HELMETH

"Integrated High-Temperature Electrolysis and Methanation for Effective Power to Gas Conversion"

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www.helmeth.eu

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PROJECT OVERVIEW

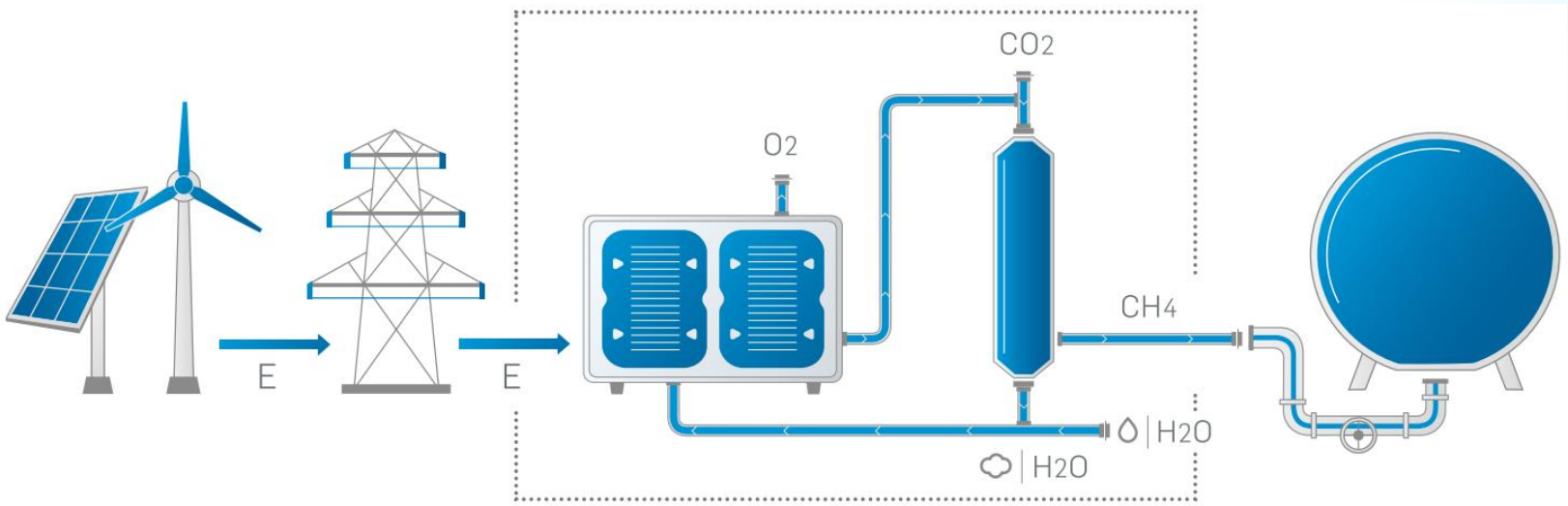
Project Information	
Call topic	New generation of high temperature electrolysers
Grant agreement number	621210
Application area (FP7)	Hydrogen production and distribution
Start date	01/04/2014
End date	31/03/2017
Total budget (€)	3,816,612
FCH JU contribution (€)	2,529,352
Other contribution (€)	-
Stage of implementation	86%
Partners	**Karlsruhe Institute of Technology, Politecnico di Torino, Sunfire GmbH, European Research Institute of Catalysis A.I.S.B.L., Ethos Energy Italy, National Technical University of Athens, DVGW - German Technical and Scientific Association for Gas and Water**

Objectives of HELMETH

Proof of concept of a highly efficient PtG technology

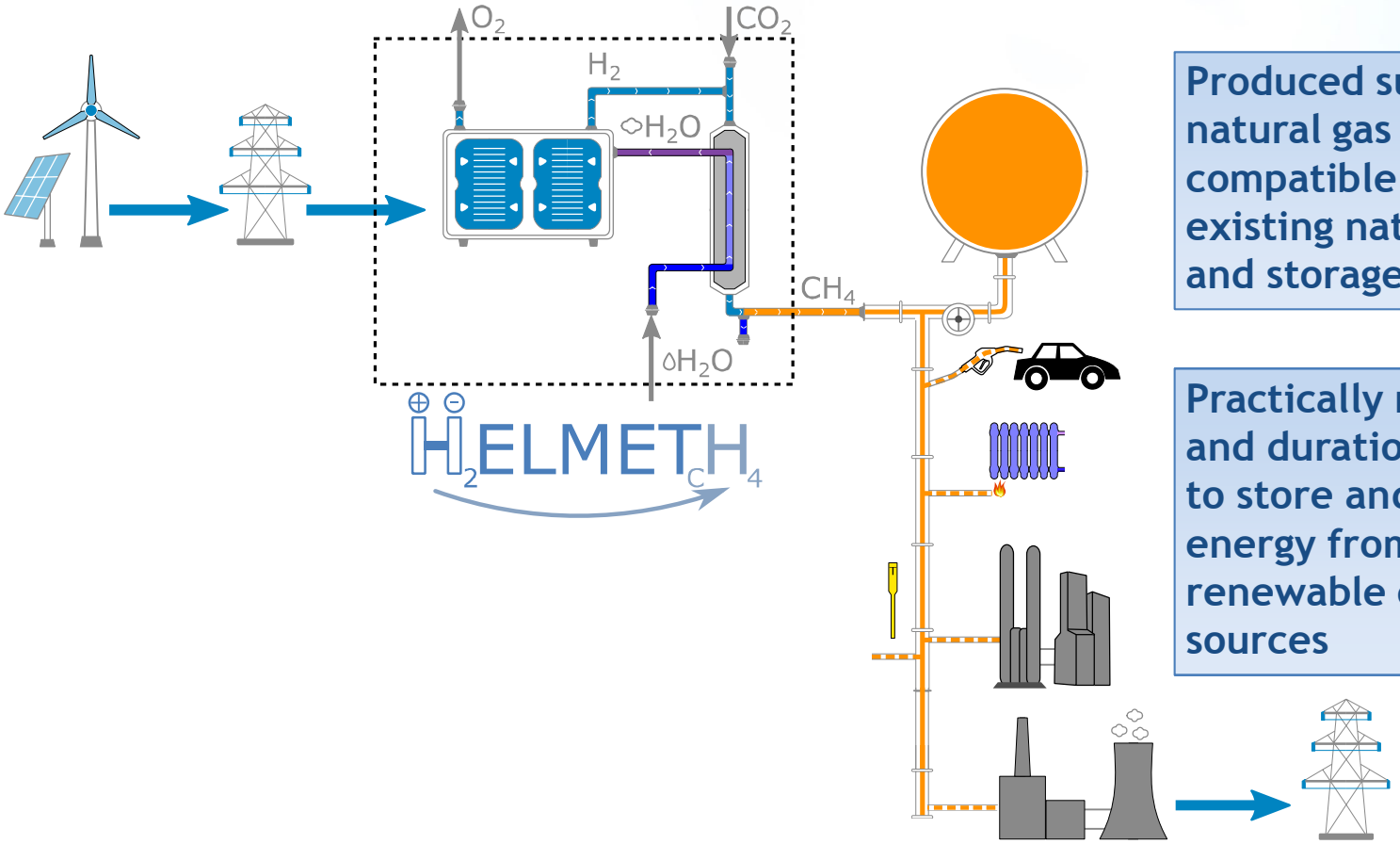
- Thermal integration of high temperature electrolysis with CO_2 methanation
- Technical feasibility of a conversion efficiency

$$\eta_{PtG} = \frac{\dot{n}_{CH_4} \cdot HHV_{CH_4}}{P_{el}} > 85\ \%$$



Objectives of HELMETH

- Elaboration of scenarios for an economic feasibility
- Demonstration that conversion of electricity into CH_4 by high-temperature electrolysis is a feasible option

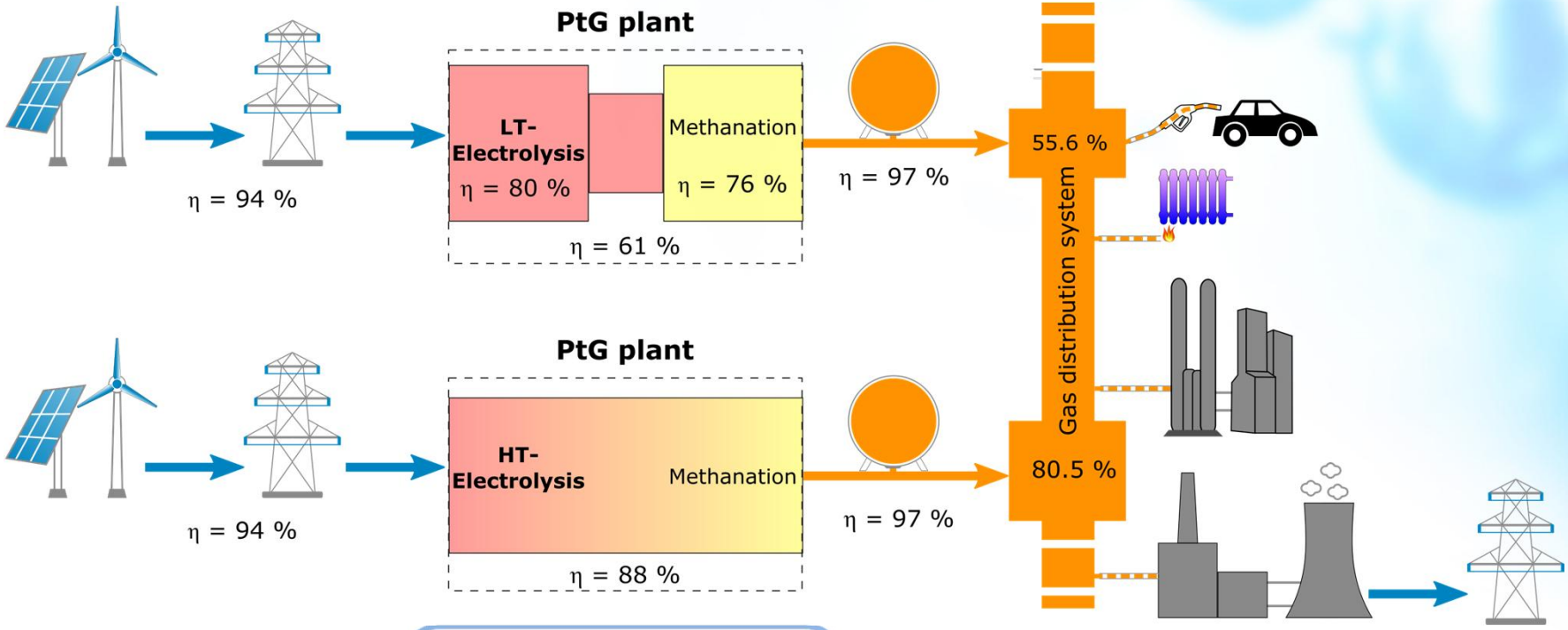


Produced substitute natural gas is fully compatible with the existing natural gas grid and storage

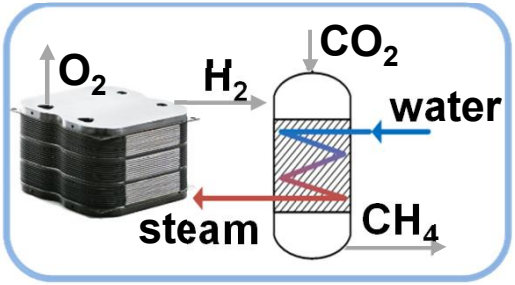
Practically no capacity and duration limitations to store and utilize energy from fluctuating renewable energy sources

HELMETH vs state-of-the-art

Increased efficiency with the use of HT-electrolysis



HELMETH: thermal integration by steam



target: $\eta > 85\%$

S. Anger, D. Trimis; *International Gas Union Research Conference 2014*

η_{PtG} based on HHV

HELMETH component targets

High temperature steam electrolysis:

- Pressure 15 bar (30 bar in future)
- Low degradation rates (< 0.5 % /1000 h for short stacks)
- Current density > 1 A/cm²

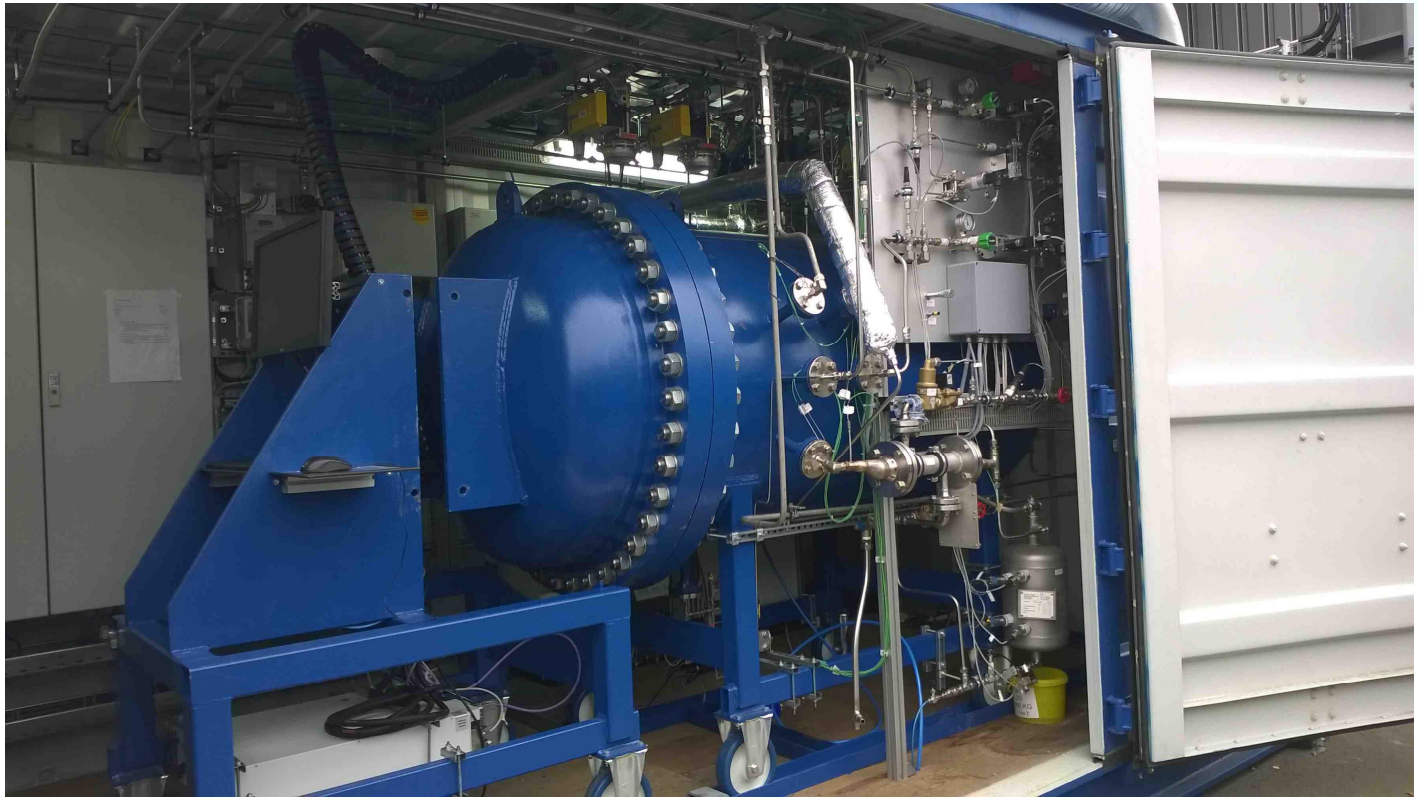
Methanation module

- Produced SNG corresponding to (future) NG grid standards
  - → Multistep reactor concept
  - → Elevated pressure
- Continuous steam generation
- Modulation from 20 to 100 % load & stand-by operation

Thermal integration of both modules

Project progress: steam electrolysis

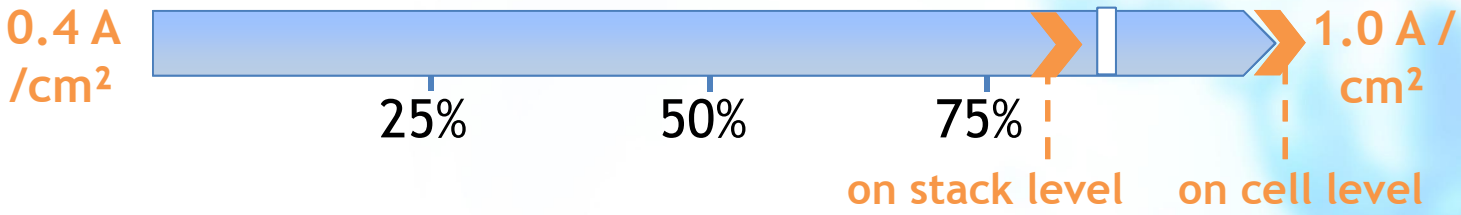
- World's first pressurized HT electrolyser module
- 5.6 kW achieved at pressures up to 8 bar
- Operation at 15 bar ongoing



PROJECT PROGRESS: Current Density

Achievement to-date

% stage of implement.



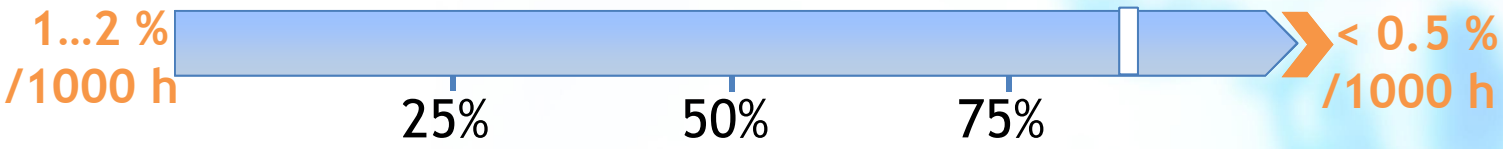
Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Current density	Current density at high temperature and pressurized condition	A/cm²	-	> 1	-	-

- State-of-the-Art: Pressurized operation only proven at cell and short stack level, sunfire is first institution to prove it on full-scale, thermally self-sustained stack.

PROJECT PROGRESS: Durability

Achievement to-date

% stage of implement.



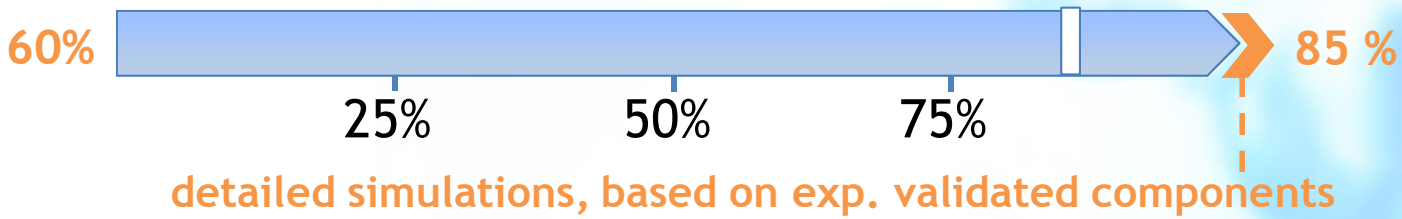
Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Durability	Degradation rates - short stack tests	%/h	< 0.5	< 0.5	-	-
Durability	Degradation rates (module)	%/h		< 1	-	-

- Single cell test >23,000 h tested, degradation 0.5% / 1,000 h
- Short stack tests (10 cells) show degradation < 0.5% / 1,000 h
- Tests on stack level are currently ongoing

PROJECT PROGRESS: Efficiency

Achievement to-date

% stage of implement.



Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Efficiency	Conversion efficiencies from electricity to methane	-	60 %*	85 %	-	-

- State-of-Art: The efficiency of a combination of low temperature electrolysis and a methanation would result in total conversion efficiencies around 60% in the best case
- Process simulations of HELMETH concept confirm efficiencies > 85 % for large scale plants based on the experimentally validated single component performances and realistic assumptions for the integration
- Next step: Experimental validation by integrated HELMETH prototype

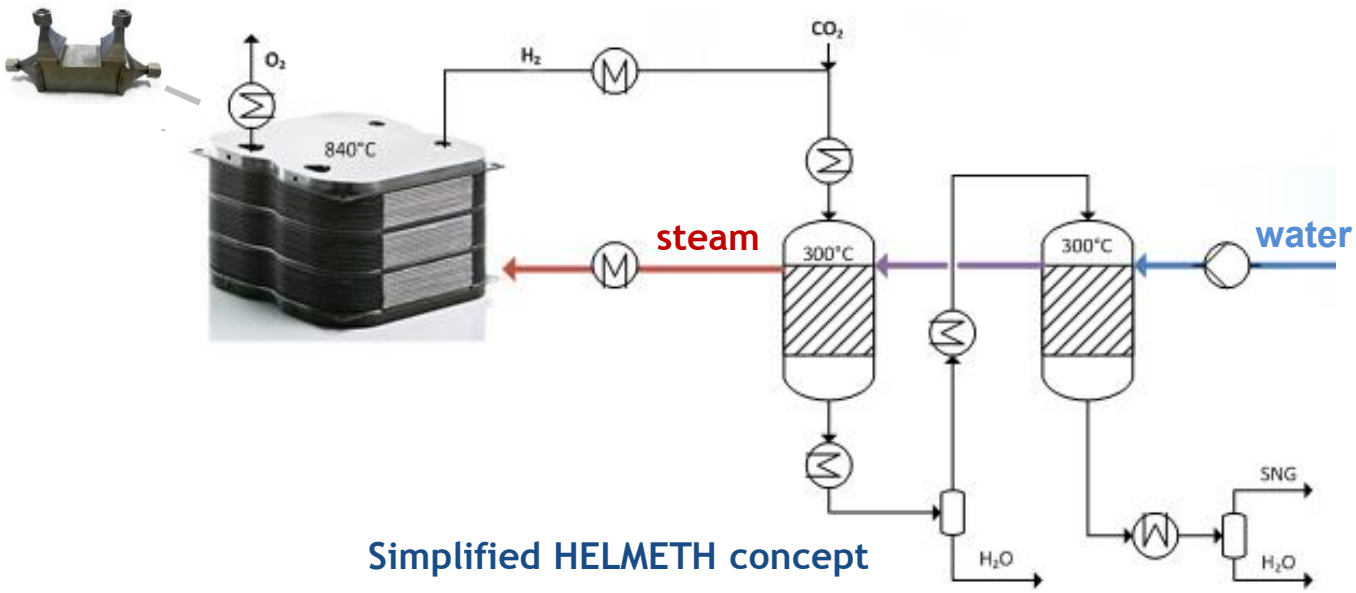
HELMETH prototype

Electrolysis module

- Operating temperature of 800-850 ° C
- Sophisticated Direct Metal Laser Sintered (DMLS) heat exchangers
- Up to 15 kW electrical input
- Pressurised operation up to 15 bar (30 bar in near future)

Methanation module

- Multistep methanation module with boiling water cooling.
- Thermal coupling with the SOEC by generated steam.
- Operational pressure of 15 bar in coupled mode and up to 30 bar at standalone tests



Simplified HELMETH concept

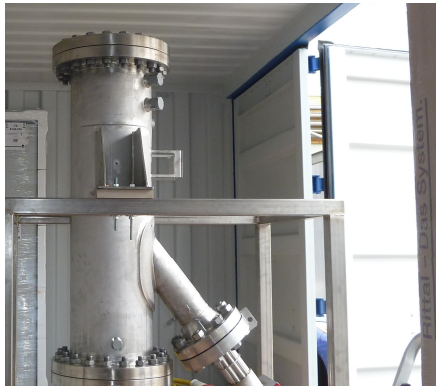
PROJECT SUMMARY

- SOEC short stack tests show degradation rates < 0.5 %/ 1000 h and feasibility of co-electrolysis. Pressurized SOEC module tests are currently ongoing.
- Multiple nickel based catalysts for the methanation developed & optimized. Lab tests confirm that SNG quality requirements are met with chosen concept. Assembling of methanation module is currently ongoing.
- Process simulation of HELMETH concept confirm efficiencies > 85 % for large scale plants based on realistic assumptions

NEXT STEPS: Completion of separate module tests and coupling of both modules

SOEC module *(in operation)*

Methanation module *(assembling phase)*



SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programmes	
GrInHy Green Industrial Hydrogen	R&D on cell and stack technology
STORE&GO	Demonstration of PtG technologies in a range of 300 kW – 1 MW
Interactions with national and international-level projects and initiatives	
"Generation of liquid fuels from CO_2 and H_2O by means of regenerative energy"	Fundamentals of SOEC technology
"Further Development of SOFC/SOEC stacks"	Development of SOFC/SOEC stacks
DemoSNG	Design of methanation module

DISSEMINATION ACTIVITIES

Public deliverables

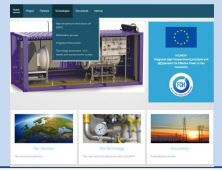
- Del. 2.2: Report on short stack testing
- Del. 5.1: Initial LCA results on the "base case" HELMETH concept system
- Del. 5.3: Social and business requirements

Conferences/Workshops

- 1 organised by the project
- 2 in which the project has participated (but not organised)

Project public page

www.helmeth.eu



Publications: 13

Synthesis, Characterization, and Activity Pattern of Ni–Al Hydrotalcite Catalysts in CO_2 Methanation, Industrial & Engineering Chemistry Research; 2016, 55, 8299–8308

Abate, S. , Barbera, K., Giglio, E., Deorsola, F., Bensaid, S., Perathoner, S., Pirone, R., Centi, G.

Catalytic Performance of γ-Al_2O_3–ZrO_2–TiO_2–CeO_2 Composite Oxide Supported Ni-Based Catalysts for CO_2 Methanation, Industrial & Engineering Chemistry Research; 2016, 55, 4451–4460

Abate, S. , Mebrahtu, C., Giglio, E., Deorsola, F., Bensaid, S., Perathoner, S., Pirone, R., Centi, G.

Patents: Patent applications ongoing (1 filed, 1 in preparation)

Thank You!

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