

We are:



Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center



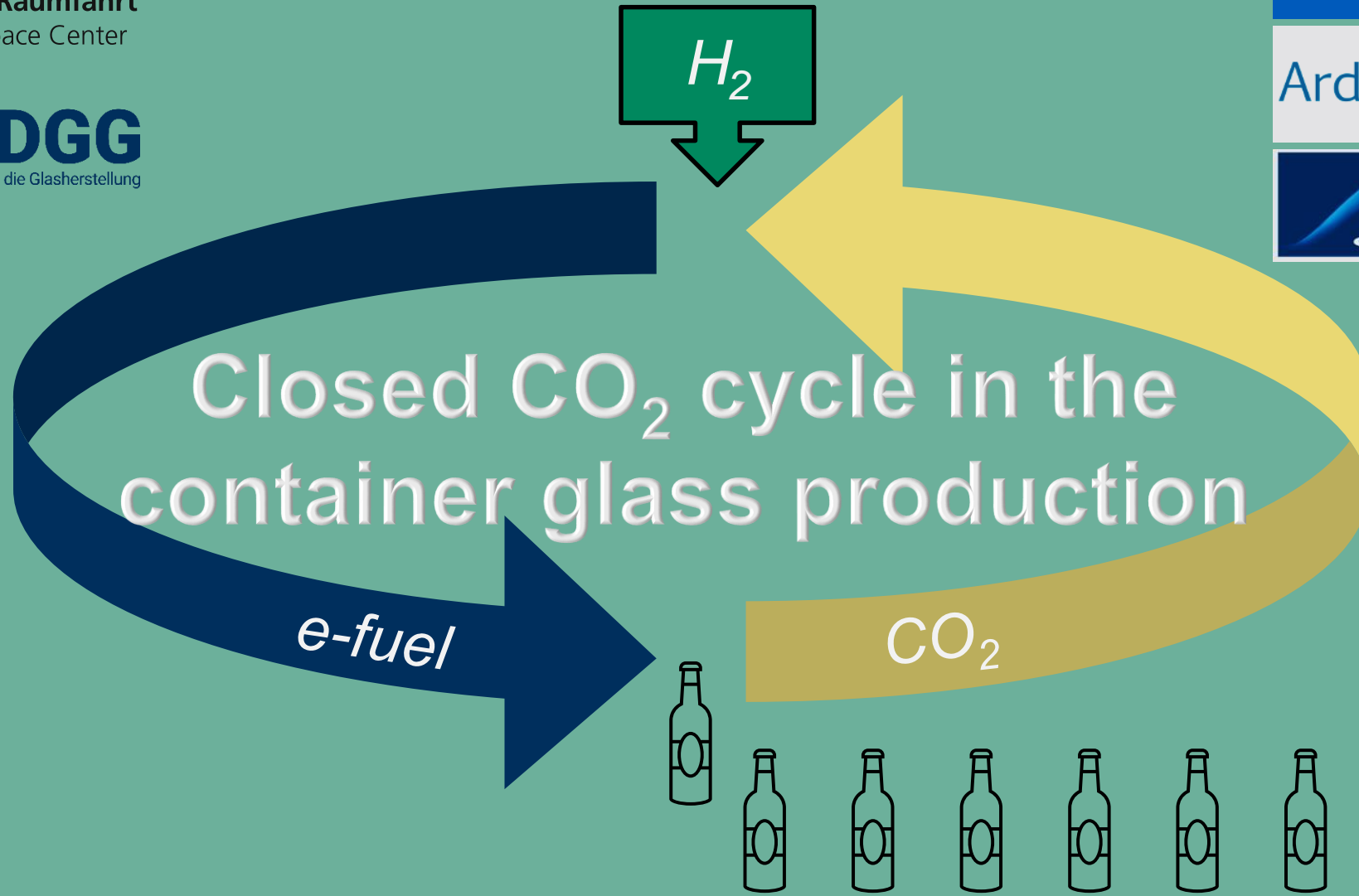
HVG-DGG
Service und Forschung für die Glasherstellung

Our partners:

SCHOTT
glass made of ideas

ArdaghGlass 

 **Linde**
Making our world
more productive



F. Drünert (HVG), F. Moser (DLR)



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OUR OBJECTIVE: CO₂-Neutral Glass Production



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Feasibility study



Technology chains



Cost estimation

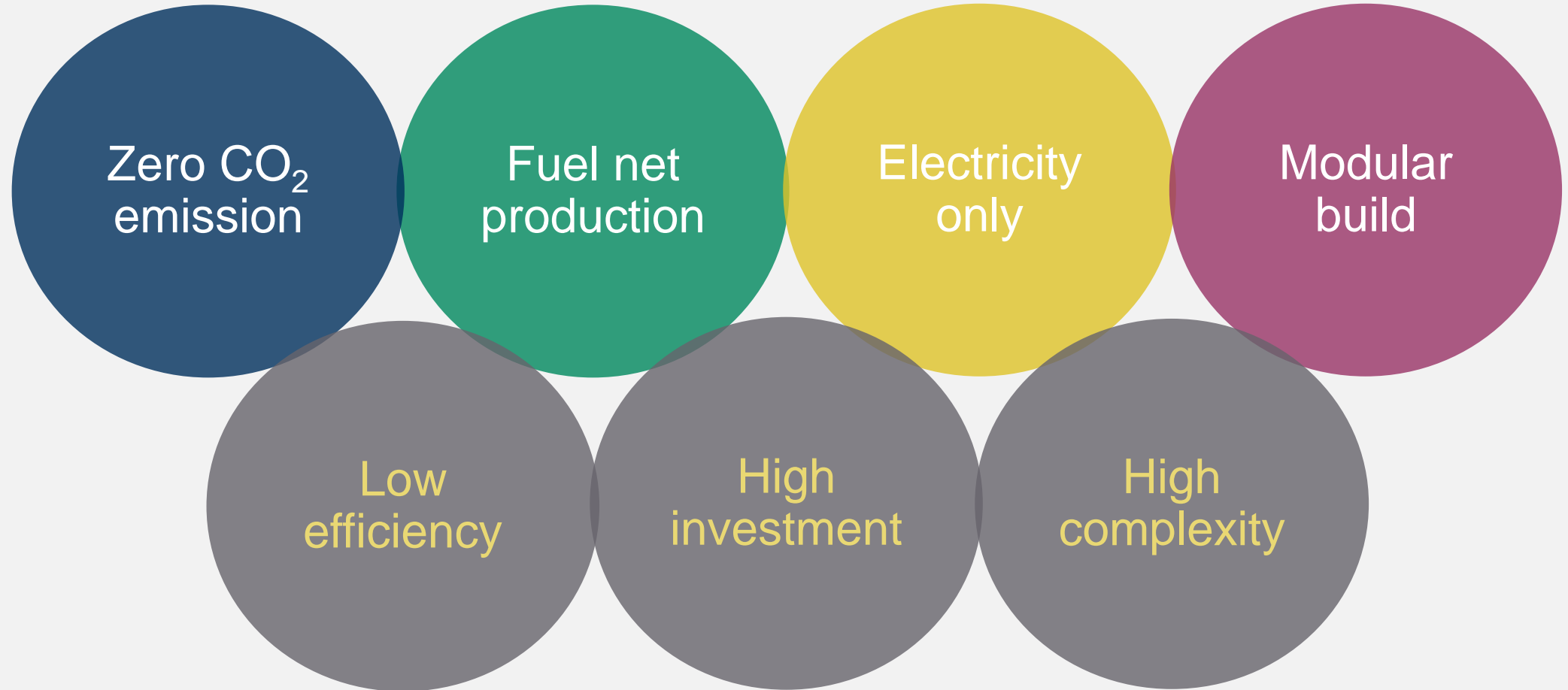


Focus: Needs of glass industry





OUR OBJECTIVE: CO₂-Neutral Glass Production



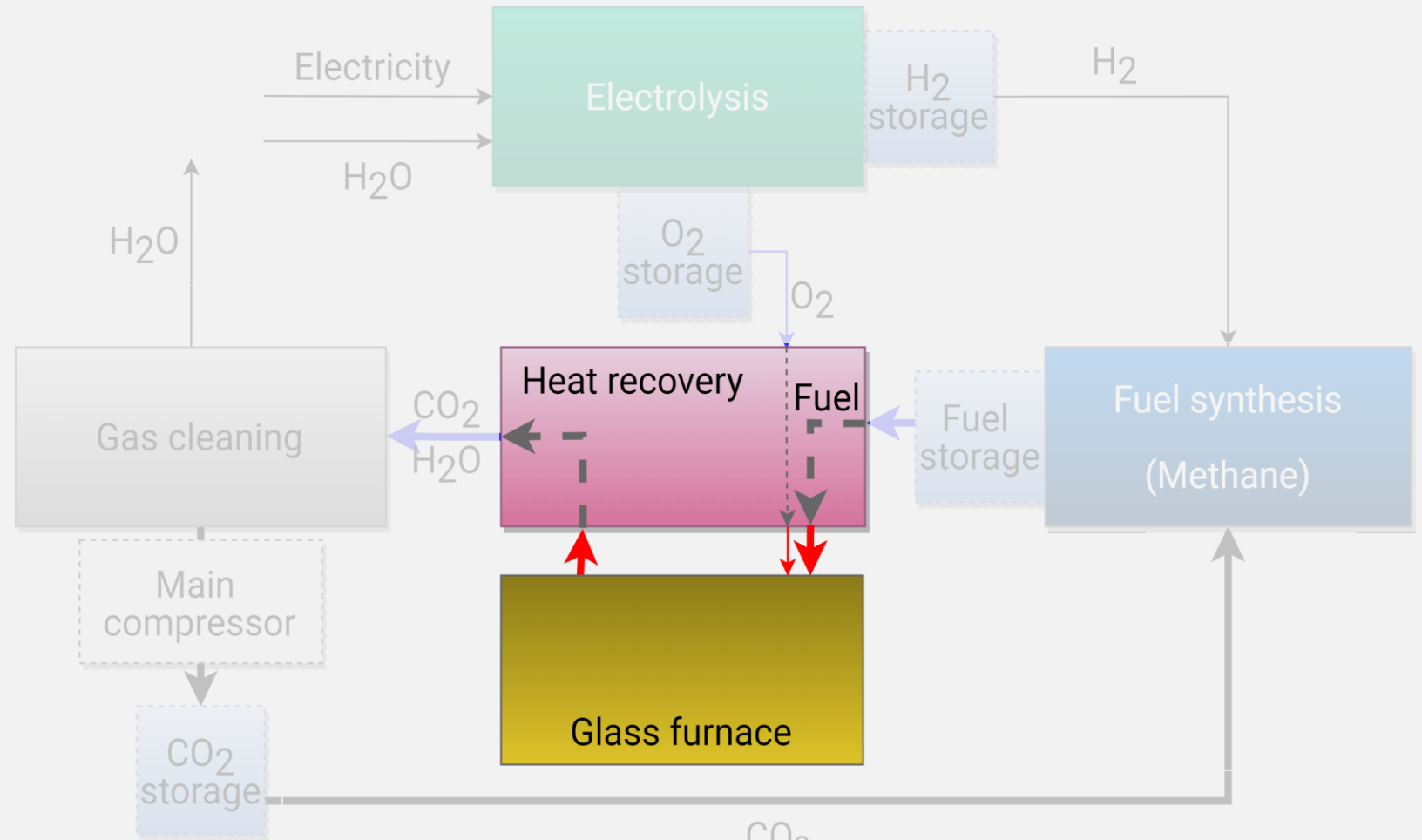


BASE SETUP

First Technology Chain



- Oxyfuel Process
- Heat recovery
- Methane synthesis
 - TREMP™-process
- PEM-Electrolysis
- Gas cleaning:
 - Wet scrubber
 - Hydrogenation
 - Guard beds



F. Drünert, F. Moser: Closed CO₂ cycle in the container glass production



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GENERAL APPROACH



Python simulation

- Flexibility / adaptability



AspenPlus®

- Process simulation



TEPET

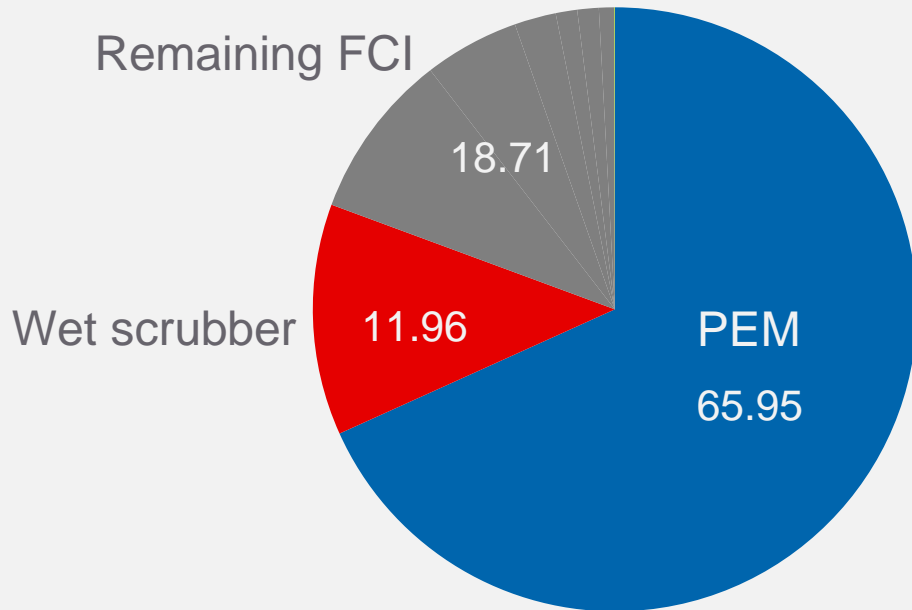
- CAPEX, OPEX & NPC



Evaluation input	
Plant production	300 [t _{glass} /day]
Synthetic fuel	Methane
Base year	2020
Interest rate	7%
Glass furnace operation	24/7/365
Full load hours of methanation plant	8000 [h/a]
Plant lifetime	30 [a]
Electricity price ⁽¹⁾	41.93 [€/MWh]

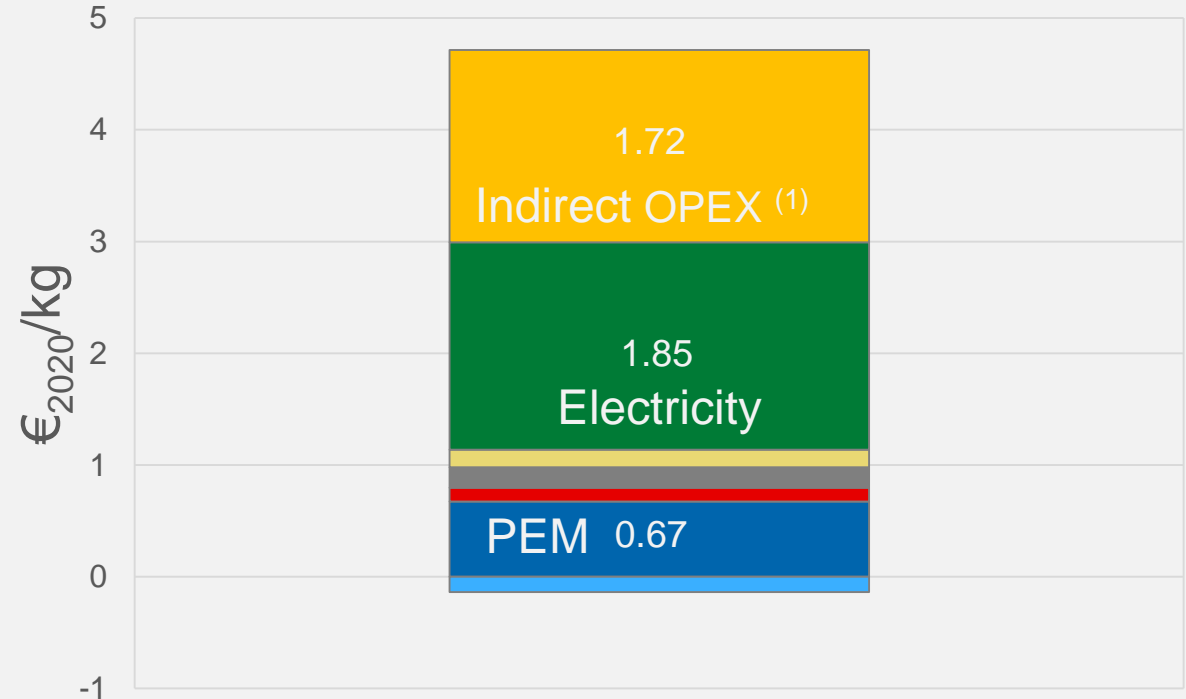
- ✓ Backup supply through gas grid
- ✓ Costs of glass furnace are excluded

Fixed Capital Investment costs
(Mio. €)



FCI: 96.7 [Mio €₂₀₂₀]

Breakdown of NPC



NPC: 4.57 [€₂₀₂₀/kg_{SNG}] ↔ 0.40 [€₂₀₂₀/kg_{Glass}]

Price NG ⁽¹⁾ (2020): 0.17 [€/kg_{NG}] → 0.29 [€/kg_{NG}]

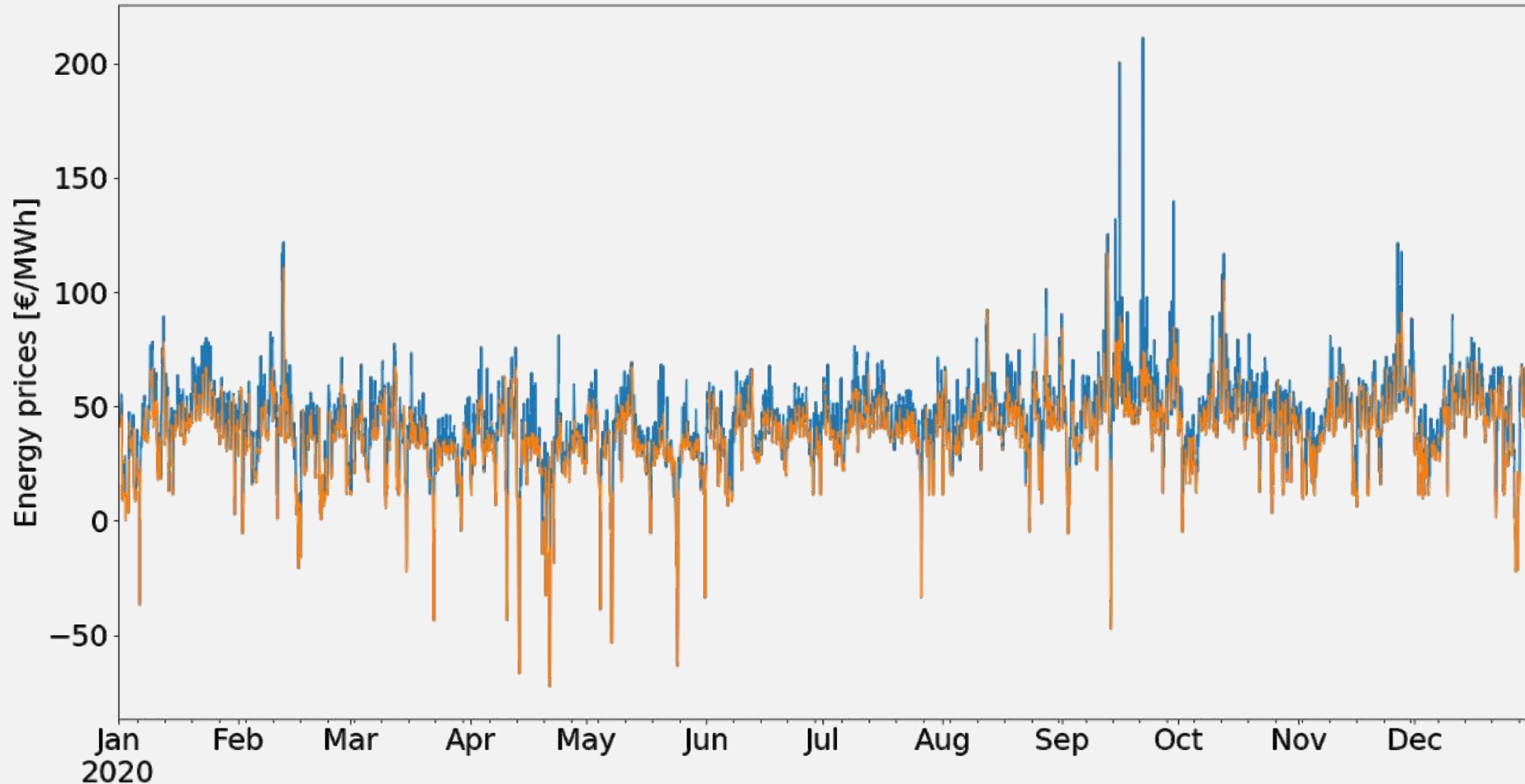
(1) M. Peters, K. Timmerhaus and R. West, Plant design and economics for chemical engineers, New York, United States: McGraw-Hill, 2004, ISBN 007-124044-6.

(2) Erdgaspreis - Natural Gas." Retrieved 29.06.2022, <https://www.finanzen.net/rohstoffe/erdgas-preis-natural-gas>

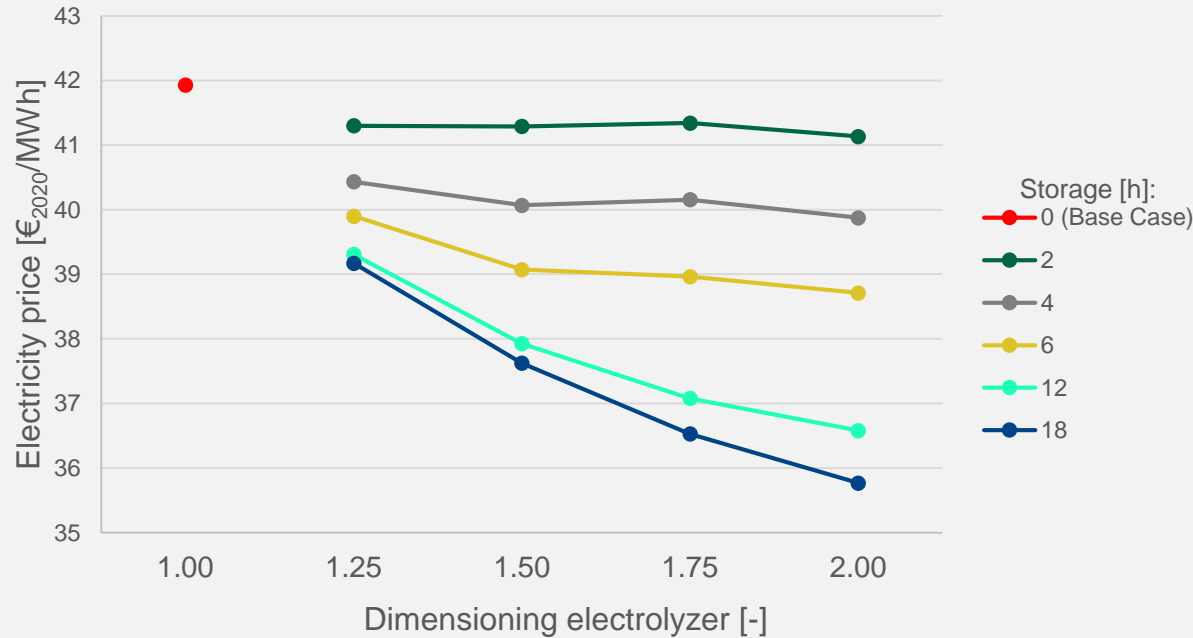


WHAT IF...

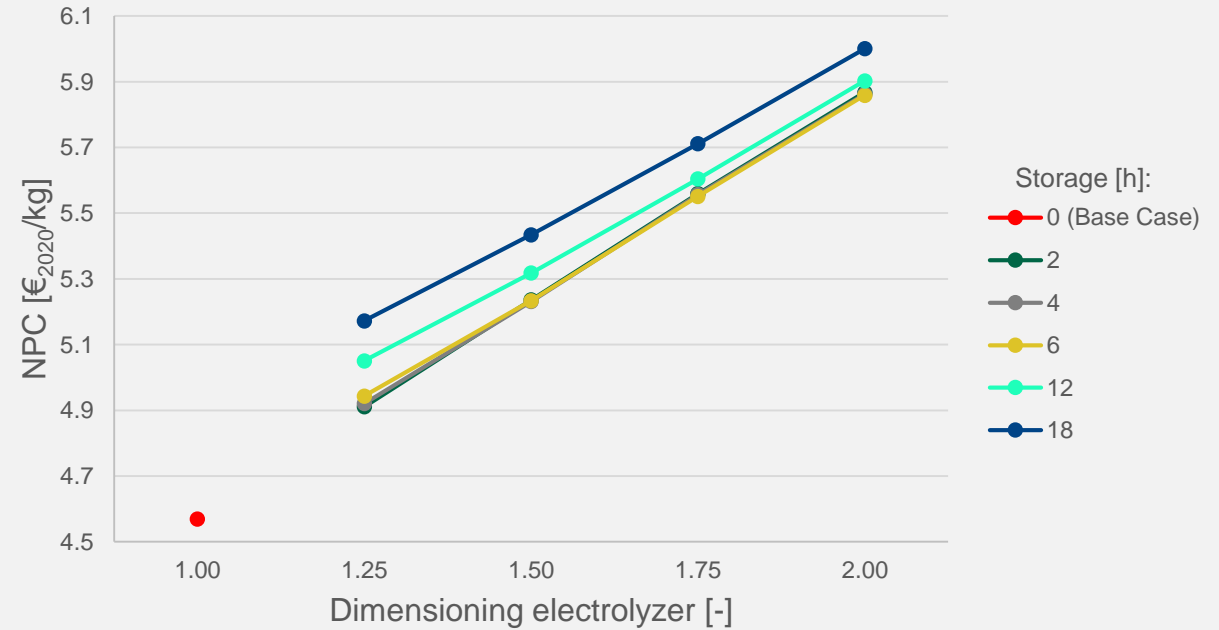
...we want to exploit low prices?



Electricity price vs. dimensioning and H₂/O₂ storage



NPC vs. dimensioning and H₂/O₂ Storage



- Storage increase leads to a higher NPC



SUMMARY



- NPC: $4.57 \text{ €}_{2020}/kg_{SNG} \leftrightarrow 0.34 \text{ €}_{2020}/kWh_{SNG}$
 - Electricity: 40%
 - PEM 15%
- Storage is not economically viable 2020
... but what if there is more fluctuations (like 2021 / 2022)?



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OUTLOOK

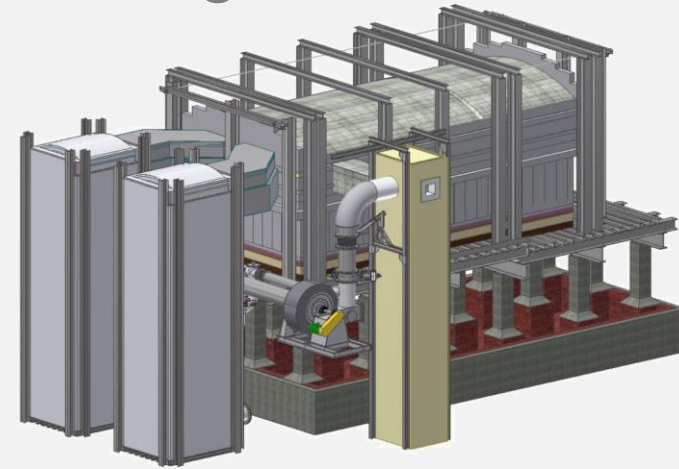
Assessment with further technologies



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Fluidized bed gasification for methanol synthesis; Advanced Methanol Amsterdam. Foto: Wikimedia Commons User Bysalt, CC-BY-SA 4.0



Linde's Model of the OPTIMELT Thermochemical Regenerator System implemented at Libbey®, Leerdam. Image: v. Valburg et al. (2017), 78th Conference on Glass Problems, Columbus, USA



Schema of a solid oxide electrolysis cell by Sunfire®, .CC-BY-ND 2.0

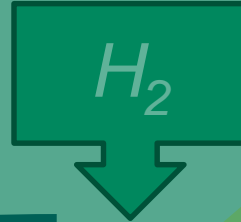
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Thank you for your attention!

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