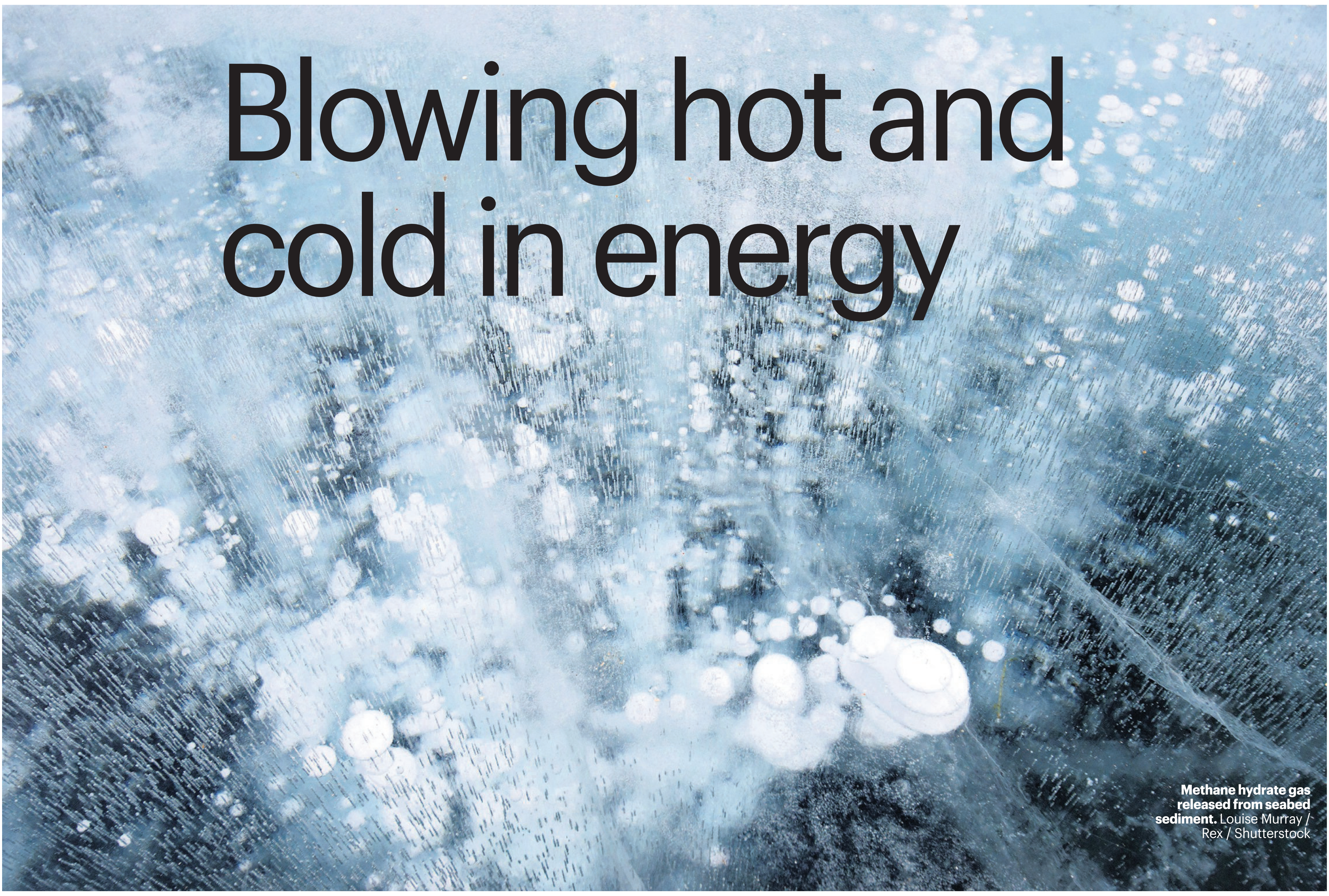
Blowing hot and cold in energy



Methane hydrate gas released from seabed sediment. Louise Murray / Rex / Shutterstock

Japan has been producing methane gas from flammable ice deep beneath the sea floor, which is opening up the exciting possibilities in power generation. The combustible combination is predicted to be commercially viable in less than a decade,

Foreign Correspondent Richard Smith reports from Tokyo

Japan recently reported that it had successfully produced methane gas from deposits of flammable ice, or methane hydrate, off its central coast, opening up a potentially vast new source of energy.

By lowering the pressure or raising the temperature, the hydrates break down into water and methane – a lot of methane. One cubic metre of the compound releases about 160 cubic metres of gas, making it a highly energy-intensive fuel.

"Japan is one of the most actively engaged countries for methane hydrate exploitation since [its] participation in the first hydrate field trial in Mallik, Canada done in 2002," Praveen Linga, associate professor at the University of Singapore's department of chemical and biomolecular engineering, tells *The National*.

A state-run corporation under Japan's ministry of economy, trade and industry, the Japan Oil, Gas and Metals National Corporation (Jogmec), is the organisation conducting the drilling. Jogmec says the government has invested about ¥106 billion (Dh3.54bn) from 2001 to 2016 to develop flammable ice as a domestic natural gas resource.

Methane hydrate has the appearance of common ice crystals, but at a molecular level the methane molecules are trapped within water molecules. It looks like compacted snow, but put a match to it and it will burst into flame and burn vigorously.

Originally thought to occur only in the outer regions of our solar system, where temperatures are low and water ice is fairly common, significant deposits of methane hydrate have been found under sediments on the ocean floors of the Earth.

Economic deposits of methane hydrate are termed Natural Gas Hydrate (NGH). Some 95 per cent of NGH is found beneath the sea floor, where it exists in thermodynamic equilibrium – a state in which it is in mechanical, chemical and thermal equilibrium and in which there is therefore no tendency for spontaneous change.

According to experts, the global sedimentary methane hydrate reservoir probably contains between two and 10 times the known reserves of conventional natural gas. Indeed, according to Geology.com, methane hydrate deposits are believed to be a larger hydrocarbon resource than all of the world's oil, natural gas and coal resources combined.

"Enormous amounts of methane hydrate have been found beneath Arctic permafrost, beneath Antarctic ice, and in sedimentary deposits along continental margins worldwide. In some parts of the world they are much closer to high-population areas than any natural gasfield.

These nearby deposits might allow countries that currently import natural gas to become self-sufficient. The current challenge is to inventory this resource and find safe, economical ways to develop it," says Hobart King, a professional geologist registered in Pennsylvania.

This represents a potentially important future source of hydrocarbon fuel but, in the majority of sites, deposits are thought to be too dispersed for economic extraction. Other problems facing commercial exploitation are the detection of viable reserves and development of the technology for extracting methane gas from the hydrate deposits.

For Jogmec researchers to extract the gas, specialised equipment was used to drill into and depressurise the hydrate deposits, causing the methane to separate from the ice. The gas was then collected and piped to surface where it was flared.

Previously, gas had been extracted from onshore deposits, but never from much more common offshore deposits. The Japanese hydrate field from which the gas was extracted is located 50 kilometres from central Japan in the Nankai Trough, 300 metres under the sea.

The initial operation was stopped because of sand production during the test, damaging process equipment such as piping, chokes, valves and fittings. "Japan has recently overcome this challenge," Mr Linga says.

Japan's recently started field production tests in two locations in the Nankai Trough region have reportedly recovered about 35,000 cubic metres of gas over 12 days. "These steps are in the right direction towards the path to commercialising technology for energy recovery from NGH," Mr Linga says.

However, a lot still needs to be done before realising this potential. Production tests need to be carried out over months to ensure a sustainable output of gas. "The gas production promise is not the only criteria for exploiting this resource, but also the recovery should be done in an environmentally safe and secure manner," Mr Linga adds.

Volumes of Japanese NGH are estimated to be of the range of 2 trillion to 14 trillion cubic metres (TCM). "According to Jogmec, the amount of methane in place in the eastern Nankai Trough alone is 1.1 TCM, which is equivalent to about 11 years of the amount of LNG imported to Japan," Mr Linga says.

However, Ingo Pecher, a senior lecturer of geophysics at the University of Auckland's school of environment, emphasises the importance of distinguishing between low-concentration gas hydrates, which are present along many of the world's continental margins, and concentrated gas hydrate deposits in high-quality reservoirs that may be of commercial interest.

In several gas hydrate provinces worldwide, the amount of gas stored in such concentrated gas hydrates is thought to be many tens of TCM, Mr Pecher says. "These are large numbers but do not exceed the volumes of gas in many conventional natural-gas provinces," he points out.

Currently, extraction methods are focusing on depressurisation. Gas hydrate requires moderate pressure and low temperatures to remain stable. If pressure is lowered, methane hydrate decomposes to freely moving gas and water. "From an engineering perspective, reservoir depressurisation is a fairly standard technique for conventional hydrocarbon production, which may well be one of the main reasons why gas hydrate extraction tests have overall been so successful," Mr Pecher says.

Once the gas is out of the reservoir, storage and transport is the same as for conventional natural gas, he says. In practice, Japanese methane gas is likely to be transported as liquefied natural gas as these locations are offshore, Mr Linga says.

The value of gas from hydrates is highly dependent on the technology and costs incurred to produce it, Mr Linga says. "However, it is too early to put a realistic cost associated with the production of gas, as the technologies are still under field trial to obtain a steady production of gas from hydrates," he says.

In Mr Pecher's view, issues such as gas value, who would get it and in what market, as well as a timetable to reach commercial viability, are all commercial considerations because once at the surface it is effectively the same as standard natural gas. For his part, Mr Linga believes exporting the NGH is probably unlikely as Japan is a major importer of gas.

"Given the challenges involved and the production targets to be met, the projected time for commercial viability may be around 2025 or later," Mr Linga says.

The successes in short-term field tests are just a beginning towards assessing commercial viability. Also, "as highlighted, the potential environmental risk has to be evaluated, and the mining technology has to be cost of production to cost effective for commercial viability," Mr Linga says.

Mr Pecher adds that perhaps there is a way to lower production costs by taking better advantage of the fact that hydrates are relatively close to the sea floor at hundreds of metres below the surface, compared to most conventional gas reservoirs which are often thousands of metres under the seabed.

Meanwhile, other countries are jumping on the flammable ice bandwagon. China reported last month it had succeeded in collecting samples of combustible ice in the South China Sea. "In addition to China and Japan, South Korea, India and the US are leading R&D into gas hydrate as a potential energy source," Mr Pecher says.

China describes its latest results as a breakthrough and, speaking to the BBC, Mr Linga agrees. "Compared with the results we have seen from Japanese research, the Chinese scientists have managed to extract much more gas in their efforts.

"So in that sense it is indeed a major step towards making gas extraction from methane hydrates viable."

An average of 16,000 cubic metres of gas with high purity have been extracted per day in the Shenhu area of the South China Sea, according to Chinese media.

Regarding the environment, since the 1990s, many reputable media outlets have carried warnings that the production of gas from hydrates may pose a significant risk to climate. In reality, experts say, this is a mix-up of two stories, that of gas hydrate production and the role of natural gas hydrates in climate change, Mr Pecher says.

Such a process is totally unrelated to gas hydrate production, he says. "Even if there were an unexpected leakage of gas into the ocean during production, the amounts would be tiny compared to the amounts that may be released from a melting Arctic."

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Above: Marine natural gas hydrate in icelike crystals. Left: the drilling rig Frigstad Shekou, now called *Bluewhale I*, extracting gas hydrate in icelike crystals in the South China Sea. Right: The deep-sea drilling vessel *Chikyu* in the Pacific; it extracted natural gas from methane hydrate on the seabed in March 2013, the first time this was done. Qianlong (2); Kyodo