Methane hydrates
What are the climate change and energy implications?
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Methane from Hydrates
Methane hydrates

There has been a surge of interest in methane hydrates in the last decade, stimulated by claims that their energy production potential could be larger than that of all the world’s known oil and gas reserves combined. The reality is that the size of the global methane hydrate inventory is unknown.

What is known is that a vast reservoir of methane (CH₄) is frozen as methane hydrates. Methane hydrates are formed when high concentrations of methane and water combine at low temperatures and high pressures. Globally, an estimated 99% of all gas hydrates occur in the sediments of marine continental margins. The remainder are mainly found beneath Arctic permafrost. In the open ocean, where average bottom-water temperatures are approximately 2-4°C, gas hydrates are found starting at depths of around 500 metres.

Gas hydrates

Gas hydrates are ice-like substances formed when methane or some other gases combine with water at appropriate pressures and temperature conditions. Large amounts of methane are sequestered in gas hydrates. Those in which methane is sequestered are referred to as methane hydrates or methane clathrates.

Methane is a potent greenhouse gas with a considerably higher warming potential than carbon dioxide (CO₂). There are many natural and anthropogenic sources of methane emissions, including wetlands, ruminant animals, rice cultivation, deforestation, coal production, incomplete fossil fuel combustion, and the production and distribution of petroleum and natural gas. Methane is the main component of natural gas.

Methane hydrates destabilize in response to warming of only a few degrees Celsius. Therefore, some scientists are concerned about how much methane could potentially be released to the atmosphere from destabilized methane hydrates as a result of global warming. If this methane did reach the atmosphere, it would in turn exacerbate global warming. However, most hydrates are in very deep oceans well within the gas hydrate stability field. Hydrates located in certain places close to the edge of the stability field could be a greater cause for concern.

A number of factors influence the extent to which methane hydrates-based natural gas production could eventually provide some countries with greater energy self-sufficiency and help address global energy needs. An important one is the global energy mix in years to come. As yet, no long-term production test has been carried out to demonstrate the viability of sustained methane production from gas hydrates. If commercialization becomes likely, a broad range of environmental risks will need to be assessed based on our growing knowledge of methane hydrates as well as, for example, the impacts of offshore oil and gas drilling (including on the seafloor and submarine slopes), and leaks during natural gas production and transport.

Read more about methane hydrates in the UNEP Year Book 2008.

Source: R. Boswell 2011 adapted by GRID-Arendal
Recent observations and knowledge

Scientists are interested in quantifying the amount of methane being released from all emission sources in the rapidly warming Arctic. They also want to better understand the effects that climate change has on these releases. However, they strongly disagree about whether global warming could conceivably trigger — in the foreseeable future — catastrophic atmospheric releases of methane from destabilized methane hydrates in this region.

As global warming continues, methane releases to the atmosphere related to thawing Arctic permafrost (but not to the methane hydrates beneath the permafrost) are expected to continue. A recent study shows that methane emissions from the East Siberian Arctic Shelf are more than twice what were previously believed. The authors suggest that these emissions result from the degradation of submarine permafrost over thousands of years. This appears to be a source of methane emissions to the atmosphere at least as significant as Arctic tundra, which is considered a major source of methane emissions.

Unexpected levels of methane have also been discovered coming from cracks in Arctic sea ice and areas where there is partial sea ice. Further research is needed to determine where this methane comes from. The enhanced methane from these cracks could be produced by a form of ocean ventilation, whereby the ocean interacts with the air and methane escapes into the atmosphere.

It is not only in the Arctic that scientists are finding out more about methane emissions and methane hydrates. According to a recent study of the Antarctic ice sheet, pressure and temperature conditions favour methane hydrate formation down to sediment depths of about 300 metres in West Antarctica and 700 metres in East Antarctica. The authors have calculated that the sub-Antarctic hydrate inventory could be of the same order of magnitude as that of recent estimates made for Arctic permafrost. They do not suggest, however, that these methane hydrates could be a source of atmospheric methane emissions.

The Antarctic ice sheet

The Antarctic ice sheet is the Earth's largest single mass of ice, extending over almost 14 million km² and containing over 90% of the freshwater in the form of ice on the planet. In East Antarctica the ice sheet rests on a major land mass, while in West Antarctica the bed can extend to more than 2500 metres below sea level. It was recently reported that a large section of the West Antarctic ice sheet is melting into the sea.
Searching for answers to some complex questions

Scientific and technological advances are being made in a number of countries, with the aim of exploring the possibilities of producing natural gas from methane hydrates. In March 2013 the world’s first offshore methane hydrate production test was conducted off the coast of Honshu Island, Japan. The test site was chosen based on seismic and well data indicating methane hydrate-rich sedimentary layers in this area. About 120,000 m$^3$ of methane gas was produced from the hydrate-bearing sediments.

Scientists and engineers are analyzing the data collected. At the same time, an international team of researchers has been studying sediment samples containing gas hydrates obtained from layers beneath the deep seafloor in the Nankai Trough off Japan. Highly sophisticated techniques were required to retrieve these samples and keep them at their natural, stable conditions.

Japan and other countries are assessing the extent of available methane hydrate deposits while simultaneously looking at technologies for commercially viable natural gas production. In Japan a long-term production test (e.g. one lasting over 18 months) now needs to be carried out to prove that sustained methane production from gas hydrates is viable. This is the critical research and development step on the path to eventual commercialization. Japan has announced plans to make its extraction technology commercially viable by the end of this decade.

In the early 2000s a team of Canadian and Japanese scientists succeeded in extracting methane from the Mallik gas hydrate site by heating the reservoir. Still better results were obtained in 2008 by lowering the reservoir’s pressure without resorting to heating. After the experiment ended, technicians on-site expressed confidence that production could have continued even longer. The success of this second land-based experiment indicates that decompression techniques may be a more viable route to commercialization of methane hydrates.

With the necessary technology and favourable market conditions, natural gas production based on extraction of methane from methane hydrates may become economically viable in some regions and for some reservoirs. Nevertheless, complex questions remain to be answered – not only about how to achieve this, but also about the future environmental impacts of continuing to use natural gas as a fuel.

It is widely recognized that international cooperative efforts are necessary to address environmental issues, including the links between fossil fuel combustion and climate change. Such cooperative efforts are carried out by the Global Methane Initiative and the Global Carbon Project, which produces regularly updated calculations of the global methane budget and trends. The most comprehensive global methane inventory can be found in the Emissions Database for Global Atmospheric Research (EDGAR).

The Global Methane Initiative

Countries and organizations cooperating in the Global Methane Initiative (GMI) aim to build capacity and overcome barriers to methane reduction projects around the world. The GMI database contains information about these projects and many other activities.

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Addressing big questions and continuing international cooperation

Methane hydrates represent a potentially large source of natural gas, although we do not know the size of the global methane hydrate inventory. Lessons being learned in countries today about oil and gas drilling, including the extraction of unconventional natural gas, may be relevant to the development of future methane hydrate policies.

Unconventional natural gas

Sources of unconventional natural gas include shale gas (found in shale deposits), coal bed methane (extracted from coal beds) and tight gas (trapped underground in impermeable rock formations). As of 2012, these types of unconventional gas had reached an estimated 18% of global natural gas production. Shale gas output is concentrated in the United States, but is rapidly spreading to other parts of the world.

Research in recent decades, aimed at resolving some of the uncertainty about methane hydrates as a potential energy source, has involved international and interdisciplinary cooperation and wide information sharing. It has also benefited from work in which the public and private sectors are both engaged. Important questions that need to be addressed through such efforts include:

- What can scientists tell us about potential releases of methane to the ocean-atmosphere system due to the breakdown of methane hydrates?
- How likely does production of methane from hydrates appear to be? What is a reasonable timeline for commercialization, and what factors might affect this timeline?
- What is the relationship between methane hydrates (and eventual offshore drilling to extract them) and seafloor destabilization?
- What would the environmental, economic and social impacts of methane hydrates-based natural gas production be?
Further information about methane hydrates


