

F. Drünert
P. Boehm
D. Walter
N.-H. Löber
B. Fleischmann



**Deutsches Zentrum
für Luft- und Raumfahrt**
German Aerospace Center

J. Weyand
Y. Rahmat
F. Moser
S. Maier
R.-U. Dietrich



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*Carbon Capture and Utilization Cycles
for a CO₂ Neutral Glass Production
KlimPro BMBF 01LJ2005 (A+B)

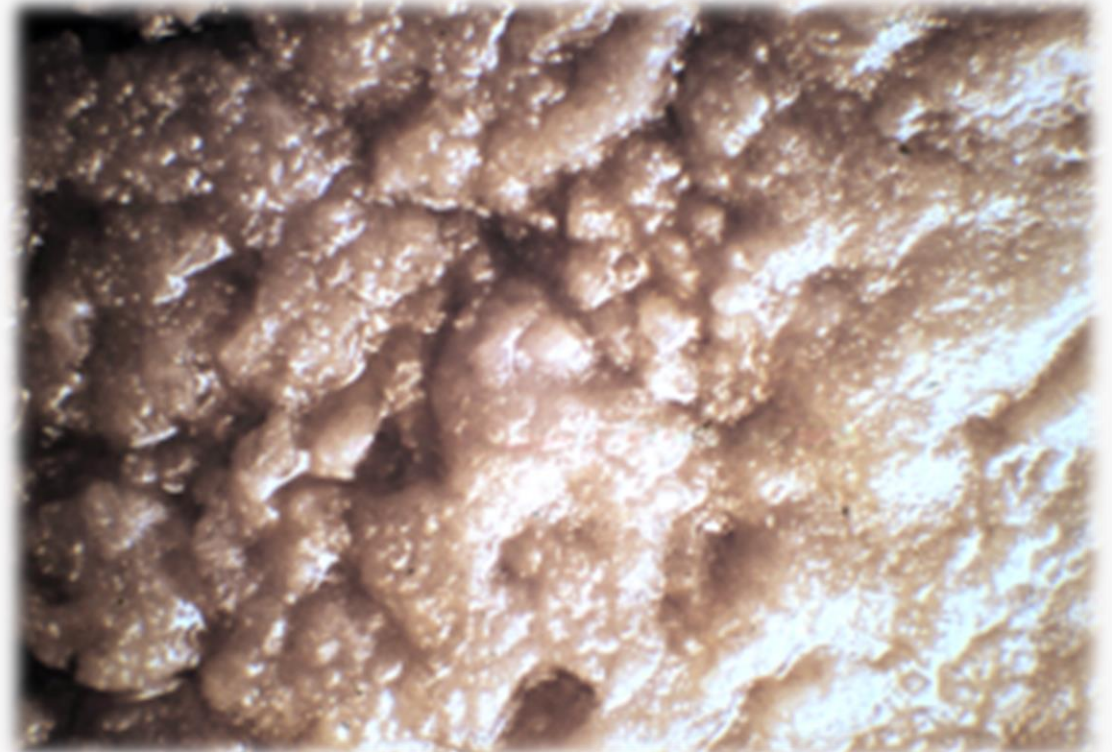


CO₂ SOURCES ... in glass production processes

Process heat (CH₄)



Batch decomposition (XCO₃)



CO₂ AVOIDANCE

Are there any good solutions?

CO₂-neutral heating

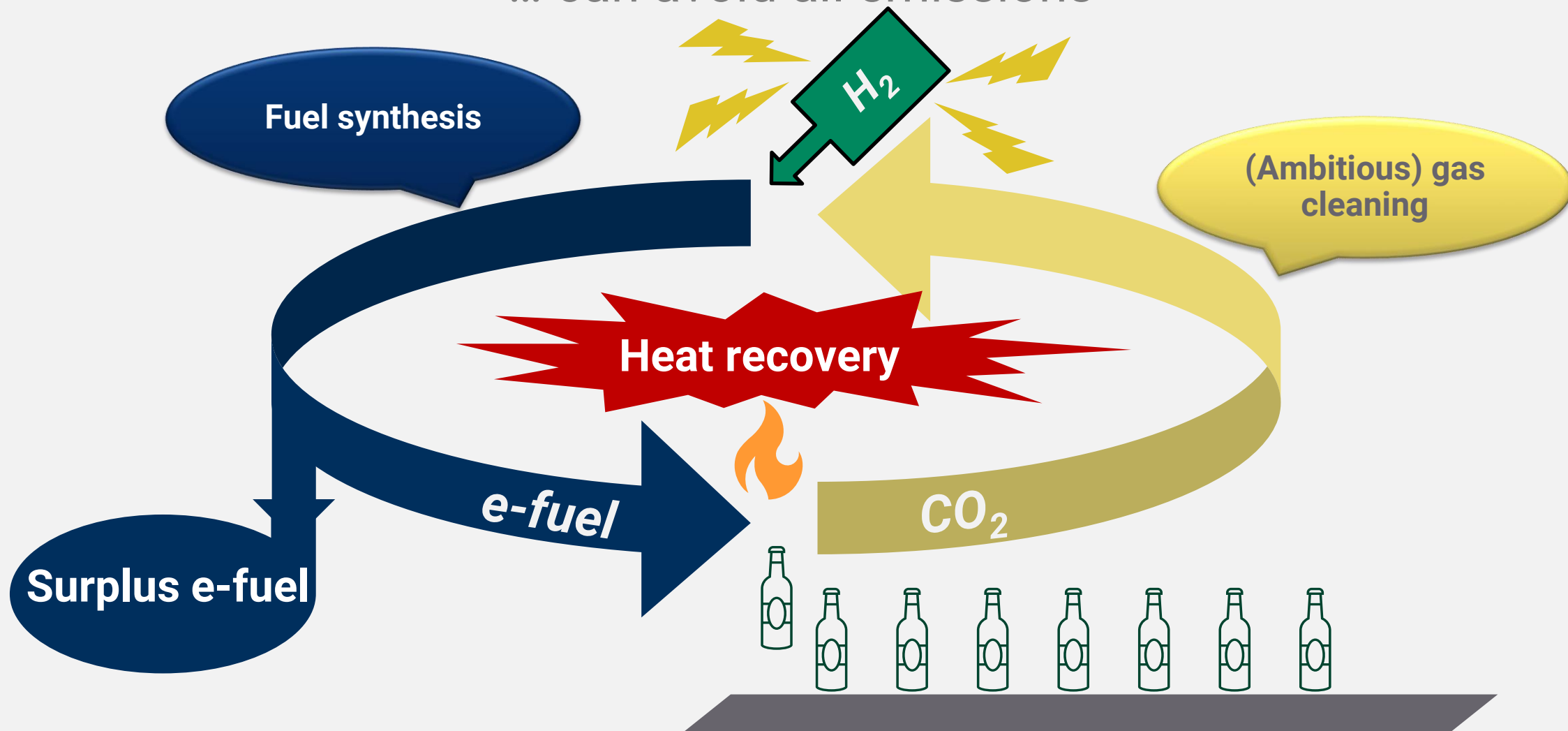


CO₂-neutral batch ingredients

???

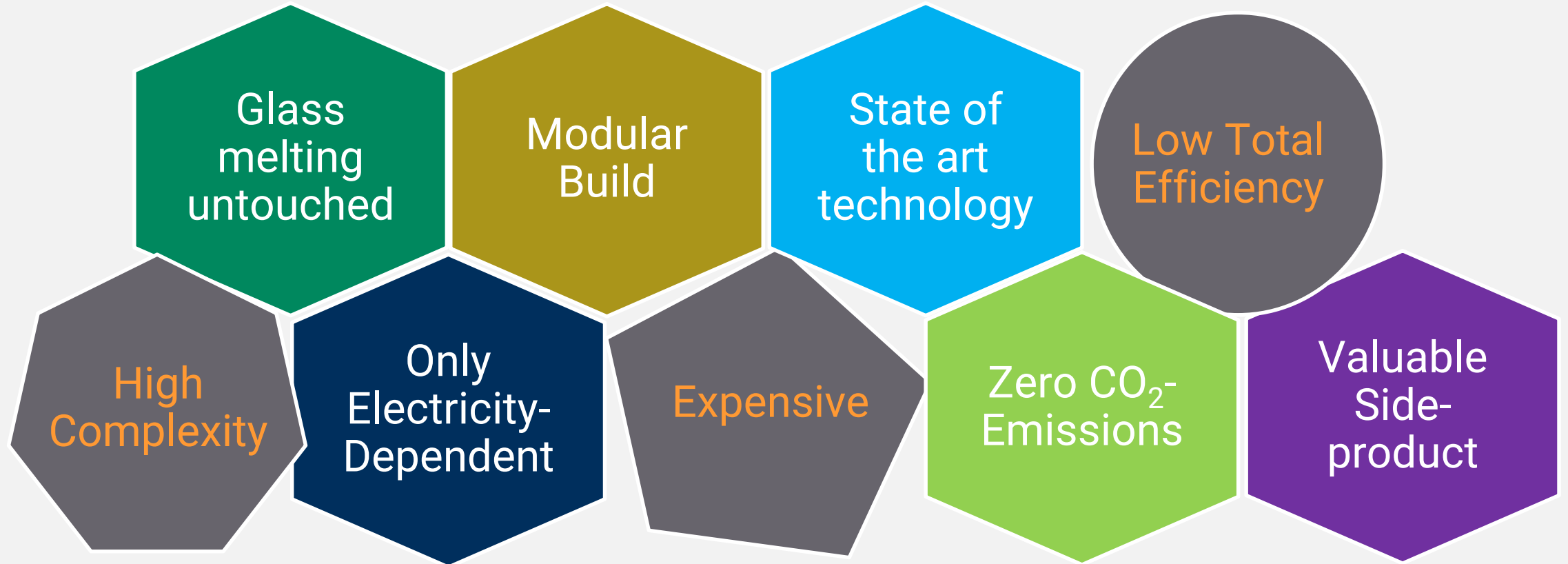


A CCU CYCLE PROCESS ... can avoid all emissions



CCU CARBON CYCLE

Pros and Cons



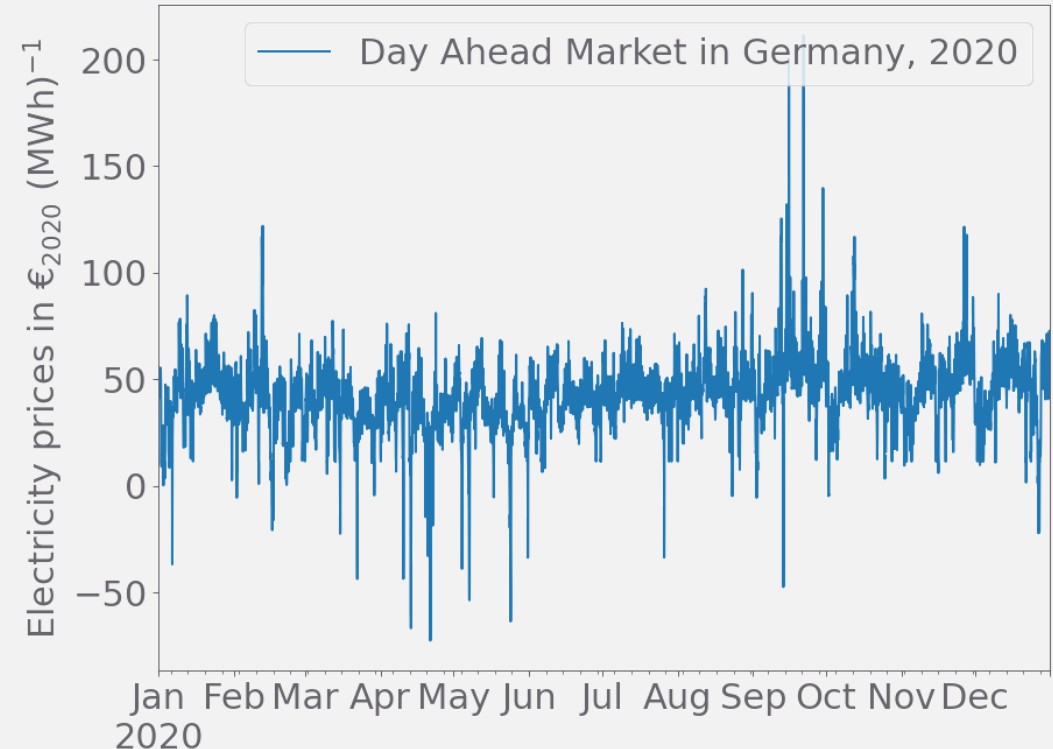
CCU CYCLE

Project-Parameters



300 t molten glass per day

- 55% cullet
- 37 kt CO₂ / a
- 20% from batch



Electricity: 42 €₂₀₂₀ per MWh

CCU CYCLE PARAMETERS

Possible Choices

Electrolyzer

PEM

- Dynamic operation possible

AEL

- OPEX / CAPEX ↓

SOEC

- OPEX / CAPEX ↑↑, Efficiency ↑

Fuel synthesis

Methane

- Well-known, grid available

Methanol

- Liquid → easy storage

Syngas

- No fuel synthesis required

CCU CYCLE EVALUATION

Efficiency (LHV)

Furnace efficiency



Electrolyzer

PEM

- $\eta = 0.51^1$

AEL

- $\eta = 0.53^2$

Fuel synthesis

Methane

- $\eta = 0.88^3$

Methanol

- $\eta = 0.69^3$

¹ Kopp et al., Int. J. Hydrog. Energy 42 (2017), 13311 – 13320

² Sánchez et al., Int. J. Hydrog. Energy 45 (2020), 3916 – 3921

³ Preliminary estimation by DLR

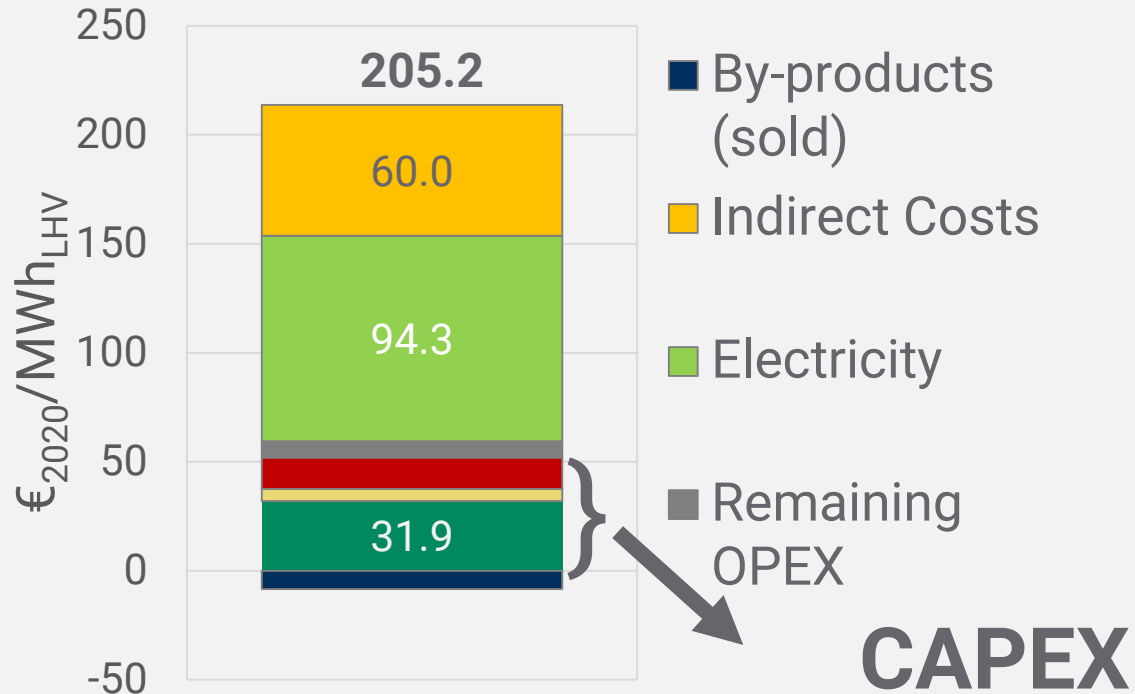
$$\eta_{tot} = \frac{Q_{fuel}}{P_{el}} \approx 0.4$$

CCU CYCLE EVALUATION

Net Production Cost (First Estimation)

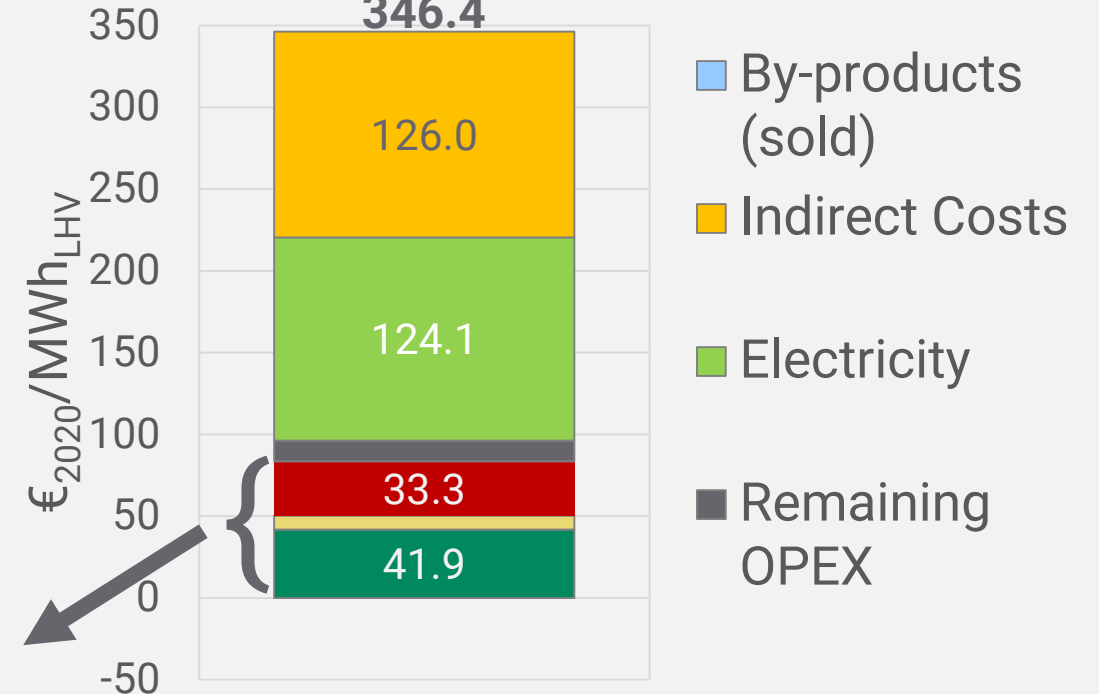
Methane (30% / 6 t d⁻¹ sold)

Breakdown of NPC



Methanol (18% / 11 t d⁻¹ sold)

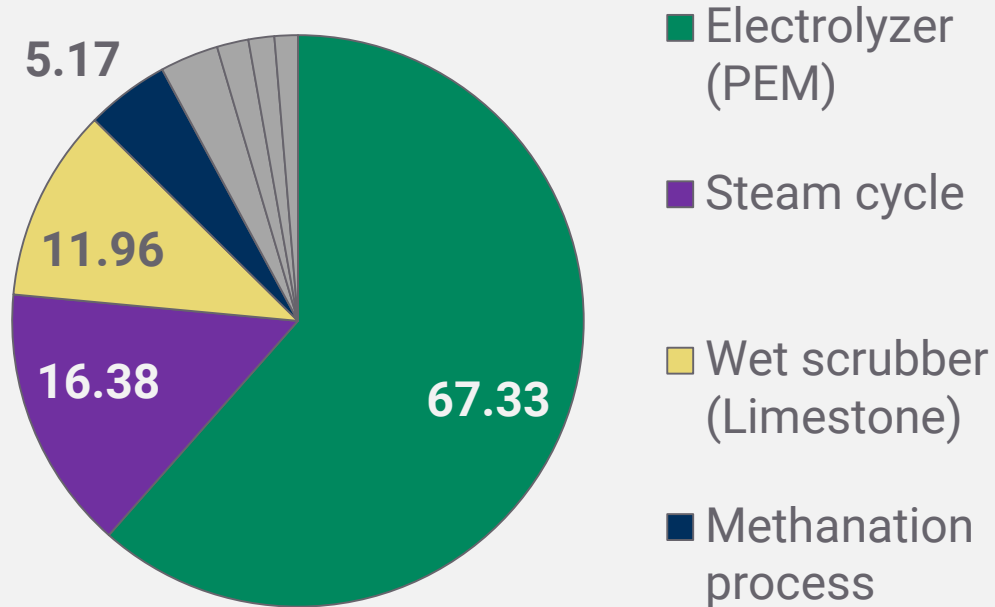
Breakdown of NPC



CCU CYCLE CAPEX (First Estimation)

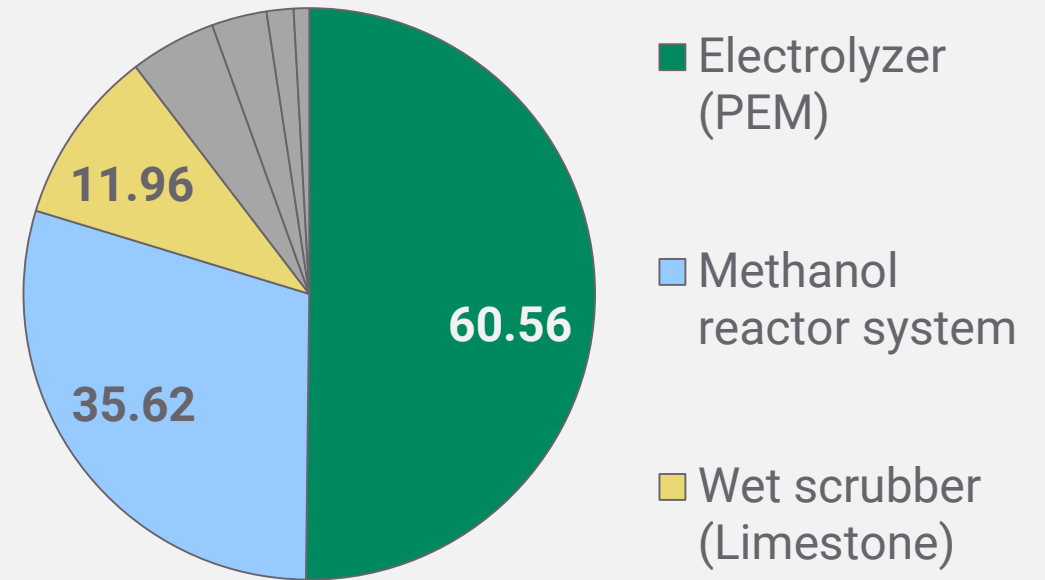
Methane: 110 Mio €₂₀₂₀

Fixed Capital Investment costs [million €₂₀₂₀]



Methanol: 115 Mio €₂₀₂₀

Fixed Capital Investment costs [million €₂₀₂₀]



- NPC between 200 and 350 € per MWh
 - Methanol cycle needs further optimization
 - Depending on local conditions

- AEL will be cheaper
 - ... but requires less dynamic operation

- High temperature co-electrolysis (H_2+CO) may be a game changer
 - However: Technology is not mature (yet)!

- No solution without CCU / CCS while using carbonate batch ingredients
- NO EXPERIENCE with CCU in the glass industry
 - Follow-up studies / pilot application required!

We are interested in your cooperation!

druenert@hvg-dgg.de



B. Fleischmann (HVG)
Fleischmann@hvg-dgg.de

R.-U. Dietrich (DLR)
ralph-uwe.dietrich@dlr.de

