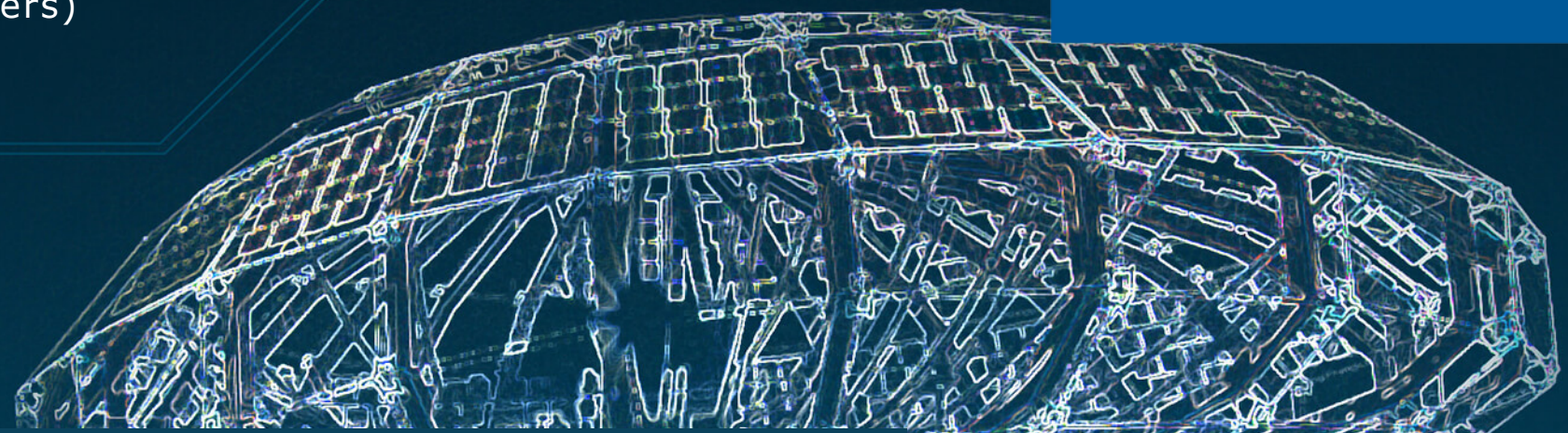
AVL List GmbH (Headquarters)



SOLID OXIDE ELECTROLYZES SYSTEM DEVELOPMENT

15. Symposium Energieinnovation
15th of February 2018

Richard Schauperl

ENTERPRISE DEVELOPMENT

RESEARCH 10% of turnover
(16 1.4 B€, Plan 17 1.52B€) in-house R&D

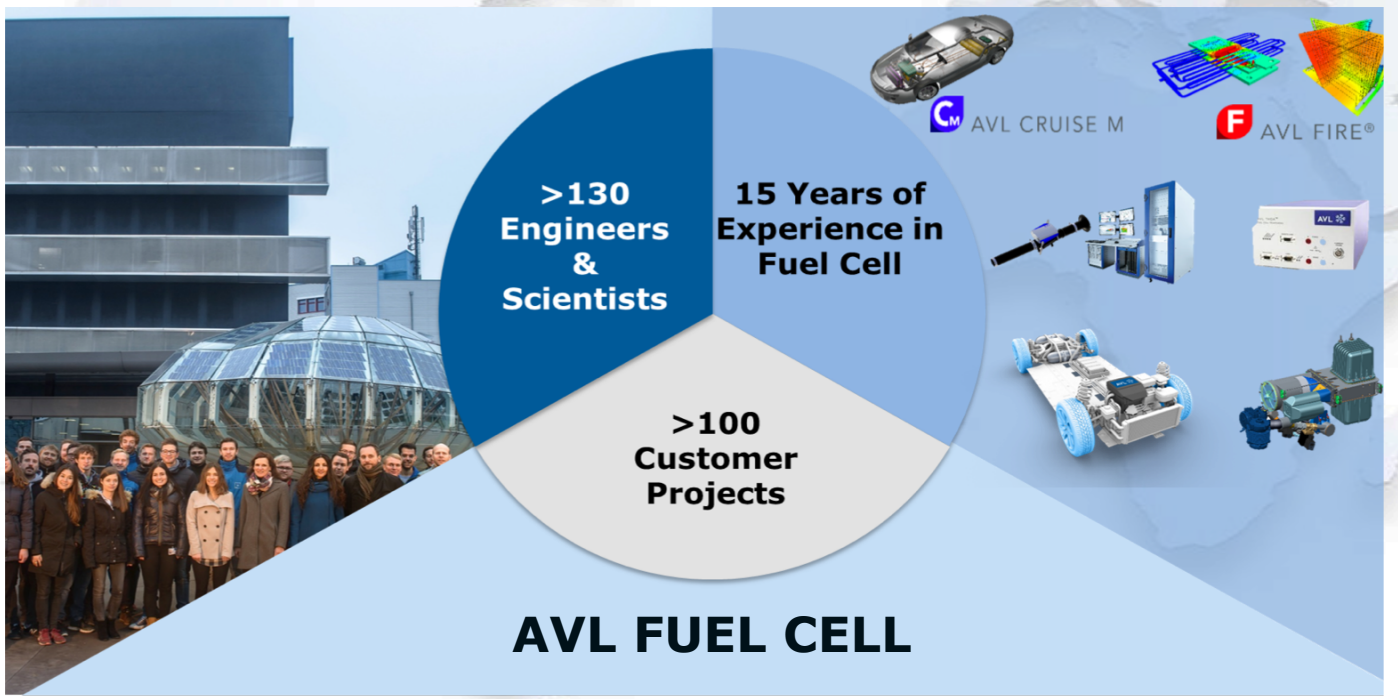
INNOVATION 1500
granted patents

STAFF

8.600 employees

65% engineers and scientists

AVL is the world's largest independent company for the development of powertrain systems

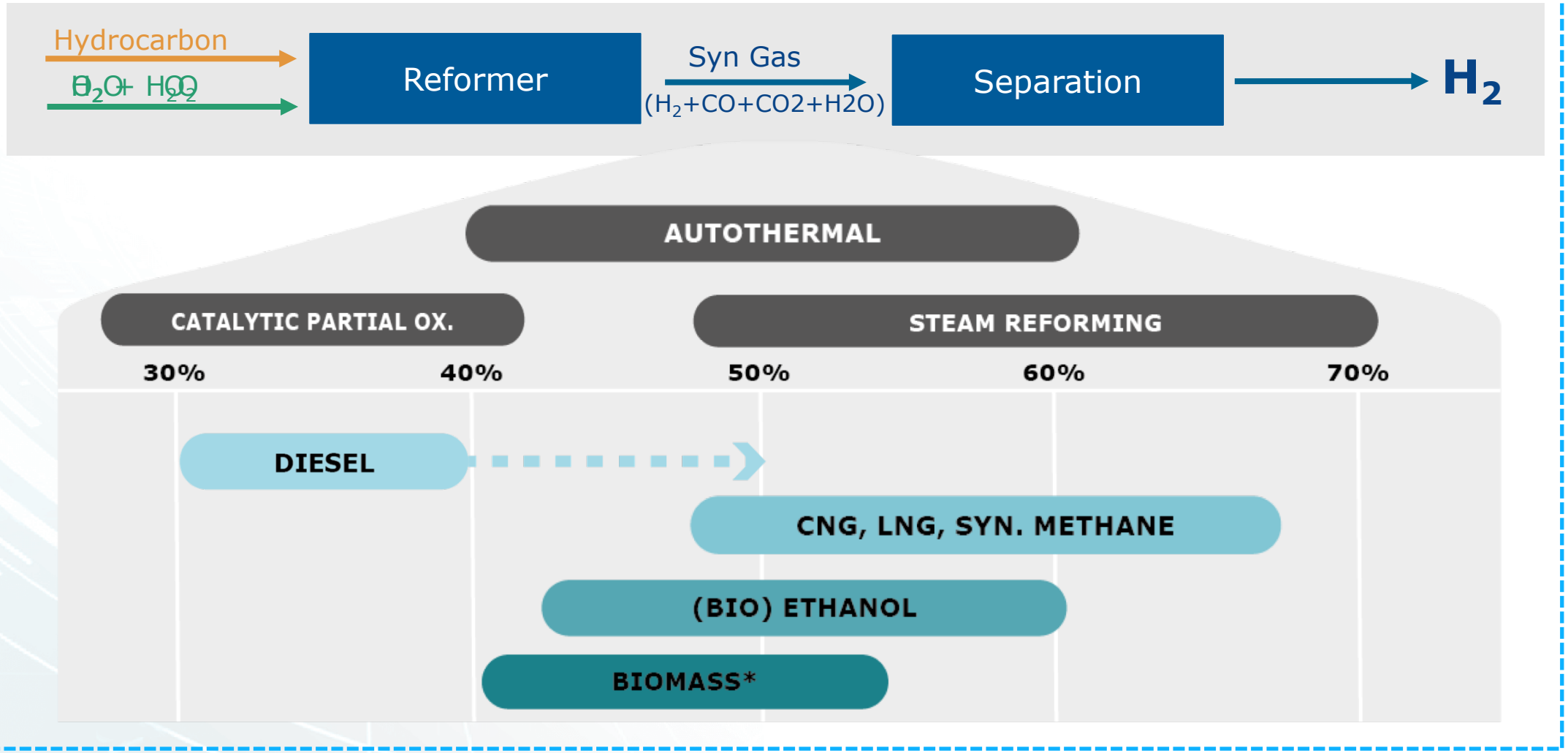


65 years of **EXPERIENCE**
15 years in PEM- / SOFC & **4** years in SOEC

ONE PARTNER Solutions for all CUSTOMER SEGMENTS

Passenger Cars Locomotive 2-Wheelers
Agriculture Power Plants
Construction Commercial Vehicle

SoA Processes for Hydrogen Production



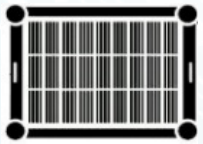
Electrical net System Efficiency [-]

With Electrolysis to GREEN Hydrogen

Primary Energy

Conversion

Final Energy Carrier



Alkaline Electrolysis Cells

Commercial η>60%

Polymer Electrolyte Membrane FC

Pre- Commercial η>60%

Solid Oxide Electrolysis FC

R&D η>80%

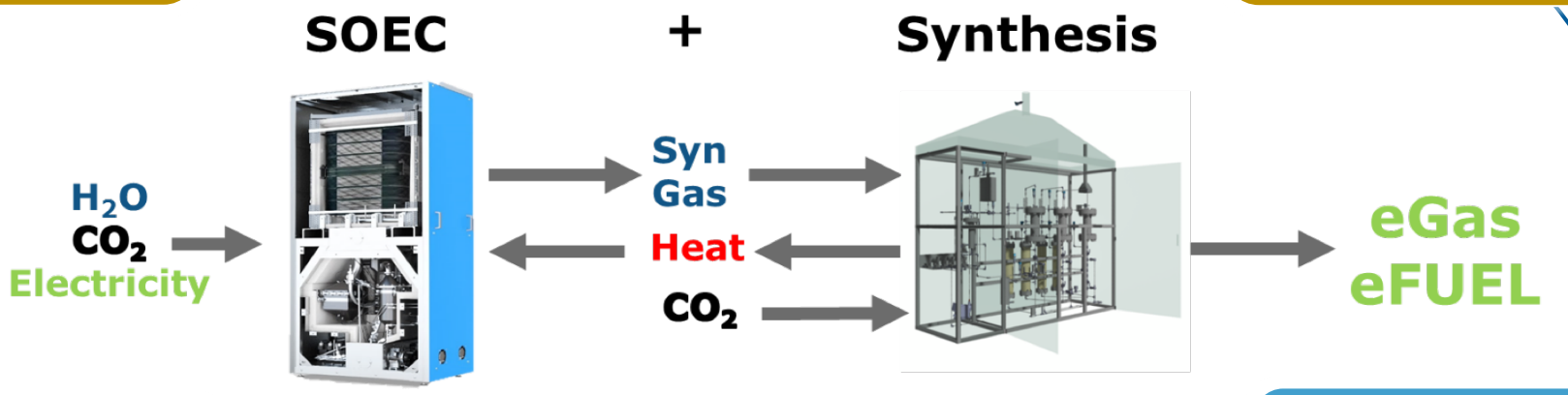
H_2

Advantages of SOEC Electrolysis

Higher efficiency compared to Alkaline and PEM

Direct utilization of CO_2 to syn. Gas

Cell voltage is lower (compensated by heat)

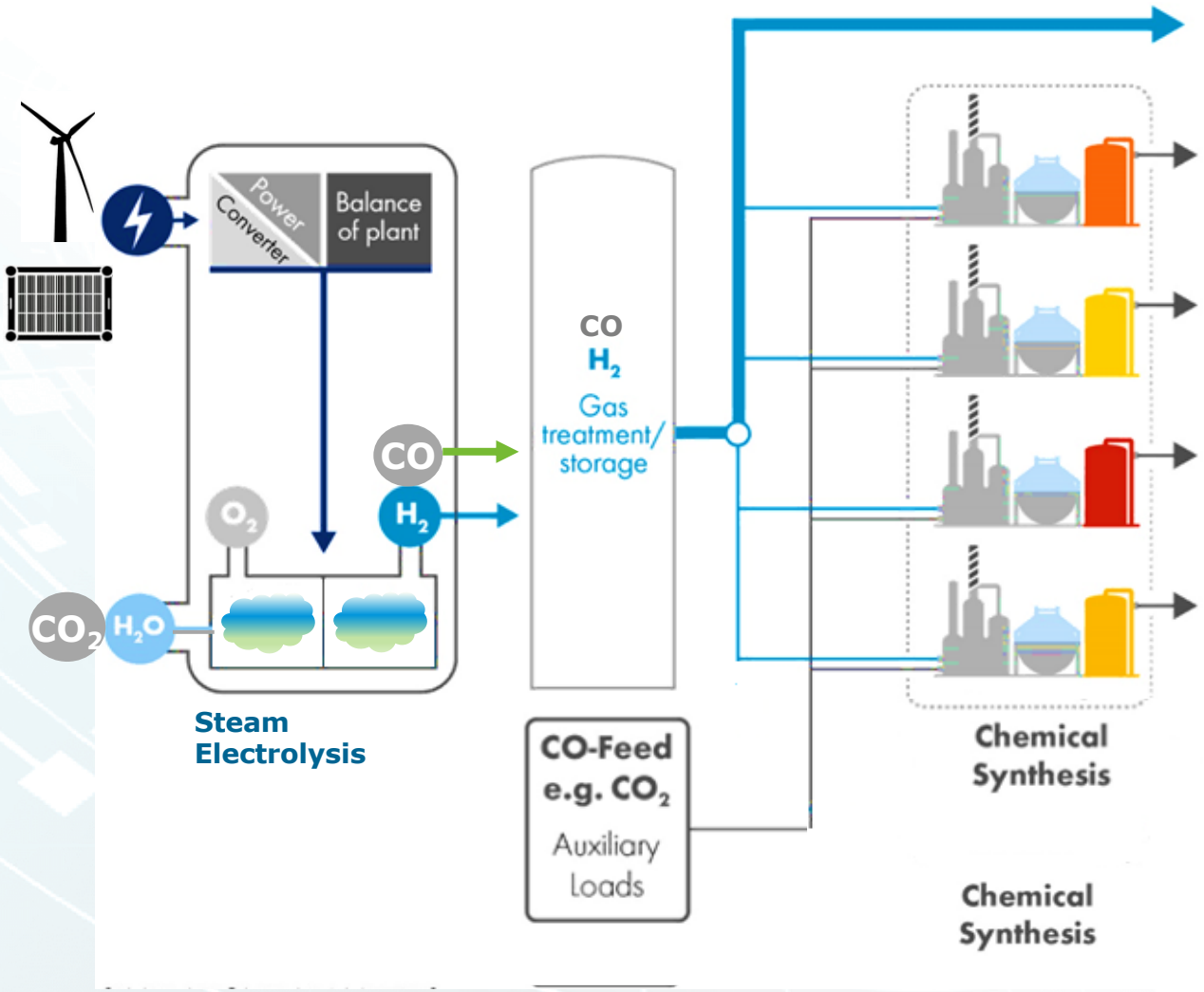


Heat coupling with exothermic synthesis

Heat coupling with waste heat from industry

Bridging Technology

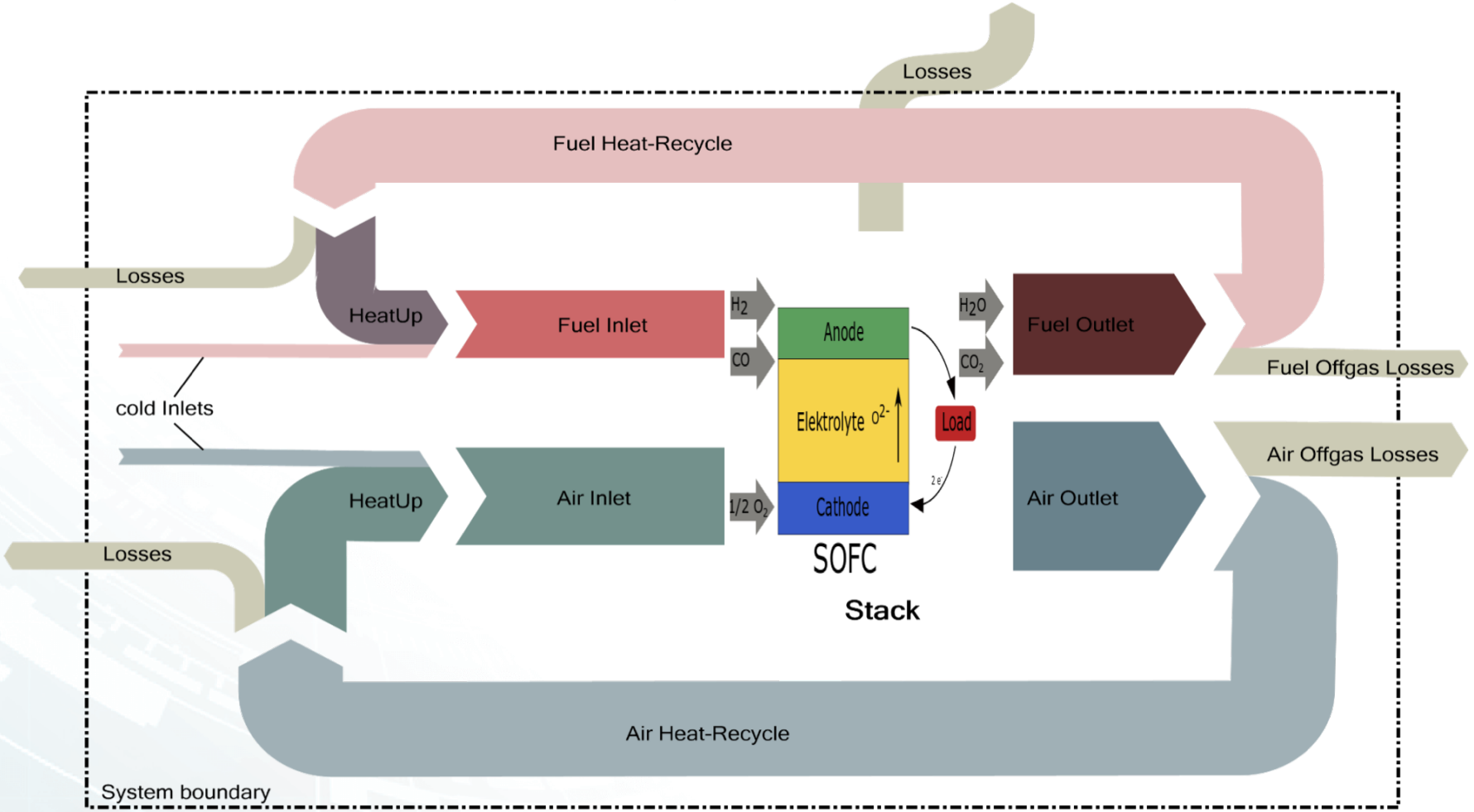
Power to X with SOEC electrolysis



	SOEC	Alkaline/PEM
Hydrogen	**η > 80%***	η = 67%
Syn. Natural Gas	**η = 85%***	η = 50%
FT Diesel	**η = 65%**	η = 45%
Methanol	**η = 75%**	η = 45%
DME	**η = 60%**	η = 30%

* Based on AVL project results

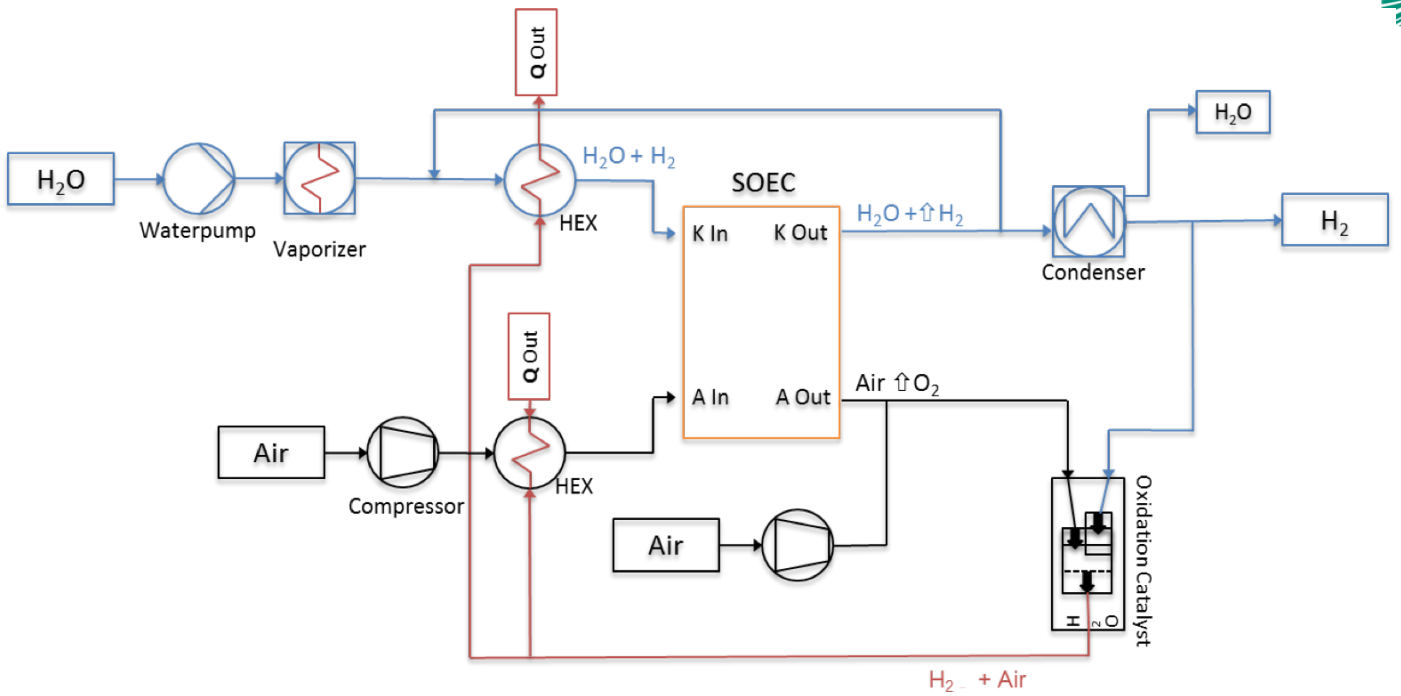
rSOC system design CHALLENGES



SOEC development

HYDROCELL (2013-2016)*

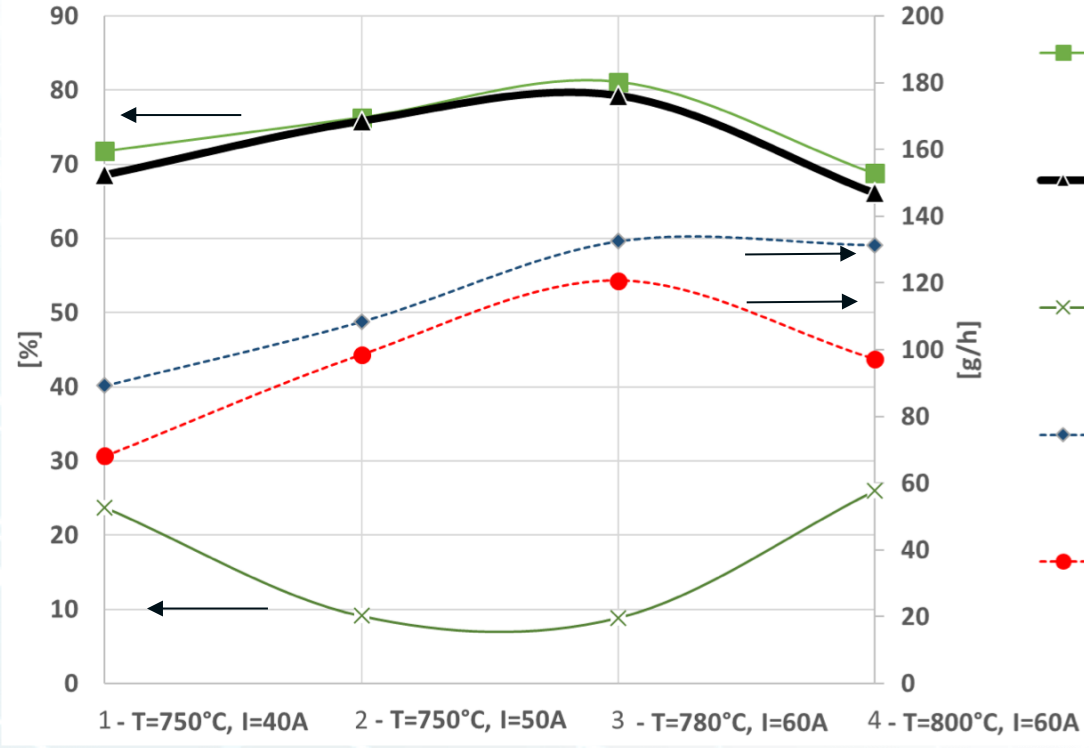
- **Adapting the simulation platform to electrolysis systems**
- **Development of an high efficient SOEC system**
- **5kW$_{el}$ proof of concept**
- **A total efficiency in hydrogen production of >80%$_{el}$ was demonstrated**



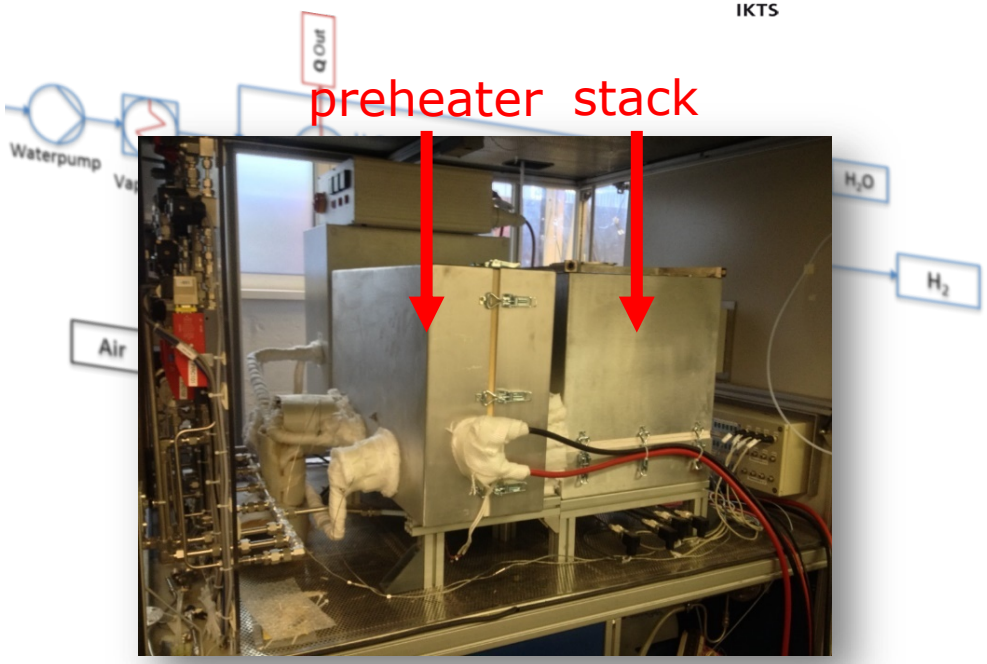
* The research has received funding from the Austrian Research Promotion Agency – FFG#838770

SOEC RESULTS FROM COMPLETED PROJECTS

HYDROCELL (2013-2016) *



- Simulation
- Proof of Concept
- H_2 Recirculation
- H_2 Production at the stack
- H_2 Production From the system



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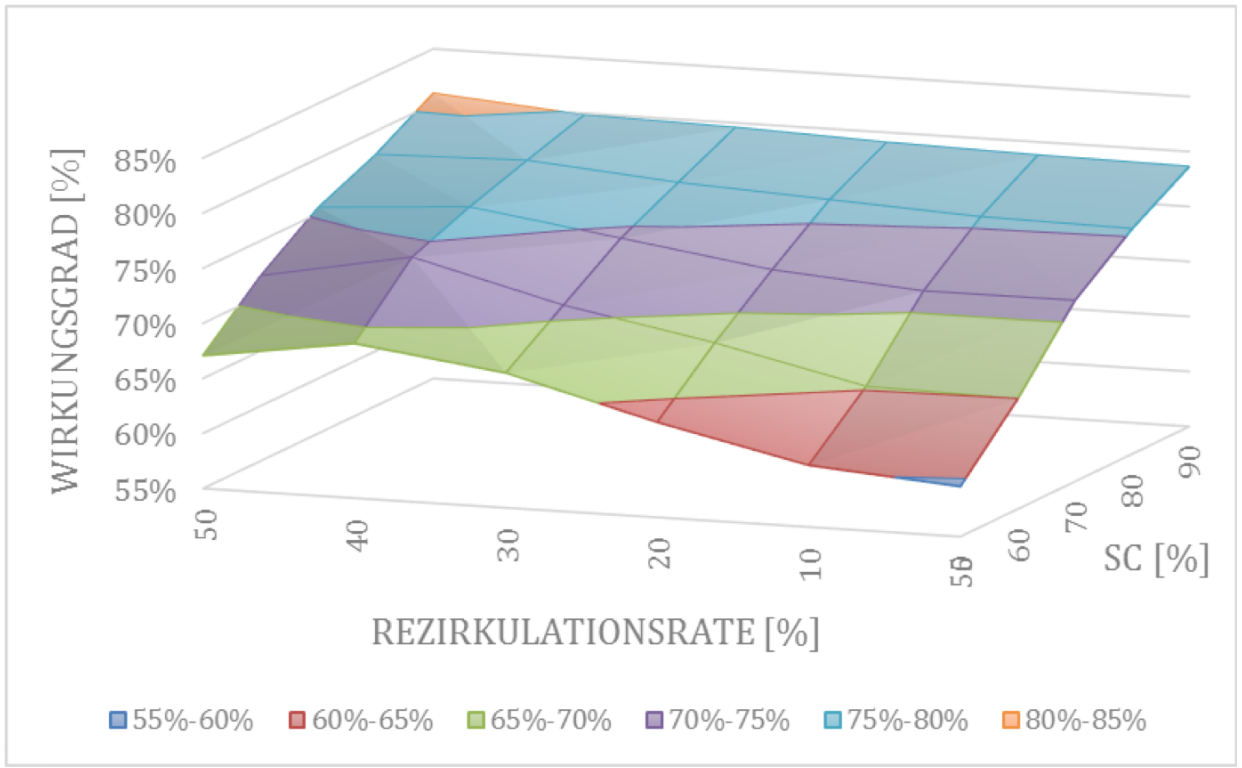
rSOC DEvelopment

AURORA (2016-2019)*

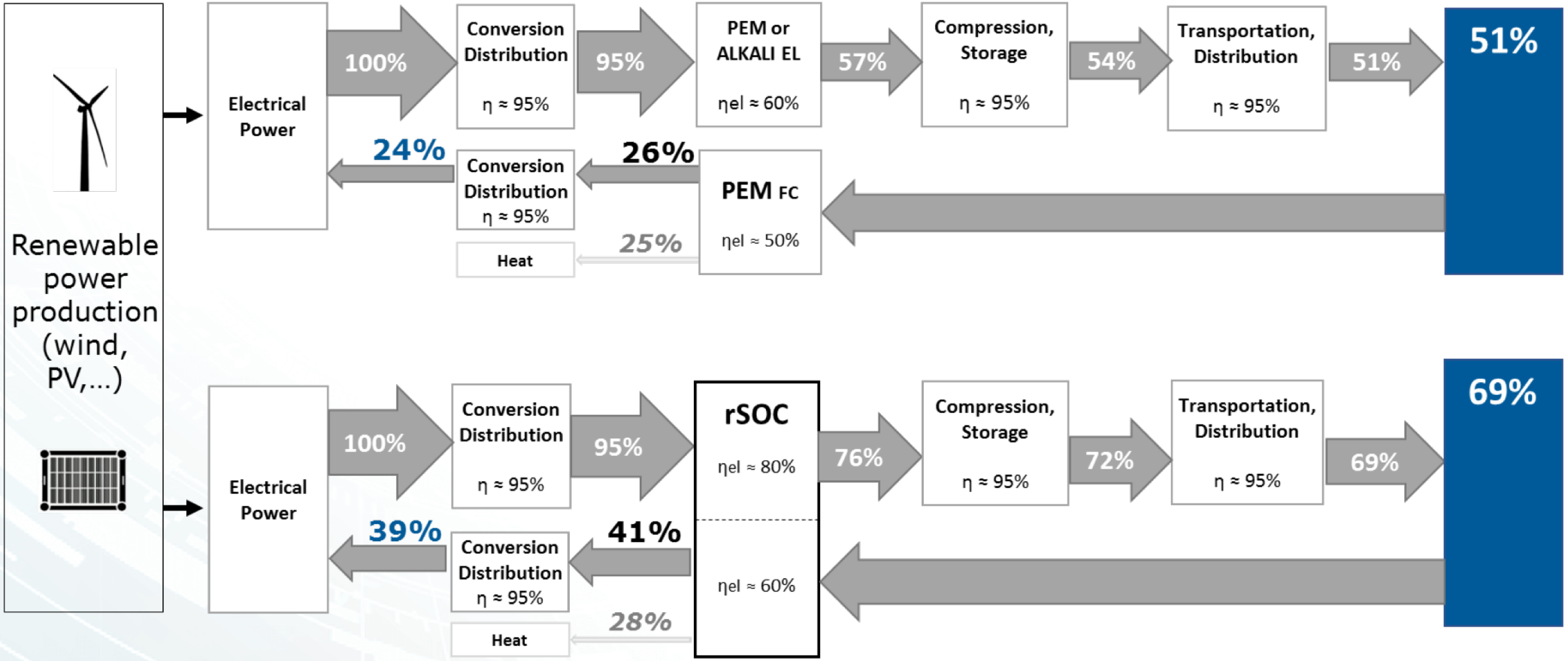
- **Modelling, design and testing of a reversible SOC System (rSOC)**
- **H_2O electrolysis and CO_2 Co-electrolysis for syngas production**
- **H_2 + CH_4 powered FC mode**
- **System with 33kW$_{FC}$ and 100kW$_{EC}$ of total power is designed**
- **1kW$_{FC}$ and 3 kW$_{EC}$ functional verification**

H_2O SOEC Modus



* The research has received funding from the Austrian Research Promotion Agency – FFG#850459

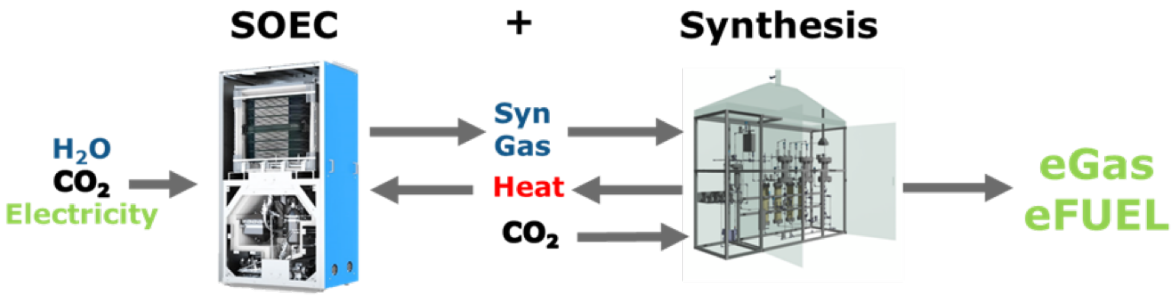
rSOC + methanation Efficiency



Co Electrolysis

HYDROMETHA (2018-2021)*

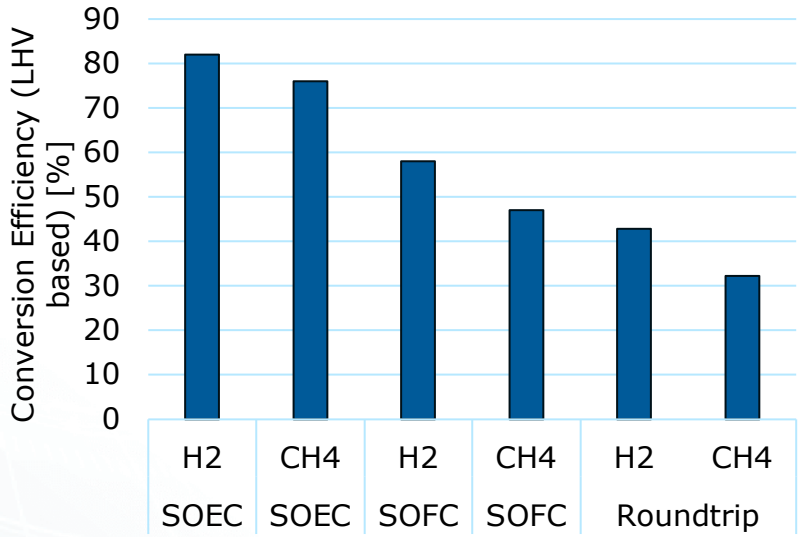
- CO_2 + H_2O Co-electrolysis and system integrated methanation
- CO2+H2O Co-Electrolysis with an overall system efficiency >90%
- Dynamic operation in a load range between 20% and 120%
- Focus on part-load, stand-by and load-following operation
- 10 kW_{EC} functional verification



* The research has received funding from the Austrian Research Promotion Agency – FFG#860947

Summary

- **SOEC proof of concept system with 80%$_{LHV}$ efficiency**
- **rSOC system with optimized heat management - design freeze in Dec. 2017**
- **Target for rSOC system efficiency's:**



- **rSOC system testing will start middle of 2018**
- **HydroMetha, Co SOEC + Methanation project has started 01/2018**

The research has received funding from the Austrian Research Promotion Agency
HYDROCELL: FFG#838770, AURORA: FFG#850459, HYDROMETHA: FFG#860947

Thank You

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