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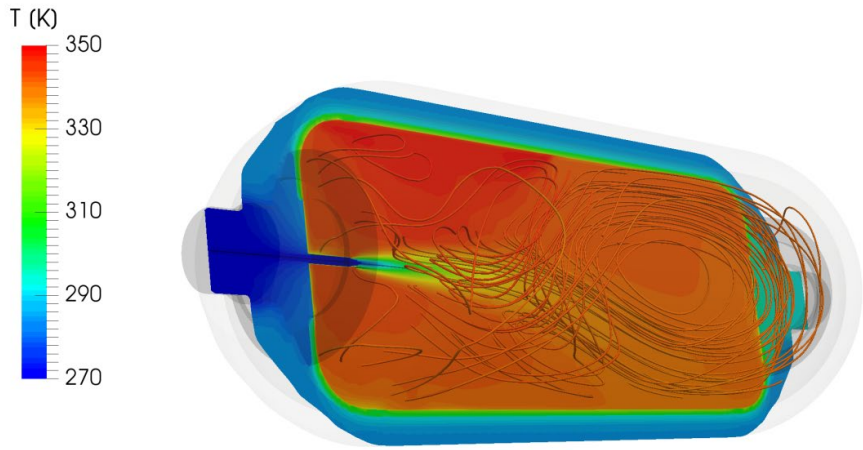
Materials Science and Technology

Efficient Hydrogen Fueling «eHF»

Research in the Field of Gaseous Hydrogen Refueling to Reduce the Energy Consumption of Filing stations



Patrick Stadelmann
Research Scientist, Automotive Powertrain Technologies

eHF on one slide

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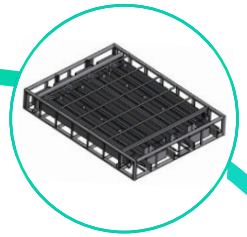
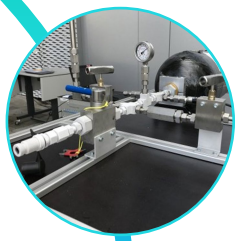
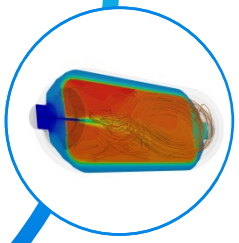
Research in the field of gaseous hydrogen refueling to reduce the energy consumption of hydrogen refueling stations



Analysis of an existing pre-cooling system



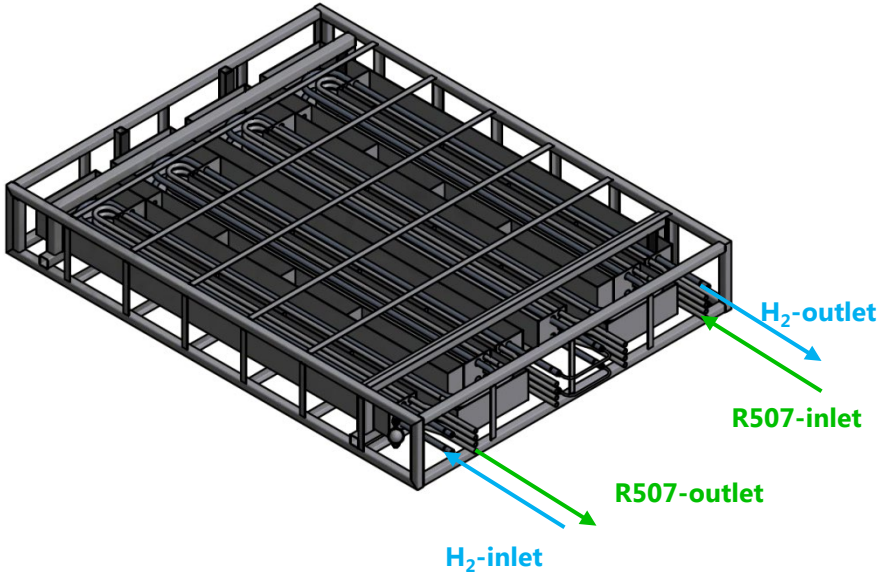
Experimental set-up to measure the temperature development in the vehicle tank

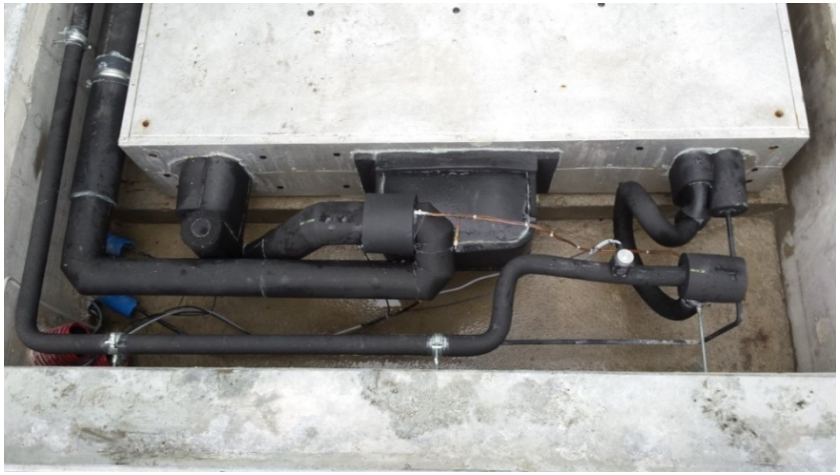


Numerical investigation of hydrogen refueling

Recommendation for energy-efficient fueling scenarios

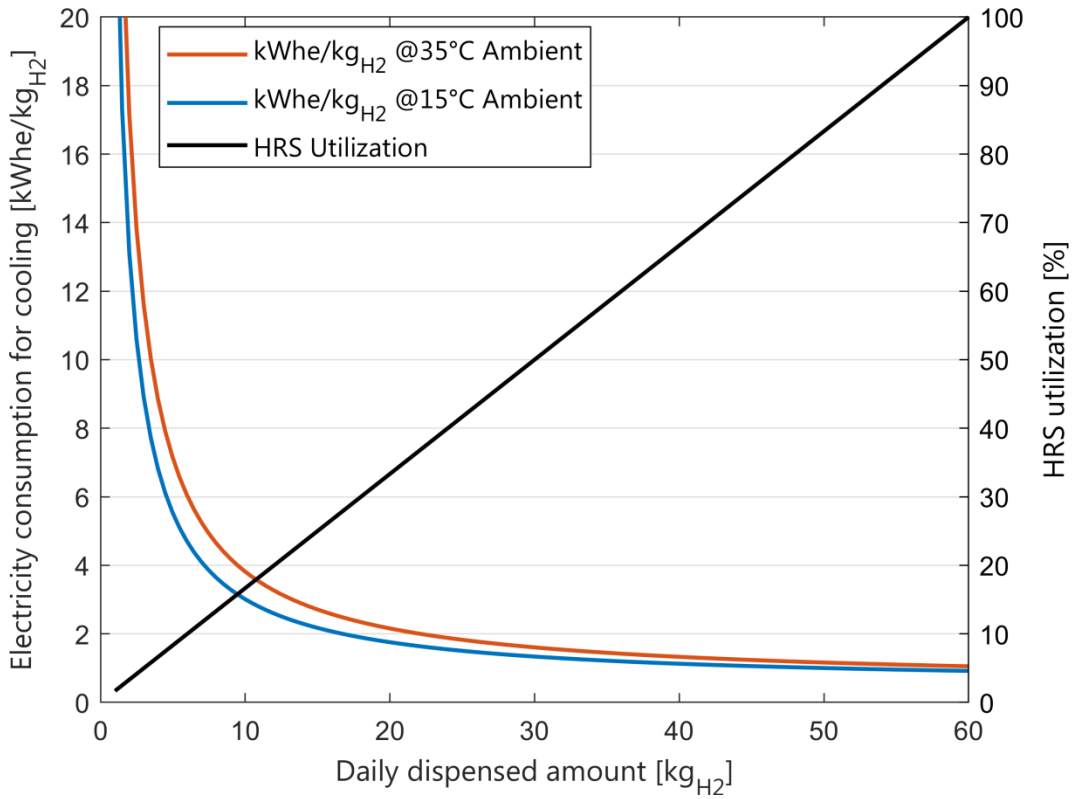
Refrigeration system at Empa





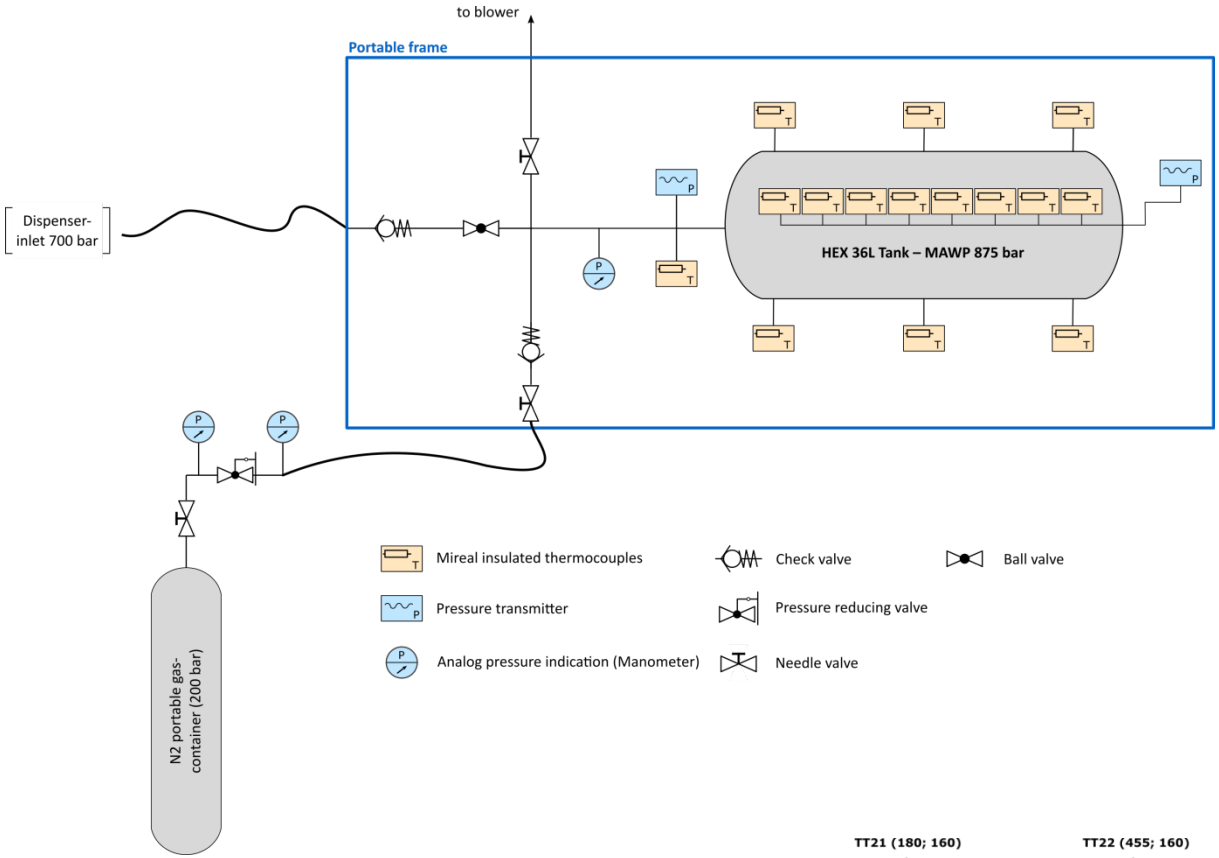
- Dimensions (l x w): 1.875 x 2.45m
- Cooling capacity: 12 kW_{el}

Electrical energy demand of the refrigeration system at Empa



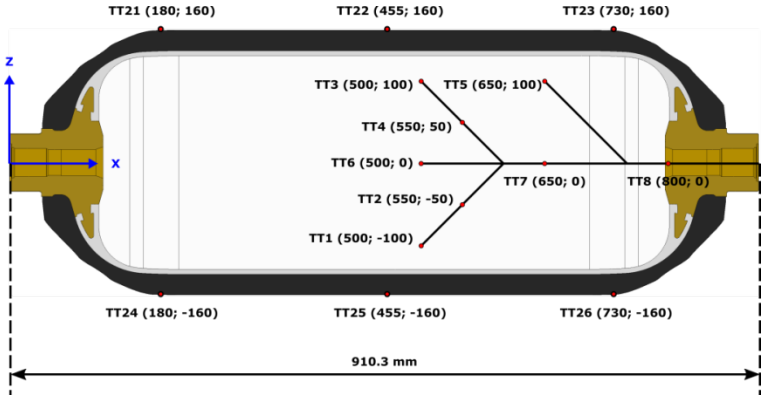
- At high refueling station capacity utilization, the electricity consumption for H_2 precooling is ~1 kWhe/kg$_{H2}$

Experimental test setup

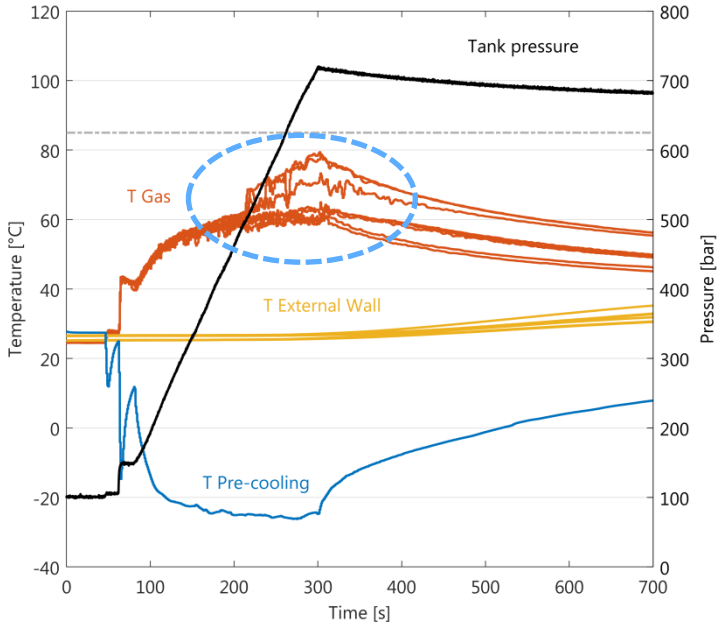


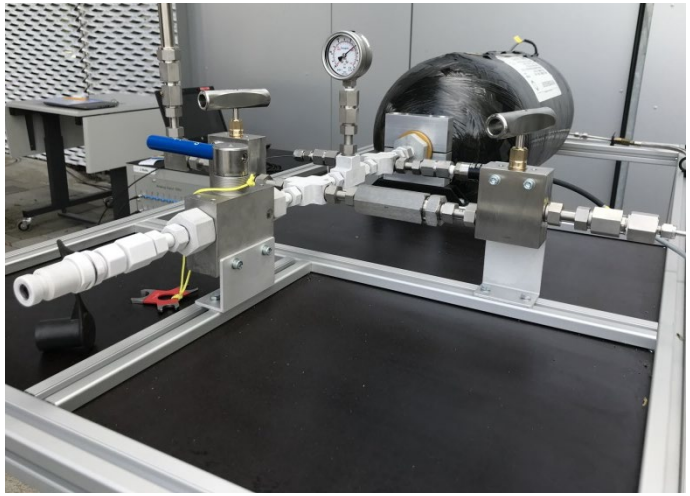
Additional measuring points at the HRS

- Mass flow rate
- Ambient temperature
- Energy consumption of the pre-cooling



1st measurement campaign





Item	Result	
Temperature in the tank	Initial tank	**24.75°C**
	Max. tank	**79.5°C**
Pressure	Initial	**10.6 MPa**
	Final	**71.7 MPa**
Fueling time	Customer reference	**239 s**
Pressure ramp rate controllability	Ambient T	**28.4 °C**
	Target APRR	**15.4 MPa/min**

CFD modeling

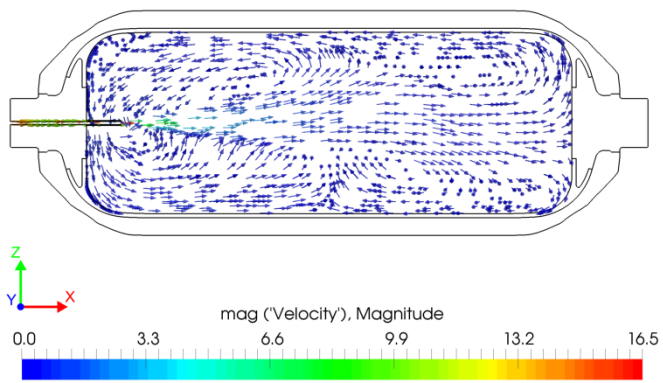
- The fueling process was simulated with OpenFOAM

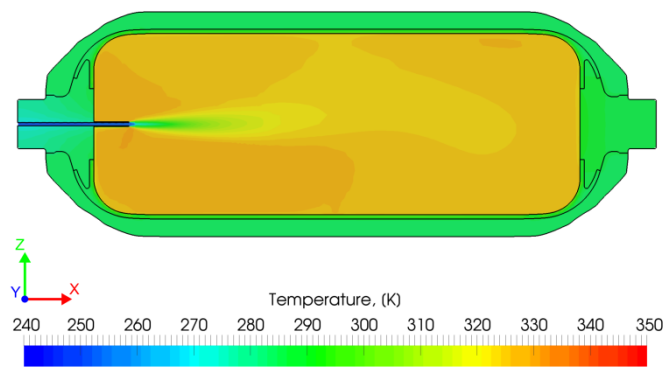
  Pros:

  - Very refined 3D simulations
  - Provide local temperature fields in the gas, liner, and composite

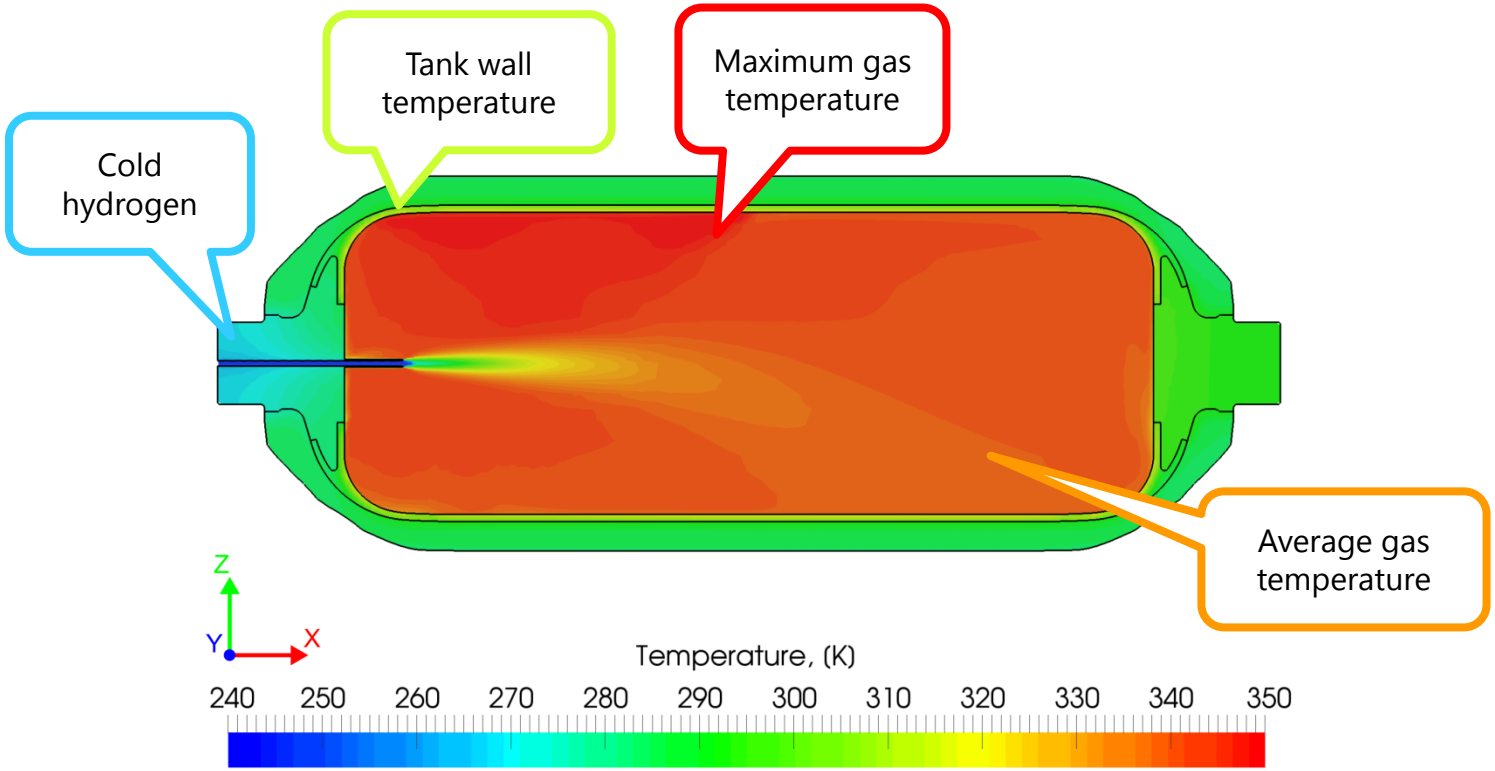
  Cons:

  - Time-demanding simulations: ~ up to 3 week for a filling simulation
- The model includes only the vessel, no other components such as pipes etc. have been considered
- Example of results: filling of type IV 36 l tank





Heat exchange gas/wall



Tanks are allowed to be operated from -40°C to +85°C.

- The position of the temperature is crucial as no bulk temperature exists during refuelling

Next steps

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- Complete validation of the CFD model
- Conduct sensitivity studies to investigate the influence of various parameters on temperature development during refueling

Acknowledgements

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Thank you for your Attention!

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