Hydrogen revolution poised to boost valve market

The fundamental currency of our planet is energy, most of which still comes from fossil fuels. Hydrogen, in concert with other renewable energy sources, has the potential to fully decarbonise the energy system. The unlocking of this potential is already underway and bound to trigger a tsunami of projects that will create significant fresh demand for process and piping equipment, including valves and actuators.

By Matjaž Matošec

Green hydrogen produced by renewable energy, one of the many ways to decarbonise the energy sector.

The stars have aligned for hydrogen. Political leaders and stakeholders from across the value chain, including European oil majors, appear to have fully embraced hydrogen as a vital component of the energy mix and key means of achieving carbon neutrality. This is clearly evidenced by the unprecedented flurry of hydrogen projects, strategies, initiatives, alliances and investment pledges announced last year across the globe – nationally and internationally. 2020 is thus likely to go down in history as the year marking an inflection point for the hydrogen economy, kick-starting what only a few years ago still seemed science fiction.

COVID-19 is an important catalyst for this shift. Having devastated economies, the pandemic necessitates bold action and economic measures to recover lost jobs and create new ones. And what better way to achieve this than by massively investing in clean technologies, thereby providing the much-needed stimulus not only to tackle the economic fallout from the pandemic, but also to accelerate global efforts to combat climate change.

Dramatic progress possible

If 2020 has laid a broad-based groundwork and created momentum for the hydrogen revolution, 2021 promises to see the existing projects, plans and pledges reaffirmed or further expanded, some of them materialised, and new ones announced, not the least from the freshly installed Biden administration.

The cost of green hydrogen has long been a major obstacle to its large-scale deployment, but the meteoric rise of solar and wind energy as well of electric vehicles is a testament to the fact that dramatic progress can be made in a short period of time within all areas critical for the success of any technological revolution: R&D, capacity build-up, cost reductions and price competitiveness with traditional technologies. Incentivised by various policies, hydrogen is destined to follow the same trajectory and become the fuel of the future, with this process already in motion.

Exponential growth

The exponential growth of solar and wind energy has benefited some equipment manufacturers, but not all. However, the rise of hydrogen powered by renewables turns technologies that used to decelerate the growth of thermal power generation capacity into an indirect demand driver for many types of equipment, including valves.

The purpose of this article is to demonstrate that the hydrogen revolution is here and that the opportunities it brings for valve manufacturers are real and significant. It will do so by focusing on green hydrogen produced through water electrolysis powered

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by renewable electricity and on its use in the industrial sector. But first, a brief overview of the current uses of hydrogen, its versatility as a fuel, and modes of its production.

Many shades

Today, hydrogen is mainly used as a chemical feedstock in oil refining, ammonia production and methanol synthesis, with the bulk of the remaining hydrogen feeding the production of other chemicals and various industrial processes. However, it is beyond these traditional uses where the greatest potential of hydrogen to step up the energy transition resides.

A clean and extremely versatile fuel, hydrogen can power all human activities. Whether combusted or oxidised in a fuel cell to generate electricity, it produces zero GHG emissions. As such, it can help decarbonise the entire energy system, including hard-to-abate sectors difficult or too costly to electrify, such as high-temperature industrial processes and heavy-duty transport.

Additionally, by blending hydrogen into natural gas pipelines, residential and commercial heating can be partly decarbonised without any modifications to existing infrastructure and appliances.

Pipeline safety studies show that blends containing up to 20 percent of hydrogen can be safely injected directly into the gas grid, with large-scale demonstrations and pilot programs testing this in practice as well as looking at converting the gas network to 100 percent hydrogen already underway or about to begin.

Energy security

The same can be observed in the power generation sector where hydrogen could eventually entirely replace natural gas as a fuel for single-cycle, CCGT (combined-cycle gas turbine) and CHP (combined heat and power) power plants. While most existing gas-fired plants will require modest to moderate equipment modifications to be able to use 100 percent hydrogen as a fuel, a growing number of planned new plants are designed to be hydrogen-ready so that they can switch to the cleaner fuel as soon as the hydrogen supply, cost and pipeline infrastructure allow it.

Another major benefit of green hydrogen is its function as an energy carrier. Cheap surplus energy from variable renewable sources available at times of off-peak demand can be converted into hydrogen which can then be immediately transported to end users or utilised as a source of seasonal energy storage, thereby optimizing the energy system and increasing its flexibility.

Finally, hydrogen is a means of improving energy security, especially for countries that heavily rely on fossil fuel imports. This characteristic should prove to be yet another important driver of the hydrogen revolution.

Dirty business

As a fuel, hydrogen may be clean, but its production can be (and currently is) dirty business. Global annual hydrogen production is about 70 million tons and nearly all of it is derived from fossil fuels, either from natural gas via steam methane reforming (SMR) or through coal gasification.

These processes generate 830 million tons of CO_2 emissions, or 1.7 percent of all global GHG emissions released annually. If CO_2 emissions from SMR are captured and stored using the CCS technology, the carbon intensity of the process is significantly reduced and the hydrogen derived from it labelled "blue" instead of "grey".

Until recently, blue hydrogen was widely considered a bridge fuel for the hydrogen economy, but its dependence on natural gas and the traction green hydrogen has gained recently somewhat diminish its attractiveness.

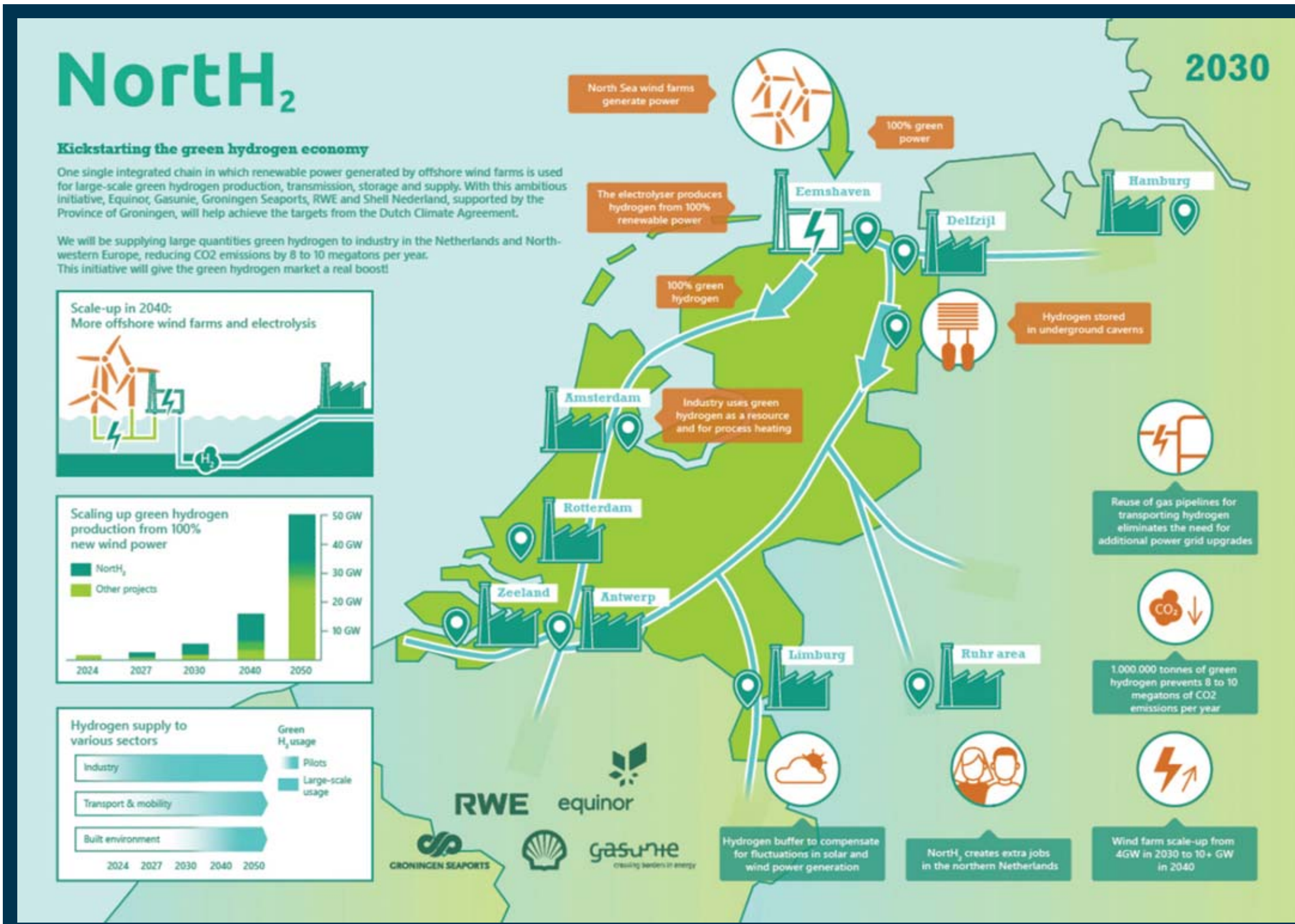
Methane pyrolysis

Another process of producing hydrogen from methane, about to undergo testing at the BASF site in Ludwigshafen, is pyrolysis. In this high-temperature process, methane is split into hydrogen and pure carbon in a molten metal alloy serving as a catalyst. Pyrolysis itself produces "turquoise hydrogen" and solid carbon, resulting in no direct CO_2 emissions, but the use of both renewable energy and biomethane is required for turquoise hydrogen to be near-carbon-free.

Only green hydrogen produced through water electrolysis using renewable electricity is truly carbon-neutral, readily scalable and enjoying wide support from all stakeholders, which makes it the most likely key driver of future valve demand for applications associated with hydrogen production, transport and storage, to which we turn next.

Electrolysis

Water electrolysis is a process using electricity to split water into gaseous hydrogen and oxygen. The hydrogen gas is either compressed or liquefied, while oxygen can either be released into the atmosphere or stored for industrial use. Electrolysers consist of metal-coated anode and cathode electrodes, separated by an electrolyte membrane. This membrane can be made of different materials, ▶



The NortH$_2$ project, the largest green hydrogen project announced so far, aims to produce green hydrogen using electricity from new offshore wind farms off the coast of the Netherlands and is planned to grow in capacity from 1 GW in 2027 to 4 GW by 2030, and to more than 10 GW in 2040. Launched in February 2020 and led by an international consortium, including Shell and Equinor, the project is awaiting the completion of the feasibility study, with project development activities expected to commence in the second half of 2021.

the most common being (1) polymer used in proton exchange membrane (PEM) electrolysers, (2) liquid alkaline solution of sodium or potassium hydroxide used in alkaline electrolysers, and (3) ceramic used in solid oxide electrolysers.
Large-scale electrolyser systems are of modular design, allowing easy capacity ramp-up to build plants of nearly any size.
However, it is in the balance of plant (BoP) where most valve applications associated with green hydrogen production are found. They include, but are not limited to, water management (storage, treatment, circulation, cooling), gas-liquid separation, hydrogen treatment, hydrogen compression, and hydrogen/oxygen tank storage.

Mature technology

Electrolyser technology is relatively mature and further advancing, with production and announced plant capacities growing from multiple megawatts to multiple gigawatts. Europe is spearheading the hydrogen revolution in many areas and is determined to continue its dominance long into the future. Most major electrolyser suppliers are European companies, including the UK's ITM Power, Germany's thyssenkrupp and Norway's NEL. Last year, all three completed or announced plans to build electrolyser gigafactories.
This major milestone comes in response to the growing global demand for electrolysers in general and to the EU's ambitious hydrogen strategy which aims to install at least 6 GW of green hydrogen electrolysers by 2024, and 40 GW by 2030, in particular. An additional 40 GW of electrolyser capacity are envisioned in neighbouring North Africa and Ukraine. These targets may seem unattainable, but the rapidly growing pipeline of projects makes them look entirely feasible.

Valve applications

The mushrooming of electrolyser project announcements is great news for valve companies, but for hydrogen to become as ubiquitous as natural gas is today, the development of sufficient transport and storage infrastructure is required, which is another demand driver for valves.
In Europe and elsewhere, large amounts of hydrogen have long been transported via dedicated hydrogen pipelines connecting production points and industrial end-users. For wide adoption of hydrogen as a fuel, however, vast hydrogen pipeline networks will have to be developed. This can be achieved by modification of existing natural gas pipelines and new pipeline construction. Limited technical considerations aside, there are no major differences between valve requirements for natural gas and hydrogen pipelines. Main applications include block, metering, pigging and compressor stations, with ball valves being the predominant valve type. The similarities between the two gases extend to valve requirements for underground storage (salt caverns, aquifers, depleted oil & gas fields).

Opportunities for valves

In July 2020, eleven European gas infrastructure companies published a paper presenting the European Hydrogen Backbone (EHB) vision, a network of hydrogen pipelines and storage facilities connecting hydrogen supply and demand from ten countries, with the potential of later being expanded further across the continent.

The EHB covers nearly 23,000 km of pipelines by 2040, 6,800 km of which are aimed to be completed by 2030. 75 percent of the proposed network consists of retrofitted existing natural gas pipelines and the remainder of new hydrogen pipelines. Preliminary estimates show that the cost of valve and seal replacements for about 17,000 km of repurposed pipelines alone would be about €690 million, which clearly demonstrates the magnitude of the opportunity at hand, let alone of the opportunity associated with all potential similar projects elsewhere in the world.

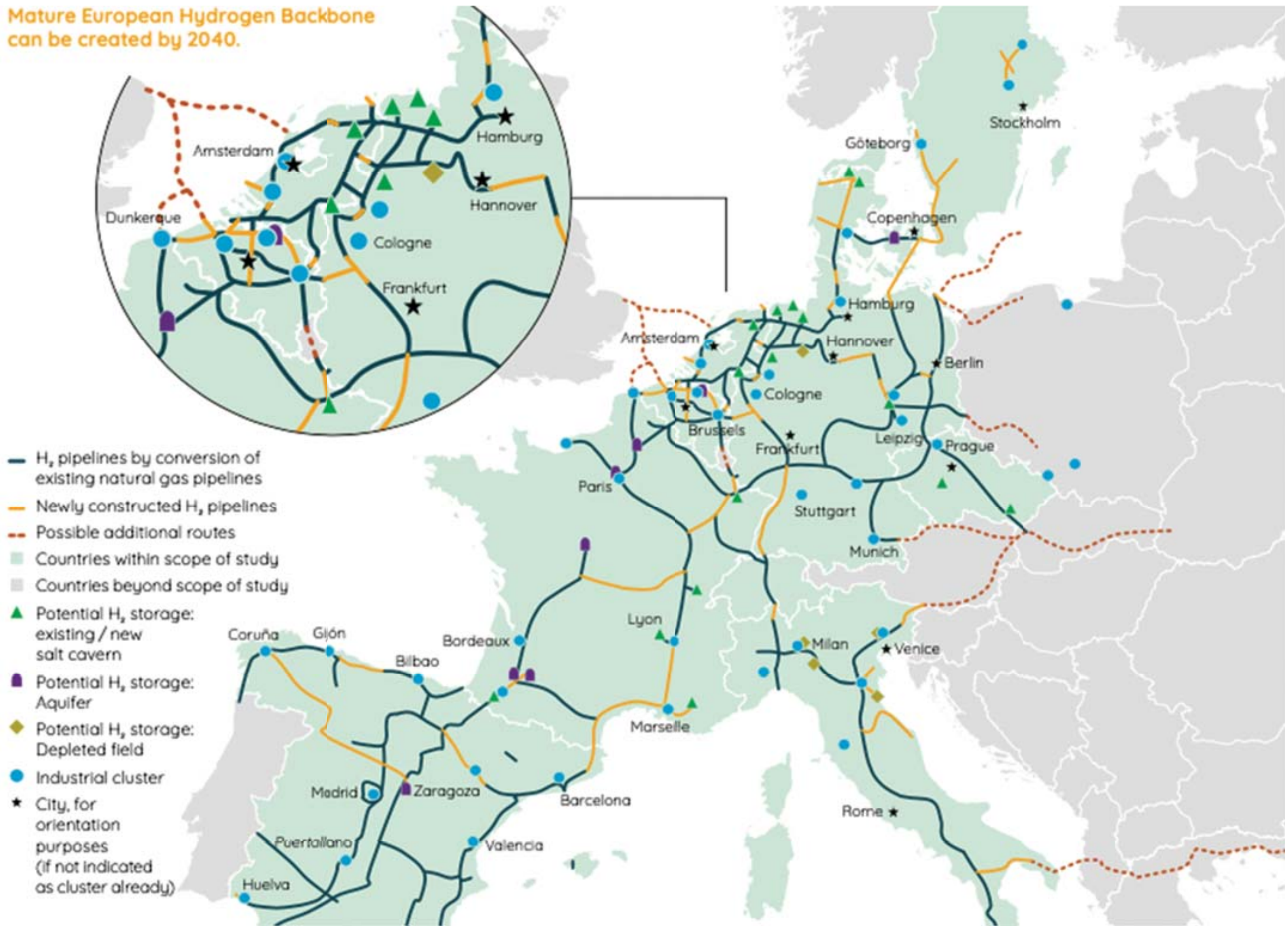
Hard-to-abate industries

The World Resources Institute (WRI) estimates that total GHG emissions were 49.4 Gt of CO_2 equivalent in 2016, with emissions from energy use accounting for around two thirds of all GHGs. Nearly half of all energy-related CO_2 emissions stem from energy used within industry, largely from hard-to-abate industries such as iron and steel, chemical and petrochemical, cement, and glass. Decarbonisation of industry is therefore key to reaching carbon neutrality. Green hydrogen could play a major role in these efforts, which is being recognised by a growing number of important heavy-industry players. A case in point is the iron and steel industry. Energy-related emissions from the manufacturing of iron and steel account for around 7.2 percent of total global GHG emissions. This roughly equals the emissions from all passenger road vehicles (cars, motorcycles, buses). In other words, fully decarbonising the iron and steel industry alone would have the same effect as electrifying all passenger road transport globally. Considering this potential impact, it is no surprise that the first phase of the hydrogen revolution is expected to be centred around regional industrial clusters.

Steel production

In Europe, the race to carbon-free iron- and steelmaking is in full motion. In November 2019, an EU-funded 6-MW electrolyser pilot plant was commissioned at the Austria steelmaker voestalpine's Linz site, while construction of the world's largest steel plant capable of attaining net-zero emissions is being completed at its Kapfenberg site. At this location, hydrogen will be used instead of coal in the reduction process for iron ore. In April 2020, hydrogen was used to power commercial steel production in an existing production environment for the first time, replacing liquefied natural gas as the source of high-temperature heat at a pilot project in Sweden. Ovako's trial at its Hofors steel mill demonstrated that hydrogen can be used simply and flexibly, with no impact on steel quality.

German steel company Salzgitter Flachstahl is due shortly to put into operation a 2.2-MW electrolyser to produce hydrogen for steel production, powered by onsite wind turbines. Many other European iron and steel companies, including SSAB, thyssenkrupp Steel Europe and ArcelorMittal, are also actively pursuing hydrogen as an alternative to fossil fuels by already testing, building or planning new facilities, refurbishing the existing ones, and securing the hydrogen supply from the rapidly emerging new production sites.



Hydrogen as a green option in high-energy sectors, such as steel, that are difficult or too costly to electrify. Fully decarbonising the iron and steel industry alone would have the same effect as electrifying all passenger road transport globally.

Game changer

In the medium to long term, hydrogen should fundamentally restructure the energy system and markets. It will take some time to build sufficient renewable power and electrolyser capacity as well as pipeline and storage infrastructure, which are all required for wide adoption of hydrogen as a fuel across all sectors, including road, sea and air transport.

However, as this article has hopefully demonstrated, the hydrogen revolution has already started and is only to accelerate. Those preparing for it now and embracing it fully are likely to benefit most, and this includes valve manufacturers.