HYMEHC
Thermal Hydrogen Compressors

HYSTORSYS AS | P.O. Box 45 | NO-2027 Kjeller | Norway

February 2018

Achievements

- **Built and operated two *proof-of-concept* MH-compressors**
- **5,000 hours of operation demonstrated**
- **Re-design and cost reduction program completed**
- **New solution ideally suited for e.g.:**
  - **Industries**
  - **RE/H_2**
  - **Bottling of hydrogen**
- **Status: Delivery**

The HYMEHC technology

Unique features of using thermal energy

- **Almost no moving parts (valves)**
  - **Low maintenance cost**
  - **High safety**
- **Silent/vibration less**
- **Flexible installation (can be wall mounted, etc.)**
- **Guaranteed gas purity (impurities are trapped by the metal powder)**
- **Utilization of waste heat**
  - **Almost no energy cost**
  - **Access to geothermal resources**

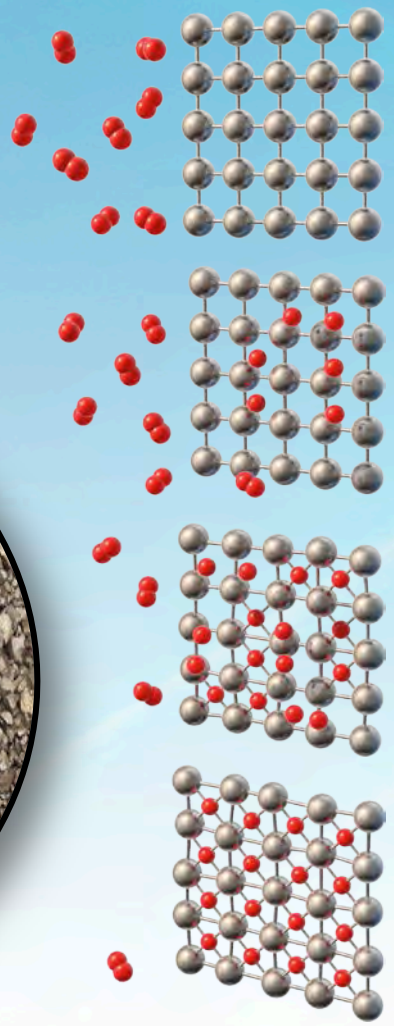
HYMEHC-05

- Capacity: 5 Nm^3/h
- Input pressure: 6 bar
- Output pressure: 200 bar
- 2-stage compressor system

HYMEHC-10

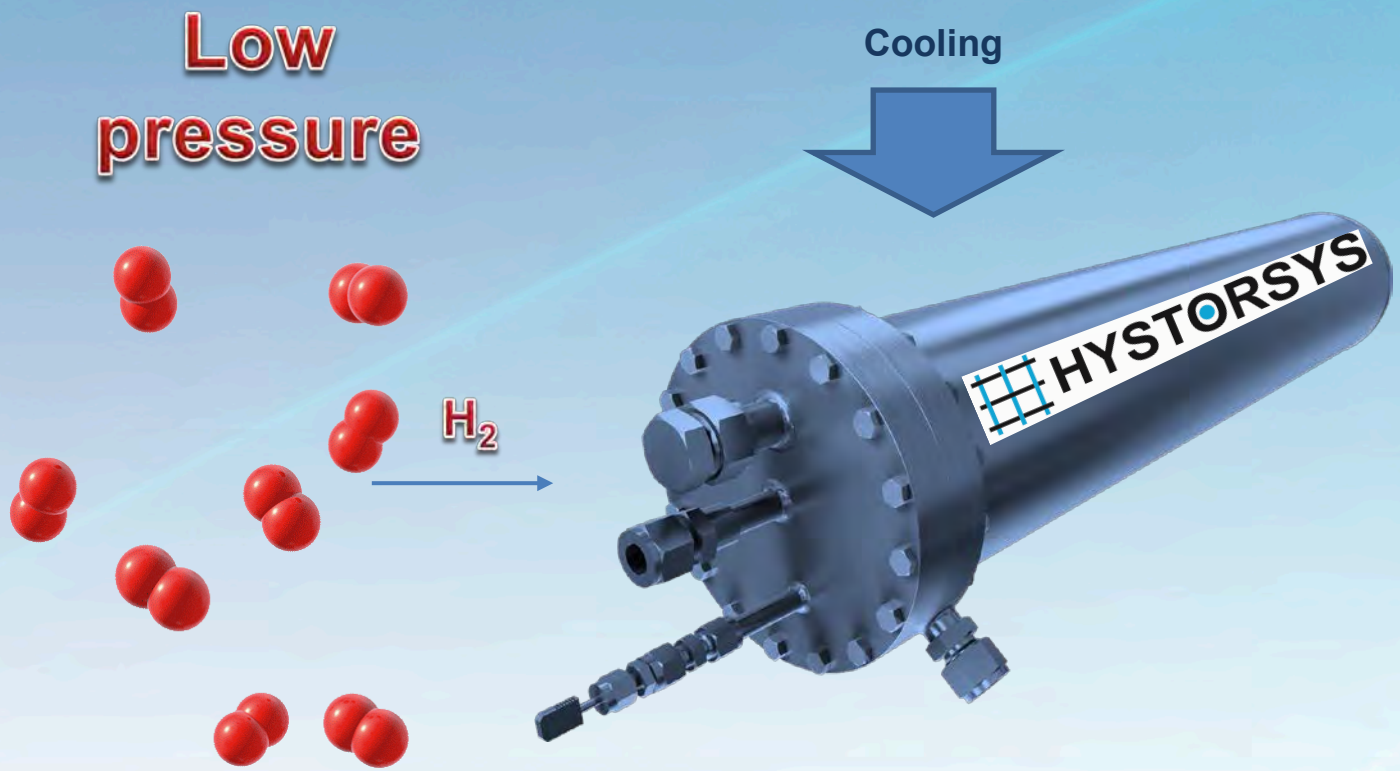
- Capacity: 10 Nm^3/h
- Input pressure: 10 bar
- Output pressure: 200 bar
- 2-stage compressor system

Thermal Hydrogen Compression



Vessel with metal hydride powder inside has a larger hydrogen capacity than an empty vessel…!

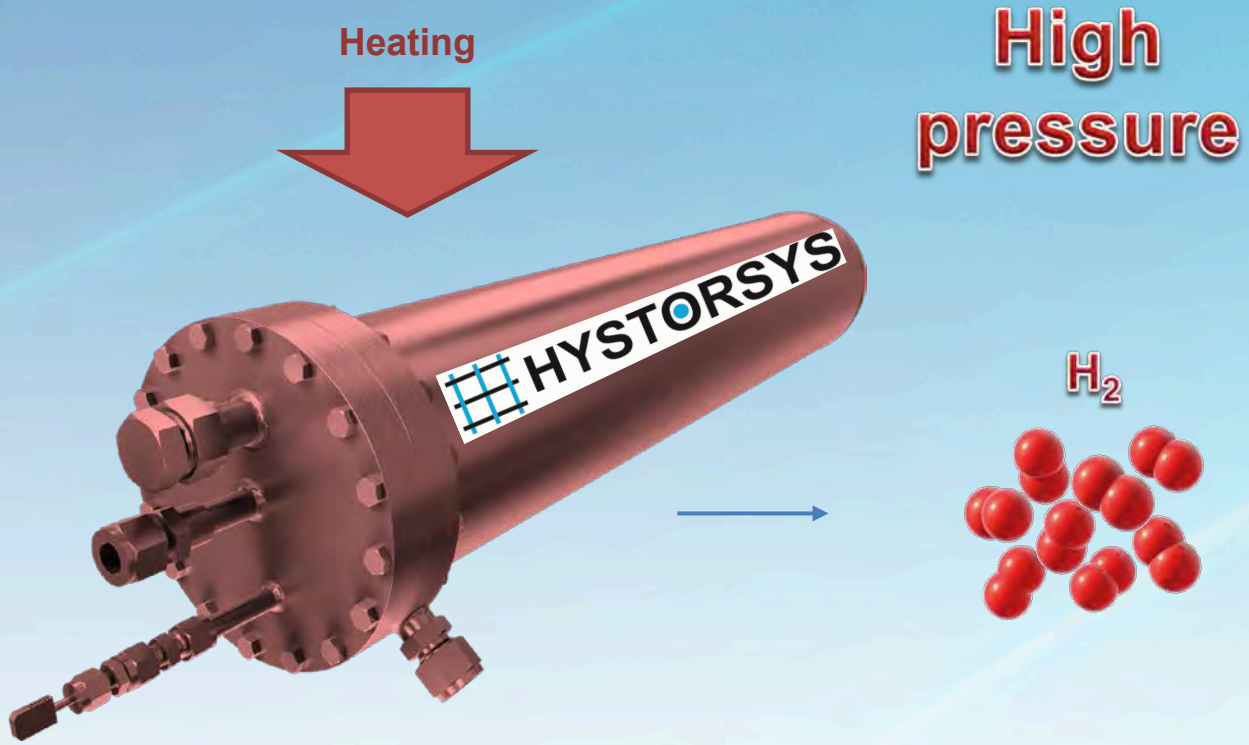
Thermal Hydrogen Compression



Put simple:

By means of a HYMEHC-system from HYSTORSYS low pressure hydrogen gas is transformed into high pressure hydrogen gas by periodically heating/cooling of the metal hydride vessels.

Thermal Hydrogen Compression



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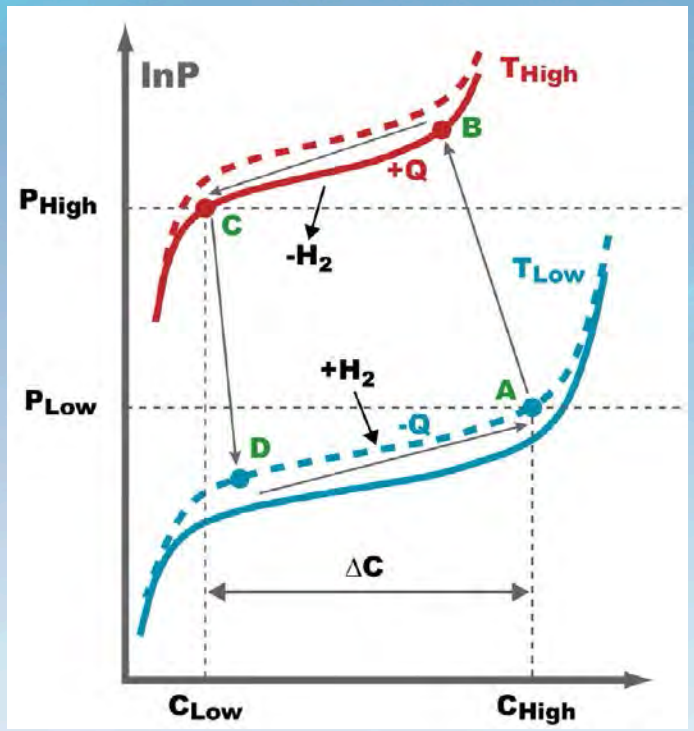
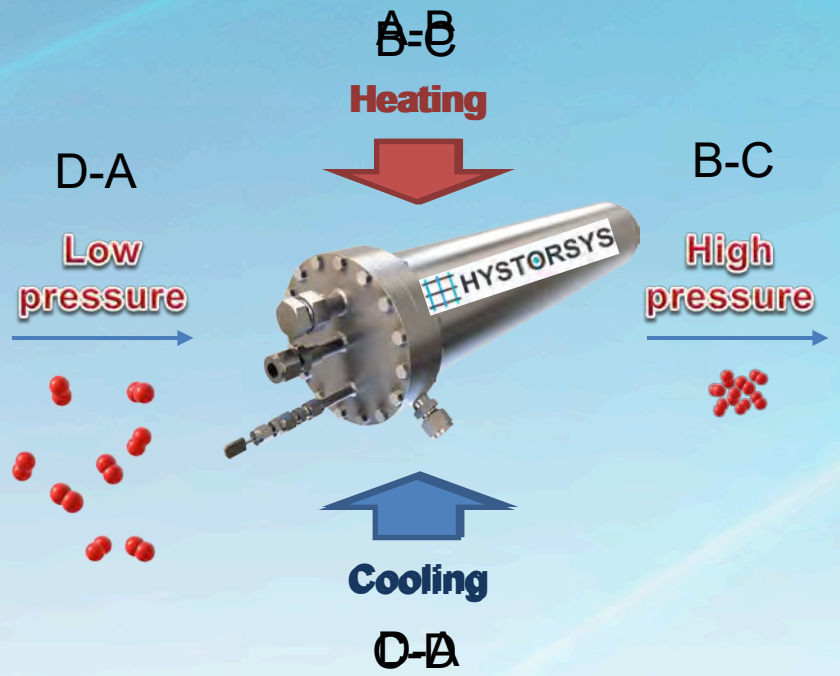


Hydrogen-Concentration



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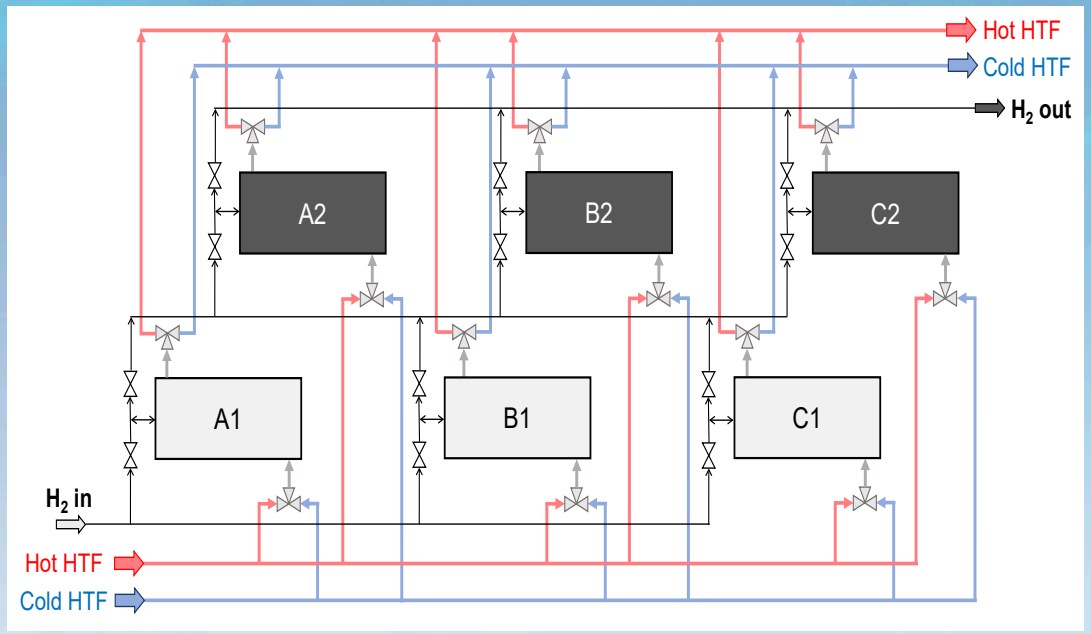
HYPROCOM

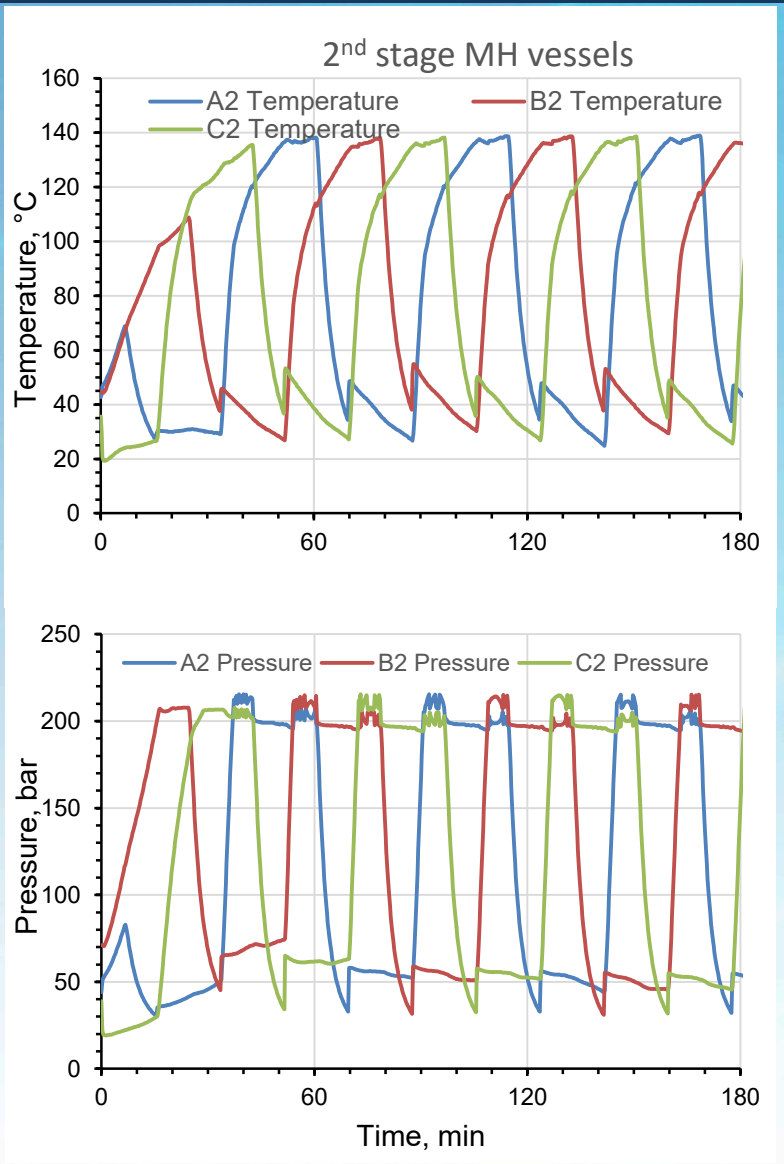
HYMEHC-05

The Eurostars Programme is powered by EUREKA and the European Community

- **Partners**: HyGear, Air Products, IFE and HYSTORSYS
- **Goal**
  - Develop an integrated natural gas based hydrogen production and compression system using steam methane reforming and metal hydride thermal sorption compression
  - **Capacity**: 5 Nm^3/h H_2, 6 → 200 bar

Operational data



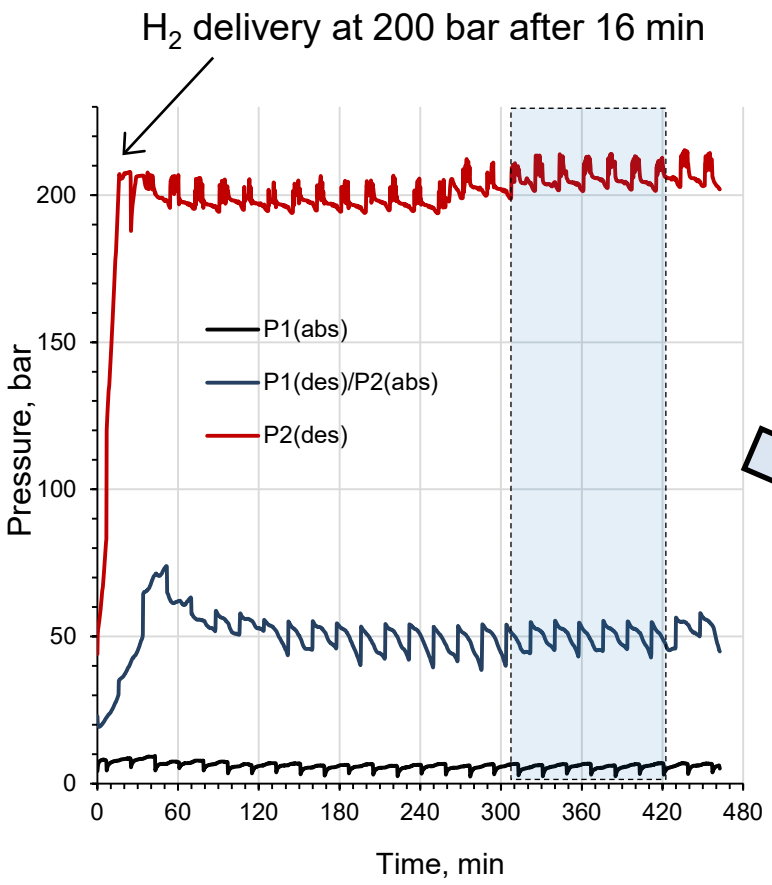


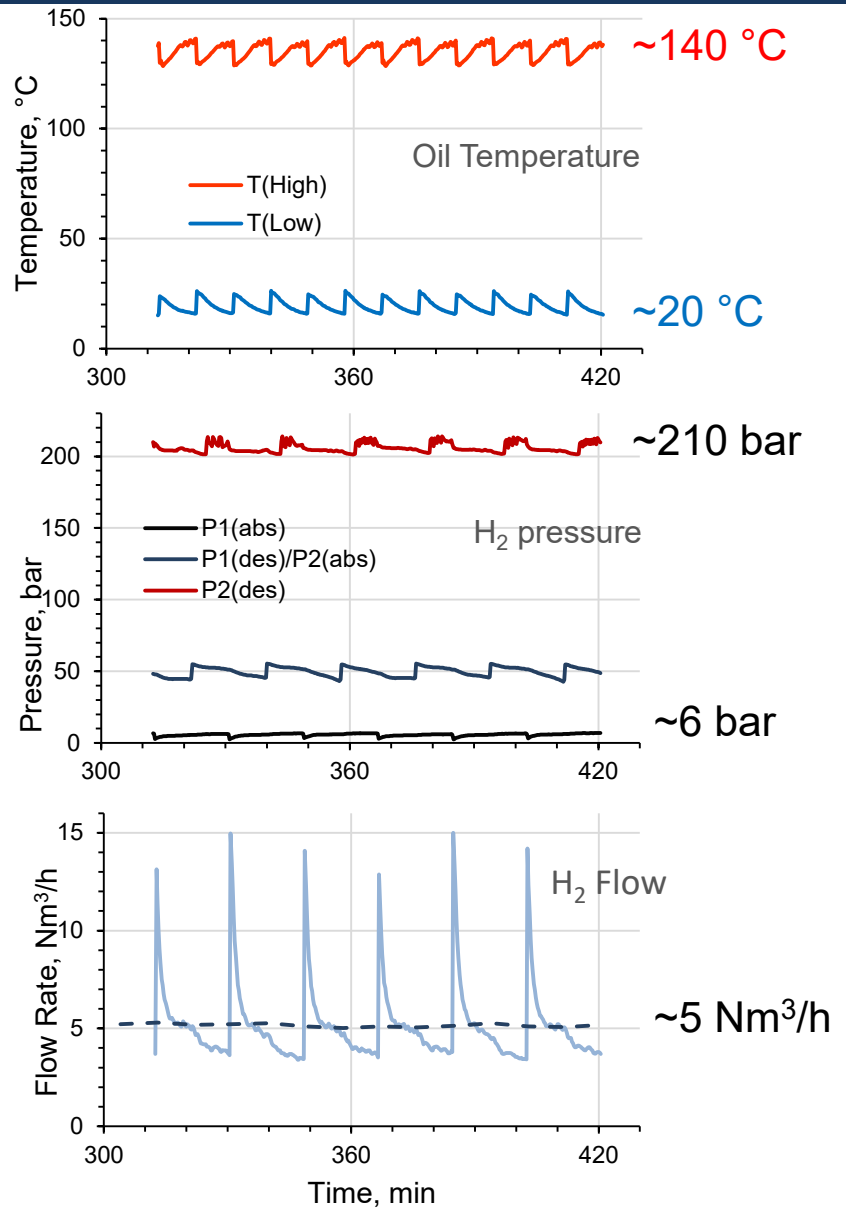
Half Cycle Time: 24-30 min

Operating HTF temperature:
$10 \leq T_{oil} \leq 150$ °C

HTF flow rate: 60 L/min

Operational data HYMEHC-5





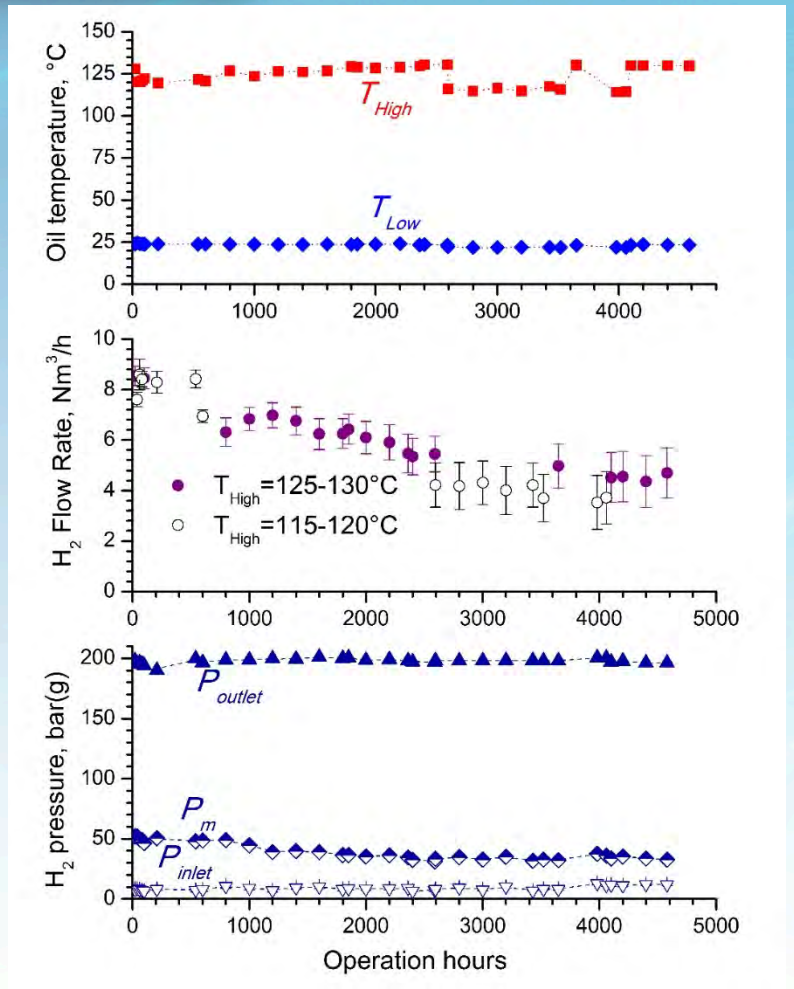
Capacity: **5.1** Nm^3/h

Compression ratio, P_{in}/P_{out}: **35**

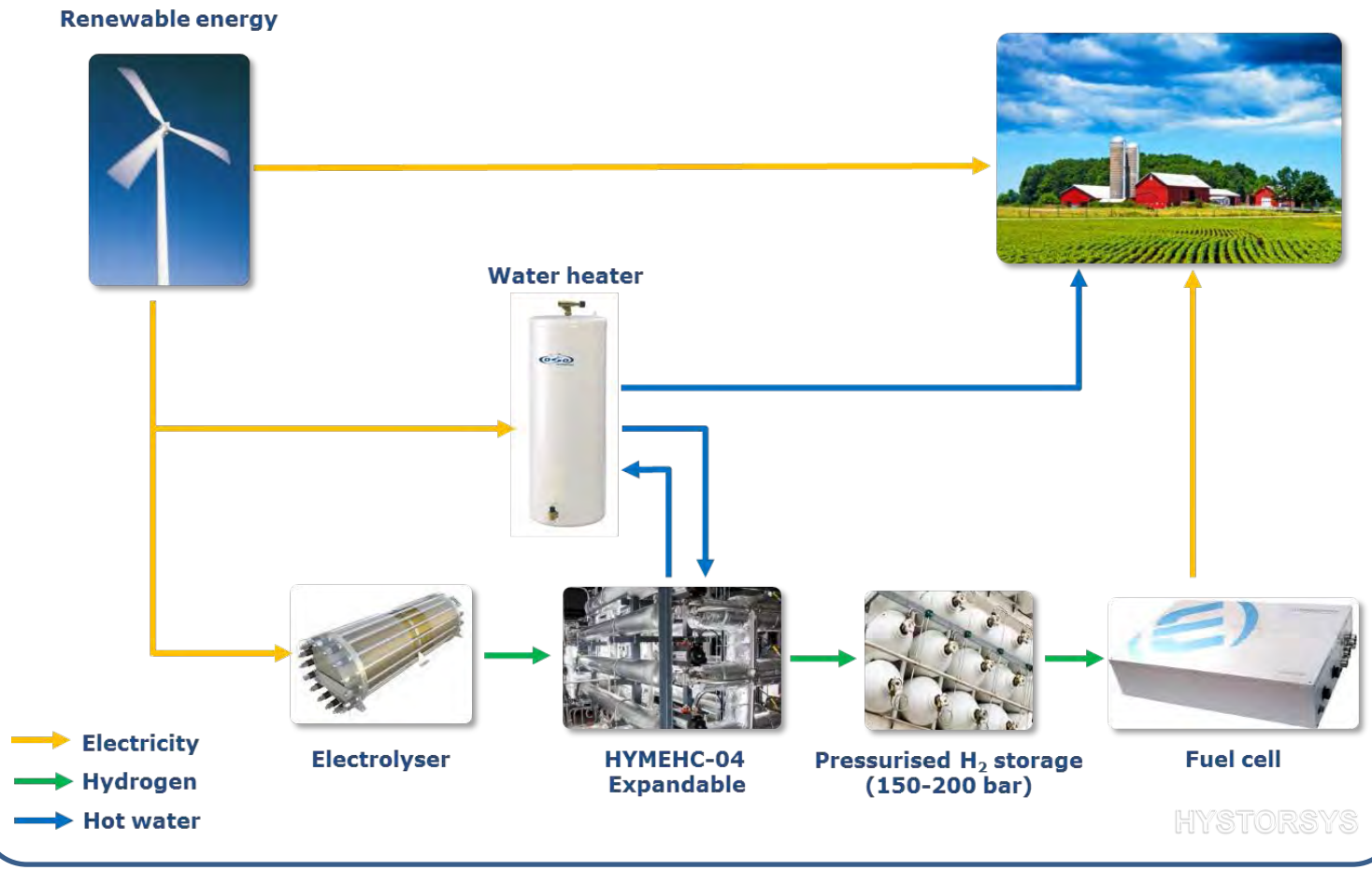
HyNor Lillestrøm

HyNor
Hydrogenveien i Norge

HYMEHC-10



Applications – Example 1

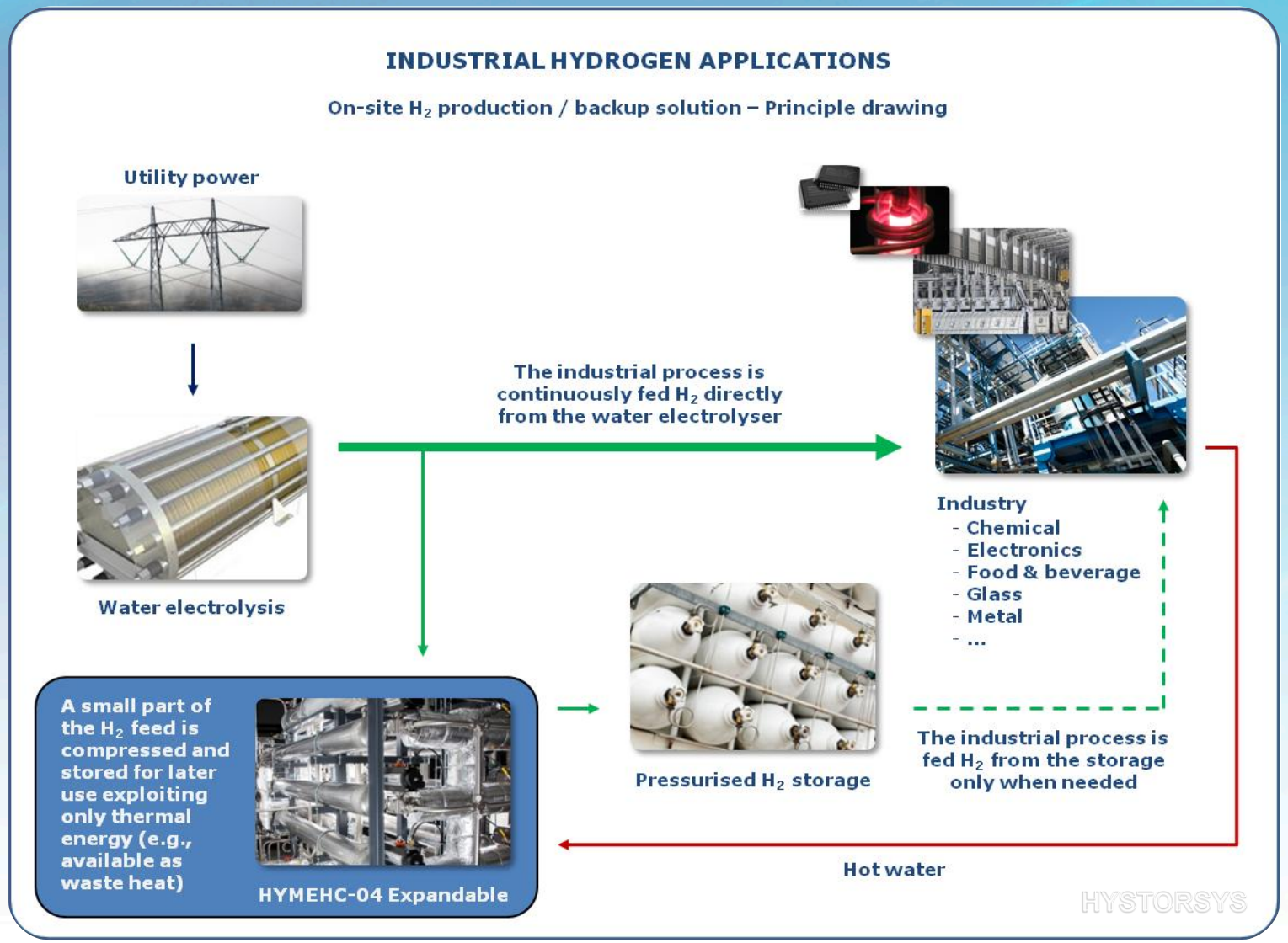


Applications – Example 1

Small-scale / distributed H_2-storage

Input:	The house:	Add-ons:	Hydrogen:
Sun (PV, solar collectors)	All-year power needs covered	BEV (in place)	2 Nm^3/h ELY
Geothermal		FCEV (planned)	2 500 Nm^3 storage

Applications – Example 2



Potential usage – Customers

- **Industrial applications**
  - **Bottling onsite, utilizing waste heat from the industrial process, almost no use of electricity**
- **Storing H_2 from e.g., wind or solar installations**
- **First stage compression at refueling stations**
  - **e.g., HyNor Lillestrøm**
- **In combination with high-temperature fuel cells**
- **Bottling of H_2**
- **Reforming of H_2 – waste heat available**
- **…**

Conclusion

- **Proof-of-concept – completed successfully**
- **R&D activities have proved and improved the technology**
- **The HYMEHC *currently in production* for market deliveries**

→ **Providing a unique way of compressing hydrogen** ←

HYSTORSYS AS

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NORSK INNOVASJONSKAPITAL
Managed by Televenture

company

Selected models – Technical details

Model	Capacity[1], Nm^3/h (SCFM)	Inlet pressure bar (psi)	Compression ratio (-)	Max. pressure bar (psi)	Heating (90°C) / cooling (20°C) water flow rate, L/min (lb/h)
HYMEHC-04	4 (2.5)	2…30 (30…430)	1:10	250 (3600)	26 (3440)
HYMEHC-08	8 (5)	2…30 (30…430)	1:10	250 (3600)	52 (6880)
HYMEHC-12	12 (7.5)	2…30 (30…430)	1:10	250 (3600)	78 (10320)

[1] *Higher capacities available on request.*

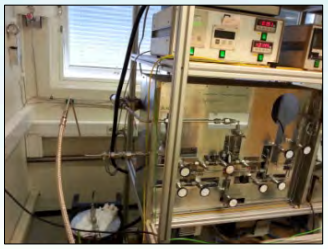
ACCEPTANCES AND CERTIFICATIONS

The HYMEHCs are manufactures in compliance with standards and directives applicable in Europe:

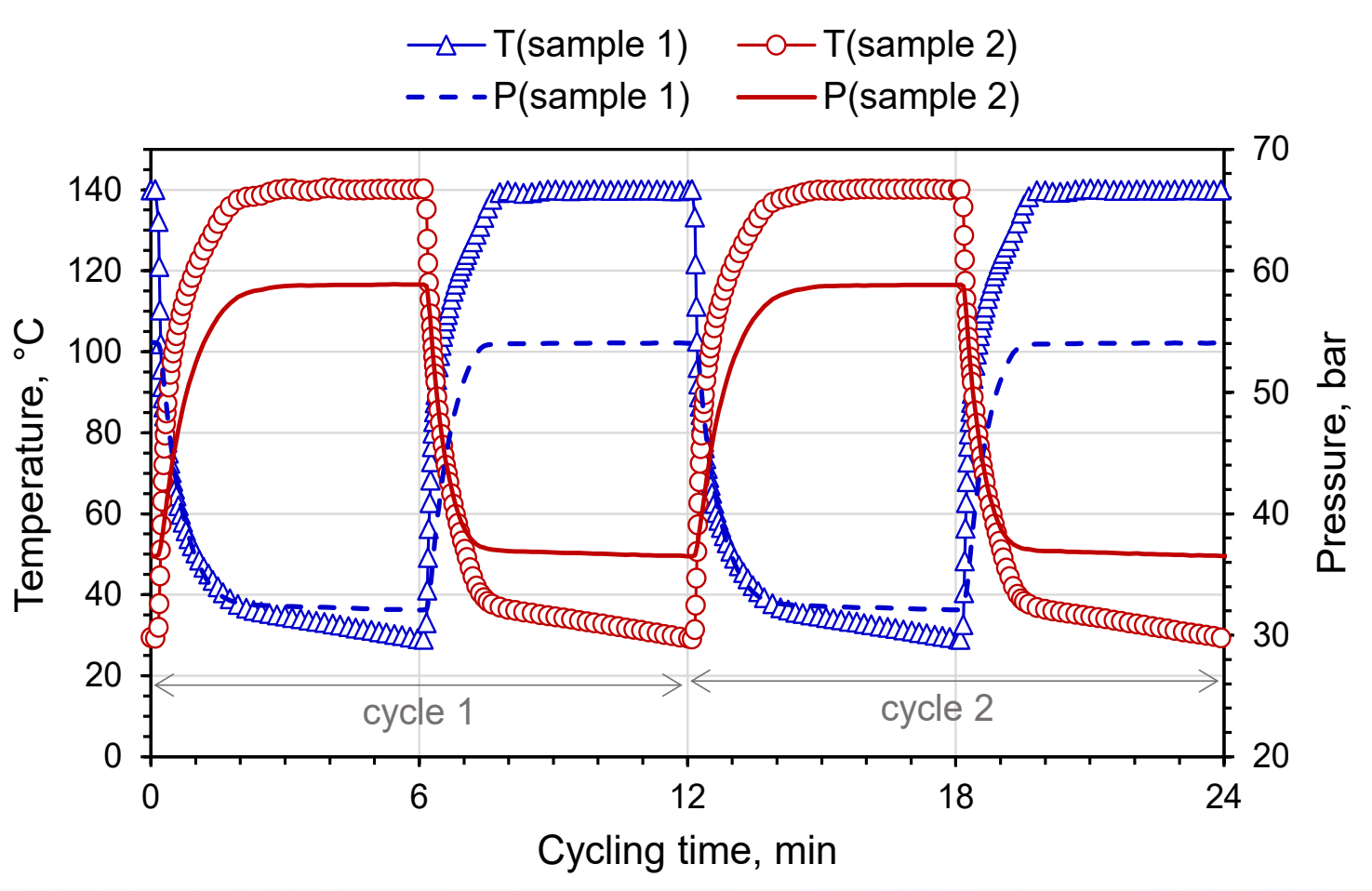
- Directive for Machinery 2006/42/EU
- Pressure Equipment Directive 2014/68/EU
- ATEX Directive 2014/34/EU
- Low Voltage Directive 2014/35/EU

Laboratory Equipment

- **Test rig:**
  - **DACS for testing of larger units**
  - **DA: Temperature, pressure, flow rate**
  - **C: Flow rate (heating/cooling and hydrogen), temperature**
- **Cycling rig:**
  - **DACS for cycling of MH-samples**
  - **DA: Temperature and pressure**
  - **C: Temperature and flow direction (heating/cooling)**
- **PCT and TDS** together with IFE
- **Arc melter / Resistance furnace** together with IFE



MH Sample - Cycling Tests



R&D: Cycle Life and PCT