A seamless hydrogen supply chain

When the ship Suiso Frontier crosses the Pacific Ocean in 2021 bearing a cargo of liquid hydrogen, the world will cross a technological frontier

In a demonstration that hydrogen has come of age as a competitive climate-friendly fuel, the ship Suiso Frontier, which was designed and built by Kawasaki Heavy Industries, will soon transport liquid hydrogen from Australia to Japan. The exercise will demonstrate a complete intercontinental supply chain — from an energy-abundant country to an energy-poor one. While other companies have transported hydrogen by reacting it with chemicals such as toluene and ammonia, this will be the first time that pure hydrogen has been transported by ship.

Just transporting 1,250 cubic metres of liquid hydrogen between hemispheres will be a triumph — the Suiso Frontier is a custom-built vessel with double-shell vacuum insulation that enables liquid hydrogen to be transported without any coolant. But Kawasaki Heavy Industries' realization of seamless end-to-end production, delivery and utilization is arguably more important because it shows no surprises could derail this promising technology.

A VISION FOR A HYDROGEN-POWERED FUTURE

"We have a vision for a sustainable energy structure that can provide a viable solution to achieving the goal of zero emission of carbon dioxide," says Motohiko Nishimura, group manager of the Hydrogen Project Development Center at Kawasaki Heavy Industries. "Research shows that hydrogen is essential for the affordable decarbonization of society, especially for countries with high energy consumption density."

Spurred by the need to achieve energy security in an affordable and environmentally benign way, the Japanese government committed to move its economy towards hydrogen by the 2030s. Already a major player in the transport and technology of liquid natural gas, Kawasaki Heavy Industries was able to pivot into the development of hydrogen technology.

"HYDROGEN IS ESSENTIAL FOR THE DECARBON-IZATION OF SOCIETY"

By 2018, Kawasaki Heavy Industries had developed gas turbines that could burn hydrogen as well as natural gas, or even mixtures of the two. Their pilot hydrogen plant in Kobe produced megawatts of heat and power and supplied them to a range of local facilities, including a hospital, a sports centre, trains and sewage works.

AN APPEALING OPTION FOR ASIA

While the first goal is for Japan to achieve energy security, Nishimura believes hydrogen is also a promising option for Japan's neighbours because of their high energy consumption densities. "Korea, Taiwan, Thailand and coastal China are now using liquid natural gas, but they are aiming at zero carbon emissions by mid-century," Nishimura says. "We'd like to contribute to the decarbonization of these countries as well as Japan."

Hydrogen is an attractive import for countries that are aiming for decarbonization but lack the renewable resources needed to become self-sufficient. Suiso Frontier's voyage will pave the way for hydrogen transportation between continents. Hydrogen's carbon footprint can be zero if it is produced using renewable energy (called green hydrogen) or if it is made from fossil fuels and the carbon is captured (called blue hydrogen).

FROM COAL TO BLUE HYDROGEN

The Suiso Frontier will carry blue hydrogen produced from the vast coal resources of Victoria in south-east Australia. Coal mined from the Latrobe Valley will be used for gasification, a partial oxidation process carried out with steam that yields hydrogen mixed with carbon dioxide. The carbon dioxide will be captured, and the hydrogen shipped 100 kilometres to the port of Hastings, on the outskirts of Melbourne in Australia. In Hastings, the hydrogen will be liquefied by cooling to −253 degrees Celsius and then loaded onto the Suiso Frontier.

A life-cycle analysis by Mizuho Information and Research Institute (Life Cycle Greenhouse Gas Emissions Analysis Report of Hydrogen Supply Chain, 2016, p. 18) confirmed that the import of hydrogen is the best approach environmentally. It showed that the well-to-wheel carbon footprint for hydrogen produced from Australian Victorian coal has a carbon dioxide capture and storage index as low as that of hydrogen generated from wind or solar power in Japan.

Now they have solved the engineering challenges of structural stability of a vacuum system that can withstand the forces on an ocean-going vessel, Kawasaki Heavy Industries is already working towards a full-scale hydrogen tanker that will have a capacity of 160,000 cubic metres.

Maritime distribution of hydrogen promises much more flexible energy transfer than transmission of electricity generated from renewables, especially for longer distances. Nishimura also points out that there are economies of scale with hydrogen storage that battery storage can't yet compete with. "Battery cost increases linearly with energy-storage capacity, but in a hydrogen system, the cost will increase more gently," he says. "Moreover, many Asian big cities such as Tokyo have baseload power stations with gigawatt power outputs: a scale that is virtually impossible to realize with secondary batteries due to the cost."

Kawasaki Heavy Industries' newly developed hybrid turbines that use a mixture of hydrogen and natural gas also have the advantage of favourable baseload characteristics. Hydrogen can be stored for long periods or brought online in less than half an hour to cover seasonal fluctuations. Even better, the burners, which are designed to control hydrogen's sevenfold-faster flame propagation speed than natural gas, can be retrofitted to existing natural-gas infrastructure. The turbines can switch between natural gas and hydrogen without modification so that companies are not locked into one energy source.

"We have developed hydrogen technology that is easy for our customers to fuel economic growth and to achieve zero emission of carbon dioxide," Nishimura says. ■

Suiso Frontier will convey hydrogen produced in Australia to Japan.


A photograph of a hydrogen-gas turbine.

The dock at Kobe, Japan, where hydrogen will be offloaded from Suiso Frontier.

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