

Making our world more productive



Linde



Extending the Reach of the Hydrogen Value Chain

With Cutting-edge Liquefaction, Distribution and
Storage Technologies

From Source to Service Every Step of the Way

Hydrogen (H₂) is increasingly being viewed as an invaluable tool in the fight against climate change. This is partly due to its flexibility. Green hydrogen has the potential to accelerate the transition towards more sustainable forms of energy, particularly as a zero-emissions source of fuel for ocean vessels, buses, cars and trains. At the same time, conventional hydrogen production schemes support current energy models with all their regional variations. Driven by this adaptability, hydrogen is growing in importance across an increasingly broad spectrum of applications and use cases.

Advanced hydrogen technologies enabling hydrogen gas to be efficiently liquefied, transported, stored and dispensed at the point of use will be key to unlocking many of these emerging use cases. Technology innovator Linde is the only company to cover every step in the hydrogen value chain from production and processing through distribution and storage to everyday industrial and consumer applications.

Our Schalchen site in Germany specializes in cryogenic equipment for H₂. Our experts engineer and build state-of-the-art components to support all steps in the value chain, extending from vacuum coldboxes for liquefaction through state-of-the-art storage tanks to a wide selection of containers, semi-trailers and liquid hydrogen (LH₂) tanks to support the full application spectrum.

Customers benefit from the fact that all key components, from LH₂ tanks through vaporizers to vacuum-insulated piping, are designed and manufactured in house based on the extensive know-how we have gathered over the decades.

Rounding out this one-stop offering, we deliver standard and customized solutions to meet customer-specific LH₂ storage capacity requirements.



Product Portfolio

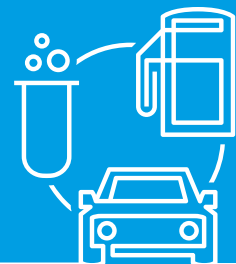
1. Liquefaction

Modular designs building on the highest quality standards for efficient performance and a long service life



2. Storage

Storage and delivery solutions to support a wide and growing number of use cases for hydrogen



3. Distribution

Optimizing distribution efficiency with custom-developed containers for transporting liquid hydrogen

4. Applications

Bringing the space and efficiency gains of liquid hydrogen to a wide application spectrum

Liquefaction and Storage

Liquefaction

Modular designs for fastest time-to-solution

Vacuum coldboxes integrate all the main components needed for the liquefaction of hydrogen, including turbo expanders and vacuum-brazed aluminum plate-fin heat exchangers (PFHE). The stainless-steel piping is ready-welded to the industry standards requested by each customer, assembled in the specially insulated coldbox, and the entire unit is delivered as a packaged, pre-tested and ready-to-run solution.

Our coldboxes are designed to the highest quality standards with operating temperatures of 20 °C and leak rates as low as 10⁻⁷ mbar/sec. Customers can look forward to extremely efficient performance and a long service life. Our flexible offering supports liquefaction capacities of 15 tons per day (tpd), and this is set to increase in the near future.



Storage

Smart designs to maximize storage efficiency

Liquid hydrogen takes up four times less space than gaseous hydrogen. Storing this gas in liquid form therefore brings space and efficiency advantages to many different applications. Drawing on its long-standing experience in the design and delivery of cryogenic storage tanks, Linde is the partner of choice when it comes to liquid hydrogen (LH₂) tanks of all shapes and sizes.

Our reliable and field-proven cryogenic tanks are widely deployed in H₂ fueling stations for example, where their compact footprint is particularly beneficial in space-constrained environments. They are also an ideal buffering solution for storing H₂ after the liquefaction step.

Key Data

Design pressure:	12 bar(g) (174 psi)
Capacity:	Up to 26 tons LH ₂
Insulation:	Vacuum insulation with perlite, super insulation or glass bubbles
Boil-off ratio:	0.25 to 0.95%/day
Design:	Horizontal and vertical
Design codes:	ASME VIII, Div 1 or EN13458

Distribution and Applications



Distribution

Efficient transit from source to service

Our hydrogen containers form the next link in the distribution chain. We offer containers exclusively for hydrogen as well as dual-use containers for LH₂ and liquid helium. In addition, we are currently working on semi-trailer solutions, and these are due to be launched in the near future.

Key Data for Dual-use Containers

Design pressure:	12 bar (174 psig)
Net capacity:	2.615 kg (at 10% ullage)
Holding time:	≥ 50 days to reach 11.4 bar(g) / ≥ 200 days with active LIN shield (i.e. dual-use container)
Design codes:	ASME VIII, Div 1
Approval:	ADR, IMDG code, ASME, TIR, CSC

Applications

Enabling a broad and growing number of H₂ use cases

Our state-of-the-art LH₂ storage tanks are enabling a growing number of use cases – especially in space-constrained scenarios such as fueling stations in urban areas. As the final step in the hydrogen value chain, these tanks bring our liquefaction competence to the point of use. For example, Linde Hydrogen FuelTech, the leading supplier of high-performance refueling concepts and technologies, builds on our LH₂ storage tanks. Almost 200 H₂ fueling stations around the world are already equipped with our technology, making us the market leader for fast, efficient and successful hydrogen refueling solutions.



LH₂ Gains Ground in the Marine Sector

Liquefied hydrogen combined with fuel-cell technology is also increasingly supporting decarbonization efforts in maritime transport. We pioneered LH₂ on-board tank systems for this sector. We are proud to have been selected to deliver the LH₂ storage system with a capacity of 4000 kg for the world's first commercial LH₂ vessel (Hjelmeland ferry in Norway). For this project, our one-stop offering covered bunkering, on-board storage and conditioning of LH₂ for fuel cell operation.

Regardless of your liquefaction and storage needs, our experts can advise on the configuration best suited to your H₂ project with one-stop, best-in-class solutions extending from liquefaction and piping through transport and storage right up to the actual point of use. Contact us today to find out more about our hydrogen portfolio.

Connecting the World of Hydrogen – from Source to Service



Looking to the future, we are committed to advancing technologies that pave the way for widespread production, distribution and adoption of greener sources of energy such as hydrogen.

Do you want to get your hydrogen project off the ground quickly, safely and based on state-of-the-art technologies? Then you should team up right from the start with a partner who covers all areas of expertise and all steps in the hydrogen value chain.

Get in touch with our team of experts:
www.linde-engineering.com/contact



Your Partner for the Production and Processing of Gases

Delivering reliable process plants for maximum capital efficiency

Linde has been optimizing gas processing technologies for 140 years, successfully delivering more than 4,000 plant engineering projects around the globe. Favoring trusted, lasting business relationships, the company collaborates closely with customers to enhance plant lifecycle productivity and innovate process flows. The company's proven gas processing expertise plays an indispensable role in the success of customers across multiple industries – from natural gas and oil refining through petrochemicals and fertilizers to electronics and metal processing.

Operational excellence along the entire plant lifecycle

We work closely with our customers to gain an in-depth understanding of individual needs. Building on the unique synergies of Linde as an integrated plant operator and engineering company, Linde offers innovative process technologies and services to exceed our customers' reliability and profitability expectations. This commitment to innovation extends along the entire plant lifecycle. The LINDE PLANTSERV® service team supports customers every step of the way – from maintenance and repairs to full revamps. Leveraging the latest digital technologies to offer on-site and remote operational and support services, we consistently take asset performance to the next level.

Making the impossible possible

From the desert to the Arctic, from small- to world-scale, from standardized to customized designs, Linde's engineering specialists develop solutions that operate under all conditions. The company covers every step in the design, project management and construction of gas processing plants and components. Customers can always rely on Linde to deliver the plants, components and services that fit their needs best – anywhere in the world.

Discover how we can contribute to your success at www.linde-engineering.com

Get in touch with our component manufacturing team:
www.linde-engineering.com/contact



Core competencies at a glance

Plant engineering

- Air separation plants
- LNG and natural gas processing plants
- Petrochemical plants
- Hydrogen and synthesis gas plants
- Adsorption plants
- Cryogenic plants
- Carbon capture and utilization plants
- Furnaces, fired heaters, incinerators

Component manufacturing

- Coldboxes and modules
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Cryogenic columns
- Cryogenic storage tanks
- Liquefied helium tanks and containers
- Air-heated vaporizers
- Water bath vaporizers
- Spiral-welded aluminum pipes

Services

- Revamps and plant modifications
- Plant relocations
- Spare parts
- Operational support, troubleshooting and immediate repairs
- Long-term service contracts
- Expert reviews for plants, operations and spare part inventory
- Operator training