NORTON ROSE FULBRIGHT

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INVESTMENT IN HYDROGEN

FW discusses hydrogen investment with Alex Kerr at Baker Botts (UK) LLP, Dalia Majumder-Russell at CMS, Marcia Hook at Kirkland & Ellis LLP, Todd Alexander at Norton Rose Fulbright and Jonathon Hannah at Sullivan & Cromwell LLP.

Q&A:

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THE PANELLISTS

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Alex Kerr advises on the development of energy projects around the world, with a particular focus on hydrogen and LNG. In addition to advising states and sponsors on project development, he has extensive experience of drafting and negotiating agreements for the sale and purchase of hydrogen (including green hydrogen and ammonia), LNG and pipeline gas. He was named as a 'Rising Star' in oil & gas by Legal 500 in 2020 and 2021.

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Dalia Majumder-Russell is a partner in CMS' energy & climate change team, specialising in complex process power and renewable projects. She is passionate about the decarbonisation agenda across the energy, heat and transport sectors. For most of her career she has advised on the commercial arrangements for renewable projects and worked on a number of hydrogen and ammonia supply, offtake and project documents. She is a member of a number of expert groups focused on developing UK hydrogen policies.

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Jonathon Hannah is a lawyer with over 15 years' experience in energy and infrastructure projects, with a particular focus on LNG and pipeline projects. He has represented sponsors, investors, developers and lenders in relation to some of the most complex and high-profile projects globally. He has broad experience providing strategic advice across diverse situations, jurisdictions and capital structures. He is a frequent writer and speaker on hydrogen developments.

FW: Could you provide an overview of hydrogen technology, the opportunities it presents for clean energy alternatives and the role it is likely to play in energy transition?

Kerr: While there has been a recent explosion of interest in hydrogen, hydrogen production is not new – it has been produced and used commercially for hundreds of years. What is new, however, is the belief that low-carbon hydrogen – be it 'green' hydrogen produced by the electrolysis of water using solely renewable power, 'blue' hydrogen produced from natural gas with the use of carbon capture, usage and storage (CCUS) technology, 'turquoise' hydrogen produced using methane pyrolysis to produce both hydrogen and solid carbon – carbon black, itself a marketable commodity – can be produced at-scale on a cost-competitive basis, and that the uses and applications for hydrogen can be expanded significantly from their current narrow focus. The growth of a low-carbon hydrogen market presents opportunities for clean energy alternatives, as it has much lower overall emissions compared to oil & natural gas. Low-carbon hydrogen can play a key role in the energy transition, firstly by decarbonising existing 'grey' and 'brown' hydrogen consumption, but also by decarbonising sectors that are difficult for electricity to support directly.

Hannah: The potential for hydrogen is breathtaking, both for its ability to decarbonise hard to decarbonise sectors and for its scale. That presents a huge opportunity for developers, investors and financiers. The focus is firmly on clean hydrogen, either green or blue. Technological advances are swiftly bringing down the cost of both electrolysers and renewable power generation, which has been a barrier to scaling green hydrogen. On the demand side, outside the traditional industrial and fertiliser use cases for hydrogen, the development of fuel cell technology and power generation turbines that can use hydrogen is advancing rapidly. Steel making is a notoriously hard to decarbonise sector and accounts for almost 10 percent of overall global emissions. A number of countries, including China and the US, have green steel initiatives involving hydrogen, and demonstration projects are already in operation, but this remains at an early stage.

Alexander: Hydrogen has the potential to replace fossil fuels across the power, industrial and transportation sectors, facilitating the global transition toward net-zero carbon emissions. Green hydrogen holds particular promise as a zero-carbon energy source. Once derived, hydrogen can be used in difficult-to-decarbonise sectors like steel manufacturing, which require high temperature industrial processes that renewable energy alone might not be able to supply. Hydrogen can also provide grid services, supplementing intermittent power generation created by renewables, such as wind and solar, with the electricity it produces. Hydrogen is ideal for aviation, trucking and marine industries, which have to carry energy supplies over greater distances, because it can be converted directly to electricity in a fuel cell, which packs more power in less space than electric batteries.

Majumder-Russell: Hydrogen can be produced in a variety of ways, some of which either do not directly result in greenhouse gas emissions or incorporate capture technology such that emissions are captured and stored rather than released into the atmosphere. Low-carbon hydrogen is now widely recognised as having an important role to play in decarbonising our energy usage, due to its versatility and potentially wide application. Hydrogen can be stored and transported, either as a liquid or a gas, and can be used to decarbonise hard to electrify areas, such as industrial processes, heavy and frequent use transport and heating.

Hook: Hydrogen has captured the attention of so many in the energy space, and in the investment community, because it can be used in numerous applications that will be key to long-term decarbonisation. Hydrogen can be used for transportation, to heat and power buildings and industry, and as an industry feedstock. Indeed, hydrogen may be the best option to decarbonise certain hard to decarbonise markets, such as heavy- and long-haul transport. Many also are excited about the prospect of running gas-fired

facilities on hydrogen pulled from storage, as such facilities could be run on zero or low emissions, serve the role of traditional baseload generators, and compliment intermittent renewables.

FW: How would you describe recent investment activity into hydrogen energy projects? What factors are driving investment?

Hannah: We have seen a sharp increase in private sector investments in hydrogen projects across the value chain from a diverse range of players, including renewable energy companies, environmental, social and governance (ESG) funds, sovereign wealth funds, oil & gas majors, trading companies, industrial gas companies, utilities, automakers and family offices. ESG investing generally has been a huge trend and developers, operators and investors have been seeking to position themselves for prevailing global megatrends such as the energy transition, as well as taking advantage of technological shifts. For green hydrogen specifically, a critical factor has been governments getting behind it, stimulating demand, developing infrastructure and incentivising development.

Alexander: The overwhelming majority of hydrogen projects to date have involved grey hydrogen, produced using fossil fuels, or blue hydrogen, using fossil fuels paired with carbon capture. But investment activity in green hydrogen energy projects is growing due to a combination of increased government, industry and public support, along with the decreasing cost of renewable energy. Investors are currently branching into 'existing use' cases for hydrogen, as a merchant and offtake scheme already exists for such projects. Examples of this include the ammonia industry, which already has an established market for fertiliser and is easier to transport than pure hydrogen, the petroleum industry, as refineries are already some of the largest consumers of hydrogen as fuel stock, and fuel cells for specialty vehicles like forklifts, which may already use electric batteries. In addition, we have seen significant recent interest in the hydrogen-to-ammonia market given the high prices for natural gas in Europe, which has made green hydrogen cost competitive as a feedstock for ammonia.

Majumder-Russell: To date, most low-carbon hydrogen projects developed have been smaller scale projects, aimed at showcasing the potential use of low-carbon hydrogen across a range of sectors and applications. Hydrogen projects are following the trajectory seen over the last 15 years with other renewable technologies, such as wind and solar. First, large-scale projects are realised with the help of public funding, primarily in the form of grants and capital expenditure subsidies for pilots and infrastructure. Industrial processes are currently the biggest consumers of hydrogen, although at this stage the vast majority of this is polluting grey hydrogen produced via unabated steam methane reformation. This existing demand offers a potentially large supply opportunity for developers of low-carbon hydrogen projects. In the automotive sector, various well-known car manufacturers have developed or announced plans to develop hydrogen fuel cell vehicles (HFCVs) and there has also been investment in HFCV fuelling infrastructure. Investment in low carbon technologies is being driven by the widely recognised need to decarbonise our energy usage in order to limit global warming in line with the ambitions of the Paris Agreement and the need for businesses to future-proof their operations in line with this goal. Investment in low-carbon hydrogen is being driven by recognition of its versatility and ability to decarbonise hard to electrify areas.

Hook: There has been a huge amount of investment interest in hydrogen energy projects. There are many factors driving this interest, including increasingly ambitious corporate, national and international decarbonisation targets, the falling costs of renewable energy and hydrogen technologies, government policies promoting hydrogen, and the fact that hydrogen could have so many potential applications in energy transition.

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> JONATHON HANNAH
> Sullivan & Cromwell LLP

Kerr: The interest in low-carbon hydrogen is undoubtedly higher than ever before. While there are hurdles to overcome, in the coming years we expect to see billions of dollars of investment in blue hydrogen projects, small-scale green hydrogen projects and a small number of green hydrogen mega-projects. There are three main factors driving investment in low-carbon hydrogen. First, firm commitments by governments, energy companies, utilities and commercial end-users to decarbonise. Second, an ever-increasing focus by consumers, investors, lenders

and other stakeholders on ESG issues. And finally, a growing acceptance that low-carbon hydrogen is needed to achieve net-zero targets and to address hard to decarbonise industry sectors. A stumbling block has been the cost of producing low-carbon hydrogen, but there is growing belief that this cost can be brought down, by a diversity of hydrogen production technologies and innovations.

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> TODD ALEXANDER
> Norton Rose Fulbright

FW: Which regions seem to offer compelling opportunities? What types of hydrogen projects are capturing the interest of investors?

Alexander: Green hydrogen has the potential to take off in regions with access to renewable resources, sufficient land for wind and solar farms, access to water, and the capability to store and transport hydrogen to end users. This could mean states like Texas – traditionally the heartland of the oil and gas industry – or Mississippi and Utah, which are projected to be the two largest green hydrogen hubs in the US. Green hydrogen also shows potential to replace natural gas in markets where natural gas prices are expected to remain elevated. Currently, various emerging use cases for hydrogen are capturing the interest of investors. The power sector is exploring hydrogen-based electricity generation, which is ripe for investment as the offtake scenario is already determined. The transportation and heavy industry sectors are looking into hydrogen fuel cells for long-term energy storage as a replacement for much heavier electric batteries – used in trains, trucks and airplanes. However, government support is needed to create the necessary infrastructure for refuelling such vehicles.

Majumder-Russell: As of 2021, an estimated 230 hydrogen projects across the entire value chain had been announced globally, the greatest number of which were in Europe, with Australia, the Middle East, Japan and Korea also being hubs. Of the approximately $300bn projected investment to 2030, about $80bn is estimated to be 'mature', specifically in projects at front end engineering and design (FEED) or final investment decision (FID) stage. About 45 percent of projected investment is predicted to be in European projects. In Japan and South Korea, there has been a focus on transportation projects, with South Korea having the largest proportion of HFCVs in operation in 2021, approximately 33 percent of the global total. Large-scale industrial usage projects have also been announced, particularly in Europe, focused on the application of hydrogen as an industrial feedstock.

Kerr: We expect that both green and blue hydrogen projects will play a pivotal role in the energy transition. Some governments and industry participants are adopting a 'twin-track' approach and see blue hydrogen as an important part of any future hydrogen economy. However, other governments and industry participants are focusing solely on green hydrogen, and do not see a role for blue hydrogen based on its consumption of fossil fuels. In terms of green hydrogen production, these projects require renewable power that can be generated and supplied at low cost, in sufficient quantities and year-round. The electrolysers used to produce green hydrogen require a steady and reliable supply of power, and this demand profile is at odds with the inherent intermittent nature of most renewable power. While these issues can be addressed, at least in part by battery storage and backup power supplies, we expect early green hydrogen projects will be developed in regions that best provide the meteorological conditions to provide dependable year-round renewable power.

Hook: There are several countries that offer compelling opportunities because their governments have committed to hydrogen deployment. These countries can offer certain natural advantages for hydrogen generation, because of cheap renewable energy or there is an existing market that could be served by hydrogen, or all the above. For example, Chile has adopted a National Green Hydrogen Strategy and half of its installed power generation capacity for 2021 was sourced from renewable energy resources. In addition, as a net importer of fuels with a large domestic mining industry, there is a robust potential domestic market for green hydrogen. Other regions that have some or all these characteristics, and therefore offer a compelling market opportunity, include Australia, Europe and, increasingly, the US.

Hannah: Once the capital investment in a green hydrogen project has been made, the return that it generates is highly dependent on the utilisation of the electrolyser that can be achieved. Areas that have a good wind and solar resources and can use primarily solar power during the day and wind power at night will have a significant advantage.

Parts of Australia, the Middle East, Africa and South America all have favourable conditions. For blue hydrogen, local natural gas resources are key, and the Middle East, Australia and parts of Africa are likely to be leaders in low-cost blue hydrogen production. Proximity to major markets will also be important, with Europe and Asia, particularly Japan and Korea, expected to be major importers. Indeed, in a significant market development, JERA, the largest power generation company in Japan, recently issued a request for proposal (RFP) for the procurement of clean ammonia – used as a carrier for clean hydrogen – under long-term supply contracts. Green hydrogen projects have most captured the imagination, but we see an important role for blue hydrogen as the world transitions away from fossil fuels. Rising natural gas prices, triggered by falling investment in fossil fuels and Russia's recent invasion of Ukraine, will improve the competitiveness of green hydrogen. The recent spike in gas prices has, in some locations, made green hydrogen competitive with grey hydrogen.

FW: To what extent are government policies and regulatory frameworks supporting hydrogen energy initiatives, and related investment?

Hook: It is undeniable that more favourable government policies and regulatory frameworks are helping certain countries surge ahead in terms of clean hydrogen development. Several countries have developed national hydrogen strategies, which can help provide long-term investment signals. Many of those countries have also adopted regulatory changes to help streamline the process of deploying hydrogen, or subsidies to incentivise hydrogen projects. These types of actions help not only attract investors but ensure that investment capital can be deployed.

Hannah: Government policies and initiatives are absolutely critical to supporting the development of clean hydrogen and stimulating investment, particularly as supply and demand will need to develop in tandem alongside necessary infrastructure. Absent support, green hydrogen is unlikely to be competitive with either grey hydrogen or other fuel sources for most use cases in the near term. A number of governments have been active supporters of the hydrogen economy. In the US, the Infrastructure Investment and Jobs Act (IIJA) included $9.5bn of funding for clean hydrogen projects with a plan to develop four regional clean hydrogen hubs across the US. In the European Union (EU), the package of policy and regulatory support measures introduced has established ambitious targets and has been hailed as a game changer for the green hydrogen industry. Elsewhere, Japan, Korea, China, the UK, Australia and many others have adopted ambitious green hydrogen policies and targets.

Kerr: Low-carbon hydrogen is not currently cost competitive with conventional alternatives. The development of the low-carbon hydrogen market will therefore, at least initially, be reliant upon financial support from governments around the world. To date, 17 governments have released national hydrogen strategies, pledging nearly $40bn in support for hydrogen projects. This support has taken the form of funding for research and development, funding for the development of pilot projects, or tax reliefs, tax credits and other financial support mechanisms. Much more is needed, however, with the International Energy Agency (IEA) predicting that putting the hydrogen sector on track for net-zero emissions by 2050 will require $1.2 trillion of investment in low-carbon hydrogen supply and use through to 2030. It is also important that government funding supports all links in the hydrogen value chain, from production all the way through to end-use.

Majumder-Russell: Over 30 countries, many of them in Europe, have already adopted hydrogen strategies and many more have announced that they are in the process of actively developing the same. Strategies are important to alleviate some of the risks associated with low-carbon hydrogen investment, around its greater production costs in comparison with grey hydrogen, for example. To date, most strategies focus on incentivising low-carbon hydrogen production rather than stimulating demand. In addition to strategies, it will be necessary to entrench hydrogen in national laws. At present, Germany is one of few European jurisdictions to have passed dedicated hydrogen legislation by updating its Energy Act. South Korea also has made changes to law to enable hydrogen projects. In the absence of dedicated laws, hydrogen will continue to be governed by existing legislation, such as that governing natural

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> MARCIA HOOK
> Kirkland & Ellis LLP

gas. As well as being unsuitable for hydrogen in some respects, this also makes the legal situation regarding hydrogen difficult to understand, which may be a disincentive to investment.

Alexander: Government support of hydrogen initiatives is on the rise. Globally, more than 30 countries have hydrogen strategies to promote global hydrogen trade, including import and export plans. The US IIJA from November 2021 dedicates $9.5bn to the development of clean hydrogen technology. That amount includes an $8bn initiative to establish regional hydrogen hubs that will promote the production, transport, storage and end-use of the substance. The US Department of Energy's Hydrogen Energy 'Earthshot' initiative seeks to reduce the cost of clean hydrogen to $1 per kilogramme in one decade. State policies are also appearing, including the California Low Carbon Fuel Standard, which promotes substitutes for conventional gasoline – including hydrogen – to reduce lifecycle carbon intensity of transportation fuels through a system of credits and deficits. Such government support is critical to setting the stage for future investment.

FW: What advice would you offer to those making investment in the hydrogen market? Are there any unique aspects or characteristics that need to be evaluated?

Hannah: Developers, investors and financiers will need to wrestle with issues including the cost, performance and reliability of new or scaled-up technologies, project-on-project risk where there is a need for related infrastructure to be put in place, offtake and marketing risk in a relatively new market, integration of government subsidies and tax incentives into investment structures and the ability to access financing. All of these issues will need to be understood by investors and their advisers and factored into investment decisions. While there are unique aspects to hydrogen projects, there are also parallels with other industries. Liquefied natural gas (LNG) projects in particular have significant similarities, including the segmented nature of the value chain, project-on-project risk, shipping and marketing requirements and the use of new technologies. The ability to utilise experience of similar projects is going to be an advantage.

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> CMS

Majumder-Russell: Given that the hydrogen market is still relatively undeveloped, and few jurisdictions have, at this stage, legislated on the treatment of low-carbon hydrogen, there remains scope to shape how the hydrogen economy will develop. Early movers will likely be able to play a part in doing this as governments seek to encourage investment. Conversely, the commercially nascent status of low-carbon hydrogen means that technology will likely develop quickly with cheaper and more efficient technologies possibly being brought to market as the sector grows. Early movers also face a risk of investing in expensive technology which could become quickly outdated. Low-carbon hydrogen is subject to several specific challenges which investors will need to carefully consider.

Alexander: Those investing in the hydrogen market must consider various factors, such as the cost of hydrogen production, the reliability of offtakers and the availability of existing hydrogen. Currently, the cost of green hydrogen is two to four times that of grey hydrogen, but this expense is continuously decreasing with time. With lower costs of production, investors will have to pay particular attention to the cost of transporting hydrogen from its production location to end-use. Investors must also ensure that proper demand for hydrogen projects exist, as many companies are price-sensitive and not willing to pay several times the cost of grey hydrogen for green hydrogen. Tapping into existing use markets is a good place for investors to start as the offtake scheme is already determined.

Kerr: As with any investment, investments in hydrogen projects and technologies require substantial due diligence. A full value chain approach needs to be adopted to this due diligence, as it is not possible to consider just one link in the chain in isolation. Production projects are reliant upon there being sufficient demand for the hydrogen produced, downstream projects are dependent upon there being sufficient hydrogen supply, and all hydrogen projects and investments are dependent upon the development of the infrastructure required to support a hydrogen economy. Hydrogen presents unique challenges due to its chemical and physical characteristics, particularly with respect to its storage and transportation. Hydrogen is the smallest molecule and the lightest element. Storage and transportation of hydrogen therefore poses challenges, as it is prone to escape from confinement, either through seals

or cracks in tanks and pipelines. Given hydrogen's extreme flammability, this can present serious safety issues that require close management.

FW: What risk management considerations do investors need to make when assessing hydrogen projects and assets? What options are available to mitigate risk and protect future value?

Majumder-Russell: Low-carbon hydrogen remains a commercially nascent industry. This presents specific challenges which should be borne in mind by would-be investors. First, demand uncertainty. Since there are currently very few commercial-scale low carbon hydrogen projects, it remains to be seen what consumer demand will be. This is particularly the case given that low-carbon hydrogen is a counterfactual for existing fuels, meaning that price will play a large role in uptake. Second, lack of dedicated regulatory and policy structure. Dedicated regulation lags behind the commercial implementation of low-carbon hydrogen that has been seen to date. The lack of coherent regulation creates a lack of clarity around how hydrogen is currently regulated and how those currently unregulated aspects will be regulated in the future. Finally, lack of physical infrastructure for distribution and storage. Effective infrastructure is required in order for low-carbon hydrogen to achieve its full potential in decarbonising our energy usage, for example to enable it to be stored and transported between the point of production and the point of use, which may not be in the same locale or even the same country.

Alexander: Investors must consider the expense of low carbon fuel investments, along with the higher risks associated with technologies – which may be difficult to deploy on a national scale. Technology obsolescence could be an issue, along with determining how to distribute risk between investors and consumers or taxpayers. This sector will likely require continued government support in its early stages, to encourage technological development and the role hydrogen can play in the future market. Industrial hubs or offtake clusters may be required to decrease costs via coordination between companies in port areas that are responsible for hydrogen transportation, as well as where power is generated or where fertiliser or steel is produced. To mitigate cost-related risks, the government may also need to step in to provide additional funding. Investors may also need to carefully examine manufacturer and engineering, procurement and construction (EPC) warranties to mitigate technology risks associated with electrolysis. Finally, investors must ensure that all of the various elements in the chain of hydrogen sourcing, production and distribution function properly, perhaps adopting end-to-end financing or looking to prior examples of multi-project financing as guidance.

Kerr: The risk management considerations are the same as for any project or investment. It is important to bring advisers on board, both from a legal and technical perspective, early in the process in order to ensure that risks are properly considered, mitigated – to the extent possible – and allocated.

Hook: There are a number of risks that must be worked through whenever one is developing complex projects. One of the key risks for hydrogen projects right now is transport risk. There is not a lot of existing infrastructure to transport hydrogen in its gaseous state. That means that a developer must be even more mindful about determining how it will transport its product to its customer. One of the most common options we have seen employed to minimise transport risk is to locate the hydrogen production facility near the end-user's site, often creating a hub or connecting to the end-user through a small network of dedicated infrastructure.

Hannah: The key questions for investors in hydrogen production projects will be: who is the hydrogen produced by the project going to be sold to, and at what price? This is a particular risk for early-stage projects, as supply and demand are developing in parallel and there is not currently a strong spot market for hydrogen. Anticipated reductions in capital costs for green hydrogen projects brought by technological advances mean that the price per tonne of hydrogen will likely fall significantly over the next 10 years, which may make early projects less competitive in the longer term. That risk can be mitigated by entering into long-term sales contracts that have appropriate pricing mechanisms with creditworthy offtakers, which we would expect to be a prerequisite to raising project financing, at least in the near term.

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> ALEX KERR
> Baker Botts (UK) LLP

FW: Going forward, what are your predictions for hydrogen investment activity through 2022 and beyond? What key factors are likely to shape transactions and investments in the years ahead?

Alexander: Investment in hydrogen is likely to grow rapidly during the coming decade, especially with increased government support and heightened geopolitical tensions incentivising Europe and other regions to secure alternatives to natural gas. One McKinsey & Company report estimates that total investments will exceed $300bn in hydrogen spending through 2030, representing a sizeable chunk of the global energy industry. Economies of scale will continue to reduce the price of green hydrogen, including its production, storage and transportation costs. Cross-border trading of hydrogen will likely increase in the 2030s. While progress in the clean hydrogen industry has grown with unprecedented momentum over the past year, its continued development will depend partially on government support and coordinated efforts among those in the industry to combine offtakers, reduce costs based on scale, and to develop the infrastructure needed to transport hydrogen from its production site to its end use. Such steps could create the perfect environment for achieving decarbonisation goals.

Hook: We expect to see increasing investment in the hydrogen space, and for more and more countries to formally adopt hydrogen strategies and policies to try to foster hydrogen investment. For example, the US just passed the IIJA, which requires the creation of a national clean hydrogen strategy and roadmap to facilitate widescale production, processing, delivery, storage and use of clean hydrogen.

Hannah: 2021 was a strong year for hydrogen investment and we expect to see consistent growth through 2022 and beyond. However, the hydrogen economy remains in its very early stages, most investments so far have been relatively small, and we see hydrogen as part of a long-term transition to low-carbon fuels that is going to be realised over the next 30-plus years. A long-term view will therefore be important. The two most significant factors that we think will fuel investment are the cost of green hydrogen production continuing to fall and further government support. We expect both of those things to happen. A desire in Europe to move away from its reliance on Russian oil and gas could further supercharge the desire of governments to incentivise the development of the hydrogen economy that has so far been driven primarily by net-zero goals. It is likely that we will see new support programmes in several countries, including the UK, Germany and the Netherlands in 2022. Overall, we see a bright future for clean hydrogen.

Kerr: In the near term, we predict relatively widespread and fast-paced development of blue hydrogen projects – due to the advantages of scale and using well-established technology, as well as lower production costs. We also expect to see a large number of pilot and small-scale green hydrogen projects, and a small number of green hydrogen mega-projects. In the short term, green hydrogen projects will almost certainly need to be underpinned by long term offtake agreements from creditworthy offtakers but, similar to the evolution of the LNG industry over the last decade, the growth of a larger and more liquid low-carbon hydrogen market should allow a gradual move toward alternative marketing models for projects.

Majumder-Russell: Hydrogen investment will be shaped by the extent to which jurisdictions continue to develop coherent strategies which render low-carbon hydrogen an investable prospect. Those which do this most effectively and combat the specific risks associated with low-carbon hydrogen will likely see the most investment in coming years. As well as national strategies, international cooperation will be needed to fully realise the potential of low-carbon hydrogen. Countries which seek to cooperate with each other will likely also maximise the opportunities that low-carbon hydrogen offers, by matching demand and supply capabilities beyond those which exist within the same national boundaries. Hydrogen, being an energy vector, operates in a global arena which is not immune from geopolitical shifts. As such, the development of projects in Australia and South America for sale to customers in Asia and Europe is, over time, poised to change the traditional trade in oil and its products. The Russian war in Ukraine has also refocused the minds of some countries on energy security and energy independence. As such, the role that hydrogen will play in encouraging and supporting the expansion of renewable generation and managing the electricity grid will be an area to watch. ■

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