ProPuls

SEMPRE-BIO.

In-situ investigation of low-cost material combinations for the development of a novel PEM water electrolysis stack based on hydraulic cell compression

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The SEMPRE-BIO project

Pillar 1: Innovative Biomethane Production Technologies

- CO_2 Biomethanation
- PEM Electrolysis
- Pyrolysis
- CO Biomethanation
- Cryo-Separation

Diversify the conversion technology basis for biomethane production

Pillar 2: Case Studies

- CASE STUDY I: El Prat de Ll. (ES)
- CASE STUDY II: Bourges (FR)
- CASE STUDY III: Adinkerke (BE)

Contribute to market up-take of biomethane related technologies in the gas market

Pillar 3: Techno-Economic Assessment

- New Types of Feestock
- Greenfield vs. Retrofitting Projects
- CO_2 Valorization

Increase cost-effectiveness of the conversion in biomethane production

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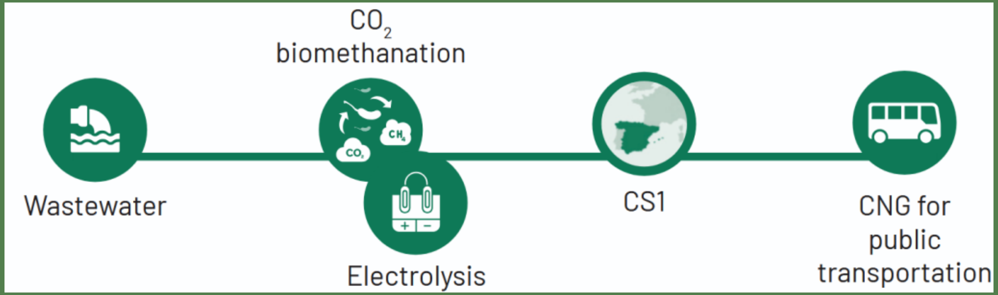
Case study I

Biogas via green hydrogen and CO_2-rich exhausts at the wastewater treatment unit in Baix Llobregat, Spain



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The SEMPRE-BIO PEMWE

20 Nm^3/h

H_2 production rate

About 100 kW_{el}

16 bar

Production pressure

Direct H_2 feed into the methanization unit

80 to 90 °C

Stack temperature

For a waste heat recuperation

10 Nm^3/h

O_2 production rate

For a potential use in the wastewater treatment unit

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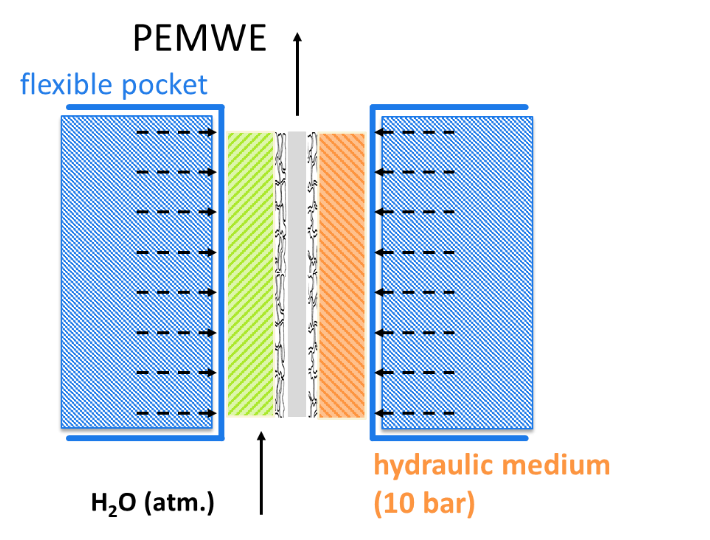
Hydraulic cell compression #1



Basic principle:

- Active cell components are entirely surrounded by hydraulic medium
- This ensures homogeneous cell compression (no hot spots, any size and any number of cells possible)
- Pressure controls allow for high-pressure operation
- This ensures homogeneous waste heat transfer
- This allows for reproducible operation conditions

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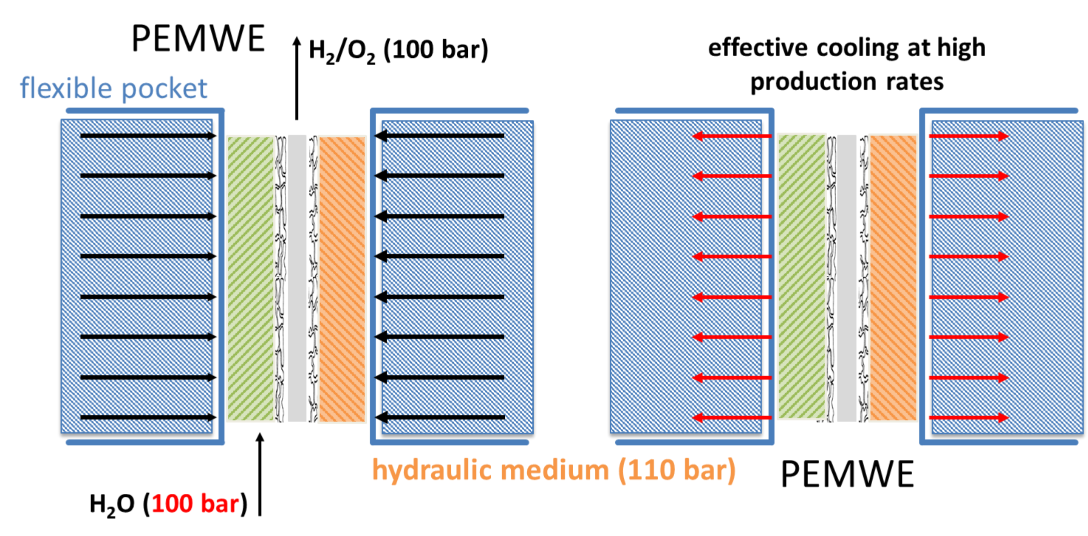
WO2011/069625:
Vorrichtung zur Energieumwandlung, insbesondere Brennstoffzellenstack oder Elektrolyseurstack

Hydraulic cell compression #2



High-pressure electrolysis:

- Control of hydraulic media's pressure level according to inner cell pressure – always keep a pressure difference of ca. 10 bar
- Less mechanical stress on the thin polymer membranes in balanced pressure mode
- Outlet pressure is dependant on outer pressure housing and BoP components

WO2014/040746:
Verfahren und System zum Betreiben eines Elektrolyseurs

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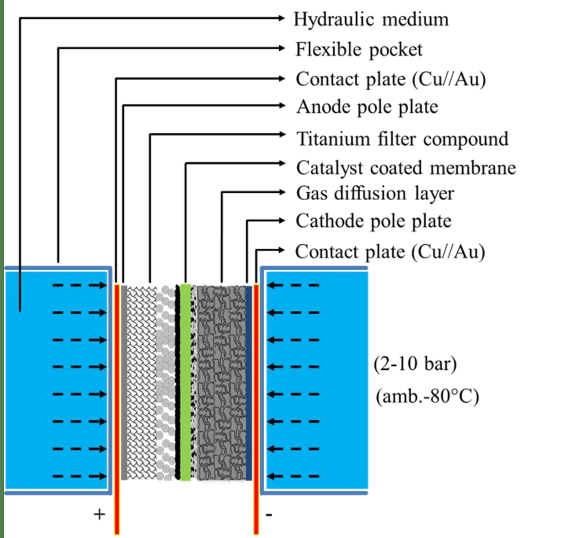
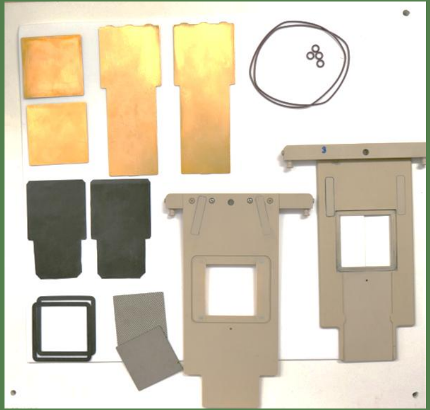
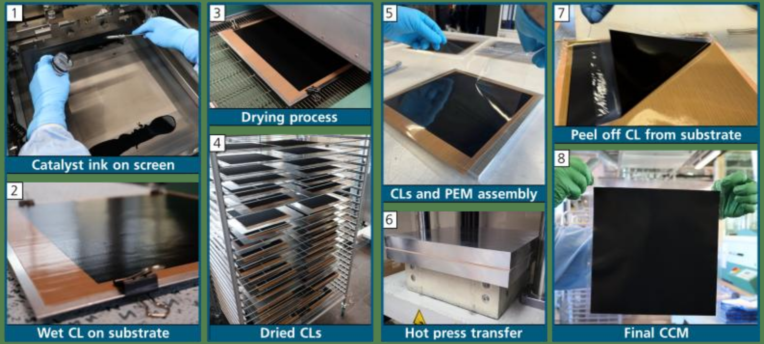
The SEMPRE-BIO test cell





U. Rost et al., Fuel Cells 22 (2022) 284–289, DOI: https://doi.org/10.1002/fuce.202200068



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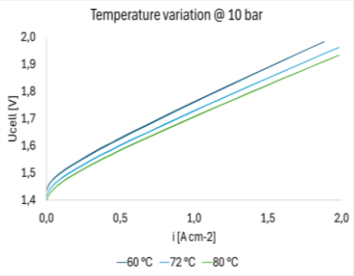
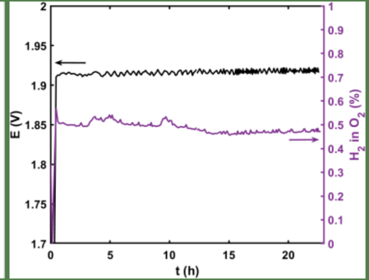
CCM: Commercially available (N115) vs. self-prepared 1 mg_{IrOx}/cm^2 (N117) 0.5 $mg_{Pt/C}/cm^2$

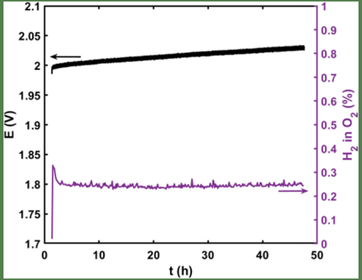
Electrode components: PP, PTL, and GDL material was selected according to availability in 500 cm^2

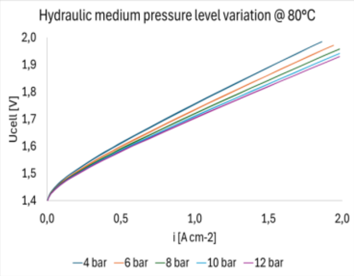
Results on test cell level #1

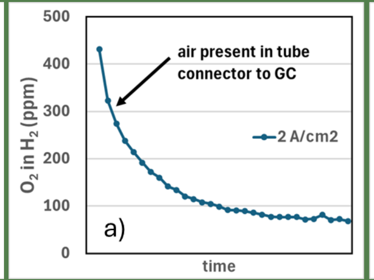
CCM	PTL	Pole plates	U [V] @ 1 A cm^{-2}	U [V] @ 2 A cm^{-2}
Commercial N115	Ti	A: Cu//Au+Ti; C: Cu//Au	1.70	1.91
		A: Ti//Pt; C: Ti//Pt	1.72	1.92
		A: Ti; C: Cu//Au	1.73	1.95
		A: Ti; C: 316L	1.73	1.94
	Ti//Pt	A: 316L; C: 316L	1.69	1.92
		A: Cu//Au+Ti; C: Cu//Au	1.68	1.87
SEM PRE-BIO	Ti//Pt	A: Ti//Pt C: Ti//Pt	1.72	1.94
		A: Ti//Pt C: 316L	1.70	1.92

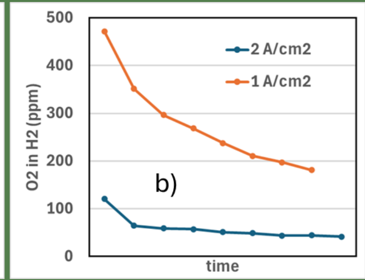












Reasonable performance of 2.0 A/cm^2 at about 1.92 V (bol) with low-cost components
Gas crossover for H_2 in O_2 is far below LEL and neglectable for O_2 in H_2

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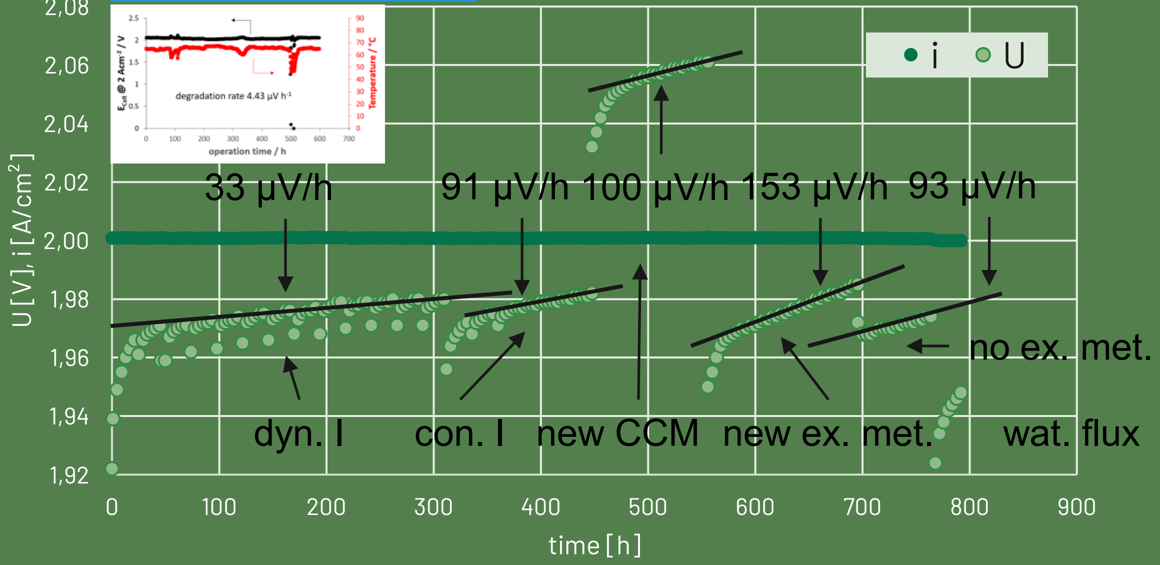
Results on test cell level #2

https://doi.org/10.1002/aenm.202100630



Long-term run:

- Initial performance of about 1.92 V at 2.0 A/cm^2 with an initial increase after several hours of operation
- The cell voltage stabilizes at about 1.98 V maintaining a degradation rate of about 33 µV/h after 300 h
- Degradation caused by bubble accumulation is recoverable

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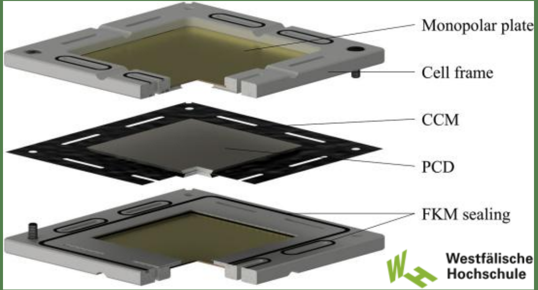
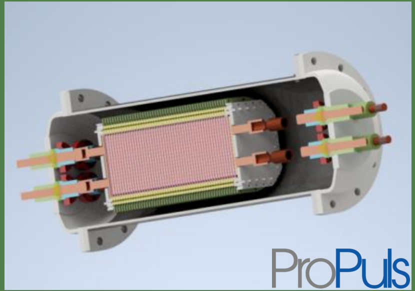
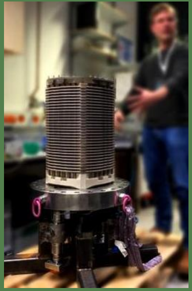
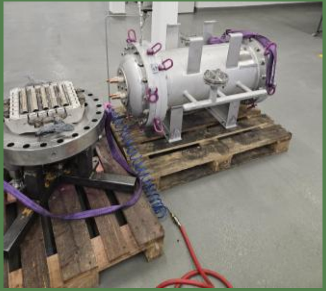
Upscaling in progress

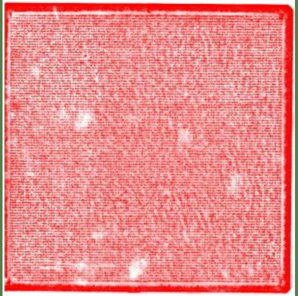


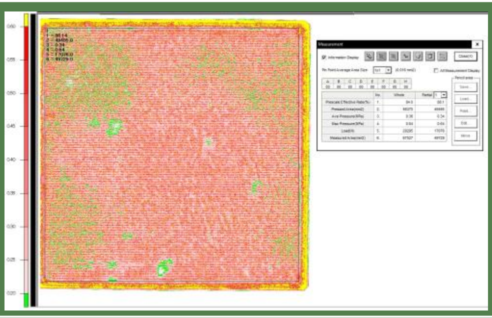
F.J. Wirkert et al., Int. J. of Hydrogen Energy, 45, 2 (2020) 1226-1235, DOI: https://doi.org/10.1016/j.ijhydene.2019.03.185

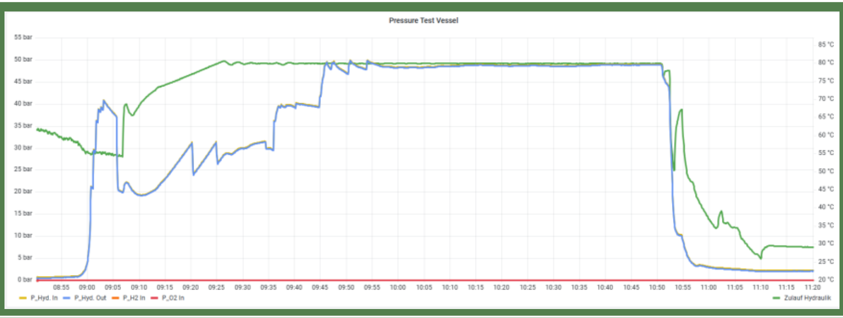












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Conclusions

- By the aid of a novel test system with hydraulic cell clamping, test results on cell level could be reproduced in two different laboratories/test benches
- Various low-cost materials were investigated, indicating the potential use of 316L as anode and cathode PP material
- For upscaling to 500 cm^2, a conservative material setup was chosen that meets the necessary stack specifications
- A long-term run with Ti expended metal sheet utilized as a flow field demonstrated the advantages of a Pt coating to reduce the degradation rate
- The cell degradation varies under dynamic operation conditions
- The stack manufacture is now underway

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Acknowledgement

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Thank you for your attention!

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