Optimizing of a hydrogen production plant by optimization of the CO_2 removal step

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Agenda

Overview of research

Gasification & syntheses

CO_2 removal

Hydrogen production

Summary & Outlook

bioenergy2020+ → BEST Bioenergy and Sustainable Technologies

WHAT Austrian competence centre for biomass utilization since 15+ years

WHERE 4 research sites across Austria

WHO ~100 researchers from all academic career levels (mostly engineers)

HOW National and international research funding + industry partners
(~9 Mio EUR turnover per year)

Graz
(Head office)

Wieselburg

Vienna

Tulln

Research Areas


Fixed bed conversion

Three main departments plus additional (crosscutting) departments:

- Microgrids
- Simulation
- Automation and control
- Supply chain


Fluidized bed conversion


Biological Conversion & Integration

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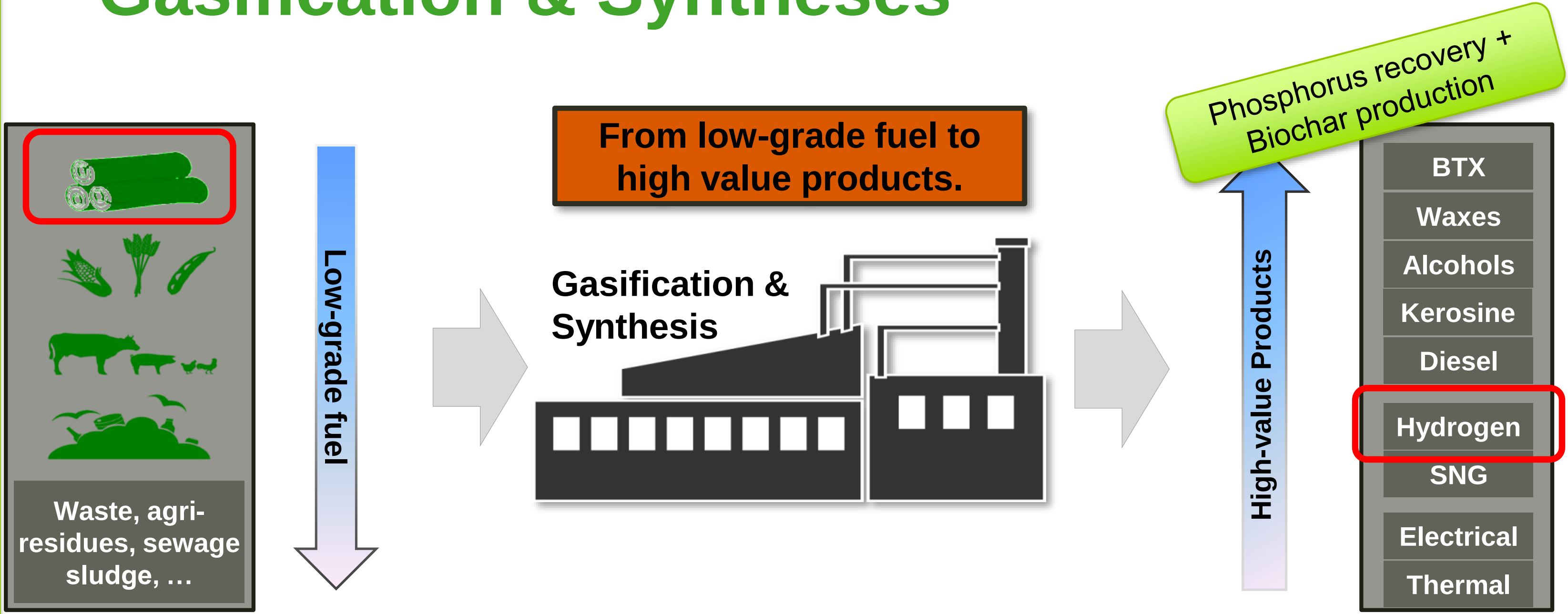
Challenges

Gasification & Syntheses



H_2 price: <5 €/kg

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CO_2 separation

10-15% of the fuel power

	Technique	Investment costs for a 500 m³/h plant [€/(m³/h)]	Running costs for a 500 m³/h plant [ct/N_{m^3}]	Costs per tons CO_2 [€/t_{CO_2}]	Electricity consump-tion (raw gas) [kWh/N_{m^3}]	Heat consump-tion (raw gas) [kWh/N_{m^3}]	Selectivity CO_2 [%]
Chemical absorption	Amine scrubber	3 500[7]	11,2[7]	40-70[1]	0,1 - 0,15[12]	0,5 - 0,75[12]	88[2]
	Benfield operation	-	-	15-25[1]	-	-	-
Physical absorption	Pressurised water scrubbing	3500[7]	9,1[7]	-	0,3[12]	not necessary	-
Adsorption	Pressure swing adsorption (PSA)	3700[7]	9,2[7]	-	0,23[12]	not necessary	-
Membrane operation	Membrane	3 500 - 3 700[7]	6,5 - 10,1[7]	21-29[1]	0,18[12]	not necessary	-
Cyrogenic operation	Cryogenic operation (distillation)	-	-	37[1]	0,72[12]	not necessary	90[1]

CO_2 separation by MEA scrubbing

+

- Removal of CO_2 and H_2S
- Pressure-less process
- Industrial proven

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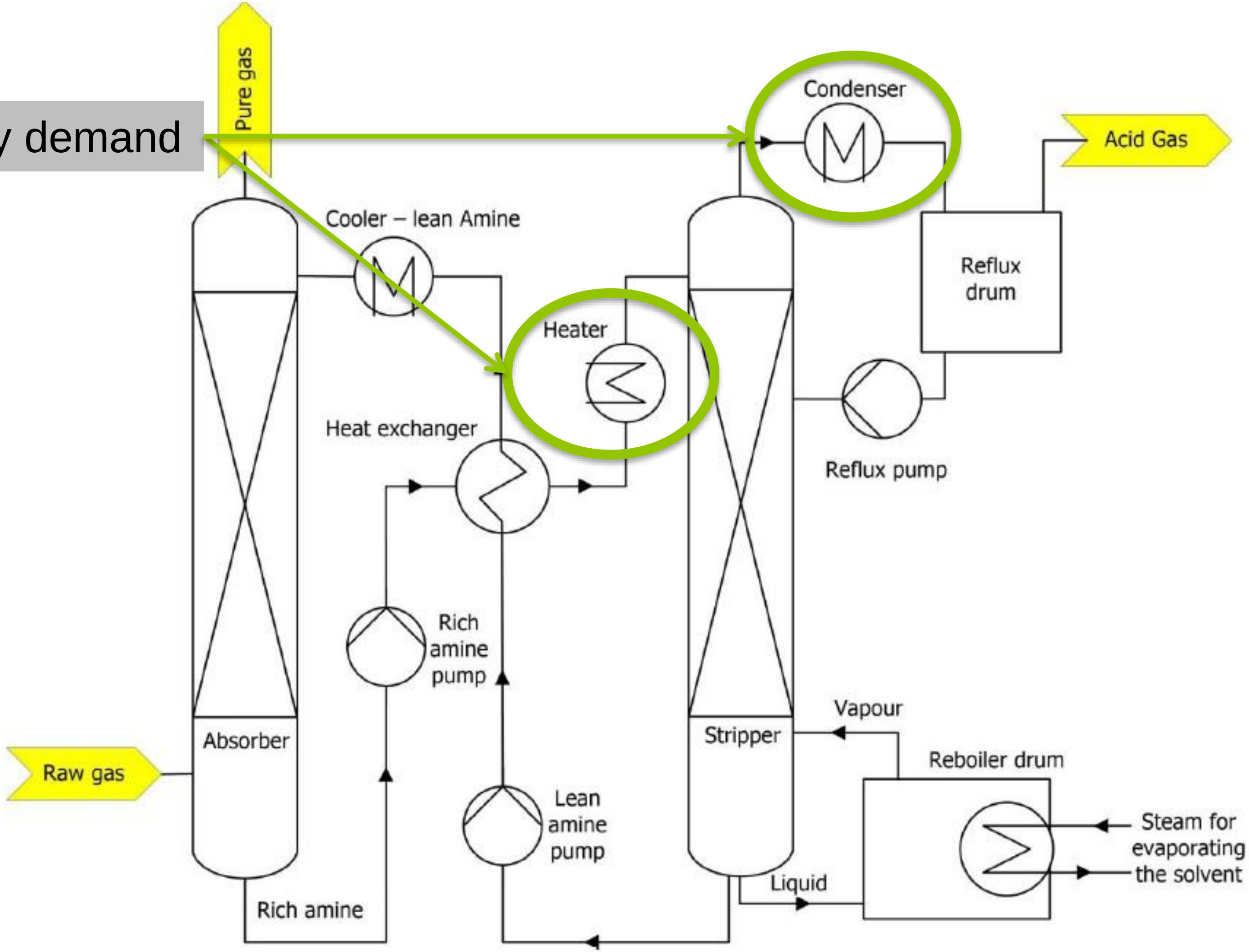
- High energy demand
  - Desorber temperature 140-160°C
- Foaming
- Poison

high energy demand

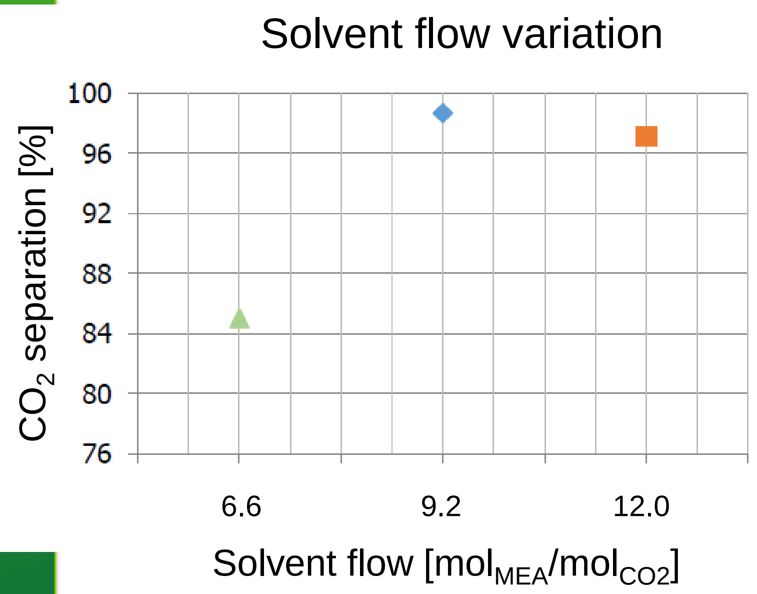


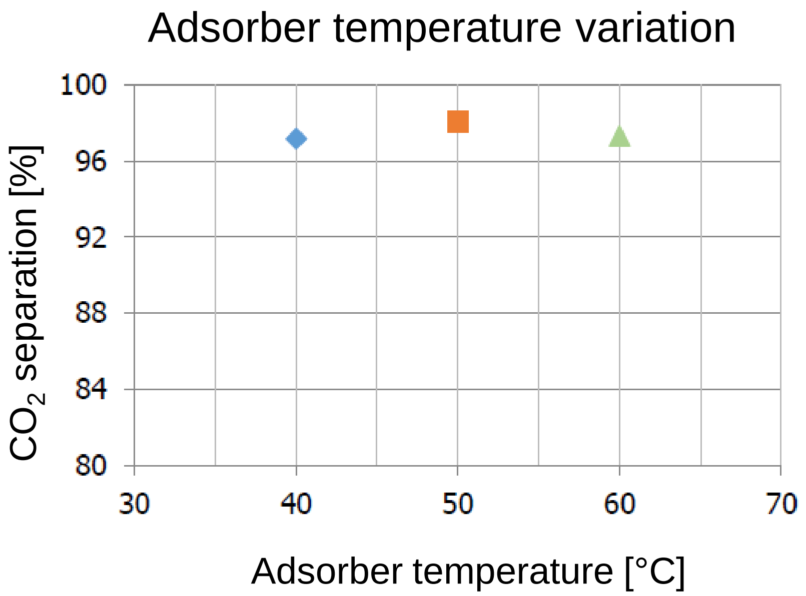
CO_2 separation by MEA scrubbing

- Parameter variation of
  - Desorption temperature (district heat level)
  - Adsorption temperature
  - Solvent flow

CO_2 separation by MEA scrubbing

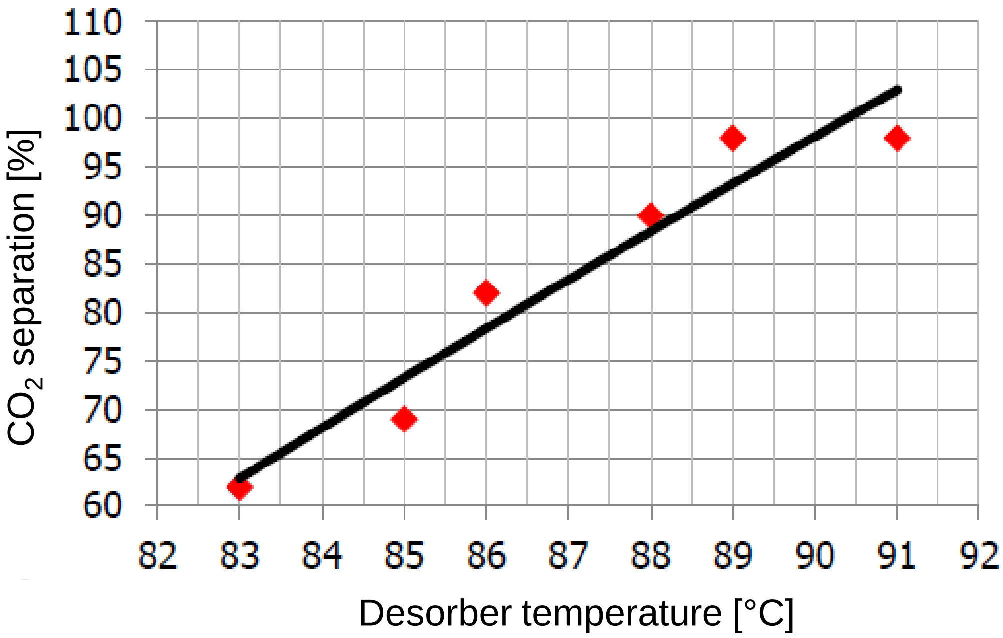
Standard parameters:
TDes. = 90°C
TAds. = 40°C
Flow solvent = 12 mol_{MEA}/mol_{CO2}





CO_2 separation by MEA scrubbing

Variation of desorber temperature



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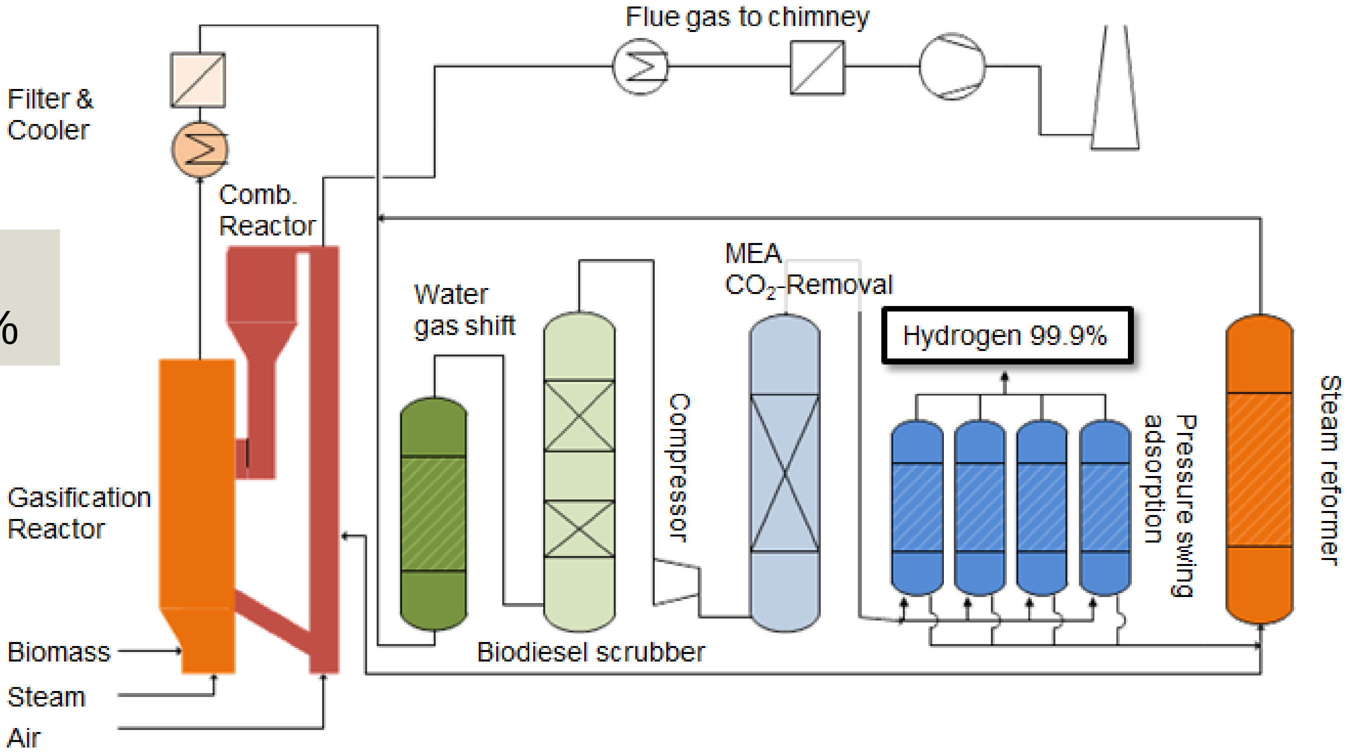
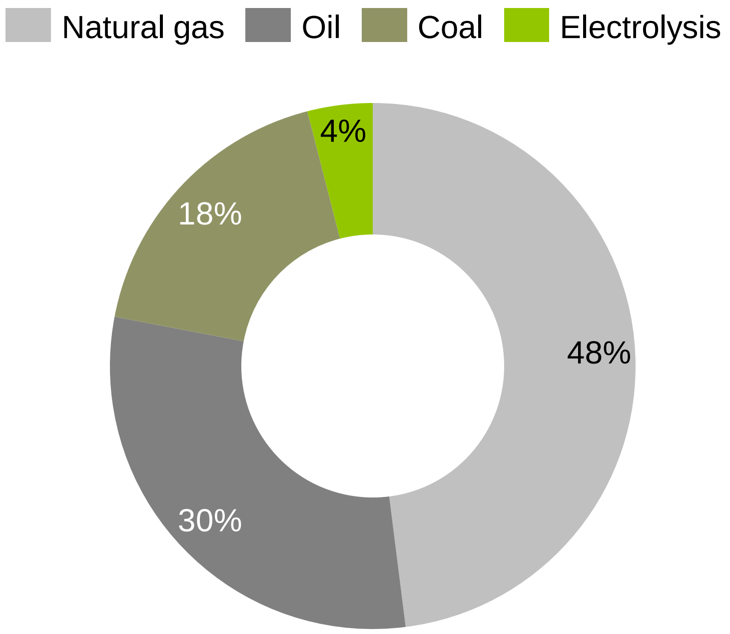
$BioH_2$ technology

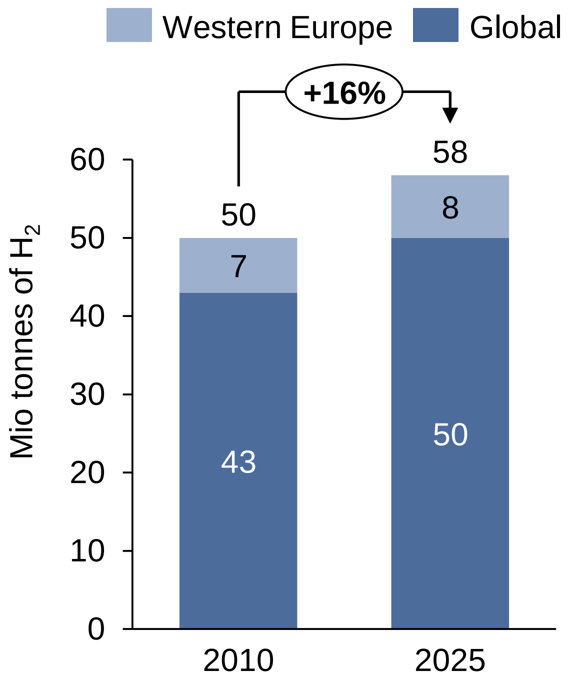
η_{H2} = 54 %
$\eta_{overall}$ = 55%



Why produce hydrogen from biomass?



Current feedstock used for H_2 production. (Arregi et al., 2018)



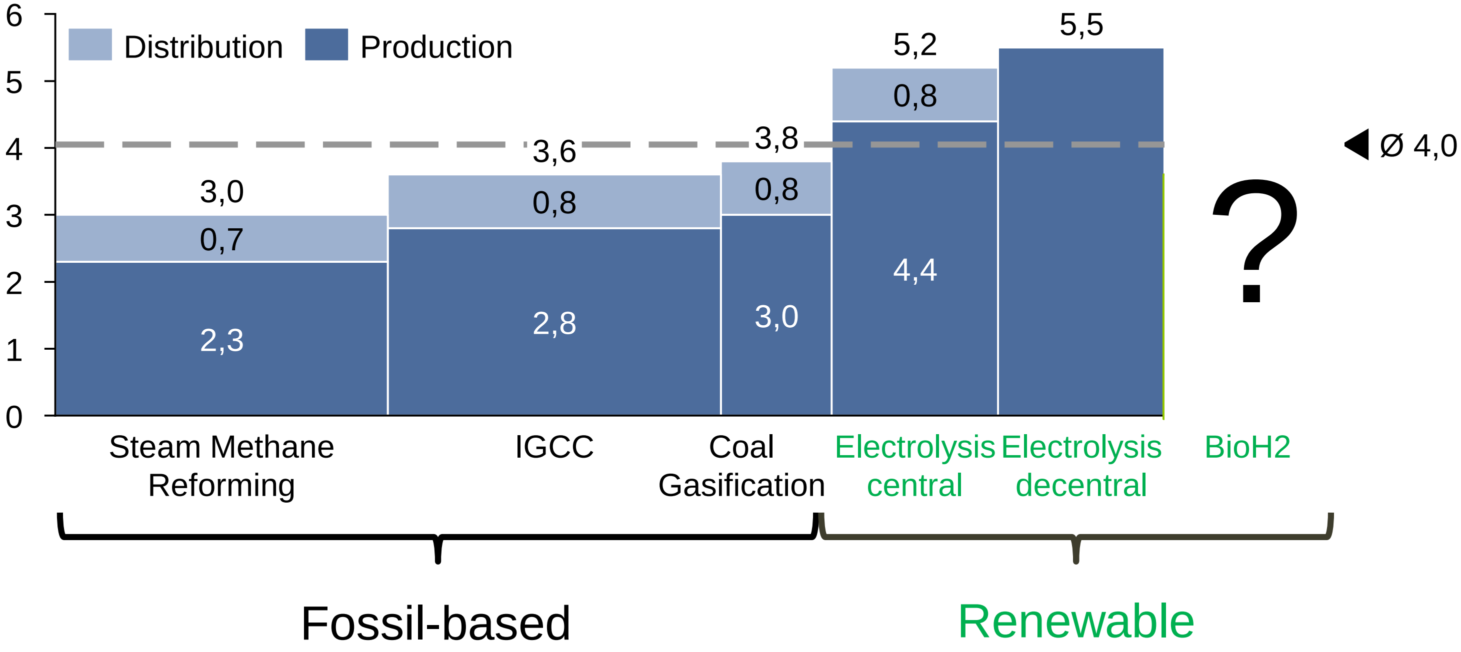
Fraile et al., 2015

Why produce hydrogen from biomass?

Projected 2030 H_2 cost [EUR/kg H_2]

References:
A portfolio of power-trains for Europe: a fact-based analysis by McKinsey

Hydrogen from biomass gasification by IEA



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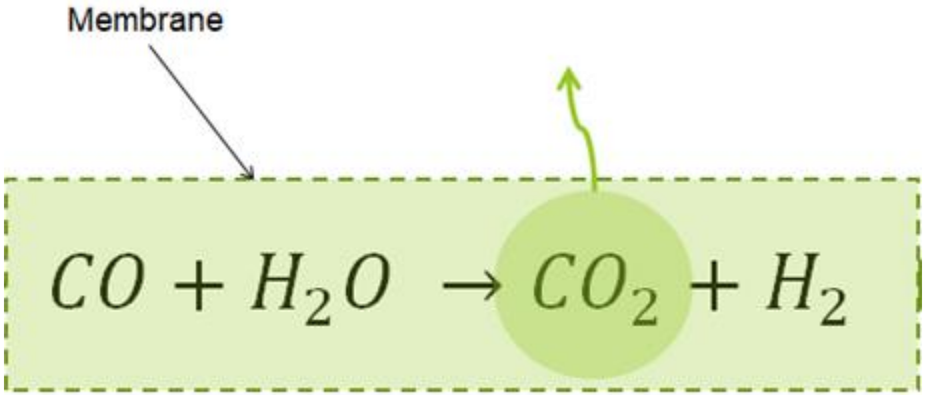
Summary

- Parametervariation CO_2 removal (district heat level possible)
- Hydrogen efficiency of 54% could be confirmed
- Hydrogen price 3.8-4.5 €/kg (depending on plant size)

Paper: Experimental Demonstration and Validation of Hydrogen Production Based on Gasification of Lignocellulosic Feedstock
https://doi.org/10.3390/chemengineering2040061

Outlook

„Combination of water gas shift and CO_2 removal gives the opportunity to reduce energy and material costs drastically“



→ http://www.romeo-h2020.eu/

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REACTOR OPTIMISATION BY MEMBRANE ENHANCED OPERATION

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