



Hydrogen storage and transport via LOHC as key vector to enable sector coupling

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Hydrogenious Technologies GmbH – a pioneer in chemical hydrogen storage

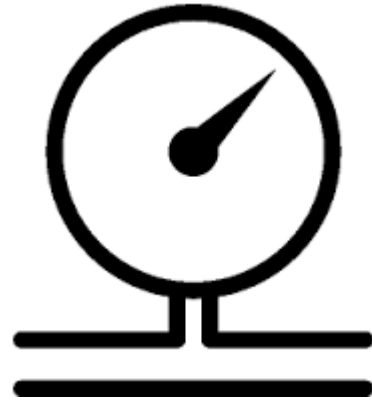
- Founded in 2013 by Dr. Daniel Teichmann and Profs. Arlt, Schlücker and Wasserscheid; staff of 55; 27 patent families filed
- Global technology leader for Liquid Organic Hydrogen Carriers (LOHC) – the revolution in hydrogen storage and transport
- Focus on commercialization of hydrogen storage and release systems for industrial and mobile applications

Key Partners:



Todays transport technologies are designed for industry handling and are thus prohibitive for a public roll-out

Compressed (CGH2)



160 – 500 bar

or



- Low storage density
- High capex and maintenance costs
- Large safety zones

Cryogenic (LH2)



-253°C

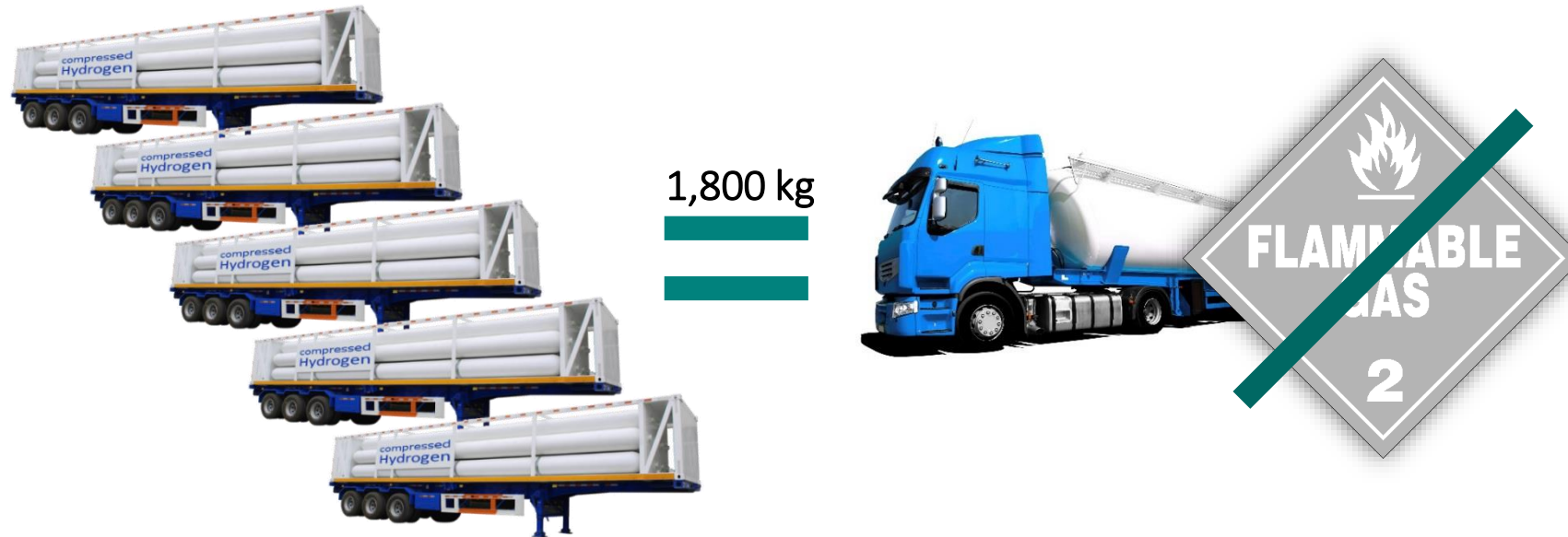
- Very high energy consumption
- Very high capex and maintenance costs
- Not suitable for longer-term storage
- Large safety zones

Liquid Organic Hydrogen Carrier (LOHC) enable a safe and efficient transport of hydrogen at ambient conditions



The LOHC technology uses basic chemical processes to eliminate the complexities of today's hydrogen handling

Our LOHC technology has significant advantages in performance and handling compared to competing technologies



Our LOHC is...

Efficient

- 630 Nm³ H₂ / m³ LOHC → 6.23 wt%
- 57 kg H₂ / m³ LOHC

Safe

- Non-explosive
- Not classified as dangerous good (ADR, etc.)

Easy to handle

- Diesel-like liquid
- Ambient conditions

Low priced

- <5 €/kg
- Reusable

Multi-modal hydrogen transport with LOHC improves economic and social viability of hydrogen roll-out significantly

Large scale ship transport



- LOHC transport by existing oil tanker fleet and fuel storage infrastructure
- International, trans-ocean transport possible at minimal cost

Medium scale rail transport



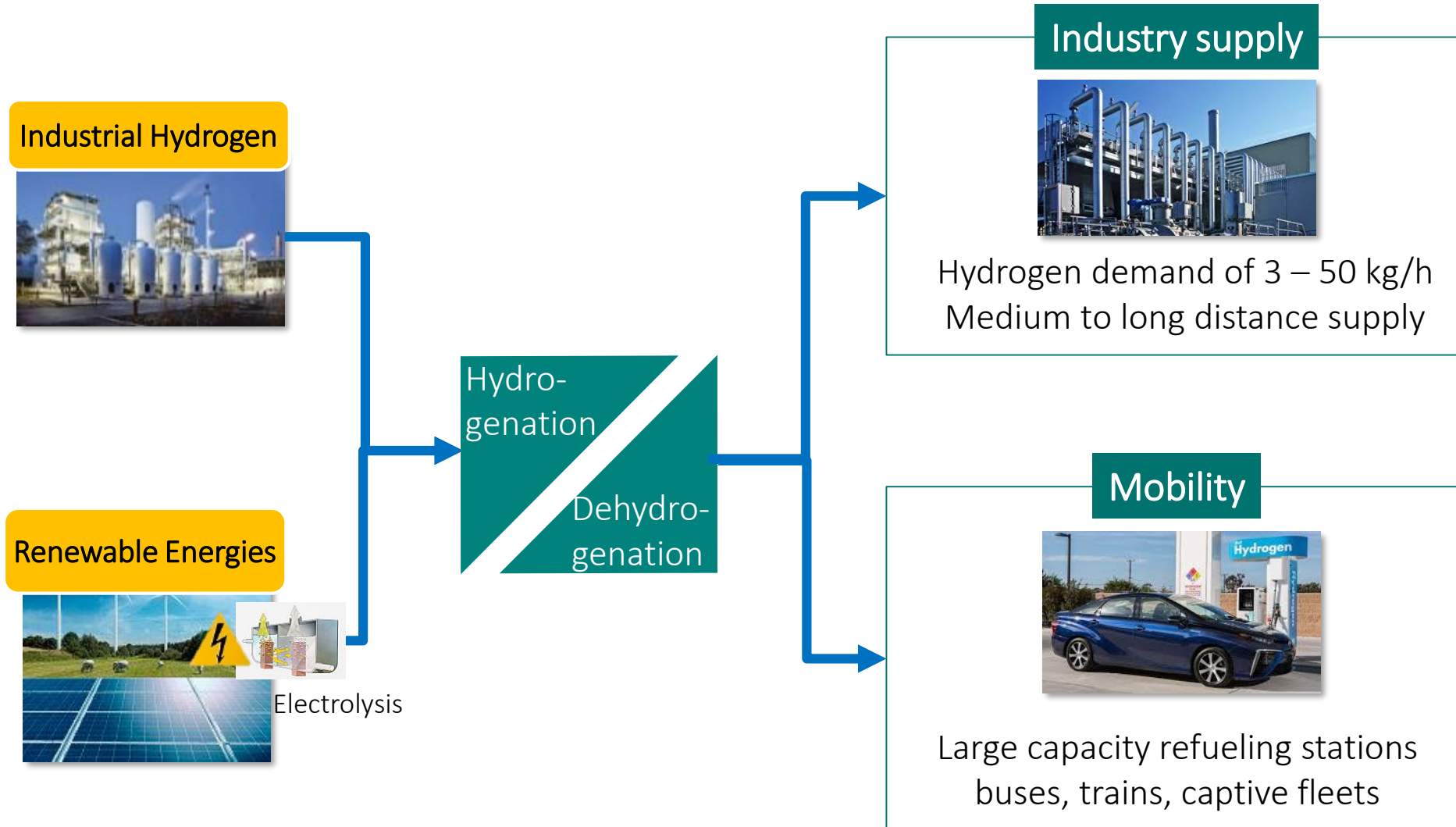
- Multi-ton transport on existing cross-European infrastructure possible
- Possibility to significantly reduce on-land hydrogen transport cost
- Easy supply of train-HRS

Road transport



- Strongly increased flexibility for hydrogen distribution by LOHC liquids
- High storage capacity at ambient conditions, leading to low costs
- Easy storage in underground tanks at HRS

... which can easily, safely and efficiently be connected
by our LOHC technology to enable a sustainable hydrogen world

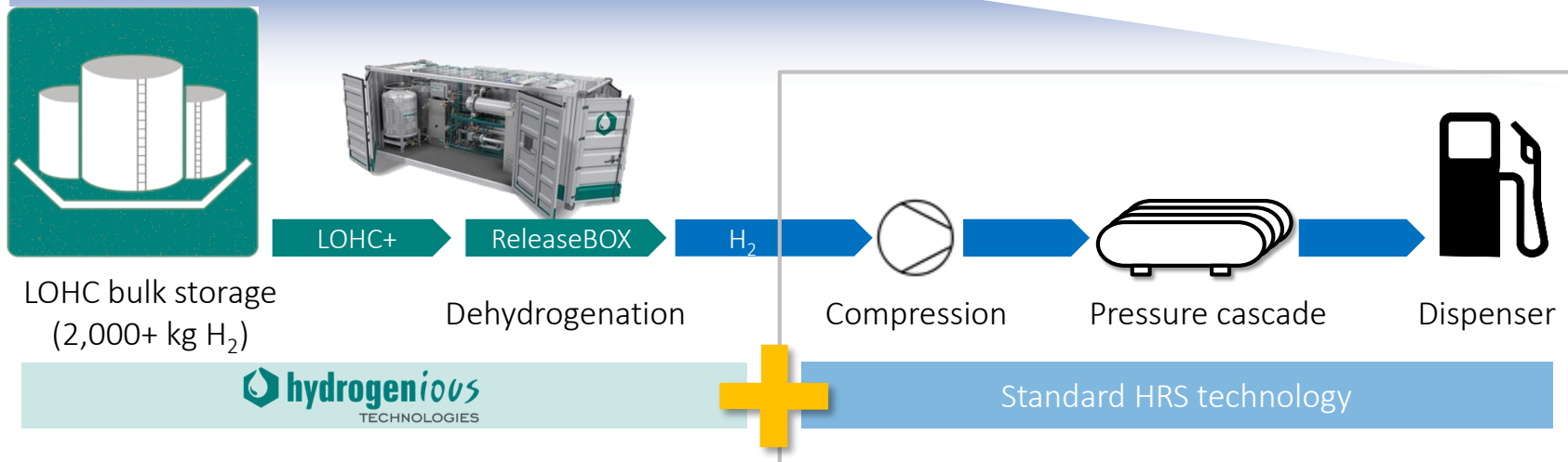


The LOHC technology offers significant advantages for large scale HRS – e.g. for bus, train or captive fleet supply...

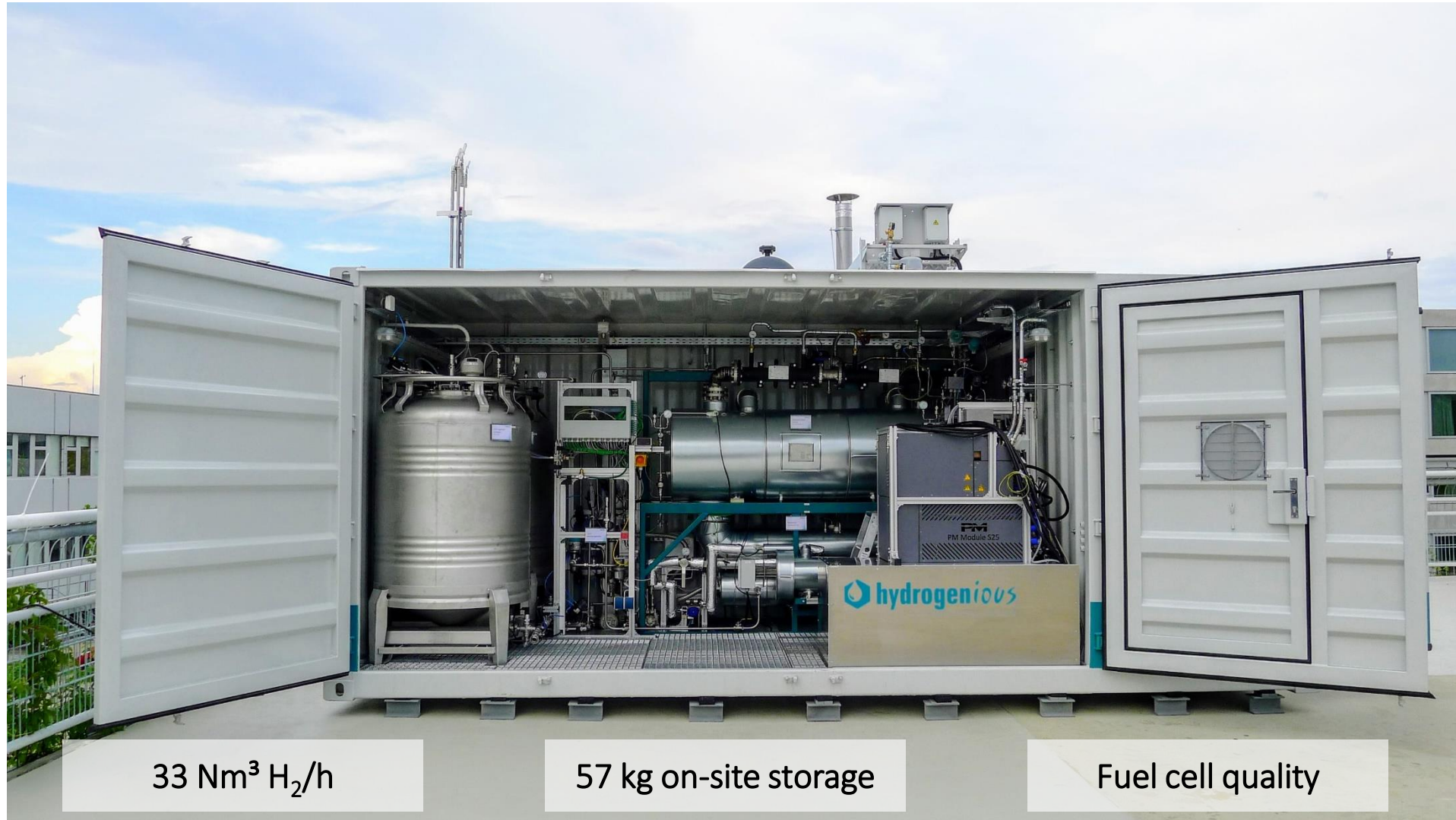


Advantages of LOHC





- ✓ Low delivery frequency to HRS
- ✓ Lowest cost for H₂ bulk storage
- ✓ No boil-off losses / discharge
- ✓ Safe handling
- ✓ Small footprint through underground storage
- ✓ Highest social acceptance through oil handling



Hydrogenious has the first LOHC-based hydrogen project in operation since June 2016 at the Fraunhofer IAO



Hydrogenious has gathered a strong consortium for a first LOHC-based HRS piloting project under EU funding

Consortium partner	Project scope
 <p>Leading Scandinavian industrial gas company</p>	<ul style="list-style-type: none"> Design and build-up of SB 10 and RB 10 (incl. optimized PSA)
 <p>Specialist for gas purification units</p>	<ul style="list-style-type: none"> 1st steps: Performance testing of RB 10 at VTT test facility <ul style="list-style-type: none"> Energy balances Hydrogen purity
 <p>Leading scientific facility on LOHC research</p>	<ul style="list-style-type: none"> 2nd step: Connection of RB 10 to HRS in Woikoski
 <p>Research center focused on fuel cells and hydrogen mobility</p>	<ul style="list-style-type: none"> Total funding: EUR 2.5 Mio. (100%) Duration: 3 years

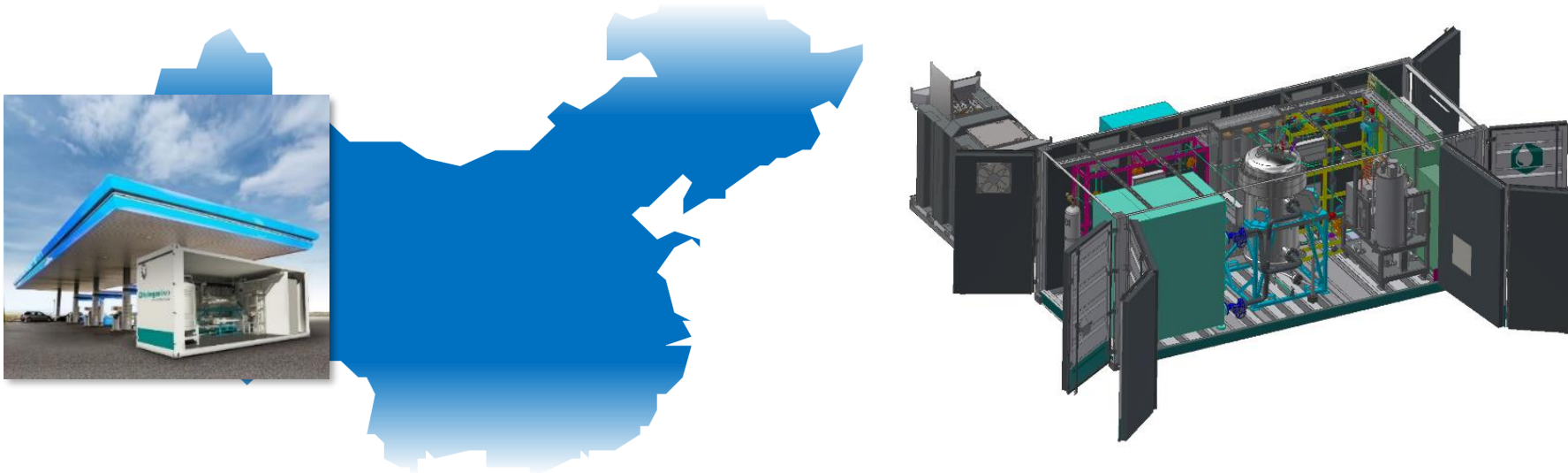
>20 companies have shown interest in project participation prior to consortium setup

Commercial project I: US market entry started with industrial demo project together with United Hydrogen Group



- Regional U.S. hydrogen distributor with >50 customers (Industry and mobility)
- **Current situation:** Limited distribution radius due to low transport capacities of pressure tube trailer technology
- **Targeted setting:** Expansion of supply radius through use of high-capacity LOHC technology
→ Win-Win setting for UHG and its customers
- Initial pilot systems contracted by UHG
 - StorageBOX 100 (9.1 kg/h H₂) - Centralized H₂ production
 - ReleaseBOX 2.5 (0.23 kg/h H₂) - Power Plants
 - ReleaseBOX 33 (3 kg/h H₂) - to be delivered in 2019

Commercial project II: Build-up of LOHC-based Hydrogen Refueling Stations in China with Broad-Ocean Motor



- Broad-Ocean with some 600 fuel-cell power trains for buses and LDV under production in 2018
- Hydrogen supply and refueling station infrastructure is major challenge regarding Chinese FC-vehicle roll-out plans
- LOHC technology seen as possible solution by Chinese government and market leaders
- Hydrogenious' market entry start with first demo-project
 - StorageBOX 150 - Centralized H₂ production
 - ReleaseBOX 150 - Connected to a HRS for FC-buses



Systems to be delivered in
Q1 2019

Thank you for your interest!

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