

# What would it take for hydrogen to be a viable energy source for Singapore?

By **Youngho Chang and Christopher Toh Meng Sung**

**A** NEW report from the International Renewable Energy Agency (IRENA), *Geopolitics of the Energy Transformation: The Hydrogen Factor*, analyses the political and economic changes taking place in the energy landscape and has identified China, India, Japan, South Korea, the European Union, and the United States as the frontrunners in the race to adopt and scale up clean hydrogen and other low-carbon fuels.

It is therefore not surprising for Singapore to turn towards green hydrogen for its future as well. The launch of Singapore's Green Plan 2030 in February 2021 reinforces the island state's efforts of using low-carbon energy to create a more sustainable society.

Over the last 50 years, Singapore has moved from oil to natural gas for cleaner power generation. We have also seen a utilisation increase in solar energy, particularly on rooftops and reservoirs.

With challenges brought about by climate change, we will need to change how we use and produce energy – particularly so if our energy demand continues to rise with our economic development.

## **Green versus blue hydrogen: challenges ahead**

However, producing and transporting low-carbon hydrogen globally has been a challenge for mass adoption. Cost is a factor and will limit how soon low-carbon hydrogen can become a significant part of Singapore's energy mix.

There are different "grades" of hydrogen which affects its costs. The cleanest green hydrogen, which comes from renewable sources like solar and wind, costs US\$10-15/kg. Blue and turquoise hydrogen – though not entirely carbon-neutral – are produced with methods that emit less carbon than existing grey hydrogen, which are the cheapest at US\$5-6/kg.

Unless electricity used for electrolysis is from renewable sources, hydrogen in Singapore is blue and not green hydrogen.

The country has invested in R&D to increase energy efficiency, harness renewable energy and decarbonise our power grid, industries, and buildings. This includes emerging technologies still in the developmental phase, such as carbon

capture, utilisation, and storage (CCUS) and low-carbon hydrogen – which are currently under exploration for potential CCUS pathways.

If either hydrogen or CCUS technologies become more commercially viable, that aids development of the other. An affordable means to capture carbon dioxide would make local production of low-carbon hydrogen more feasible.

Access to hydrogen would allow carbon dioxide to be turned into fuel and chemical feedstock. To be considered a green fuel, the generated hydrogen should have zero emissions and no fossil fuels consumed during its process. These emerging technologies, including CCUS, are crucial for helping Singapore decarbonise and cut its carbon footprint.

However, CCUS technologies have drawbacks. The low concentrations of CO<sub>2</sub> emissions make it expensive and challenging to capture for subsequent conversion or storage. A lot of energy is required to separate or capture the gas for other applications, and Singapore may not have any suitable geological formations for the permanent storage of CO<sub>2</sub> underground.

There are also technical and economic challenges, such as an extensive infrastructural support required for the transport, storage and use of the gas, and the limited availability of renewable energy resources for electricity generation.

Hydrogen has a far lower boiling point than natural gas, so commercially viable storage and transport is an engineering challenge – one that Singapore is taking on by exploring different carriers, including ammonia, liquid organic hydride carriers and liquefied hydrogen.

Large-scale deployment of hydrogen will require the government to put in place extensive facilities and infrastructural support, new regulations and more.

Due to its relatively small land area and geographical limitations, Singapore does not currently possess large-scale facilities for mass hydrogen production and high pressure insulated tanks to store it.

Singapore will need a well-defined legal framework for the production and usage of hydrogen. There is the added concern of health and safety as hydrogen is highly flammable when it burns.



**A hydrogen fuel cell truck made by Hyundai, seen here at the Swiss Museum of Transport in Luzern. Hydrogen has a far lower boiling point than natural gas, so commercially viable storage and transport is an engineering challenge. PHOTO: REUTERS**

## **The move forward**

Hydrogen is abundant in the environment, and it makes strategic sense for Singapore to continue its focus on developing clean hydrogen.

Singapore lacks the natural resources needed to deploy sufficient levels of wind or solar to generate clean hydrogen at scale. What Singapore can and should do is develop long-term supply agreements to import hydrogen from overseas to continue its drive towards green hydrogen.

Singapore would need to explore various supply pathways for price-competitive low-carbon hydrogen.

The National Climate Change Secretariat, Economic Development Board and Energy Market Authority of Singapore are studying ways hydrogen can be imported via ships or pipes and whether it can be produced in a low-carbon way domestically.

The drawbacks of adopting CCUS technologies in Singapore, can be overcome by collaborations and partnerships with companies and countries with suitable geological characteristics.

Singapore has been pursuing international collaboration and has already inked agreements with New Zealand, Chile, and Australia to develop low-carbon hydrogen

and low-emissions solutions. These steps are crucial to study new chemical processes that could utilise captured carbon more effectively and overcome barriers surrounding CCUS technologies.

Singapore has continued to invest in research to overcome these barriers and reduce the costs of CCUS. The Singapore government has set aside S\$49 million to fund R&D to find new solutions in these areas over the next five years.

It is also studying how hydrogen can be used in various industries. For instance, the Maritime Port Authority (MPA) has announced a centre to focus Singapore's efforts on maritime decarbonisation.

Hydrogen surfaced as an alternative fuel for ocean-going vessels. This greatly reduces emissions and helps with decarbonisation.

Electricity generation, the maritime and heavy transportation sectors, and specific industrial processes, are areas where Singapore can potentially decarbonise with hydrogen as part of the country's efforts to build and transition the city-state into a sustainable city.

**Associate Professor Youngho Chang is head, Business & Management Minors at the Singapore University of Social Sciences (SUSS). Christopher Toh Meng Sung has recently been conferred a DBA (Doctor of Business Administration) from SUSS.**