U.S. DEPARTMENT OF ENERGY | Fossil Energy

OFFICE OF OIL & NATURAL GAS

Gas Hydrate

Gas hydrates consist of molecules of natural gas (most commonly methane) enclosed within a solid lattice of water molecules. Gas hydrate deposits are found wherever methane occurs in the presence of water under elevated pressure and at relatively low temperature, such as beneath permafrost or in shallow sediments along deepwater continental margins. Once thought to be rare, gas hydrates are now believed to occur in vast volumes and to include 250,000–700,000 trillion cubic feet (Tcf) of methane. This large store of organic carbon raises a wide range of science and technology issues, including gas hydrate's role in global carbon cycling, natural geohazards, and as a potential future source of energy. Investments by the U.S. Department of Energy's (DOE's) Office of Fossil Energy (FE) through the National Energy Technology Laboratory (NETL)—along with collaborations with academia, industry, states, and international partners—have led to substantial progress in addressing these issues through scientific drilling and sampling programs, numerical simulation, and laboratory experimentation.

Background

DOE was designated as the lead research and development (R&D) agency for gas hydrate research by the Methane Hydrate Research and Development Act of 2000, which was reauthorized by the Energy Policy Act of 2005. As a result of these legislative actions, DOE has constructed a U.S. R&D Program, in collaboration with six other federal agencies; a national Fellowship Program with the National Academies of Science; a series of International R&D agreements; and a Methane Hydrate Advisory Committee. DOE has also sought the external review of the National Academies of Science and the Secretary of Energy Advisory Board.

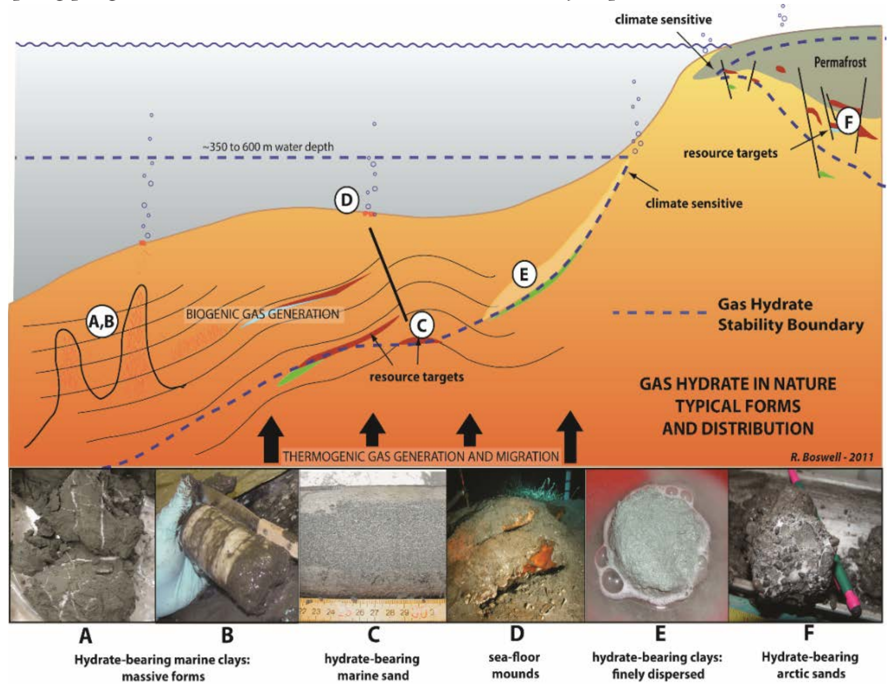

Figure 1. Types of gas hydrate deposits.

The early phases of DOE research began in 2001 and successfully addressed industry concerns about the safety of drilling through deepwater gas hydrates. Previously, industry avoided gas hydrate shallow hazards due to a lack of reliable information on hazard location. In 2005, NETL partnered with an international industry consortium led by Chevron to develop tools and technologies to mitigate drilling hazards associated with deepwater gas hydrates. Progress continued during the past decade as FE and NETL worked with international and federal agency partners to focus gas hydrate energy research on the most promising accumulations and determine the most effective hydrate exploration and extraction technologies. A primary finding of the wellbore stability modeling and data analysis conducted prior to and during the DOE Joint Industry Project 2005 field program was that the hazards were readily mitigated with simple controls on drill fluid temperature. In 2009, that same collaboration demonstrated the occurrence of resource-grade gas hydrate in the Gulf of Mexico, with an exploratory drilling program that discovered high concentrations of gas hydrate in reservoir-quality sands at two of three sites drilled.

NETL partnered with the U.S. Geological Survey (USGS) and Alaska North Slope operators in 2007 (BP) and 2011/2012 (ConocoPhillips) to assess the nature and production potential of gas hydrate through drilling and testing programs. Laboratory studies of chemical injection into gas hydrate formations indicated that CO_2 injection could be designed to produce a relatively rapid and efficient molecular substitution to achieve the permanent storage of CO_2 in hydrate form in exchange for the simultaneous release of methane. However, complications can arise due to the likely presence of free water in natural gas hydrate formations, which would bind injected CO_2 into a CO_2 hydrate prior to interaction with the native methane hydrate. In partnership with DOE and the Japan Oil Gas & Metals National Corporation, the ConocoPhillips-operated Ignik Sikumi test well was designed to test this chemical exchange in the field. That test used a CO_2-N_2 gas mixture to address the free water issues and confirmed that gas injection is sustainable in water-bearing gas hydrate reservoirs, that some degree of bulk exchange of chemical species does occur, and that it may have certain beneficial effects such as increasing the mechanical stability of the sediments. The test concluded that chemical injection will likely serve a complementary role in ultimate integrated production systems in certain settings, but it is unlikely to achieve the production rates achievable through approaches that are based on reservoir depressurization. Therefore, going forward DOE will focus on depressurization as the highest priority for future gas hydrate production R&D.

DOE's gas hydrate research also includes NETL collaboration with academia, other DOE national labs, and USGS to better understand gas hydrate's role in the natural environment, including its potential response to a changing climate. This collaboration gathers field data in climate sensitive areas to conduct the first forward climate modeling that incorporates potential gas hydrate feedbacks. Overall, the DOE program has become recognized as an international leader in the field, and collaborates actively with researchers from Japan, Korea, India, Canada, and other nations.

Objectives and Benefits

The primary mission of DOE's gas hydrate research program to advance the scientific understanding of gas hydrates as they occur in nature so that their resource potential and role in climate change can be fully understood. A key aspect of this program is collaboration with domestic and international agencies, and industry. Over the long term, the science and technology programs supported by DOE will provide valuable insight into the nature of gas hydrate geohazards, inform climate and ocean policy, and support the evaluation of the potential for expanded energy supply options for the United States and its allies.

Research Scope

Production Feasibility: Gas hydrate formations occur in a variety of types beneath the permafrost and offshore, on and below the seafloor. DOE research has identified the most promising types (Figure 1) and is focused on gathering field data and conducting scientific production tests to determine the commercial viability and environmental implications of production of natural gas from hydrates.

Research and Modeling: DOE is studying innovative ways to predict the location and concentration of subsurface gas hydrate before drilling. DOE is also conducting experimental studies to understand the physical properties of gas hydrate-bearing strata and how they respond to potential production activities.

Climate Change: DOE is studying the role of gas hydrate formation and dissociation in the global carbon cycle. Another aspect of this research is incorporating science into climate models to understand the relationship between global warming and methane hydrates. Findings to date indicate that gas hydrate may have played a significant role in climate events, particularly those that are large, acute, and global in scale. The signals from climate feedbacks might be first manifested in the Arctic, where climate change is more pronounced and gas hydrates more closely coupled to the atmosphere/ocean system. Overall, while the magnitude of methane releases in the Arctic appear to be minor in comparison to those from other methane sources, the issue warrants further study. Initial work to incorporate gas hydrate science into forward projections under future climate scenarios has recently been undertaken; cumulative results indicate that methane release will likely be chronic, not catastrophic, and that the vast majority of methane derived from dissociating gas hydrates will not reach the atmosphere due to a variety of natural sinks within sediment and ocean waters. The implications for methane release on ocean geochemistry, including potential acidification, are receiving increased attention and further study would help clarify the possible roles of hydrates and various possible drivers and feedbacks in our rapidly changing environment.

International Collaboration: International collaboration continues to be a vital part of DOE's gas hydrate research program, as the gas hydrate portfolio represents research challenges and potential that are global in scale.

Examples of Ongoing Work

A major focus of DOE gas hydrate activity has been in the Gulf of Mexico. DOE's 2009 drilling program provided initial confirmation of a 2008 study by the U.S. Bureau of Ocean Energy Management (BOEM) that indicated gas hydrate resources in the basin could be in excess of 5,000 Tcf. In consultation with the USGS and the BOEM, DOE is now partnering with the University of Texas–Austin to conduct two drilling and coring programs years to further confirm resource potential. In Alaska, DOE and Alaska's Department of Natural Resources entered into a memorandum of understanding confirming the need for and interest in energy development and unconventional resource R&D in Alaska's Arctic region. In 2014, NETL partnered with agencies of the Japanese government with the goal of developing opportunities for extended-duration production tests in Alaska. At present, DOE, Japan and the USGS are working to evaluate potential drilling locations and develop viable project structures. Internationally, DOE and the USGS are collaborating with the government of India to assess findings of two past drilling programs in the Bay of Bengal and to develop plans for future deepwater production testing.

Next Steps

DOE will continue to work with domestic and international partners to pursue production tests, collect pressurized cores of marine hydrates for analysis, integrate gas hydrate science into climate and global carbon cycle models, further constrain U.S. resource volumes, and provide educational and training opportunities for U.S. universities.

For more information, please visit
energy.gov/fe/science-innovation/oil-gas-research