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HYPOS

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Energy with Future.
Environment and Responsibility.

Green hydrogen for CO_2 conversion to valuable chemicals

Development of a combined process for CO_2 scrubbing and hydrogenation to methanol

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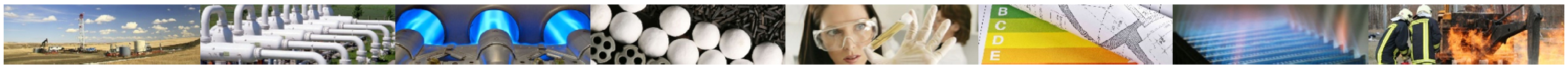
DBI Gas- und Umwelttechnik GmbH

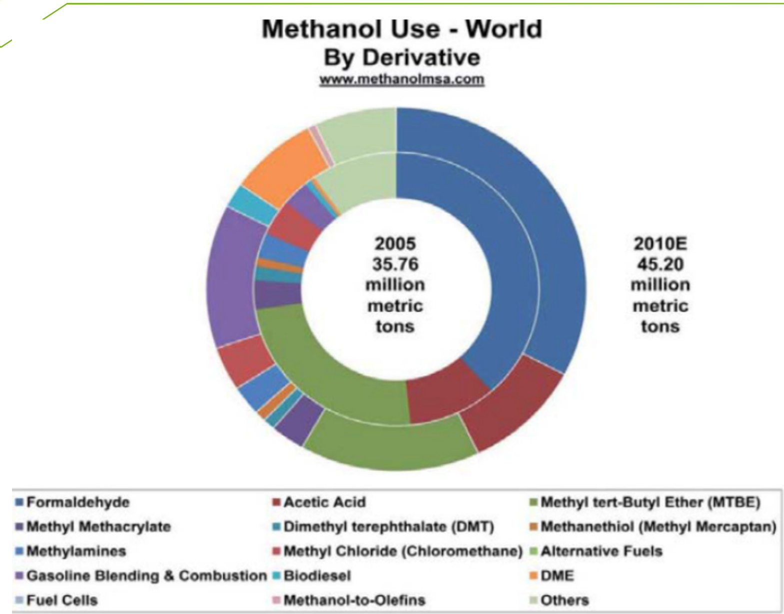
Advanced alkaline electrolysis and applications – 2nd workshop of Elyntegration

Dresden, September 19th 2018

DVGW



- Expanding production and demand (p.a., world)
  - 2005: 35.8 million t [1]
  - 2010: 45.2 million t [1]
  - 2015: 75.0 million t [2]
- Broad usage
  - Chemical industry
    - Formaldehyde – further treated to resins, glues and plastics
    - Acetic acid – polyester fibres and PET plastics
    - Olefins – via MTO process, new fast growing market (PRC)
  - Transportation
    - Blend (M15) or direct/indirect use (MTBE)
    - High octane number (106)
    - Reduction of emissions (NO_x, HC, CO)



www.methanolmsa.com / 2012

www.bluefuelenergy.com / 2018

[3] www.methanol.org / 2018

[1,2] Bolle, F.-W., RWTH Aachen, 2012

DBI

- Conventional production
  - Feed: Natural gas/coal
  - Conventional methanol synthesis
  - Primary energy demand (world): appr. 700 TWh [3]
  - CO_2 emissions: about 175 million t

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

$$CO + 2H_2 \rightarrow CH_3OH$$

- Usage of carbon dioxide and hydrogen
  - Carbon dioxide demand: 100 million t
  - Hydrogen demand: 14.2 million t
    → 18.5 million m³/h (8500 h/a)

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

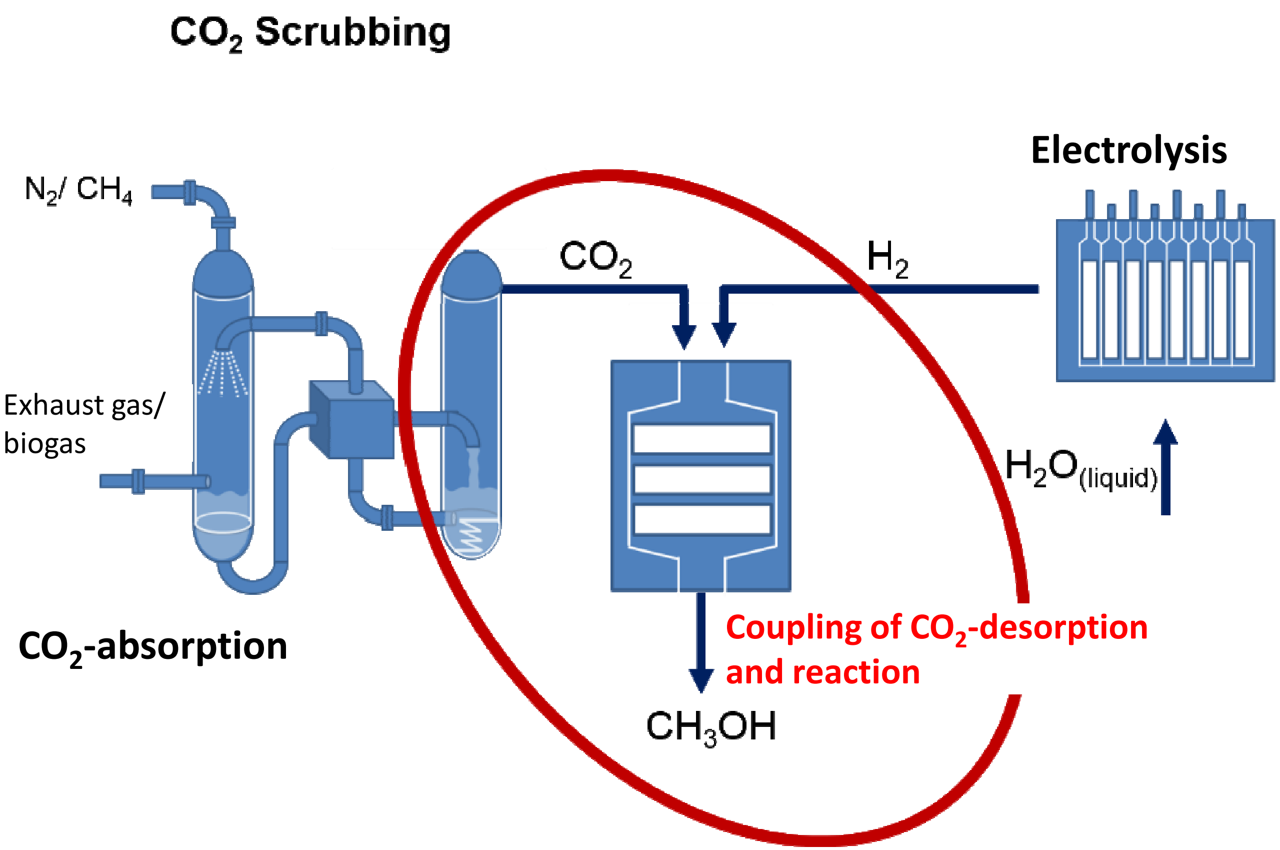
Ely Technology Level	Conventional	Advanced
Ely efficiency (η_{ely})	65 %	85 %
Ely plant size	10 MW	100 MW
Required electrical power	85.4 GW	65.3 GW
Number of electrolysers	> 8000	650

- Convert greenhouse gas CO_2 in usable substance
  - Methanol as an energy source, fuel and basic chemical

- State of the art:
  - Washing of CO_2-containing exhaust gases and biogases with alcohol-amines → CO_2 absorbed in amines
  - Separation of CO_2 and alcohol-amines
  - Hydrogenation of CO_2 to methanol

- Idea: conversion of the absorbed CO_2 to methanol in an one-step process at lower temperatures

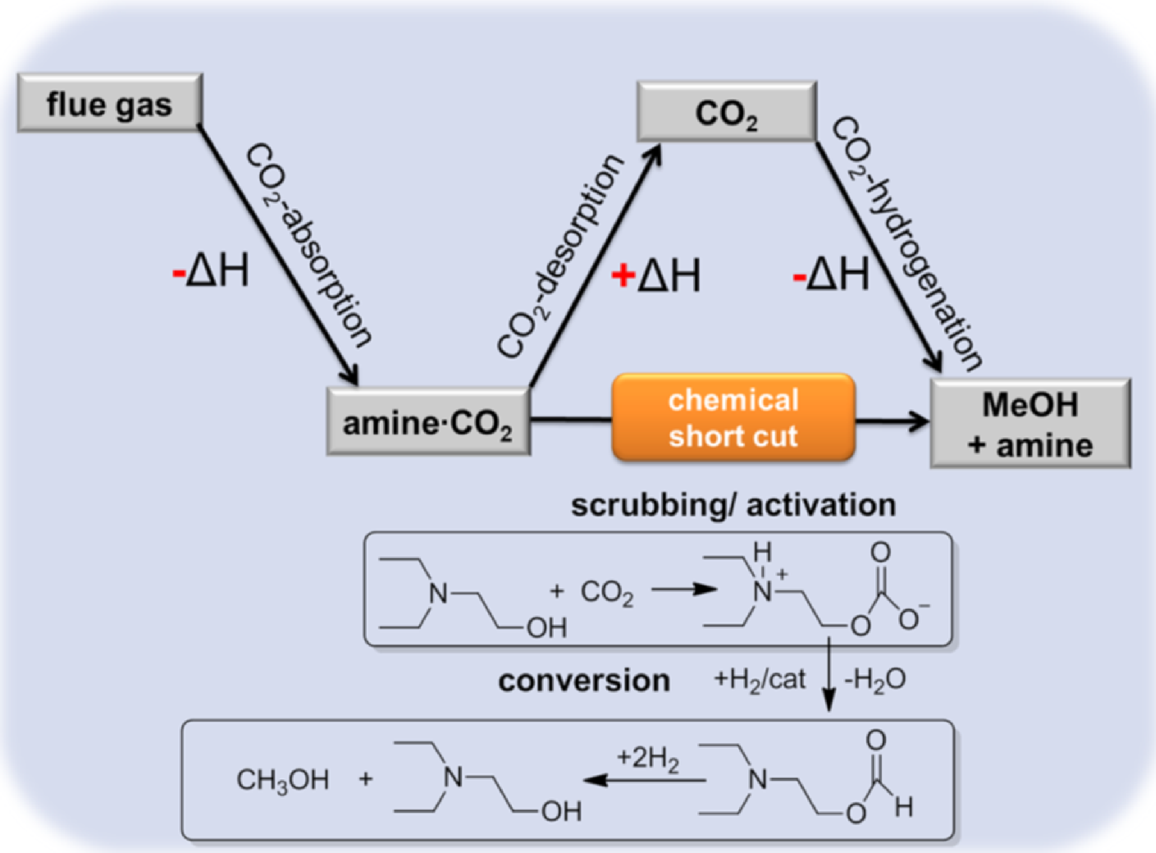
Schematic view of the COOMet idea



TU Freiberg (IPC)

- Technical process
  - 50…100 bar
  - 240…260 °C
  - Cu-ZnO/Al_2O_3
  - Recycle unreacted educt
- New COOMet process
  - 20…30 bar
  - 130…170 °C
  - Cu-ZnO/Al_2O_3-Amin

CO_2-Absorption and Hydrogenation in one Step



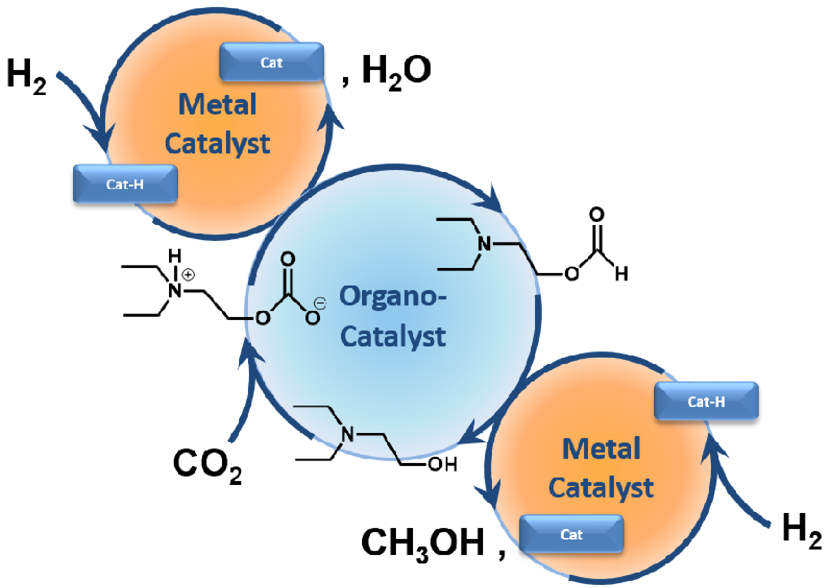
TU Freiberg (IPC)

- Aim
  - Development of a coupled process of CO_2 collecting and methanol-synthesis
  - High efficiency of integrated heat transfer

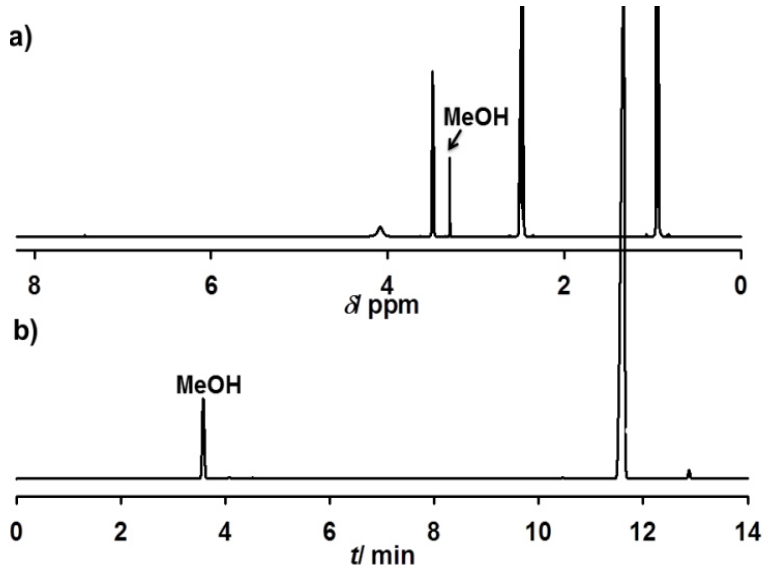
Partly compensation of ΔH_{des} and ΔH_{hydr}

Reaction: $CO_{2(g)} + 3\ H_{2(g)} \leftrightarrow CH_3OH_{(g)} + H_2O_{(g)}$ $\Delta H_R° = -49$ kJ/mol

- Metal catalyst + amine (function as an organo-catalyst)
- Methanol is the only product
- The other peaks are the amine

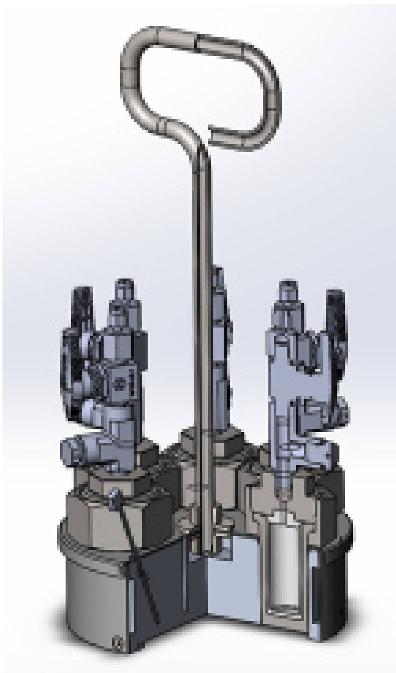


Scheme of the catalyst system © TU Freiberg (IPC)



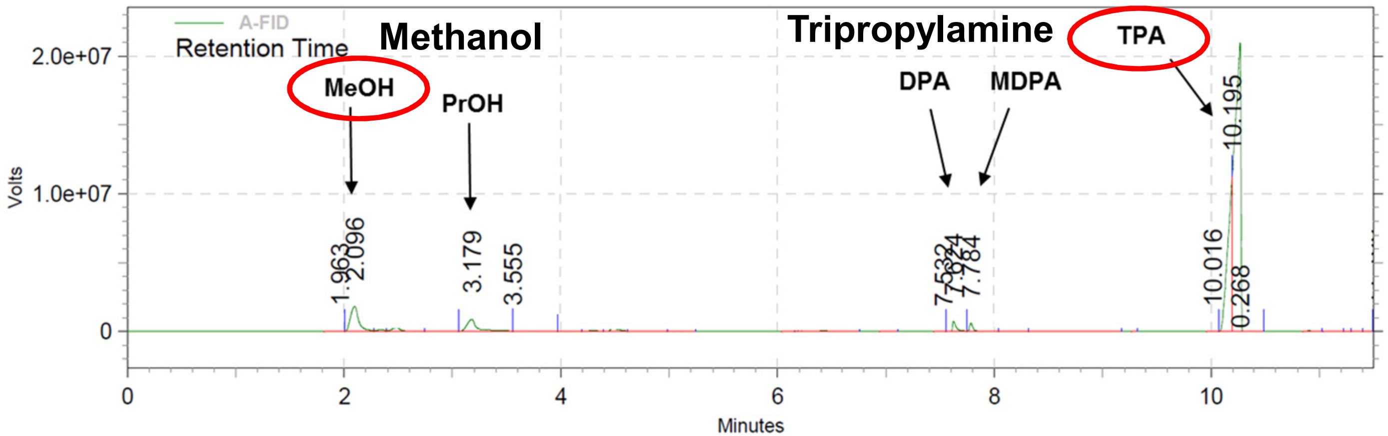
Analysis of NMR-spectroscopy © TU Freiberg (IPC)

- First results are created in a batch reactor of TUBAF in 2013 (patented process no.: DE2013201246A1)
- Currently use of a multiplex-reactor-system and a headspace gas chromatograph to get fast in-situ analysis of the product



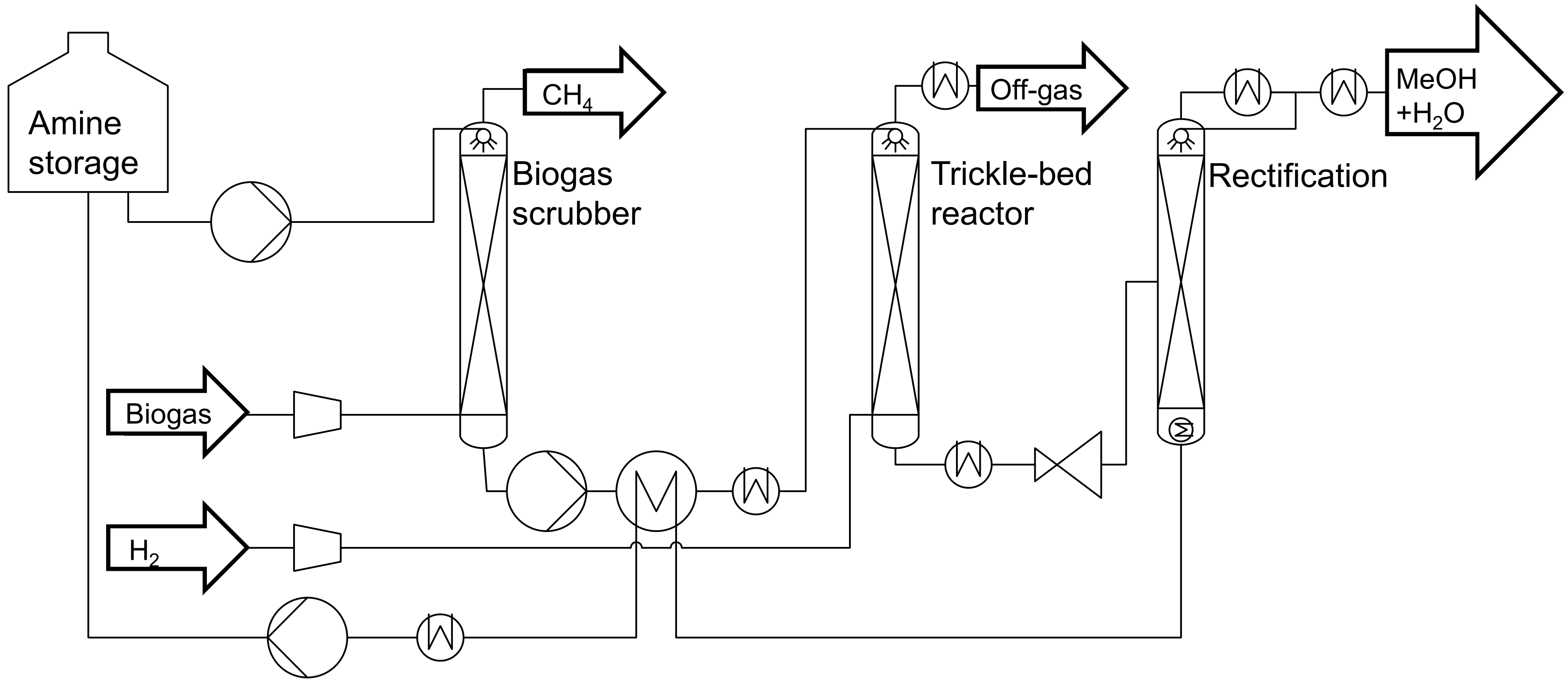
Multiplex-reactor-system © TU Freiberg (IPC)

- Scientific aims
  - Understanding the reaction mechanism
  - Determination of the reaction kinetics



Headspace gas chromatograph © TU Freiberg (IPC)

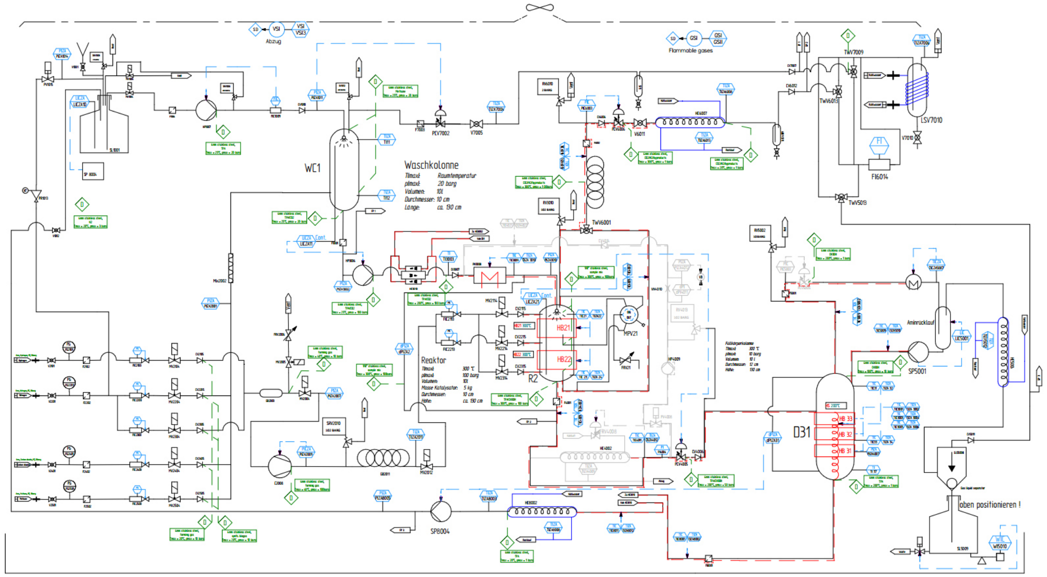
COOMET - CONCEPT OF THE TECHNICAL PLANT



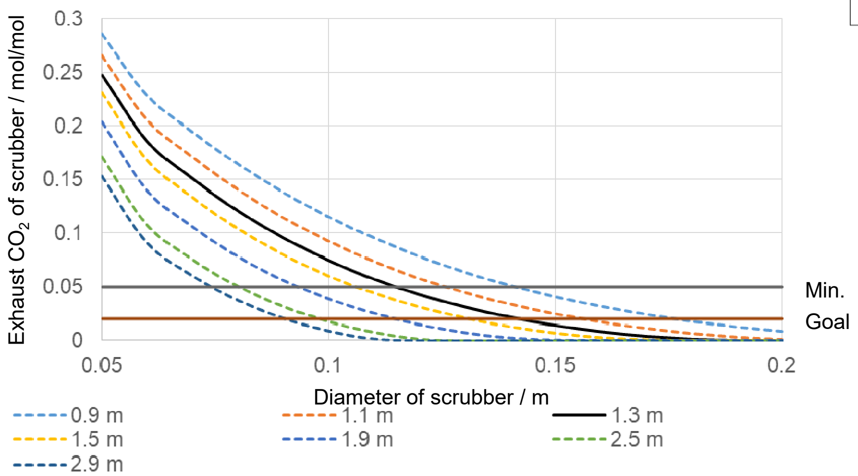
- Process parameters:
  - Up to 100 bar (20 bar expected)
  - Up to 300 °C (160 °C expected)
  - Max. product capacity 0.2 l/h methanol (1 l/h expected)

COOMET - CHALLENGES

- Challenges
  - Complex process for lab scale
  - Amines have low CO_2 capacity
    - → high recycling rate
  - Amine stability
  - Activity and stability of catalyst
  - Low amine loss
  - High methanol selectivity



P&ID © Amtech



Simulation of scrubber

- Size of the lab
- Handling of reactor
- Process handling

COOMET – SUMMARY / NEXT STEPS

- Summary
  - Process is running in lab scale
  - For faster results multiplex-reactor-system and a headspace GC necessary
  - Planning of the technical scale was difficult but is nearly finished
  - Downscale of technical plant necessary for well handling

First layout construction © Amtech

- Next steps
  - First experiments will be conducted after final planning and construction of the technical plant in the beginning of 2019
  - First results are expected in Q2 2019

PROJECT-PARTNER AND SUPPORT

- Technische Universität Bergakademie Freiberg (Institut für Physikalische Chemie)
- DBI Gas- und Umwelttechnik GmbH
- John Brown Voest GmbH
- Advanced Machinery & Technology Chemnitz GmbH
- The project HYPOS-COOMet “Entwicklung eines gekoppelten Verfahrens zur Nutzung von CO_2 für die energetisch optimierte Methanolherstellung” is funded by the Federal Ministry of Education and Research (funding code: 03ZZ0726B).

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THANK YOU FOR YOUR ATTENTION!

Your contact partner

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