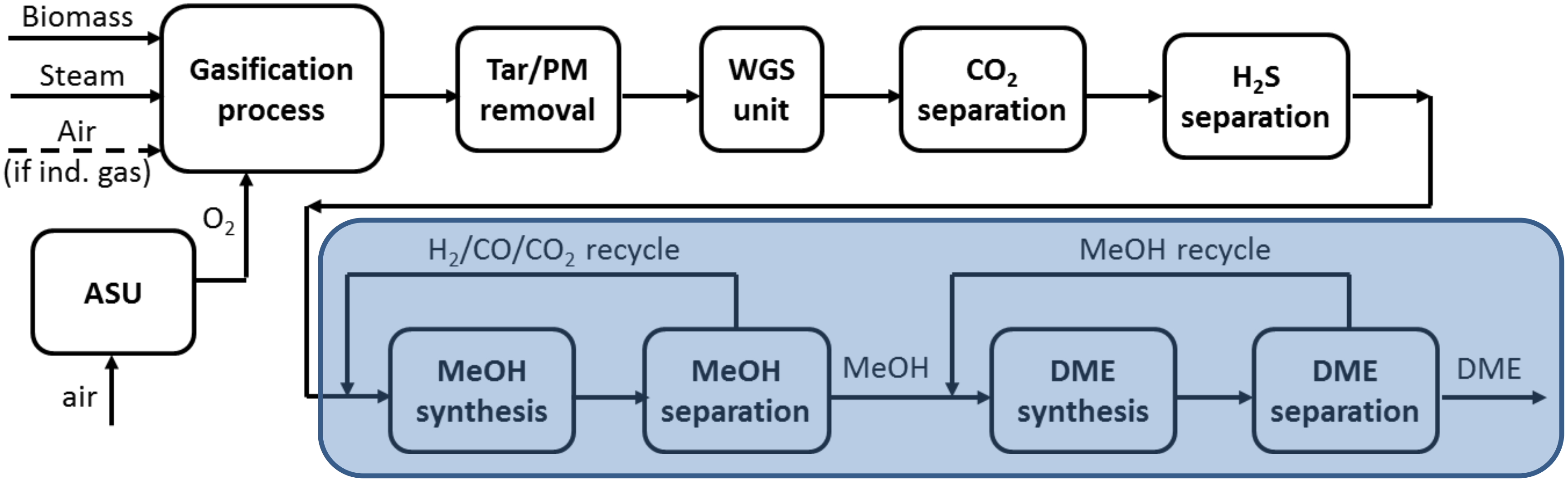
Conventional production of DME



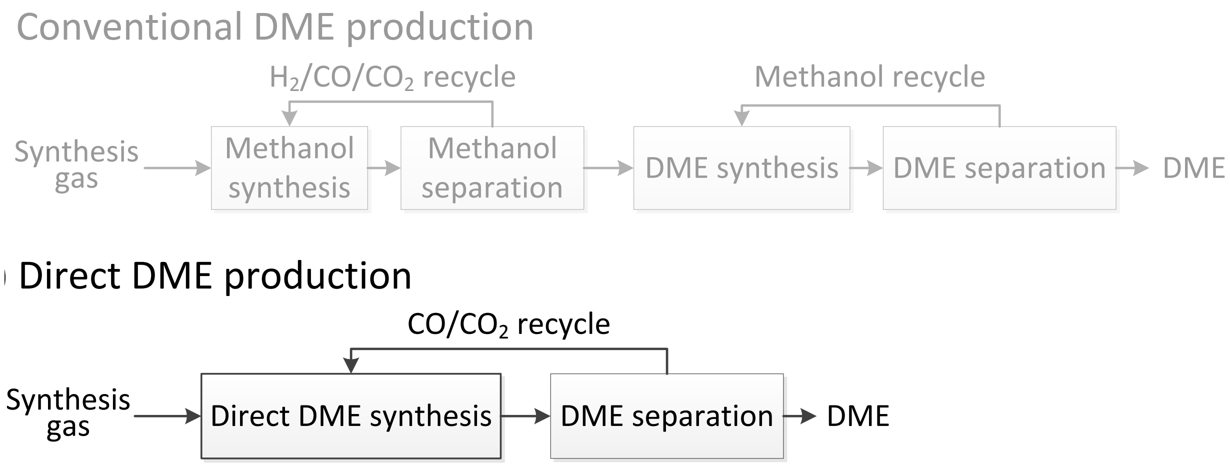
Conventional production of DME



Production of DME from biomass



Conventional versus direct synthesis



Steam separation enhanced DME synthesis

Methanol synthesis

$$CO_2 + 3H_2 \rightleftharpoons CH_3OH + \mathbf{H_2O}$$

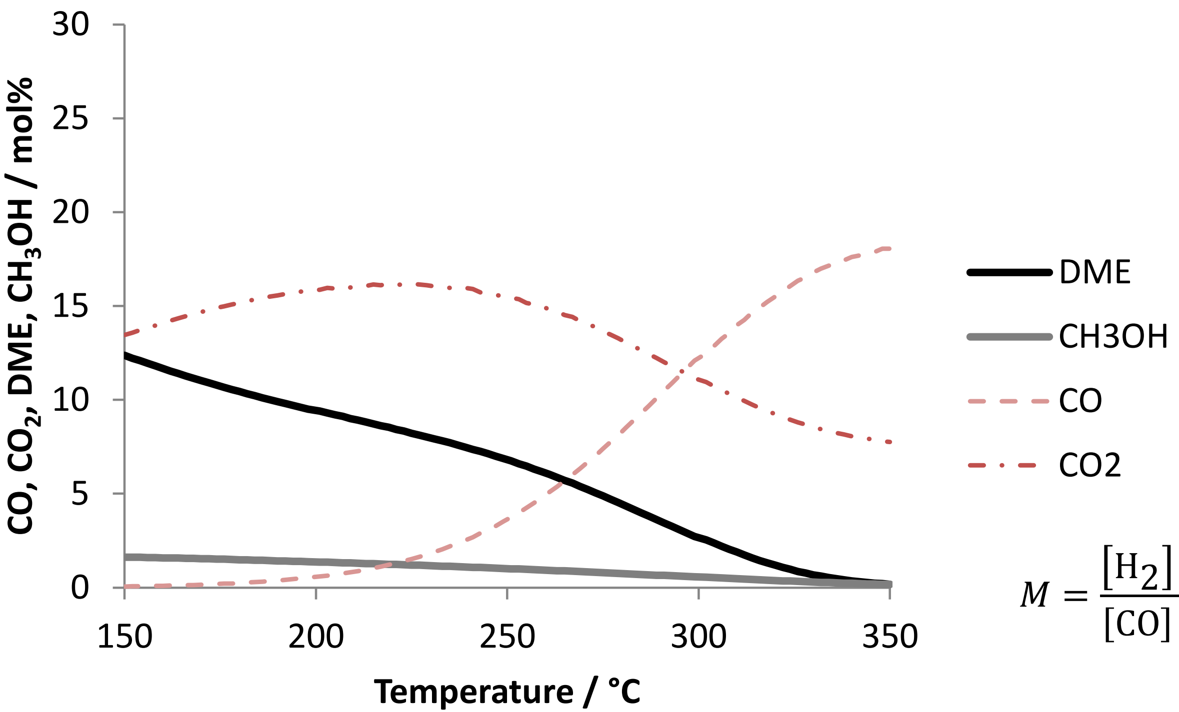
Water-gas shift (WGS)

$$CO + \mathbf{H_2O} \rightleftharpoons H_2 + CO_2$$

Methanol dehydration

$$2CH_3OH \rightleftharpoons CH_3OCH_3 + \mathbf{H_2O}$$

Thermodynamic equilibrium

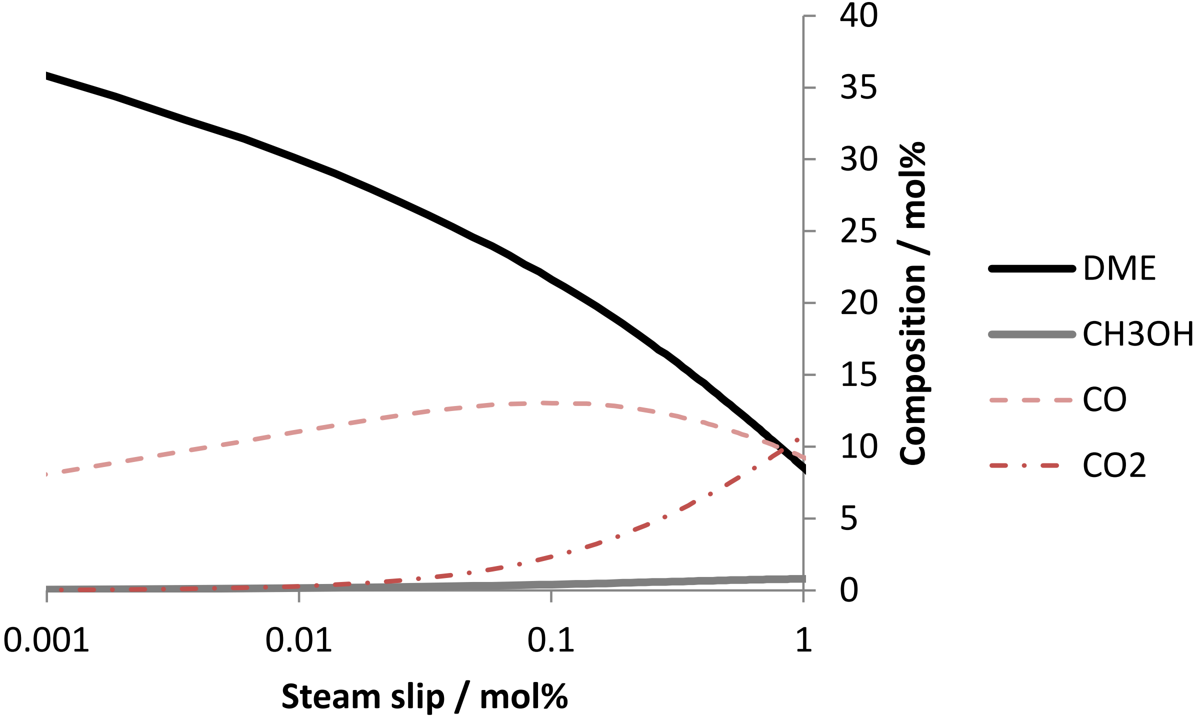


25 bar(a)

54 mol% H_2
15 mol% CO
7.7 mol% CO_2

$$M = \frac{[H_2] - [CO_2]}{[CO] + [CO_2]} = 2$$

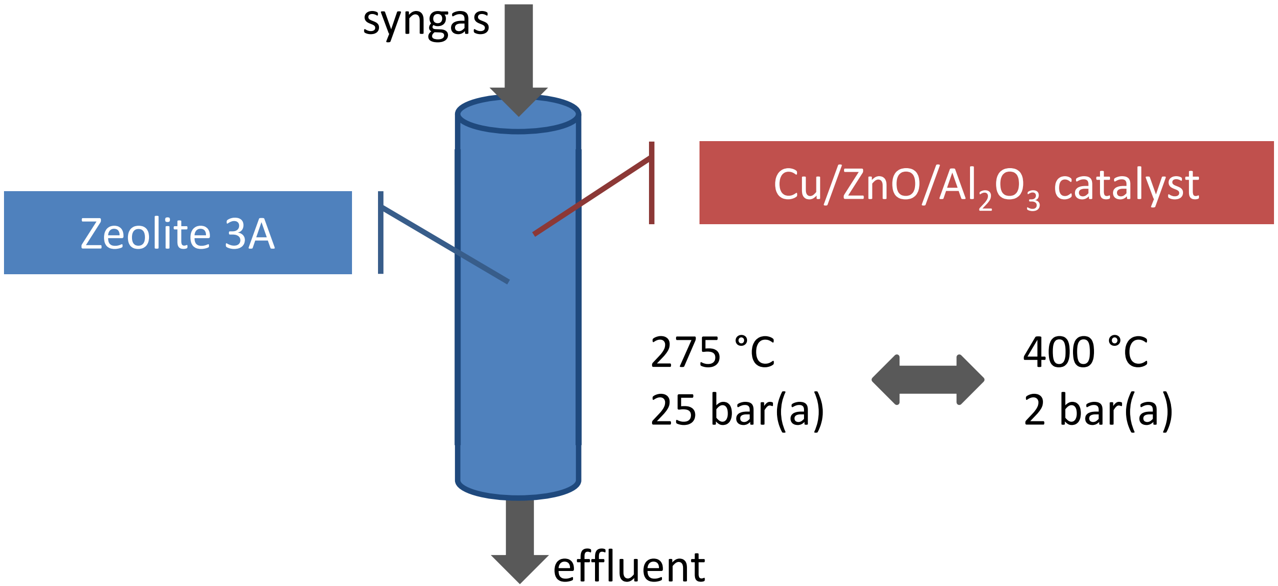
Equilibrium with in situ water removal



275 °C
25 bar(a)

54 mol% H_2
15 mol% CO
7.7 mol% CO_2

Experimental: sorption enhanced DME synthesis

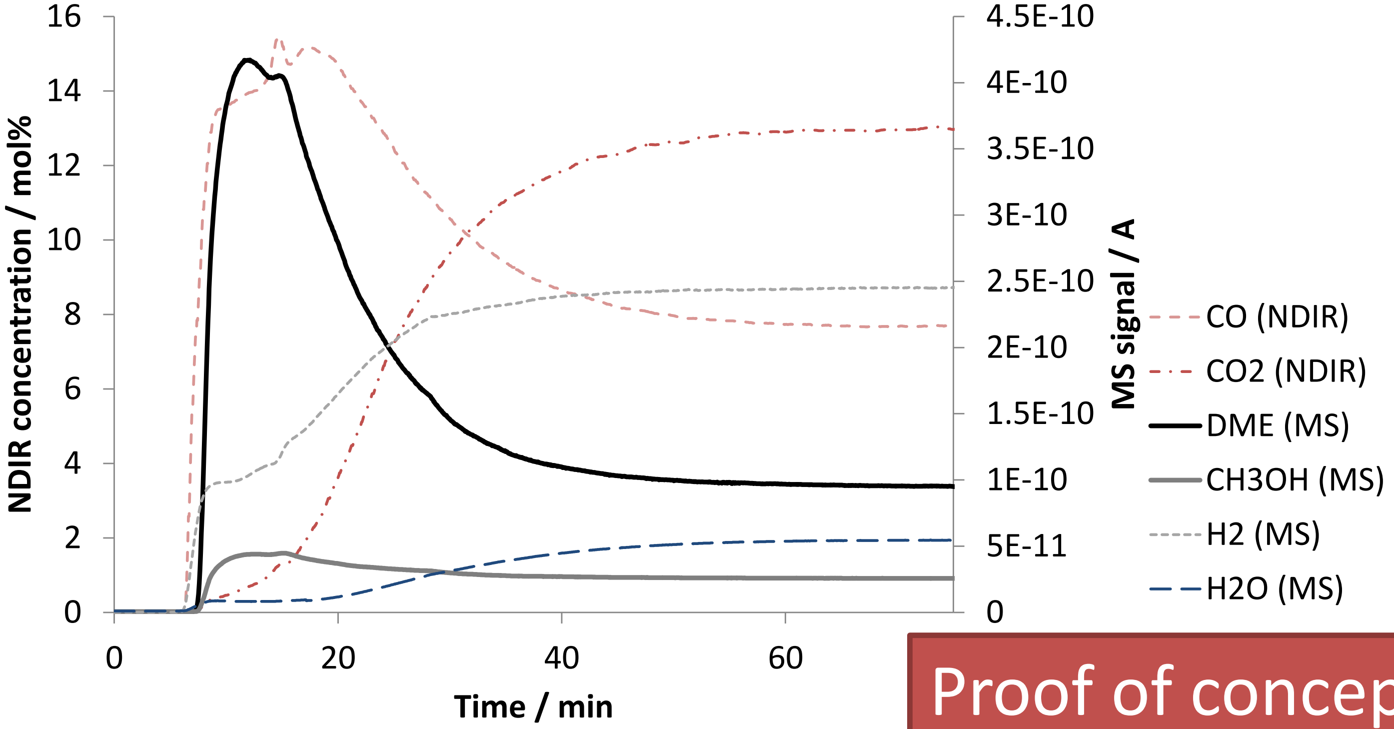


275 °C
25 bar(a)

400 °C
2 bar(a)

Experimental: sorption enhanced DME synthesis

Experimental: breakthrough test

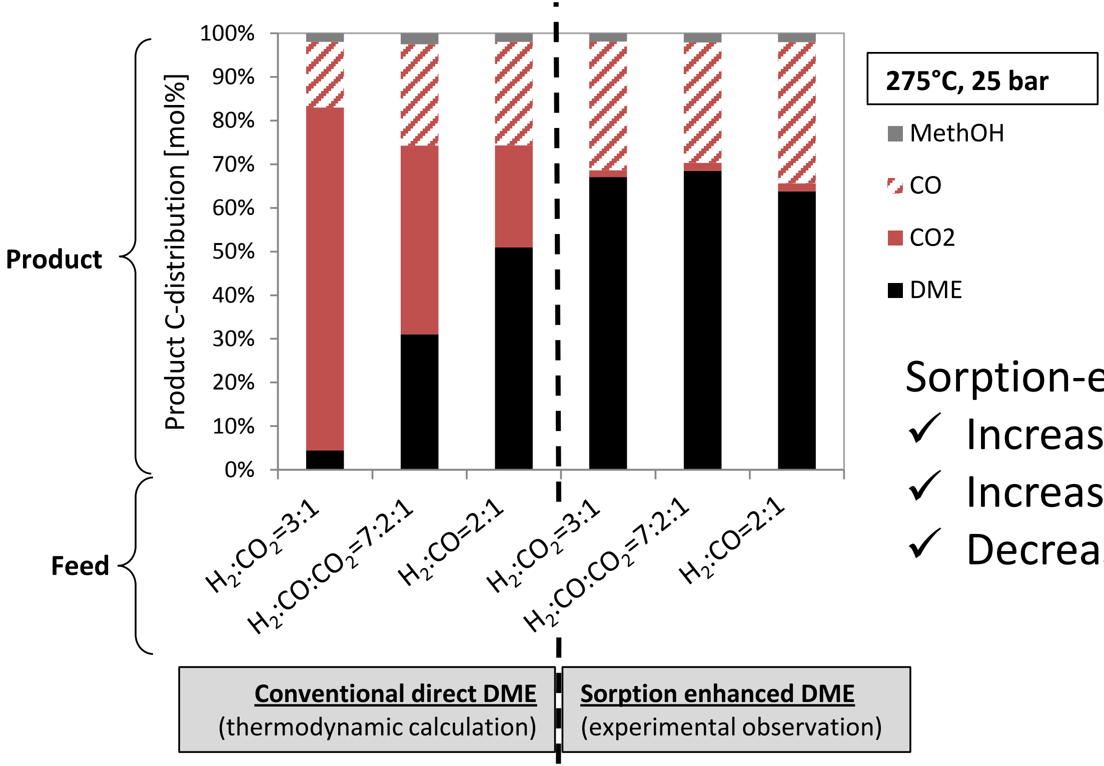


275 °C
25 bar(a)

54 mol% H_2
15 mol% CO
7.7 mol% CO_2

Proof of concept

Separation enhanced DME synthesis



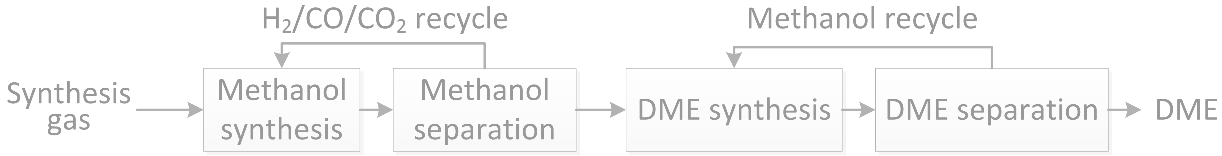
$$M = 2$$

Sorption-enhanced DME synthesis

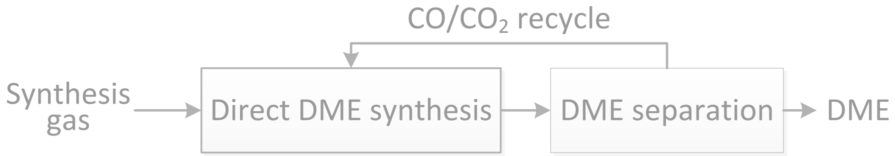
- ✓ Increased CO/CO_2 flexibility
- ✓ Increased DME yield
- ✓ Decreased CO_2 content

Conventional, direct, sorption-enhanced synthesis

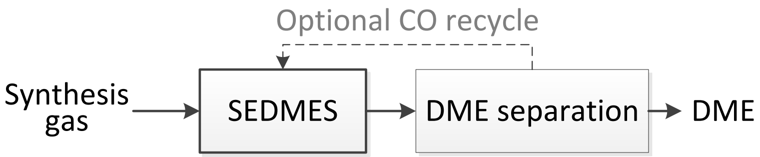
Conventional DME production



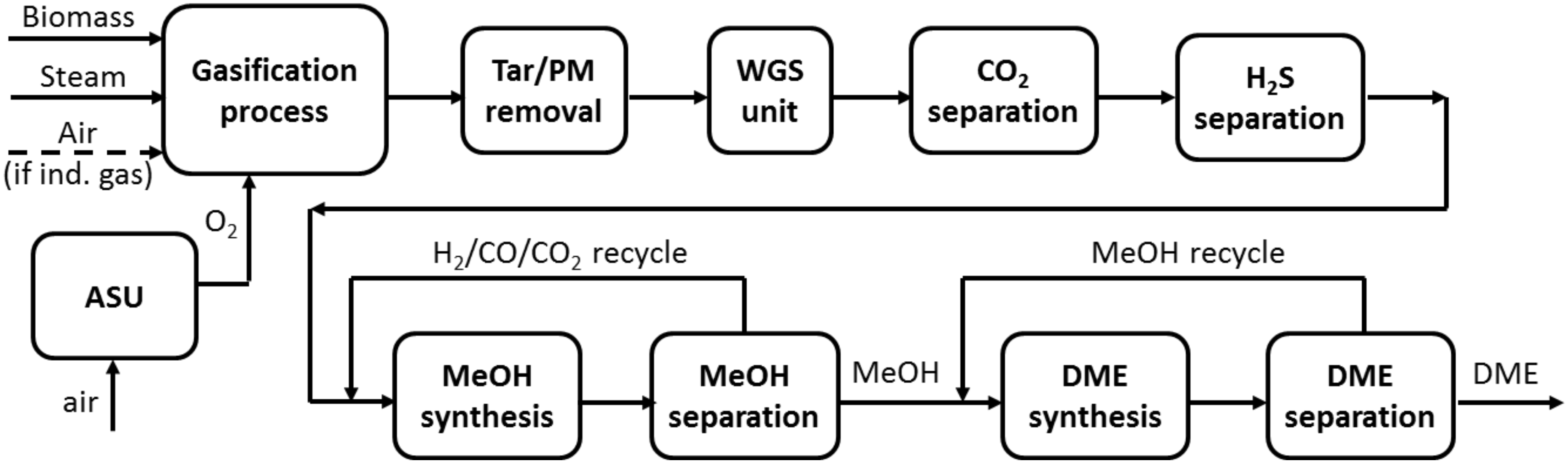
Direct DME production



Sorption-enhanced DME production (SEDMES)

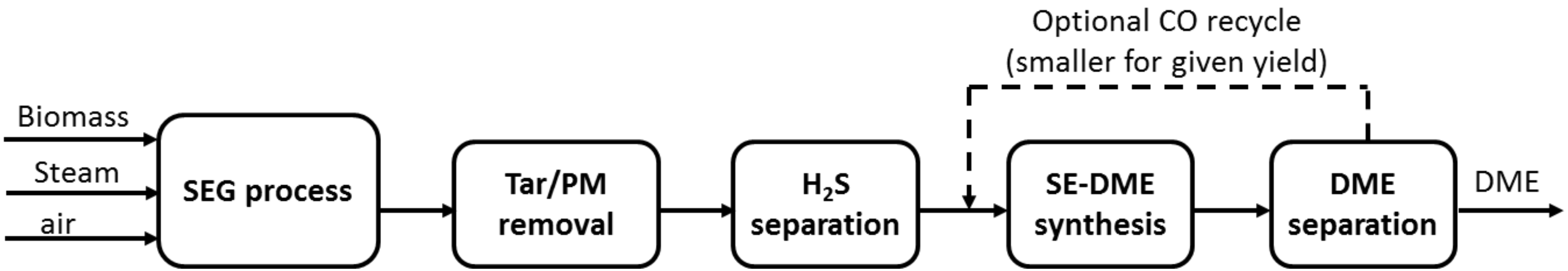


Production of DME from biomass



Production of DME from biomass

The ***FLEDGED*** project will deliver a process for ***bio-based dimethyl ether (DME)*** production from **biomass** gasification, validated in ***industrially relevant*** environment (TRL5).



Sorption-enhanced gasification

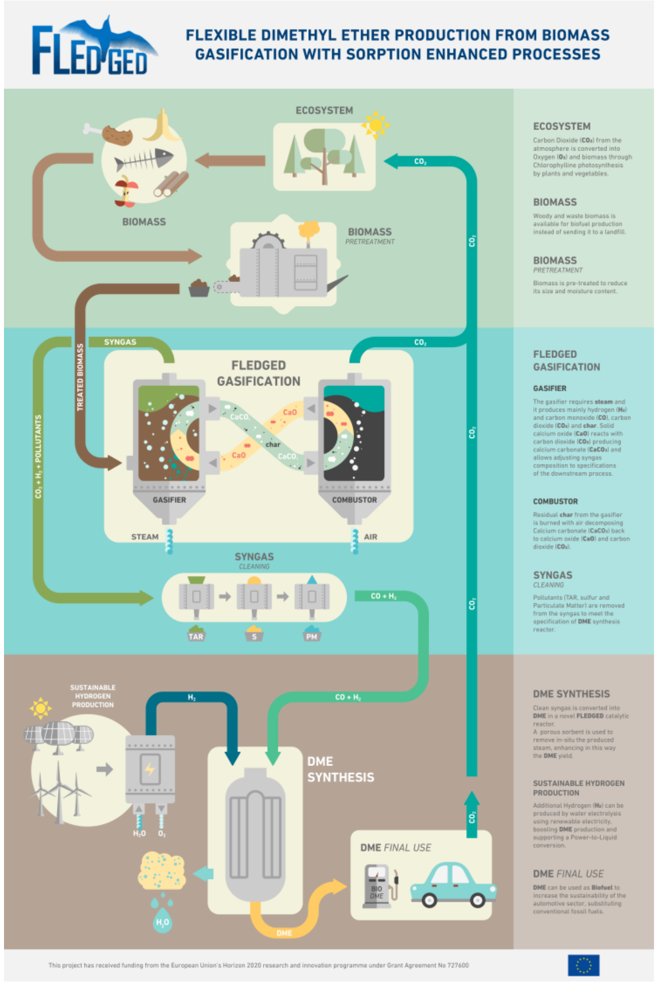
Sorption-enhanced DME synthesis

Separation enhanced DME synthesis

- DME: promising fuel for compression ignition vehicles
- Production of DME from biomass
- Conventional production of DME
  - Low DME yield
  - CO_2 production
  - Complex separation
- Sorption enhanced DME synthesis
  - Increased CO/CO_2 flexibility
  - Increased DME yield
  - Decreased CO_2 content
- Fledged: DME from biomass, renewable electricity

http://www.fledged.eu/

@FledgedProject



http://www.ecn.nl/research-programme/energy-and-industry/

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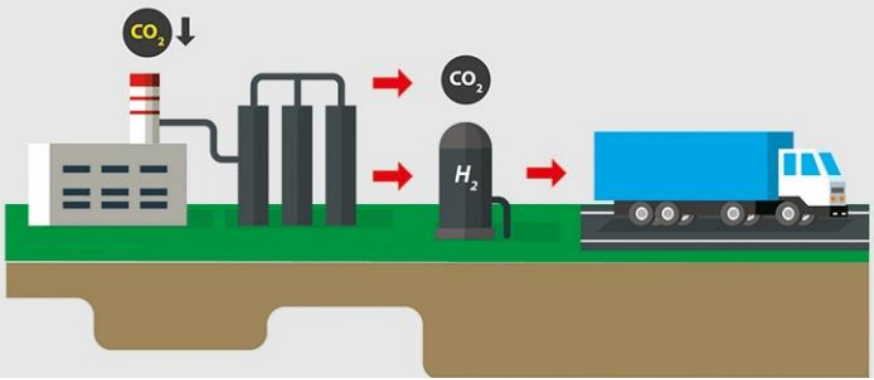
Gas separation, treatment & conversion

- Development of sorption technology to reduce industrial CO_2 emissions
- Development of membrane reactors for hydrogen production
- Conversion of industrial waste streams into chemicals and transport fuels



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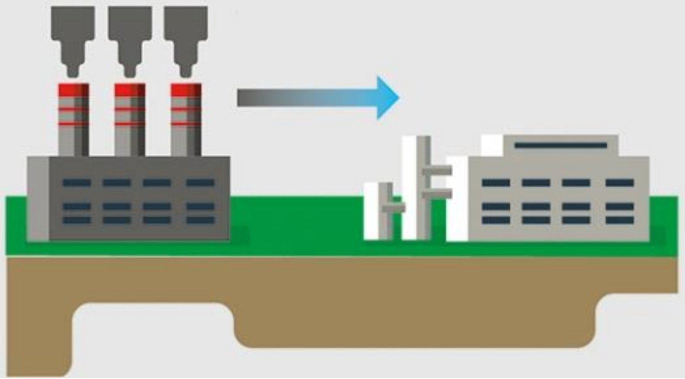
Industrial integration of renewable electricity

- Development of processes to produce chemicals and fuels with the help of electricity, e.g. hydrogen
- Development of technology to flexibly convert renewable electricity into heat



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