PROJECT HYGRID

Flexible Hybrid separation system

for H2 recovery from NG Grids

HyGrid

European Hydrogen Week

Fausto Gallucci

Eindhoven University of Technology

https://www.hygrid-h2.eu/

F.Gallucci@tue.nl

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FCH

European Commission

Project Overview

- Call year: 2015
- Call topic: H2020-JTI-FCH-2015-1 - Development of technology to separate hydrogen from low-concentration hydrogen streams
- Project dates: 01 May 2016
- % stage of implementation 01/11/2020: 85%
- Total project budget: €3,167,710.00
- FCH JU max. contribution: €2,527,710.00
- Other financial contribution: €300,000 from Switzerland
- Partners: Eindhoven University of Technology, Tecnalia, SAES (T), Hygear, HYET, Quantis, Naturgas

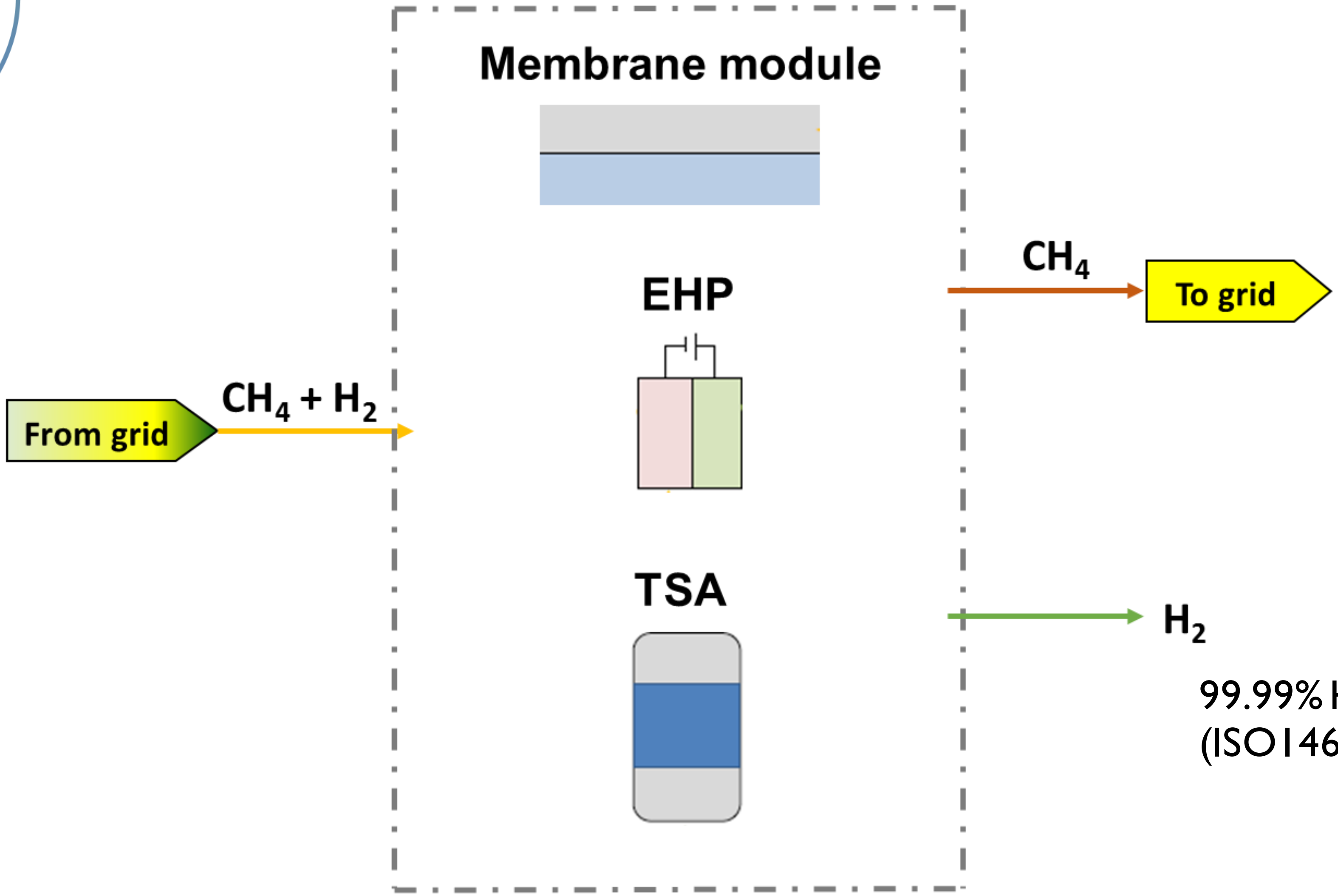
Project Summary

HyGrid aims at developing of an advanced high performance, cost effective separation technology for direct separation of hydrogen from natural gas networks.
The system will be based on:

Design, construction and testing of an novel membrane based hybrid technology for pure hydrogen production (ISO 14687) combining three technologies for hydrogen purification integrated in a way that enhances the strengths of each of them: membrane separation technology is employed for removing H2 from the "low H2 content" (e.g. 2-10 %) followed by electrochemical hydrogen separation (EHP) optimal for the "very low H2 content" (e.g. <2 %) and finally temperature swing adsorption (TSA) technology to purify from humidity produced in both systems upstream.

The project targets a pure hydrogen separation system with power and cost of < 5 kWh/kgH2 and < 1.5 €/kgH2. A pilot designed for >25 kg/day of hydrogen will be built and tested at industrially relevant conditions (TRL 5).

Project Summary



99.99% H_2 purity (ISO14687)

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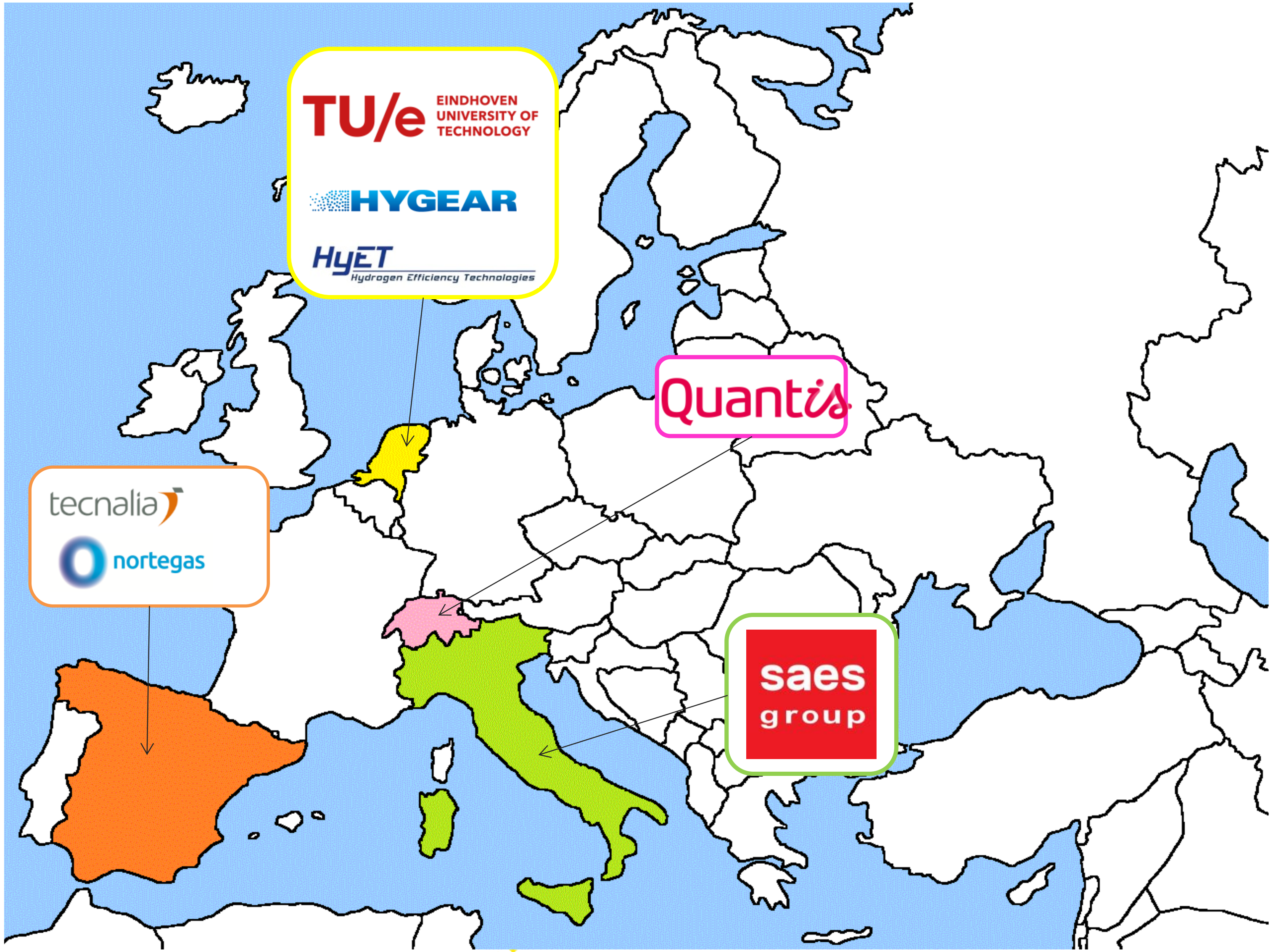
Partners



Project Progress/Actions - Aspects

Membrane module at TRL5

Achievement to-date

TRL3 → TRL5

25% 50% 75%

Project Progress/Actions - Aspects

Electrochemical hydrogen purification

Achievement to-date

TRL3 — 25% — 50% — 75% — TRL5

Full-size EHP package stack tested

KPIs are confirmed:

- **Recovery rate of 60% for H_2**
- **Energy demand of 4 kWh/kg H_2**
- **Pressure drop of 100 mbar**

Final full-size EHP stacks assembled

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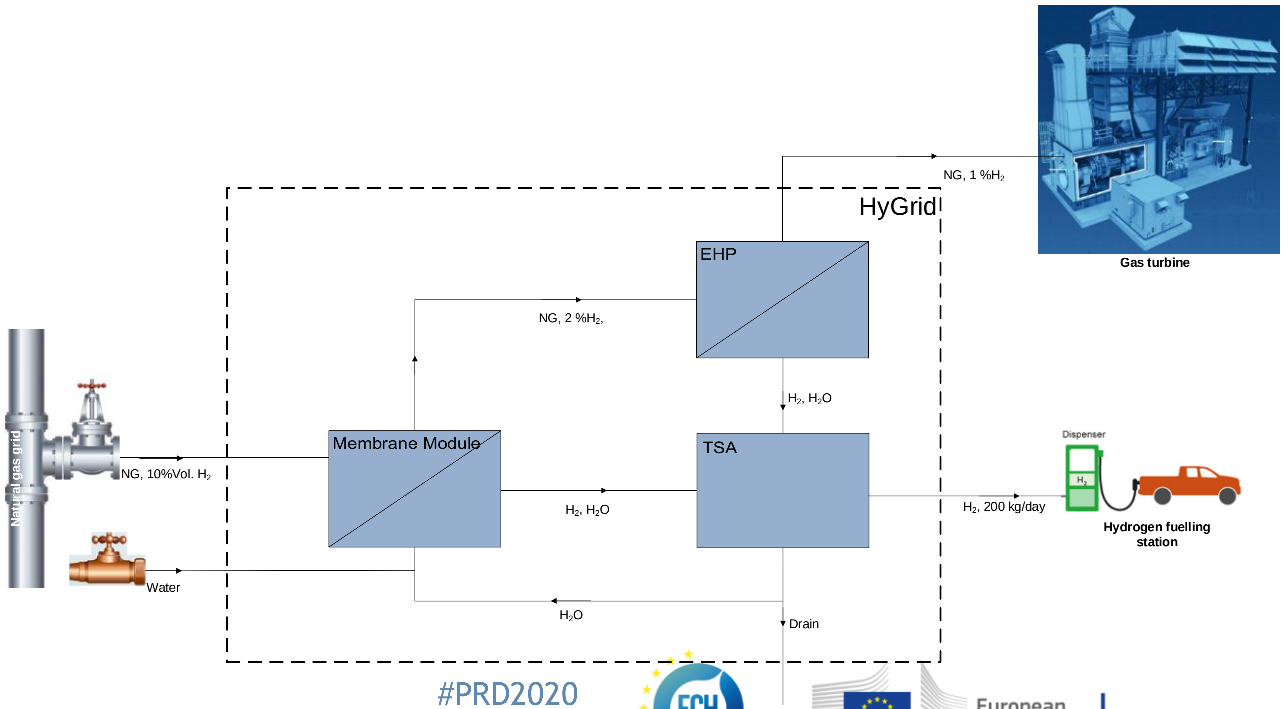
Project Progress/Actions - Aspects

Full HyGrid system

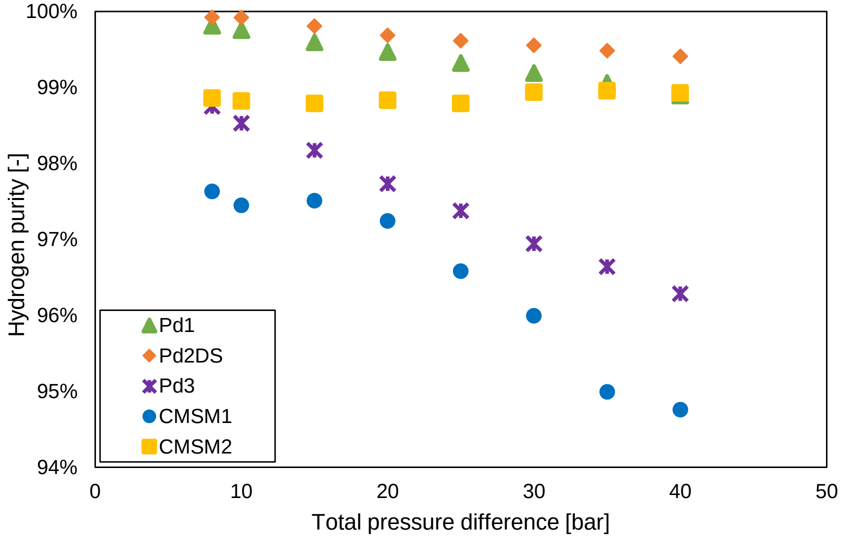
Achievement to-date

TRL1 — 25% — 50% — 75% — TRL5



Membranes fundamentals

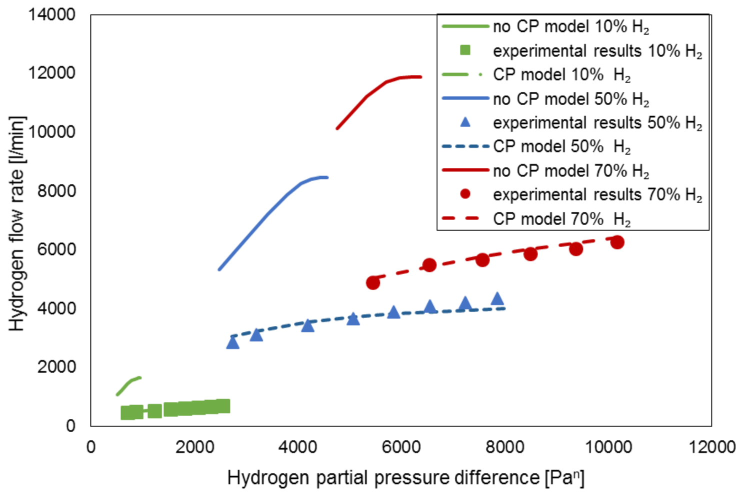
Membrane code	Membrane type	H_2 permeance [mol/s/m²/Pa]	Pressure exponent [-]	H_2/CH_4 selectivity [-]
Pd1	Pd-Ag	$1.18 \cdot 10^{-6}$	0.66	24300
Pd2DS	Pd-Ag	$1.35 \cdot 10^{-6}$	0.63	65200
Pd3	Pd-Ag	$4.36 \cdot 10^{-6}$	0.58	4280
CMSM1	CMSM	$7.02 \cdot 10^{-8}$	1	527
CMSM2	CMSM	$5.23 \cdot 10^{-8}$	1	1020

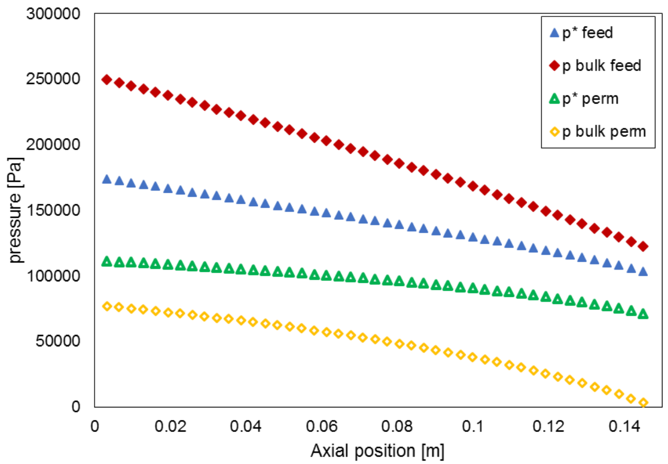


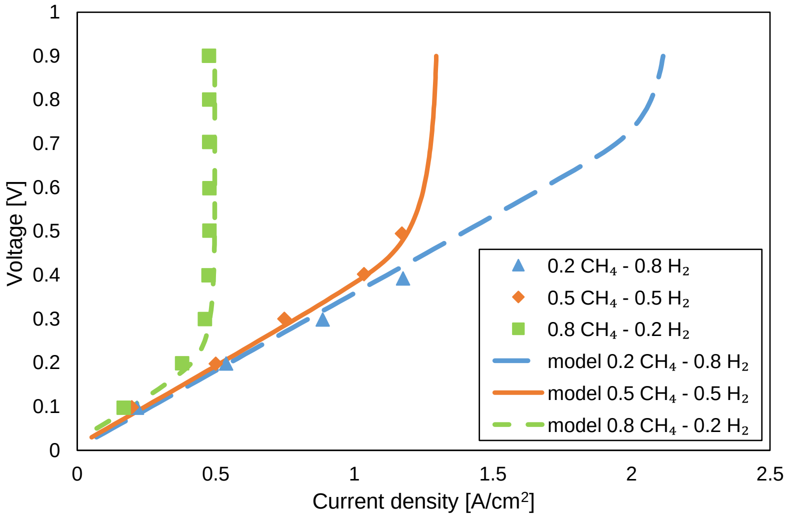
10% H_2 - 90% CH_4

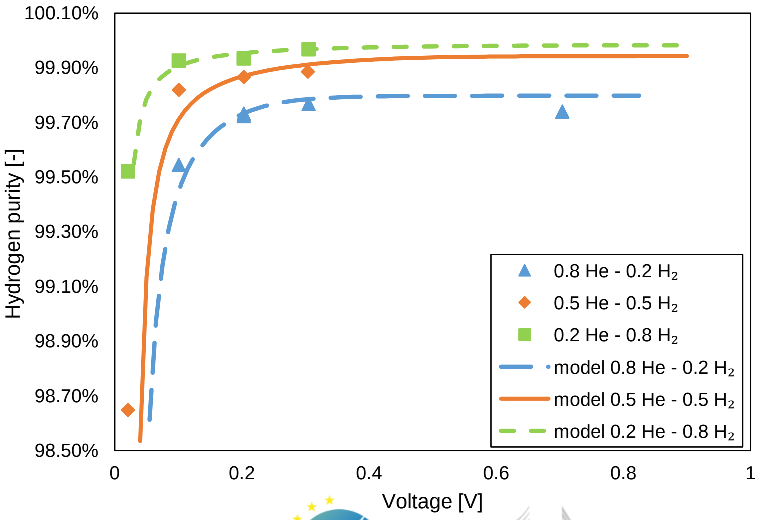
- No concentration polarization effect for CMSM
- Pd-Ag and CMSM can have similar H_2 purity at different temperatures
- CMSM economically convenient at higher pressure

EHC fundamentals



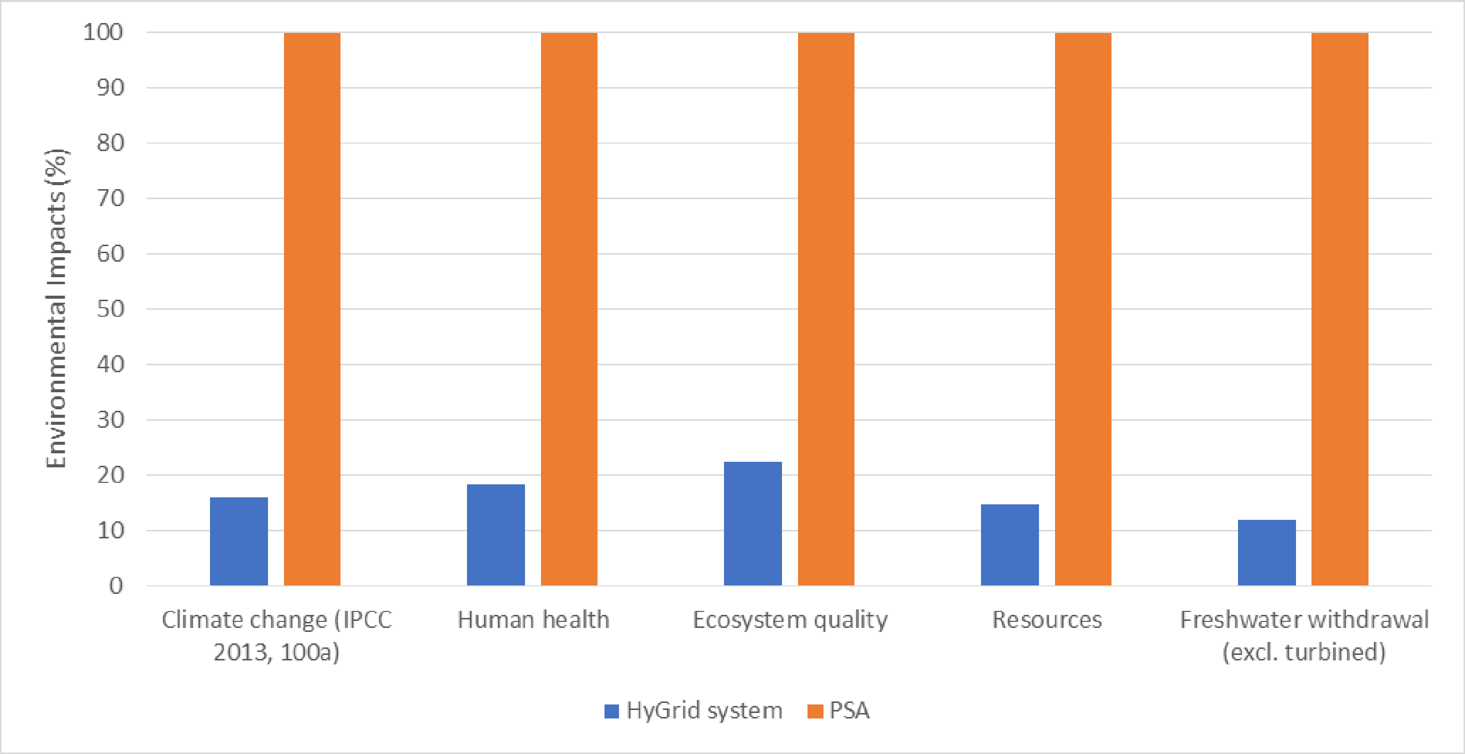






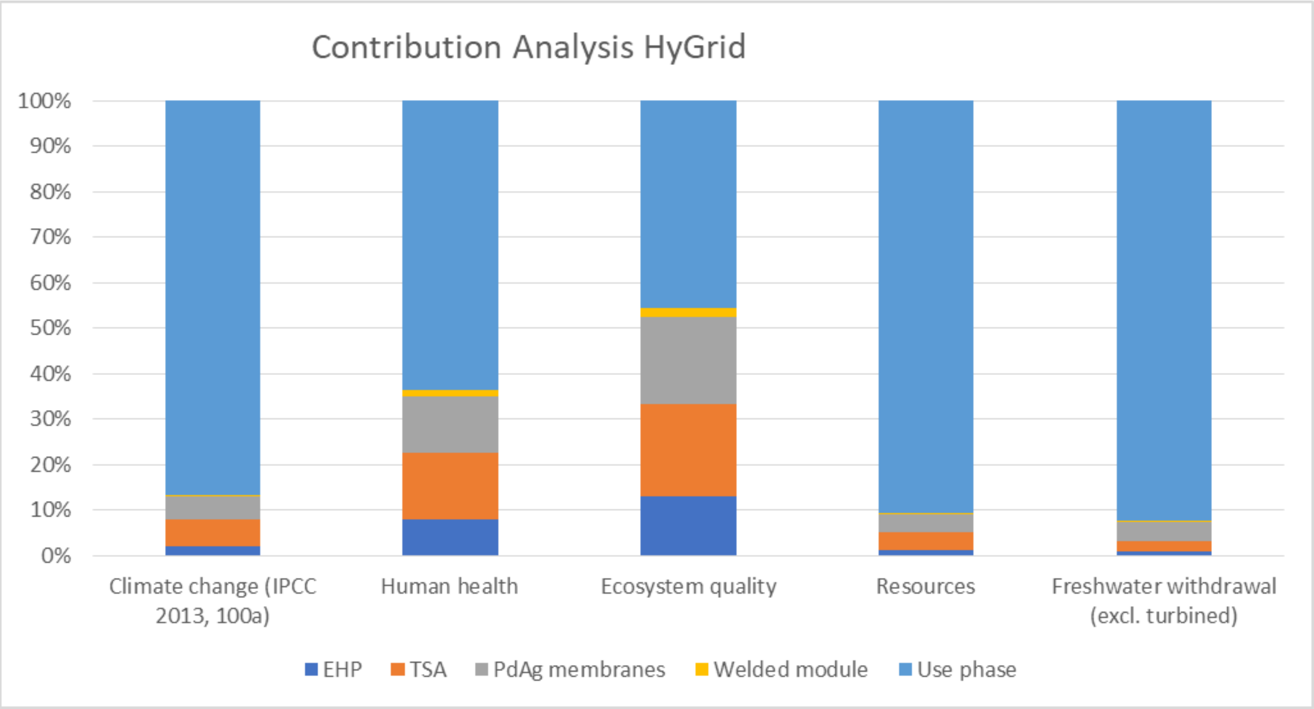
- External concentration polarization
- Porous support mass transfer limitation
- Dusty gas model
- Model validation

Comparison HyGrid system - PSA (preliminary)



The impacts of PSA are to 95%-99% due to the electricity use of the PSA system, which is around 10 times the HyGrid system.

Contribution analysis



The contribution analysis shows that the use phase (energy use) is main contributor to the impacts.

In the next phase, scenarios will be caculated to better understand the importance of different parameters of the HyGrid scenarios, concentrating on the most important contributors.

HyGrid system optimization

Configuration	Membrane area 1 [m^2]	Membrane area 2 [m^2]	Hydrogen separated [kg/day]	Purity from membrane [%]	% H_2 from EHC	Total purity [%]	Electricity consumption [kWh/kg_{H2}]	Heat consumption [kWh/kg_{H2}]
A	1.62	-	25	99.92	34.92	99.93	5.19	-
A1	2.92	-	25	99.9876	34.92	99.99	5.05	-
A2	2.80	-	25	99.92	23.13	99.94	4.29	-
A3	1.07	-	25	99.41	34.92	99.42	5.09	-
A4	5.27	-	25	99.00	34.92	99.00	4.36	-
B	2.53	-	25	99.90	34.92	99.91	6.23	11.23
B1	4.22	-	25	99.96	34.92	99.97	6.29	11.23
C	3.85	-	25	99.92	0	99.92	3.94	-
D	2.42	0.5	25	98.75	34.92	99.9997	7.95	-
E	6.32	0.5	25	91.61	34.92	99.99	5.62	-
E1	2.97	0.5	25	96.28	34.92	99.99	6.38	-
E2	2.51	0.62	25	96.11	34.92	99.99	6.30	-
E3	2.23	0.78	25	96.02	34.92	99.99	6.22	-
E4	5.85	0.62	25	91.53	34.92	99.99	5.48	-
E5	5.33	0.78	25	91.40	34.92	99.99	5.40	-
F	-	-	25	-	100	100.00	12.64	-
G	3.67	0.5	25	99.94	32.92	99.95	8.02	11.23

Risks, Challenges and Lessons Learned

Integration of TRL5-6 systems

Components are often too large for small scale and too small for industrial scale. this results often in delay in commissioning.

Exploitation Plan/Expected Impact

Exploitation

KERS identified during an INTERNAL EXPLOITATION EVENT supported by SSERR

Membranes
EHC
TSA
System
Models

Impact

2 patent applications

IP generated by TUE and Tecnalia transferred to H2SITE, spinoff company created in 2020 and now employing 6 people

Communication and Dissemination

Patent applications	Scientific publications	Presentations	Workshops
2	7	14	2

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