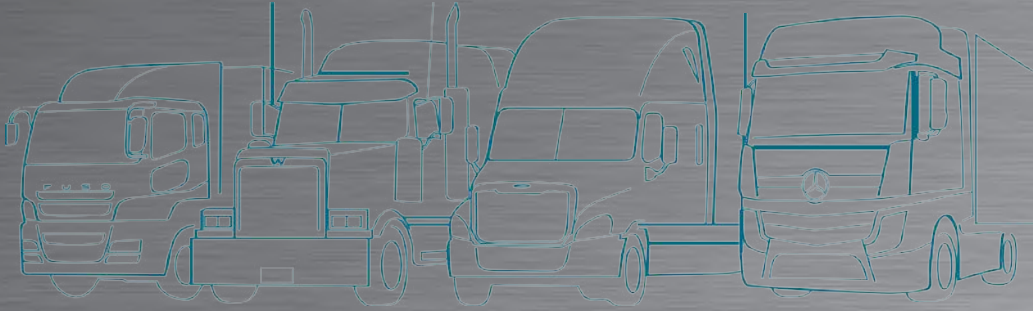


DAIMLER



Technology Pitch: Subcooled Liquid Hydrogen (sLH2)

Linde Hydrogen FuelTech, Dr. Simon Schäfer
Daimler Trucks Advanced Engineering, Dr. Steffen Maus

NOW & CEP Heavy Duty Event, April 21st , 2021



Agenda

- 1) Advantages of the sLH2 Fueling Station
- 2) Advantages of the sLH2 Vehicle Tank System
- 3) Detailed Fueling Process Description
- 4) Summary

sLH2 Fueling Stations for heavy duty land vehicles

Main characteristics of sLH2 Fueling Stations:

- Filling of subcooled LH2 at approx. 26 K into a vehicle tank to pressures up to 1.6 MPa
- Advancement of known technology LH2 filling (at pressures up to 0.6 MPa)
- sLH2 Filling offers many advantages over LH2 filling
- Allows high flow fueling ($> 400 \text{ kg H}_2/\text{h}$) with very low TCO
- Linde and Daimler collaborate on making sLH2 the leading heavy duty H2 technology
- sLH2 Fueling Process and Interface shall be standardized in open CEP working groups

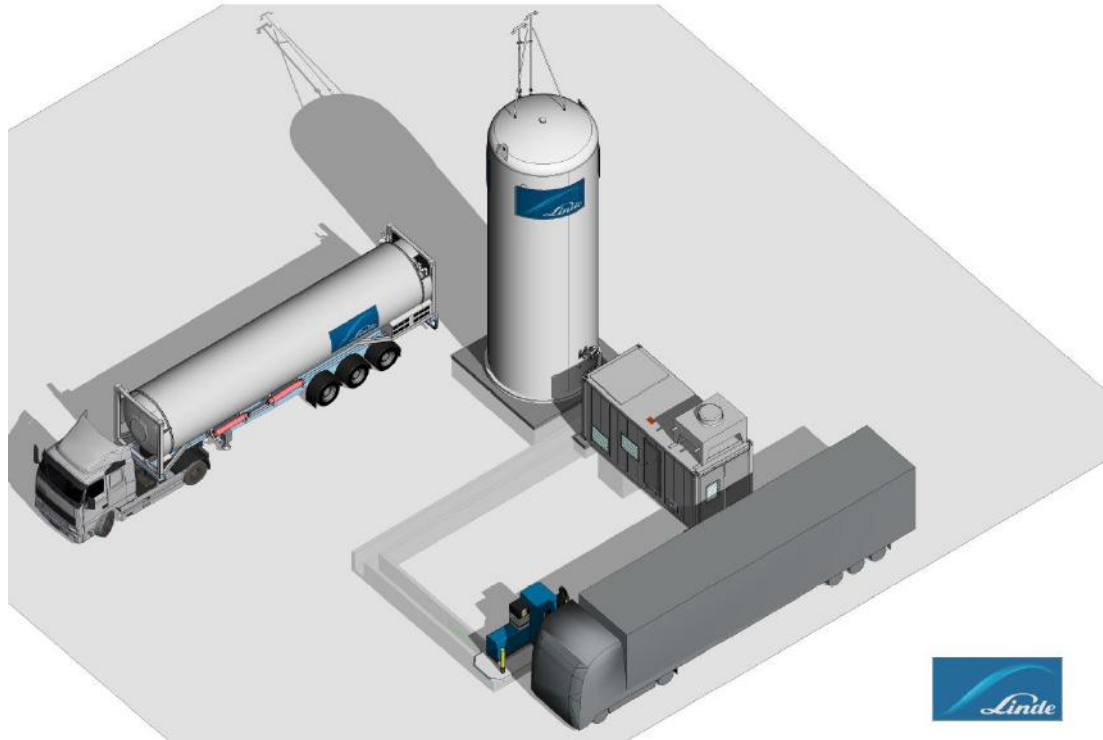


Guildford, UK, December 10, 2020 - Linde (NYSE: LIN; FWB: LIN) has signed an



Press Releases in December 2020

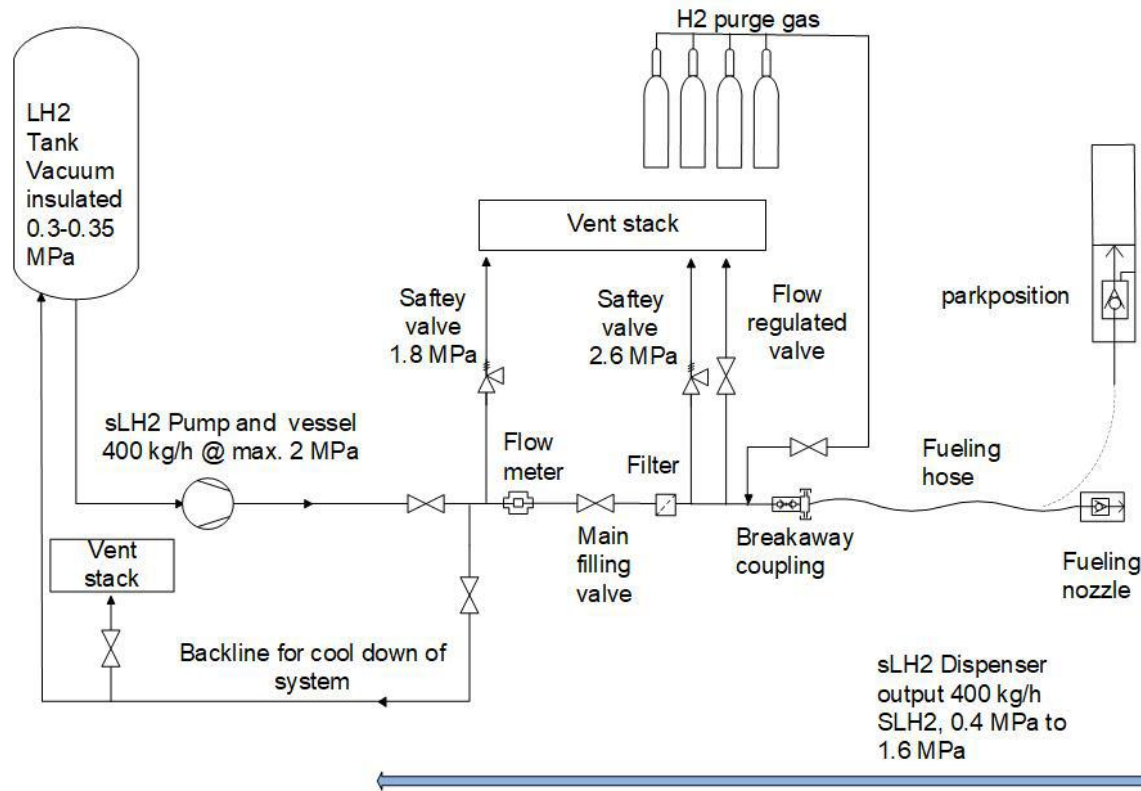
sLH2 Fueling Stations offer key advantages



Layout of sLH2 Fueling Station

- 400-500 kg/h flow rate per sLH2 pump
- 4.000 kg LH2-storage Tank
- Total energy demand 0.05 kWh/kg dispensed (compared to 1.5 kWh/kg for 70 MPa GH2 fueling with Linde Cryopump CP90/100)
- Back-gas free single flow fueling
- No data transmission necessary
- Stop of fueling at target pressure of 1.6 MPa
- Fueling of multiple vehicle tank in parallel
- Fueling capability 4.000 kg / 10 h (continuous, back to back, upgradable)
- Low station footprint (50 m² w/o dispenser)
- Low TCO

Main Process Parameters of sLH2 Fueling Stations



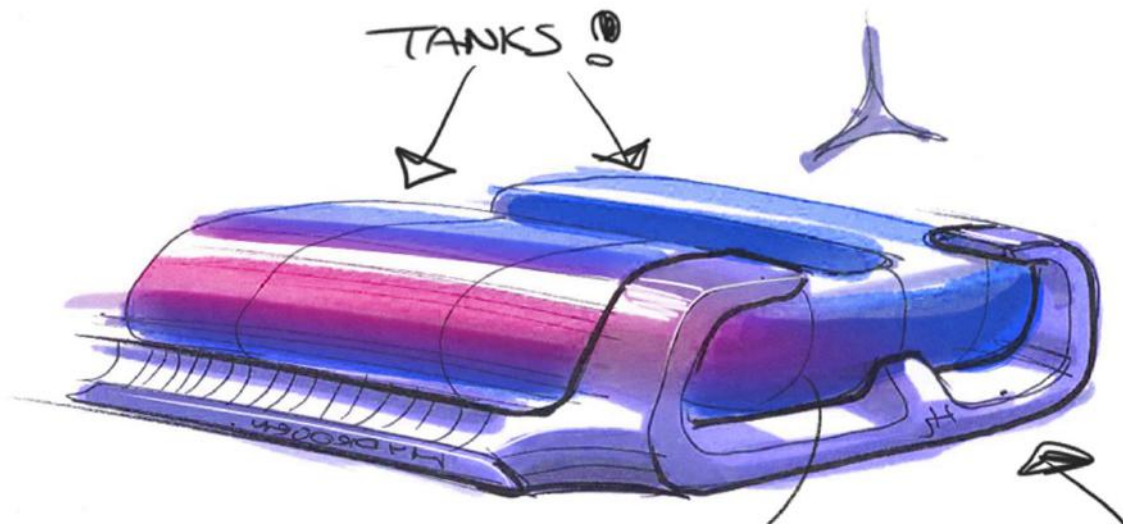
Flow Diagram of sLH2 Fueling Station

- Average fueling time 10 - 15 minutes
- Safety valve at sLH2 pump: 1.8 MPa
- Safety valve at hose and nozzle: 2.6 MPa
- Dedicated H2 purging of hose and nozzle
- Backline for cool down of system
- Pressure corridor of sLH2 fueling is typically between 0.4 MPa to 1.6 MPa
- Automatic cool down of warm vehicle tanks
- Low design pressures allow to use standard components with low wall thickness, good insulation and small dimensions

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sLH2 Tank System is engineered for efficient Usage



Key Specification

MAWP (Maximum Allowable Working Pressure) between 2.0 MPa(a) to 2.5 MPa(a)

Vacuum insulated lines between receptacle and tank for simultaneous filling of multiple vehicle tanks

Low design pressures allow the use of stainless steel containers without additional reinforcement

No data communication to fueling station needed for safe fueling process, e. g. stop of filling at 1.6 MPa(a)

sLH2 Tanks enable high Driving Range for Long Haul Trucks



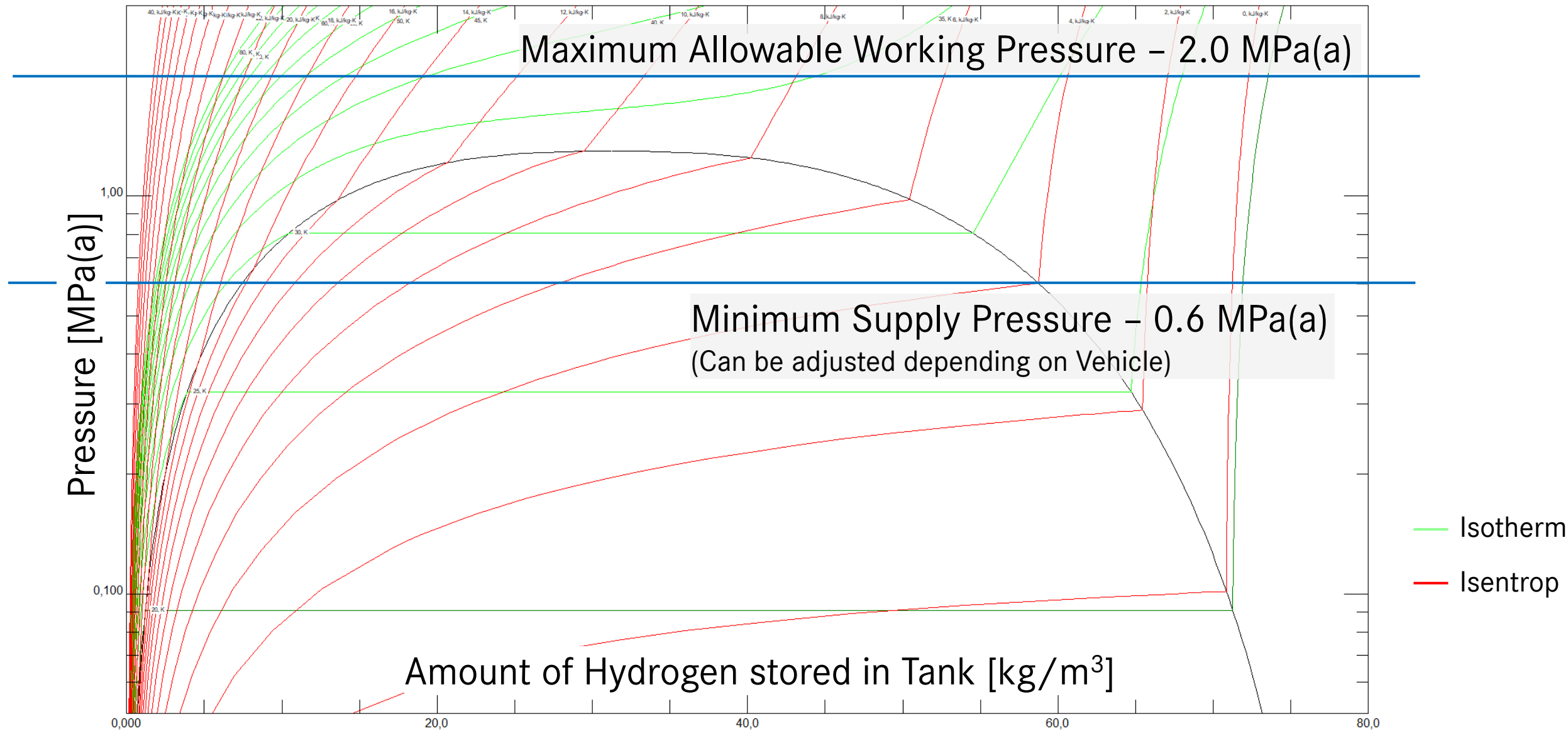
sLH2		
<i>Operating Pressure</i>	0.4 .. 0.8 MPa (adjustable via software)	
<i>Total Tank Volume (2500 x 710 mm incl. BoP)</i>	ca. 760 l	
<i>Max. Filling Level</i>	100%	
<i>Net Usable H₂ in 2 Tanks</i>	up to 88 kg	
<i>Multiple Tanks</i>	Fueling via one connection	
<i>Hold Time⁽¹⁾</i>	@100 %	10 h
	@ 80 %	130 h
	@ 50 %	200 h
	@ 20 %	130 h

⁽¹⁾ Assuming 5W heat transfer and depending on operating pressure

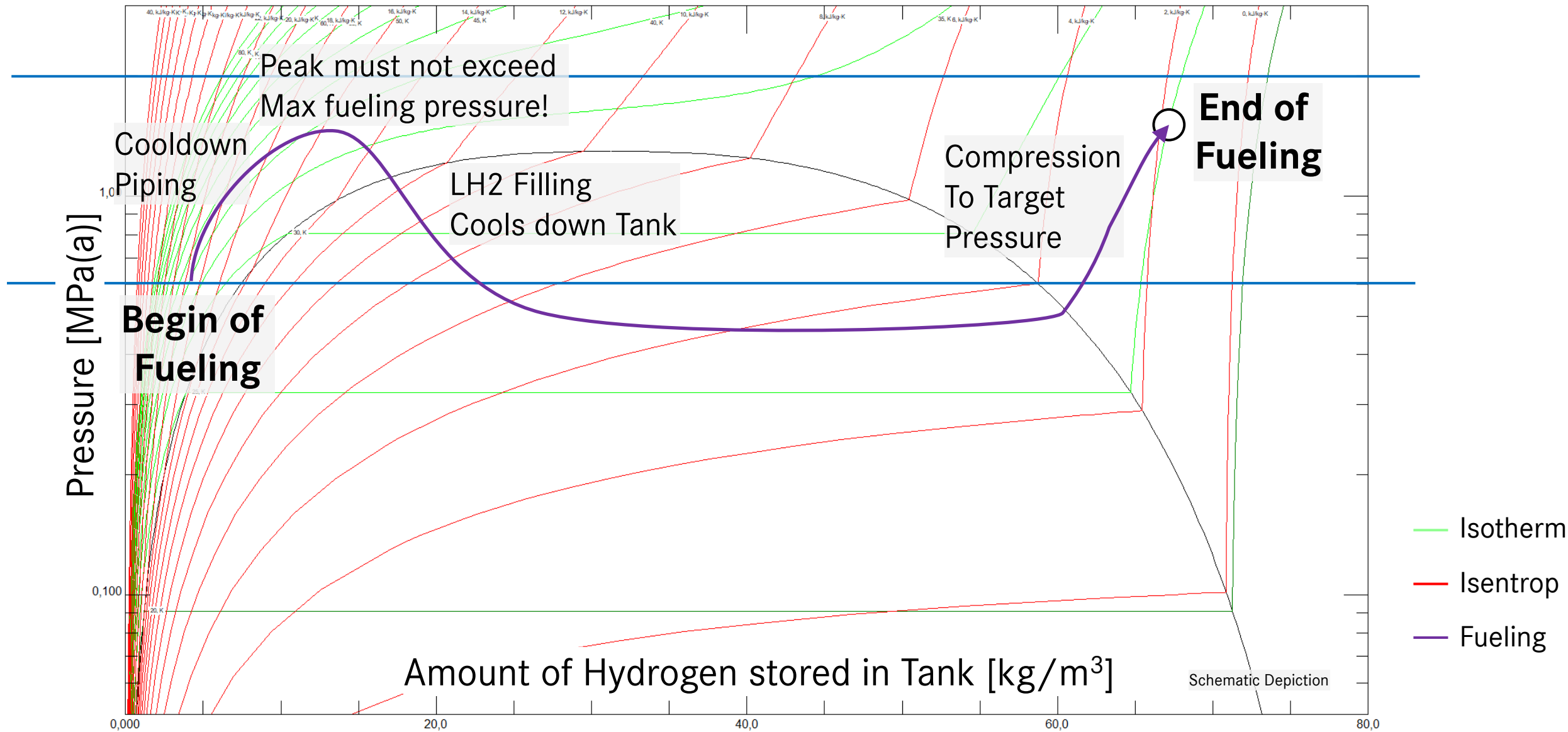
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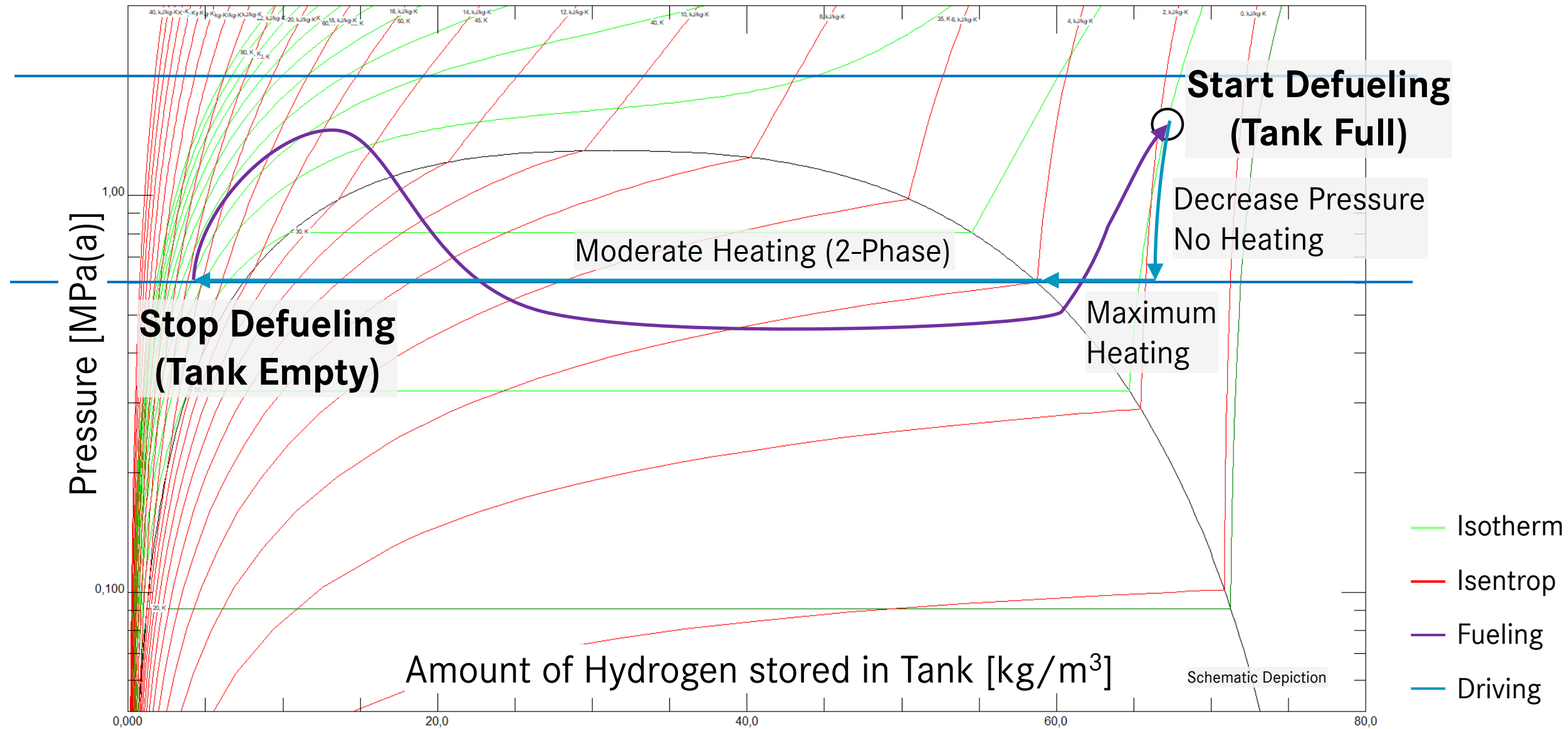
sLH2 Operating Conditions - Boundaries



sLH2 Operating Conditions - Fueling



sLH2 Operating Conditions - Defueling



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High Storage Capacity

Up to 88 kg H₂ usable in Tractor

Cost efficient

No Carbon Fiber for Tanks required

Energy efficient

Fueling with significantly lower Power than CHG



Thank you very much for your attention!

