the ENERGY lab

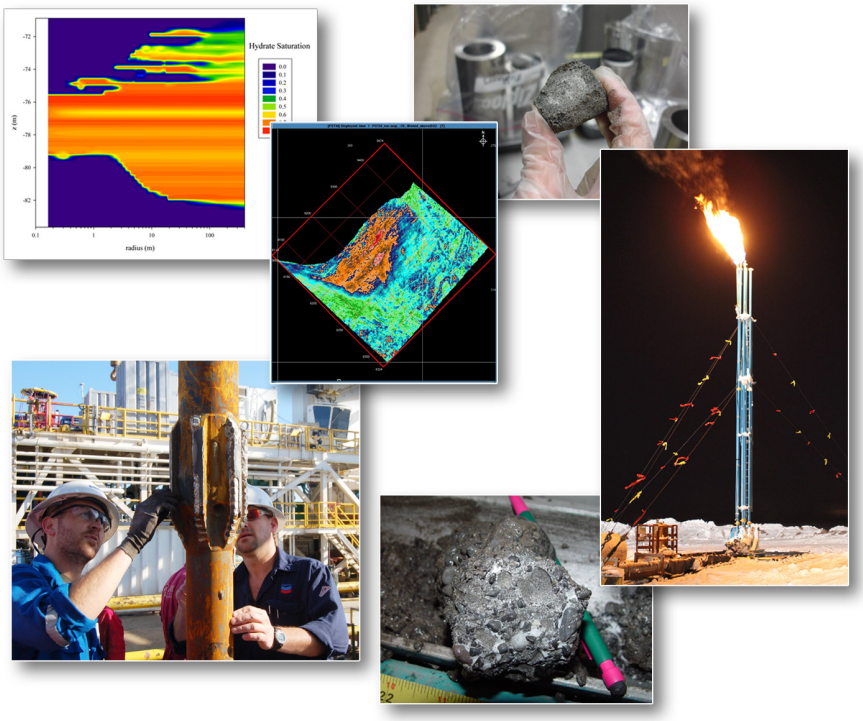
PROGRAM FACTS

Strategic Center for Natural Gas & Oil

Methane Hydrates R&D Program

Gas hydrates are a naturally-occurring combination of methane gas and water that form under specific conditions of low temperature and high pressure. Once thought to be rare in nature, gas hydrates are now known to occur in great abundance in association with arctic permafrost and in the shallow sediments of the deep-water continental shelves. The most recent estimates of gas hydrate abundance suggest that they contain perhaps more organic carbon that all the world's oil, gas, and coal combined.

The primary mission of the Methane Hydrates R&D Program is to advance the scientific understanding of gas hydrates as they occur in nature such that their full resource potential can be fully understood and realized. In pursuit of this primary mission, the program is proceeding along three parallel paths. The first path is to confirm the scale and nature of the potentially recoverable resource through drilling and coring programs. The second is to develop the technologies to safely and efficiently find, characterize, and recover methane from hydrates through a combination of field testing, numerical simulation, and controlled laboratory experimentation. The third is to better understand gas hydrate's role in the natural environment, including its linkages to global climate change.



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U.S. DEPARTMENT OF ENERGY

The Issues

It was only recently that gas hydrates were recognized to exist at a massive scale in the natural environment. This finding leads to a number of important scientific issues:

- Gas hydrates are potentially a source of significant supplies of methane gas for meeting future energy needs. Large resources are available in Alaska (the Department of Interior's U.S. Geological Survey (USGS) in 2008 reported a mean estimate of 85 trillion cubic feet or more, technically recoverable) that can have real implications for native communities, can broaden U.S. gas supplies, and enable access to other Arctic resources—including viscous oil and stranded conventional gas. In the Gulf of Mexico, marine in-place gas hydrate resources in the most favorable reservoir settings have recently been assessed by the Department of the Interior's Bureau of Ocean Energy Management (BOEM) at more than 6,000 trillion cubic feet, and a 2012 report from BOEM indicated large potential resources off the U.S. Atlantic and Pacific coasts as well.
- International interest and investment is high, as gas hydrates have the promise of providing supplemental energy resources to a number of economies that are largely and increasingly reliant on energy imports.
- The role of gas hydrates in mediating the movement of carbon in the geosphere is not well known but could have major implications on both long- and short-term environmental processes, particularly climate change. This issue is most acute in Arctic regions where climate change is most pronounced and where gas hydrate deposits are common and least effectively buffered from environmental change.
- Unintended dissociation of gas hydrates while producing from deeper oil and gas reservoirs can threaten the integrity of wells and destabilize surface structures. To address these hazards, industry has historically opted for simple avoidance, and only recently has this issue begun to be studied.

INTERAGENCY COORDINATION TEAM

DOE-NETL
U.S. Geologic Survey
Bureau of Ocean Energy Management
National Oceanic & Atmospheric Administration
Naval Research Laboratory
Bureau of Land Management
National Science Foundation

RELEVANT LINKS

NETL MethaneHydrates home page: http://netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/maincontent.htm

Fire in the Ice: A periodical highlighting the National Methane Hydrate R&D Program
http://netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/newsletter/newsletter.htm

FE web page: http://www.fe.doe.gov/programs/oilgas/hydrates/index.html

The need for scientific data collection and technology development is being driven by the following:

- Resource volumes, particularly those resources in the marine setting that are the most prospective for production, remain poorly defined, but could be substantial. Large areas of the U.S. outer continental shelf are virtually unexplored, with only a handful of wells having been drilled for hydrate evaluation in the Gulf of Mexico and the Pacific and Atlantic seaboards.
- The commercial viability of gas hydrate reservoirs is not yet known. Only a very limited number of production tests have been conducted to date, though these have shown positive results. A series of controlled scientific field experiments, followed by extended duration production test wells and leading to commercial-scale multi-well demonstrations, are needed to determine the rates and volumes at which methane can be extracted and to assess the potential environmental impacts.
- Multiple gas hydrate production scenarios are under evaluation. Simple depressurization seems to hold the most promise in terms of potential rates; however, methane production via carbon dioxide (CO_2) injection (and sequestration) has shown potential in the lab. Data from the first field trial of this approach, just completed in April 2012, are currently under study.
- The environmental impacts of potential gas hydrate production scenarios (such as movement of liberated methane and geomechanical stability of produced reservoirs) must be closely studied in the lab through modeling and by being closely monitored during field tests.
- A need for a fuller understanding of gas hydrate's role in the potential release of methane (a powerful greenhouse gas) into the natural environment, including its impacts on the health of the oceans and as a potential near-term feeback to climate change.

Project Portfolio Overview

Since 2009, 48 different projects under the Methane Hydrates Program have received funding. The efforts represent a total potential value of roughly $150 million, including both government and non-government costs. The bulk of the funding supports large field programs being conducted through partnerships with industry and academia and supported by work conducted with DOE's National Laboratories and the collaborating federal agencies. A 2010 review of the gas hydrate program, conducted by the National Research Council, can be found at http://www.nap.edu/catalog.php?record_id=12831.

Investigations of the production potential of gas hydrates are currently utilizing the natural laboratory of the North Slope of Alaska to pursue a range of field test options. The current portfolio includes the following:

- ConocoPhillips and the Japan Oil Gas and Metals National Corporation have recently completed a field trial in the Prudhoe Bay region to assess the potential for injecting CO_2 into a gas hydrate reservoir where it will be sequestered while releasing the methane (CH_4) for use as an energy resource.
- BP Exploration Alaska is continuing to pursue options to evaluate gas hydrate resources within the Milne Point unit of the Alaska North Slope. Previous work conducted at the Mount Elbert site in the Milne Point unit in 2007 has successfully demonstrated arctic gas hydrate assessment technologies, provided critical reservoir data that enable advances in international modeling capabilities, and confirmed that methane can be produced from gas hydrates via depressurization.

Recent and ongoing investigations of the nature and occurrence of marine gas hydrate resources include the following:

- Chevron, through its leadership of an international industry consortium (Joint Industry Partnership), has conducted a range of field and laboratory studies to assess the implications of gas hydrate occurrence in the Gulf of Mexico. A 2005 expedition provided major advances in gas hydrate remote detection and an analysis of drilling hazards. A 2009 expedition confirmed gas hydrate prospecting methodologies, provided initial validation of very promising Department of Interior gas hydrate resource estimates, and confirmed the existence of resource-quality gas hydrate accumulations in the Gulf of Mexico. The program is now focused on the development of required devices that will enable the sampling and evaluation of these occurrences.
- Fugro GeoConsulting, Inc. and the Consortium for Ocean Leadership are developing detailed scientific and operational plans and recommendations for future offshore drilling, logging and pressure coring campaigns
- NETL is working with the U.S. Geological Survey and the BOEM on a USGS-led effort to acquire high-resolution imaging and multi-component acoustic data needed to characterize gas hydrate-bearing sediments at the Gulf of Mexico gas hydrate occurrences discovered by the DOE-funded Gas Hydrate Joint Industry Project during 2009 drilling.
- Ohio State University is conducting research in collaboration with the BOEM to access well data from more than 1,700 deepwater wells to evaluate indications of gas hydrate in the northern Gulf of Mexico;
- The geophysical evaluation of gas hydrates is being advanced through separate projects with Oklahoma State University and with Fugro GeoConsulting which utilize extensive log data gathered over two Gulf of Mexico deepwater sites in 2009.
- Bilateral agreements have enabled DOE participation in international field studies of gas hydrates, including India (2006) and Korea (2007 and 2010).
- The University of Texas-Austin is developing conceptual and numerical models to analyze conditions under which gas may be expelled from existing accumulations of deepwater gas hydrate into the overlying ocean

Recent investigations of the environmental role of gas hydrates included the following:

- Southern Methodist University, in collaboration with the USGS, Oregon State, and others, are conducting numerical modeling, field data collection, and experimental studies to characterize the contemporary state of gas hydrates at the landward feather edge of stability on the Alaskan Beaufort continental slope and to predict their response to ongoing climate warming. This effort is coordinated with ongoing work by the USGS to assess similar gas hydrate issues on the inner Beaufort Shelf. In a separate, but related effort, the University of California at San Diego is developing a new electromagnetic (EM) remote sensing system for very shallow water use and will apply the system to determine the extent of "relict" permafrost on the Beaufort inner shelf.

- Oregon State University is generating computer models that will enable researchers to interpret modern day methane fluxes and reconstruct past episodes of methane flux in gas hydrate-bearing regions from shallow geochemical data. In an allied effort, the University of New Hampshire is reconstructing the history of methane flux at three sites on the Cascadia margin using sedimentological data.
- The University of Mississippi are investigating the use of time-series, direct current resistivity methods to investigate temporal variations in gas hydrate occurrence at cold vent sites on the continental slope of the northern Gulf of Mexico.
- The Naval Research Laboratory (Rick Coffin, PI) will provide geochemistry expertise in a collaborative field program with New Zealand and Germany to investigate climate-driven changes in gas hydrate stability on the Hikurangi margin, offshore New Zealand
- The Lawrence Berkeley National Lab and Los Alamos National Lab will complete an ongoing effort to couple leading gas hydrate reservoir simulators and ocean circulation models to enable predictions of the response of marine gas hydrates to changing conditions and the potential impact of methane hydrate destabilization on ocean ecology.

These field efforts are supported by a wide range of fundamental science investigations, including the following:

- An international modeling consortium (led by NETL) that has enabled significant advances in all the leading methane hydrate numerical simulators.
- Experimental efforts at Georgia Tech, Lawrence Berkeley National Laboratory, NETL, and elsewhere that have advanced the understanding of the physical nature of gas-hydrate-bearing sediments.
- Georgia Tech is investigating the behavior of gas hydrates hosted in fine-grained sediments to further evaluate the potential to produce gas from such deposits.
- The Colorado School of Mines is conducting laboratory experimentation to further the ability to determine the concentration of gas hydrates in deep sediments using seismic data.
- Wayne State University is providing improved parameterization of capillary pressure and relative permeability phenomena for use in the numerical simulation of gas hydrate dissociation and gas production.
- The Lawrence Berkeley National Lab is continuing its program of integrated laboratory and numerical modeling efforts designed to enable the accurate prediction of gas hydrate response to depressurization-induced production. Pacific Northwest National Lab is completing ongoing modeling efforts focused primarily on the evaluation of the CO_2-CH_4 exchange.
- NETL is conducting a range of experimental and numerical modeling studies designed to enable improved planning, implementation, and interpretation of DOE-sponsored field programs related to gas hydrate resource potential.

Together, these projects are advancing marine resource characterization and enabling initial assessments of gas hydrate production potential through Arctic field tests. International collaboration continues to be a vital part of the program since gas hydrates represent research challenges and resource potential that are important on a global scale. The fundamental science insights needed to properly plan and evaluate the field data are being provided through a range of efforts in the laboratory and through numerical modeling.

Recent key accomplishments include:

- Characterization of potential testing sites on the Alaska North Slope, including the drilling and evaluation at the Ignik Sikumi test site in 2011 and a three-month production trail of CO_2-CH_4 exchange technology during early 2012.
- Confirmation of the ability to reliably detect and characterize gas hydrate accumulations prior to drilling.
- Confirmation of the occurrence of resource-quality gas hydrate accumulations in the Gulf of Mexico.
- Acquisition of data in Alaska that has enabled the first quantification of technically recoverable resource volumes from gas hydrates.
- Development of new tools to enable measurement of the physical properties of gas hydrate-bearing sediment samples acquired in the field.
- Development of collaborative agreements with leading global gas hydrate research programs.
- Expansion of numerical modeling capability to enable the first field-scale production, geomechanical stability of hydrate bearing sediment, and gas hydrate-climate change simulations.

Overall, the Gas Hydrates program is working to advance the science and technologies necessary to fully understand the energy resource and environmental implications of naturally-occurring gas hydrate.