RISK BULLETIN

ALLIANZ GLOBAL CORPORATE & SPECIALTY®

THE HYDROGEN ECONOMY: OPPORTUNITIES AND RISKS IN THE ENERGY TRANSITION

ALLIANZ RISK CONSULTING

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Hydrogen is predicted to play a leading role in the energy transition with the "green oil of the 21st century" increasingly promoted by governments worldwide. As an alternative to fossil fuels, it could be a valuable tool for tackling climate change in future, helping many industries to reduce their CO2 emissions. This risk bulletin from Allianz Global Corporate & Specialty (AGCS) highlights some of the opportunities and challenges of a trend at the forefront of the energy industry and also assesses the risk environment of technologies associated with the production, storage and transportation of green hydrogen.

THE CASE FOR HYDROGEN

Hydrogen (produced from low-carbon or even renewable energies) is of growing importance for the substitution of fossil fuels in the fields of energy, supply, mobility and industry. It is widely available with its main advantage being that it only emits water when burned and it can be produced without releasing CO2. Hydrogen can be stored, liquified and transported via pipelines, trucks or ships. Ultimately, it could help several hard-to-abate sectors such as the steel, petrochemical and cement industries to decarbonize and reduce CO2 emissions while even buses, ships and trucks could also run on hydrogen in the future. Hydrogen has the potential to morph from a niche power source into big business, with countries committing billions to scale up their infrastructure and with projects being introduced around the globe. Despite these successes, there are challenges to overcome for hydrogen to become a major part of the energy transition *(see advantages/disadvantages box).*

HYDROGEN PRODUCTION

There are various methods by which to produce hydrogen (and these can be divided into two groups regarding the fuel to do so – **fossil fuels** and **renewable sources** *(see chart)*. The vast majority of hydrogen today is currently made from fossil fuels. Currently, global hydrogen production is about 120 million tons per year,[1] of which two-thirds is pure hydrogen and one-third is mixed with other gases. About 95% of all hydrogen is produced from natural gas and coal while 5% is a by-product of chlorine production through electrolysis. Currently, there is no significant hydrogen production from renewable sources, as this is an energy-intensive process which is often considered uneconomical, particularly compared with "gray" production. But for the purposes of achieving net-zero emissions in future, hydrogen production will need to be increasingly switched from "gray" to "green" and "blue" and ultimately "green." Green hydrogen is produced by electrolysis, a process that uses an electrical current to split water into hydrogen and oxygen, using power generated from renewables.

TYPES OF HYDROGEN PRODUCTION

- **Green:** Generated using electrolysis powered by renewable electricity
- **Blue:** Production is based on fossil fuels but with CO2 emissions captured
- **Gray:** Made using fossil gas with no emissions captured
- **Black:** Made using coal
- **Brown:** Made using lignite
- **Turquoise:** Heat is used to split fossil gas in a process known as "pyrolysis"
- **Purple, pink or yellow:** Electricity and heat from nuclear reactors could both be used to produce hydrogen, but there is no widely agreed color for such methods.

Source: Adapted from Carbon Brief, In-depth Q&A: Does the world need hydrogen to solve climate change?, November 30, 2020

GLOBAL PROMOTION

Driven by climate change, the possibilities of energy storage, use as a fuel and the long-term intention to replace reliance on coal and oil, many countries around the world have already launched significant hydrogen funding programs. As of the beginning of 2021, over 30 countries have produced hydrogen roadmaps and governments worldwide have committed more than $70bn in public funding according to consulting firm McKinsey.[2]

Governments have also included new capacity targets and sector level regulation to support these hydrogen initiatives. The German government, for example, is betting on hydrogen as part of its decarbonization strategy and has recently announced that it will fund hydrogen projects in the billions of euros. One of the most significant announcements has been the European Commission's "hydrogen strategy for a climate-neutral Europe", released in July 2020, which includes an ambitious target of 40 gigawatts (GW) of European electrolyzer capacity to produce "green" hydrogen by 2030.

China plans to invest several billion yuan in the promotion of fuel cell technology – which converts hydrogen to electricity – over the next four years, which should result in innovative hydrogen production facilities throughout the country. In the US, more than 30 states have already adopted action plans to promote hydrogen technology. The goal is to build a broad-based hydrogen industry that will generate $140bn in annual income and employ 700,000 people by 2030. The UK government has said it will unveil a hydrogen strategy in 2021 to help reach its 2050 net-zero goal.

$300BN IN PROJECTS

Such government initiatives mean that project activity is picking up speed around the world. According to an analysis by consulting firm McKinsey,[3] there are more than 200 large-scale production projects in the pipeline and, if all projects come to fruition, total investments will exceed $300bn in hydrogen spending through 2030 – the equivalent of 1.4% of global energy funding.

In analyzing private investments among Hydrogen Council members, which represent over $6.8trn in market capitalization and more than 6.5 million employees, McKinsey sees a clearly accelerating trend. Members expect to increase investments six times through 2025 and 16 times through 2030, compared with 2019 spending.

Europe leads the way, accounting for more than half of these projects, with Australia, Japan, Korea, China and the US also seeing strong growth. There also are activities across the Latin America and Middle East regions.

The largest projects include the "North H2" project in the North Sea near Groningen in the Netherlands ($20bn investment), the Asia Renewable Energy Hub in the Pilbara region in Australia ($15bn) and in the Neom Mega-City development in Saudi Arabia ($5bn). In a previous report for the Hydrogen Council[4] McKinsey estimated the global sales market for hydrogen technology at $2.5trn annually in 30 years.

HYDROGEN USES

Hydrogen offers several options for the transition to a renewable economy: as an energy carrier and storage medium for conversion back to electricity, as fuel for all means of transport and mobility and as a substitute for fossil hydrocarbons in different industries, such as, steel production, petrochemicals and refineries.

In industry, gas turbines, reciprocating engines and fuel cells are currently being further developed for the use of hydrogen. Its use in the petrochemical industry is also being tested. Furthermore, hydrogen in fuel cells can be used for heavy transport in trains, airplanes or ships. Hydrogen not only makes it possible to drive without CO2 emissions, but also helps to cover longer distances and refuel faster than battery-powered vehicles.

Here, too, one can see concrete projects are operational: The Korean car manufacturer, Hyundai, has delivered its first series of trucks with hydrogen tanks to Switzerland. Industrial group, Thyssenkrupp, wants to use hydrogen to replace coking coal in steel production by 2030. And in Austria, a hydrogen train of the French railway company, Alstom, has started regular operation.

ADVANTAGES AND DISADVANTAGES OF HYDROGEN

ADVANTAGES

- Burns cleanly, releasing only water and energy. (without CO2-emissions)
- Enables coupling of different energy sectors (electricity, heat supply and mobility)
- Stores more energy per unit of weight than most other fuels
- Can be made from low-carbon sources
- Can be used as a fuel, to transport energy from one place to another, as a form of energy storage or as a chemical feedstock
- Can be used to decarbonize "hard to abate" sectors with few alternatives
- Offers wider benefits for energy security, industrial strategy and air quality.

DISADVANTAGES

- Almost all production today is from high-carbon sources
- Currently expensive to produce and cost reductions are uncertain
- Bulky and expensive to transport and store
- Inefficient to produce, raising costs and requiring a larger energy supply overall, with even faster scaling up of clean energy production
- Supply and value chains for its use are complex and need coordination
- Needs new safety standards and societal acceptance.

Source: Adapted from Carbon Brief, In -depth Q&A: Does the world need hydrogen to solve climate change?, November 30, 2020

ASSESSING THE RISK ENVIRONMENT

Work is underway worldwide to further develop technologies in the fields of hydrogen electrolysis, storage and transport. Many of the technologies used for the generation of hydrogen and energy from hydrogen are well known in principal.The vast majority of hydrogen today is produced and used on-site in industry. The production of ammonia and oil refining are the prime purposes, accounting for two-thirds of hydrogen use. Ammonia is used as nitrogen fertilizer and for the production of other chemicals. At petroleum refineries, hydrogen is added to heavier oil for transport fuel production.[5] AGCS risk consultants have considerable experience with handling hydrogen projects in a number of different areas. What is new is that the type and scale of its adaption is changing fundamentally, with the expected rapid growth of plants in future. New companies are entering the market as planners, manufacturers and operators, but there is a definite learning curve involved. Established players size up their offers and are simultaneously required to find skilled staff and realize cost-saving potential. As such, all projects require careful risk assessment.

Below is an outline of the risk environment associated with green hydrogen production, storage and transportation:

Fire and Explosion hazard: The main risk when handling hydrogen is of explosion when mixed with air. In addition, leaks are hard to identify without dedicated detectors since hydrogen is colorless and odorless. A hydrogen flame is almost invisible in daylight.

Loss investigation statistics show that many hydrogen fires result from the self-ignition of sudden hydrogen release through rupture of disks and pressure relief valves. About 25% of the losses were attributed to leaks. Of these leaks, 40% were undetected before the loss.[6] Contributing factors were inadequate ventilation and inadequate purging. The data shows the advantage of locating hydrogen equipment outdoors. Hydrogen has been accidentally released outdoors many times without ignition. Almost all indoor releases have ignited. Indoor releases resulted in more than three times as many explosions than fires, whereas outdoor releases have resulted in an approximately equal number of fires and explosions.

Breakdown and business interruption in water electrolysis technologies:

- Damage to the electrolysis cell could result in significant losses and claims due to extensive interruption of production
- Membranes (polymer electrolyte membrane electrolysis) are sensitive to impurities, which can challenge reliable long-time operation
- Lead time for new membranes could be long (several months), resulting in production delays
- Short circuits due to corrosion on the electrodes could cause an oxygen-hydrogen-gas explosion
- Diaphragm damages could be caused due to local overload
- Cathodes/electrodes also represent a possible source of damage (again leading to potential long production delays).

Material Embrittlement: Diffusion of hydrogen can cause metal and steel to become brittle and a wide range of components could be affected, for example, piping, containers or machinery components. In conjunction with embrittlement, hydrogen-assisted cracking (HAC) can occur. For the safety of hydrogen systems, it is important that problems such as the risk of embrittlement and HAC are taken into account in the design. This is done by selecting materials that are suitable under the expected loads. The choice of materials is as important as the consideration of the operating conditions (gas pressure, temperature, mechanical loading). High-yield strength steels are particularly at risk of hydrogen-related damage. Austenitic steels are less susceptible to hydrogen embrittlement than ferritic steels. However, converting existing natural gas pipelines to hydrogen requires detailed investigation.

Handling hydrogen and business interruption in liquefaction plants: The main risk in liquefaction plants is the handling of the explosive hydrogen, which requires sufficient protective measures.

To date, only single-line production plants have been built. This means a high risk of business interruption costs may ensue in case of failure of individual components. Spare parts for some process equipment, such as compressors, can easily be kept in stock, but larger equipment, such as heat exchangers, are unique and therefore critical with respect to business interruption.

Storage and Transportation Techniques: Storage of pressurized hydrogen in large caverns is already successfully done. The risks associated with the storage of pressurized hydrogen in tanks are well understood, as this form of storage has been used for decades. With liquefied hydrogen, there has been significant improvement in the durability and quality of tanks used with incidents of damage rare.

The risk of pipeline transport of hydrogen and the associated infrastructure, such as compressor stations, needs to be assessed individually. Besides the use of suitable materials to avoid embrittlement (*see Material Embrittlement*), the risk assessment should address the increased flammable range of hydrogen/air mixtures compared to natural gas (*see Fire and Explosion Hazard*). The transport of liquefied or compressed gaseous hydrogen in containers is a known risk and mitigation measures are usually well established, as the transport has been in use for decades.

Health And Safety: Hydrogen is not toxic and the end product of combustion is clean water. However, careful occupational health and safety measures are necessary not least because of the flammability of hydrogen/air mixtures.

ANALYSIS: FIRE AND BUSINESS INTERRUPTION CLAIMS TAKE THEIR TOLL

An AGCS analysis of more than 470,000 claims across all industry sectors over five years shows how costly the risk of fire and explosion can be. Fire and explosions caused considerable damage and destroyed values of more than €14bn ($16.75bn) over the period under review. Excluding natural disasters, more than half (11) of the 20 largest insurance losses analyzed were due to this cause, making it the number one cause of loss for businesses worldwide.

Business interruption (BI) costs following a fire can significantly add to the final loss total. For example, AGCS analysis shows that across all industry sectors, the average BI loss from a fire incident is around 45% higher than the average direct property loss – and in many cases the BI share of the overall claim is much higher, especially in volatile segments such as oil and gas. The risk of machinery breakdown should also not be underestimated. In the period under review, 5% of the total value of all claims were due to damage to technical and mechanical equipment.

MITIGATING FIRE AND HANDLING RISKS

Fire and explosion protection can be considered on three different levels:

Primary explosion protection – Avoidance of explosive mixtures: Preventing the escape of flammable gases as much as possible. by ensuring that the systems are technically sealed, since hydrogen is the smallest molecule and therefore highly prone to leakage, and keeping detachable connections to a minimum.

This also includes detecting any gas leak and discharging the gas as quickly as possible without danger. Sensors should be positioned near exit routes, but also at the highest point of the room, due to the properties of hydrogen. The gas supply should be shut off immediately to limit the amount of gas.

Secondary explosion protection – Avoidance of ignition sources: This protection includes ensuring safe design of electrical and other installations in rooms where the formation of a mixture cannot be completely excluded. If possible, alternatives to electrical components should be used. Proper earthing of all relevant parts and conductive floors should also be considered.

Tertiary explosion protection – by design measures: This includes designing and constructing buildings and facilities to withstand an explosion with limited damage. It is not about preventing explosions, but rather about limiting the damage caused.

Furthermore, it is advisable to carefully maintain the facilities and machines according to the manufacturer's recommendations. A combination of predictive maintenance measures and periodic maintenance procedures is recommended.

Storage and handling considerations: Proper handling of hydrogen gas is critical, and any emergency situation requires appropriate fire safety equipment. The safe handling of hydrogen, like the safety of all flammable gases, is based on five main considerations:

1. **Identifying** hazards and defining risk mitigation measures.
2. **Ensuring** the integrity of the system.
3. **Ensuring** proper ventilation to prevent accumulation (manage discharges).
4. **Ensuring** that leaks are detected and isolated.
5. **Ensuring** adequate training of staff.

INSURANCE OUTLOOK

Image: iStock

Given the numerous projects planned around the world, insurers can expect to see a significant increase in demand for insurance in future to construct and operate electrolysis plants and pipelines for green hydrogen production and transportation.

While this has the potential to be a notable new area of growth for energy insurers, underwriters will need to stay on top of the potential downsides as this risk bulletin demonstrates. Insurers will need to develop a more detailed underwriting approach to this segment and apply the same rigor in risk selection and underwriting as they do on existing energy construction and operational business.

These are complex industrial and energy risks involving partly prototypical technologies, which require high levels of engineering expertise and insurance know-how in order to be able to provide coverage. However, many of the risks, such as the risk of fire, are well known to insurers such as AGCS from many years of insuring the oil and gas sectors. While fire and explosion are key perils, as with any energy risk, business interruption and liability exposures are also important. Transit and installation issues and mechanical failure exposures are also present. Hydrogen production, as part of integrated refining and petrochemical facilities, and as a part of AGCS' coverage of industrial gas programs in its property book, has long been a staple of AGCS' insurance portfolio.

For an insurer such as AGCS, the growth of the hydrogen sector represents another crucial step in its efforts to support society and industry, alike, in the journey to a carbon-neutral future. It also represents an evolution of its current energy insurance product capabilities. AGCS is already a leader in the energy insurance space and the development of this sector plays to its strengths as risks and coverages span onshore and offshore, energy and power segments. The fact that AGCS has all these capabilities under one 'roof' means the ability to seamlessly insure these risks.

At this stage AGCS does not envisage a need for new insurance products as such in future to meet the demands of market growth – although these cannot be ruled out entirely. It is more about tailoring existing product capabilities for this new segment. An example is potential cross-class solutions – for example, joining marine, liability and energy and construction coverages for smaller hydrogen facilities, if there is demand for a cross-product offering, as is currently done at AGCS in the onshore wind and solar photovoltaics (PV) segments.

Ultimately, AGCS expects to see a significant ramp-up in insurance opportunities due to the rapid growth of the segment and that opportunity is global.

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