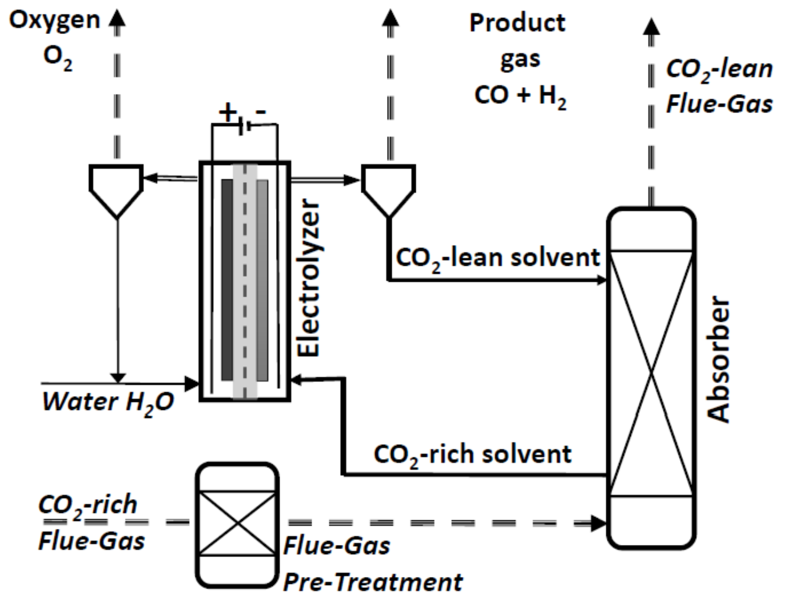
Projekt directCCE:

Ko-Elektrolyse als innovativer Ansatz zur Nutzung unvermeidbarer CO2-Emissionen



Univ. Prof. Dr. Markus Haider, TU Wien,
FH-Prof. Dr. Georg Brunauer, NOVAPECC GmbH (Vortragender)

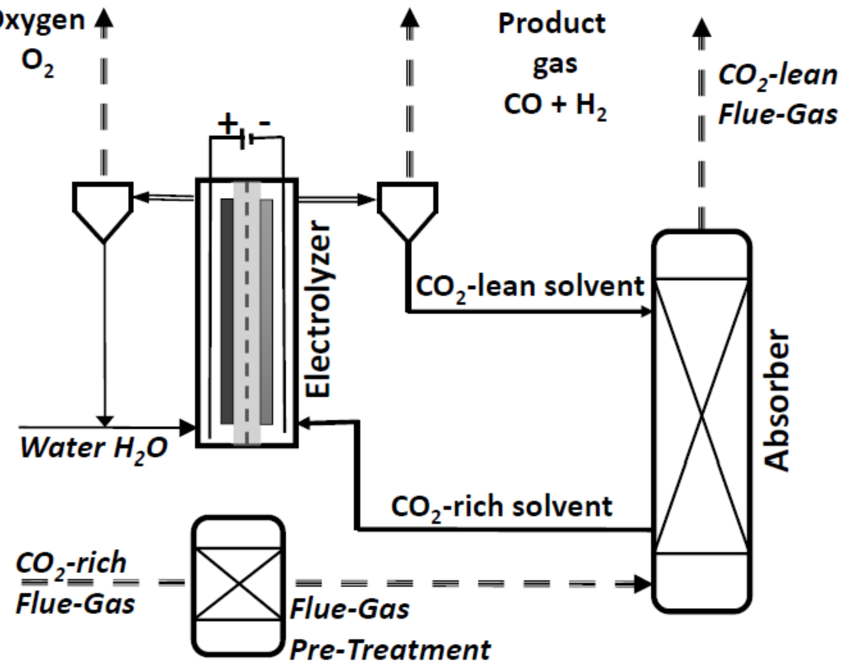
Dieses Projekt wird gefördert von:

6. Branchentag Wasserstoff
25. April 2024
Wien-Vösendorf

Inhalt

1. Projektskizze
2. Wege zu CCSU in MVA und Zement
3. Referenzprojekte NOVAPECC
4. Elektrolyse-Technologien
5. Co-Elektrolyse + Projektstatus

1. Projektskizze

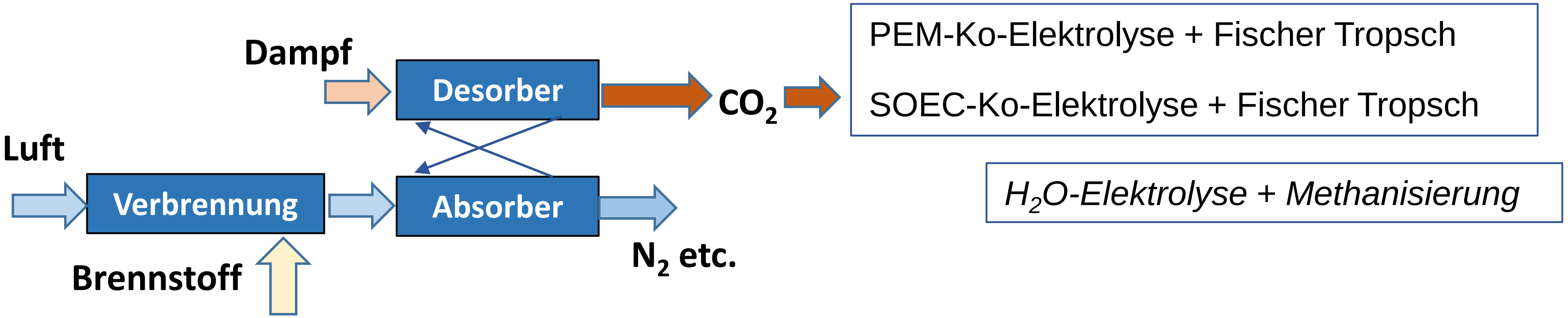


- <u>GRUNDIDEE:</u> Direkte Ko-Elektrolyse des im Katholyt gebundenen CO_2 ; => kein Desorber, keine Desorptionsenergie
- <u>PHASE 1:</u> Entwicklung der optimalen Kombination aus Katholyt / Rauchgaswäsche /Elektrolyseur (pH-Wert, Membran, Katalysator, Bipolarplatten)
- <u>PHASE 2:</u> nach 30 Monaten, Demonstration in der MVA Simmering, Pilot-Anlage mit 15kW Elektrolyseur (0.7t CO_2/Woche)
- <u>BEGLEITFORSCHUNG:</u> Patentanalyse, Prozessanalyse, Prozesskette, Wirtschaftlichkeit,
- Gesamtbudget 3.95M€

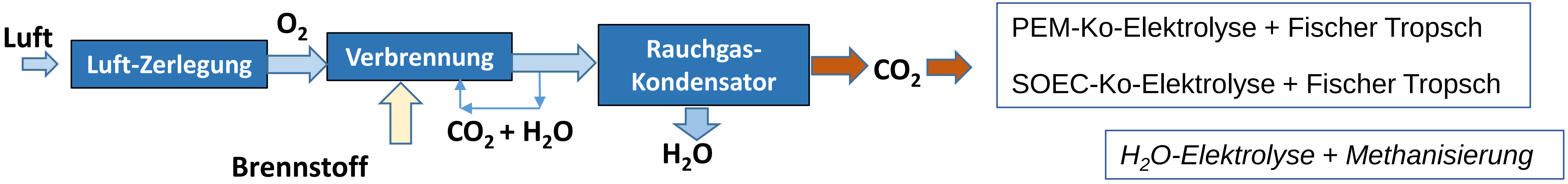
2. CCU in MVA und Zement – Referenz-Prozesse

TECHNISCHE UNIVERSITÄT WIEN

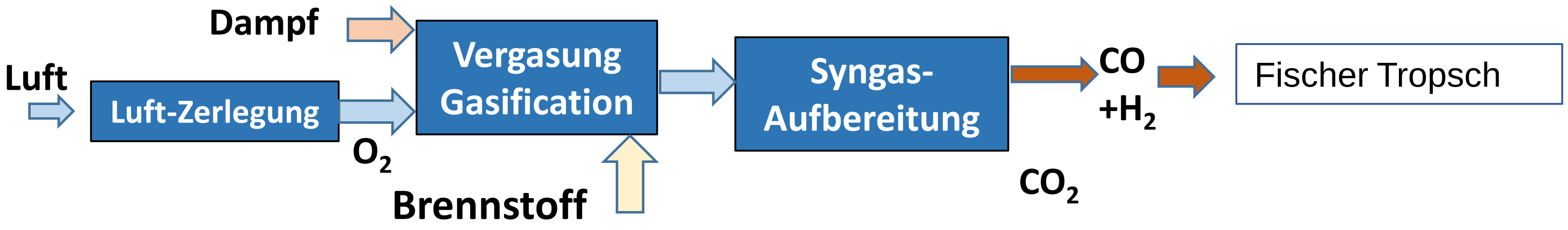
Indirekte Post Combustion Capture



Oxyfuel



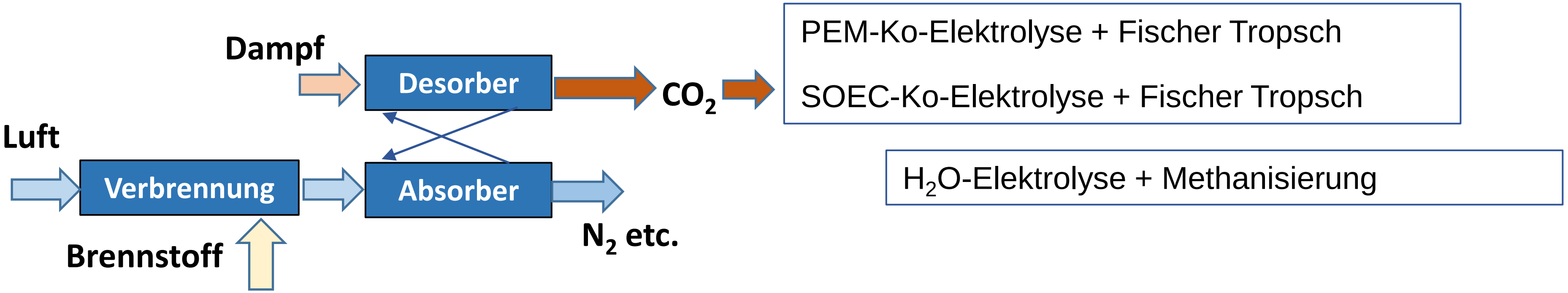
Pre-Combustion Capture



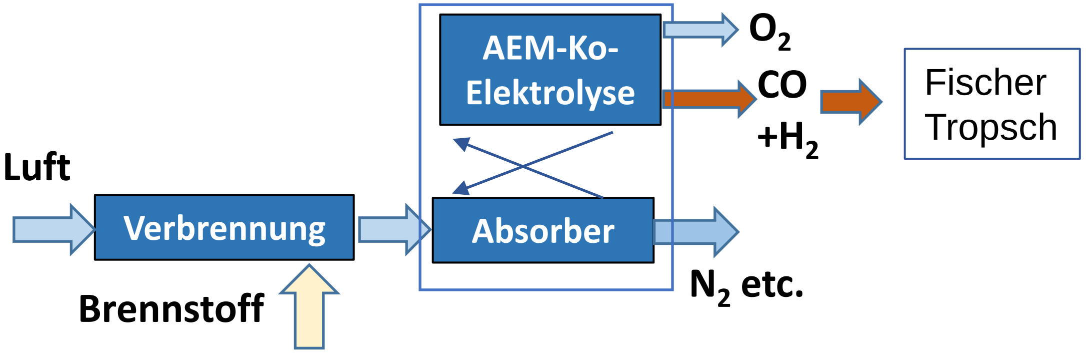
2. Indirekte vs. Direkte Post Carbon Capture + Elektrolyse

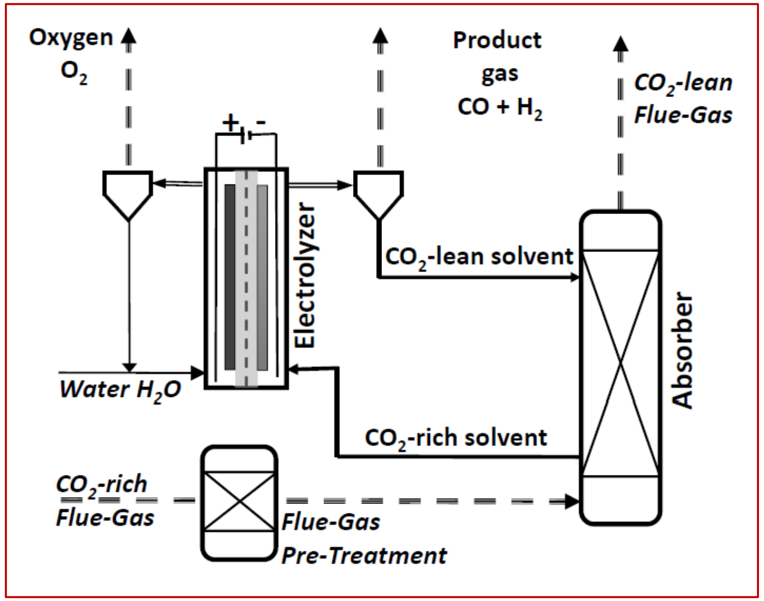
TECHNISCHE UNIVERSITÄT WIEN

Indirekte Post Combustion Capture



Direkte Post Combustion Capture





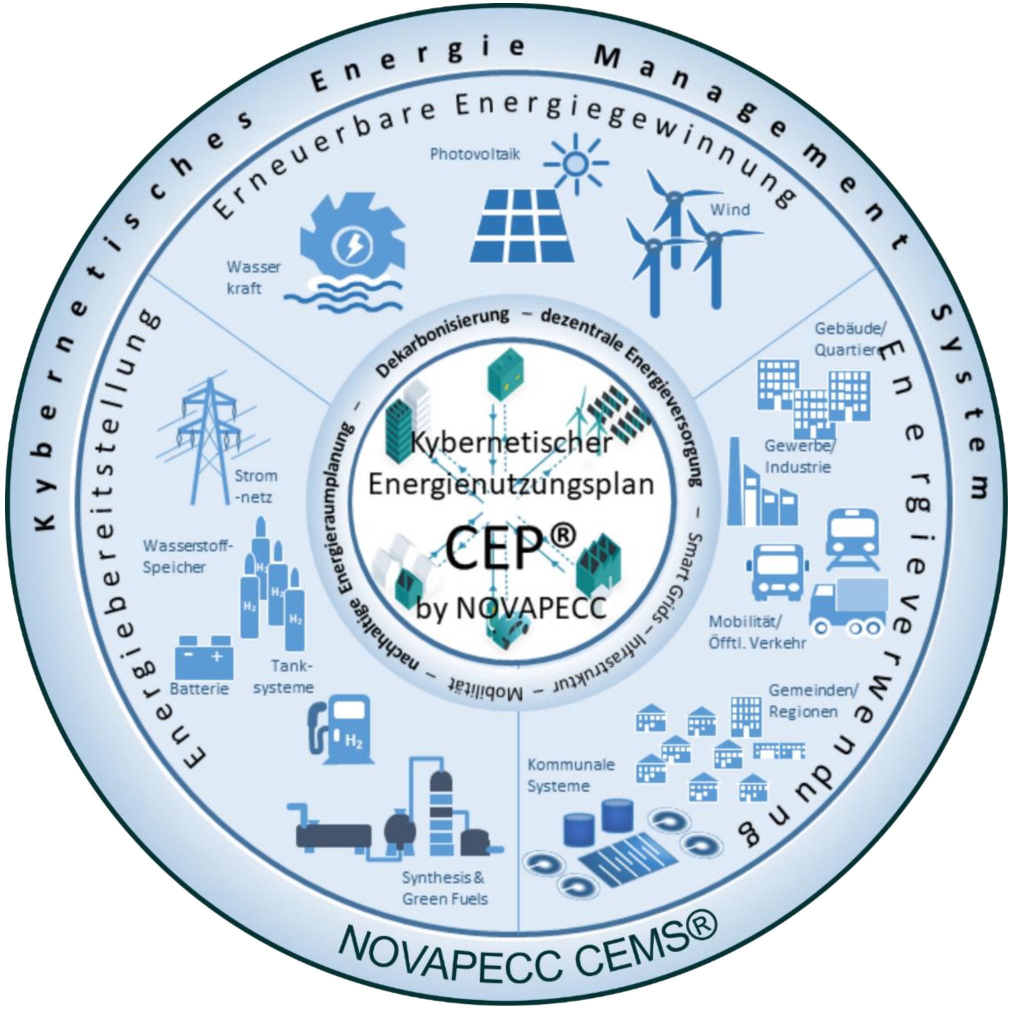
Rolle von Fa. NOVAPECC im Projekt

- ➢ **Elektrolyseur-Entwicklung**
- ➢ **Systemintegration**

Energiegewinnung
aus regenerativen Energiequellen:
WASSER – SONNE - WIND

Energiebereitstellung
durch hybrid-regenerative Anlagen

Energieverwendung
in regionalen Energiekreisläufen zur
Förderung lokaler Wertschöpfungsketten

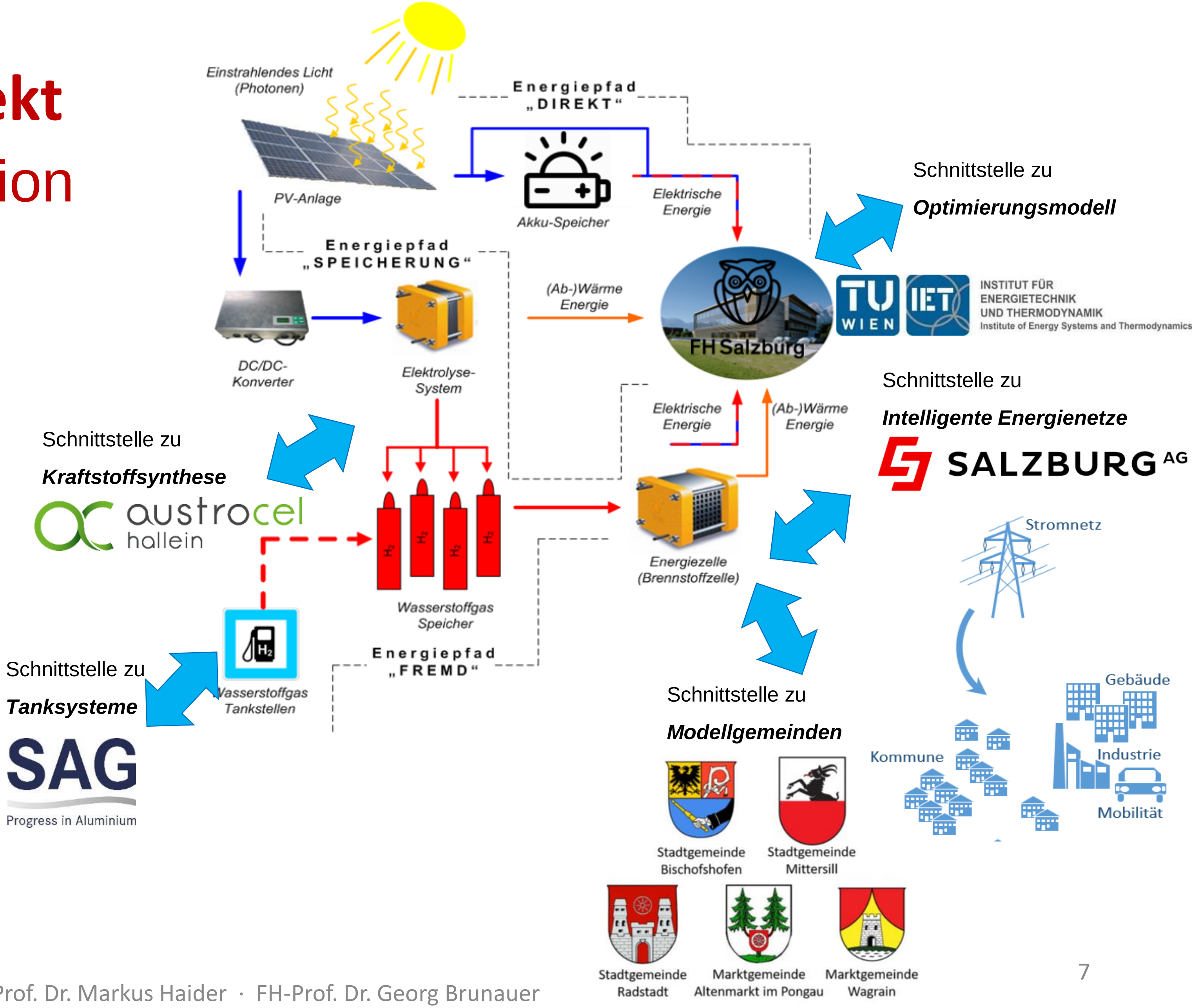


Quelle: Eigene Abbildung; Übersicht H2-integriertes Energiesystem

NOVAPECC
The Nature of Energy.

NOVAPECC Referenzprojekt

H2-DemoLab – Smart Region



Fördergeber:

LAND SALZBURG

WISS 2025

NOVAPECC
The Nature of Energy.

H2-DemoLab – Smart Region

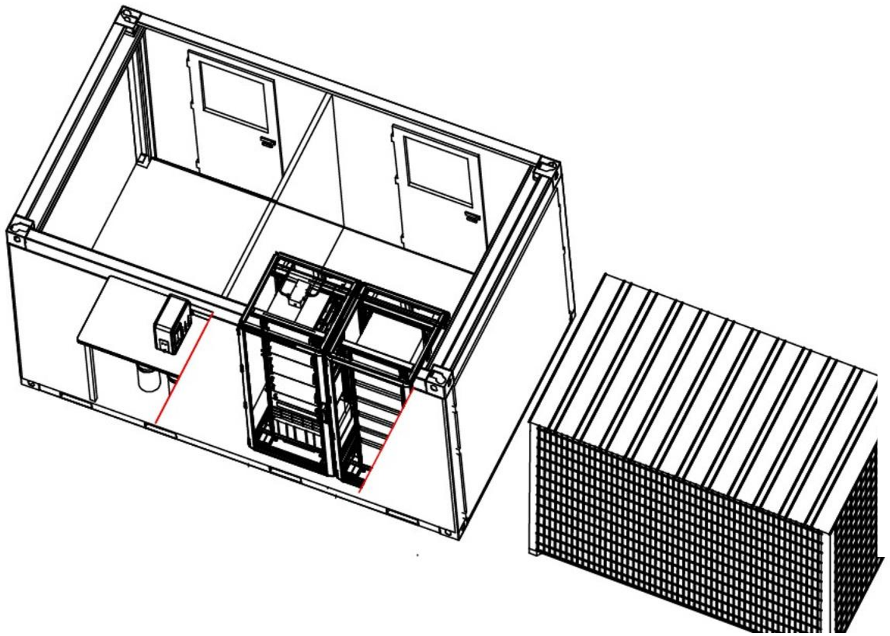
Dezentrale Wasserstoffproduktion, Speicherung und Rückverstromung zu Lehr- und Forschungszwecken

Basisleistung Elektrolyseur: 2,5 kW (modular erweiterbar)

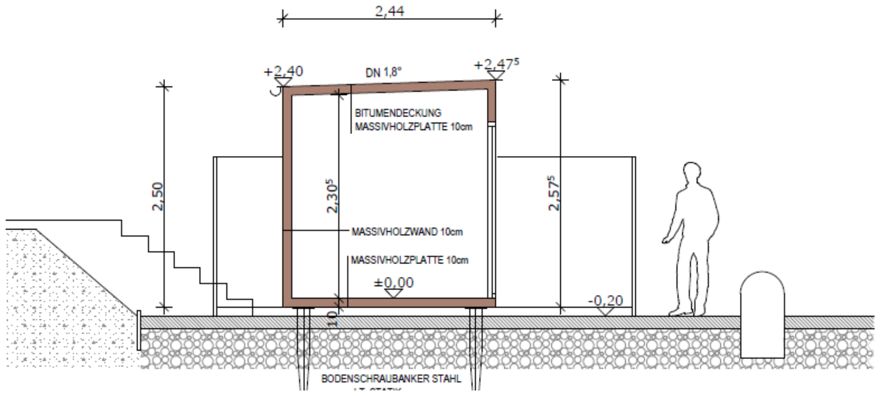
H_2-Produktionsrate: 500 NL/hr

Basisleistung Brennstoffzelle: 2,5 kW (modular erweiterbar)

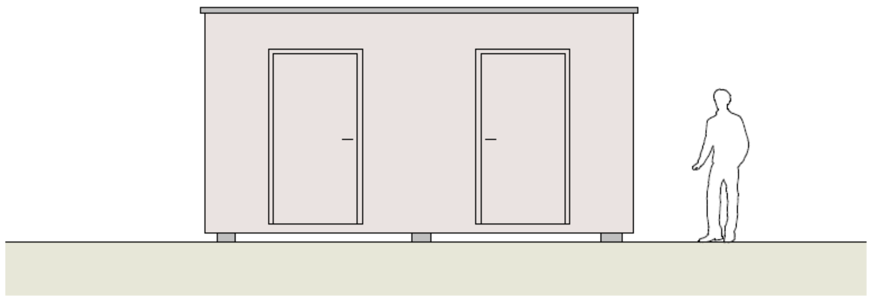
H_2-Gasspeicher



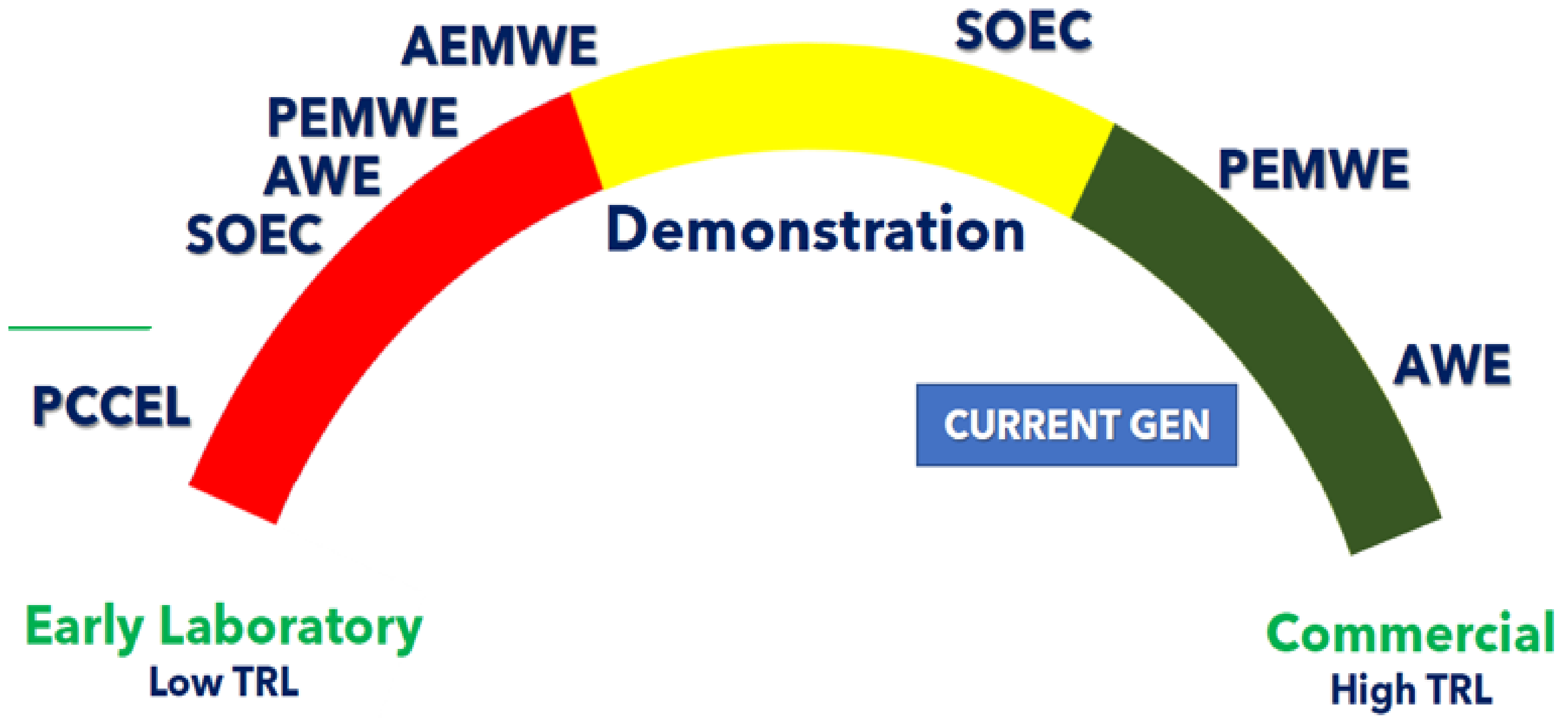
SCHNITT A-A



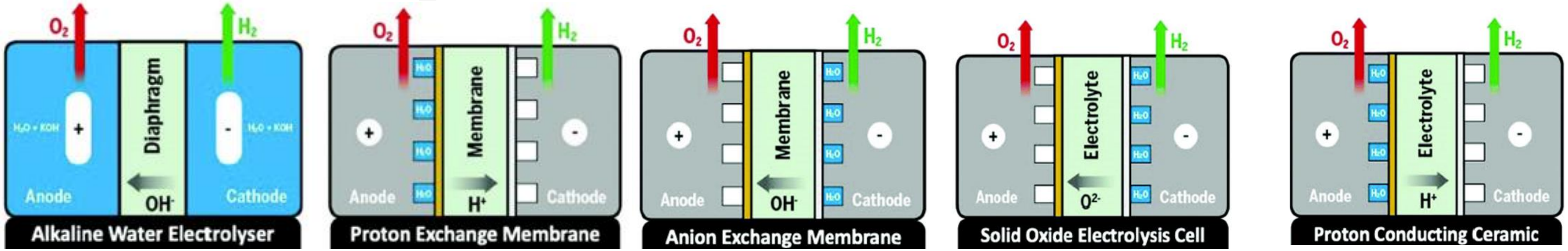
VORDERANSICHT



Entwicklungsstand H_2O-Elektrolyse



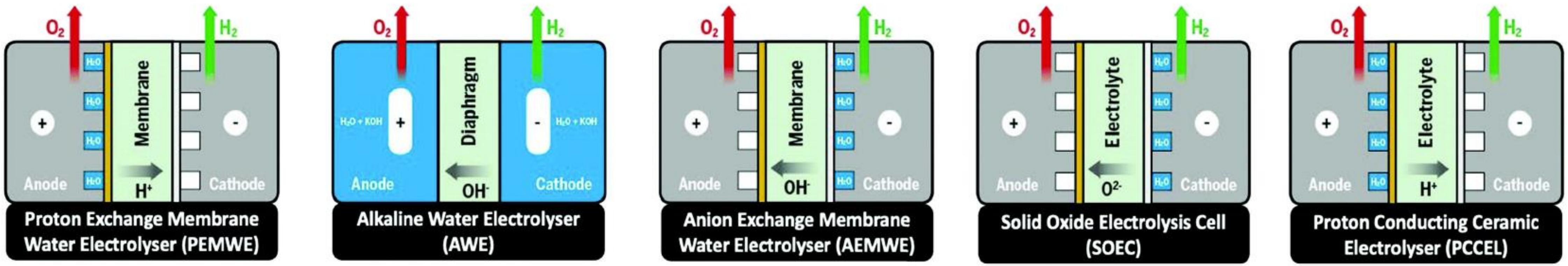
Technologie Spektrum H_2O-Elektrolyse



	AEC atm./press.	PEM	AEM	SOEC	PCCEL
Temperature	70-90°C	50-80°C	**40-60 °C**	**700-850°C**	**300-600 °C**
Pressure	**1-30 bar**	**<70 bar**	**< 35 bar**	1 bar	1 bar
Electrolyte	KOH-**lye**	**PEM,** Nafion® polymer **membrane**	**AEM,** polysulphone type polymer **membrane,** e.g. Fumasep®	YSZ, **solid** electrolyte	Y-Ba oxide **solid** electrolyte
Ion mobility of	**OH-**	**H+**	**OH-**	**O_2-**	**H+**
Anode catalyst	Ni on SS	**IrO_2**	Ni or NiFeCo	Perovskite type (LSCF, LSM, Ni/YSZ,..)	Perovskite type (LSCF, LSM, Ni/YSZ,..)
Separator	**diaphragm**/mesh, of ZrO_2 (Zirfon® etc.) or asbestos	solid polymer **membrane**	solid polymer **membrane**	**solid** electrolyte	**solid** electrolyte
Cathode Catalyst	Ni on SS	**Pt/ C**	Ni	Ni/YSZ	Ni/YSZ
Current density	**0.2-0.8 A/cm2**	**1.-3. A/cm2**	**0.2-2. A/cm2**	**0.3-1. A/cm2**	
Frames & sealing	PTFE	PTFE, ETFE	PTFE, silicon	Ceramic glass	Ceramic glass

Quelle: International Association for Hydrogen Energy (IAHE)

Herausforderung H_2O-Elektrolyse (Komponenten und Systemaufbau)



SYSTEM

Power electronics
Water treatment
Gas separators
Gas purifiers

STACK

Sealings
Connectors
Modules
End plates

COMPONENT

Membrane Electrode Assemblies (MEA)
Electrodes
Bipolar plates (BPP)
Porous transport layers (PTL)
Seals

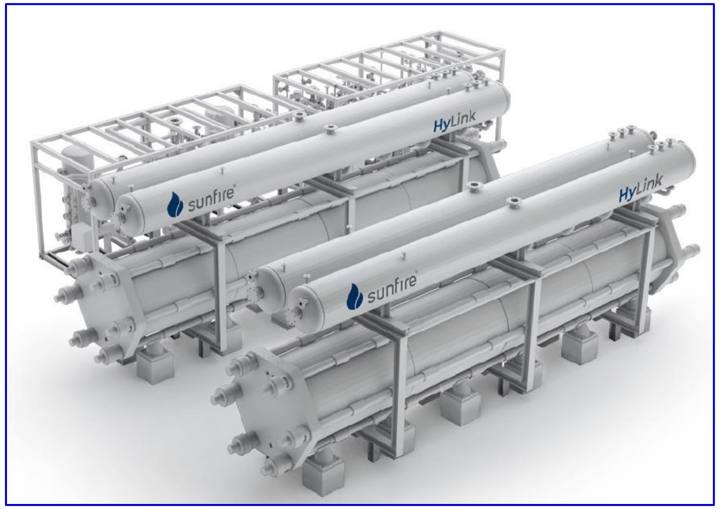
MATERIAL

Coating
Catalyst
Polymers
Sealing

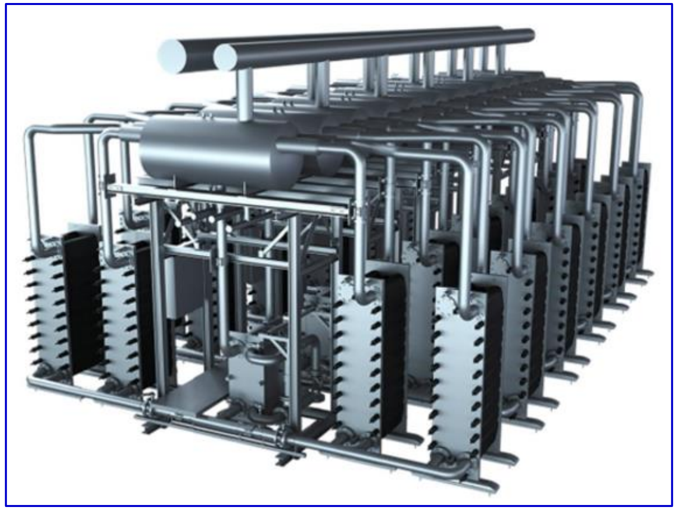
Quelle: International Association for Hydrogen Energy (IAHE)

4. Elektrolyse-Technologien

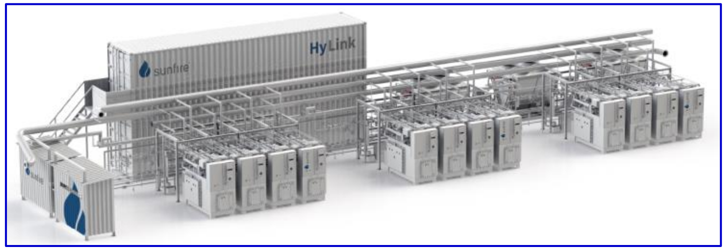
Der aktuelle Elektrolyse-Weltmarkt



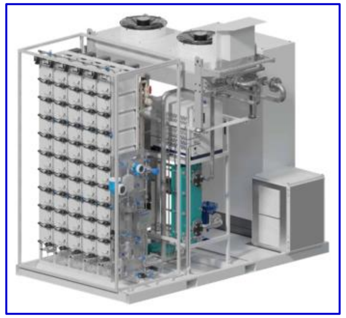
AEC (e.g. Sunfire)
~80%



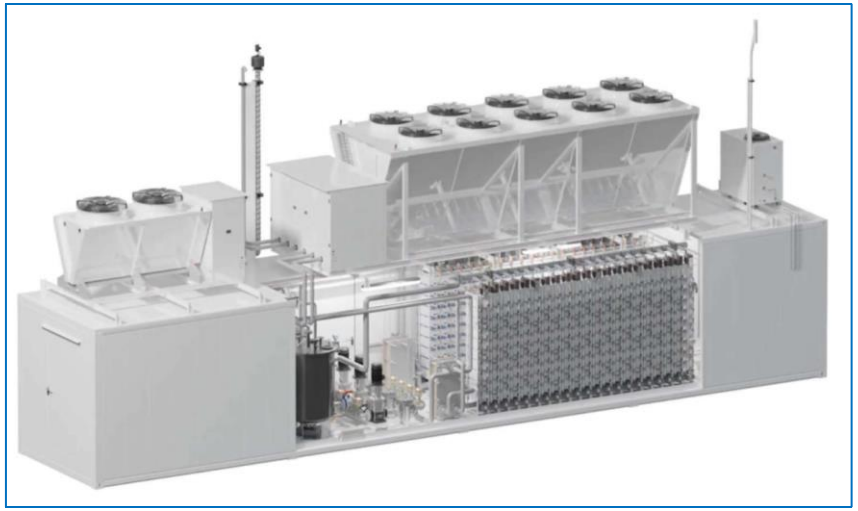
PEM (e.g. Siemens)
~20%



SOEC (e.g. Sunfire)
<1%



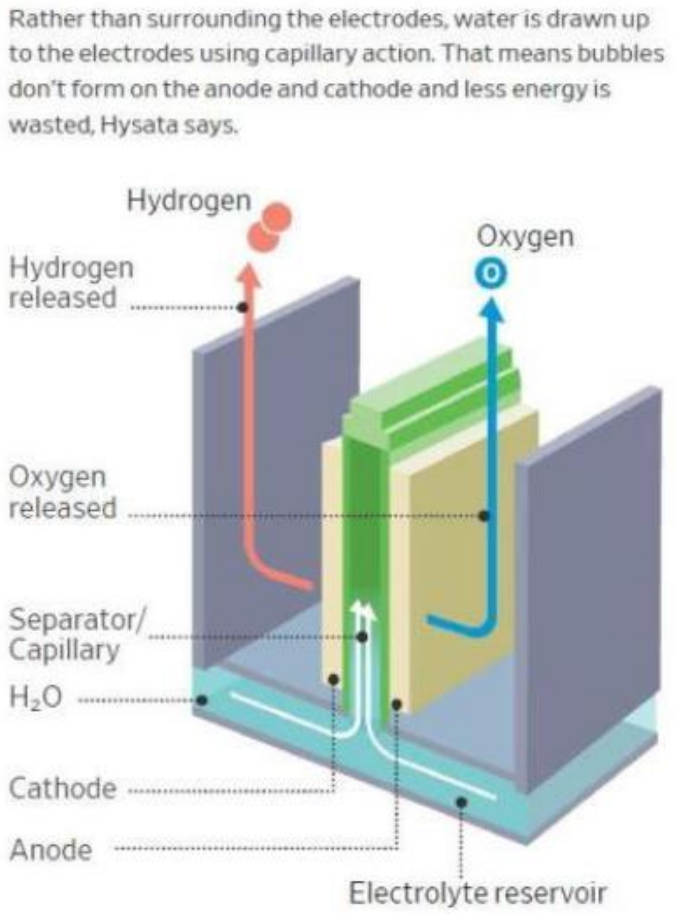
AEM (e.g. Enapter)
<1%



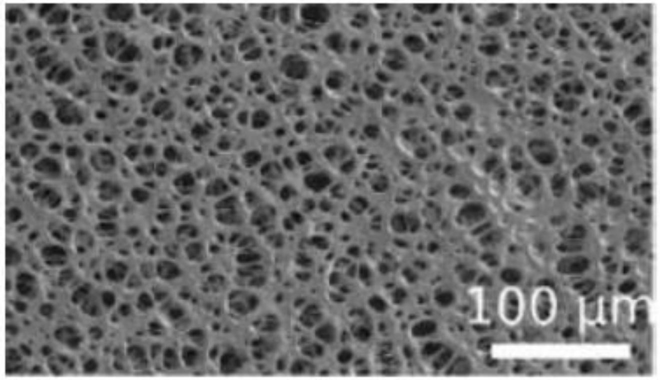
Multicore-AEM (e.g. Enapter)
<1%

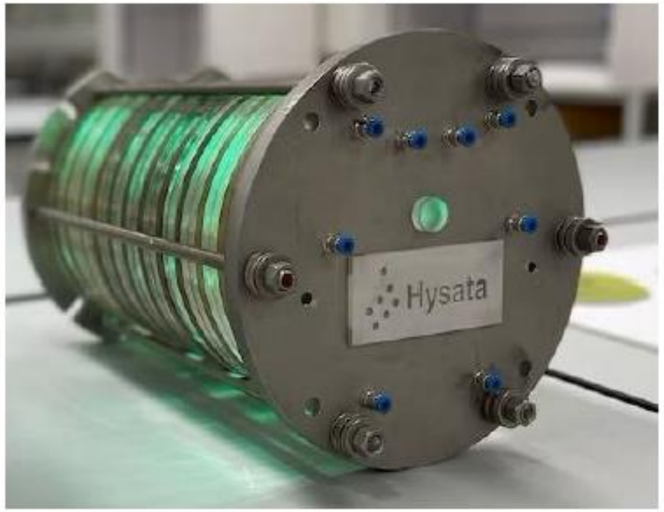
Quelle: Sunfire, Siemens, Enapter

Hysata – vielversprechende Innovation in AEM-Technologie



- NiFeOOH Oxygen electrocatalyst
- Pt/C Hydrogen electrocatalyst
- 27 wt% KOH lye eletrolyte
- 80 – 85 °C operating temperature
- 95% efficiency (HHV) at 0.8 A/cm^2 current density
- 100% efficiency (HHV) at 0.3 A/cm^2 current density
- 39.4 to 41.5 kWh / kg H_2
- Porous, hydrophilic polyether sulphone (PES) capillary separator





https://www.wsj.com/articles/startups-bring-down-cost-green-hydrogen-11668117024?reflink=share_mobilewebshare
https://www.nature.com/articles/s41467-022-28953-x
https://www.abc.net.au/news/2023-08-15/hysata-begins-building-worlds-most-efficient-electrolyser/102729908

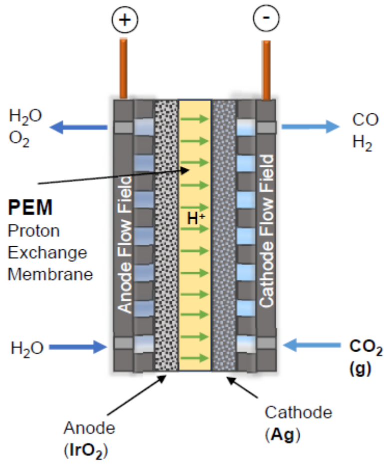
Technologie Spektrum **Co**-Elektrolyse H_2O-CO_2

Heiße, indirekte Wasserdampf/CO_2 - Co-Elektrolyse, SOEC

(+) TRL
(-) heiß, doppelter Dampfbedarf (für SOEC und Desorption)

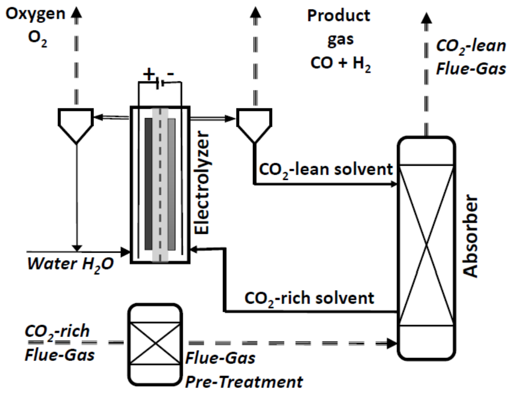
Kalte, indirekte saure Wasser-CO_2 - Co-Elektrolyse, PEM

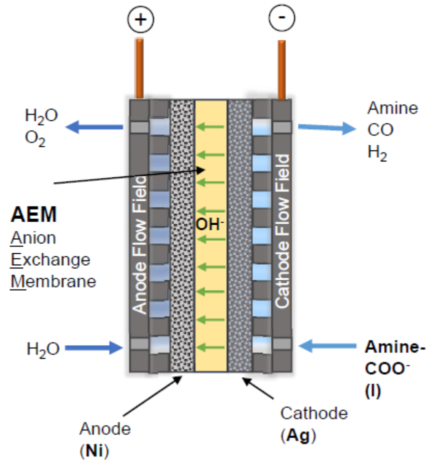
(+) kalt
(-) Dampfbedarf (Desorption), TRL



Kalte, direkte, basische Wasser-CO_2 - Co-Elektrolyse, AEM

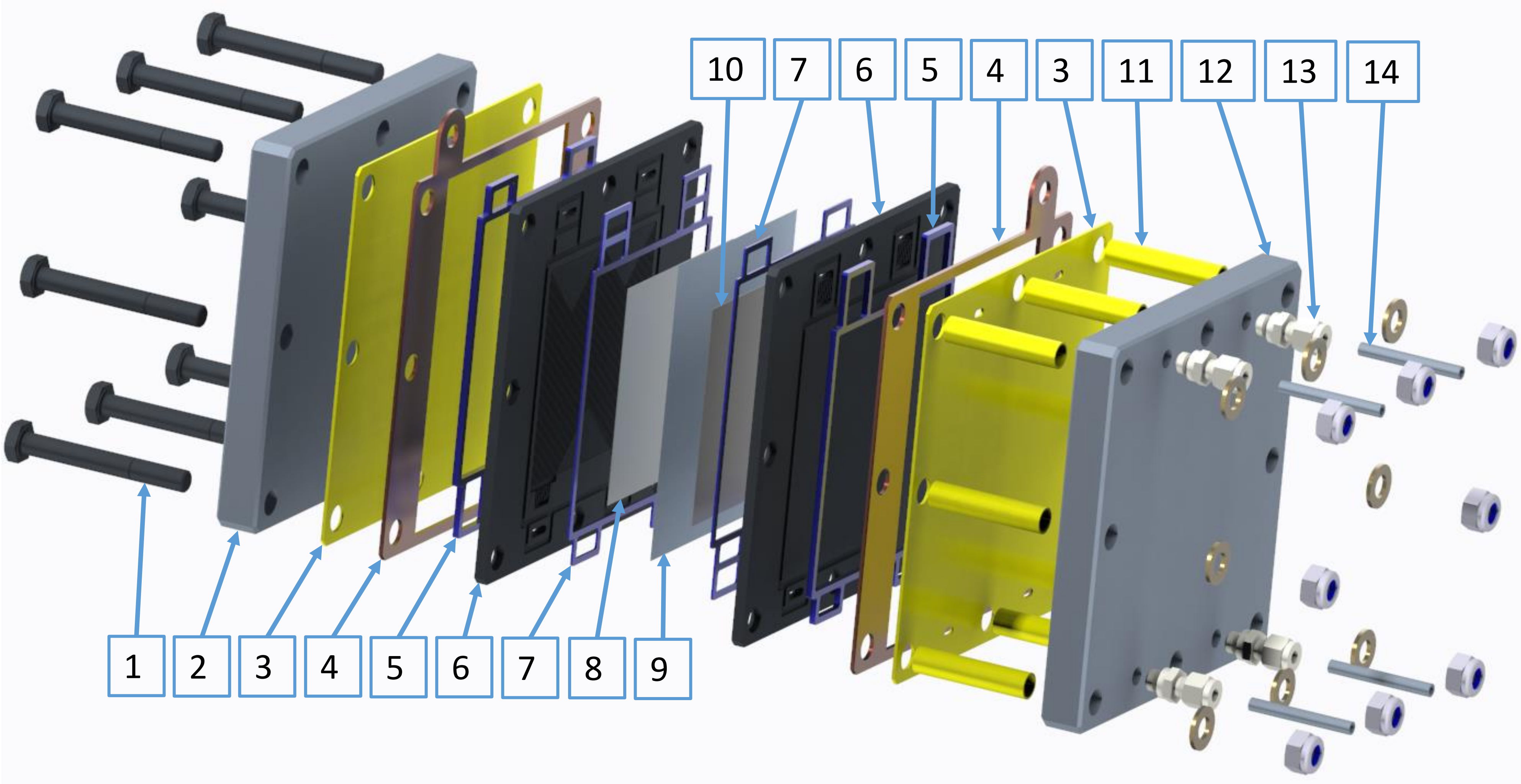
(+) kalt, kein Dampfbedarf, einfach, alkalisch
(-) TRL





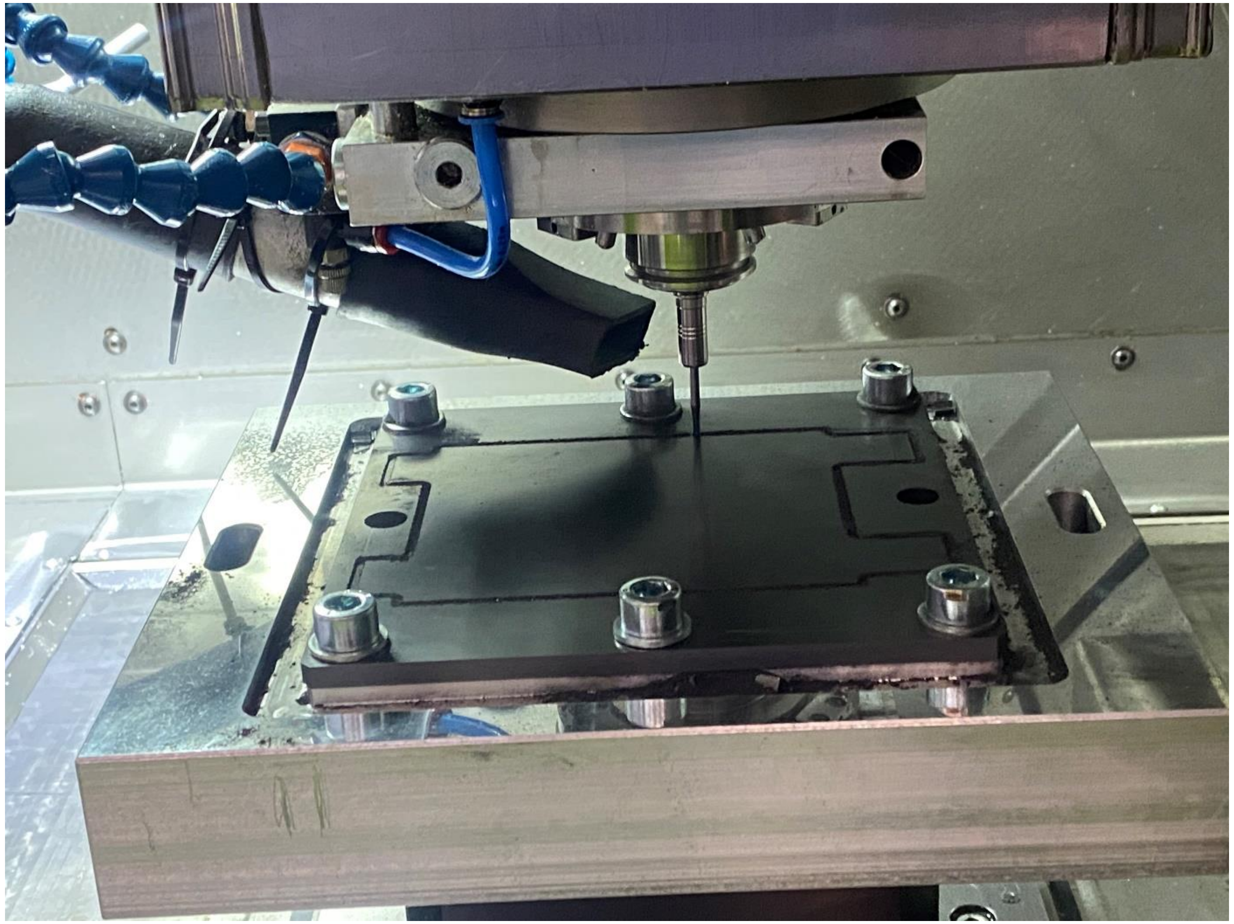
Infrastruktur

Aufbau 100 cm² Elektrolyseur



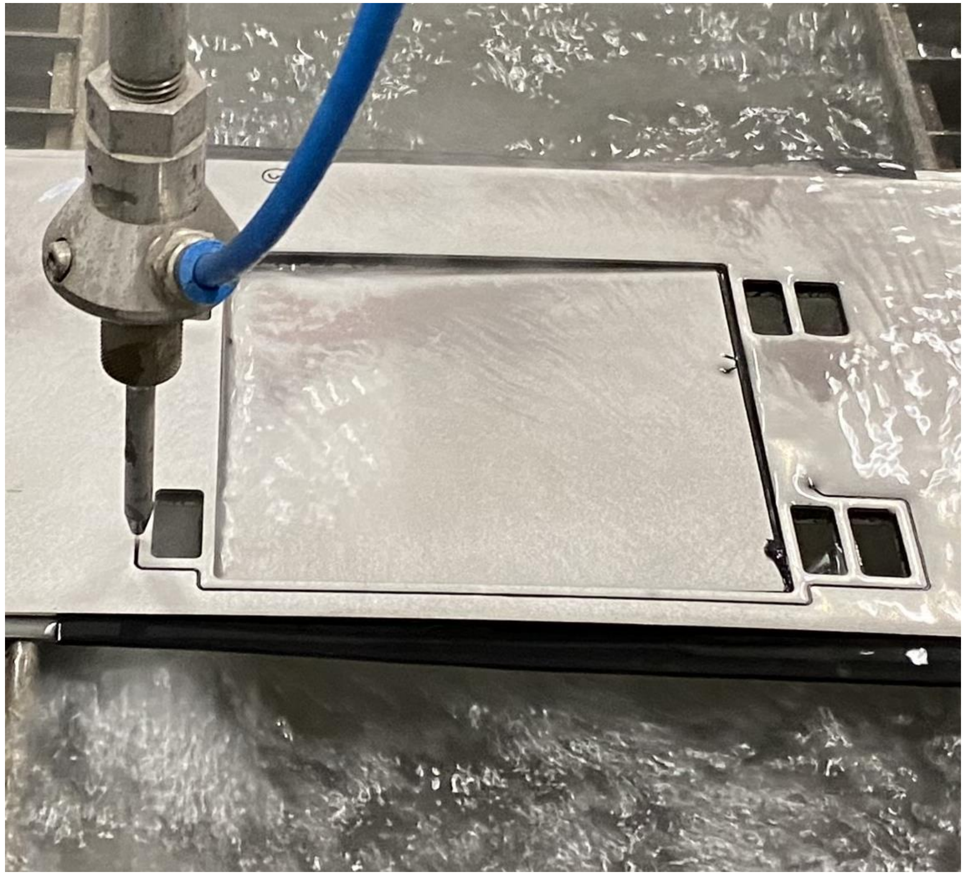
	Benennung
1	Sechskantschrauben M10
2	Edelstahlplatte 1
3	weiche Isolator Platte
4	Kupfer Platte
5	Flachdichtung außen
6	Flow Field
7	Flachdichtung innen
8	Elektrode (Anode)
9	Membran
10	Elektrode (Kathode)
11	Isolatorhülse
12	Edelstahlplatte 2
13	Rohrverbinder
14	Zuleitungen

Fertigung der Flow Fields

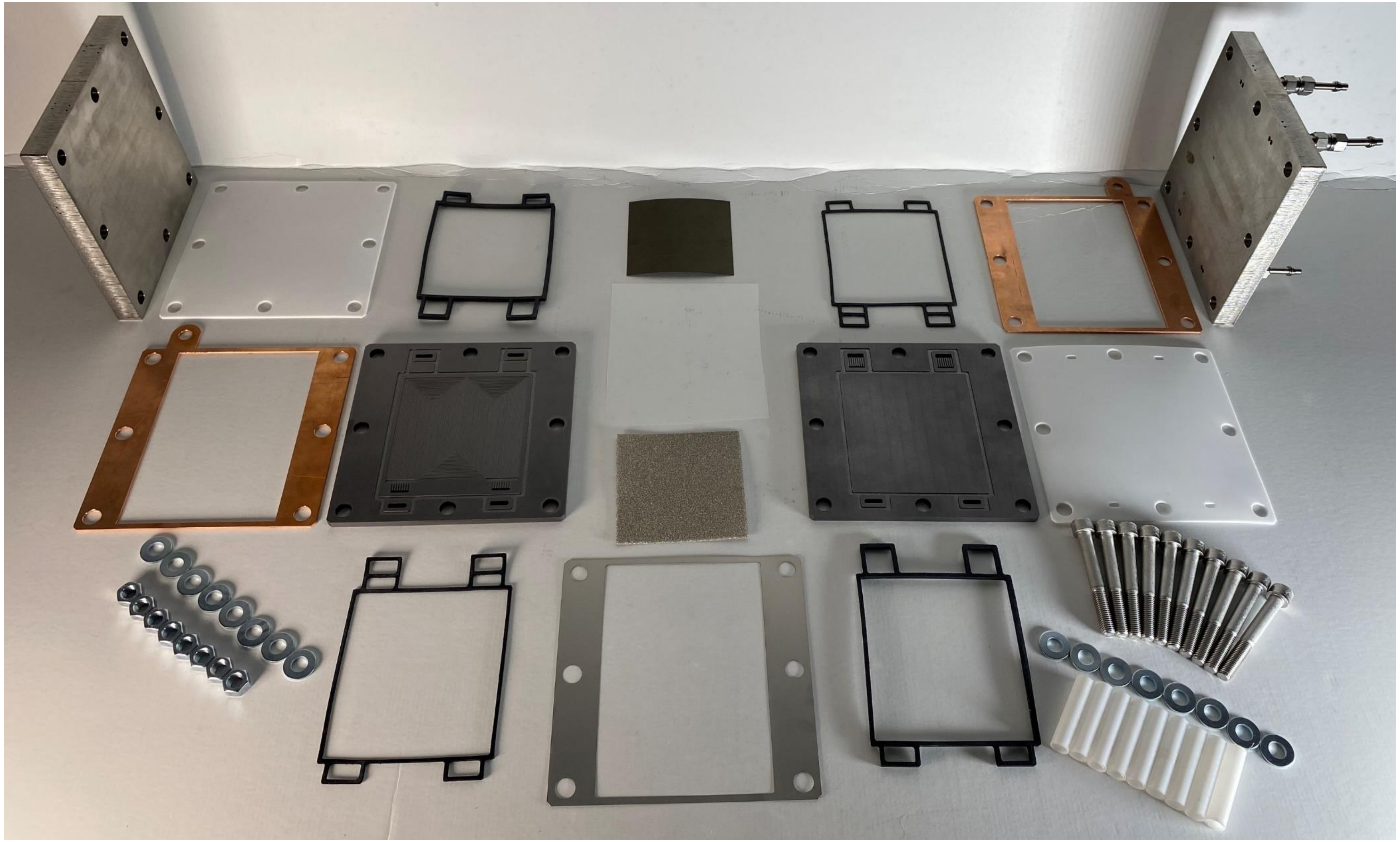


5. Co-Elektrolyse

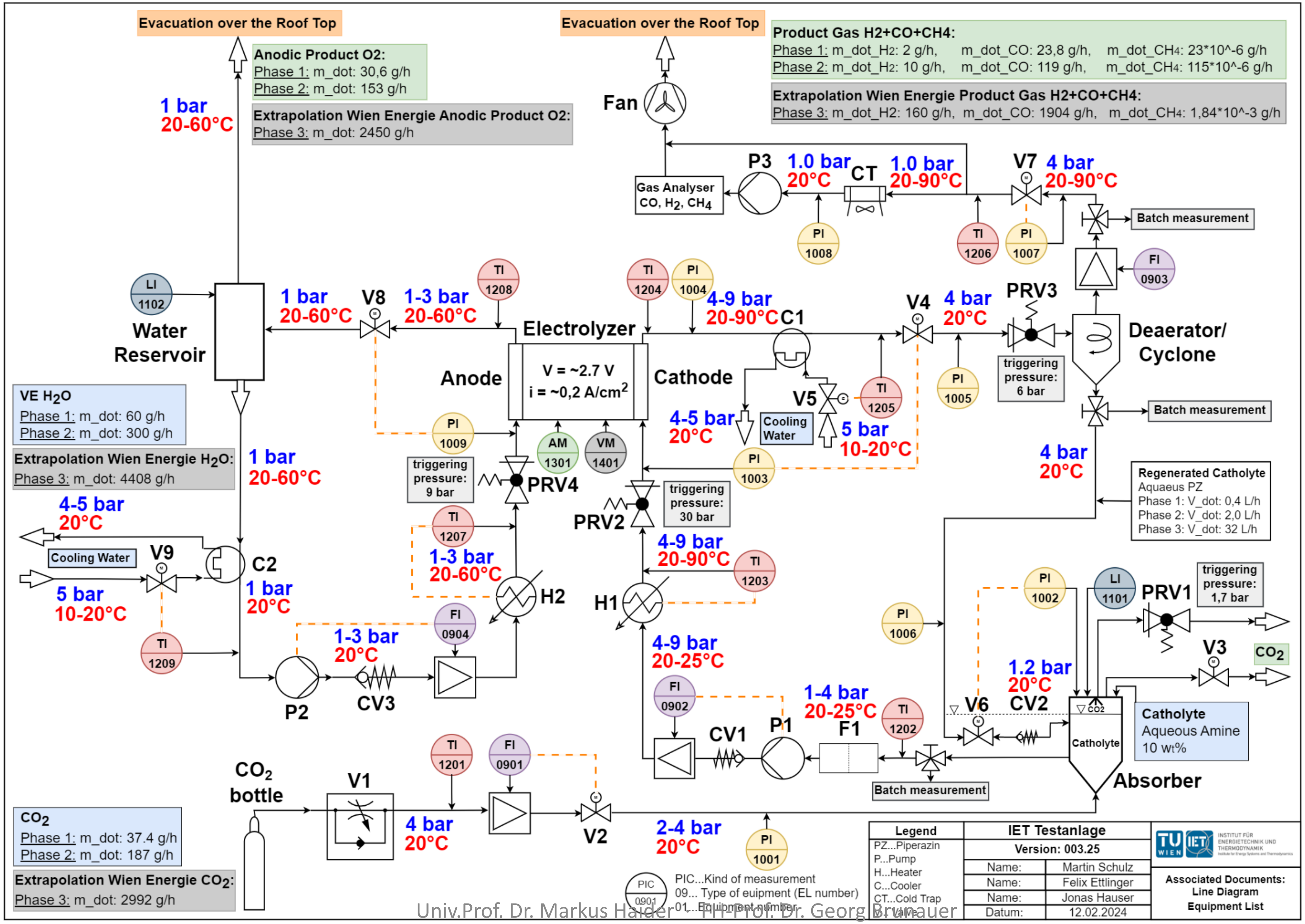
Fertigung der Dichtungen



Komponenten 100 cm² Elektrolyseur



R&I



Evacuation over the Roof Top
Evacuation over the Roof Top
Anodic Product O2:
Phase 1: m_dot: 30,6 g/h
Phase 2: m_dot: 153 g/h
Extrapolation Wien Energie Anodic Product O2:
Phase 3: m_dot: 2450 g/h
Product Gas H2+CO+CH4:
Phase 1: m_dot_H2: 2 g/h, m_dot_CO: 23,8 g/h, m_dot_CH4: 23*10^-6 g/h
Phase 2: m_dot_H2: 10 g/h, m_dot_CO: 119 g/h, m_dot_CH4: 115*10^-6 g/h
Extrapolation Wien Energie Product Gas H2+CO+CH4:
Phase 3: m_dot_H2: 160 g/h, m_dot_CO: 1904 g/h, m_dot_CH4: 1,84*10^-3 g/h
Fan
1 bar
20-60°C
Gas Analyser
CO, H2, CH4
P3
1.0 bar
20°C
CT
1.0 bar
20-90°C
V7
4 bar
20-90°C
Batch measurement
PI 1008
TI 1206
PI 1007
FI 0903
LI 1102
Water Reservoir
1 bar
20-60°C
V8
1-3 bar
20-60°C
TI 1208
TI 1204
PI 1004
4-9 bar
20-90°C
C1
V4
4 bar
20°C
PRV3
Electrolyzer
Anode
V = ~2.7 V
i = ~0,2 A/cm2
Cathode
triggering pressure: 6 bar
PI 1005
Deaerator/ Cyclone
Batch measurement
VE H2O
Phase 1: m_dot: 60 g/h
Phase 2: m_dot: 300 g/h
Extrapolation Wien Energie H2O:
Phase 3: m_dot: 4408 g/h
PI 1009
AM 1301
VM 1401
4-5 bar
20°C
Cooling Water
V5
TI 1205
5 bar
10-20°C
1 bar
20-60°C
triggering pressure: 9 bar
PRV4
PI 1003
4 bar
20°C
4-5 bar
20°C
triggering pressure: 30 bar
PRV2
Regenerated Catholyte
Aqueous PZ
Phase 1: V_dot: 0,4 L/h
Phase 2: V_dot: 2,0 L/h
Phase 3: V_dot: 32 L/h
Cooling Water
V9
C2
TI 1207
1-3 bar
20-60°C
4-9 bar
20-90°C
TI 1203
5 bar
10-20°C
1 bar
20°C
H2
H1
PI 1002
LI 1101
PRV1
triggering pressure: 1,7 bar
TI 1209
FI 0904
1-3 bar
20°C
PI 1006
V3
CO2
4-9 bar
20-25°C
1.2 bar
20°C
P2
CV3
FI 0902
1-4 bar
20-25°C
TI 1202
V6
CV2
Catholyte
Catholyte
Aqueous Amine
10 wt%
CV1
P1
F1
Absorber
Batch measurement
CO2 bottle
V1
TI 1201
FI 0901
4 bar
20°C
V2
2-4 bar
20°C
PI 1001
CO2
Phase 1: m_dot: 37.4 g/h
Phase 2: m_dot: 187 g/h
Extrapolation Wien Energie CO2:
Phase 3: m_dot: 2992 g/h
PIC 0901
PIC...Kind of measurement
09... Type of euipment (EL number)
01... Equipment number
Legend
PZ...Piperazin
P...Pump
H...Heater
C...Cooler
CT...Cold Trap
IET Testanlage
Version: 003.25
Name: Martin Schulz
Name: Felix Ettlinger
Name: Jonas Hauser
Datum: 12.02.2024
Associated Documents:
Line Diagram
Equipment List