

LOHC technology

an important building block for flexible and demand-oriented hydrogen supply to decarbonize the steel industry

• LOHC technology | Dr. Peter Gleß | 05.04.2023

• LOHC is a technology to transport H2 over long distances globally - bridging mismatch of capacity and demand



Green hydrogen cost in USD/kg 2030

Public | Hydrogenious LOHC Technologies

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LOHC technology leverages existing liquid-fuel infrastructure by transporting hydrogen as a liquid at ambient conditions



Established in 2013, we're the global LOHC pioneer



Investors

Technology cooperation partners



employees

>200

>55 patent families

>€80m investor funding



With this proven technology Hydrogenous will be a strong partner in the decarbonation process of the steel industry



11 commercial pilot systems in field and many more research systems





Industrial scale up project in **permitting stage** (5 tH2pd)





Funding for next scale (24 tH2pd)



and full scale supply network advanced



Pre-Engineering of 100 tH2pd systems started



International project pipeline build up due to high interest in technology



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Expectations towards steel industry...

- Steel plants will become a mayor player in the new hydrogen market. We see the steel industry as a strategic partner with high priority
- Hydrogenious is a world leading pioneer and technology company offering a unique solution for transport and storage of hydrogen – with **disruptive potential to unlock** further value for the steel industry
- Consequently we are eager to enter a cooperation considering a variety of options with you



IPCEI provides multiple opportunities to roll out further large plants in Europe (roll-out of Northern Green Crane and Blue Danube projects)



Building the LOHC infrastructure network in Europe, erecting several storage & release plants

Both projects qualified in Germany for the IPCEI preselection process (among 62 others in Feb 2021) along with partner applications in Sweden and the Netherlands (part of fast moving RHATL wave) Our LOHC – BT technology is a perfect combination of safety, flexibility and efficiency



Superior in safety & flexibility, while...

- Hardly flammable with flash point 130 °C, non-explosive, even when loaded with hydrogen
- Handling under ambient temperatures and pressure during storage and transport
- No self-discharge over time multi-month storage without losses
- Hazard potential even smaller than for diesel and thus clearly superior to ammonia



...high in efficiency.

- Conventional liquid fuel infrastructure reusable
- Competitive volumetric storage density 54 kg hydrogen per m³ LOHC
- Carrier material commercially available and reusable hundreds of times
- Fuel cell grade hydrogen purity according to ISO 14687 by using off-the-shelf purification technology



Leading studies confirm that LOHC is a highly cost competitive, high potential mid-stream solution



Estimated long-term cost components of hydrogen shipping options

Pipeline transport assumes 48 inch (1,200 mm) in thickness, 12.7 GW and 80 bar for both new and repurposed pipelines



Long-term, LOHC is the most economic option for transport via shipping



All-in costs for North-West Europe importing green hydrogen from Saudi Arabia in 2022

Cost of delivering green hydrogen from Saudi Arabia to Europe USD per kg H2 $\,$



LOHC is "the" hydrogen carrier in terms of TCO and other aspects

Source: Press search, Guidehouse, Goldman Sachs (2022), Lux (2022)

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Liquid and chemical hydrogen storage in 2022



Toluene

Benzyl-

toluene

LOHC, and **BT in particular,** is well positioned vs. alternatives

Ammonia

C

Liquefied

hydrogen

Handling hydrogen as an oil and being independent of pipelines

Procurement of green hydrogen from economically attractive sources across the world via conventional transport methods such as ships, railways, and trucks

Ability to feed into the production plants **independently** of gas pipelines

Use of **existing unloading**, **loading** and **storage infrastructure** after adaptation

Option of **expanding** the installed **ReleasePlant** capacities

C Hydrogen Teo

LOHC technology | Dr. Peter Gleß | 05.04.2023

ReleasePLANT layout

- Designed for continuous and flexible operation
- Designed for coupling with hydrogen hubs and pipeline networks
- To be combined with underground stocking facilities

Dehydrogenation process: Endothermic, with a solid catalyst Heat demand: Approx. 11 KWh/kg H2, 250 – 300°C Elevated reaction pressure: Approx. 2-3 barg Quality of released hydrogen: Purity >99.9% (fuel cell quality)



Example: 1.5 tpd incl. x m³ tanks to be built in Rotterdam/NTL in 2025/26

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Meet the upcoming challenges at your production plant with Hydrogenious

Plant flexibility can be increased by expanding the existing ReleasePLANT / LOHC storage capacity



Plant independence from renewable energy sources by using LOHC storage units to provide hydrogen during shortages



Connection of individual reactor modules for a wide range of operations
Scheduled modulation of the single reactors in the specified load range
Activation & deactivation of individual reactors e.g., for maintenance purposes



> Plant auxiliaries and H2 conditioning equipment can be shared for all reactor modules

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Because Hydrogenious' LOHC solution is...

distances before 2030.

flexible in handling

long-term storage









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Permitting possible also in urban areas, no extensive training of personnel necessary

Ideal to meet the requirements of realistic supply chains incl. underground and





... a means of **delivering large quantities of feedstock (molecular) hydrogen** over long



... making use of existing fossil fuel infrastructure

Limited alternatives available.

E.g., storage in ports & refueling stations, transportation by existing trucks, trains, and ships.

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Guidehouse

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Together, let's decarbonize steel mills under the usage of LOHC technology

LOHC technology is a key solution in the energy transition. With our technology, hydrogen transport can be carried out **pipeline-independently** for offtakers. Our LOHC solution turns hydrogen into a secure power storage technology. It is an excellent hydrogen stocking medium to stabilise need-based hydrogen release.

The commercial attractiveness and effectiveness of LOHC technology will increase significantly as ReleasePLANTS are upscaled step- bystep. Thanks to our **long-term R&D collaboration** with academic and industrial partners, we can help industrial plant transition to a **cleaner industry** and **contribute to climate targets**.



Let's begin our Q&A session

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