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Red Hydrogen for a More Sustainable Future in Aviation

By Alvin Chew and Karryl Sagun-Trajano

SYNOPSIS

In 2026, air travel out of Singapore will be more costly as the authorities mandate the use of Sustainable Aviation Fuel – a type of jet fuel produced from feedstock that is more sustainable and carbon-friendly. This is part of Singapore's effort to gradually decarbonise the aviation sector by switching to alternative fuels from the more pollutive kerosene fuel. Still, the long-term solution to deeply decarbonise the aviation sector is a complete switch to using hydrogen as an energy carrier.

COMMENTARY

As the world grapples with the pressing need to address climate change, conversations around sustainable energy solutions have intensified. One promising contender emerging on the horizon is the use of Red Hydrogen – a concept poised to revolutionise our energy landscape and pave the way to Net Zero Emissions by 2050. As the transportation sector is responsible for almost a third of the world's carbon emissions, deep decarbonisation in the aviation industry worldwide will help to reduce carbon emissions on a global scale.

The Hydrogen Colour Spectrum

Hydrogen is the most abundant element in the universe and is the next densest carrier of energy after nuclear energy. A tonne of hydrogen can produce almost three times as much energy as a tonne of coal. Hence, there is much potential for it as a clean energy carrier, with its versatility in both fuel cell technology and as a direct fuel for internal combustion engines. Currently, the most efficient way to produce hydrogen is through the use of fossil fuels.

Hydrogen, while colourless, is ranked in cleanliness via a colour spectrum. Using coal

– the most pollutive form of fossil fuel – to produce hydrogen would yield a product labelled as Black or Brown Hydrogen. The prefix of the colour description indicates the process by which hydrogen is produced.

If natural gas, which is less pollutive than coal, is used in an industrial process known as steam methane reforming, the hydrogen produced is termed Grey Hydrogen. Although hydrogen is non-pollutive, the process of producing it, i.e., the burning of natural gas, is.

As the industry becomes more sensitive to carbon taxes, mitigative strategies are being developed to capture and store carbon during the production cycle. With Carbon Capture Storage components in place – the process of capturing carbon dioxide produced from emission sources – the hydrogen produced is termed Blue Hydrogen.

The cleanest form of hydrogen is produced by using renewables where carbon is absent in the entire energy equation. Water can be separated into hydrogen and oxygen, a process known as electrolysis, by using electricity generated via concentrated solar power. The hydrogen produced in this manner is known as Green Hydrogen, and the process does not emit any carbon dioxide.

However, Green Hydrogen is expensive due to the process of electrolysis and is estimated to cost 25 times that of Black Hydrogen. Furthermore, the intermittency of solar power does not guarantee a stable supply of Green Hydrogen, which is why it forms less than 1 per cent of the total supply of hydrogen.

There is also Pink Hydrogen, produced via the electrolysis process but using nuclear energy instead of solar power. However, when considering nuclear power as an input source, it opens up more efficient pathways for producing hydrogen. Nuclear power not only produces electricity but can also generate high levels of heat. Japan is at the forefront of using High- Temperature Gas Reactors (HTGRs) that are capable of producing heat above 700 degrees Celsius, and the heat generated from these reactors can be used in a thermochemical reaction that is more efficient in producing what is known as Red Hydrogen.

Red and Pink Hydrogen, both produced via the nuclear process, are undoubtedly carbon-free. The potential to produce Red Hydrogen in large quantities has made it sustainable and given it the “future of clean energy” moniker.

Red Hydrogen and the Aviation Industry

There is an urgent need to prioritise environmental sustainability in aviation. With the industry aiming to decarbonise, it is imperative to strive for an aviation future that has more sustainable energy sources and less environmental impact. In the future, carbon taxes will be imposed on conventional jet fuel, which will lead to increases in the cost of air travel.

Presently, the use of Sustainable Aviation Fuel (SAF) derived from renewable sources could significantly reduce carbon emissions by up to 80 per cent, thereby aligning Singapore with global efforts to achieve net-zero emissions by 2050. However, the SAF used is conventional jet fuel blended with 50 per cent of biofuels to balance efficiency and carbon emissions. To fully decarbonise the aviation sector, a carbon-free energy carrier is needed as a fuel.

Red Hydrogen holds promise in this regard. The prospect of having hydrogen-powered aircraft, as exemplified by Airbus' ambitious plans for a hydrogen fuel-cell airplane by 2035, underscores the feasibility of a transition towards carbon-free aviation.

Instinctively, one will be reminded on the safety of using hydrogen as a fuel given the Hindenburg tragedy that occurred in 1937. However, up to this day, it has not been conclusive that hydrogen was the main cause of the explosion, with experts arguing that hydrogen burns with a blue flame instead of red as in the case of the Hindenburg airship.

Nevertheless, advancements in technology have improved the safe use of hydrogen in various industries. It is now used extensively in the chemical industry to produce ammonia, which is subsequently used in fertilisers for agricultural purposes. In the transport sector, hydrogen fuel cells are being developed by car manufacturers as an alternative fuel source.

In the realm of space, hydrogen is being used as rocket fuel, which needs to comply with stringent safety guidelines laid down by the National Aeronautics and Space Association (NASA) and the American Institute for Aeronautics and Astronautics (AIAA). In 2020, Airbus shared the results from a survey it conducted where 73.2 per cent of the participants responded favourably to the use of hydrogen fuel as a mode of transport.

Aircraft of the future will be designed to carry hydrogen fuel-cells, or cryogenic tanks to take in hydrogen as a direct fuel for the internal combustion engines. For the latter, using liquid hydrogen as a direct fuel will not cause carbon emission, but will produce a low level of nitrogen oxide. In both cases, airports of the future need to develop the necessary infrastructure to store readily available hydrogen as a fuel source for aircraft.

The challenge remains that the hydrogen economy is relatively new, and technologies to produce clean hydrogen are costly. However, it appears that nuclear energy produced by advanced HTGRs is a viable solution to produce Red Hydrogen on a sustainable basis. With its potential to address both energy security and climate change challenges, nuclear energy presents a compelling opportunity to usher in a new era of sustainable development.

Towards the Use of Hydrogen in Southeast Asia

Both nuclear energy and hydrogen are clean sources of energy that do not emit any carbon. In addition, nuclear energy can be used to produce hydrogen, either through electrolysis or a thermochemical process. As such, nuclear energy and hydrogen are potential options for deep decarbonisation efforts in Southeast Asia.

Within the region, there is as yet no operational nuclear power plant. Indonesia has been making long-term plans for nuclear energy as part of its energy transition efforts toward net-zero emissions. It has partnered with China in developing an HTGR that has the potential to produce red hydrogen.

Other steps are also being taken towards hydrogen production, that of green hydrogen in particular. Singapore, Malaysia, and Indonesia have already made moves to adopt this form of hydrogen in their energy mix. The Philippines, Thailand, and Vietnam have also announced plans to establish hydrogen plants.

Singapore launched its National Hydrogen Strategy in 2022 in a bid to accelerate its shift to net zero emissions and to bolster its energy security. This strategy includes the possibility of using low-carbon hydrogen as an alternative to fossil fuels in the aviation industry. As a leading air hub, Singapore could serve as a catalyst for more sustainable aviation in the region and across the globe.

Conclusion

Nuclear energy can be harnessed to fight climate change although the deployment of advanced nuclear reactor technologies for civilian purposes must align with the IAEA's safeguard protocols. In an era defined by the urgency of climate action, we need to seize the opportunity to embrace clean, renewable technologies that will secure our planet for generations to come. Innovative solutions like Red Hydrogen are not just a choice but a necessity.

Dr Alvin Chew is a Senior Fellow at the S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University (NTU), Singapore. Dr Karryl Sagun-Trajano is a Research Fellow in Future Issues and Technology (FIT) at RSIS.
