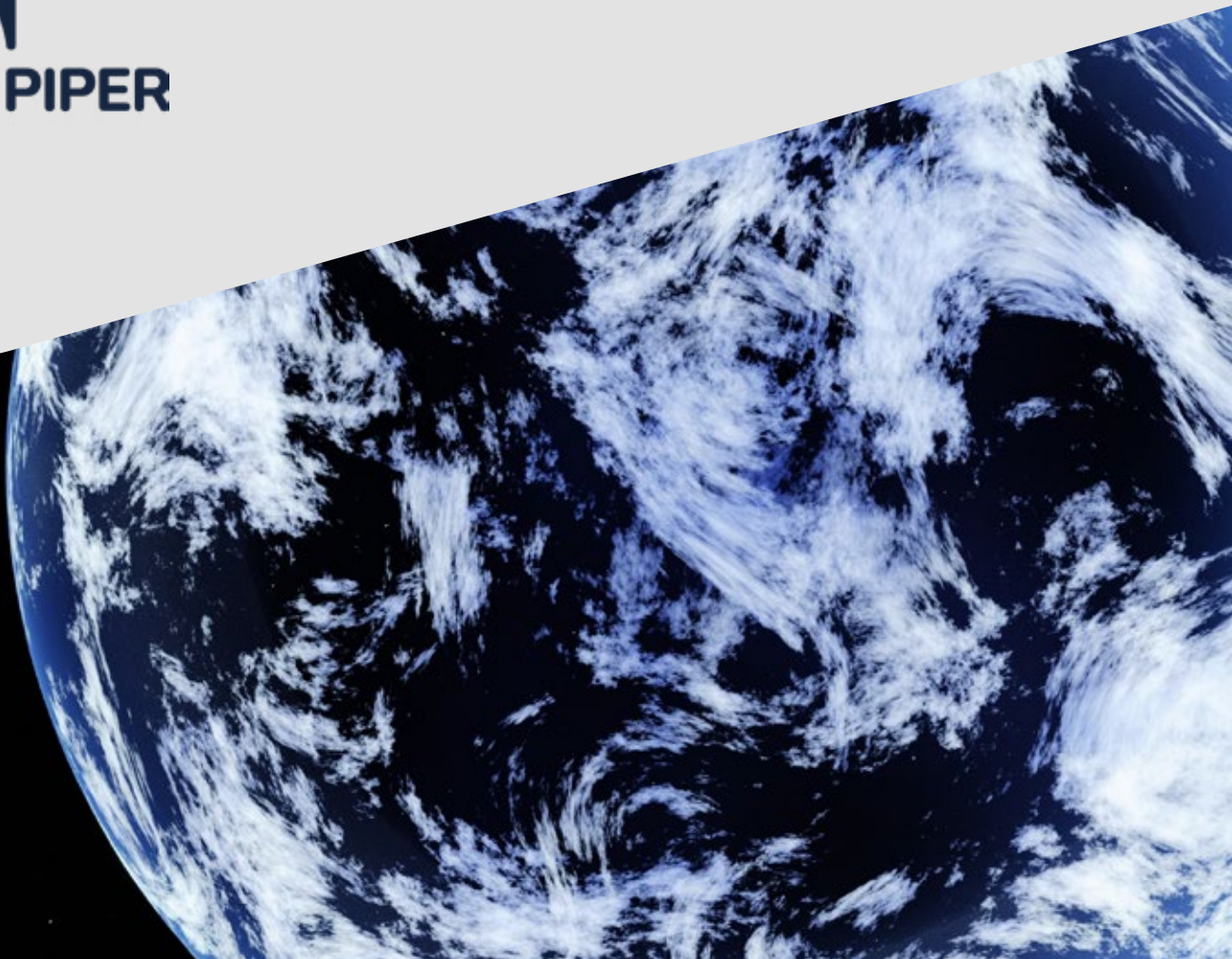




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THE KEYS TO UNLOCKING THE GLOBAL LOW-CARBON HYDROGEN ECONOMY

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INTRODUCTION

Green hydrogen, ammonia and other renewable fuels of non-biological origin look set to play an important role in the transition to a cleaner, lower-carbon economy. Their use could be key in the future global energy mix, with hydrogen playing an essential role as a fuel and feedstock that can help decarbonise entire industries, those that are not suited to electrification.

A diverse group of businesses—including funds, developers, utilities, energy majors and technology companies—are eager to invest in this fast-moving sector, as evidenced by a slew of recent transactions and project announcements.

Notable developments in the clean hydrogen space include NEOM's joint venture with ACWA Power in Saudi Arabia, Engie's Project Yuri hydrogen facility in Western Australia and Iwatani Corp's offtake agreement with SG H2 Energy Global in Southern California.¹

While interest in clean hydrogen is soaring, the nascent stage of the market and the need for scalability means collaboration and strategic partnerships are a necessity for players looking to build up the industry from scratch. This paper, prepared in association with DLA Piper, a global law firm active across the full clean hydrogen value chain, draws on the sessions presented at Reuters Events' Hydrogen 2023 event to provide a snapshot of the challenges and opportunities facing the industry.



A WORLD THAT IS RACING TOWARDS HYDROGEN

RECENT EVENTS HAVE ACCELERATED CLEAN HYDROGEN DEVELOPMENT, MAKING IT IMPERATIVE FOR POTENTIAL INDUSTRY PLAYERS TO EMBRACE OPPORTUNITIES NOW RATHER THAN ADOPTING A WAIT-AND-SEE APPROACH.

Low-carbon hydrogen is poised for take-off amid mounting interest and growing investment worldwide. At the European Commission, which leads Europe's charge towards a hydrogen economy, "a lot has happened" even since the unveiling of a regional strategy in 2020, according to Alexandre Paquot, a director in the Commission's Directorate-General for Climate Action.

"We've had the pandemic, the war in Ukraine, the economic crisis—many were saying this is the end of the Green Deal," he said at Hydrogen 2023. "It's not at all. It's a reconfirmation that we need to have this energy transition, and we need to make it happen even faster."

In response to gas shortages caused by the Ukraine crisis, the Commission's REPowerEU plan is looking to fast-track low-carbon hydrogen use, with a European Union target of 10 million tonnes of production and 10 million tonnes of imports by 2030. Some of the world's largest energy companies and investors are on board.

"We've seen, since the beginning of last year, an acceleration not only towards the development of hydrogen but, as well, ammonia," said Matias Saettone, general manager of hydrogen products at Chevron New Energies.

Meanwhile at Santander Corporate and Investment Banking, which provided 4 billion euros of renewables lending in 2022, "We've been building up our capability around hydrogen," said Bart White, head of energy structured finance in Europe, Middle East and Africa. "We're hiring engineers as opposed to people with a finance background," he noted.

Shell sees early demand arising from three sectors, according to Paul Bogers, vice president of hydrogen at the oil major. The first is the current hydrogen industry, where up to 95 million tonnes of the gas is used each year as a feedstock for fertilisers and industrial chemicals. The second is steelmaking, where direct reduction of iron, using hydrogen, is seen as an optimal decarbonisation pathway. Finally, Bogers said, Shell sees demand from heavy road transport.

Currently, he said, "It is all about connecting demand to the emerging hydrogen supply system."



HYDROGEN IN HARD-TO-ABATE SECTORS: ROAD TRANSPORT

COLLABORATION AND PARTNERSHIPS ARE LIKELY TO BE VITAL FOR HYDROGEN ADOPTION IN ROAD TRANSPORTATION FOR AT LEAST THE NEXT HALF DECADE. THE POTENTIAL FOR INNOVATION AND RISK SHARING THAT THIS CREATES WILL BE KEY IN HELPING HYDROGEN TO SCALE, ALTHOUGH IT IS LIKELY THERE WILL ALSO BE A CONTINUED NEED FOR PUBLIC SECTOR SUPPORT.

While the efficiency of electrification means batteries are likely to be the low-carbon power source of choice for passenger cars, heavy goods vehicles may end up using hydrogen as a fuel because of the longer range it allows. However, European fleet owners are finding it hard to adopt hydrogen because of a lack of short-term availability of vehicles, servicing networks and fuelling infrastructure in public space, says Sylvia Ebersberger, partner and global co-chair of the automotive sector at DLA Piper.

“What we are seeing is there is a strong need for partnership,” she says. “There is not much transparency on available components and know-how on the market, and no broad interface and integration expertise. At this point, the market will only be successful if players collaborate and share insights.”

The need for collaboration has led to hydrogen and fuel-cell industry intermediation platforms such as Hyfindr, which make it easier for ecosystem players to find each other and strike up partnerships.



HYDROGEN IN HARD-TO-ABATE SECTORS: AVIATION

ELECTRIFICATION CANNOT DECARBONISE AVIATION ALONE, SO HYDROGEN WILL ALMOST CERTAINLY PLAY A MAJOR ROLE IN HELPING AIR TRANSPORT MOVE TO NET-ZERO EMISSIONS. WHILE AIRCRAFT MAKERS ARE PREPARING A NEW GENERATION OF HYDROGEN-READY DESIGNS, MUCH STILL NEEDS TO BE DONE ON THE INFRASTRUCTURE AND PRICING OF THE FUEL.

Hydrogen is increasingly being viewed as a decarbonisation tool by aviation. “Last year, our Fly Zero report looked at the potential for zero-emissions aircraft, considering electrification, ammonia and hydrogen,” said Adam Morton, head of technology at the Aerospace Technology Institute in the UK.

“It concluded that the leading three concepts were all liquid hydrogen concepts either utilised in gas turbines or PEM [proton exchange membrane] fuel cells,” he added. “In aviation, we feel that liquid hydrogen is essential.”

While aircraft can use sustainable aviation fuels (SAFs) made from organic matter, hydrogen—or more generally the power-to-liquids—is likely to make up 50% of the SAF market from around the mid 2030s, he said. Using liquid hydrogen directly as an aviation fuel could reduce contrail formation and the release of non-carbon pollutants, he claimed.

Arnab Chatterjee, vice president of infrastructure at the hydrogen-electric-engine developer ZeroAvia, said historically, “There has been little imperative to move liquefaction technology from either space or from labs to something that is in the civil environment.”

There is now “incentive and opportunity to move quickly,” he said.

Tony Payne, partner and co-chair of the aviation sector at DLA Piper notes that while some bodies, such as the Civil Aviation Authority, support moves to reduce emissions, the industry still has a long way to go in building relevant skills sets and investments needed for scale.

In addition, “Certification bodies need to be on board from the beginning,” he says. “Manufacturers have a responsibility to involve them—this is a crucial area of collaboration.”

HYDROGEN IN HARD-TO-ABATE SECTORS: SHIPPING

THERE IS CONSIDERABLE SCOPE FOR HYDROGEN GROWTH IN SHIPPING AND THE WINNERS IN THIS MARKET WILL BE DETERMINED BY GEOGRAPHY. PLAYERS IN JURISDICTIONS WITH THE BEST OPPORTUNITIES TO INVEST IN AND PRODUCE LOW-COST HYDROGEN-BASED FUELS, PARTICULARLY IF GOVERNMENT SUPPORT IS AVAILABLE, WILL HAVE A DISTINCT ADVANTAGE.

Like road transport and aviation, shipping cannot rely on electrification for long-distance journeys and so requires low-carbon molecular fuels to reduce emissions. Clean hydrogen could play a major role as a precursor for these fuels or as the fuel itself, experts believe. The shipping industry is seeking low-carbon alternatives to bunker fuel but is unlikely to adopt low-carbon hydrogen directly for ship propulsion because the gas would need to be stored at low temperatures and high pressures, which could pose a security risk on vessels.

Instead, hydrogen will likely be used as a precursor for ammonia, methanol or similar alternative fuels. None of these can be produced at the scale required to power the entire shipping industry, so there will likely be a mix of engine and fuel types in future.

This will require fleet owners to create new partnerships with a range of fuel suppliers and distributors.



HYDROGEN IN HARD-TO-ABATE SECTORS: HEAVY INDUSTRY

HEAVY INDUSTRIES FACE GROWING STAKEHOLDER PRESSURE TO DECARBONISE THEIR OPERATIONS AND HYDROGEN IS A KEY TOOL IN MANY SECTORIAL NET-ZERO PATHWAYS, BUT AS IN OTHER AREAS IT WILL BE ESSENTIAL FOR COMPANIES TO FORGE PARTNERSHIPS FOR THE DEVELOPMENT OF EARLY HUBS.

Besides transportation, one of the biggest emerging markets for clean hydrogen is expected to be heavy industry. Industrial processes such as steelmaking, which alone accounts for about 8% of global emissions, are heavily reliant on fossil fuels, and there is interest in using hydrogen as a fuel and feedstock replacement en route to decarbonisation.

Companies such as H2 Green Steel are already working on European steelworks powered with hydrogen.

“We are using green hydrogen to take out about 95% of the CO2 emissions from producing steel,” said Kajsa Rytberg-Wallgren, executive vice president and head of H2 Green Steel’s hydrogen business unit. “We do that by replacing coal in the iron-making process. Instead of having a blast furnace, we use direct reduction, and instead of using natural gas for it, we use pure hydrogen. That hydrogen is produced through about 800 MW of electrolysis that we will build and operate ourselves.”



FINANCING HYDROGEN AND SECURING OFFTAKE AGREEMENTS

EARLY HYDROGEN SCHEMES ARE EXPECTED TO RELY ON GOVERNMENT SUPPORT BUT INDUSTRIAL PLAYERS MUST LOOK FOR COLLABORATIONS THAT CAN HELP REDUCE THE COST OF PRODUCTION SO IT CAN BE VIABLE WITHOUT SUBSIDIES.

The key to securing finance in these early stages of clean hydrogen commercialisation is being able to secure customers for versions of the gas that remain more expensive than traditional supplies. By 2050, experts hope clean hydrogen will become a tradeable commodity like other fuels.

Today, “we have poor deliverability options,” said Rhys Vigna, energy transition partner at PA Consulting. “The market is regionally bound,” he said. “We have localised, over-the-counter contracts that trade with high price disparity. We’ve got proxy pricing models linked to natural gas. We have blind transacting, so we don’t have a great viewpoint of what

contracts and transactions are going on around the world. And we have heterogenized quality.”

In non-exchange markets, where traditional or grey hydrogen is traded, there is effective deliverability, index benchmarking, recognised physical product specification and active physical trading, with little regionality. Exchange market trading, which is used today for commodities such as gas, includes features such as exchange-traded derivatives and arbitrable markets.

Such markets seem a long way off for clean hydrogen, and a lack of customers is stopping projects from reaching a final investment decision—“at least, not enough, not fast enough,” said Tarek Helmi, future of energy and global hydrogen lead at the consulting firm Deloitte. “The hydrogen market will be developing point to point, supply and demand, and they have to go together. They have to synchronise investments and synchronise how hydrogen is produced.”

To improve the viability of contracts, clean hydrogen customers must be able to pass on the higher cost of the gas compared to traditional sources, said Thomas Malango, director of hydrogen, renewable fuels and circular economy at Repsol. In the ammonia industry, for example, “Green fertiliser has a very small impact on the overhead cost of the product but a huge impact on CO2 reduction,” he said.

SCALING UP PRODUCTION

EXPERTS BELIEVE EUROPEAN CERTIFICATION WILL DETERMINE WHAT GREEN HYDROGEN IS FOR OTHER MARKETS, ESPECIALLY THOSE EXPORTING TO EUROPE. HOWEVER, THE EUROPEAN UNION'S WORK ON CERTIFICATION SO FAR IS CONSIDERED OVERLY COMPLEX COMPARED TO THAT BEING ADOPTED IN THE UNITED STATES.

As demand for clean hydrogen supplies begins to mount, a key issue for the industry will be how to scale to the industrial levels needed to replace traditional 'grey' supplies and sustain hard-to-abate sectors in a decarbonised world. "Today, we have to start building the infrastructure and start creating hubs in order to get this hydrogen economy working," said Hyung de Zeeuw, executive director and senior energy transition specialist at Rabobank.

Hubs—locations where clean hydrogen is produced and consumed at the same time—are seen as vital for the early development of the industry as they will minimise the need for costly storage and transport infrastructure. In the United States, Mitsubishi Power Americas is building a 220-megawatt (MW) green hydrogen project that can produce 100 tonnes a day.

"We've since become very much integrated, with hydrogen hubs being set up through the Americas region and specifically in the United States," said Jason Bargender, Mitsubishi Power America's vice president of commercial strategy.

The scale of production being envisaged in the industry will require multi-gigawatt (GW) levels of electrolyser capacity, up from the megawatt levels seen today. Companies such as refinery operator Neste are carrying out large-scale feasibility studies with green hydrogen. Neste hopes its Porvoo site in Finland could become Europe's most sustainable refinery by 2030, said Heidi Bergman, head of renewable hydrogen investment projects at the company.

The company is also looking at green hydrogen production in its Rotterdam and Singapore facilities. Its Rotterdam project will feature the world's largest solid oxide electrolyzer cell array, at 2.6 MW. The Spanish oil company Cepsa, meanwhile, is aiming to have 2 GW of green hydrogen electrolysis capacity operating by 2030. "We're fully relying on hydrogen to support our growth," said Ana Maria Vidaurre, Cepsa's head of hydrogen project structuring.

Scaling hydrogen production will be helped by certification schemes, said Daria Nochevnik, director of policy and partnerships at the Hydrogen Council, an industry body. "There is a lack of clarity of the concepts we use in that space," she said.

DLA Piper partner Andreas Gunst says certification must address two linked issues.

"There's the question of the electricity going into electrolysis and the temporal, regulatory boundary and other conditions for treating it—under the legal fiction the certificates create—as fully renewable despite a different grid average emissions factor of the electricity actually consumed by the electrolyser," he says.

"Then there's how you prove, through certificates or a chain of custody or mass balance approach, that renewable hydrogen produced this way is still accepted as renewable at the point of consumption, despite commingling or conversion. The more flexible the conditions for the electricity certificates, the less it makes sense to heavily regulate conditions for mass balance or chain of custody in addition to hydrogen certificates, as you have already accepted the use of a legal fiction associated with book and claim for the creation of the renewable hydrogen."

INFRASTRUCTURE FOR STORING AND TRANSPORTING HYDROGEN

WHILE EARLY CLEAN HYDROGEN PROJECTS WILL LIKELY AIM TO CO-LOCATE PRODUCTION WITH CONSUMPTION, OVER TIME IT WILL BE NECESSARY TO STORE AND TRANSPORT THE GAS FROM GENERATION TO DEMAND CENTRES. THIS IS CHALLENGING BECAUSE EXISTING NATURAL GAS PIPELINES ARE NOT ALL SUITABLE FOR HYDROGEN TRANSPORT.

Companies such as Italian grid operator Snam are looking at how infrastructure can be adapted to create a European hydrogen backbone spanning 2,200 km, possibly extending as far as North Africa where renewable resources could support lowest-cost production.

“Our vision is that hydrogen will be produced in massive amounts and then transported via pipeline to be cost effective,” said Giovanna Pozzi, Snam’s head of decarbonisation analysis and design. “The hard thing is to pull together all the different operators along the entire value chain.”

Hydrogen pipelines will be particularly important in powering Europe’s industrial heartland, in Germany.

“When you look at the European hydrogen backbone, all pipelines do sort of end up in Germany,” said Niko Bosnjak, head of energy policy at German gas pipeline grid operator Open Grid Europe (OGE). “We, as OGE, Germany’s largest transmission system operator, absolutely believe there’s enough demand. Most of the studies are pointing towards 600 terawatt-hours, 700 terawatt-hours in the 2040s. In our company we believe it’s going to be a lot more.”



THE AMMONIA OPPORTUNITY

AS WITH HYDROGEN, A CLEAR CERTIFICATION SCHEME IS NEEDED FOR LOW-CARBON AMMONIA—ALTHOUGH EUROPE'S PROPOSALS ARE SEEN AS BEING TOO COMPLICATED FOR COMPANIES SETTING UP PLANTS TODAY.

While clean hydrogen may well end up being used in its gaseous or liquid form for industrial processes and aviation, there are several applications where it will need to be combined with nitrogen to form ammonia. Foremost among these is fertiliser production, which is the biggest consumer of ammonia today. "Agriculture is responsible for over 8% of greenhouse gas emissions," said Tim Hard, senior vice president of energy transition at information provider Argus Media.

He went on to say that within agriculture, ammonia is responsible for around 1.5% of global energy system emissions. Tackling these is obviously key, he stated.

Iain Elder, a partner at DLA Piper, said at Hydrogen 2023: "There's already about 200 million tonnes of grey ammonia

produced in the world every year. It's the second-largest commodity chemical produced in the world, but it uses about 2% of global energy in its production and produces about half a billion tonnes of CO₂ emissions every year. Of the 200 million tonnes, only about 20 million tonnes are traded globally."

"We have identified four energy carriers that may at some point in time scale to a volume at which they will become relevant on a global scale," said Torben Norgaard, chief technology officer for energy and fuels at the Mærsk McKinney Møller Center for Zero Carbon Shipping. "Also, during the transition, they will most likely be available at a cost that is competitive, not to fossil-based fuels but to other alternative low-emission fuels. Those are bio-oils, methane, methanol and ammonia."

The magnitude of fuel requirements in shipping is such that none of these alternative fuels is likely to corner the market, Norgaard said. "We need to activate all of them, and they need to operate in parallel," he added.

As well as being used as a fuel, ammonia production is likely to benefit from ammonia's potential as a hydrogen carrier. "Nitrogen is a very good wrapper for hydrogen transport," said Alicia Eastman, president of project developer Intercontinental Energy. "It's kind of a no-brainer to make ammonia instead of hydrogen because it can be used as ammonia, and it can also be used as a carrier."



OUTLOOK AND CONCLUSIONS

Hydrogen 2023 showcased immense enthusiasm for low-carbon hydrogen but also evidenced the work that still needs to be done to drive the industry to maturity. In these early stages of market development, the importance of collaboration and partnership cannot be overestimated since no single player has the experience and capabilities needed to act as a vertically integrated provider.

Another vitally important task is to advance certification schemes that can deliver certainty to the market while

retaining enough flexibility to encourage growth. On this front, it will be important for industry to engage with policymakers in Europe and elsewhere, pushing for appropriate certification schemes and raising awareness of the challenges that overly complex regulations might create.

DLA Piper stands ready to assist with these tasks. To find out more, visit www.dlapiper.com/en-gb/capabilities/industry/energy-and-natural-resources/hydrogen.

REFERENCES

- ¹ DLA Piper, 2023: Hydrogen. Available at <https://www.dlapiper.com/en-gb/capabilities/industry/energy-and-natural-resources/hydrogen>.

