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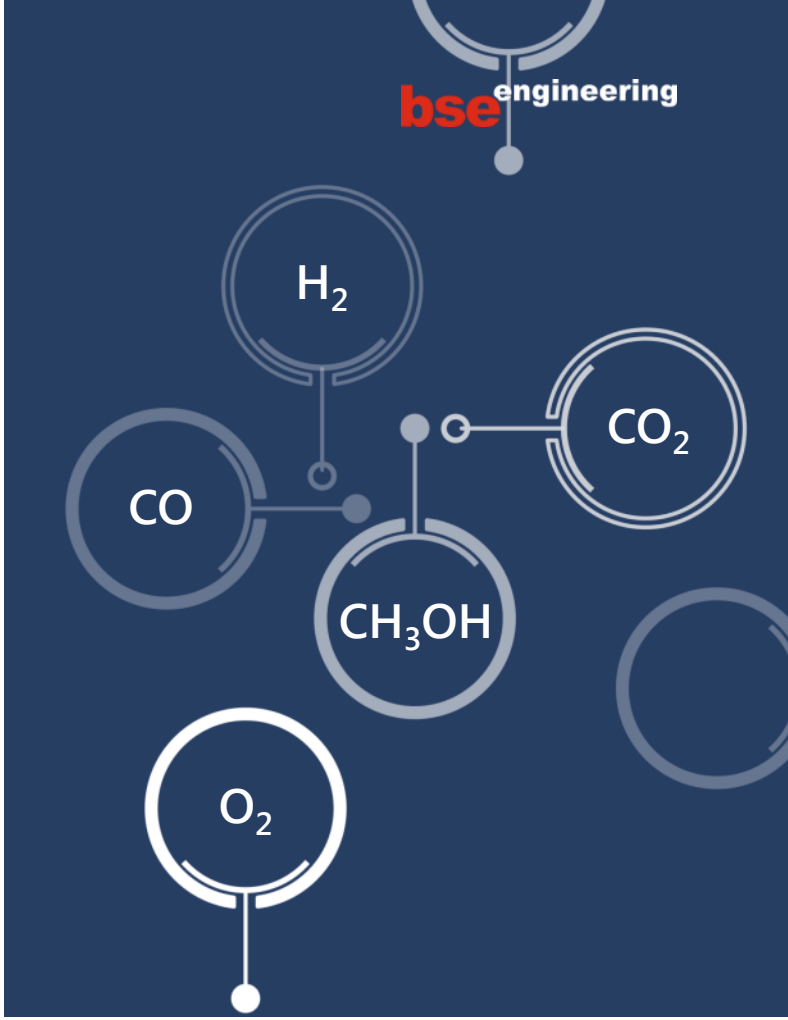
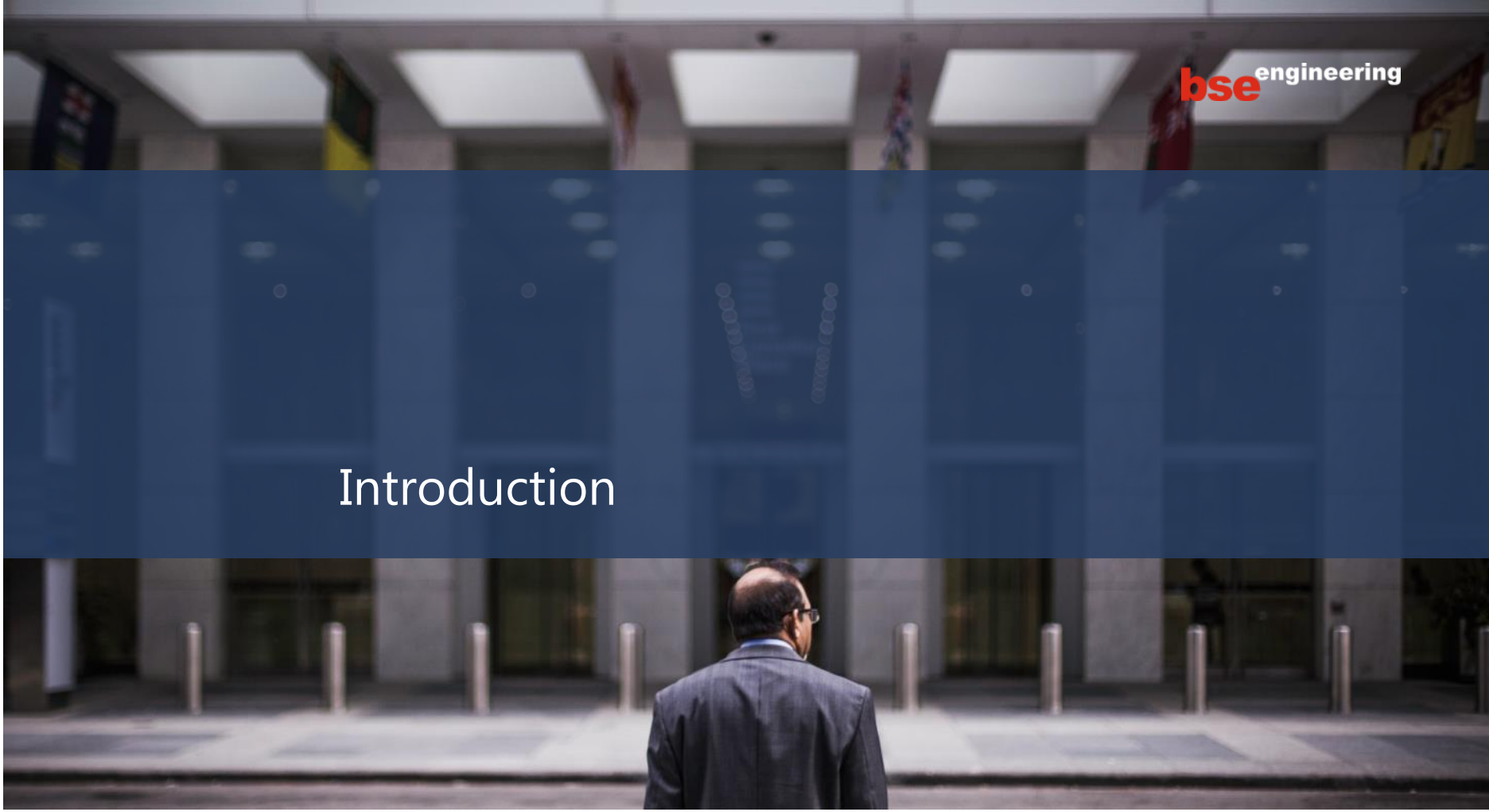
Small scale Methanol Plants a chance for re-industrialisation

International Methanol Conference
8-10 May 2017

Content

- Introduction
- Industrial Sectors
- Methanol
- Political Framework
- Technical Feasibility
- Commercial Aspects
- Realisation





Introduction

Company Profile

Our Expertise

- Company for consultant, client engineering and project management since 1990
- Since 2012 continuous normative development in the field of CO_2
- Several speeches and expert consultations at international conferences and for the EU Commission
- Market development for small-scale methanol plants including IP
- Various project developments for E-Methanol plants up to 100,000 t/y
- Initiator of full service package (EPCM) of small-scale methanol plants including engineering, licencing and execution

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We Are

process engineer
consultant + engineer
business manager + structural designer
legal expert + developer
economist

References of BSE Methanol

- 2014 Feasibility study MeOH from Bioethanol CO_2 50 MW
- 2015-17 Start Bio-M: Intermitting MeOH production from green CO_2, Germany
- 2015/16 Business case study chemical energy storages via MeOH
- 2016 Pre-Engineering MeOH from flue gas CO_2 WtE 5 MW (Execution 2019)
- 2016 Pre-Engineering MeOH from flue gas CO_2 WtE 10 MW (Execution 2018)
- 2016 Strategy development of 2 biomass power plant for integrated chemical CO_2 utilisation 100 MW (Execution 2020/2024)

Start of the first project estimated 2018.

Methanol Platform

Development of Common Synergies

Methanol Institute

EurA innovation

TU Bergakademie Freiberg

Deutsches Zentrum für Luft- und Raumfahrt

Network: Regeneratives Methanol Innovationsnetzwerk

DECHEMA

concepts for mobile and stationary applications

Regeneratives Methanol Innovationsnetzwerk

Bundesministerium für Wirtschaft und Technologie

ZIM für wachstum

Motivation

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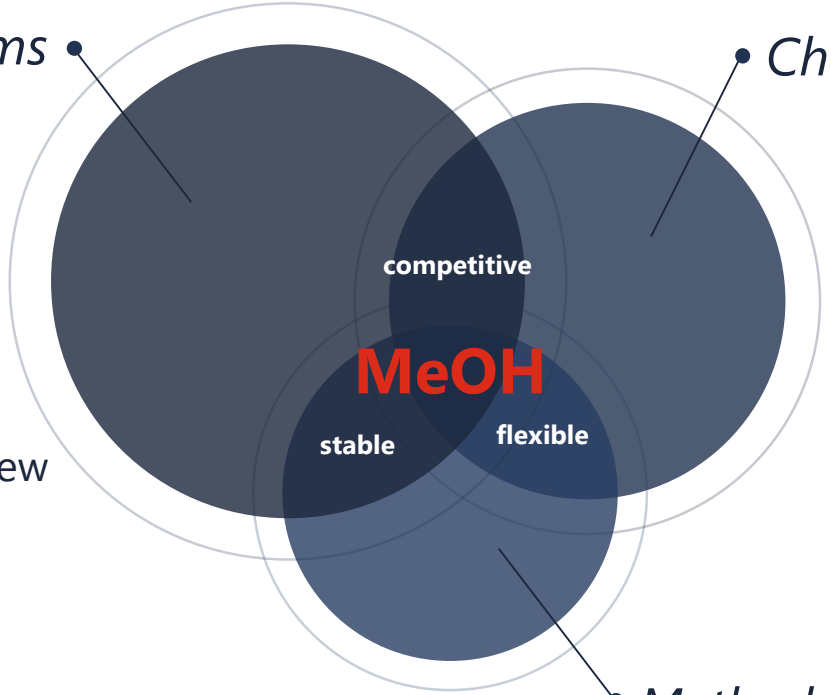
Aims

- Decentralisation
- Reduction of investment risk
- Market-oriented production
- Fast reaction to flexible markets
- Development of new markets



Challenges

- Self-sufficient raw materials supply
- Flexible markets
- Diversification of product range
- Carbon recycling

Methods

- Modularisation
- Scalability
- Compatibility
- Process integration

Megatrends Post-2020

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Low-Carbon Economy 2050

- Cost-efficient reduction of yearly GHG emissions 40% (by 2030), 60% (by 2040), 80% (by 2050)
- Power sector can almost totally eliminate CO_2 emissions; Industry must achieve 80%

Circular Economy

- More Carbon Recycling
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030
- A ban on landfilling of separately collected waste
- Promotion of economic instruments to discourage landfilling
- Concrete measures to promote re-use and stimulate industrial symbiosis - turning one industry's by-product into another industry's raw material (C-Recycling)

Resource Efficiency

- Turning waste into a resource
- Ensuring efficient mobility

Reindustrialisation

- Increasing the manufacturing sectors' share in EU's GDP from the current 16% to 20% in 2020.

Conclusion Megatrends

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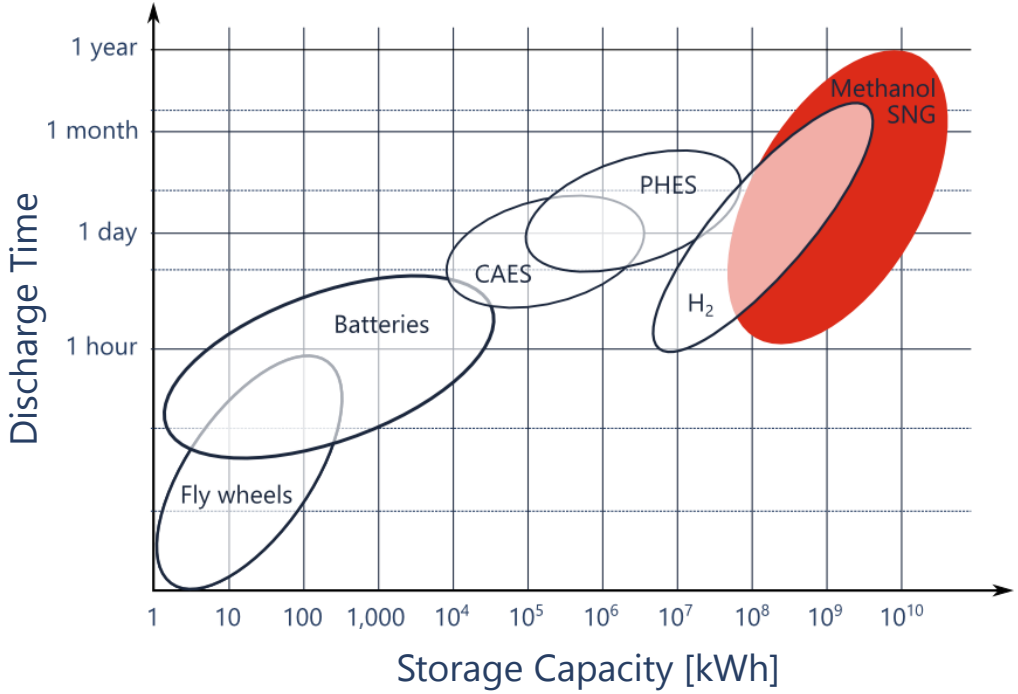
- Wind and photovoltaic electricity is generated regardless of the demand
- Power becomes temporary an unused resource
- Carbon dioxide is a available carbon source

- Options to use power when available in:

Battery	Power Storage
Power-to-Heat	Power Sink
Power-to-Fuel	Transport Sectoral Coupling
Power-to-Gas	Power Storage for Repowering
Power-to-Chem	Re-Industrialisation

Methanol as Energy Storage



PHES (Pumped Heat Electrical Storage) SNG (Synthetic Natural Gas)
CAES (Compressed Air Energy Storage)

Methanol is a long-term chemical energy storage.

- Energy density: 4.4 kWh/l
  5.5 kWh/kg
- Boiling point: ~ 65 °C
- Ignition Temp: 455 °C
- Aggregate state: liquid

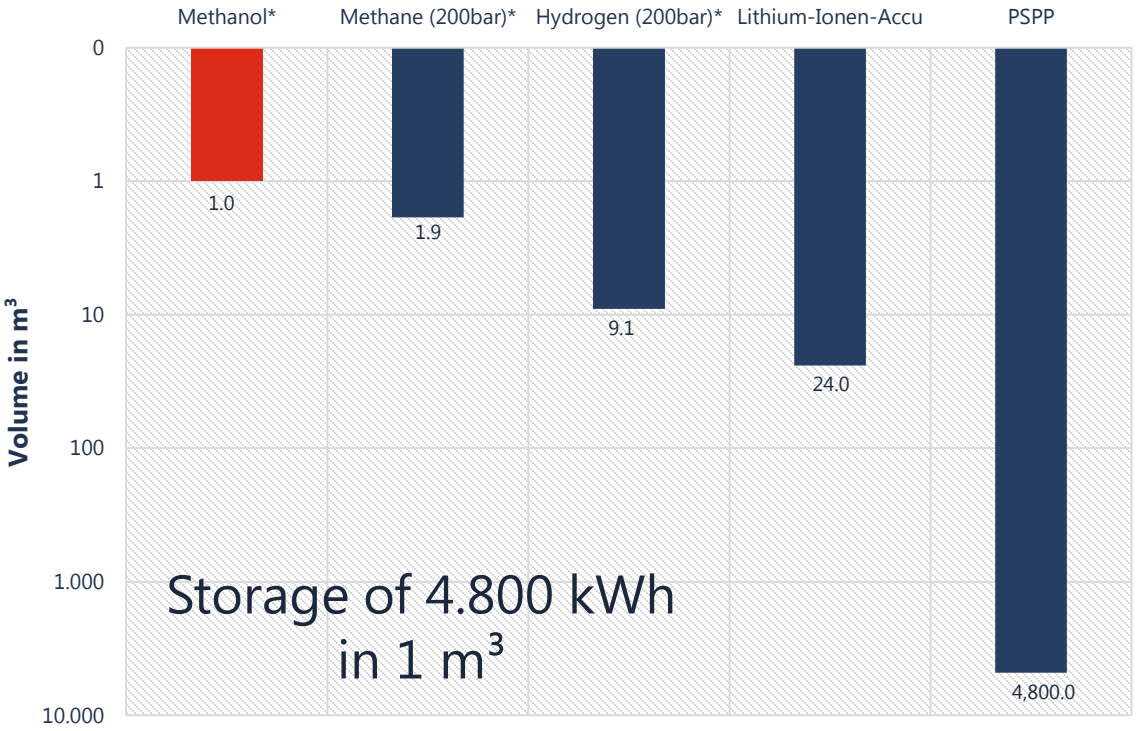
Source: According to Sterner, Thema; FENES, OTH Regensburg, 2014

Methanol

Base Chemical and Liquid Energy Storage

Methanol is the simplest representative of alcohols, mostly produced organic chemical.

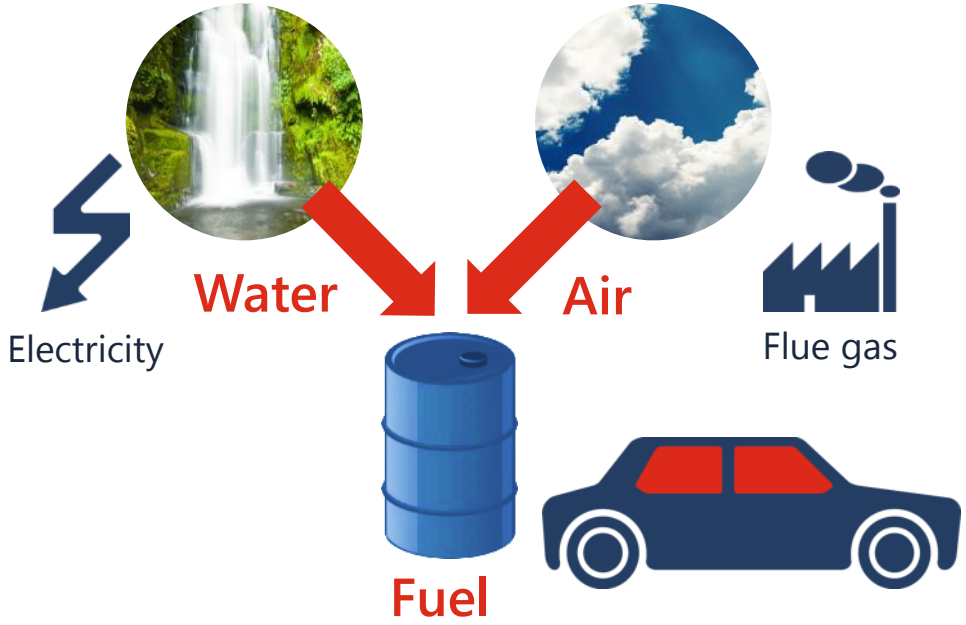
Volumetric density of 4.4 kWh/l is almost 6 times higher than that of hydrogen.



*Calculation without conversion losses based on the heating values.

Upgrading Electricity to Fuel

Chemical Energy Storage



Fuels are made out of water and air.

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Production of E-Methanol – the technical photosynthesis!

Main Statements

Excerpts from Experts

"We believe that the technology for the production of methanol from biogenic CO_2 streams is a resilient technology for the production of fuels and the storage of electrical power in the existing infrastructure."

KIC Innoenergy

"Methanol from CO_2 will take an important role as needed bulk chemical and global commodity."

nova-Institut GmbH

"Sexy Fuels"

EU Commission (Ms Donnelly, DG Energy)

"In 2030 only e-mobility and synthetic fuels should be allowed." BMUB

"The company's statement to the 37th BImSchV we can support (..) as well as referenced solutions." Wirtschaftsrat CDU e.V.

"The utilization of this CO_2 finally results into an inversion of the organic chemistry that will be based on C-1 building blocks." BioEconomy Cluster

Market Abstract

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CO_2-Sources

- Flue gas incineration
- Biogas purification
- Ethanol fermentation
- Steel mills
- Lime, cement industry
- Air capture

Excess Power Sources

- Must run plants (waste incineration)
- Biomass power plants
- Fossil power plants
- Grid stabilisation
- Wind and PV

Excess Hydrogen Sources

- Reforming process
- Chloralkali process

CO_2 Emission Imports

- Natural Gas
- Petrochemical liquids
- Bulk chemicals used in transport

Constellation Power-to-Fuel Plants

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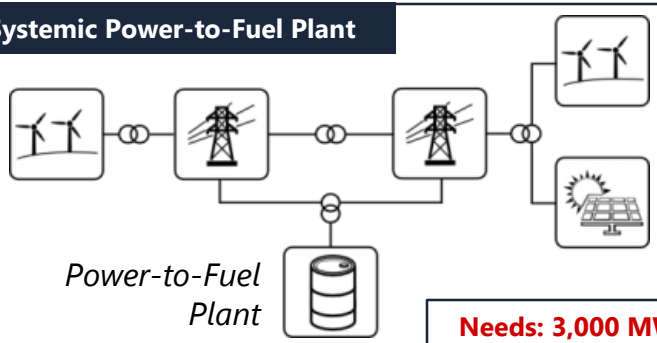
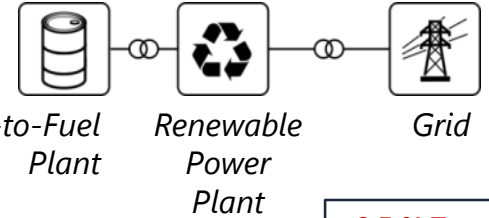
Systemic Power-to-Fuel Plant



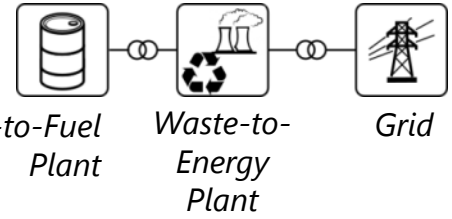
Needs: 3,000 MW

Renewable Power-to-Fuel Plant

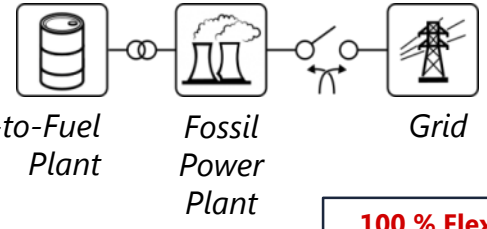


0.5 % Target FQD

Must Run Plant



Grid relief by fossil power plant using on site power sink



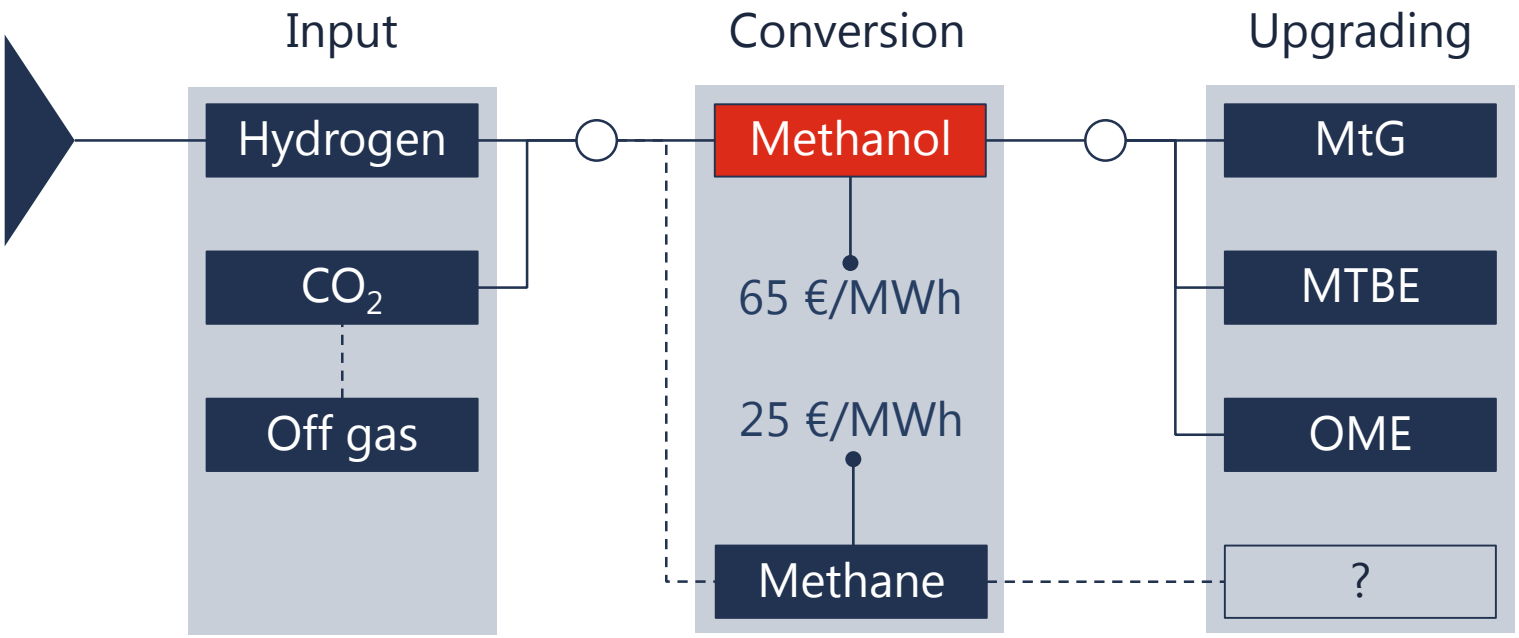
100 % Flexibility

EU-strategy: power based fuels, decarbonisation, resource efficiency, re-industrialisation, securing power supply

Methanol – Solution, Market

Power-to-fuel Options

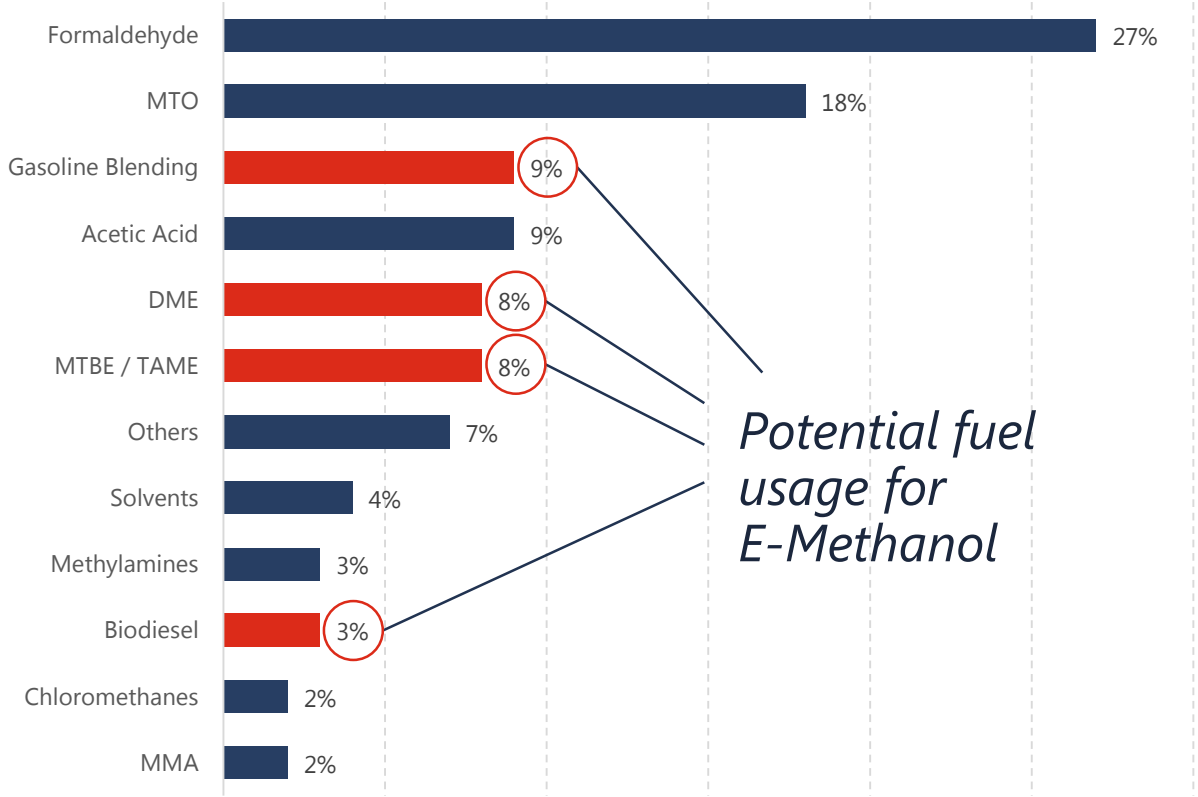
Methanol as Prefered Chemical Energy Storage



Methanol has the highest value after the conversion of electricity with the best upgrading possibilities.

Usage of Methanol by End-Use

High Fuel Sector Usage



- Already 28% of Methanol are used in the fuel sector
- Highest potential in direct blending of fuel and further processing to MTBE

Source: IHS (2015)

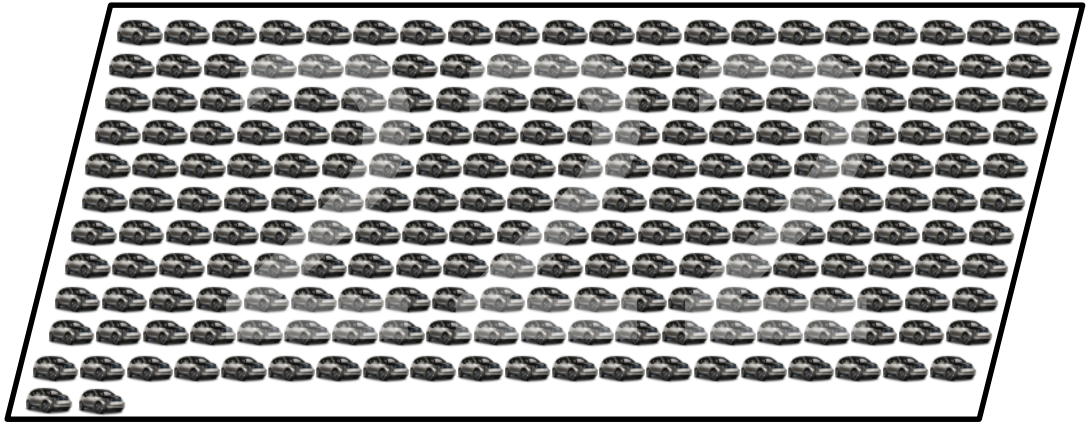
Power-to-Fuel vs. Power-to-E-Mobility

Chemical Power Storage vs. E-Mobility

1 cubic meter of liquefied power (E-Methanol) compares with **222** BMW i3 (full electric car)!*

1 m³
Methanol
4.4 kWh/l

=

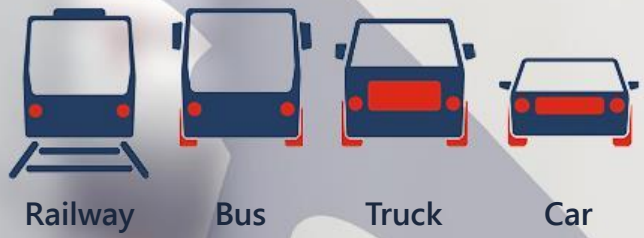


*Storage capacity of one BMW i3 battery is 21,6 kWh.

Advantages E-Methanol

Value Chain

- Contribution to the National Climate Protection by requiring blending
- Cascade usage of CO_2
- Utilisation of Methanol in the fuel sector:
  - Blending M3 without any adjustments possible
  - Methyl-tert-butylether (MTBE, antiknock agent)
  - Biodiesel (Production)
  - Dimethylether
- Utilisation without adjustments of the infrastructure possible
- Substituting biofuels from food



Methanol is already applicable as fuel without adjustments

Market Volume

Methanol as Fuel

Large Methanol Potential in transport sector (EU 2015):

Typ	DE	EU	Unit
MTBE	1.20	5.50	Mio. t/y
Biodiesel	0.25	1.10	Mio. t/y
Direct blending (potential)	0.55	4.20	Mio. t/y

Demand of Advanced Fuels (EU target 2020):

- 1.4 Mio. t/y Methanol in gasoline to achieve the 0.5% sub target

Methanol and Small-Scale Methanol Plants are an increasing market!

Legal Framework

European Legal Framework

Effective Validity of ETS, RED/FQD

ETS - EU Emission Trading System

2005 - 2007	2008 - 2012	2013 - 2020	2021 - 2030
Phase I	Phase II	Phase III	???

RED/FQD - Renewable Energy and Fuel Regulations

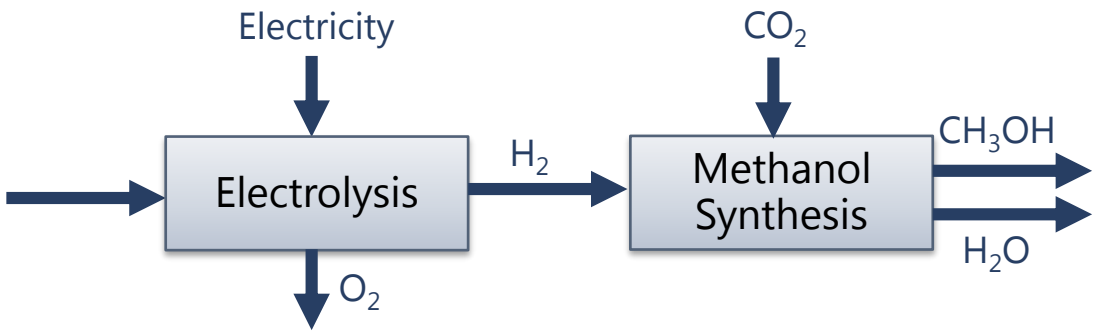
ILUC DIR 2015 ✗ Proposal RED II ✗

2009 - 2017	2017 - 2020	2021 - 2030
RED/FQD	Amended RED/FQD	RED II

Technical Feasibility

Solution is Methanol Synthesis

Production of Advanced Fuels



Catalytic, exothermic reaction of CO_2 and H_2 to Methanol and Water

$$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O \qquad \Delta H_R^O = -49{,}6\ kJ/mol$$

$$CO_2 + H_2 \leftrightarrow CO + H_2 \qquad \Delta H_R^O = +41{,}2\ kJ/mol$$

$$CO + 2H_2 \leftrightarrow CH_3OH \qquad \Delta H_R^O = -90{,}8\ kJ/mol$$

Process Concept Off-Grid Solution

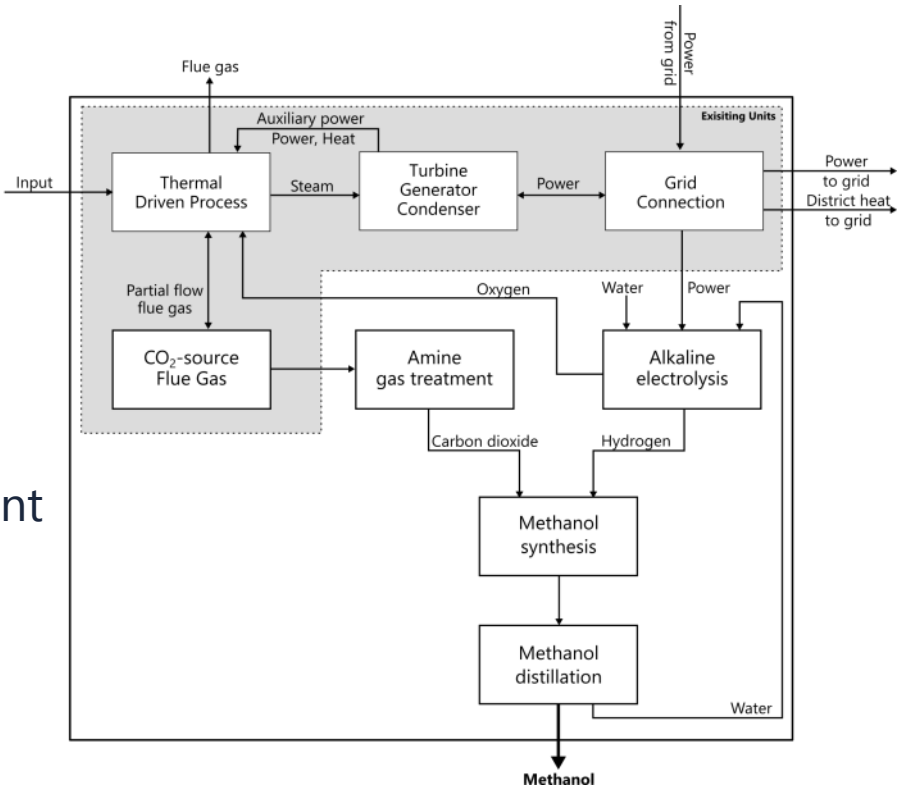
Materilisation

Existing units:

- CO_2-source flue gas
- Power generator
- Thermal driven process
- Grid connection

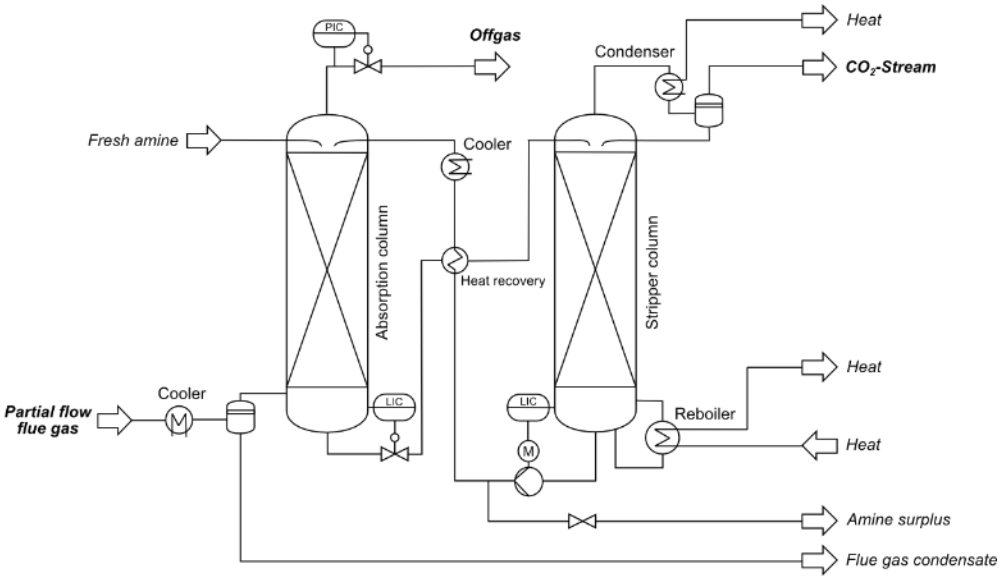
Expansion units:

- CO_2-separation / amine gas treatment
- Alkaline electrolysis
- Methanol synthesis
- Methanol distillation



CO_2-Separation

Step 1b – Process Flowsheet



Heat for further process: 140°C
Energy consumption: low pressure steam

Flexibility range: 50 – 100 %

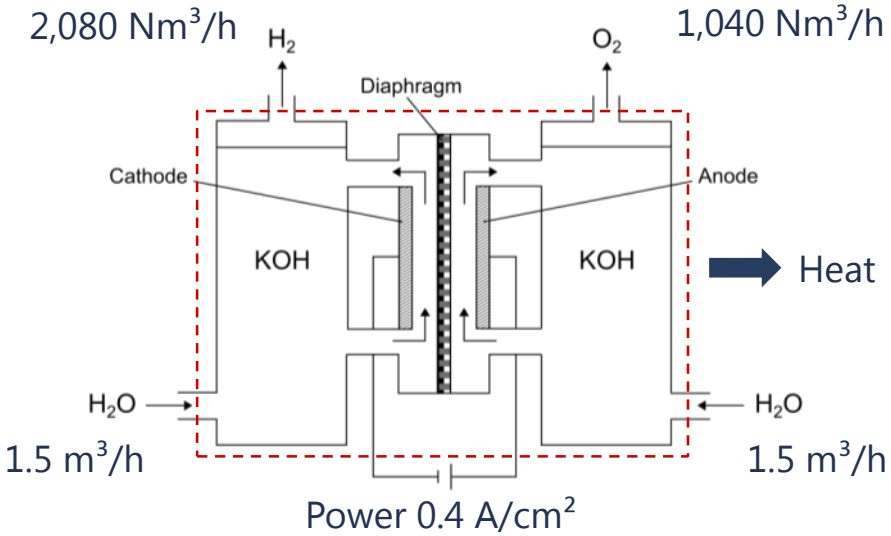
CO_2-Separation plant from flue gas (Norway)

State of the Art

Quelle: Aker Solutions (2016)

Electrolyser

Step 1a – 10 MW Electrolysis



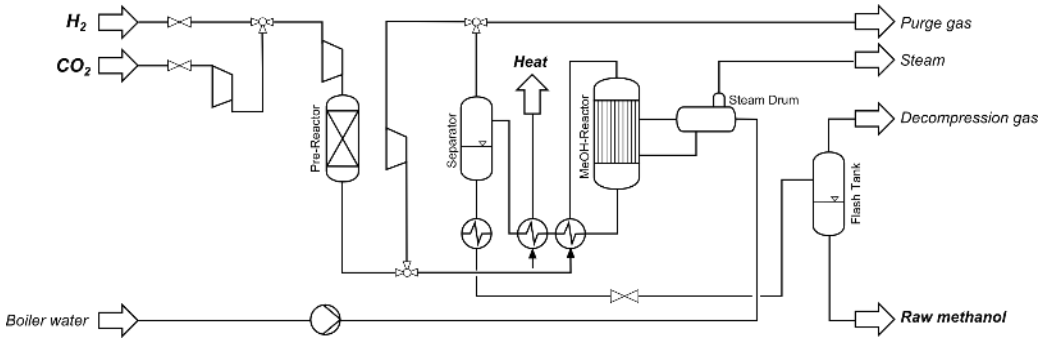
Theoretic energy and mass balance
Heat for further process: 80°C
Energy consumption: 4.8 kWh/Nm^3_{H2}

Flexibility range: 10 – 120 %

Methanol Synthesis

Step 2 – Methanol Synthesis

Catalytic exothermic reaction of CO_2 (1.36 t/h) and H_2 (0.19 t/h) to raw methanol (1.55 t/h)



Excess steam to distillation
Raw methanol: 64% MeOH and 36% H_2O

Flexibility range: 10 – 120 %

Quelle: CRI (2016)

Bio-M

Production of E-Methanol Under Fluctuating Conditions

Objectives:

- Development of a new flexible and sustainable process for producing methanol from biogenic carbon dioxide and hydrogen
- Demonstrate technical feasibility and industrial relevance
- Evaluation of stress resistant, stable catalyst which comply with the needs of a dynamic energy market

Project duration:

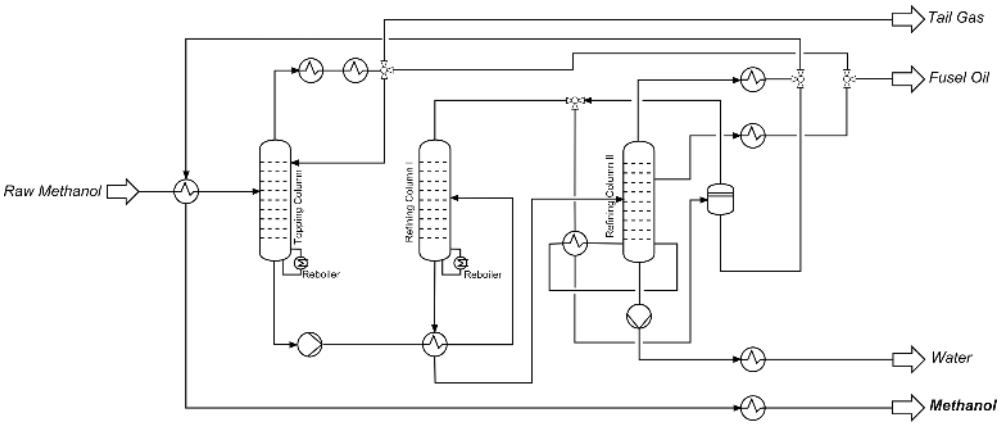
- 2015-10 – 2017-06

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

In cooperation with:

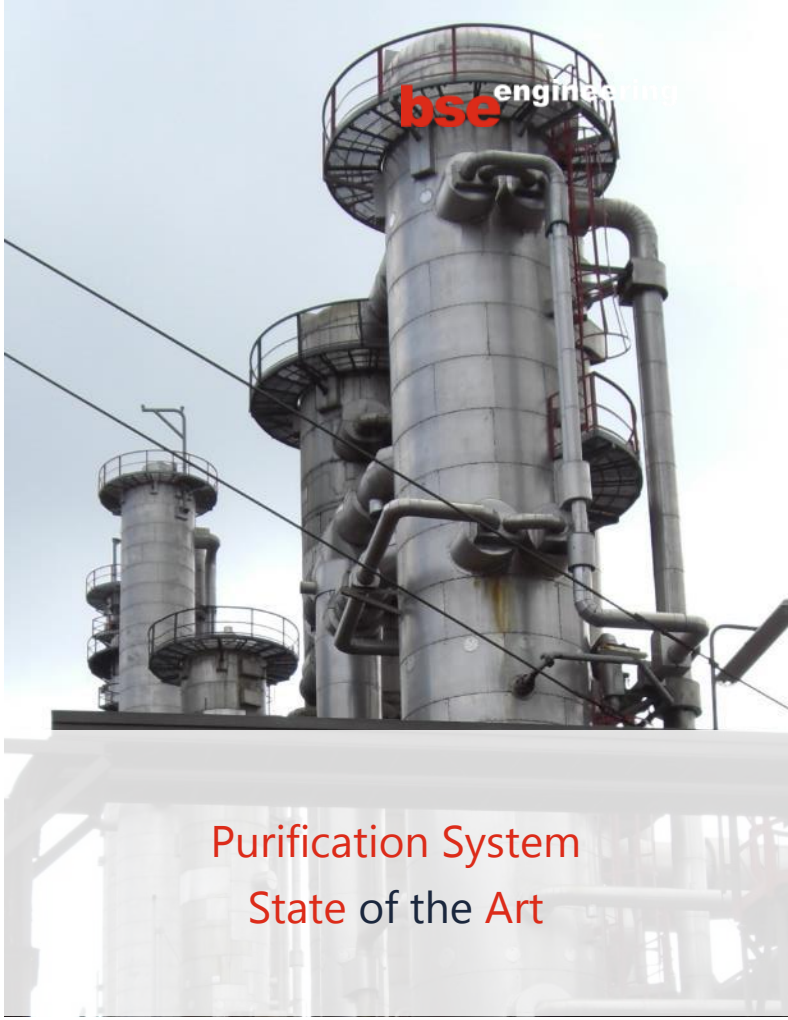
Methanol Purification

Step 2b – Methanol Distillation



Topping plus two stage refining distillation
Methanol according IMPAC specification (> 99.85 %w/w)

Flexibility range: 70 – 120 %

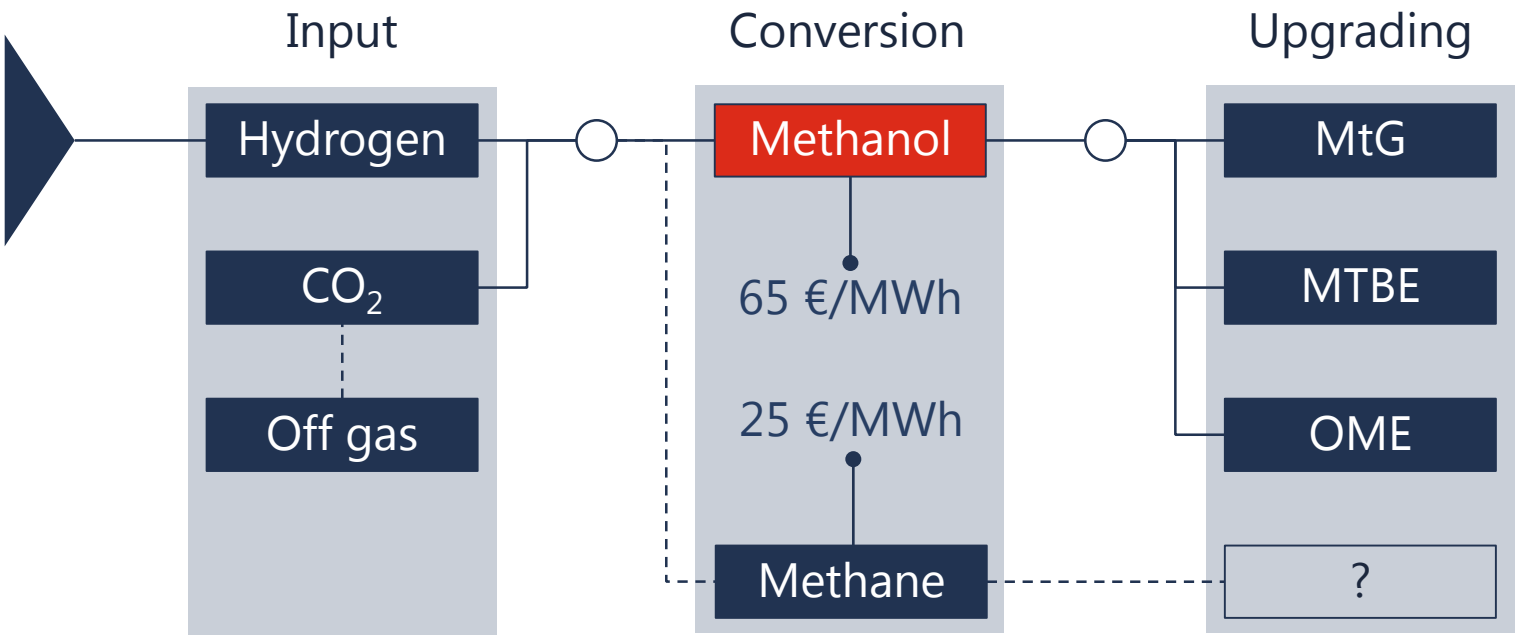


Source: CRI (2016)

Commercial Aspects

Power-to-fuel Options

Methanol as Prefered Chemical Energy Storage



Methanol has the highest value after the conversion of electricity with the best upgrading possibilities.

Key Performance Indicators

Overview Main Products

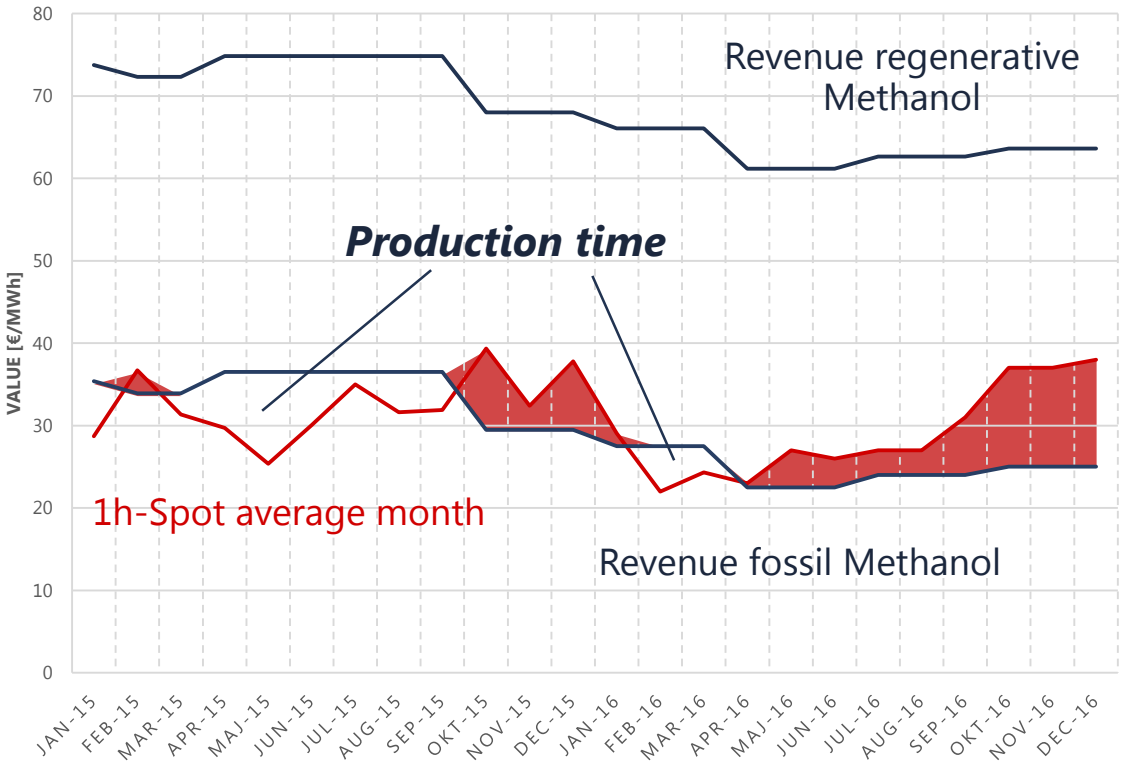
Categories	Unit	10 MW Electrolysis	20 MW Electrolysis	80 MW Electrolysis
*Output**				
Methanol	t/y	7,440	14,880	59,520
Water	t/y	4,320	8,640	34,560
Input				
Power Demand	MWh/a	80,000	160,000	640,000
CO_2 Demand	t/y	10,880	21,760	87,040
Water Demand	t/y	22,800	45,600	182,400
Catalyst Demand	t	3.1	6.2	24.8
Required Area	m^2	1,600	2,900	9,500
Technical Depreciation				
Physical lifetime	a	25		

*based on 8,000 full load hours

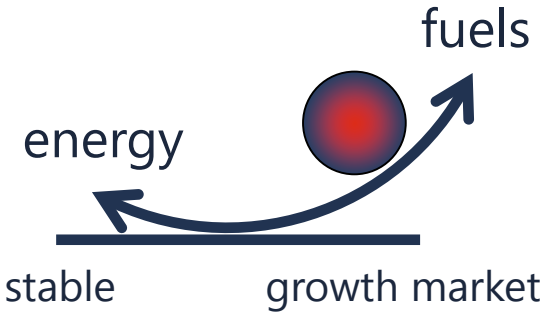
Total Efficiency >65 % (depending on energy recovery)

Value of Used Power

Power Market Operated



flexible market



Power price vs. operating hours

Offtake Concept

- Production capacities can not be planned (availability from 4,000 h to 8,000 h)
- Different counting for advanced fuels in the EU member states
- Need of pooling the produced capacities in a trade house to enter the premium markets
- Distribution of income according to the individual production

Pooling as best value market

Realisation

Full Service Small-Scale Methanol Plants

Execution

CO_2-Separation

AkerSolutions

Electrolysis

McPhy

Power Supply Mode

WEMAG

BASF
We create chemistry

bse engineering
Licencing

Methanol Offtake

nordic green

Methanol Synthesis

InfraServ KNAPSACK

Methanol Distillation

SULZER

Project Finance

Subsidies,
Grants, etc.

First rollout
of a 10 MW plant
in 2019/20

Engineering Procurement Construction (M)

Small-Scale Methanol Plants

bse engineering

bse engineering

Less buildings, more solutions

Project Coordinator

Germany

www.bse-engineering.de

Company

- Founded in 1990
- Engineering and process provider

Competence/Performances

- Project coordination
- Project development
- Basic, detail engineering
- Plant integration
- Exclusive BASF - Catalyst supplier
- Licencing

References

nafta, SÜDZUCKER, Pfeifer & Langen, suez environnement SITA, ROSNEFT, LEAG, ALBA

Catalyst Producer

Exclusive Supply for Small-Scale Methanol Plants

BASF
We create chemistry

Catalyst

Germany

www.basf.com

Company

- Founded 1865
- Company listed in the DAX
- Turnover 70 bill. € in 2015

Competence/Performances

- World leading company in catalyst supply

References

- First patent for methanol synthesis in 1913
- First plant for methanol synthesis in 1923
- Exclusive JDA and supply agreement for small-scale methanol plants globally with bse

CO_2-Separation

Exclusive Partner of BSE

bse engineering

AkerSolutions

Leading technology provider of carbon capture world-wide

HQ in Norway
13,000 employees
20 countries
48 locations

www.akersolutions.com

Company

- 20 years of CCUS know-how, 30 experts and 300 employees engaged in CCUS projects
- Core competence: Cost-efficient carbon capture technology
- Invested ~ 45 Mio. € in capture technology
- Technologies for fossil fuel power, cement and WtE plants

Competence

- Flue gas treatment
- CO_2 separation with improved amine solvents
- Design, construction, start-up and operation of amine plants

References

- Sleipner CO_2 platform (1,000 CO_2 kt/a, Statoil 1996)
- CO_2 capture plant Mongstad, TCM (80 CO_2 kt/a, 2012)
- Mobile Test Unit – MTU (own and operate, 2008)
- Winner of UK CCS Competition, Longannet (2011)

Methanol Synthesis

Exclusive Partner of BSE

InfraServ KNAPSACK

Holistic engineering

Germany
840 employees

www.infraserv-knapsack.de

Company

- Experience since 1997
- Various industrial and chemical services

Competence/Performances

- Plant optimisation
- Process development
- Conceptual design
- Basic, detail engineering
- Plant construction

References

LANXESS Energizing Chemistry

CLARIANT

Kao

ICL Where needs take us

Chemtura

Bayer CropScience

Methanol Distillation

Exclusive Partner of BSE Under Negotiation

SULZER

Chemtech – process technology

Switzerland
15,200 employees

www.sulzer.com

Company

- Providing process solutions since 1940
- Global sales and manufacturing network
- Broad Know How, numerous patents

Competence/Performances

- Most complete portfolio of distillation components
- The leading expert and solutions provider for continuous, single-/multi-stage distillation
- Taylor made design of highly efficient separation process
- Guaranteed performance

References

- > 100,000 columns are operating in over 500 different applications

Performance of the Consortium

Steps of Execution

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- Technical, economical, legal project definition
- Technical integration
- Energy and mass balance
- Operating concept
- CAPEX/OPEX
- Grant options

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- Project Management
- Basic engineering
- Detail Engineering
- Schedule & Cost Control
- Licencing
- Start-up

meoh consortium

- Turn key supply
- Unit supply
- Core equipment supply
- Catalyst supply
- Performance test

meoh consortium

- Maintenance
- Catalyst Refilling
- Power Supply mode
- Offtake

Concept → **Engineering** → **Construction** → **Operation**

Individual Project Contract

We are supported by

Regeneratives Methanol Innovationsnetzwerk

Methanol Institute

DECHEMA

DLR Deutsches Zentrum für Luft- und Raumfahrt

TU Bergakademie Freiberg

Our R&D Partners

Bio-M

InfraServ Knapsack

Fraunhofer CBP

AC FHI

In cooperation with:

BioEconomy Cluster

BASF We create chemistry

HYPOS

bse Engineering

Thank You

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