

# Green hydrogen is finally showing its true colours



**Benjamin Kelly**  
Senior Analyst,  
Global Research



**Heiko Schupp**  
Global Head of  
Infrastructure

**There continues to be a remarkable focus on green hydrogen as a clean alternative to traditional fossil fuels, with the past year further accelerating its potential widespread adoption. So, what is driving all this hype, is hydrogen the sustainability disruptor, and why has there been such remarkable recent progress?**

## What and how?

Hydrogen is the most abundant molecule in the universe, found primarily locked in water and hydrocarbons. Its qualities have been known for a long time, and it has been used for more than 100 years as an industrial chemical. While the concept of hydrogen as a source of energy isn't novel, it has never been feasible on a large scale – until now.

Hydrogen is a colourless gas, but it is categorised by colour, each representing a different production pathway. Grey hydrogen is generated via the use of fossil fuels, so its production emits CO<sub>2</sub>. Blue hydrogen is grey hydrogen paired with carbon capture and storage that covers the majority of carbon emissions produced in its generation. Green hydrogen, meanwhile, is produced by the electrolysis of water, splitting it into hydrogen and oxygen, and as long as renewable energy is used it is a zero-emission energy source. Thus, if created at scale green hydrogen has the potential to become key in decarbonising hard-to-abate sectors of the economy.

## Catalysts for uptake

For hydrogen to become a viable solution, both greater demand and reduced costs are required. But we are now seeing movement on three key drivers. Firstly, climate change is accelerating. This feeds directly into a second key driver – policy support for the need to do something about it (Figure 1). Since the Paris Agreement in 2015 governments have turned their attentions to climate

change and committed themselves to achieving emissions reduction targets that could lead to carbon neutrality by 2050. The Covid-19 pandemic has only accelerated the urgency surrounding these policies. As policymakers look for ways of cutting emissions, hydrogen technology could be a feasible alternative. Excitingly, the Hydrogen Council suggests hydrogen could reduce global emissions by 6 gigatons – or 17% of global 2020 emissions – by 2050.<sup>1</sup> Currently, around 66 countries have net-zero emissions targets, of which around 20 have unveiled hydrogen roadmaps. We expect more to follow.

The third key driver is that green hydrogen prices have fallen dramatically in the past 10 years due to efficiency improvements. The renewable energy used in electrolysis accounts for about 70% of the cost of producing hydrogen and has fallen in price by approximately 70% in the past decade.<sup>2</sup> Additionally, the price of an electrolyser has declined by about 60% in that time.<sup>3</sup> It is reasonable to expect these price falls will continue, adding to the appeal of green hydrogen. →

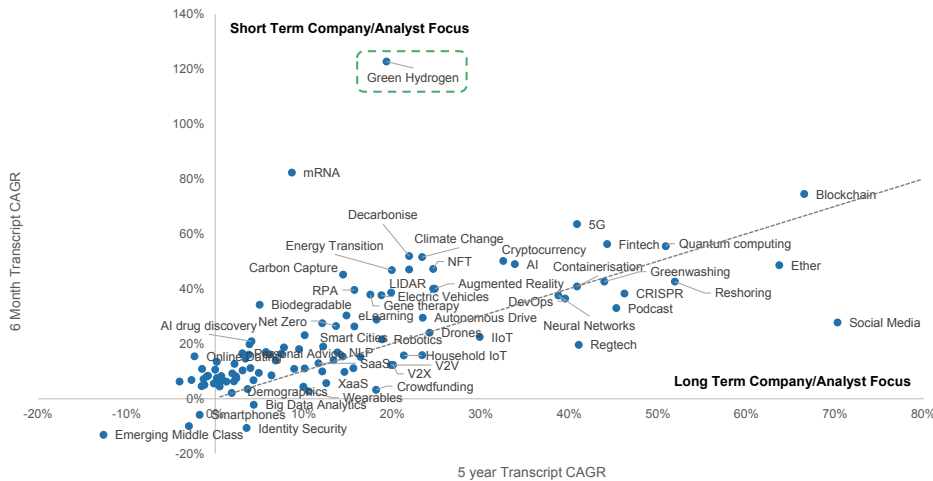
**Figure 1: Governments with national hydrogen strategies; announced targets; priorities for hydrogen and use; and committed funding**

Country and public investment committed	Document, year	Deployment targets (2030)	Production	Uses
<b>Australia</b> AUD 1.3 bln (~USD 0.9 bln)	National Hydrogen Strategy, 2019	None specified	Coal with carbon capture, utilisation, and storage (CCUS) Electrolysis (renewable) Natural gas with CCUS	
<b>Canada</b> CAD 25 mln by 2026 <sup>(1)</sup> (~USD 19 mln)	Hydrogen Strategy for Canada, 2020	Total use: 4 Mt H <sub>2</sub> /y 6.2% TFEC	Biomass By-product H <sub>2</sub> Electrolysis Natural gas with CCUS Oil with CCUS	
<b>Chile</b> USD 50 mln for 2021	National Green Hydrogen Strategy, 2020	25 GW electrolysis <sup>(2)</sup>	Electrolysis (renewable)	
<b>Czech Republic</b> n.a.	Hydrogen Strategy, 2021	Low-carbon demand: 97 kt H <sub>2</sub> /yr	Electrolysis	

Country and public investment committed	Document, year	Deployment targets (2030)	Production	Uses
<b>European Union</b> EUR 3.77 bln by 2030 (~USD 4.3 bln)	EU Hydrogen Strategy, 2020	40 GW electrolysis	Electrolysis (renewable) Transitional role of natural gas with CCUS	
<b>France</b> EUR 7.2 bln by 2030 (~USD 8.2 bln)	Hydrogen Deployment Plan, 2018 National Strategy for Decarbonised Hydrogen Development, 2020	6.5 GW electrolysis 20-40% industrial H <sub>2</sub> decarbonised <sup>(3)</sup> 20 000-50 000 FC LDVs <sup>(3)</sup> 800-2 000 FC HDVs <sup>(3)</sup> 400-1 000 HRSS <sup>(3)</sup>	Electrolysis	
<b>Germany</b> EUR 9 bln by 2030 (~USD 10.3 bln)	National Hydrogen Strategy, 2020	5 GW electrolysis	Electrolysis (renewable)	
<b>Hungary</b> n.a.	National Hydrogen Strategy, 2021	Production: 20 kt/yr of low-carbon H <sub>2</sub> 16 kt/yr of carbon-free H <sub>2</sub> 240 MW electrolysis Use: 34 kt/yr of low-carbon H <sub>2</sub> 4 800 FCEVs 20 HRSS	Electrolysis Fossil fuels with CCUS	
<b>Japan</b> JPY 699.6 bln by 2030 (~USD 6.5 bln)	Strategic Roadmap for Hydrogen and Fuel Cells, 2019 Green Growth Strategy, 2020, 2021 (revised)	Total use: 3 Mt H <sub>2</sub> /yr Supply: 420 kt low-carbon H <sub>2</sub> 800 000 FCEVs 1 200 FC buses 10 000 FC forklifts 900 HRSS 3 Mt NH <sub>3</sub> fuel demand <sup>(4)</sup>	Electrolysis Fossil fuels with CCUS	
<b>Korea</b> KRW 2.6 tln in 2020 (~USD 2.2 bln)	Hydrogen Economy Roadmap, 2019	Total use: 1.94 Mt H <sub>2</sub> /yr 2.9 million FC cars (plus 3.3 million exported) <sup>(5)</sup> 1 200 HRSS <sup>(5)</sup> 80 000 FC taxis <sup>(5)</sup> 40 000 FC buses <sup>(5)</sup> 30 000 FC trucks <sup>(5)</sup> 8 GW stationary FCs (plus 7 GW exported) <sup>(5)</sup> 2.1 GW of micro-cogeneration FCs <sup>(5)</sup>	By-product H <sub>2</sub> Electrolysis Natural gas with CCUS	
<b>Netherlands</b> EUR 70 mln/yr (~USD 80 mln/yr)	National Climate Agreement, 2019 Government Strategy on Hydrogen, 2020	3-4 GW electrolysis 300 000 FC cars 3 000 FC HDVs <sup>(6)</sup>	Electrolysis (renewables) Natural gas with CCUS	
<b>Norway</b> NOK 200 mln for 2021 (~USD 21 mln)	Government Hydrogen Strategy, 2020 Hydrogen Roadmap, 2021	n.a. <sup>(7)</sup>	Electrolysis (renewables) Natural gas with CCUS	
<b>Portugal</b> EUR 900 mln by 2030 (~USD 1.0 bln)	National Hydrogen Strategy, 2020	2-2.5 GW electrolysis 1.5-2% TFEC 1-5% TFEC in road transport 2-5% TFEC in industry 10-15 vol% H <sub>2</sub> in gas grid 3-5% TFEC in maritime transport 50-100 HRS	Electrolysis (renewables)	
<b>Russia</b> n.a.	Hydrogen roadmap 2020	Exports: 2 Mt H <sub>2</sub>	Electrolysis Natural gas with CCUS	
<b>Spain</b> EUR 1.6 bln (~USD 1.8 bln)	National Hydrogen Roadmap, 2020	4 GW electrolysis 25% industrial H <sub>2</sub> decarbonised 5 000-7 500 FC LDVs-HDVs 150-200 FC buses 100-150 HRSS	Electrolysis (renewables)	
<b>United Kingdom</b> GBP 1 bln (~USD 1.3 bln)	UK Hydrogen Strategy, 2021	5 GW low-carbon production capacity	Natural gas with CCUS Electrolysis	



Figure 2: Company and analyst transcript mentions



Source: MS Sept 2021.

## What has changed in the past 12 months?

While discussion around green hydrogen has seen steady growth, there have been disproportionate levels of debate over the past six and 12 months (Figure 2), far exceeding any other topic including 5G, Blockchain and AI.<sup>4</sup> So why the surge of interest?

First and foremost, there is continuing momentum in a number of factors that have been key catalysts for increased uptake over the past decade. Regarding efficiency and costs, 2021 projections suggest reductions in the hydrogen cost curve, while manufacturing scale should support a rapid pick up in adoption from 2030 onwards in many different industries ranging from chemicals to trucking fuel cells.<sup>5</sup> A recently revised forecast by Bloomberg puts green hydrogen costs 13% lower than previously suggested by 2030.<sup>6</sup> With prices of carbon at high rates globally, and at recent all-time highs within the EU,<sup>7</sup> hydrogen's potential as a significant decarbonisation solution has never had as much commercial viability.

The emergence of multiple exciting hydrogen projects over the past 12 months have been influential in these reduced estimates of cost and efficiency improvements. Between December 2020 and August 2021 alone, the number of green hydrogen projects increased more than three-fold,<sup>8</sup> with 359 large-scale projects announced globally. Europe is leading the way with investments of \$130 billion, but other regions are catching up. China is also emerging

as a potential hydrogen giant with more than 50 projects in the pipeline following its announcement of net-zero emissions by 2060.<sup>9</sup>

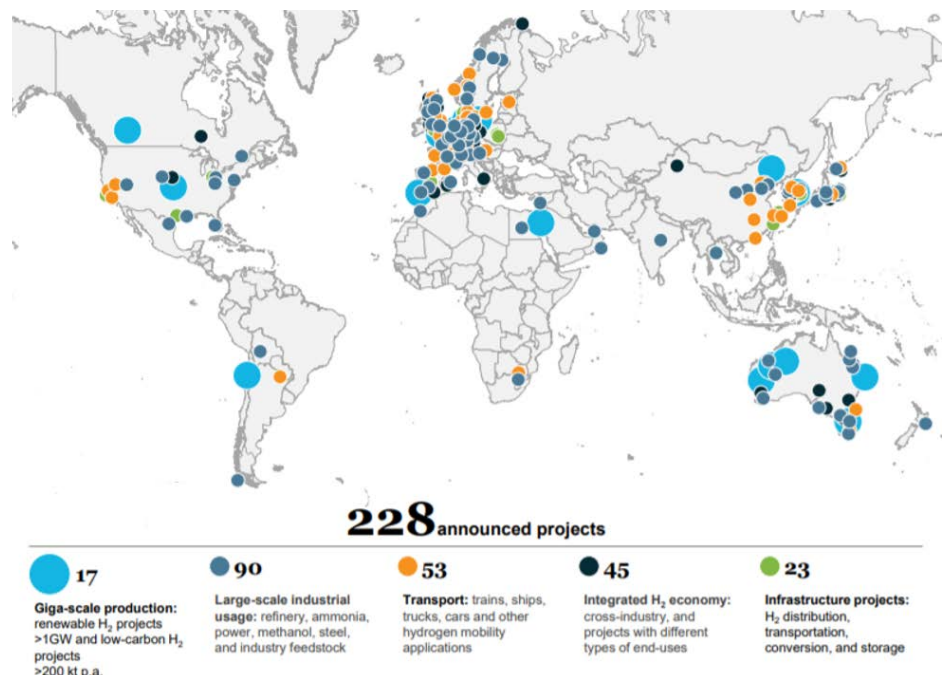
A major cost development came to light in the Q3 2021 report of NEL, the world's largest electrolyser producer. It had been widely expected that the cost of green hydrogen would be less than \$2/kg by 2030.<sup>10</sup> But costs are falling rapidly and NEL now has a green hydrogen cost target of \$1.50/kg by 2025. This illustrates the pace of innovation within green hydrogen and continued decline in the cost of renewables globally.

Arguably the most influential element in the progress of green hydrogen production as a sustainability disruptor is government support. Simply put, governments across the world need a plan for life after fossil fuels, and their ability to create policies and regulations to support green hydrogen both financially and in terms of infrastructure could prove vital in its viability. It is one thing producing green hydrogen at a cost of \$1.50/kg, but for uptake to be aligned with net-zero targets it needs to be delivered to the end customer at a price that is competitive with fossil fuels. Infrastructure is needed to facilitate this process.

In the past year, the Chinese government has made \$20 billion of public funding available for hydrogen projects. So far, 50% of its announced projects are linked to transport applications, a key sector in its energy transition plan.<sup>11</sup> Meanwhile, the US has renewed its net-zero commitment by re-entering the Paris Agreement following President Biden's inauguration.<sup>12</sup>

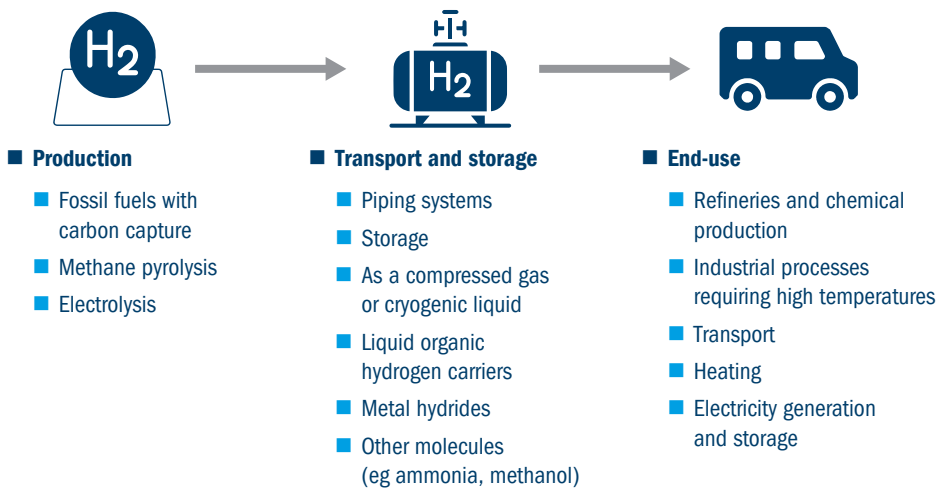
In August 2021, the UK government set its sights on developing a thriving green carbon sector to overcome the decarbonisation challenges facing its economy, in the form of the UK Hydrogen Strategy. Its ambition is to build 5GW of low carbon hydrogen production capacity by 2030. This could produce hydrogen equivalent to the amount of gas consumed by more than three million households

Figure 3: Private equity, infrastructure and hydrogen



Source: Morgan Stanley – The Hydrogen Handbook. The Hydrogen Council.

Figure 4: Identifying infrastructure investments across the hydrogen value chain



Source: Arup Hydrogen.

in the UK each year.<sup>13</sup> The UK Hydrogen Strategy is all encompassing and takes a holistic approach to developing a thriving hydrogen sector. It sets out what needs to happen to enable the production, distribution, storage and use of hydrogen, and to secure economic opportunities across the UK.<sup>14</sup>

We are beginning to see an emergence of companies specialising in the production, distribution and usage of Hydrogen. Globally there are 228 ongoing hydrogen projects across the value chain (Figure 3), 17 of which are giga-scale production schemes. Two notable recent acquisitions

are of the Canadian electrolyser company Hydrogenics for \$290 million<sup>15</sup> by power firm Cummins, and MAN Energy Solutions' majority share in German-based electrolyser manufacturer H-TEC Systems for an undisclosed fee.<sup>16</sup>

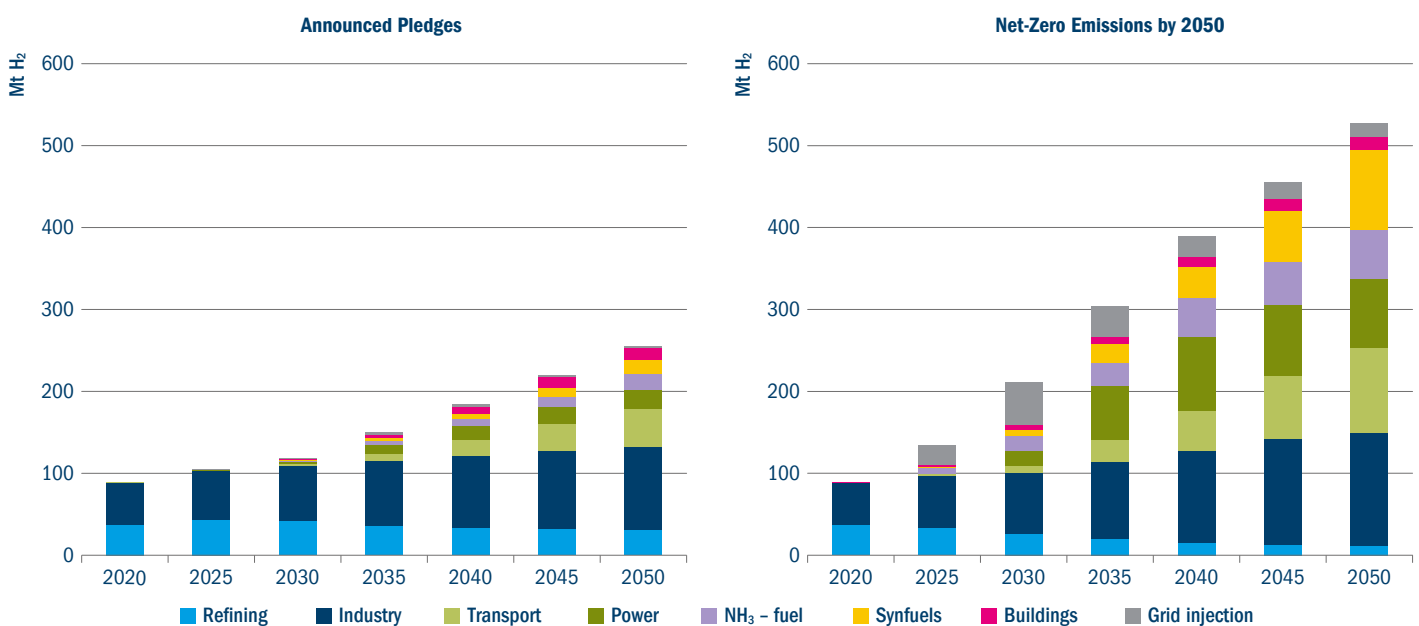
Interestingly, we are also seeing investment in riskier early-stage hydrogen start-ups focused on the non-electrolysis production of hydrogen. The funding of such project development and integration services could be indicative of a maturing sector.<sup>17</sup> The Hydrogen Council estimates total investment in the hydrogen value chain could exceed

\$300 billion by 2030 and, according to the Energy Transitions Commission, reach approximately \$15 trillion by 2050.<sup>18</sup> This demonstrates both the requirement of, and opportunity for, private investment within the chain (Figure 4).

While there are multiple barriers for the uptake of hydrogen within the mainstream – from cost to efficiency – we believe there are two main ones. The first is current limited demand. While from a production perspective policy support is expanding, technology is improving and cost is going down, there is still a limited actual demand for the molecule. Net-zero pledges could however bolster demand (Figure 5). Further infrastructure development will be a critical determinant as to whether green hydrogen becomes the panacea of decarbonisation.

Second is the underappreciation of hydrogen within society. There has been a stigma surrounding its use as a fuel ever since the Hindenberg disaster in 1937. Consumers and investors must be made aware of the promise and safety of hydrogen before it enters the mainstream. We believe asset managers are becoming increasingly aware of its potential and are attempting to educate their investors. We hope the public can be educated in much the same way. We believe there is a huge opportunity for the infrastructure sector in all of this: without infrastructure projects, there will be no mainstream consumption of hydrogen.

Figure 5: Hydrogen demand in the IEA's Announced Pledges and Net-Zero Emissions scenarios



Source: IEA: 2021 Hydrogen Review.

## Conclusion

The opportunity for green hydrogen to disrupt the sustainable energy industry cannot be denied – from increasing technological improvements to scalability and policy support, the past 12 months have witnessed huge advancements – and the pace at which it could do so must not be underestimated. On a walk down New York's Fifth Avenue in 1900 you would likely have seen 1,000 horses and one automobile. Just a decade or so later it's likely the opposite was the case. In 1900 the car was inefficient, unreliable and expensive versus the

horse, but the long-term opportunity was salient. Perhaps a decade from now we will be questioning why there was ever a debate about hydrogen.

Lack of demand is currently the main barrier for the mainstream consumption of hydrogen. While policy support is growing exponentially, it is not close to the level needed to achieve net-zero energy system emissions by 2050.

A mixture of such support, through incentivisation mechanisms for the utilisation of hydrogen and development of infrastructure, will be vital. Signs of

growing investment in the latter are positive. However, to retain this momentum policy will need to focus not just on reducing costs but on creating supporting infrastructure to ensure demand. Policy support is strong, as illustrated in Figure 1, but there is scope for more, especially as countries outline their net-zero goals. The recent rise in energy prices may fast-track policies in the next 12 months. Post-COP26 we should have better insights around policy support, and we may be able to identify prominent, fruitful infrastructure opportunities.

<sup>1</sup> Morgan Stanley Research: The Hydrogen Handbook.

<sup>2</sup> Kepler Cheuvreux, All About Hydrogen, September 2020/Goldman Sachs, Carbonomics, The rise of clean hydrogen, July 2020.

<sup>3</sup> BNEF, Hydrogen Economy Outlook, March 2020.

<sup>4</sup> Morgan Stanley Research: The Hydrogen Handbook.

<sup>5</sup> Morgan Stanley Research: The Hydrogen Handbook.

<sup>6</sup> Fuel Cell Works – <https://fuelcellworks.com/news/green-hydrogen-is-on-track-to-be-cheaper-than-natural-gas-by-2050-bnef/>

<sup>7</sup> SP Global – <https://www.spglobal.com/platts/en/market-insights/latest-news/energy-transition/082721-eu-carbon-prices-power-up-to-new-all-time-high>

<sup>8</sup> Statista – <https://www.statista.com/statistics/1011849/largest-planned-green-hydrogen-projects-worldwide/>

<sup>9</sup> Hydrogen Insight Updates July 2021 – <https://hydrogencouncil.com/en/hydrogen-insights-updates-july2021/>

<sup>10</sup> Green hydrogen will be cost-competitive with grey H2 by 2030 – without a carbon price' – Recharge News.

<sup>11</sup> Hydrogen Council – Updates July.

<sup>12</sup> <https://www.state.gov/the-united-states-officially-rejoins-the-paris-agreement/>

<sup>13</sup> UK Hydrogen Strategy – [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1011283/UK-Hydrogen-Strategy\\_web.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf)

<sup>14</sup> UK Hydrogen Strategy – [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1011283/UK-Hydrogen-Strategy\\_web.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf)

<sup>15</sup> Cummins closes on its acquisition of Hydrogenics <https://www.cummins.com/news/releases/2019/09/09/cummins-closes-its-acquisition-hydrogenics>

<sup>16</sup> MAN Energy Solutions is replacing GP JOULE as the main owner of H-TEC SYSTEMS – <https://www.man-es.com/company/press-releases/press-details/2021/06/16/man-energy-solutions-is-replacing-gp-joule-as-the-main-owner-of-h-tec-systems>

<sup>17</sup> Global Hydrogen Review 2021.

<sup>18</sup> Catalysing hydrogen investment – ARUP.

To find out more visit  
**COLUMBIATHREADNEEDLE.COM**



**Important Information: For use by professional clients and/or equivalent investor types in your jurisdiction (not to be used with or passed on to retail clients). This is an advertising document.** This document is intended for informational purposes only and should not be considered representative of any particular investment. This should not be considered an offer or solicitation to buy or sell any securities or other financial instruments, or to provide investment advice or services. **Investing involves risk including the risk of loss of principal. Your capital is at risk.** Market risk may affect a single issuer, sector of the economy, industry or the market as a whole. The value of investments is not guaranteed, and therefore an investor may not get back the amount invested. **International investing** involves certain risks and volatility due to potential political, economic or currency fluctuations and different financial and accounting standards. **The securities included herein are for illustrative purposes only, subject to change and should not be construed as a recommendation to buy or sell. Securities discussed may or may not prove profitable.** The views expressed are as of the date given, may change as market or other conditions change and may differ from views expressed by other Columbia Threadneedle Investments (Columbia Threadneedle) associates or affiliates. Actual investments or investment decisions made by Columbia Threadneedle and its affiliates, whether for its own account or on behalf of clients, may not necessarily reflect the views expressed. This information is not intended to provide investment advice and does not take into consideration individual investor circumstances. Investment decisions should always be made based on an investor's specific financial needs, objectives, goals, time horizon and risk tolerance. Asset classes described may not be suitable for all investors. **Past performance does not guarantee future results, and no forecast should be considered a guarantee either.** Information and opinions provided by third parties have been obtained from sources believed to be reliable, but accuracy and completeness cannot be guaranteed. This document and its contents have not been reviewed by any regulatory authority.

**In the UK:** Issued by Threadneedle Asset Management Limited, registered in England and Wales, No. 573204. Registered Office: Cannon Place, 78 Cannon Street, London EC4N 6AG. Authorised and regulated in the UK by the Financial Conduct Authority.

**In the EEA:** Issued by Threadneedle Management Luxembourg S.A. Registered with the Registre de Commerce et des Sociétés (Luxembourg), Registered No. B 110242 44, rue de la Vallée, L-2661 Luxembourg, Grand Duchy of Luxembourg.

**In the Middle East:** These materials may only be used in one-on-one presentations. This document is distributed by Columbia Threadneedle Investments (ME) Limited, which is regulated by the Dubai Financial Services Authority (DFSA). The information in this document is not intended as financial advice and is only intended for persons with appropriate investment knowledge and who meet the regulatory criteria to be classified as a Professional Client or Market Counterparties and no other Person should act upon it.

**In Switzerland:** Threadneedle Asset Management Limited. Registered in England and Wales, Registered No. 573204, Cannon Place, 78 Cannon Street, London EC4N 6AG, United Kingdom. Authorised and regulated in the UK by the Financial Conduct Authority. Issued by Threadneedle Portfolio Services AG, Registered address: Claridenstrasse 41, 8002 Zurich, Switzerland.

**In Australia:** Issued by Threadneedle Investments Singapore (Pte.) Limited ("TIS"), ARBN 600 027 414. TIS is exempt from the requirement to hold an Australian financial services licence under the Corporations Act and relies on Class Order 03/1102 in marketing and providing financial services to Australian wholesale clients as defined in Section 761G of the Corporations Act 2001. TIS is regulated in Singapore (Registration number: 201101559W) by the Monetary Authority of Singapore under the Securities and Futures Act (Chapter 289), which differ from Australian laws.

**In Singapore:** Issued by Threadneedle Investments Singapore (Pte.) Limited, 3 Killiney Road, #07-07, Winsland House 1, Singapore 239519, which is regulated in Singapore by the Monetary Authority of Singapore under the Securities and Futures Act (Chapter 289). Registration number: 201101559W. This advertisement has not been reviewed by the Monetary Authority of Singapore.

**In Japan:** Issued by Columbia Threadneedle Investments Japan Co., Ltd. Financial Instruments Business Operator, The Director-General of Kanto Local Finance Bureau (FIBO) No.3281, and a member of Japan Investment Advisers Association.

**In Hong Kong:** Issued by Threadneedle Portfolio Services Hong Kong Limited 天利投资管理香港有限公司. Unit 3004, Two Exchange Square, 8 Connaught Place, Hong Kong, which is licensed by the Securities and Futures Commission ("SFC") to conduct Type 1 regulated activities (CE:AQA779). Registered in Hong Kong under the Companies Ordinance (Chapter 622), No. 1173058.

**Columbia Threadneedle Investments is the global brand name of the Columbia and Threadneedle group of companies.**  
[columbiathreadneedle.com](http://columbiathreadneedle.com)

Issued 11.21 | Valid to 05.22 | J31890 | 3891931