LLOYD'S

September 2021

Greener energy

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Lloyd's Futureset

01. Introduction

Alternative energy sources are critical in achieving a successful global transition to a low carbon economy, and the insurance industry, Lloyd's and the SMI Insurance Task Force all have an important role to play in supporting offshore wind, nuclear and hydrogen with their particular ambitions.

In the last thirty years, Britain's reliance on coal for electricity has decreased significantly from 70% in 1990 to less than 3% today. A major part of this transition has been driven by the growth in electricity generation from **wind energy**, with 9.9% of the UK's electricity in 2019 being generated by offshore wind.

The UK Government has ambitions to increase offshore wind production to 40GW by 2030, and other countries in Europe, Asia and North America also have ambitious targets. To achieve this growth in the offshore wind sector, supporting infrastructure must be transformed with significant investment in larger wind farms, bigger turbines, cabling and transmission infrastructure. Risk engineering and risk transfer to the insurance industry are both vital to enable this investment.

As the second largest source of low-carbon energy, **nuclear energy** now provides around 10% of global electricity supply, generated from 440 power reactors across 31 countries. Due to the unique nature of these risks, over the last 70 years the global insurance industry has established a structure of risk pooling, alongside public-private partnerships, to insure nuclear projects.

Several barriers exist which limit the expansion of nuclear insurance capacity, including the inherent volatility of nuclear insurance claims given the low frequency and high severity of potential losses. In recent years technology has evolved to reduce the risks associated with nuclear energy, therefore making investors more likely to take on the risks of nuclear and ultimately support the expansion of the sector.

Hydrogen produces no direct greenhouse gas emissions when combusted in a fuel cell with oxygen, and is widely used as a low-carbon alternative in many industrial applications. Hydrogen is predominantly used today in industrial processes, however its potential uses span across the entire value chain from renewable energy generation, through to transportation, homes and buildings.

Key obstacles to the success of hydrogen include the costs and risks associated with achieving scale. Hydrogen itself is costly to produce and the conversion of existing natural gas pipelines to deliver hydrogen requires significant investment. Green Hydrogen, the form of hydrogen with the lowest carbon footprint, is the most costly to produce as it requires significant amounts of renewable energy. The insurance industry, alongside a long-term government policy framework, can help to de-risk investment into hydrogen infrastructure and incentivise private-sector investment. This will ultimately enable the hydrogen economy to achieve scale and therefore drive down production costs.

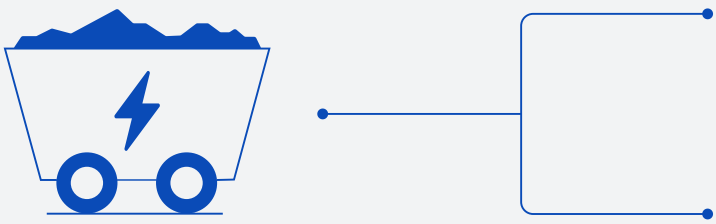
Greener energy focuses on the offshore wind, nuclear and hydrogen industries, outlining the global pathway towards a lower carbon footprint and the challenges on that journey which require solutions and support from insurance.

02. Offshore wind

Introduction

Wind energy is central to facilitating a global transition towards a future-proof energy system. China, Germany and the UK were the world's largest offshore wind producers in 2020, and China is leading on new capacity installations[1]. In the last thirty years, Britain's reliance on coal for electricity has decreased significantly from 70% in 1990 to less than 3% today[2]. A major part of this transition has been driven by the growth in electricity generation from wind energy, with 9.9% of the UK's electricity in 2019 being generated by offshore wind[3].

Proportion of Britain's electricity derived from coal



70%
in 1990

3%
today

[1]REVE - World Gets 2.5 GW of Offshore Wind Energy in H1 2020 | REVE News of the wind sector in Spain and in the world (evwind.es)
[2]Department for Business, Energy & Industrial Strategy - End of coal power to be brought forward in drive towards net zero - GOV.UK (www.gov.uk)
[3]GOV.UK - Wind_powered_electricity_in_the_UK.pdf (publishing.service.gov.uk)

The future of offshore wind

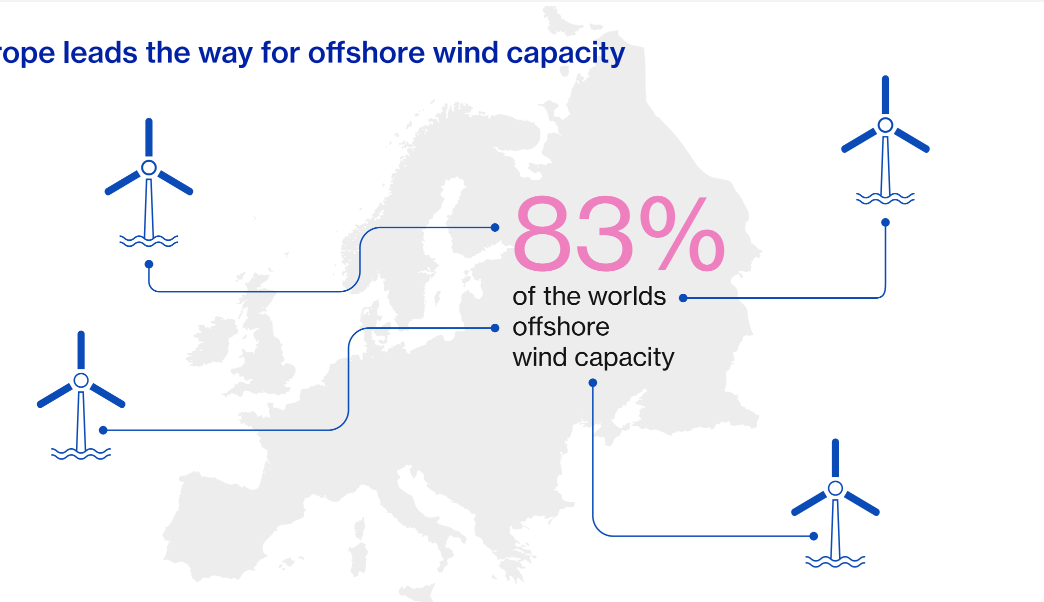
The global offshore wind market is evolving rapidly, and technology innovation will be key to driving growth as the sector matures. Advancements in floating wind technology are helping to accelerate growth in areas further from shore and in deeper waters. This in turn is unlocking wind energy generated in regions previously considered unsuitable for fixed-base offshore wind installations, posing a significant growth opportunity for the sector.

This is driving the emergence of new offshore wind markets outside Europe, which previously dominated the market.

At the end of 2018, 83% of the world's offshore wind capacity was produced in Europe; over the next decade, however, it is anticipated that Asia and the US will account for 48% and 11% of new offshore wind development respectively[4].

Turbine technology is evolving, with blades continuing to increase in size and energy production from a single turbine also continuing to increase. New drone technologies are being tested and are expected to play a vital role in the inspection and maintenance of these larger wind turbines, given they are typically positioned in less accessible locations further offshore.

Europe leads the way for offshore wind capacity



Key commitments to offshore wind development

Significant commitments have been made globally to increase offshore wind production. The UK Government, for example, has stated its ambitions to increase offshore wind production to 40GW by 2030. This includes 1GW of innovative floating offshore wind, which is equivalent to over fifteen times current worldwide volumes of production[5]. It is this backdrop of a substantial growth trajectory combined with a changing risk landscape that paves the way for insurers and their distribution partners to play a critical role in driving the success of the sector.

> **The UK Government, for example, has stated its ambitions to increase offshore wind production to 40GW by 2030.**

[4] REY – Which Direction is Offshore Wind Blowing? (www.ey.com)
[5] GOV.UK - New plans to make UK world leader in green energy – GOV.UK (www.gov.uk)

Key challenges

Key commitments to offshore wind development

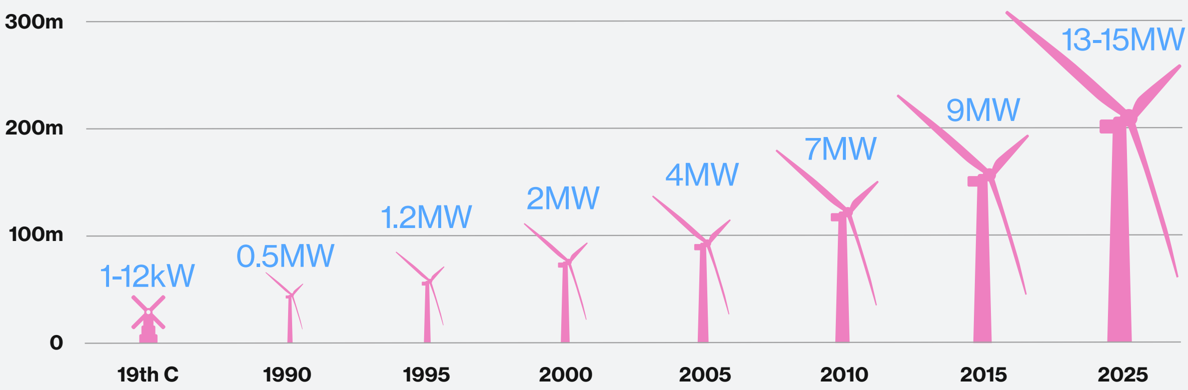
In order to achieve continued growth in the offshore wind sector, supporting infrastructure must be transformed with significant investment in bigger turbines, cabling and transmission infrastructure to connect new wind farms to the onshore electricity grid. The cost of installing this infrastructure will be a key barrier to success in this sector.

In order to overcome this, corporates are increasingly seeking economies of scale by developing turbines with bigger capacities; 15MW turbines are expected to be standard by 2030, compared with an average capacity of 4MW ten years ago[6], in turn resulting in increased need for significant investment from a breadth of capital providers and private investors. These investments must be backed by insurance programmes that can help to de-risk these investments and facilitate the necessary capital flows.

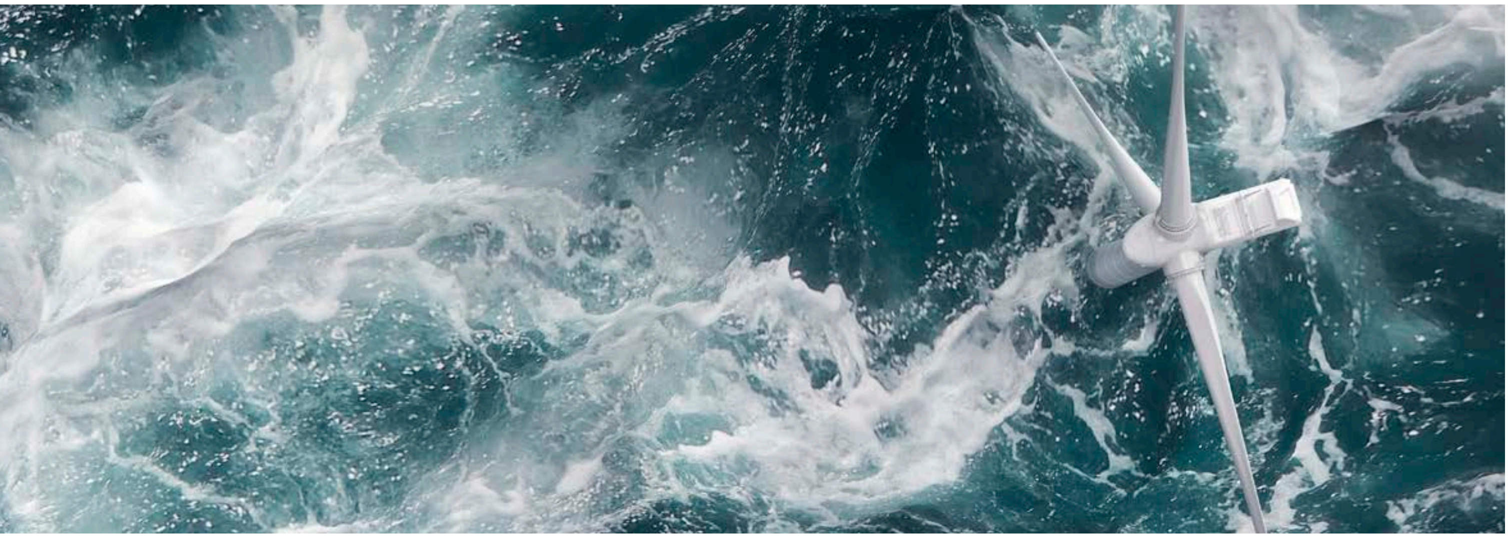
It is also important to reflect on historic wind energy assets currently in operation. The lifespan of wind farms is much lower than coal-fired power stations, with a wind farm typically considered to have a design life of 20 years[7]. A growing number of turbines are thus reaching the end of their operational lifetimes, and in 2021 we expect owners of around 4.8GW of onshore capacity to be faced with end-of-life decisions on the assets[8]. This creates challenges with respect to the decommissioning and recycling of materials, with the high price of decommissioning acting as a deterrent for some insurers entering the market[9].

This brings into focus the full carbon life cycle of wind farms, including the use of carbon intensive materials such as concrete for turbine construction. The carbon payback period, defined as the time for the carbon emissions displaced by wind power to equal the life cycle carbon emissions of the wind farm, is an average of 0.6 years for an offshore wind farm, therefore significantly lower than its design life[10].

Evolution of wind turbine heights and output



[6]ORE Catapult - Delivering 40GW - Accelerating the UK's Transition to net zero (catapult.org.uk)
[7]ClimateXChange - Life Cycle Costs and Carbon Emissions of Offshore Wind Power (climatexchange.org.uk)
[8]Bloomberg NEF - Energy, Transport, Sustainability – 10 Predictions For 2021 | BloombergNEF (bnef.com)
[9]Lloyd's of London Emerging Risk Report 2017 Innovation Series - https://www.lloyds.com/~/media/files/news-and-insight/ risk-insight/2017/stranded-assets.pdf
[10]ClimateXChange - Life Cycle Costs and Carbon Emissions of Offshore Wind Power (climatexchange.org.uk)



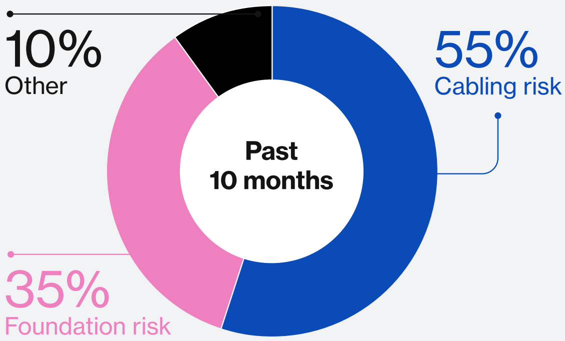
Evolving risk landscape

As offshore wind farms become bigger and move further from shore, the risk landscape in this sector is evolving. The development of larger wind farms, both in terms of size as well as turbine capacity, is likely to result in new claims challenges, including increased mechanical breakdowns, cable faults resulting in lapses in power generation, and foundation-related damage, particularly at deeper-water sites. In addition, there will be heightened exposure to natural catastrophe risk at deep-water sites, both in terms of physical damage as well as potential project delays caused by extreme weather events.

Furthermore, operational floating windfarms in deeper locations could have their own unique risk profile, one that does not necessarily match any existing claims data, although it is already clear that there will be an increased probability of cable damage due to the longer cables required to transmit energy back to shore.

Claims losses for the offshore wind sector have so far primarily been driven by cabling and foundation-related risk events, with analysis from California-based GCube, a leading insurance provider in the renewable energy market, indicating that these accounted for 55% and 35% of total claims respectively over the past 10 months[11]. There have also been significant mechanical breakdown losses incurred at all but one of the worldwide floating wind installations currently in operation.

Claims losses for the offshore wind sector as per GCube analysis[11]



Insurers will ultimately need to understand the changes to the risk profile of offshore wind assets and respond with appropriate insurance cover that is reflective of the changing risks, as well as supporting corporates in managing them. There is an opportunity for the insurance industry to work closely with energy companies and share their expertise in modelling natural catastrophes. This would ensure a consistent and deeper understanding of risk across the sector, and establish a successful platform to provide specialist cover for natural catastrophe and extreme weather events.

This is particularly the case in emerging markets in Asia-Pacific, which face more volatile weather conditions combined with less history in the sector relative to established markets.

[11]GCube - Claims: Offshore wind must quickly respond to changing global risk profile : GCube Insurance Services » Renewable Energy Insurance Coverage (gcube-insurance.com)

Variability in energy generation

As wind energy contributes to an ever-increasing proportion of global electricity generation, there are concerns around the variability of electricity generation from wind and the extent to which this may complicate the case for further investment. Part of the solution may lie in expansion of offshore wind farms to locations further offshore, where wind conditions are more consistent. New technologies are also being explored, such as hydrogen fuel cells, which harness and store excess offshore wind energy for when generation is reduced.

Financial guarantees will be necessary to solve the complex issues of variability in electricity generation; national governments in regions such as the Nordics, for example, provide availability guarantees to protect operators in this sector from the revenue risk associated with this variability. For those who do not benefit from such government guarantees, the insurance market has taken some steps to provide operators with protection against variability in wind volumes in the form of index-based parametric cover, which goes some way to mitigating this risk.

Roadmap for action

Offshore wind projects continue to increase in scale and complexity, with advances in turbine technology (with respect to foundation depth, distance from shore and power output of each turbine) evolving rapidly. The global insurance industry has a unique opportunity to further expand the coverage it provides to the offshore wind sector to meet demands for additional insurance capacity, which is being driven by the rapid advancement of new offshore wind technology including turbines and floating wind technology.

In addition, given the size of many offshore wind projects, a blended financing model is necessary which typically requires a combination of investment from private corporates (often large utilities and/or oil and gas companies), overseas investors and large institutional investors to achieve success.

To support and accelerate the growth of offshore wind, the SMI Insurance Task Force will:

- Convene a workstream focused on supporting and encouraging more sustainable investment, including into offshore wind projects. In 2021, the workstream will launch a green investment proposal, outlining the intent and capability of the insurance industry to make resources available to support green investment, and the regulatory changes required to realise this ambition.
- Provide a platform to ensure there is co-ordinated action between the insurance industry, operators in the offshore wind sector and private investors.

In addition, Lloyd's will:

- Commit to expanding its coverage to ensure capacity constraints do not limit the growth of the industry.

03. Nuclear

Introduction

Since the origins of nuclear power generation in the 1950s, the global insurance industry has provided insurance for the unique needs of nuclear energy projects through risk pooling, alongside public-private partnerships. Nuclear pools were formed to insure civil nuclear risks within their national market and provide inter-pool reinsurance. They were created in the spirit of a trilateral relationship between the newly forming sector, governments and the insurance market.

As the second largest source of low-carbon energy, nuclear energy now provides around 10% of global electricity supply, generated from around 440 power reactors across 31 countries[12]. Predictions from the 2020 World Energy Outlook suggest electricity generation from nuclear could increase by almost 55% by 2040 in its sustainable development scenario[13]. Nuclear energy provides many developed and developing countries with a reliable source of energy that complements more intermittent renewable energy which relies on external conditions such as weather. A blend of both nuclear and renewable energy sources therefore enables cities and countries to achieve a stable supply of low-carbon power to their electricity grids.

Nuclear energy state of play

10% Global electricity

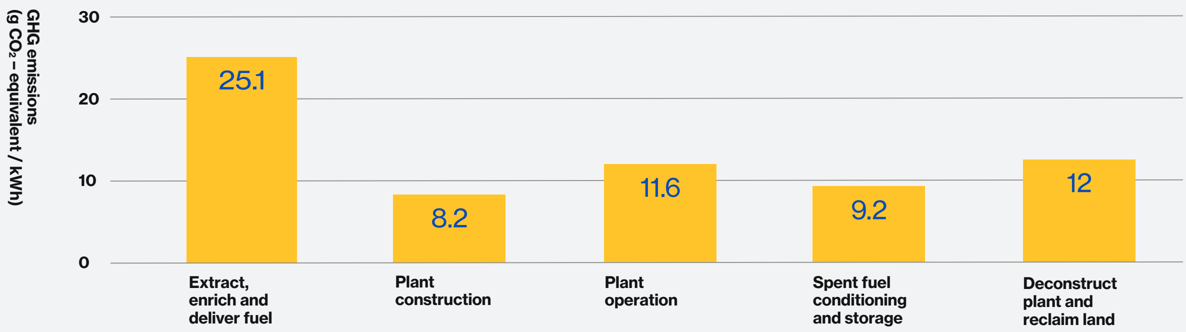
440 Power reactors

31 Countries

[12]World Nuclear Association - https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in- the-world-today.aspx
[13]The International Energy Agency – The World Energy Outlook Report 2020

Although some scepticism remains as to whether nuclear energy should be a long-term solution, owing to the carbon intensity of the construction and decommissioning of nuclear power plants and the safety of nuclear waste disposal, emissions during the construction period are typically offset between 18 months and five years of operation. Over the 60 to 80-year lifespan of a nuclear power plant, it is therefore expected to generate a negative carbon footprint.

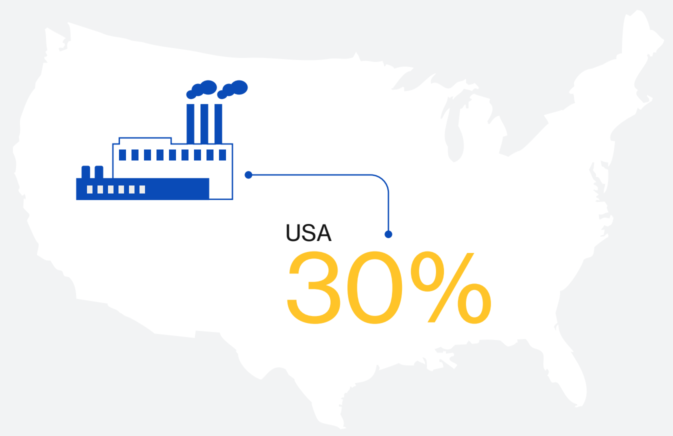
The carbon lifecycle of a nuclear project



Development of global nuclear capacity

The US is currently leading the nuclear energy market, accounting for more than 30% of worldwide nuclear generation of electricity[14], closely followed by France[15]. Nuclear power capacity worldwide is increasing steadily, with around 50 reactors currently under construction[16], in countries including China and the United Arab Emirates. In the UK, nuclear power stations are amongst the highest performing in the world, generating 20% of the country's electricity[17].

Worldwide nuclear generation of energy



This impressive output provides carbon savings equivalent to taking one third of all cars off UK roads. This nuclear power capacity is being further developed through new large-scale nuclear projects, including Hinkley Point C, the first nuclear power station to be built in the country in over two decades[18].

The future of nuclear technology

The next generation of nuclear technology is also being actively explored. For example, the Advanced Reactor Demonstration Program in the US provides initial funding to develop, test, licence and build advanced nuclear reactors. These technologies potentially address several challenges of larger nuclear power plants, by reducing upfront capital investment and build time while simultaneously enhancing efficiency and maintaining high levels of safety standards and protection.

Nuclear applications also extend beyond its direct use as a low carbon energy source. There is a potential future role for nuclear technology in powering the production of green hydrogen, which could act as a key enabler in facilitating decarbonisation across a range of sectors. In addition, nuclear technology has potential applications in the maritime industry through the use of low carbon nuclear propulsion on ships using liquid fuelled micro-reactors.

[14]International Energy Agency - Nuclear - Fuels & Technologies - IEA
[15]World Nuclear News - Macron stresses importance of nuclear energy for France : Nuclear Policies - World Nuclear News (world- nuclear-news.org)
[16]World Economics Forum - Where are the world's 449 nuclear reactors? | World Economic Forum (weforum.org)
[17]World Nuclear Association - Nuclear Power in the United Kingdom |UK Nuclear Energy - World Nuclear Association (world- nuclear.org)
[18]Nuclear Industry Association - Fortyby50_TheNuclearRoadmap_201009.pdf (niauk.org)

Key obstacles and role of the insurance industry

The nuclear insurance landscape

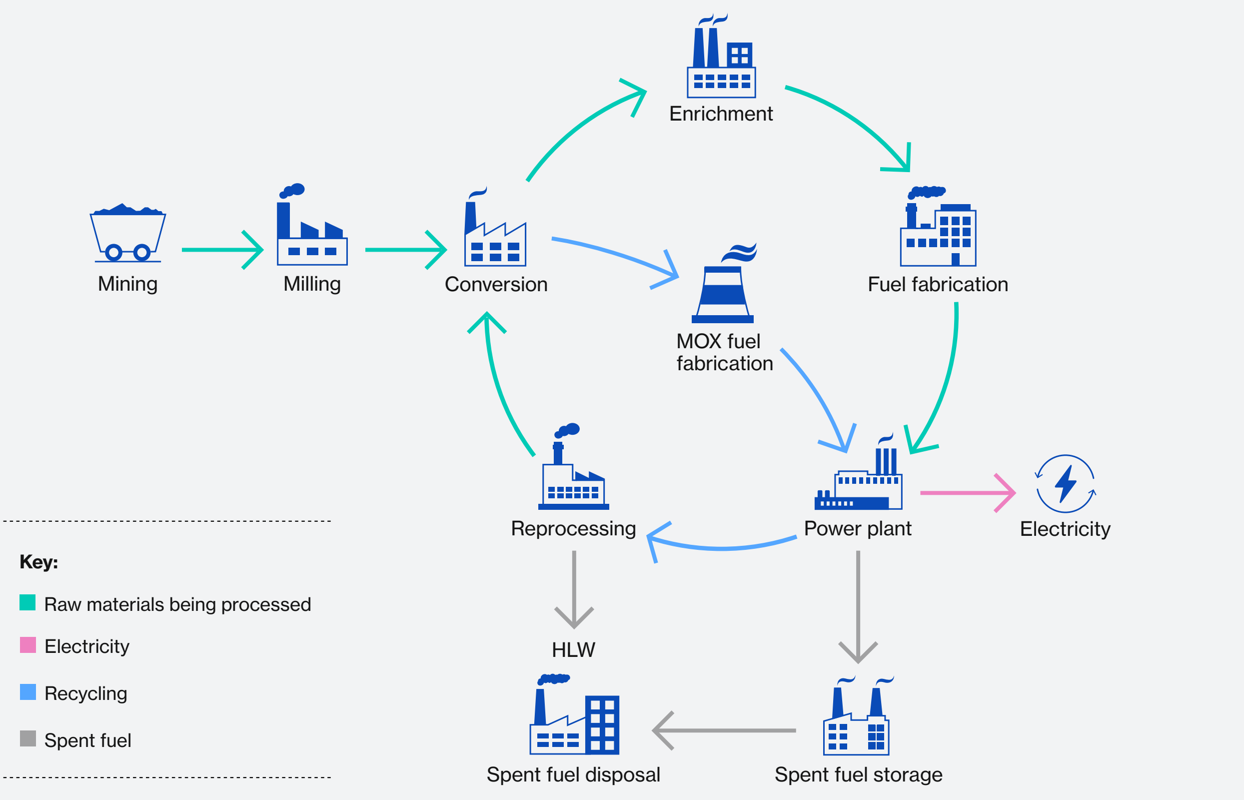
Nuclear insurance typically includes first-party liability covering property, machinery and business interruption, and third-party liability covering site and transit liabilities. The complex, large-scale and catastrophic risks that nuclear projects present have meant that commercial insurance markets have not been able to provide the net capacity to insure civil nuclear industry risks.

In addition, since the formation of the sector in the 1950s, general insurance policies have applied a nuclear exclusion clause to exclude damage caused by nuclear or radiatio[19]. These two factors combined have created the need for bespoke and innovative coverage solutions.

Globally, there are 28 government insurance pools for nuclear risks, 19 of which are in Europe[20]. These offer reciprocal reinsurance capacity to reach the required level of cover for nuclear power plants (NPPs) and the wider civil nuclear industry fuel cycle (see infographic below), and enable both governments and the insurance industry to work together to provide accessible solutions for the civil nuclear industry. In doing so, they can protect the communities in which NPPs are situated and provide a large part of the social licence for nuclear operators to operate.

This is an example of the insurance industry collaborating to create a successful insurance solution to a regionally systemic risk, something which Lloyd's has been involved in from the establishment of the British Insurance (Atomic Energy) Committee in 1956, the forerunner of NRI. Lloyd's is aiming to replicate this approach more broadly through Futureset, its global platform and community to create and share risk insight, expertise, and solutions to our most challenging insurance problems.

Simplified artistic view of the typical nuclear fuel cycle



[19] LMA5202 Nuclear Risk Exclusion Clause (Property Reinsurance) (lmalloyds.com)
[20] Nuclear Risk Insurers - Nuclear Pools

The other major sources of insurance capacity for nuclear risks are through captives and mutual insurance entities of which there are several operating today – providing nuclear first and third-party liability capacity in partnership with commercial insurers, of which the Lloyd's market is the global leader.

The nuclear industry has traditionally been excluded from the mainstream insurance markets of most countries, creating the specific need for bespoke coverage. A significant proportion of this is provided through the Lloyd's market, with a number of syndicates providing specialist coverage for civil nuclear installations, property damage, machinery breakdown, business interruption, nuclear third-party liability, nuclear transit liability and construction. The Lloyd's market remains involved in the provision of insurance on new projects such as Hinkley Point C in the UK and other builds internationally, during construction through to operation and eventual decommissioning.

Nuclear development costs

While nuclear power generation offers significant benefits in providing low-carbon and consistent energy to the grid, the lifecycle of a nuclear project is a costly endeavour which requires both significant up-front investments to fund the design and construction of a plant, together with the eventual and time-consuming decommissioning of the site once the reactor has reached its useful limit.

Currently, the majority of decommissioning costs in the UK are met by the Government through the Nuclear Liabilities Fund, however this approach differs by country. In France, for example, decommissioning costs are primarily met by the nuclear industry.

The significant cost of capital represents a key challenge for the expansion of the sector, requiring an appropriate funding model for new nuclear capacity that drives a better return on investment. The high upfront costs of new nuclear and long construction timelines mean that new financing models have been required to make projects more viable – notably the regulated asset base (RAB) model of financing, which the UK Government has backed as a "credible model for large scale nuclear projects"[21].

[21] Department for Business, Energy & Industrial Strategy - Regulated Asset Base (RAB) model for nuclear - GOV.UK (www.gov.uk)

Another related issue is the extent to which investors are willing to take on the unique risks that nuclear power brings, such as the potential to cause long-term, catastrophic health and environmental impacts, for example as a result of improper disposal of nuclear waste. A key dependency will be on whether nuclear energy is included in the EU's sustainable finance taxonomy, a decision on which is expected soon by the European Commission, which will impact whether nuclear energy is considered a sustainable investment. The global insurance industry via the nuclear pools has a role to play in providing sufficient coverage to ensure private investors are comfortable with the residual risk to which they are exposed.

Attempts to minimise construction risks and costs are also being actively explored by the nuclear sector, for example through replication of existing designs as well as increasing the use of Small Modular Reactors. In the UK, the Government is targeting a 30% reduction in the cost of new nuclear projects by 2030[22]. Nuclear energy providers are also working to reduce the environmental impacts of the construction and decommissioning phases by reducing volumes of materials used, reducing and reusing waste, and effectively managing water resources.

In the UK, the Government is targeting a 30% reduction in the cost of new nuclear projects by 2030[22].

Nuclear liability capacity

Several barriers exist to limit the expansion of insurance capacity, including the inherent volatility of nuclear insurance claims, given the low frequency and high severity that losses can present. Despite strong safety and performance records of the nuclear industry, the perceived risk of nuclear energy remains a key barrier to entry for many insurers and investors, and a greater level of education will be required to address these existing concerns.

Nuclear operators' third-party liabilities are governed through a number of international conventions. Under revisions to the Paris Convention that are expected to come into force from January 2022, third-party liability limits will increase significantly for operators in participating countries.

The amended Paris Convention will cover a broader range of damage than it does today, and the claims period for nuclear damage in relation to life and personal injury will be extended from ten to 30 years[23], significantly increasing the scope and complexity of claims and impacting some insurers' appetite to offer the increased insurance coverage that many operators will be seeking.

In particular, an increase in the mandated claims period could significantly increase the loss of life and personal injury claims incurred by nuclear operators, as an extended claims period will consequently capture claims from those suffering from longer term illnesses or the delayed effects of harmful nuclear exposure.

[22]Nuclear Industry Association - Fortyby50_TheNuclearRoadmap_201009.pdf (niauk.org)
[23]Nuclear Energy Agency – 2004 Protocol to Amend the Paris Convention

Losses due to nuclear site accidents are generally covered by very few policies, with liability channelled through the site operator, creating further concentration risk and increasing the volatility of outcomes for insurers. In addition, despite a few significant nuclear accidents in recent years, the availability of comprehensive actuarial data from the nuclear industry is low because of the low incidence of losses.

However, there is an opportunity for insurers to support the future development of low carbon nuclear projects through the provision of cover for tranches of construction risk relating to new nuclear capacity. With statutory third-party liability cover for the nuclear industry expected to increase substantially due to a pending change in regulations, combined with new nuclear capacity being developed, there is demand on the non-mutual insurance market to alleviate some of these pressures by providing the requisite additional capacity. Given the scale of the risks, this will likely need to be in parallel with government support packages.

There is an opportunity for insurers to support the future development of low carbon nuclear projects through the provision of cover for tranches of construction risk relating to new nuclear capacity.

Insuring the future of nuclear technology

Nuclear power technologies have been evolving in recent years and new innovations such as passive safety systems and digital continual plant assessment are significantly reducing nuclear risks. Small Modular Reactors also contribute to lowering risks, as they contain smaller quantities of radioactive materials and are designed to rely more on inherent safety characteristics rather than operational measures and human intervention.

Another emerging technology is nuclear fusion which, in contrast to nuclear fission, carries no risk of nuclear reactor meltdown (as it produces no chain reaction) or high activity, long-lived nuclear waste. As a result, the type and level of third-party liability insurance will inevitably need to be tailored.

Critically, there will be a need in the immediate term for innovation and customised solutions to provide protection for such new technologies, from construction through to operation.

Roadmap for action

The global insurance industry has a unique opportunity to further expand the coverage it provides to the nuclear industry in order to meet demands for additional insurance capacity, which is being driven by anticipated regulatory changes, the introduction of new technologies and the development of new nuclear capacity.

The Lloyd's market provides significant capacity to nuclear risk specialists NRI (the British Nuclear Insurance Pool) and Northcourt (an independent MGA), who take an active lead in identifying how to increase insurance capacity for the sector, and what combination of government support, risk pooling, and mutual arrangements is needed to ensure adequate protection is available.

As global leaders in providing insurance for the nuclear energy sector, Lloyd's will support the increase in nuclear insurance capacity through:

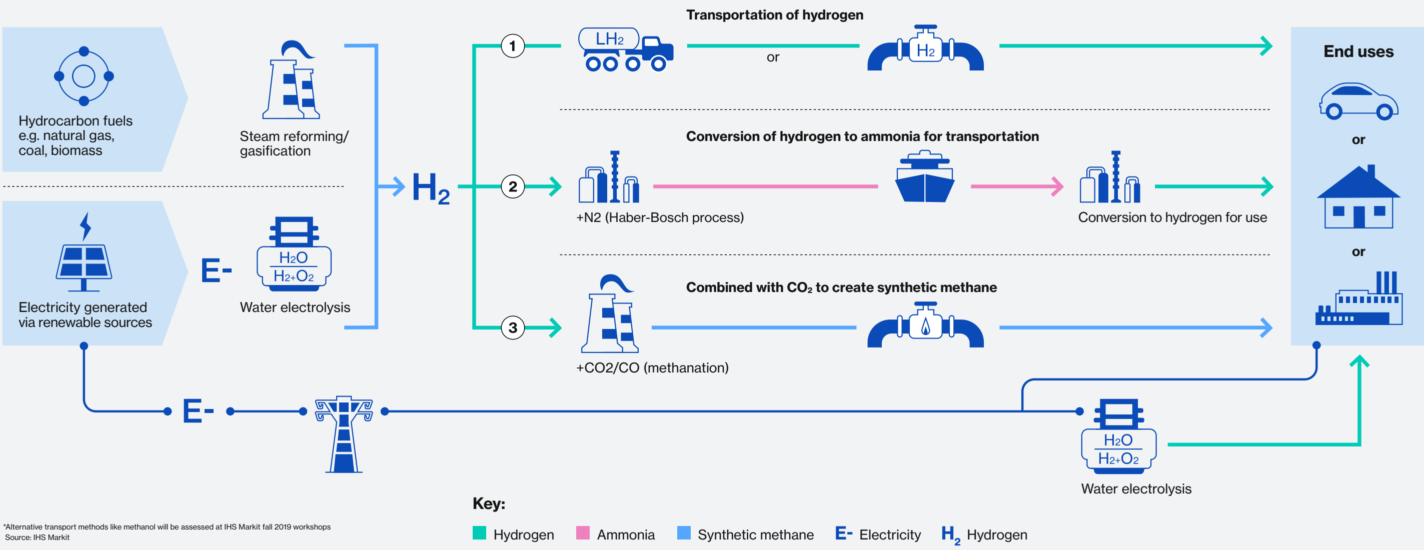
- Providing a platform to ensure there is co-ordinated action between the insurance industry, civil nuclear sector and government, and to ensure that nuclear operators are able to meet the additional liability required by regulations.

04. Hydrogen

What is hydrogen?

Hydrogen is a fuel that produces no direct GHG emissions or other pollutants when combusted. Its lightness and energy density, combined with its ability to act as an energy carrier that can be used to store, move and deliver energy produced from other sources, makes it a key enabler in accelerating the decarbonisation of a range of sectors, including metals and mining, chemicals, domestic and international freight, heavy transportation, cement and agriculture. In addition, as a liquid fuel, hydrogen has key advantages in storage and transportation.

Simplified artistic view of the typical nuclear fuel cycle

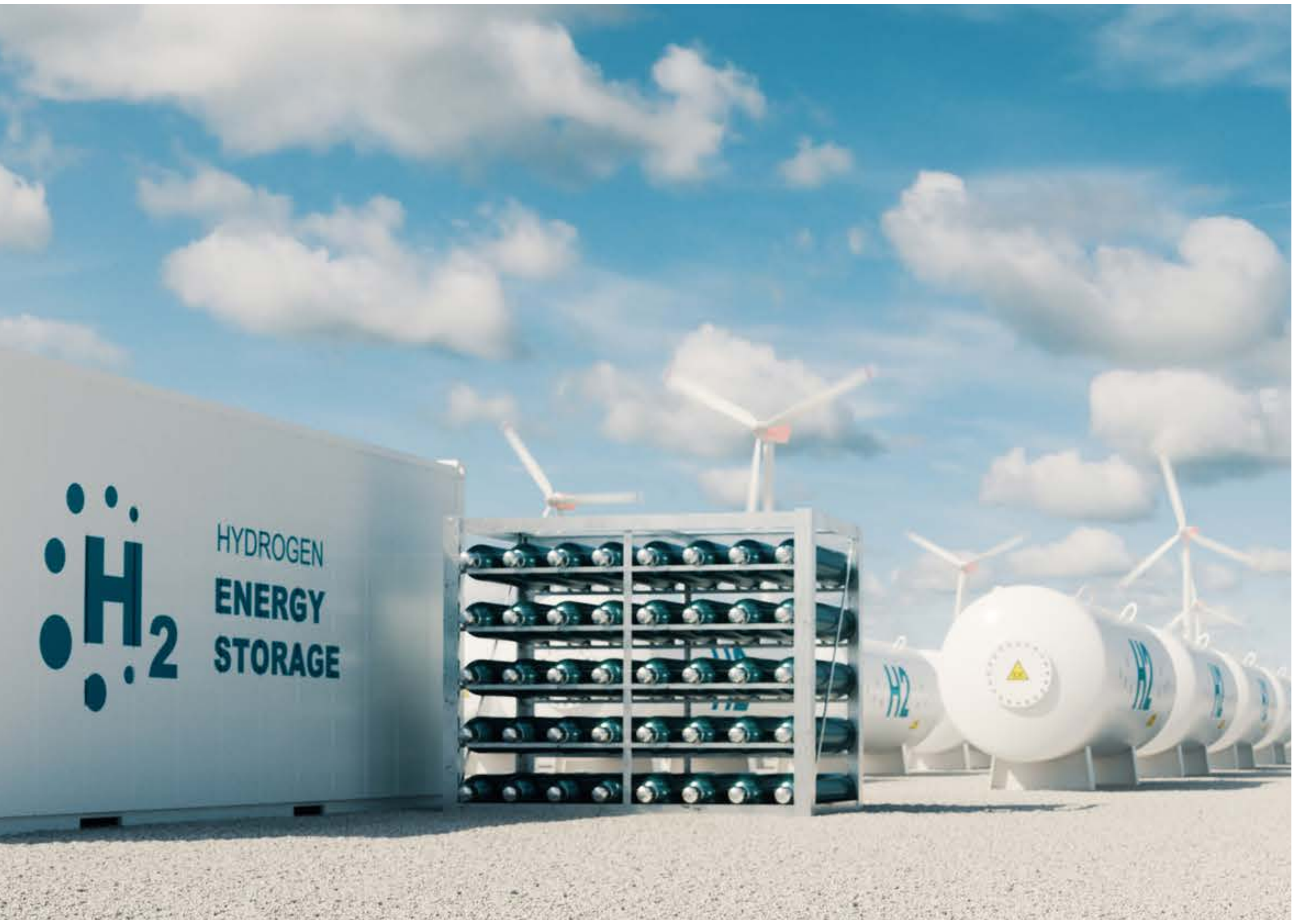


*Alternative transport methods like methanol will be assessed at IHS Markit fall 2019 workshops Source: IHS Markit

How is hydrogen produced?

Hydrogen can be produced from a variety of sources, such as natural gas, biomass, and renewable power, and this in turn informs its classification – grey, blue or green. Currently, the majority of hydrogen is grey hydrogen, which has a high carbon footprint and is often produced using fossil fuel inputs.

Blue hydrogen, on the other hand, has a lower expected carbon footprint and uses natural gas and carbon capture and storage as feedstock for its production; it is typically generated at historic oil and gas production sites.



Green hydrogen goes one step further and has an even lower carbon footprint than blue hydrogen. It is produced by splitting water by electrolysis using electricity that has been produced using excess energy from renewable energy sources such as wind and solar. The most critical factor driving the cost of green hydrogen is the price of the renewable energy used as an input; in the first instance, it is likely that the majority of growth in clean hydrogen production will be driven by blue hydrogen until renewable energy achieves sufficient scale to make production of green hydrogen economically viable[24].

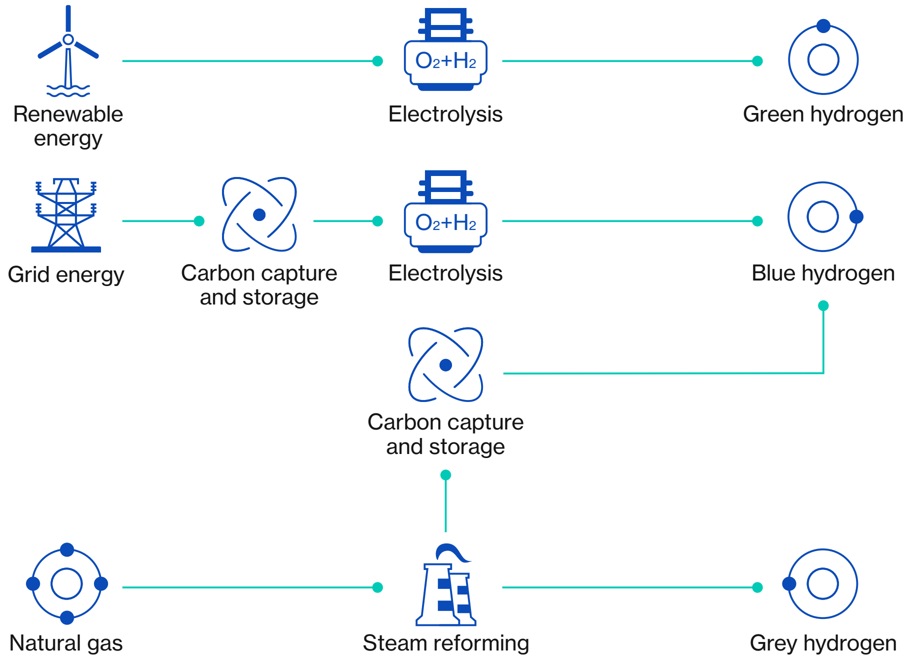
[24]IEA - The clean hydrogen future has already begun – Analysis - IEA

Green hydrogen

Green hydrogen is produced by using electricity to split water (H_2O) into its component parts – hydrogen and oxygen. If the electricity is produced by renewable power, such as solar or wind, the resulting hydrogen is carbon-free.

Green hydrogen has the potential to play a particularly prominent role in the storage and transmission of excess energy output from intermittent renewable energy assets, which can then be redeployed globally for heat, electricity and as a key energy input for industry.

Hydrogen process



How can hydrogen be used to support decarbonisation?

Hydrogen is widely used as a low-carbon alternative in many industrial applications as a fuel which is burned with oxygen. It can be used in fuel cells, internal combustion engines and industrial heating processes.

Hydrogen use today is mainly dominated by industry, however its potential uses span across the entire value chain from renewable energy generation, through to transportation, and homes and buildings. Hydrogen fuel cell technology can be used to power anything that uses electricity, with applications across transportation such as electric vehicles and aviation, and offers the benefit of higher energy efficiency than traditional combustion engines.

Hydrogen can also be blended into existing gas networks to provide power to homes and public buildings.

In addition, hydrogen can be a leading option for storing renewable energy when converted into a carrier such as ammonia, helping to manage both the variable output from renewables as well as the transportation of renewable energy over long distances, such as from offshore wind farms.

Green steel

Steel is traditionally produced using iron ore and/or scrap metal as a basic material, together with a reducing agent which removes oxygen from the iron ore. Traditional manufacturing uses coke as a reducing agent, which emits carbon dioxide when it reacts with the oxygen in the iron ore.

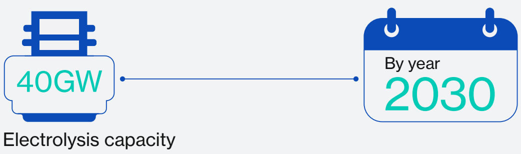
Green steel is produced using hydrogen instead of coke as the reducing agent. While hydrogen also reacts with oxygen in the iron ore, the result is water vapour rather than carbon dioxide.

Plans are underway to build a green steel production facility in Sweden, using a fossil-free manufacturing process which will be powered by the world's largest green hydrogen plant. The size of H2 Green Steel's hydrogen plant is expected to be around 800 megawatts, with its end-product replacing coal and coke in the steel manufacturing process. Steel production is expected to begin in 2024, and by 2030 the aim is to have the capacity to produce 5 million tonnes of steel per year.

Hydrogen strategies

The EU has put hydrogen at the heart of its green recovery, with a target of 40GW of electrolyser capacity by 2030[25]. It also has ambitions to strengthen the hydrogen transportation network in the region, working with gas grid operators to develop the 'European Hydrogen Backbone' which leverages existing gas transmission pipelines to connect the demand and supply of hydrogen.

The EU's hydrogen ambition



Similarly, the UK Government has identified the growth of hydrogen as a strategic imperative and aims to develop 1GW of low carbon hydrogen production capacity by 2025 (increasing to 5GW by 2030). It also plans to launch a £240m net zero hydrogen fund to promote low carbon hydrogen production in the UK, and will release its formal hydrogen strategy later in 2021[26].

The Sustainable Markets Initiative has established a Hydrogen Taskforce to support and accelerate the deployment of hydrogen globally as one of the decarbonisation tools critical to facilitating net zero emissions. The Task Force, chaired by Shell, has committed to a number of actions ahead of COP 26 in November 2021 including: creating a template for a hydrogen ecosystem to act as a basis for a hydrogen energy-based economy, developing formal pledges with participating companies committing to the use of clean hydrogen in their supply chains, and identifying policy and regulatory levers needed to accelerate the adoption of hydrogen fuel cells in transportation.

[25]Environment Analyst - Environment Analyst Global | Environment Analyst Global (environment-analyst.com)
[26]HM Government - The Ten Point Plan for a Green Industrial Revolution (publishing.service.gov.uk)

Key challenges

Hydrogen infrastructure networks

A key obstacle to the success of hydrogen is the infrastructure required to achieve scale. Though the technology to use hydrogen for heat, electricity and as an input for industry has existed for some time, infrastructure is essential to enable the hydrogen economy to operate across its full value chain from upstream production, to midstream storage and transmission to downstream fuelling and distribution.

Any development should enable hydrogen to be transported at scale through the existing gas transmission network or via the use of specialised vehicles that can transport hydrogen safely. The conversion of existing natural gas pipelines to deliver hydrogen is a significant and costly undertaking as hydrogen's potential to embrittle steel pipelines above a certain concentration threshold will result in the need for pipeline modification.

> **Green hydrogen production costs could fall by up to 30% by 2030 according to some projections.**

In addition to the cost of any hydrogen transportation infrastructure modification or introduction, hydrogen itself is currently costly to produce. Green hydrogen production costs could fall by up to 30% by 2030 according to some projections, however such a reduction would be dependent on a decline in the cost of renewable energy, an increase in production to benefit from economies of scale, and significant investment to achieve economic viability[27].

The production of low-carbon hydrogen is in its early stages, with less than 0.7% of hydrogen production globally currently "clean" (i.e. blue or green hydrogen)[28]. There is an expectation that this proportion will grow significantly should national governments achieve the ambitions contained within their respective hydrogen strategies, however it remains to be seen whether these obstacles to success can be overcome collectively by industry, insurers and government.

The insurance industry can help to de-risk investment into hydrogen infrastructure and incentivise private-sector investment. This will ultimately enable the hydrogen economy to achieve scale and therefore drive down production costs.

This will, however, require a long-term government policy framework to give investors the certainty they require, connectivity between individual projects and a broader infrastructure network to ensure the hydrogen economy can operate across its entire value chain, and a clear risk allocation mechanism between governments, the private sector and insurance providers where such risks are too great for one stakeholder to carry alone.

[27] International Energy Agency - The Future of Hydrogen – Analysis - IEA
[28] EUI Florence School of Regulation – Clean hydrogen

The nature of hydrogen risks

As the hydrogen economy continues to grow, there will likely be significant changes to the risk landscape of the industries looking to utilise this energy source, which may naturally give rise to additional safety risks, for example due to its flammability and explosive properties. These risks exist across the entire hydrogen value chain, including during transportation and storage at the point of use, where leakages can be catastrophic.

The insurance industry therefore needs to understand, and then help companies operating across the hydrogen economy to better understand the changing risk profile and subsequent coverage requirements. The insurance industry is uniquely placed to support this centrally, using its experience across multiple industries to create global best-practice guidelines.

The Lloyd's market is already providing specialist insurance cover for safety risks associated with the transportation of hydrogen. Such cover will likely need to be scaled, particularly as the modification of existing gas transmission pipelines continues to gather pace.

Insurance cover is already relatively well established for offshore wind projects involved in green hydrogen production (recognising that this subset of the offshore wind market is still in early stages of development). There is a precedent on which the insurance industry can build to provide broader coverage to other segments of the hydrogen economy and its value chain.

Roadmap for action

Hydrogen is a vector of change and facilitator of decarbonisation for several sectors and significant investment will be required to develop hydrogen infrastructure. The use of hydrogen also introduces unique safety implications which will need to be appropriately identified, measured, monitored and managed, and insurers are well-placed to support customers across multiple industries with this.

Insurers should enter dialogue with corporates operating across the hydrogen value chain to better understand the challenges they are facing in obtaining specialist insurance cover, and consider how cover may need to be segmented or consolidated across components of the hydrogen value chain to prove effective.

To help facilitate the development of hydrogen, the SMI Insurance Task Force will:

- Work closely with the SMI Hydrogen Task Force to open up discussion with customers operating in this space on the specific challenges they are facing to develop insurance coverage for innovative or prototypical hydrogen technologies and infrastructure.

To support this, Lloyd's will:

- Lead research through Lloyd's Futureset into the specific risks posed by hydrogen, including its flammability, and how these risks might emerge in different ways according to how this fuel is used at a sectoral level. This will help corporates and private investors to understand how these risks can be managed and where specialist coverage may need to be introduced or expanded, for example in relation to the transportation of hydrogen.

05. Committing to action

Lloyd's and the global insurance industry are uniquely positioned to facilitate efforts across communities, businesses and governments around the world to drive a transition to a lower carbon economy.

We have engaged with a range of insurers, Lloyd's market participants and corporates to assess the scale and complexity of decarbonisation ambitions across the energy sector (offshore wind, nuclear and hydrogen energy). The actions taken by the insurance industry today to support the scale and pace of ambition from both governments and businesses will be critical in driving positive, long-term change.

	Offshore wind	Nuclear	Hydrogen
Action the global (re)insurance industry should take	Insurers have a unique opportunity to further expand the coverage they provide to the offshore wind sector to meet demands for additional insurance capacity, which is being driven by the rapid advancement of new offshore wind technology including turbines and floating wind technology.	Insurers should expand the coverage they provide to the nuclear industry to meet demands for additional insurance capacity, which is being driven by regulatory changes and the development of new nuclear capacity.	Insurers should also enter dialogue with corporates operating across the hydrogen value chain to better understand the challenges they are facing in obtaining specialist insurance cover and consider how cover may need to be segmented or consolidated across components of the hydrogen value chain to prove effective.
Actions that will be delivered through the Sustainable Markets Initiative InsuranceTaskforce	The SMI Insurance Task Force has convened a workstream focused on supporting and encouraging more sustainable investment, including into offshore wind projects. The Task Force will also ensure there is co-ordinated action between the insurance industry, operators in the offshore wind sector and private investors.	N/A	Work closely with the SMI Hydrogen Task Force to open up discussion with customers operating in this space on the specific challenges they are facing to develop insurance coverage for innovative or prototypical hydrogen technologies and infrastructure.
Actions that Lloyd's will take	Commit to expanding its coverage to ensure capacity constraints do not limit the growth of the industry.	Provide a platform to ensure co-ordination between the insurance industry, civil nuclear sector and government and ensure that nuclear operators are able to meet the additional liability required by regulations.	Lead research through Lloyd's Futureset into the specific risks posed by hydrogen. This research will help corporates and private investors to understand how these risks can be managed and where specialist coverage may need to be introduced or expanded.

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