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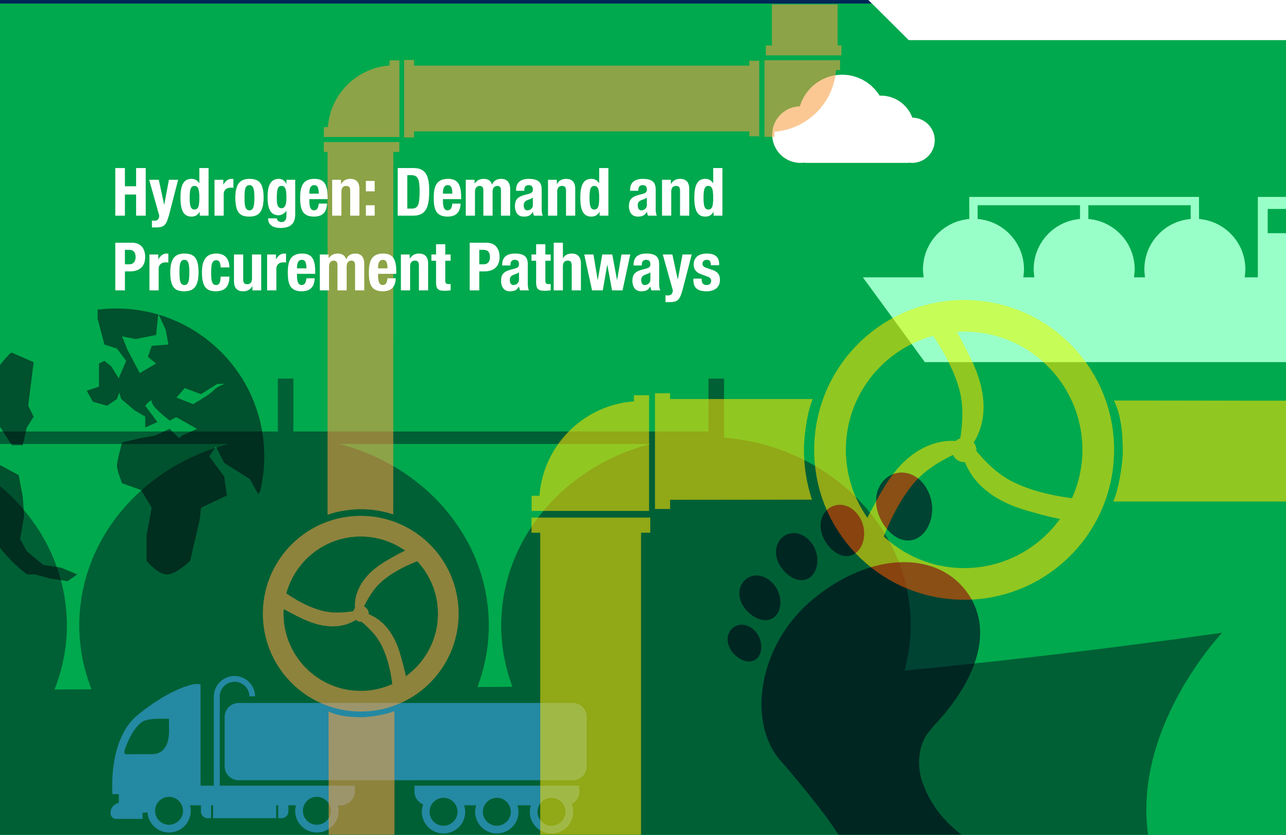
Hydrogen: Demand and Procurement Pathways



From the “Time for an Energy Ch2ange” series.

Where there's hydrogen, there's a way.

At a glance

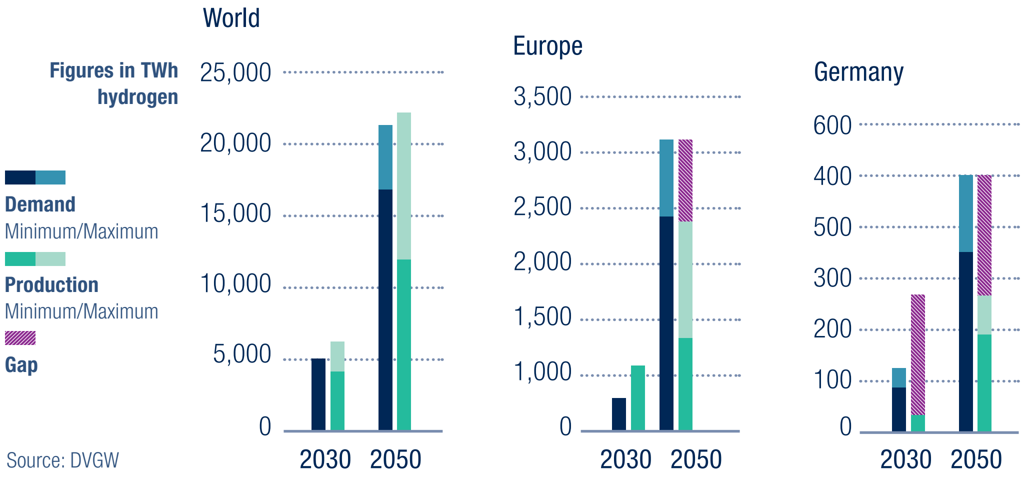
- Hydrogen demand is rising sharply.
- The global production potential is large, but needs to be harnessed more quickly.
- Imports make good sense and are cheapest via pipelines from other European countries and neighbouring regions.
- Even shipping from distant regions can make sense in the case of inexpensive production.
- Transport options for hydrogen and its derivatives still need to be developed further.
- Production and import capacities need to be expanded much faster than has been the case to date.

Hydrogen demand rising sharply

A broad consensus exists worldwide that hydrogen produced in a climate-friendly manner will make a fundamental contribution to securing a climate-friendly energy supply in the future. In order to achieve the internationally agreed climate targets and replace fossil fuels, many countries are already focusing on this energy source.

The global demand for hydrogen will increase in the coming decades. The ramp-up of production capacities must pick up speed accordingly. As an energy importing country, Germany in particular will be dependent on sourcing hydrogen both from other European countries and further afield, across the globe. This is because it is highly unlikely that national demand will be fully covered by domestic production capacities – despite energy savings and increasing energy efficiency.

The global production potential exceeds the forecast demand



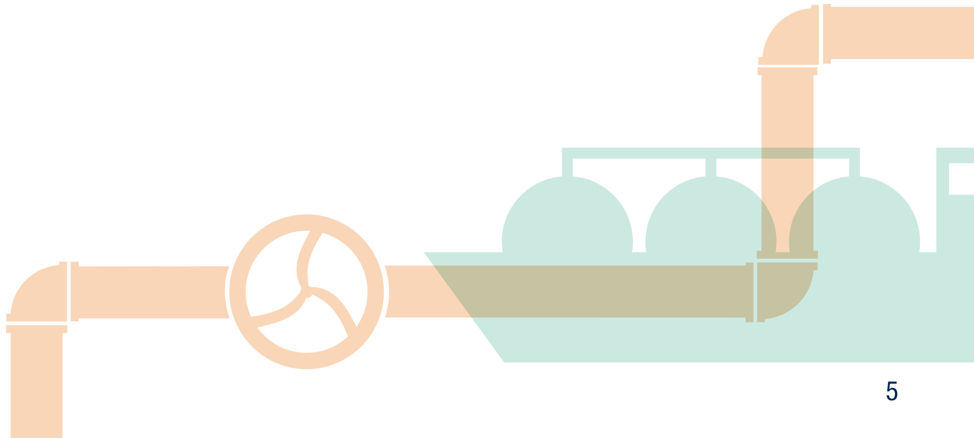
Source: DVGW

Supply and demand – is this sufficient?

A review of the literature conducted by the DVGW Research Centre at the Engler-Bunte Institute (KIT) has shown that several studies and forecasts assume a global demand for climate-friendly hydrogen production of 5,000 terawatt hours (TWh) by 2030. By 2050, this figure will even rise to between 17,000 and 22,000 TWh of hydrogen. Even if these quantities appear ambitious from today's perspective, the techno-economic generation potential exceeds the forecast demand of up to 22,700 TWh by 2050, depending on the scenario.

In **Europe,** imports from other regions will be necessary in the long term. While demand in 2030 may still be covered by European production, there will be a gap between supply and demand by the middle of the century.

Germany will continue to be dependent on energy and hydrogen imports. In the update of its National Hydrogen Strategy, the Federal Ministry of Economic Affairs even assumes that around 50 to 70 per cent of German demand will need to be covered by imports of hydrogen or its derivatives in 2030. Imports can be made either via pipelines or by ship transport.



Shipping or pipeline can be worthwhile, depending on the distance

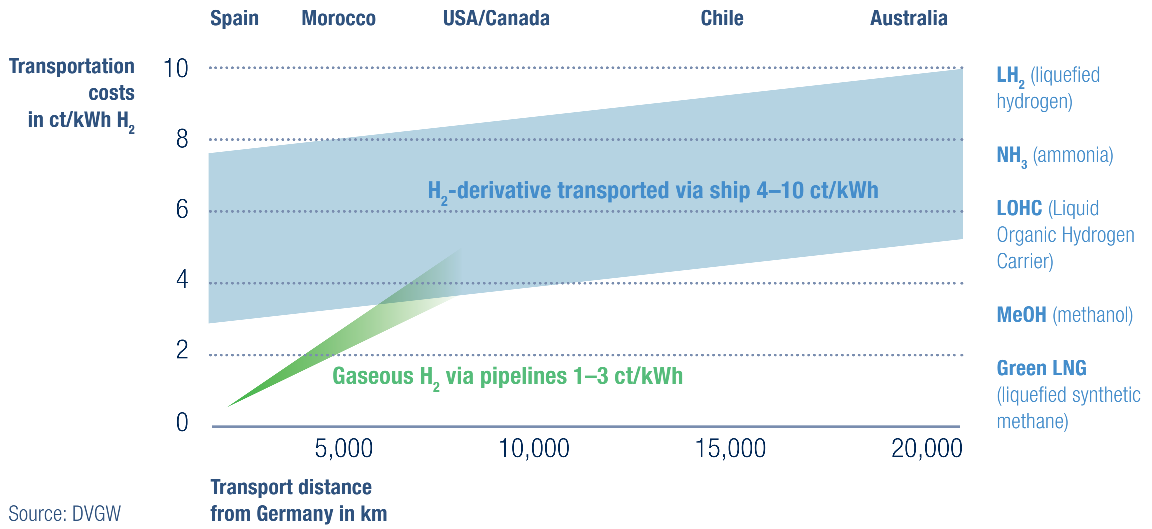
There are various options for importing large quantities of hydrogen. It can either be transported to Germany as a gas via pipeline or – over longer distances – in liquefied form or bound in derivatives via ship.

For distances of up to around 5,000 kilometres, transport via pipeline is the cheapest and most efficient option. In this case, gaseous hydrogen can be used. Imports of gaseous hydrogen by pipeline are particularly suitable for less distant countries, for example from other European countries or the MENA region (Middle East and North Africa). These will be the most favourable in the future. Existing natural gas pipelines can also be converted to hydrogen for this purpose.

If the distance between the place of production and the importing country is greater than that, the only feasible option is transport by ship. To make this worthwhile, large quantities are required. To achieve this, hydrogen must either be liquefied at low temperatures or converted into a derivative using various processes. This import option is particularly suitable for more distant regions that have a high potential for producing climate-friendly hydrogen at low cost, especially for sources that are over 6,000 kilometres away. The distance then only has a minor influence on the transport costs

Sample calculation:
The transportation costs of liquefied hydrogen only increase from around five to six cents per kilowatt hour if the distance is doubled from 10,000 to 20,000 kilometres. This means that if the production costs are comparatively much lower, transport between distant regions can still be cost-effective.

Pipelines are cheaper than ship transport for distances of up to 5,000 kilometres



Source: DVGW

Hydrogen and its derivatives – what is what?

Liquefied hydrogen (LH_2):
Gaseous hydrogen is supercooled to –253°C and liquefied. It therefore has a higher density and a smaller volume for the same quantity. This provides benefits for storage and transport. Once it reaches its destination, the hydrogen is vaporised and restored to its gaseous state.

Ammonia (NH_3):
Gaseous hydrogen is first compressed and then bound in the form of ammonia (NH_3) using the Haber-Bosch process with the addition of nitrogen. This can be liquefied at ambient pressure and at temperatures as low as –33°C. Although the substance is corrosive and toxic, it has been used in agriculture and the chemical industry for decades. The handling of this substance is therefore already tried and tested, and technically mature.

LOHC:
Certain liquid organic compounds can absorb and release hydrogen through chemical reactions, which is why they are referred to as liquid organic hydrogen carriers (LOHC). These can be stored or transported at room temperature and normal pressure conditions. To recover the hydrogen, LOHCs are dehydrated and he hydrogen is released.

Synthetic methane (Green LNG):
As with natural gas, this refers to methane or CH_4 – apart from it not being extracted from deep layers of rock, but being chemically produced from climate-friendly hydrogen and CO_2. This process is also known as methanisation. The gas can either be transported via existing pipelines or in liquefied form (Green LNG) by ship.

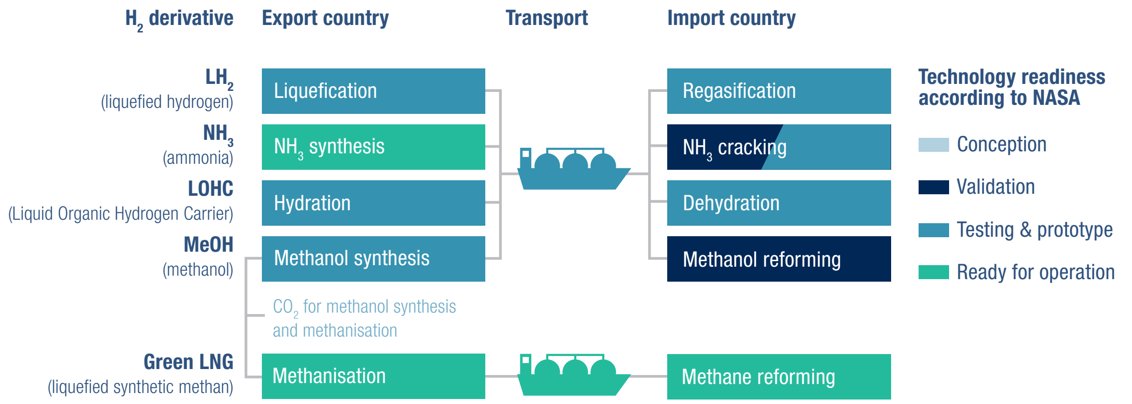
Methanol (MeOH):
For the production of green methanol, water is mixed with CO_2. As with methanisation, methanol is produced from H_2 and CO_2. However, the molecule produced contains an additional oxygen atom CH_3OH. Methanol is liquid like petrol or diesel and can therefore be filled up at a conventional petrol station. In the car, the methanol is safely converted back into hydrogen, which in turn is converted into electricity in the fuel cell.

Many paths lead to hydrogen

Researchers from the DVGW Research Centre at the Engler-Bunte-Institut of the KIT (DVGW-EBI) have investigated various process chains and transport options in the “H2 Import” project and compared them in regard to various technical criteria. Most of the transport options include process steps that are not yet commercially available.

For example: The cracking of ammonia (NH_3) for the recovery of hydrogen; ships of the appropriate size for the transport of liquid hydrogen (LH_2); or large-scale facilities for the dehydrogenation of liquid organic hydrogen carriers (LOHC). However, all forms should be pursued in order to reach the desired objectives as quickly as possible.

Development requirements for the production and reconversion of hydrogen derivatives for ship transport



Source: DVGW

Example transport routes and costs of hydrogen

Possibilities for hydrogen transport

- The "Green LNG" process chain is the most readily available (see Fig. p. 9). However, CO_2 management has not been implemented on the necessary scale

- The logistics chain for ammonia is also relatively well tested and technologically advanced. To import large quantities as a hydrogen carrier, however, individual sections of the value chain still need to become more efficient. For example, there is still a lack of cracking processes on an industrial scale to recover the hydrogen after transport.

- The transport of LH_2 promises the highest degree of utilisation in the long term and is therefore the most efficient. Provided there are leaps in development, this could prove to be the best option

Making more hydrogen available more quickly

The global production potential of climate-friendly hydrogen far exceeds the forecast demand. Various studies and simulations take into account factors such as supply and demand, trade relations and technologies. They assume possible production volumes of 1,200 to 5,300 TWh for the year 2030, which could increase to 12,300 to 22,700 TWh by 2050.

The existing and projected generation capacities of the announced projects for climate-neutral hydrogen production have increased steadily and significantly in recent years. However, the total quantities only correspond to around 20 to 30 per cent of the forecast demand.

Further initiatives and projects are required to increase the availability of hydrogen at the speed needed. This requires a reliable regulatory framework that offers investment security. The development of technologies for synthesising derivatives and recovering hydrogen should be supported. International co-operations and supply agreements can be expanded. Last but not least, it makes sense to use blue hydrogen to bridge the gap until enough green hydrogen is available.

"It is not only the transport costs that are decisive for the total cost of providing hydrogen in Germany, but also the production costs abroad. This is why hydrogen imports from South America or Australia can also be economically competitive with imports from the EU."

CHRISTIANE STAUDT

Project Engineer, DVGW Research Centre at the Engler-Bunte-Institut of the KIT

Source: DVGW-EBI

"Time for an Energy Ch2ange"
DVGW publications

Hydrogen is the energy carrier of the future and a key element in climate protection and the energy transition in Germany. DVGW has already been committed to this area for more than 10 years. Its research institutes are working on a large number of projects concerning the production, transport, distribution and utilization of hydrogen.

In addition, the codes of practice of DVGW have been almost entirely adapted to hydrogen operation. Our series "Zeit für einen Stoffwech2el" (Time for an Energy Ch2ange) covers in a compact form the current status of research and the range of technical know-how collected during work on standards

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Sources

Brief DVGW study on hydrogen transport options conducted by the DVGW Research Centre at the Engler-Bunte Institute of KIT
www.dvgw.de/h2-import

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DVGW Deutscher Verein des
Gas- und Wasserfaches e. V.
Technisch-wissenschaftlicher Verein
Josef-Wirmer-Straße 1-3, 53123 Bonn

Phone: +49 228 9188-5
Email: info@dvgw.de
Internet: www.dvgw.de

Design: waf.berlin

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