

H2HP: EFFICIENT HYDROGEN BASED HEAT PUMPS FOR SECTOR COUPLING

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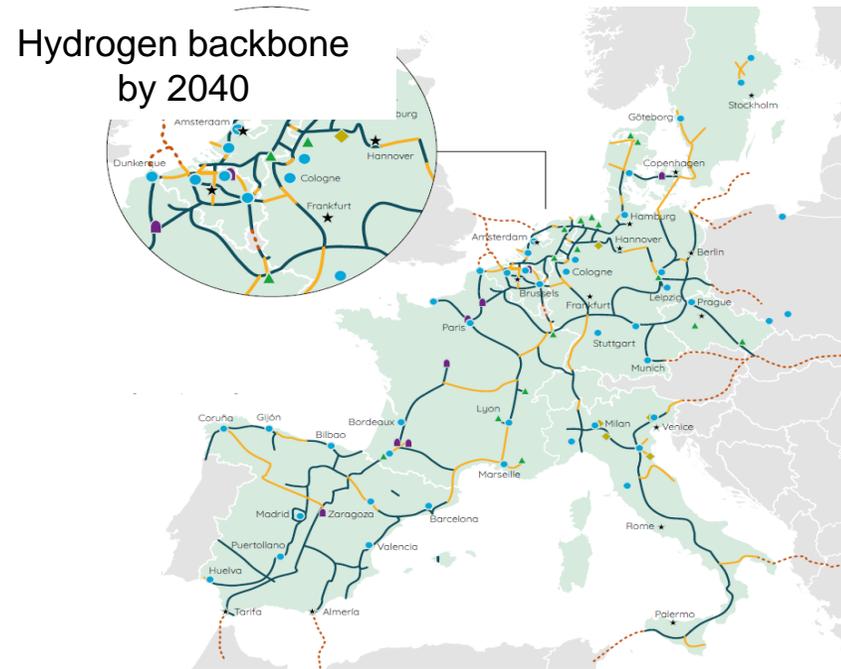
4TunaTES meets its sisters and brothers –creating synergies between EU-projects

Oct. 23rd, 2025, Messina, Italy

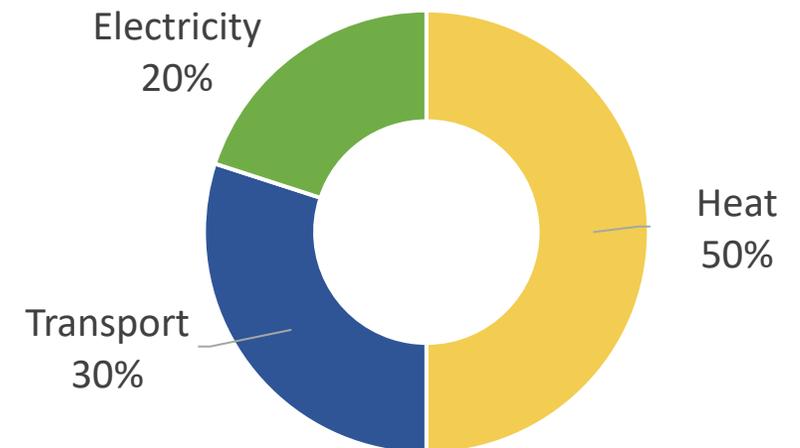


Hydrogen based heat pumps for stationary applications

- Hydrogen infrastructure is expected to increase in the next decade
 - One example is the European H₂ backbone
- Heating/Cooling represent 50% of global energy consumption
 - mainly by fossil fuels (CO₂ emissions)
 - electrification required
 - heat pump technology as option



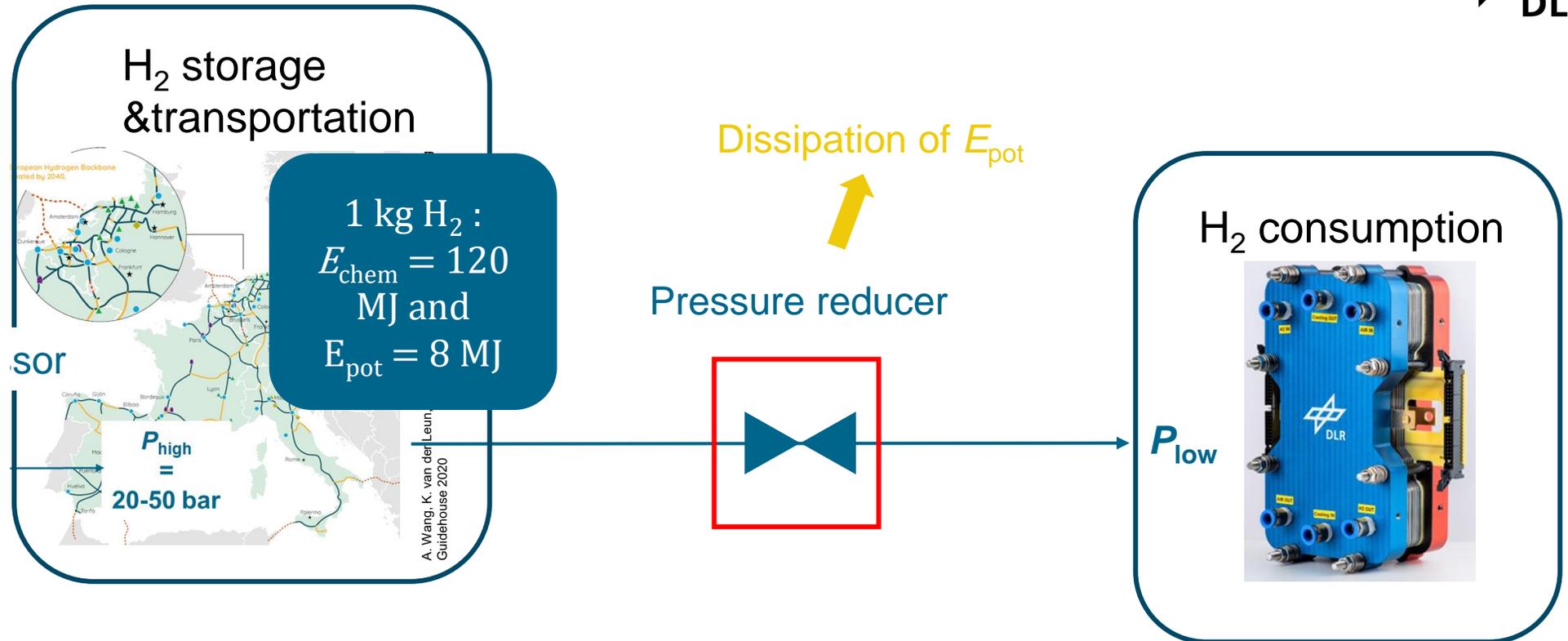
Global Energy Consumption
~116 000 TWh/a



Graph based on data from 2021: <https://www.iea.org/data-and-statistics/data-product/world-energy-balances>

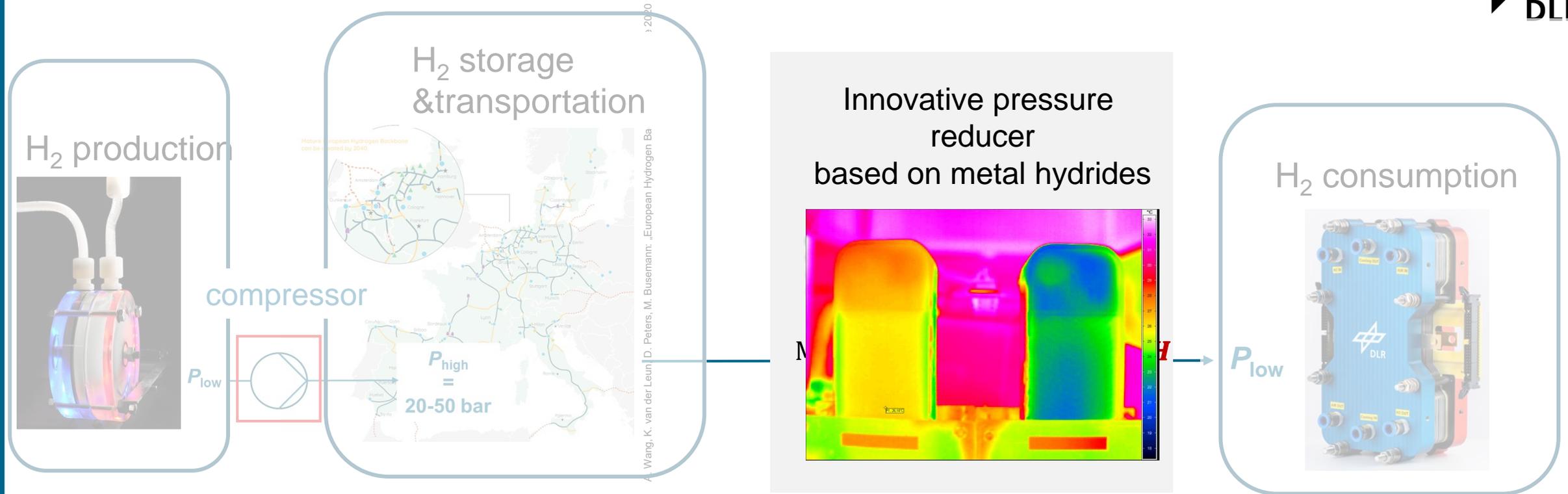
A hydrogen heat pumps is developed for heating or cooling

Idea: combine H₂ infrastructure with heat/cold demand



A. Wang, K. van der Leun, Guidehouse 2020

Integration of Metal hydride heat pump into H₂ infrastructure



GOAL: An innovative pressure reducer as H₂HP

- Make use of (part of) this potential energy for heat pump effects → No H₂ consumption
- Utilize the $T&P$ dependence of the MH-H₂ reaction for a quasi-continuous process
- Heat pump system without need for electricity!

Pre-requisites & Energy savings

Requirements to use energy in H₂ infrastructure:

- H₂ flow rate
- Pressure ratio between supply and consumer:
 $P_{\text{supply}}/P_{\text{cons}} \sim 5$
eg.: Supply: 30 bar, consumer: 6 bar

Energy savings:

- 10 - 30 % of LHV of hydrogen
- ~20% of P_{el} of a fuel cell ($\eta = 0,5$)



Example:

H₂ flow rate: 1 g/s

$P_{\text{inlet}} = 30 \text{ bar}$

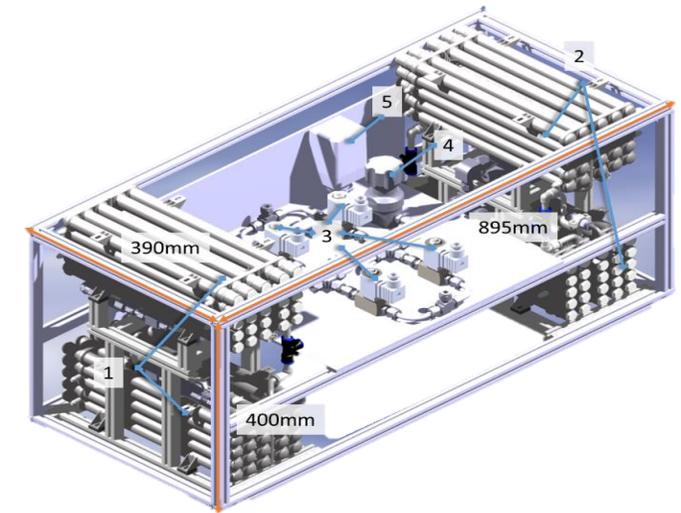
$P_{\text{supply}} = 6 \text{ bar}$

→ 12 kW_{cold} „for free“

System mass + system volume & investment cost: first estimation

15 kW_{cold} system:

- Mass: 24 kg metal hydride
→ system mass: ~ 50 kg
- Volume: 20 L metal hydride
→ system volume: ~ 100 L
- Cost estimation
for small series production: 8000 €

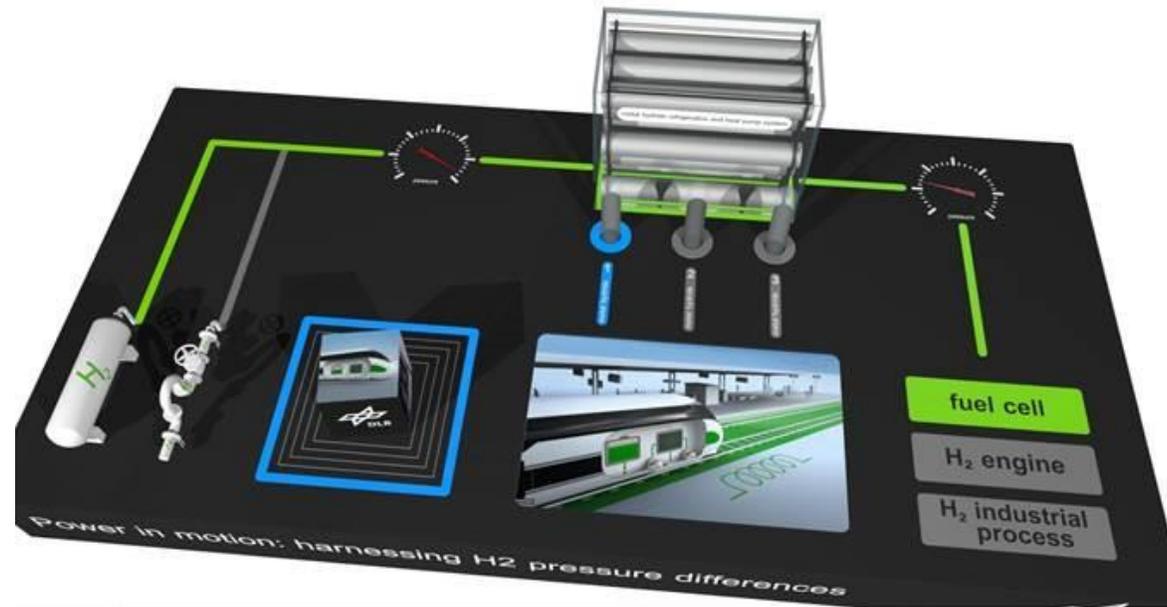


Example:

15 kW cold using a conventional AC → 7,5 kW_{el}
Electricity price: 0,2 €/kWh
Operating hours/year: 3750 h/year

→ Savings/year: 5600 €/year

H2HP: Summary of features



Features of H2HP:

- Pressure ratio of 5 \rightarrow Temperature lift: $\Delta T \sim 30\text{-}50\text{ K}$
- Material selection \rightarrow adapt T -range
- 10-30% of LHV_{H_2} can be „pumped“
- In case of continuous H_2 consumption \rightarrow fast return on invest

Current status of the technology at DLR

- >10 Years of development
→ Focus on mobile application
- 9 scientific journal papers
- 5 tested prototypes
- 4 patents

✓ integration project on a train platform → TRL 6

Looking for partners for stationary integration !

Material qualification



component development



Wimmer A, Applied Thermal Engineering, 241 (2024) 122250
Wimmer A, Applied Energy, 391 (2025) 125911

System testing



Weckerle, Bürger et al., Applied Energy 256 (2019), 113958

Technology demonstration



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THANK YOU

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