

References.

Hydrogen projects and partnerships.



HyCentA in Graz, Austria. Gaseous hydrogen fuelling station.



Gaseous hydrogen fuelling station, Graz, Austria

Description The HyCentA (Hydrogen Center Austria) promotes the use of hydrogen as a regenerative energy carrier. With its hydrogen test centre and the first hydrogen fuelling station in Austria, the HyCentA acts as a focal point and information platform for hydrogen-oriented research and development activities.

Details Linde was the turnkey supplier for the HyCentA hydrogen fuelling station. For this project, Linde engineered and supplied a compressed gaseous hydrogen fuelling system and installed a liquid hydrogen storage tank.

Technical data

	<u>CGH₂ fuelling technology</u>
<u>Location</u>	Graz, Austria
<u>Start of operation</u>	2005
<u>Accessibility</u>	Non-public
<u>Hydrogen source/storage</u>	Liquid hydrogen tank
<u>Fuelling technology</u>	Dry-running (lubricant-free) piston compressor
<u>Fuelling pressure</u>	35 MPa
<u>Throughput</u>	12 kg/h
<u>Fuelling couplings</u>	35 MPa (cars and buses)
<u>Additional information</u>	→ Austria's first hydrogen fuelling station

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Shell/Tongji in Shanghai Anting, China. Gaseous hydrogen fuelling station.



Gaseous hydrogen fuelling station, Anting New Town, China

Description In close cooperation with Tongji University and Shell Hydrogen, Linde has been involved in building Shanghai's first hydrogen fuelling station. Officially opened in November 2007, this station is part of the Chinese government's programme to commercialise fuel-cell vehicles in China. The Shell/Tongji fuelling station in Shanghai Anting has the capacity to fuel three fuel-cell buses (with 45 kg of hydrogen each) and 20 fuel-cell automobiles (with up to 3 kg of hydrogen each).

Details For this pioneering project, The Linde Group provided the engineering design and consulted on logistics, supply methods and the compression, storage and dispensing systems. Moreover, Linde is responsible for the delivery of compressed gaseous hydrogen to the new station via CGH₂ trailers.

Technical data

	CGH ₂ fuelling technology
Location	Anting New Town, near Shanghai International Auto City, China
Start of operation	2006
Accessibility	Public
Hydrogen source/storage	Linde's steam methane reforming plant in Shanghai, supply via CGH ₂ tube trailers, 250 kg at 16 MPa, planned upgrade to 20-MPa trailer supply
Fuelling technology	Diaphragm compression system
Fuelling pressure	35 MPa
Max. throughput	56 kg/h (2 x 28 kg/h)
Fuelling couplings	35 MPa (cars and buses)
Additional information	First stationary hydrogen fuelling station in China by Linde

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Nuclear Research Institute REZ in Prague, Czech Republic. Gaseous hydrogen fuelling station.



Gaseous hydrogen fuelling station, Prague, Czech Republic

Description

In 2009, a consortium of Czech and other European companies and institutions (the Czech Nuclear Research Institute REZ and Škoda Electric, along with Veolia Transport of France and Linde, among others) opened the first hydrogen fuelling station in the Czech Republic. This hydrogen fuelling station will be joined by another one in the Czech Republic in the near future as the country prepares to build a hydrogen infrastructure to support the development of zero-emission transport and industry.

Details

The new station serves a zero-emission hydrogen bus made by Škoda Electric AS. It is located north of Prague, in the town of Neratovice, near the local unit of Linde, which produces the required hydrogen fuel from natural gas. Furthermore, Linde was chosen to equip the station with its innovative hydrogen fuelling station technology.

Technical data

	CGH ₂ fuelling technology
Location	Prague, Czech Republic
Start of operation	2009
Accessibility	Public
Hydrogen source/storage	High-pressure storage
Fuelling technology	Dry-running (lubricant-free) piston compressor
Fuelling pressure	35 MPa
Max. throughput	30 kg/h
Fuelling couplings	35 MPa (cars and buses)
Additional information	→ First hydrogen fuelling station in the Czech Republic → Station serves H ₂ cars and buses

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Statoil in Stavanger, Norway. Gaseous hydrogen fuelling station.



Gaseous hydrogen fuelling station, Stavanger, Norway

Description The Hynor hydrogen highway project in Norway was established in 2003 with the objective of a broad market demonstration of hydrogen for transportation in Norway. It is part of the Scandinavian hydrogen highway partnership with HyFuture (Sweden) and Hydrogen Link (Denmark). There are seven hydrogen fuelling stations planned along the 580-kilometer (360-mile) route. The planned highway is to run between the Norwegian capital, Oslo, and the port of Stavanger.

Details Norway's first 35-MPa and 70-MPa public hydrogen fuelling station was opened in February 2007, near Stavanger, as an integrated part of a petrol station. Linde was chosen to equip this hydrogen fuelling station with its innovative hydrogen fuelling technologies.

Technical data

	<u>CGH₂ fuelling technology</u>
<u>Location</u>	Stavanger, Norway
<u>Start of operation</u>	2007
<u>Accessibility</u>	Public
<u>Hydrogen source/storage</u>	Hydrogen trucked in by CGH ₂ trailer, high-pressure storage
<u>Fuelling technology</u>	Dry-running (lubricant-free) piston compressor
<u>Fuelling pressure</u>	35 and 70 MPa
<u>Throughput</u>	45 kg/h
<u>Fuelling couplings</u>	35 MPa and 70 MPa (cars)
<u>Additional information</u>	→ First public hydrogen fuelling station in Norway → First 70-MPa hydrogen fuelling station in Norway

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AC Transit in Emeryville, California. Gaseous hydrogen fuelling station.



AC Transit hydrogen fuelling station, Emeryville, California, USA

Description AC Transit's hydrogen fuelling station at Emeryville is designed to serve hydrogen fuel-cell cars as well as hydrogen fuel-cell buses. The station features Linde's innovative ionic compressor system for 35-MPa (350-bar) hydrogen fuelling as well as a dry-running, lubricant-free piston compressor capable of 70-MPa (700-bar) hydrogen fuelling. Hydrogen can be supplied from an on-site liquid hydrogen tank or via an on-site electrolyser.

Details The hydrogen fuelling station at Emeryville is the first implementation in the US of Linde's ionic compressor system for bus fuelling. The ionic fuelling system is a high-throughput, low-maintenance and efficient compression technology that can fuel up to 12 AC Transit fuel-cell buses each day with 30 kg of hydrogen per bus. The car fuelling station is the first public hydrogen fuelling station in the San Francisco Bay Area and will serve as a building block for the development of the Bay Area cluster for fuel-cell vehicles. Linde supplies the liquid hydrogen and maintains all equipment to ensure high reliability and uptime.

Technical data

	Bus fuelling	Car fuelling
Location	Emeryville, California, USA	
Start of operation	Q3 2011	
Accessibility	Semi-public	
Hydrogen source/storage	Electrolyser (60 kg/day) and liquid hydrogen tank	
Fuelling technology	Ionic compressor	Dry-running (lubricant-free) piston compressor
Fuelling pressure	35 MPa (350 bar)	35 MPa and 70 MPa (350 bar and 700 bar)
Throughput	360 kg per day	240 kg per day
Fuelling couplings	35 MPa (350 bar)	35 MPa and 70 MPa (350 bar and 700 bar)

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Arlanda Airport, Stockholm, Sweden. Gaseous hydrogen fuelling station.



Gaseous hydrogen fuelling station near Arlanda Airport, Stockholm, Sweden

Description Sweden's largest and Stockholm's first hydrogen fuelling station is located near Arlanda Airport and was commissioned in 2015. The station is mainly used by environmentally friendly taxicabs that are available at Arlanda Airport. With hydrogen produced by water electrolysis and electricity from wind power, the CO₂ emission figure for hydrogen is very close to zero. The hydrogen fuelling station received EU funding through HIT-2 (Hydrogen Infrastructure for Transport).

Details The Arlanda Airport station is equipped with Linde's patented ionic compressor IC90 with a continuous hydrogen fuelling capacity of 30 kg/h and high-pressure storage of > 60 kg at 85 MPa. Hydrogen is supplied via high-pressure container vehicles from the Linde production plant in Sandviken, which is about 150 km away. The Arlanda Airport hydrogen fuelling station was designed to manage the fuelling of 200 fuel-cell-powered electrical cars per day.

Technical data

	CGH ₂ fuelling technology
Location	Arlanda Airport, Stockholm, Sweden
Start of operation	Q3/2015
Accessibility	Public
Hydrogen source/storage	Hydrogen from electrolyzers
Fuelling technology	Linde ionic compressor
Fuelling pressure	70 MPa
Throughput	30 kg/h
Fuelling couplings	WEH TK H2 IR
Additional information	→ Fulfills SAE TIR J2601 A-70 (improved fuelling standard)

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Hydrogen centre in Bolzano, Italy. Production and distribution centre for gaseous hydrogen.



Production and distribution centre for gaseous hydrogen in Bolzano, Italy

Description The hydrogen centre in Bolzano was commissioned in 2014 as a production facility and hydrogen fuelling station for cars and buses. Operated by IIT, the hydrogen centre represents the newest generation of Linde's turnkey product lines with a very small footprint. The hydrogen production facility has been funded by the European Regional Development Fund (ERDF).

Details Built into a provided building infrastructure, the ionic compressors developed by Linde compress hydrogen to a fuelling pressure of 35 MPa and 70 MPa. The on-site production system has been installed next to the compressors and the produced hydrogen can be stored for distribution in 55 MPa or 100 MPa tube storage tanks. As it ideally integrates a hydrogen unit with minimal required space into a local infrastructure, the hydrogen centre Bolzano can be seen as a model for further facility layouts.

Technical data

	CGH ₂ fuelling technology
Location	Bolzano, Italy
Start of operation	Q2/2014
Accessibility	Semi-public
Hydrogen source/storage	On-site production
Fuelling technology	Ionic compressor IC90, IC50
Fuelling pressure	35 and 70 MPa, cars and buses
Throughput	Approx. 30 kg/h (compressed)
Fuelling couplings	35 MPa, 70 MPa
Additional information	→ First fuelling station with 70 MPa in Italy

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7-Eleven and 76 in San Juan Capistrano, California, USA. Liquid hydrogen fuelling station.



7-Eleven and 76 liquid hydrogen fuelling station, San Juan Capistrano, California, USA

Description In January 2016, Linde's first hydrogen fuelling station in Southern California opened in San Juan Capistrano. The public station is located on a 7-Eleven and 76 petrol station property. It was funded by the California Energy Commission and the South Coast Air Quality Management District.

Details For the hydrogen station in San Juan Capistrano, Linde provided the ionic compression technology and a Quantum dispenser. Liquid hydrogen is supplied by an aboveground 11,360-litre liquid hydrogen tank. The San Juan Capistrano hydrogen fuelling station stores approximately 60 kg of hydrogen at high pressure.

Technical data

	CGH ₂ fuelling technology
Location	San Juan Capistrano, California
Start of operation	Q1/2016
Accessibility	Public
Hydrogen source/storage	Liquid hydrogen from SMR source
Fuelling technology	Linde IC90 and Quantum dispenser
Fuelling pressure	35 and 70 MPa
Throughput	Over 300 kg/day
Fuelling couplings	35 MPa, 70 MPa
Additional information	→ Located at a 7-Eleven and 76 petrol station

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Ramos Oil in West Sacramento, California, USA. Liquid and gaseous hydrogen fuelling station.



Ramos Oil liquid and gaseous hydrogen fuelling station in West Sacramento, California, USA

Description In January 2015, Linde's first public hydrogen fuelling station in California opened in West Sacramento. The station closely collaborates with the California Fuel Cell Partnership (CaFCP) and is approved by the OEMs as well as the Department of Weights and Measures. The project received funding from the California Energy Commission.

Details The station is equipped with Linde's 90 MPa ionic compression technology and a Linde Quantum dispenser. Liquid hydrogen is supplied by an above-ground 11,360-litre liquid hydrogen tank. The West Sacramento hydrogen fuelling station stores approximately 60 kg of hydrogen at high pressure.

Technical data

	CGH ₂ fuelling technology
Location	West Sacramento, California, USA
Start of operation	Q1/2015
Accessibility	Public
Hydrogen source/storage	Liquid hydrogen from SMR source
Fuelling technology	Linde IC90 and Quantum dispenser
Fuelling pressure	35 MPa and 70 MPa
Throughput	Over 300 kg/day
Fuelling couplings	35 MPa, 70 MPa
Additional information	→ Located at a multi-fuel station on Ramos Oil site

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Iwatani in Shibakoen, Tokyo, Japan. Gaseous hydrogen fuelling station.



Iwatani gaseous hydrogen fuelling station, Tokyo, Japan

Description

Iwatani's hydrogen fuelling station, which opened in 2015, is Japan's first hydrogen fuelling station with a showroom and simultaneously Tokyo's most central one. It is located in Shibakoen, Minato-ku, Tokyo, and operates as an information hub for realising a hydrogen society. The public station includes a showroom that showcases the Toyota Mirai, a hydrogen fuel cell vehicle released in late 2014, along with videos and other displays that introduce the features of the vehicle and provide information about hydrogen.

Details

For the hydrogen station in Shibakoen, Linde provided its ionic compressor IC90. The required hydrogen is produced off site and stored in liquid hydrogen tanks. The Iwatani hydrogen fuelling station is designed to serve educational purposes for the promotion of a hydrogen society and to act as a hub for related information. Located in the city centre, it respects the surrounding landscape. Additionally, it will also test the use of pure-hydrogen-type fuel cells for power supply.

Technical data

	CGH ₂ fuelling technology
Location	Shibakoen, Minato-ku, Tokyo, Japan
Start of operation	Q2/2015
Accessibility	Public
Hydrogen source/storage	LH ₂ tank
Fuelling technology	Ionic compressor IC90
Fuelling pressure	70 MPa
Throughput	340 Nm ³ /h
Fuelling couplings	2 x 70 MPa WEH
Additional information	→ Station includes showroom that showcases the Toyota Mirai hydrogen fuel cell vehicle

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Toyota Ecoful Town in Toyota City, Japan. Gaseous hydrogen fuelling station.



Toyota Ecoful Town gaseous hydrogen fuelling station, Toyota City, Japan

Description In collaboration with Toho Gas Co., Ltd., Iwatani constructed and commissioned a hydrogen fuelling station in Toyota, Aichi Prefecture. The station is part of a joint research project between the Research Association of Hydrogen Supply/Utilization Technology (HySUT) and the New Energy and Industrial Technology Development Organization (NEDO). It acts as a demonstration model for future commercial hydrogen stations by fuelling fuel cell vehicles and fuel cell buses.

Details The public station consists of a package-type hydrogen station from Linde and because of that achieves improved convenience, takes up less space and reduces costs. It is equipped with two Linde ionic compressors, which compress hydrogen to a fuelling pressure of 35 MPa and 70 MPa. Hydrogen is supplied by City Gas and stored in GH₂ tube storage tanks.

Technical data

	CGH ₂ fuelling technology
Location	Toyota City, Japan
Start of operation	Q2/2013
Accessibility	Public
Hydrogen source/storage	City Gas, GH ₂ tube storage tanks
Fuelling technology	HydroGear 90
Fuelling pressure	35 and 70 MPa
Throughput	Up to 2,000 Nm ³ /h
Fuelling couplings	35 MPa, 70 MPa
Additional information	→ Direct fuelling method for fuel cell vehicles and fuel cell buses

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Aberdeen, Scotland. Gaseous hydrogen fuelling station for buses.



Gaseous hydrogen fuelling station in Aberdeen, Scotland

Description The station in Aberdeen was commissioned in 2015 as a hydrogen fuelling station for buses. Operated by BOC, a member of The Linde Group, the station represents the newest generation of Linde's turnkey product lines with a very small footprint. The Aberdeen hydrogen fuelling station is the biggest hydrogen fuelling station for buses in Europe. The project has been co-funded by Scottish, UK and European partners.

Details The station is equipped with the Linde ionic compressor IC60, which compresses the hydrogen to a fuelling pressure of 35 MPa. The on-site production system has been installed next to the compressors and the produced hydrogen can be stored for distribution in 55 MPa tube storage tanks. As it ideally integrates a hydrogen unit with minimal required space into a local infrastructure, the station can be seen as a model for further station layouts.

Technical data

	CGH ₂ fuelling technology
Location	Aberdeen, Scotland
Start of operation	Q2/2015
Accessibility	Non-public
Hydrogen source/storage	On-site production
Fuelling technology	Ionic compressor IC60
Fuelling pressure	35 MPa
Throughput	Approx. 20 kg/h
Fuelling couplings	35 MPa
Additional information	→ Fuelling station for bus fleet

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