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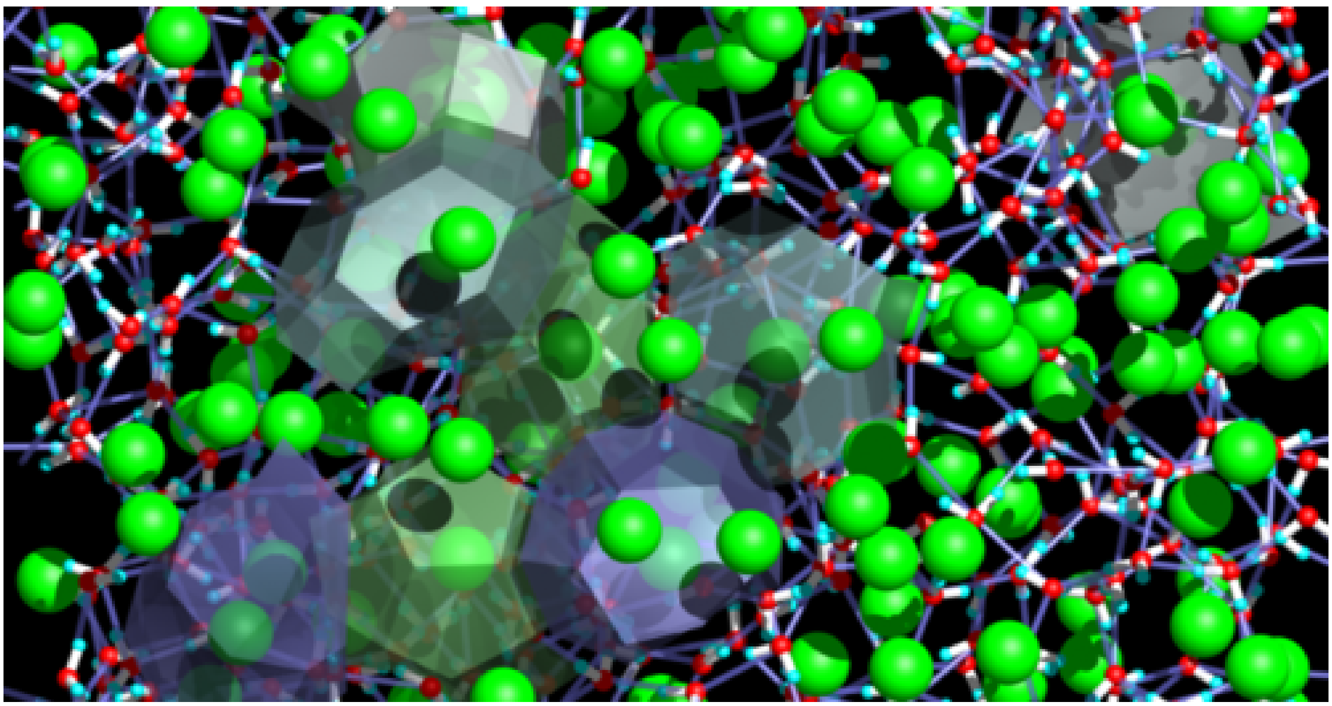
The Ice That Burns: Are Methane Hydrates the Next Big Resource?



By John Rennie

Petroleum engineers in the 1930s knew what to think about methane hydrates, the magical "ice that burns": they were a big nuisance. Chunks of these flammable frozen solids would sometimes clog oil and natural gas pipelines and slow production, so eliminating them became a priority. For decades, methane hydrates remained a worthless, vexing curiosity to industry.

But yesterday's trash becomes today's treasure, and methane hydrates nov h abundant energy source that could help power the global economy as it shifts away from dirtier coal and oil. They could make some countries energy independent, and might even be able to help counter global warming by locking away some of the carbon dioxide (CO2) warming the climate. That is, the hydrates could become all of those things if engineers and scientists can develop a cost-competitive way to use them.

Methane hydrates consist of molecules of the hydrocarbon caged inside the crystalline lattice of water ice. They form spontaneously wherever natural gas mixes with water under the right combination of low temperatures and high pressures. In the 1960s, large fields of methane hydrates were found under the permafrost in oil-rich regions of Siberia and Canada, and mounds of the hydrates later turned up on parts of the seafloor near methane seeps. Then, over the past 20 years, geologists discovered even more extensive methane hydrate deposits in formations of sand and shale under the seafloor.

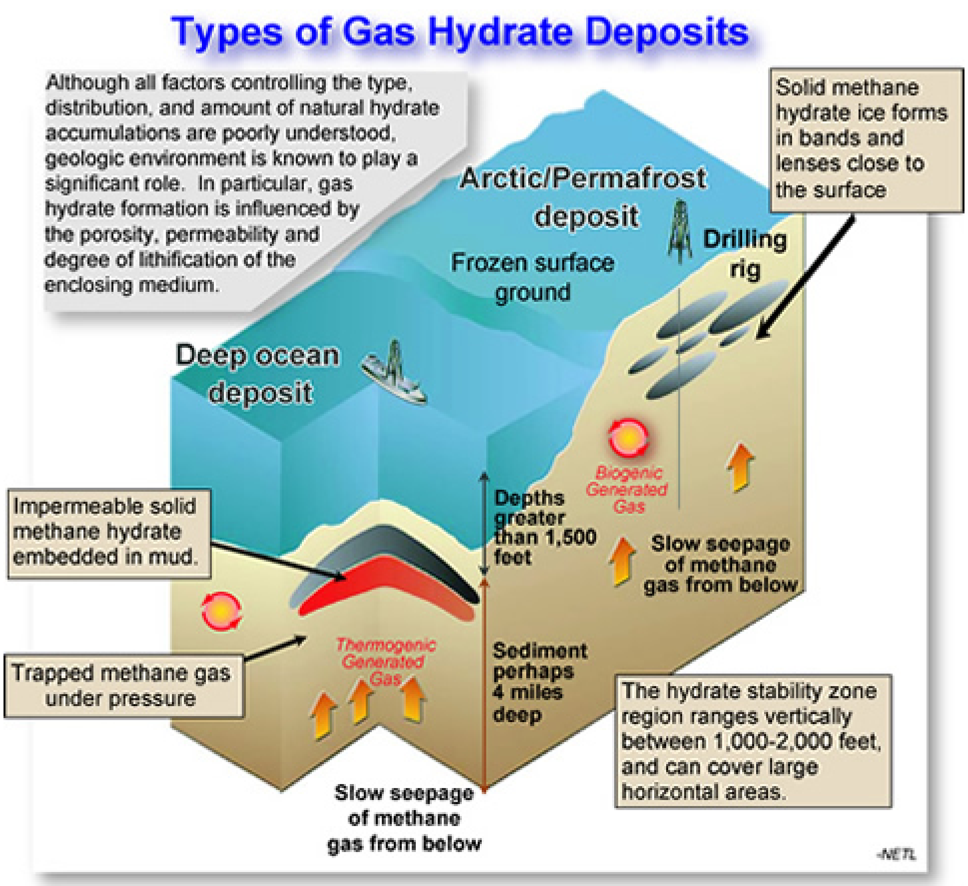
Suddenly, energy policymakers and corporations could ignore methane hydrates no longer: they represented some of the largest known reservoirs of natural gas in the world.

One million, trillion cubic feet of gas

Estimates of how much methane is tied up in hydrates globally vary widely but are on the order of 1,000,000 trillion cubic feet. Most of that is flatly unattainable, explains Ray Boswell, the methane hydrates technology manager for the U.S. Department of Energy's National Energy Technology Laboratory. Nevertheless, in 2010, he and Timothy S. Collett, a research geologist for the U.S. Geological Survey, estimated that even if gas producers restricted themselves to the most workable, sandy formations, the amount of recoverable methane in hydrates could be around 10,000 trillion cubic feet. That quantity compares favorably to the roughly 16,200 trillion cubic feet that the M.I.T. Energy Initiative's

2010 "Future of Natural Gas" report lists as recoverable from all of the world Follow txchnologist d sources.

For the U.S. and other countries that have extensive shale formations or other domestic options for natural gas, the lure of methane hydrates may not be immediately compelling. But Japan, which imports about 95 percent of its resources and pays eight times as much for industrial energy as the U.S. does, has much stronger incentives. It is avidly seeking to exploit the abundant methane hydrates in its waters as a windfall to its economy and industrial security.



The challenge is how to tap into that wealth of methane economically and safely. At first, scientists and engineers thought that collecting and transporting the methane hydrates might demand complex dredging or mining systems for extracting gas hydrates from the deep sediments, Boswell says. Meanwhile, environmentalists feared that disturbing brittle hydrate formations might cause sudden huge releases of methane gas and intensify the greenhouse effect on the climate.

Further work has convinced researchers, however, that the risks of catastro Follow txchnologist

no extraordinary production methods are needed. Rather, methane can be harvested from hydrates by drilling and pumping techniques not unlike those long used to work tired gas fields.

Offshore production tests in 2012

So far, techniques for extracting methane from hydrates have been tested only in the laboratory and in brief field tests: a Japanese research consortium produced about 460,000 cubic feet of gas onshore over six days in 2008. The true tests will begin next year, when Japan will attempt the first offshore production tests from hydrates in the eastern Nankai Trough.

More burning ice. Courtesy/Natural Research Council Canada

The technique with the most evident commercial promise may be depressurization: A well bored down into a hydrate would pump water and gas out of the formation; the low pressure area it created would prompt the adjacent hydrates to decompose into liquid water and methane gas, perpetuating the flow. According to Collett, small amounts of chemicals might be used within the borehole to prevent the hydrates from refreezing on their way to the surface but very little of these substances would reach the environment, which would minimize the risks of contamination.

Moreover, Collett says, because the sandy hydrates targeted for production [Follow txchnologist] or more beneath the seafloor and the hydrates would naturally tend to reform under the ambient conditions, runaway releases of methane should be impossible (though he also emphasizes that ongoing monitoring should always be part of developers' plans). Rather, a more realistic concern is destabilization of the local seabed, because the hydrates are part of what holds the sandy geology together. Even small shifts in the seabed could damage the boreholes—posing an expensive problem for the drillers, and at least transiently allowing leakages of methane or other chemicals.

Keeping the hydrate formations stable is just one of the advantages of an ambitious alternative to depressurization that scientists are considering. This technique, pioneered by South Korean, Japanese and Norwegian researchers, would not only produce methane but would sequester unwanted industrial CO_2 away from the atmosphere—a double win in the current fight against climate change. Warm, pressurized CO_2 (in a so-called supercritical state that allows it to have a liquid's density and a gas's expansiveness simultaneously) would be injected into methane hydrates. Molecules of the CO_2 would then insert themselves into the icy lattice, forming an even more stable form of hydrate and liberating the trapped methane, which could then be pumped to the surface. Because the hydrate material would never melt, the local geology ought to remain intact.

Ten to 15 years away from production

Klaus Wallman heads up a CO_2-based extraction project called SUGAR funded by the German ministries and coordinated by the Leibniz Institute for Marine Sciences (IFM-GEOMAR). Although he is enthusiastic about the possibilities, he acknowledges a drawback: the reaction that swaps CO_2 for methane in the hydrates is even slower than depressurization, which means that gas production would also be slow. "The question is whether it will ever become economic," Wallman says. The SUGAR researchers are exploring whether the use of certain chemicals injected with the CO_2 might hasten the methane release, but doing so would further add to the costs and the potential environmental risks.

According to Boswell, the U.S. DOE and ConocoPhilips will test CO_2 injection at a site in Alaska's North Slope next year as well, and an agreement has been reached in principle for tests with BP and other companies for a test of depressurization as well, although the timing is still not settled. (Scheduling tests can be difficult because they would take place around active oil fields, where disruptions are expensive.)

Germany's IFM-GEOMAR SUGAR project aims to test its CO2 technology in th Follow txchnologist S
Korea, Norway and other countries also remain intensely interested in developing the technology.

Analysts commonly conclude that methane hydrates are 10 to 15 years away from contributing significantly to commercial natural gas supplies, although Japan has also announced that it intends to begin some pilot production as early as 2018. But that timeline for development may ultimately depend less on favorable technology and geology than on favorable economics and politics. Any policies that might strengthen future demand for natural gas—such as restrictions on nuclear power or curbs on greenhouse emissions—might motivate the industry to exploit methane hydrates sooner rather than later.


John Rennie served as editor in chief of Scientific American between 1994 and 2009. Based in New York, he continues to work as a science writer and editor, and as an adjunct instructor in New York University's Science, Health and Environmental Reporting Program. John blogs at The Gleaming Retort can be found on Twitter as @tvjrennie.

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