

VOLVO

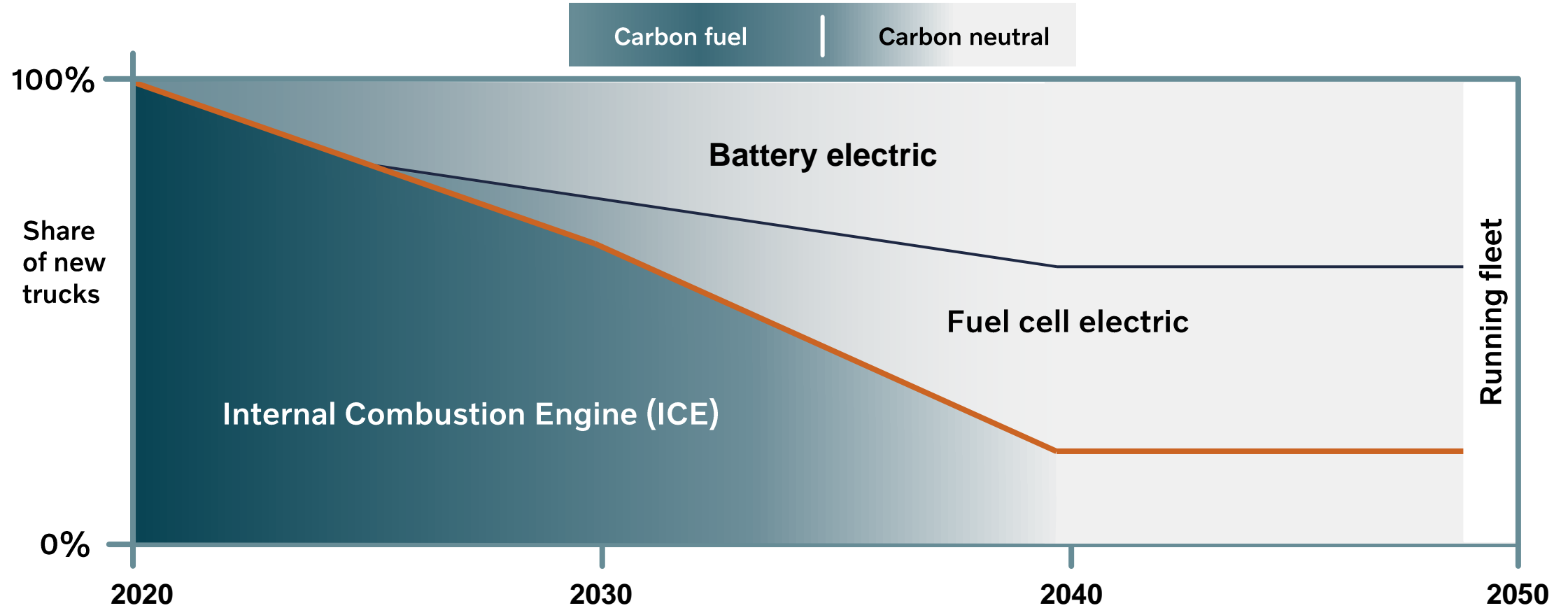
# **KOLDIOXIDNEUTRALA PRODUKTER SENAST ÅR 2040: Vätgasteknologier för tunga lastbilar och off-road fordon**

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Senior Technical Advisor Volvo Group Trucks Technology

December 2023

# 100% fossil free Volvo Group vehicles from 2040



V O L V O

OUR LONG TERM AMBITION

100%

Safe

Fossil free

More productive



How to make it?



**First mover advantage on electric vehicles thanks to global modularity**



VOLVO

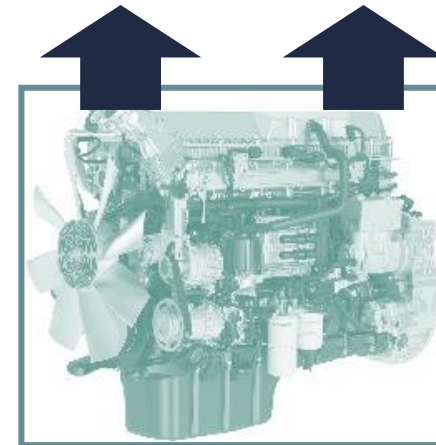
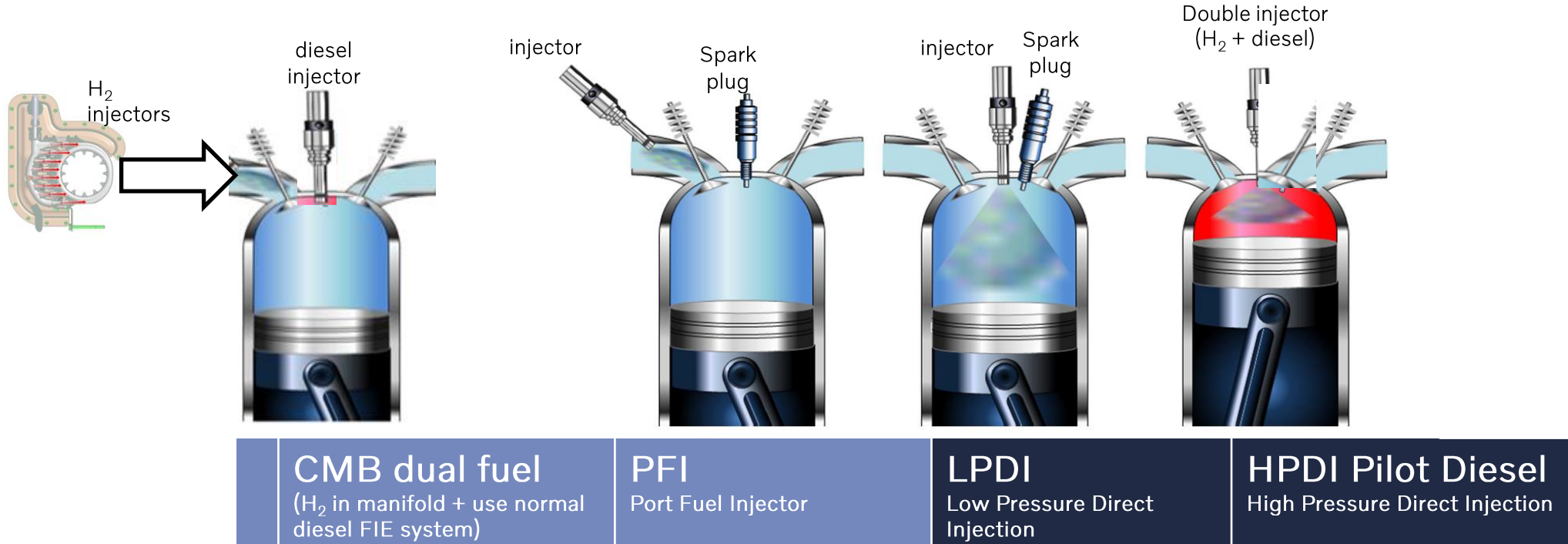


Need of three technological paths to decarbonize heavy transportation by zero emission:



- Battery Electric
- **Hydrogen Fuel Cell Electric**
- **Hydrogen ICE mechanic**
  - with a need of Hydrogen infrastructure

# Hydrogen Combustion Concepts H<sub>2</sub> ICE under evaluation



# HyCET German Partfunded

- HyCET kick-off held January 28
- Engineering kick-off with Keyou February 9
- Keyou responsibility agreement February 23
  - Keyou: Simulation, Design, Procurement and build of (Volvo) engine, Testing and Performance Calibration
  - Aim to use (modified) ECM4
  - EATS aim to achieve EU7 (with present EU6 EATS)
  - Short term: Engine first fire 22w49, vehicle Q3 2023 at Hällered
- Swedish FFI/Energimyndigheten project application "HYCET" filed and high hope for approval:
  - Funding part of Volvo undertaking

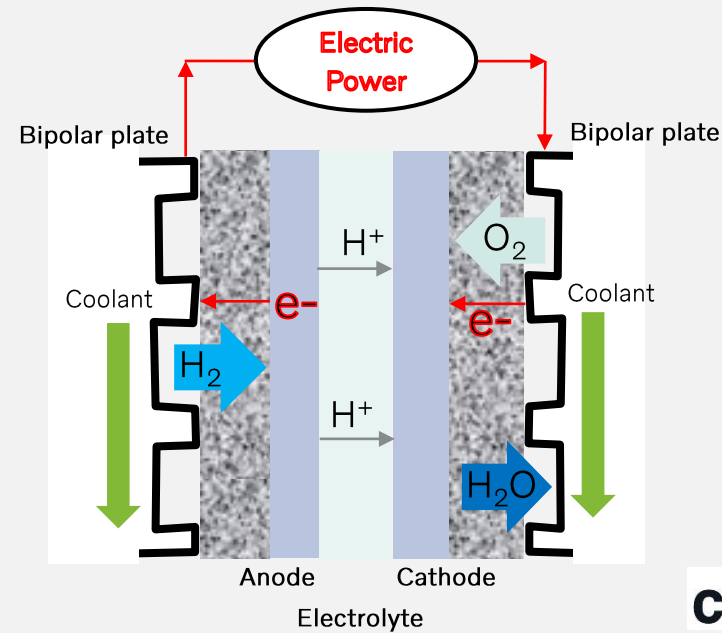




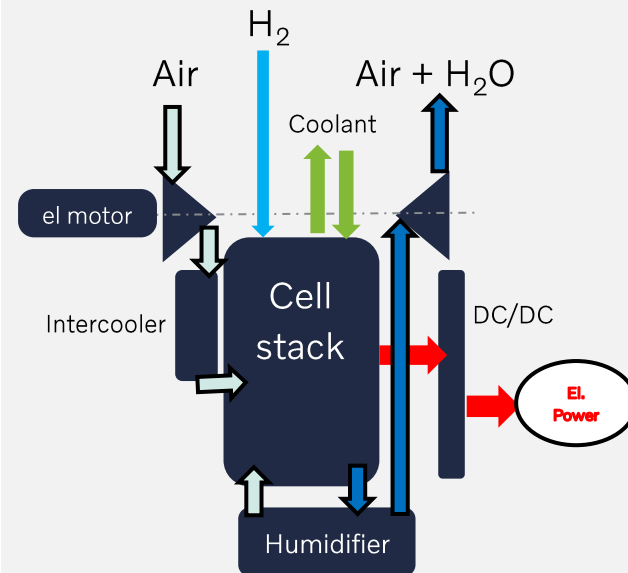
# Fuel Cell technology overview

- Key areas to master in the fuel cell technology

- Primary Heavy Duty fuel cell technology
  - High durability
  - High efficiency
  - Full load capability
  - Mass production possible component design
- Balance of Plant Technology (BoP)
  - Versatile control for Volvo Product range
  - High efficient & durability BoP; Turbo compressor, humidifiers, etc.
  - High efficient HD truck interface,; DC/DC Power
  - 25 000-hour system durability



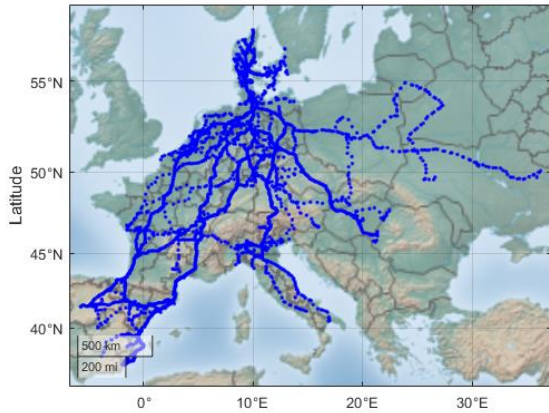
cellcentric



150 kW Net power unit

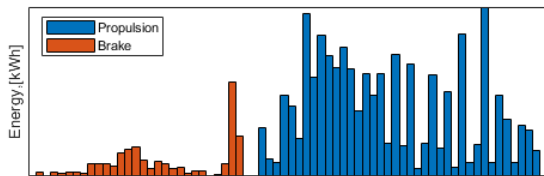
# Customer data acquisition

Key to develop FCEV vehicle concept for different applications

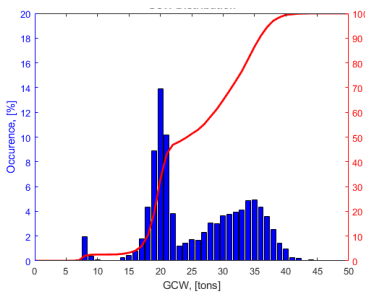


GDPR compliant

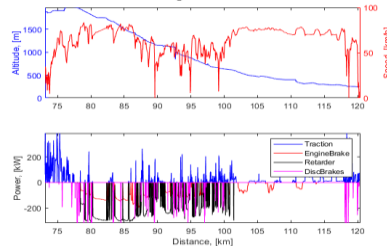
Load weight distribution (tons)



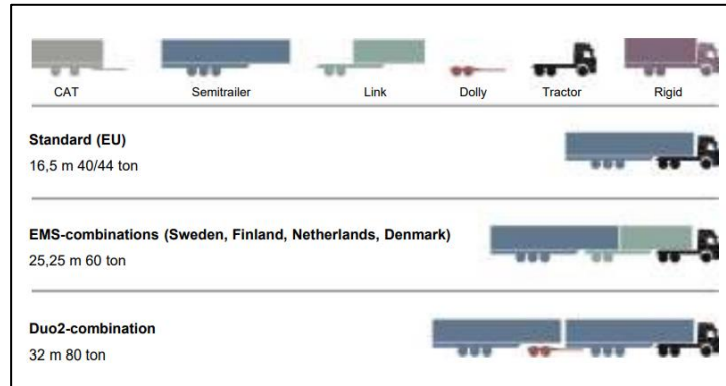
Power distribution



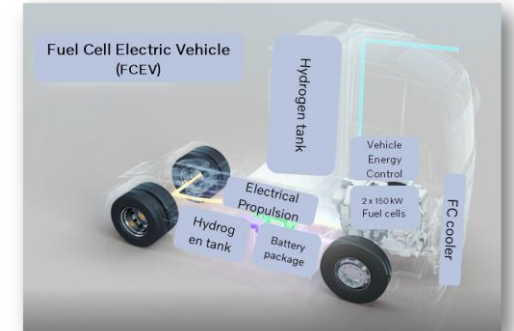
Power usage vs distance



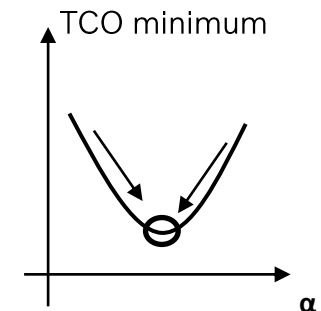
Transport combinations data separation



FCEV  
Vehicle configuration derivatives



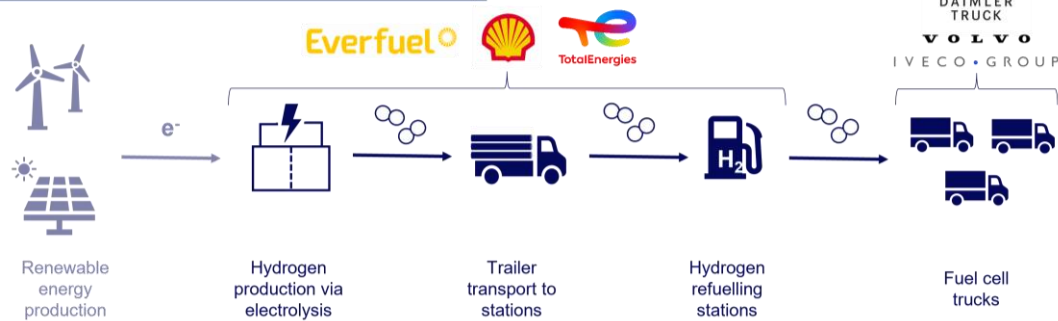
Energy & Efficiency Control & mission management



# FCEV on- and off-road mule vehicle testing in different climates



# H2Accelerate TRUCKS



Collaboration to build market – truck & infrastructure and technology assessment

150 fuel cell trucks - Volvo participate with ~10 customers

Duration 2023-2029 (deployment in later part)

[Press release 2023-03-14](#)



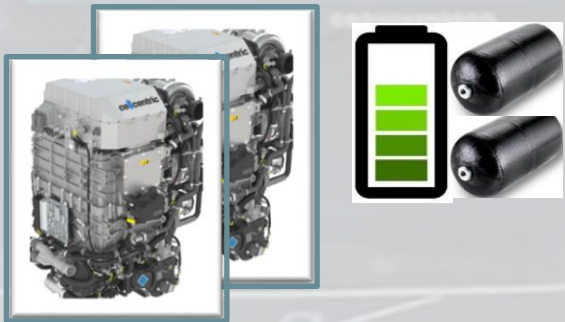
# Two H2 Energy conversion technologies

Hydrogen Fuel Cell Electric Vehicle

Hydrogen electrochemically oxidized to electricity & H2O. Hybrid powertrain



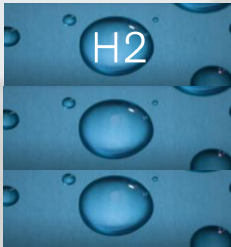
Driveline



Exhaust



H2 consumption

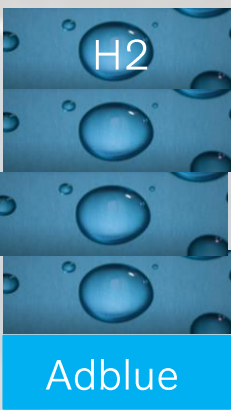
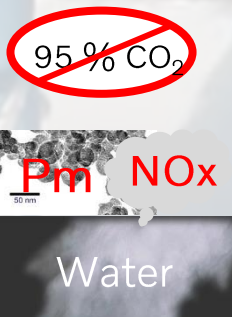
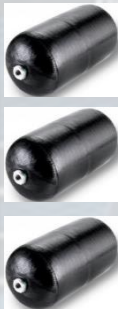
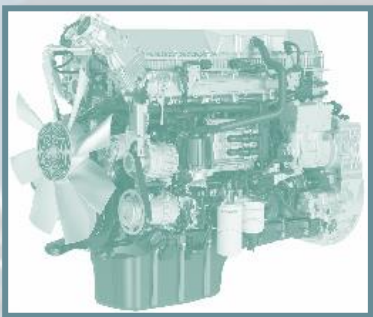


Product cost



Hydrogen ICE mechanical vehicle

Hydrogen combusted in an internal combustion engine.



V O L V O

RENAULT TRUCKS

RENAULT TRUCKS

T-EVO

82-BSL-5

# Circularity Ambition

**CIRCULAR  
BY DESIGN**

**CARBON NEUTRAL  
PRODUCTS**

**PHASE-OUT  
SUBSTANCES  
OF CONCERN**

# World's first in fossil free steel

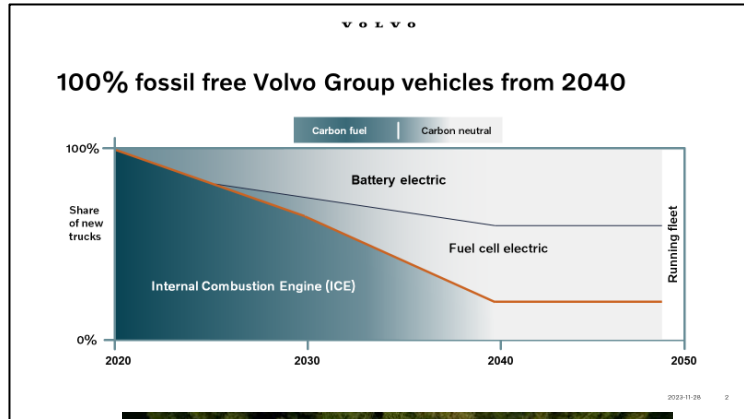


A world's first – construction machine built using fossil free steel delivered to a customer



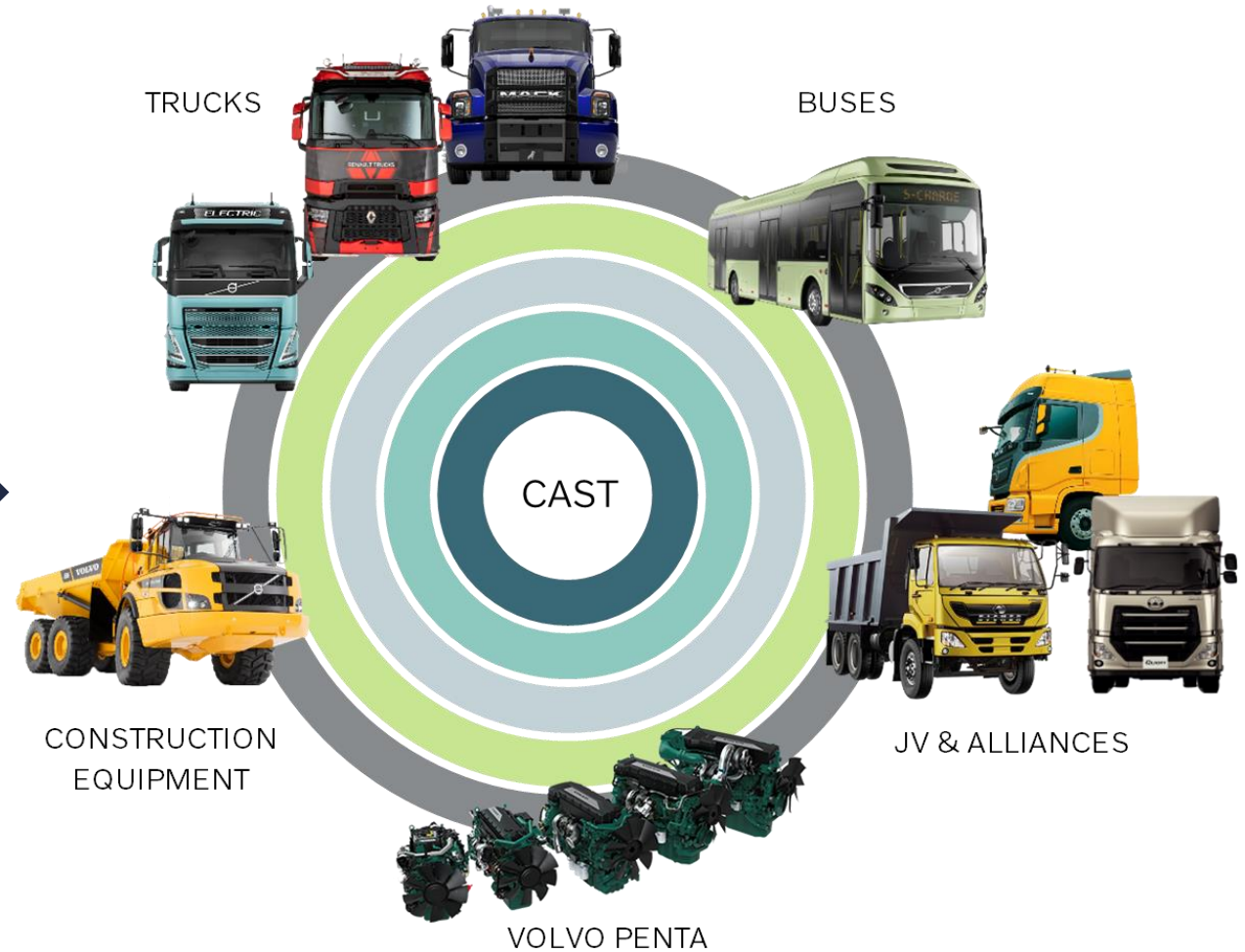
A world's first – fossil free steel in trucks

# Common Architecture & Shared Technology, Volvo Group Synergies



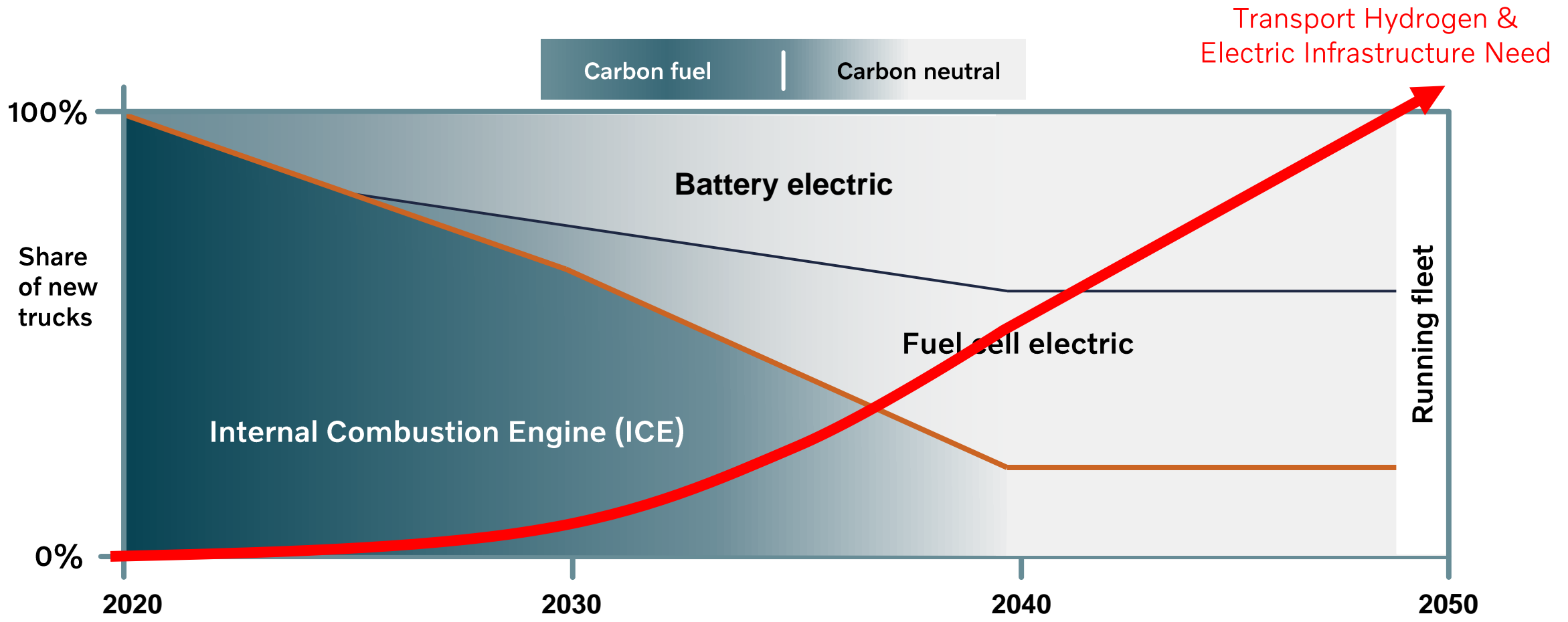
**Need of three technological paths to decarbonize heavy transportation by zero emission:**

- Battery electric
- Hydrogen Fuel cell electric
- Hydrogen ICE mechanic
  - With a need of Hydrogen Infrastructure





# Energy transition and infrastructure **will need to grow!**



# Low CO2 Hydrogen sources diversity, storage path are broad

*Local production:*

*Electrolysis path:*

- Off-shore wind
  - Dual H2 and electricity
- On-shore wind
  - stand alone and grid connected
- Solar land
- Solar industrial roofs
- Industrial waste heat
- Steel industry synergy
- Bio waste based
- E-methane Pyrolysis
- Chemical industry synergy/surplus
- Nuclear
  - side production
  - main production



*Import energy:*

- Green Ammonia
- Blue Ammonia
- Green Methane
- Green H2 gas pipeline
- Blue H2 gas pipeline
- Green LH2??

*Energy storage:*

- Using existing caverns for storage
  - For Ammonia + reformer
  - Re-lined for Hydrogen
- Bicarbonate low density H2 storage liquid ~2%
- Metal hybrids H2
- H2 Gas storage 350-500 Bar
- LH2 storage ?

*Volvo future hydrogen transport mission off take:*

- Hydrogen Fuel cell hybrid truck
- Hydrogen ICE truck
- Hydrogen mobile fuel stations
- Hydrogen industrial use
- Hydrogen Marine
- Hydrogen Off-road



**Price for production storage and delivery will probably vary significantly**

# OVAKO steel mill

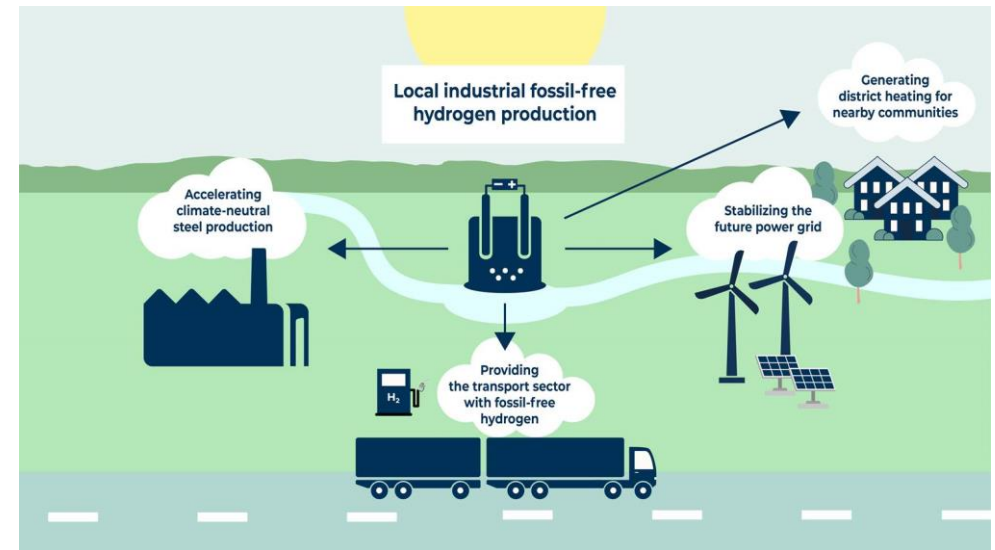
20 MW elektrolyser

September 2023 start-up

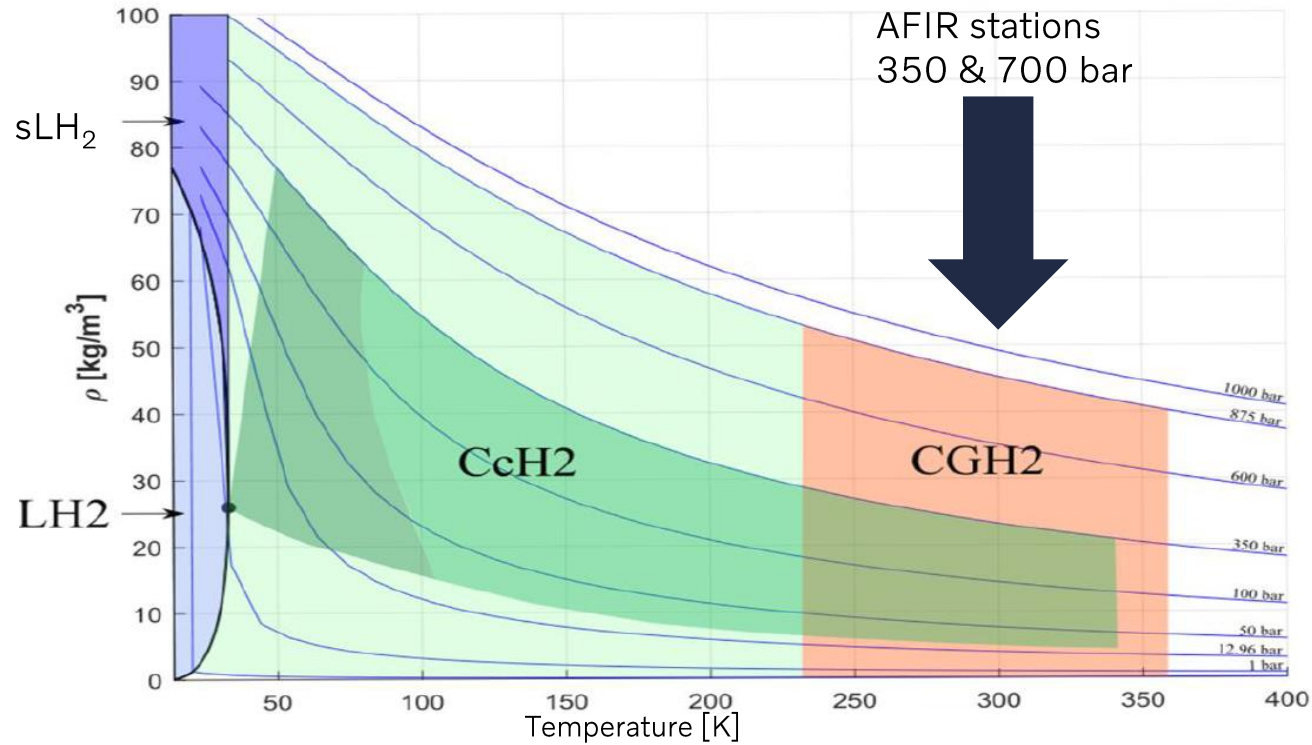
Partnership with [Volvo Group](#), [Hitachi Energy](#), [H2 Green Steel](#) and [Nel Hydrogen](#).

The plan is to use local hydrogen production in all Ovako's units where steel is rolled by 2030, provided there is a good supply of fossil-free electricity.

- Five Alkaline 4 MW unit + water scrubber and H2 and O2 storage tanks.
- Both H2 and O2 and produced Heat are used by Ovako internal processes
  - <https://www.ovako.com/en/newsevents/stories/hydrogen-plant-ramping-up/>
- Pilot vehicle transport testing in plan to used H2 access from this steel plant.

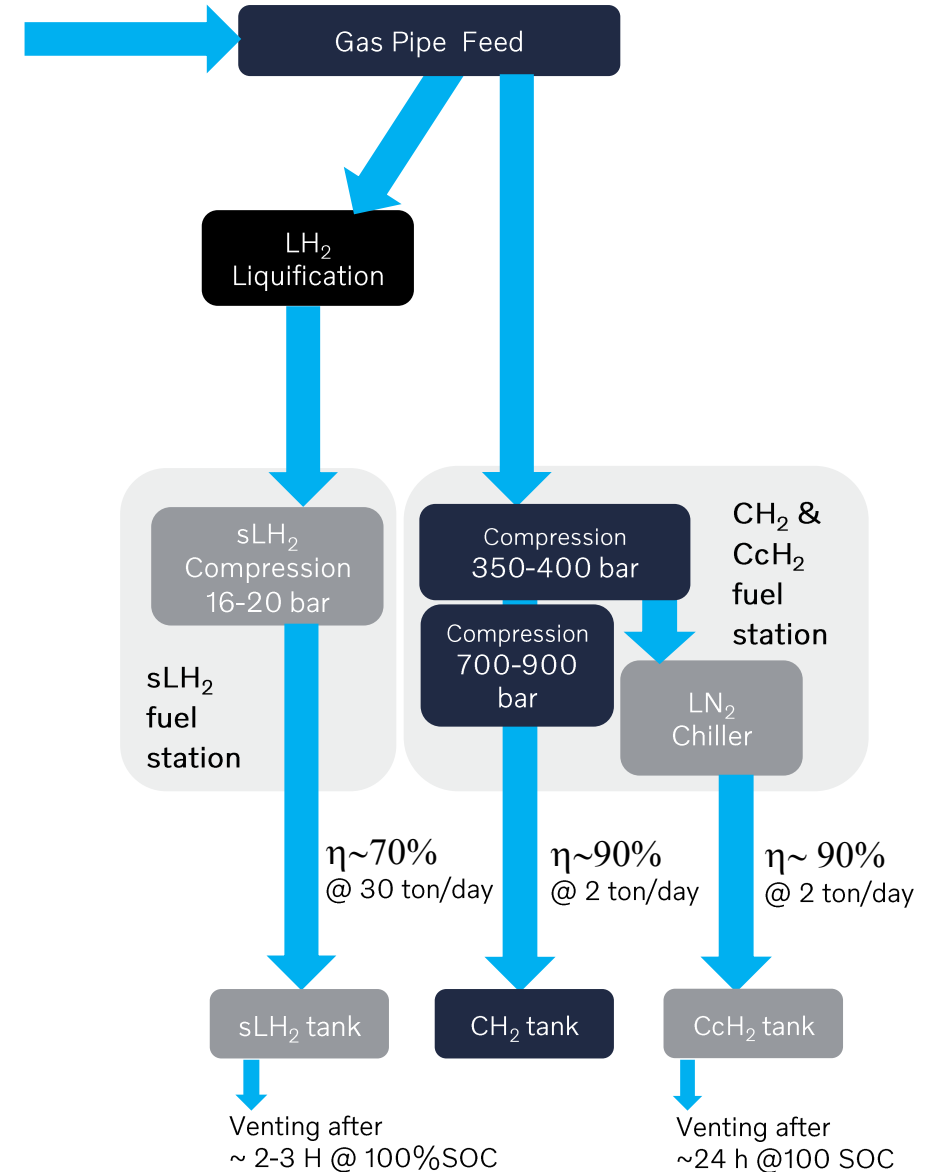


# Compressed & Cryo-storage ( $\text{CH}_2$ , $\text{CcH}_2$ & $\text{sLH}_2$ )



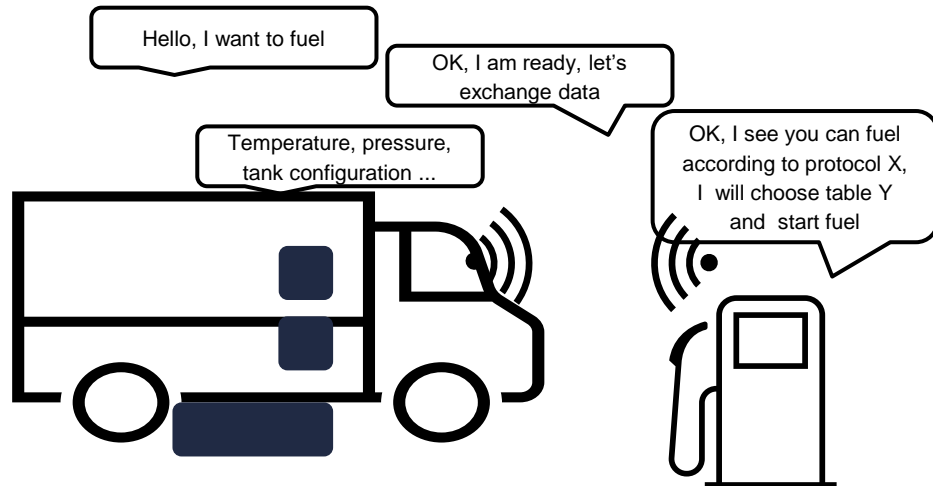
Definition of H<sub>2</sub> in tank 100% SOC:

- ( $\text{CcH}_2$ )Cryo-compressed hydrogen (~60K, 400bar, ~70g/l)
- ( $\text{sLH}_2$ )Subcooled liquid hydrogen (25K, 16bar, ~62g/l)
- ( $\text{CH}_2$ )Compressed gaseous hydrogen (298K, 700bar, ~40g/l)



# Fueling standards that still needs to be refined and set

- Safe and fast fueling (~10 min)
- Interoperability
- Station reliability and uptime
- Fuel cell grade quality



Standards needed

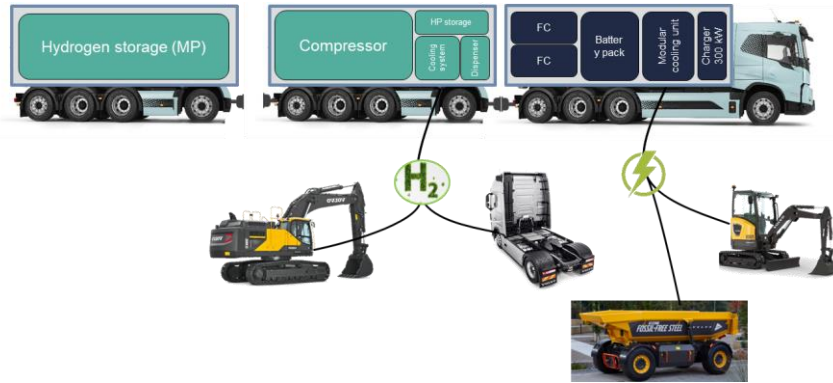
Truck refueling 700 bar & 80 kg tank  
Best guess ready 2025



Protocol	J2601-5 (2023), <b>ISO 19885-3 (2025?)</b>
Comm	<b>J2799 (2024), ISO 19885-2 (2025?)</b>
Hardware	<b>ISO17268 – 2 (2025)</b>

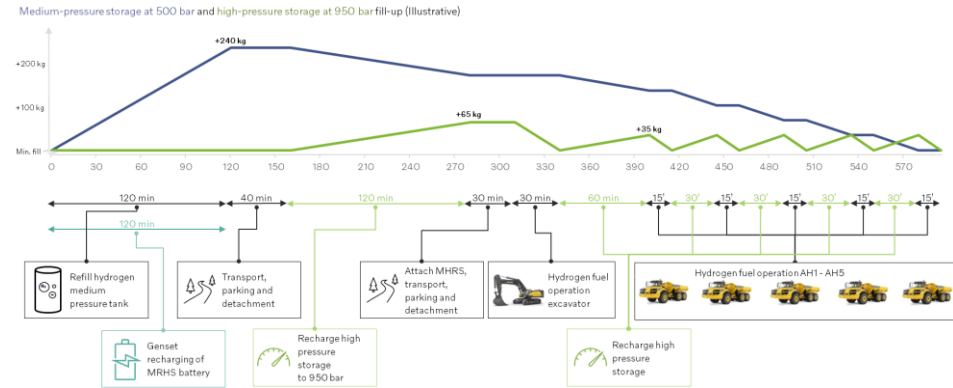
# Mobile Hydrogen Refuelling Solution (MHRS)

## CONCEPT



- Mobile
- Off-road
- Combine electrical charging and hydrogen refuelling
- Off-grid
- Modular
- Temporary locations
- Latest available technology

## DIMENSIONING HYDROGEN USE CASE



- 1 Excavator, fuelled with 65 kg hydrogen
- 5 Articulated haulers, fuelled with 35 kg hydrogen
- Hydrogen @ 700 bar
- Fuelling speed aligned with latest available technology

Formal partners: Volvo Technology AB and Euromekanik AB,  
 Collaboration: Volvo Technology, Volvo Penta, Volvo CE and Euromekanik  
 Time: 15<sup>th</sup> of October 2022 – 31<sup>st</sup> of Mars 2025, Demonstration in Sweden  
 Part funded by: SE Energy Agency

**V O L V O**