ENERGY

Weighing the Climate Risks Of an Untapped Fossil Fuel

As the energy industry hungrily eyes methane hydrates, scientists ponder the fuel's impact on climate

VIENNA, AUSTRIA—A recent workshop* on methane hydrates felt like a powwow of 19th century California gold prospectors, looking ahead to both riches and peril. Sizing up the prize, Arthur Johnson, a veteran geologist of the oil industry who is now an energy consultant based in Kenner, Louisiana, predicted that "within a decade or two, hydrates will grow to 10% to 15% of natural gas production," becoming a more than $200 billion industry. And the peril? "The worst-case scenario is that global warming triggers a decade-long release of hundreds of gigatons of methane, the equivalent of 10 times the current amount of greenhouse gas in the atmosphere," said David Archer, a climate modeler at the University of Chicago in Illinois. Although no current model predicts such an event, said Archer, "we'd be talking about mass extinction."

When methane molecules become locked in atomic cages of water called clathrates, they form icy chunks that ignite when lit. These solids form wherever methane encounters water at high pressure and low temperature. The necessary conditions reign in permafrost and in some sea-floor sediments, forming a "ring around the bathtub" on continental slopes. This exotic fuel was discovered by the Soviet petroleum industry more than 3 decades ago, but even a few years ago many doubted its commercial potential (*Science*, 13 February 2004, p. 946). After several successful pilot drilling studies and heavy research investment over the past 4 years, says Johnson, "the question now is not whether industry will exploit hydrates but how soon."

Considering the skyrocketing price of oil, the answer seems to be soon, says one of the workshop organizers, Nebojša Nakićenović, an energy economist here at the International Institute for Applied Systems Analysis (IIASA) outside Vienna. "And yet hydrates are absent from most of the climate discussions," he says, "and virtually absent from the IPCC fourth assessment report," last year's 1000-page tome by the Intergovernmental Panel on Climate Change (*Science*, 11 May 2007, p. 812). The goal of the IIASA workshop was to bring together researchers from all the different fields that touch hydrates—from chemistry and economics to climate impact—to get an "interdisciplinary perspective" on the uncertainties.

"It's clear that one of our biggest knowledge gaps is figuring out the distribution," says Michael Riedel, a marine geophysicist at McGill University in Montreal, Canada. "We still don't know how much there is in the world, not even within an order of magnitude."

Another crucial gap is the flux of methane, which drives hydrate formation over time. The largest amounts of methane hydrates are thought to reside in sub–sea-floor sediments. In a newly built sea-floor–monitoring network called NEPTUNE off the western coast of Canada, Riedel is part of a team studying methane-spewing vents to get a handle on their flow rate and marine chemistry. Where the conditions are just right, methane hydrates form caps over pockets of such gas. These not only are sweet spots for those who want to tap hydrates for energy but also represent a major worry for climate modelers.

"If the sea floor warms up by a few degrees Celsius, the most vulnerable hydrates will melt, and then you're going to get a massive release of methane," says Euan Nisbet, a marine geologist at Royal Holloway, University of London. That warming and release is expected to take centuries or even millennia even in the most extreme climate scenarios. Riedel says the methane bubbles from sea-floor vents are sponged up by the ocean water. But if a methane release were large and shallow enough, it would reach the atmosphere, says Archer. What is unclear is whether the climate system has methane-driven positive feedback mechanisms that could lead to abrupt climate change.

Johnson threw cold water on the scenario of a massive release of submarine hydrate-trapped methane to the atmosphere. Most hydrate deposits found so far "are as deep as a kilometer below the sea floor," he says, "and they aren't going anywhere." Walter Oechel, an ecologist and carbon-cycle expert at San Diego State University in California, doesn't find the "doom-and-gloom scenarios" very likely either. "The real story for me is hydrates as yet another chronic contributor to greenhouse gas emissions," he says.

Great balls of fire! When methane meets water under high pressure and low temperature, it forms icy chunks that burn when lit.

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Others considered methane hydrates part of a greenhouse gas solution. A plan proposed by Vladimir Yakushev, a geologist at Gazprom, the world's largest natural gas corporation, based in Moscow, involves simultaneously extracting methane and methane hydrates while pumping liquefied carbon dioxide into the underground spaces left behind. Researchers also discussed the idea of using hydrates for electricity generation or even manufacturing on the spot. "We have to try to make it carbon-neutral if we're serious about climate change," says Nisbet.

The overarching question of whether methane hydrates should play a major role in climate change debate was up for grabs. Considering the workshop discussions, "the methane hydrate issue is one risk that shouldn't drive policy considerations at the moment," concludes Brian O'Neill, an IPCC author and climate modeler at the National Center for Atmospheric Research in Boulder, Colorado. "There are bigger fish to fry." But Neil Hamilton, director of the International Arctic Programme for the World Wildlife Fund, based in Oslo, Norway, says, "It's absolutely shocking that hydrates have gotten so little attention." The risk of a massive methane release, however unlikely, "is reason enough for very serious concern," he says. More meetings like these are clearly needed.

–JOHN BOHANNON

* "Vulnerability and Opportunity of Methane Hydrates Workshop," IIASA, 13–14 March 2008.

Published by AAAS