2023

September

The Hydrogen Rainbow – Looking Beyond the Colours

Webinar White Paper

The Al-Attiyah Foundation

01 OUR MEMBERS

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The Abdullah bin Hamad Al-Attiyah Foundation for Energy and Sustainable Development provides robust and practical knowledge and insights on global energy and sustainable development topics, communicating these for the benefit of the Foundation's members and community.

Since 2020, the Foundation has hosted a series of webinars, in partnership with Refinitiv (an LSEG Business), to explore key trends and insights during a period of unprecedented global uncertainty due to the COVID-19 pandemic, supply chain constraints, the Ukraine conflict, extreme price volatility and the climate emergency as they impact the energy industry.

WEBINAR WHITE PAPER

H.E. Abdullah bin Hamad Al-Attiyah founded the Foundation as a platform for knowledge exchange and support for the global community in the quest towards a sustainable energy future.

The Webinar Series, which began two years ago, is a crucial networking and learning opportunity in the calendar of industry CEOs members and Foundation partners.

Hydrogen is a colourless gas. Yet when it comes to describing the varying methods of manufacture, an entire rainbow of possibilities exists - from grey and brown, to blue, turquoise, and red.

While this simplified classification system has enabled a greater understanding of why making environmentally friendly hydrogen will be a key alternative to fossil fuels in many use cases, it focuses on feedstock rather than carbon intensity.

For instance, green hydrogen, which is made via renewable electricity-powered water electrolysis, is usually favoured over blue hydrogen, which is produced from natural gas and supported by carbon capture and storage (CCS).

Yet colour labelling does not factor in the emissions over the entire lifecycle of hydrogen production. For example, shipping solar panels across the ocean to produce renewable energy for green hydrogen generates sizeable CO2 emissions.

Similarly, colour codes say nothing of the emissions profile of hydrogen electrolysis when its electricity comes from fossil fuel power plants: just because green hydrogen projects do not emit carbon in making the gas, it does not mean CO2 is not emitted during the transportation, installation, or manufacture of components.

As more advanced production pathways emerge in the fast-moving hydrogen industry, the overly broad colour-coding system will likely need to be refined and updated.

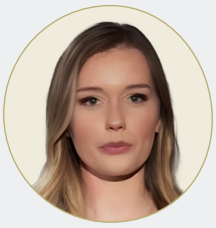
According to the International Energy Agency (IEA), using colours to refer to different production routes obscures many levels of potential emissions and deters would-be investors.

Similarly, the UN Economic Commission for Europe has urged the European Union to go 'beyond colours' and agree on how to quantify the sustainability of hydrogen.

In the Foundation's third webinar of 2023, internationally renowned industry experts debated the merits of the hydrogen rainbow, the best means to evaluate the carbon footprint of varying hydrogen production methods and the prospects for new international standards that will mark a significant step in ending these ambiguities.

WEBINAR SPEAKERS

Moderator:



Mhairi Beveridge, International News Journalist, formerly BBC Southeast, TRT World and Al Jazeera.

Speaker

Alex Barnes, Director & Associates.

Speaker

Julio Dal Poz, Managing Director in the Energy Transition practice FTI Consulting.

Speaker

Michal Zuk, Hydrogen Analyst Refinitiv (an LSEG Business).

Speaker

Charley Rattan, Global Hydrogen Trainer and Advisor Charley Rattan Associates.

Differing definitions of hydrogen, not only the various colours but also terms such as "clean hydrogen" are causing confusion among policymakers, industry protagonists and investors, slowing the development of large-scale environmentally friendly hydrogen production which panellists agreed will be a vital tool in decarbonising society.

Alex Barnes, Director of Alex Barnes & Associates, said the ideal definition of low-carbon hydrogen would analyse the carbon intensity on a "well to wheel basis", which considers hydrogen's entire life cycle and is a comprehensive means to assess energy emissions and efficiency.

He highlighted how European Union documents refer to green, renewable and clean hydrogen. The bloc uses those three terms interchangeably and distinguishes between hydrogen made through water electrolysis via renewable electricity and nuclear power and from methane in conjunction with carbon capture and storage. Yet such classifications are erroneous, said Mr Barnes.

"The real distinction should be on the carbon footprint," he said.

The EU only introduced definitions for renewable energy in mid-2023, having previously set a deadline of doing so by the end of 2021. Such regulatory uncertainty has hindered the development of the hydrogen industry, Mr Barnes warned, criticising the use of colours to describe differing methods of producing the gas.

"Highlighting how hydrogen is produced doesn't really help, it's the carbon footprint (that matters)," Mr Barnes reiterated.

In a first webinar poll, 63 percent of audience members said the hydrogen rainbow system to describe the differing ways in which industry can produce the gas was a "meaningful and handy tool and helps illuminate hydrogen", while 37 percent shared a similar view to Mr Barnes in that "it confuses things further and distracts from the decarbonisation goal".

Charley Rattan, Global Hydrogen Trainer and Advisor at Charley Rattan Associates, explained some of the shortcomings in renewable electricity-powered electrolysers, which function far better with an uninterrupted source of power. As such, the intermittence of renewable electricity – solar does not produce when the sun isn't shining, wind turbines lie idle when there is no wind, for example – is problematic.

In such instances, electrolysers could halt production, or could switch to on-grid power, which would create CO2 if that electricity were made from fossil fuels.

"That could make the carbon footprint of supposed green hydrogen very high as well," said Mr Barnes. "It's not that people don't know about this. Governments are measuring carbon intensity, but people use different terms as to what is clean and renewable."

For example, in the United States, clean hydrogen includes green, blue, turquoise and pink, whereas in the EU "clean hydrogen" solely means green hydrogen.

"But because of the way the EU has designed its rules, green isn't just (made from) renewable electricity, some of it could be grid and ... could have a higher carbon footprint," said Mr Barnes.

"This comes back to why I don't think that the rainbow system is a meaningful tool - because you have to calculate the carbon emissions

associated with the hydrogen and take account of all the bits in the supply chain."

"You want to ensure that the carbon footprint of the hydrogen is lower, otherwise you're just taking one step forward and two steps back," he added.

A new generation of electrolysers is imminent. These will be more efficient and function better than their predecessors when electricity is intermittent, said Mr Rattan.

Electrolyser capacity is rapidly increasing, from 1 megawatt a couple of years ago to probably hundreds of megawatts in 2024 or 2025, said Michal Zuk, a Hydrogen Analyst at Refinitiv (An LSEG Business), predicting the final investment decision on 1-gigawatt electrolyser plants were near.

"In the next few years, we will see quite an impressive growth of production capacity and also the emergence of new trade routes that weren't there even a few years ago," said Mr Zuk.

Governments will shift their focus towards investments that prioritise hydrogen with low carbon intensity regardless of the colour of the hydrogen in question, he predicted.

"It's better to have some legislation that isn't perfect but it's there and enables funding, research and development of the technologies needed to reach the (climate) goals," said Mr Zuk.

International organisations, such as the International Organization for Standardization (ISO) are developing a methodology to calculate the CO2 intensity of producing hydrogen through its various manufacturing methods. The EU refers to ISO proposals in its legislation, explained Mr Zuk.

"I don't see why governments across the world wouldn't take this opportunity to refer to a set of well-developed standards once they are finally published in a year or two," he said.

The webinar's audience took a similar view with 67 percent of respondents in a second poll saying regulatory frameworks could be an alternative way to define clean hydrogen and reflect the emissions intensity of production methods, while 33 percent advocated for certification schemes instead.

India is one such country that has sought to define clean hydrogen, on August 19 publishing its green hydrogen standard. This uses the typical colour coding for hydrogen, but also includes carbon intensity measures, Mr Zuk explained in a detailed presentation.

The framework is part of India's efforts to produce 5 million tonnes of green hydrogen annually by 2030. The gas will be mostly consumed domestically, with some also sold for export.

India believes production could even reach 10 million tonnes per year by the end of the decade and it aims to achieve a 10 percent market share of the global hydrogen industry.

That would make India among "potentially the biggest players", said Mr Zuk.

Yet controversy surrounds India's definition of green hydrogen, which it says must produce no more 2 kilograms of carbon dioxide equivalent per kilogram of hydrogen. Ostensibly, that appears a tougher threshold than those of the European Union and United States, whose limits are 3.38kg and 4kg of CO2 equivalent espectively.

"The truth may be a little bit more complicated," said Mr Zuk, noting India's definition of green hydrogen not only includes making the gas via water electrolysis but also through biomass conversion. The standard also appears muddled in terms of evaluating carbon emissions from associated electricity generation.

Mr Zuk further explained the current status of green hydrogen and the prospects for the development of a green hydrogen market, which remains miniscule compared with the likes of gas or coal.

"It's still localised," said Mr Zuk. "Most of what's produced is used either within the same facility or somewhere close by to the production site. We're still quite far away from seeing the full potential."

Nevertheless, as Mr Zuk noted, the first commercial green hydrogen projects are starting production. These include the Chinese energy company Sinopec's green hydrogen plant, which will produce 20,000 tonnes annually via solar power and began operations in late June

Mr Rattan highlighted how ammonia could be key to transporting hydrogen, which is difficult and costly; Ammonia's chemical symbol is NH3 and is a compound of nitrogen and hydrogen.

"If you mix ammonia with hydrogen, you can move four times as much hydrogen as hydrogen in its own right, so if you want to move a lot of it to market, it's a useful substance to consider," he said.

Liquefying hydrogen – in order to be transported - requires cooling it to minus 253 Celsius, whereas ammonia reaches the same state at minus 33C and so is cheaper and simpler to do, he explained.

Julio Dal Poz, Managing Director of FTI Consulting's Energy Transition practice, said renewable electricity represents around 70-75 percent of the cost of making green hydrogen, while the capital expenditure in building a green hydrogen plant was about 15 percent.

"We expect electrolyser costs to go down over time the same way that photovoltaic solar panels have gone down," he said, noting the installed global electrolyser capacity was currently just 3 gigawatts.

"We'll need a hundred times that - 300 gigawatts of electrolyser capacity by 2030 to get us onto the net zero path," said Mr Dal Poz. "Today, green hydrogen is around three times more expensive as unabated grey hydrogen. That needs to be cost competitive towards 2030."

CONCLUSION

Despite some teething problems in its infancy, green hydrogen still offers the best chance of decarbonising hard-to-abate industries such as steelmaking, residential heating, and many forms of transportation.

Green hydrogen will become a $1.4 trillion market by 2050 according to Deloitte, and so although there are some ambiguities and uncertainties that policymakers and the industry must resolve, its potential remains immense.

"Hydrogen is going to be really important to decarbonise those sectors which can't use electricity," added Mr Barnes. "The important thing is that we have clear and proper greenhouse gas accounting so that we really are reducing emissions."

09 PAST ISSUES

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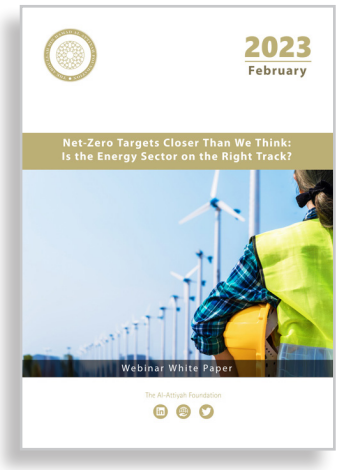

February – 2023

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With little time left to halt the continuous increase in greenhouse gas (GHG) emissions into the atmosphere (i.e., achieving net-zero), the next few years will be critical for our planet. Already, the earth is about 1.1°C warmer than it was in the late 1800s.

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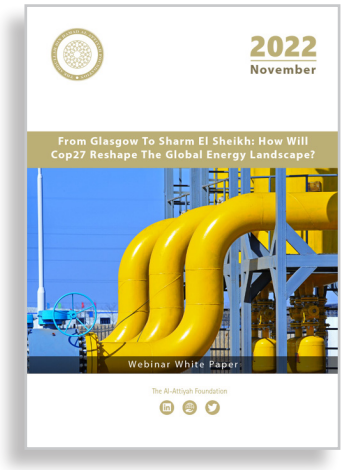

November – 2022

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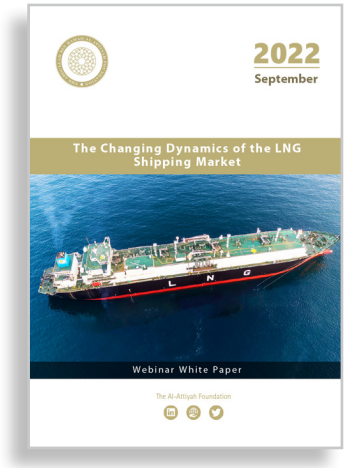

September – 2022

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