Special Report **Japan and Sustainability**

Japan

Japan bets on ammonia as the fuel of the future

The pungent gas could offer the best way for the country to import renewable energy

Toxic asset: an ammonia storage facility. A poisonous gas at room temperature, ammonia can be burned to provide zero-carbon energy © Shutterstock

Robin Harding JULY 23 2020

Ammonia is a pungent, corrosive and highly toxic chemical but by the year 2030 it should provide more than 1 per cent of Japan's total electricity supply, according to a consortium of leading players in the industry.

In an interview with the Financial Times, gas industry executive Shigeru Muraki — a representative director of the Green Ammonia Consortium — says the fuel is forging ahead of alternatives, with Japan's electricity industry planning for commercialisation in the next few years.

The push to use ammonia highlights Japan's ambitious plans to import renewable energy from other countries after the 2011 Fukushima disaster led to the shutdown of many nuclear reactors. If successful, it could lead to important changes to global energy markets, with shipments of ammonia replacing coal or natural gas.

"For decarbonisation we need to use renewable energy as much as possible on a global basis," Mr Muraki says. But densely populated, mountainous Japan has limited potential to produce sustainable energy of its own, so the country is looking for ways to import.

In practice this means fixing energy in some kind of hydrogen-containing compound that can be transported by sea as a liquid.

"We've been looking at liquid hydrogen, organic hydrides and ammonia," Mr Muraki says. The conclusion is that ammonia — a compound comprising three atoms of hydrogen to one of nitrogen — is the "most viable option".

Though ammonia contains no carbon, it is only emission-free if no carbon is used to produce it

The Green Ammonia Consortium includes utilities such as Kansai Electric Power, oil companies such as Shell Japan, and trading houses such as Mitsui and Marubeni, plus industry players such as Mitsubishi Heavy Industries.

Under the Japanese plans, resource-rich countries such as Australia would initially produce hydrogen either by gasification from fossil fuels with the carbon captured and stored — so-called "blue" hydrogen — or by electrolysis of water using renewable wind or solar electricity, known as "green" hydrogen.

The question then is how to move that energy to Japan. A government-funded project, led by Mr Muraki, considered different "energy carriers", compact chemical forms in which it can be shipped, and ways to use it on arrival.

One possibility is to ship liquid hydrogen itself. Last December, Kawasaki Heavy Industries launched the 8,000 tonne *Hydrogen Frontier* to test the shipment of hydrogen liquefied at -253 degrees Celsius. Cooling hydrogen that much takes a lot of energy, however, and some is lost during storage.

With organic hydrides there is a large cost to converting the chemical back to hydrogen before it is used to generate electricity in a fuel cell vehicle or burnt in a power plant.

Ammonia is a liquid at minus 33 degrees, and, because it is widely used to make fertiliser and other chemicals, there is an existing commercial infrastructure for shipping it. Like organic hydrides, there are large energy costs involved in making ammonia and turning it back to hydrogen — but there is another option: to burn the ammonia directly in a power plant. That offers significant cost advantages.

"We found that ammonia is the most viable hydrogen energy carrier for early utilisation, expected to start in the middle of the 2020s," Mr Muraki says.

Saudi Aramco, the oil company, and the Institute of Energy Economics in Japan have conducted a feasibility study that is intended to result in a demonstration shipment of carbon-free ammonia to Japan.

Initially, Japan plans to burn ammonia alongside coal to generate electricity. An experiment at Chugoku Electric Power in 2017 successfully burnt ammonia and coal in an existing power station. Another part of Mr Muraki's project developed several small gas turbines powered by 100 per cent ammonia.

Ammonia is attracting worldwide interest as a potential carbon-free fuel for marine engines, and ultimately it could be burnt by itself to drive power station turbines, although engineers are still working to control polluting nitrogen oxide (NOx) emissions.

Although ammonia itself contains no carbon, it is only emission-free if no carbon was used to produce it. Most existing ammonia is produced from natural gas, mainly methane, in a process responsible for about 1 per cent of global greenhouse gas emissions. For Japan to import and burn such ammonia would be less efficient and more polluting than importing the methane directly.

Making renewable ammonia from fossil fuels will require carbon capture and storage (CCS). Japan is hoping that CCS will eventually become economically viable and politically acceptable in countries such as Australia, giving it a supply of carbon-free fuel.

Alternatively, it hopes that renewable energy production in large countries such as Australia will eventually reach such a scale that they can export "green" hydrogen or ammonia to Japan.

Availability of green hydrogen is a long-term prospect, however, and there is a risk of ignoring the global environmental impact in a rush to declare that Japan has cut its own carbon emissions.

Some of the biggest supporters of ammonia are Japan's biggest emitters of carbon dioxide, says Takeo Kikkawa, professor of management at the International University of Japan. "The electricity industry is particularly keen on ammonia. They have a lot of coal-fired plants that are highly cost-competitive but emit a lot of greenhouse gases.

"If they can burn ammonia together with coal then they can reduce the criticism of those plants and keep them operating as long as possible."