FOCUS

LR Kältetechnik

More than cold. I H_2 Mobility

Refrigeration technology for hydrogen infrastructure

Two concepts for cooling during refuelling

Refrigeration technology for hydrogen infrastructure

Two concepts for cooling during refuelling

Now is the time: the hydrogen economy is (finally) being given a boost. In order to use this element with the atomic number One as fuel in vehicles, you need ultra-low temperatures – otherwise the refuelling process takes decidedly longer than drivers want to wait. L&R has already gained experience through project planning for the required refrigeration technology. Two different concepts are being implemented. The usage profile of the petrol station determines which one applies. With regard to refrigerants, Low-GWP-HFOs and CO_2 are available as natural and environmentally-friendly coolants.

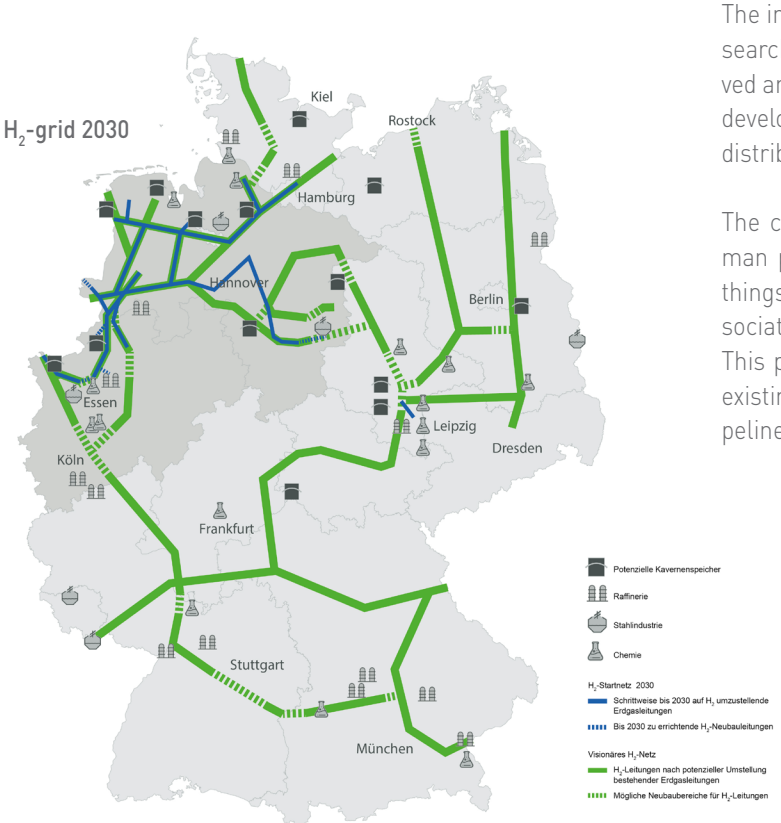
Electrical current versus hydrogen: which of these energy sources will change the future course of mobility? This discussion has undergone a shift in perspective since autumn 2020. Both the German federal government and the EU have adopted billion-euro programmes to give a boost to the hydrogen economy, thus advancing the introduction of non-fossil fuels. The main focus of this is sustainable central extraction and extensive, cross-sector use of "green" hydrogen.

The network of hydrogen stations is growing (©: Toyota/ H2 Mobility)

Goal: infrastructural enhancement

The initiatives and programmes are less oriented towards research and development since the major technologies involved are known and have been tried and tested. The focus is on developing an infrastructure – from production to storage and distribution and eventually provision.

The concept of an almost 6,000-kilometre, nationwide German pipeline network for hydrogen is proof of the fact that things are moving forward. It has been designed by the Association of Gas Transmission System Operators (FNB Gas). This plan is attractive since it stipulates using many already existing (natural gas) pipelines in addition to exclusive H2 pipelines, thus saving costs.



Disclaimer: Bei der Karte handelt es sich um eine schematische Darstellung, die hinsichtlich der eingezeichneten Speicher und Abnehmer keinen Anspruch auf Vollständigkeit erhebt.

Overview of the German nationwide hydrogen network (©: FNG gas)

30 YEARS QUALITY

Short-term objective: 100 vehicle hydrogen fuelling stations
This network could be ready for operation in 2030. The end customers receiving the hydrogen would include service stations. The H_2 Mobility consortium, a group consisting of car manufacturers, service station operators and gas producers, is focusing on its design and construction.

H_2 Mobility's initial goal is the operation of 100 hydrogen-vehicle fuelling stations (i.e. for 700 bar refuelling) in seven German metropolitan areas and on motorways. This goal has almost been reached: currently, there are 92. Once number 100 has been opened, more than six million drivers can switch to hydrogen use without having to make any major detours, and fuel cell vehicles will become more appealing for daily use. There are six stations where commercial vehicles can refuel with 350 bar.

Refrigeration accelerates the refuelling process
We will need refrigeration technology for those stations and any others to be built in the next few years. The reason is that the (adiabatic) compression of hydrogen in the vehicle tank can potentially cause unacceptably high temperatures. To counteract this effect, the hydrogen is cooled down to as low as –40°C. This has another advantage: the colder the hydrogen is when it flows from the local storage into the vehicle tank, the faster the refuelling process. Consequently, cooling not only has to occur centrally, but also as close as possible to the vehicle, i.e. at the fuel dispenser. This means that efficient refuelling cannot be achieved without powerful (ultra-low temperature) refrigeration technology.

The measure of all things: SAE J 2601
The central parameters for refuelling (fuel temperature, refuelling speed, final pressure, etc.) are set out in the SAE standard J2601. The average flow rate for vehicle refuelling at public service stations is approximately 30 g/s with a maximum rate of 60 g/s.

For the hydrogen temperature during refueling, the colder the better.

Further reading

Some tips for further reading on the topic: the Fraunhofer Institute ISE published a "Hydrogen Roadmap for Germany" (in October 2019). It predicts the market development for the hydrogen economy over the coming decades:
(https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/2019-10_Fraunhofer_Wasserstoff-Roadmap_fuer_Deutschland.pdf

Current news about hydrogen (and electric mobility) can be found on the "NOW GmbH Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie" website (www.now-gmbh.de)

Keep up to date on the topic of the "Expansion of the hydrogen station network in Germany" on the H_2 Mobility network's website: www.h2.live, where you will also find numerous press releases issued by the network partners.

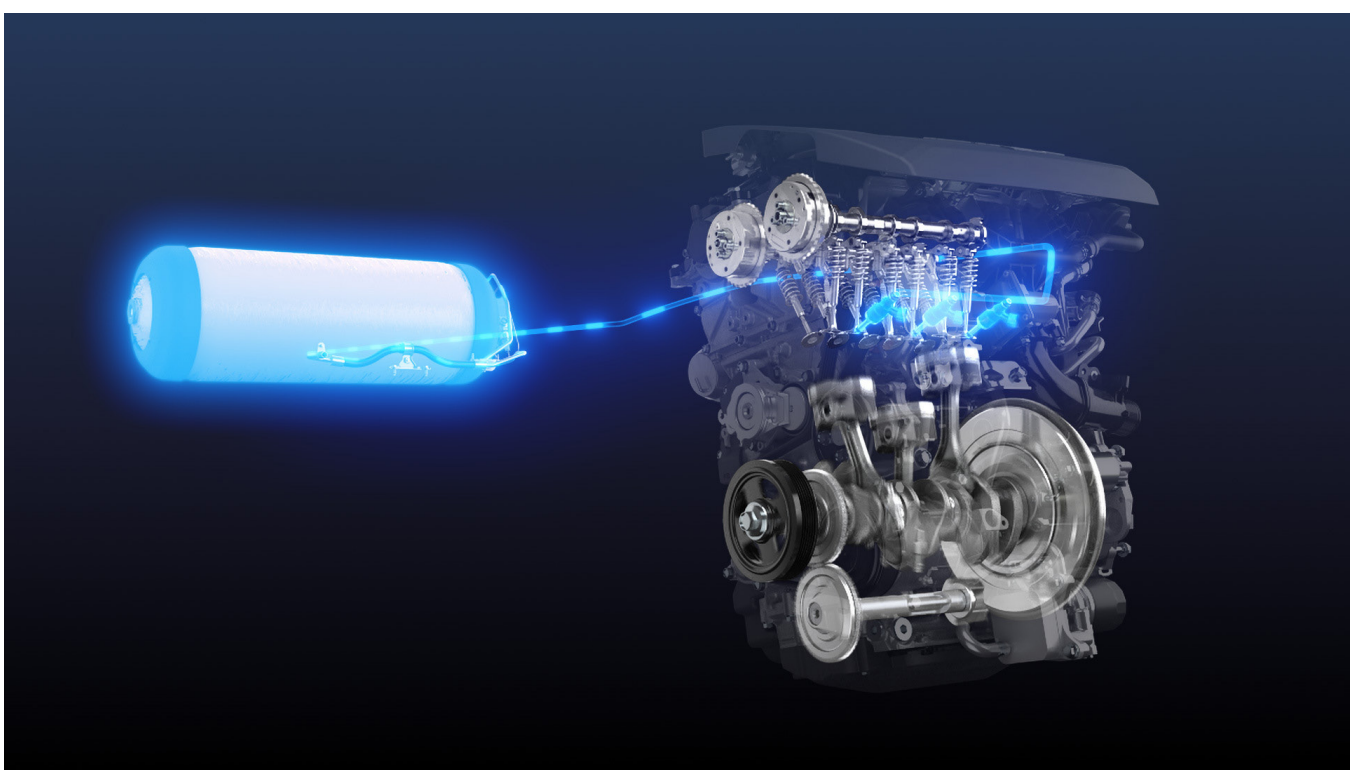
Not just for fuel cell vehicles

Which refrigerant should be used?
When choosing the refrigerants, the plant manufacturer and/or the service station operator is not bound by any restrictions. For this application, L&R has implemented refrigeration plants with R 449A – a Low-GWP-HFO blend (HFO = hydrofluoroolefin); with an additional potassium formate-based brine being used for the intermediate circuit plants.

Natural refrigerants are another alternative, especially since these applications aim to be sustainable and provide climate protection. L&R holds the view that CO_2 is the right choice of refrigerant. Its features fit the refrigerating requirements for hydrogen fuelling stations almost perfectly, and L&R has already implemented CO_2 ultra-low-temperature plants for various applications. CO_2 as a refrigerant has become indispensable for foodstuff and supermarket refrigeration. Now, L&R is also able to offer this option for industrial applications.

Not just for fuel cell vehicles
The speed with which this market develops and how many fuel cell vehicles will be on the road in Germany in 2025 or 2030 cannot yet be accurately determined. However, it is clear that the respective infrastructure is being built. Many additional public hydrogen service stations are at the planning stage or under construction. The demand for private service stations is developing even more rapidly, e.g. those being used by transport and logistics companies.

And when you refer to hydrogen as a fuel, this does not necessarily imply fuel cell drives. Combustion engines can also be operated with hydrogen. BMW has operated an H2 test fleet for several years, but has ceased activities in this field, giving priority to electric and fuel cell drives. Toyota, on the other hand, has just recently presented a hydrogen-operated racing engine, and MAN exhibited a lorry with an H2 combustion engine. What's more, the engine manufacturer Deutz presented the prototype for the TCG 7.8 H2 six-cylinder in-line engine: a hydrogen engine for mobile working machines that can be used in various hybrid configurations in combination with electric drives.



Hydrogen can also be used to operate suitably adapted combustion engines. (© Toyota)

L&R delivers optimized chillers for H_2-filling stations

At this hydrogen station, the refrigeration machine with the hydrogen treatment is clearly visible in the background. (©: H2 Mobility)

For H_2 service stations catering to lorries, buses and trains (usually operated by private companies), flow rates of 80 to 120 g/s are usually reached. However, this is largely sufficient if refuelling takes place over a markedly longer period of time than passenger vehicle refuelling. However, some cooling of the hydrogen is normally involved here as well. Basically, the rule is: the colder, the better.

The standard sets out three categories that comprise the crucial factor for refrigeration technology with regard to the hydrogen temperature during refuelling: T20, T30 and T40, with T40 corresponding to a temperature of –40°C. This category eventually defines the refuelling speed. Therefore, you need an ultra-low temperature refrigeration plant to cool the hydrogen (which currently does not flow from a pipeline but is stored in cylinders on the service station premises) to the desired temperature. Basically, the rule is: the colder, the better.

At a hydrogen temperature of –40°C, the tank can take enough compressed hydrogen (up to 10 kg) within three to five minutes to reach a fill level of 95 to 100%. Depending on the vehicle and fuel tank volume, the range is then 500 to 700 kilometres. This means that fuel cell drives eliminate the often-feared "range-phobia" associated with electric mobility.

Direct evaporation or intermediate cooling?

L&R has already acquired comprehensive knowledge on designing and planning refrigeration systems for H_2 service stations through working on private and public service stations in Germany, France, England and Spain. Basically, there are two different concepts that can be applied. Ultimately, the refuelling profile is crucial for deciding which of the two concepts to use.

For public H_2 service stations with a larger, discontinuous demand for hydrogen, the principle of direct evaporation or open circuit cooling has proven to be effective. The refrigeration unit (which has to be appropriately dimensioned and large enough) then directly cools the hydrogen via an H_2 heat exchanger when it is needed.

If the site is a service station that is only active at certain times or in irregular intervals, it is more economic if the hydrogen is cooled by means of "energy storage" in the form of special ultra-low temperature fluid. This storage is recharged by the refrigeration machine during the refuelling intervals. To achieve this, an intermediate circuit is required. This technology is therefore somewhat more complex; however, a refrigeration system with less power can be used, which results in a clear cost saving.

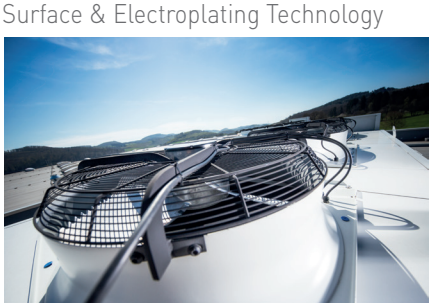
Author: Christoph Wiemer, Head of Special Systems Sales

Industrial refrigerations systems
Ultra low temperature units
Control technology

L&R Kältetechnik

As individuell as your project!!

Surface & Electroplating Technology

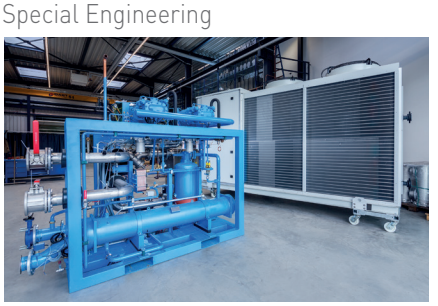


Chemical & Pharmaceutical Industry

Plastics & Rubber Industry

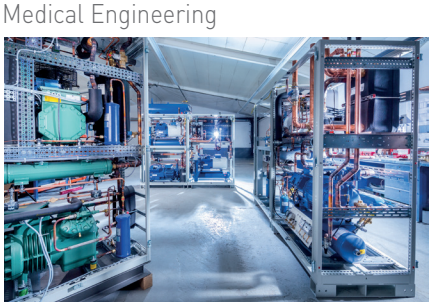
Food Industry

Special Engineering



Plant & Machine Technology

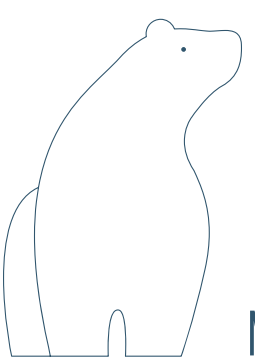
Medical Engineering



Metal Processing

Ready for your Business!

L&R Kältetechnik GmbH & Co. KG
Hachener Straße 90 a-c
59846 Sundern-Hachen · Germany
Tel. +49 2935 9652 0
info@lr-kaelte.de
www.lr-kaelte.de



More than cold.