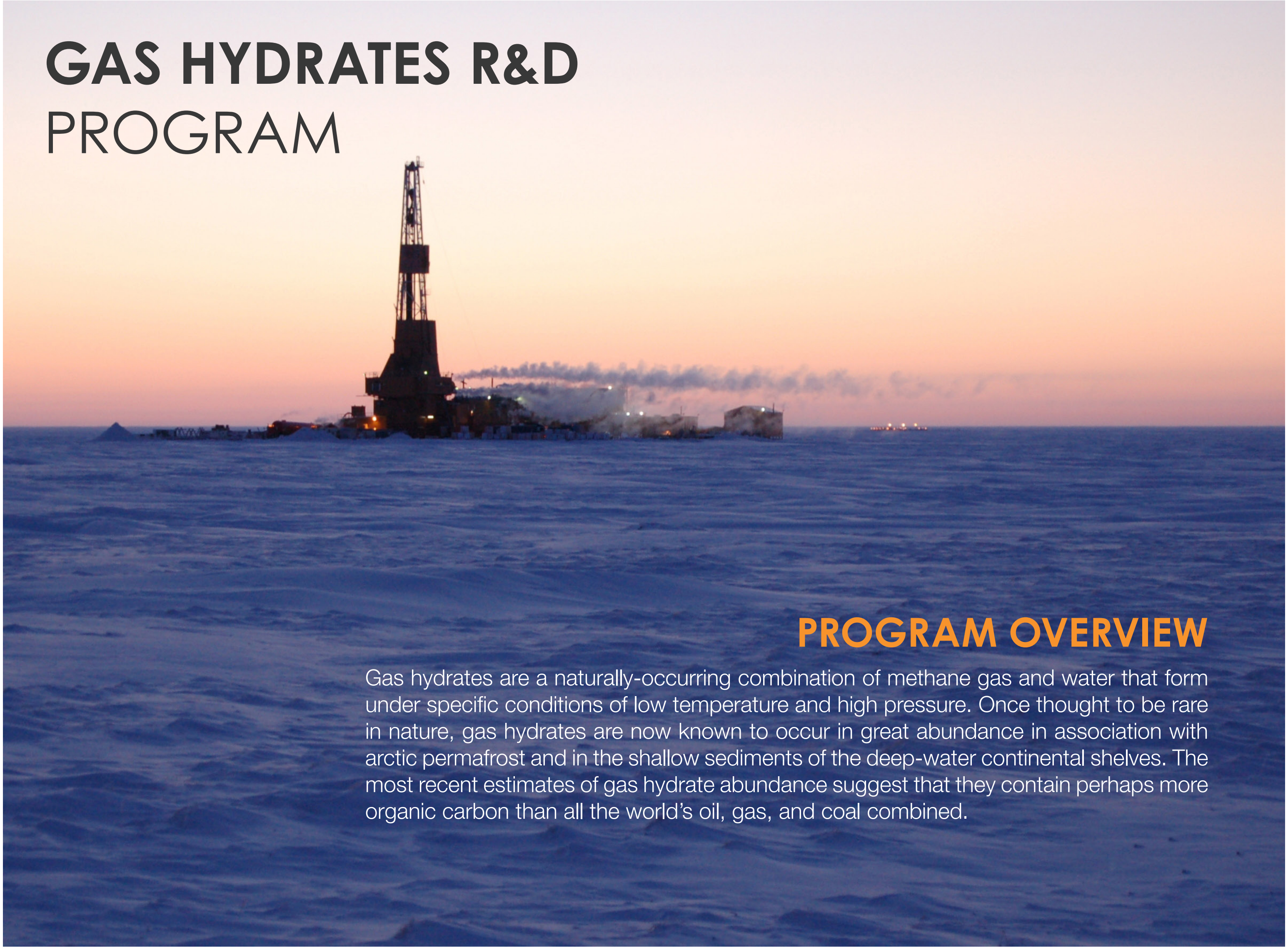
GAS HYDRATES R&D PROGRAM



PROGRAM OVERVIEW

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 than all the world's oil, gas, and coal combined.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

The primary mission of the Gas Hydrates R&D Program is to collaborate with industry, academia, international research organizations, and other U.S. government agencies to advance scientific understanding of gas hydrates as they occur in nature so that their role as a resource and in the environment can be more fully understood. 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 complex drilling and coring programs. The second is to develop the technologies needed to safely and efficiently find, characterize, and recover methane from hydrates through field testing, numerical simulation, and laboratory experimentation. The third is to better understand gas hydrates' role in the natural environment.

THE ISSUES

Gas hydrates have only relatively recently been recognized to exist at a massive scale in the natural environment. This finding has prompted research that, in turn, has highlighted three important issues:

- Gas hydrates are potentially a significant source of clean-burning natural gas for meeting future domestic energy needs. Large volumes are available in Alaska. The U.S. Geological Survey (USGS), in 2008, reported a mean estimate of 85 trillion cubic feet of technically recoverable resource. This could supply Alaskan native communities, broaden U.S. gas supplies, and enable access to other Arctic resources, including stranded conventional gas. In the Gulf of Mexico, the marine in-place gas hydrate resource in the most favorable reservoir settings has been assessed by the 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.

- The opportunities for international scientific collaboration on methane hydrate research have never been greater. International interest and investment is high, because gas hydrates have the promise of providing supplemental energy resources to a number of economies that are largely and increasingly reliant on energy imports.

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 Gas Hydrates home page:
https://www.netl.doe.gov/oil-gas/gas-hydrates

Fire in the Ice: A periodical highlighting the National Methane Hydrate R&D Program: http://www.netl.doe.gov/research/oil-and-gas/methane-hydrates/fire-in-the-ice

DOE's Office of Fossil Energy Methane Hydrate web page: http://energy.gov/fe/science-innovation/oil-gas-research/methane-hydrate

- Unintended dissociation of gas hydrates while drilling to and 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. However, this issue has only recently begun to be studied in detail.

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

- 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 respect to methane hydrates. Only a handful of wells have 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. A very limited number of production tests have been conducted to date, with the first deepwater test occurring offshore Japan in 2013. A series of controlled scientific field experiments, followed by extended duration production tests that lead to commercial-scale multi-well demonstrations, are needed to quantify the rates and volumes at which methane can be extracted and to assess any potential environmental impacts.

- Multiple gas hydrate production scenarios are under evaluation. Simple depressurization holds the most promise in terms of potential rates. However, methane production via carbon dioxide (CO_2) injection (and storage) and thermal stimulation may have roles in what will ultimately become the optimal production system.

- The potential environmental impacts of possible gas hydrate production scenarios (such as movement of liberated methane and geomechanical stability of produced reservoirs) are not yet known. These must be closely studied through laboratory modeling and closely monitored field tests.

- There is need for a more robust understanding of gas hydrates' role in the natural environment, including the potential for release of methane (a powerful greenhouse gas) into the natural environment and its impact on the health of the oceans.

PROJECT PORTFOLIO OVERVIEW

Since 2009, more than 50 projects under the Methane Hydrates Program have received funding. The efforts represent a total potential value of roughly $160 million, including both government and non-government costs. The bulk of the funding supports field and laboratory programs conducted through partnerships with industry and academia and supported by work conducted with DOE's national laboratories and collaborating federal agencies.

Investigations of the production potential of gas hydrates have used the natural laboratory of the Alaska North Slope to pursue a range of scientific field experiments.

- DOE/NETL, JOGMEC, USGS, and Petrotechnical Resources of Alaska are working together to provide specific planning, analytical, arctic engineering, and environmental services associated with the drilling of methane hydrate stratigraphic test well(s) and a long-term methane hydrate prodcution test well(s) on the North Slope of Alaska.

- NETL maintains separate memoranda of understanding with the State of Alaska's Department of Natural Resources (DNR) and the Japan Oil, Gas, and Metals National Corporation (JOGMEC) designed to advance opportunities for gas hydrate field-based research on the Alaska North Slope. DOE and JOGMEC are currently working with the USGS and Petrotechnical Resources, Alaska to develop field testing plans and engage potential industry partners.

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

- The University of Texas at Austin is currently leading the effort to conduct gas hydrate sampling at the Gulf of Mexico sites discovered in 2009, and to pursue further advances in gas hydrate exploration and resource confirmation.

- The University of Texas, Ohio State University, and Columbia University are using the 2009 data to investigate the nature and formation of marine accumulations.

- Georgia Tech developed a prototype of the borehole tool for the characterization of hydrate-bearing sediment properties.

Recent and ongoing investigations of the environmental role of gas hydrates include:

- The University of Texas at Austin change to developed models to assess conditions under which gas may be expelled from deepwater gas hydrate into the overlying ocean.

- Oregon State change to developed in an international investigation of gas hydrate response to climate change offshore Norway.

- Texas A&M and Georgia Tech developed and validated a fully coupled numerical model that advances the ability to integrate geomechanics into simulations of the behavior of hydrate deposits.

- Southern Methodist University, the USGS, Oregon State, and others conducted numerical modeling, field data collection, and experimental studies on constraining the nature of gas hydrates on the U.S. Arctic and Atlantic shelves and their response to environmental change.

- The University of Washington investigated gas hydrates in the Pacific Northwest and discovered that continued warming of North Pacific Intermediate Water has the potential to impact the methane hydrate reservoir in sediments at greater depths along the slope.

- Oregon State University developed Crunch-Flow based modules that 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 investigated the history of methane flux at three sites on the Cascadia margin using sedimentological data.

- The University of Rochester will advance understanding of the environmental implications that methane leaking from dissociating gas hydrates could have on the ocean-atmosphere system. It will also enhance knowledge of the distribution and amount of methane emissions from the U.S. Atlantic Margin upper continental slope in the mid-Atlantic zone.

- Texas A&M University is leveraging prior NETL research and its own data to study the fate of methane in water columns. This effort will result in new analysis and improved models that will help to clarify hydrate's role in the global natural environment.

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

- An international modeling consortium (led by NETL) that has catalyzed significant advances in all the leading methane hydrate numerical models.

- 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 investigated the behavior of gas hydrates hosted in fine-grained sediments to further evaluate the potential to produce gas from such deposits. production.

- The Lawrence Berkeley National Lab is continuing its program of integrated laboratory and numerical modeling to enable the prediction of gas hydrate response to depressurization-induced production.

- Pacific Northwest National Lab is using the STOMP-HYD code for evaluation of the CO_2-CH_4 exchange.

- NETL is using PetroMod petroleum systems models to investigate the evolution and dynamics of gas hydrate systems in the deepwater Gulf of Mexico.

- NETL conducted 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.

- The University of Texas at Austin is conducting a laboratory evaluation of the dynamic petrophysical attributes of gas hydrate–bearing sands in response to pressure reduction at macro- and micro-scale. This research will enhance understanding of hydrate system behavior, improve the ability to simulate hydrate production, and make more realistic estimates of the hydrate resource.

- Louisiana State University conducted a laboratory evaluation of the migration of fine-grained particles during gas production, with a specific focus on factors unique to gas production from hydrate-bearing sediments.

- Texas A&M University is advancing the capabilities of a leading integrated model for hydrate system behavior. The research will increase understanding of deep oceanic and arctic hydrate deposits and will yield simulation capabilities useful in assessing and predicting production-related performance of hydrate deposits.

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

ACCOMPLISHMENTS/PROGRAM SUCCESS

Key accomplishments of the program to date are described briefly below.

Field Programs:

- Confirmation of the occurrence of resource-quality gas hydrate accumulations in the Gulf of Mexico—including successful drilling, logging, and sampling of test wells at multiple sites in the Gulf of Mexico; confirming the presence of high gas hydrate saturation in sand reservoirs; and, most recently (May 2017), successful pressure core sampling, with recovery of approximately 30 meters of undisturbed hydrate-bearing sediments for laboratory analysis.

- Successful proposal submission and selection by the International Ocean Discovery Program for a large-scale, offshore gas hydrate research expedition at rigorously selected sites in the Gulf of Mexico (currently planned for January 2020).

- Confirmation of the occurrence of technically-recoverable gas resource volumes from hydrate accumulations on the North Slope of Alaska—including drilling and evaluation of methane hydrate deposits in the Mount Elbert (2007) and Ignik Sikumi (2011) test wells; and a successful three-month production trial of CO_2-CH_4 exchange technology at the Ignik Sikumi site (2012).

- Selection of a preferred location for future testing within the west end of Prudhoe Bay Unit which includes known gas hydrate, existing infrastructure, and no ongoing industry activity.

- Successful sampling and analysis of sediments off the coast of Svalbard, to understand gas hydrate mounds, gas hydrate pavements, and methane seepage and the relationship of these phenomena to environmental change in the arctic.

- In December 2018, Prudhoe Bay Unit owners, DOE/NETL, working in partnership with the Japan Oil, Gas and Metals National Corporation, the U.S. Geological Survey (USGS), and Petrotechnical Resources-Alaska, successfully drilled and logged an initial test well (Stratigraphic Test Well) in the greater Prudhoe Bay oil field that has confirmed the occurrence of gas hydrates in two reservoirs that are suitable for potential future testing.

Tool Development and Experimental Work:

- Development of new tools to aid sampling and analyzing methane hydrate properties—including instruments for measuring physical properties of gas hydrate-bearing sediment samples in the field; pressure coring devices for sample collection, retrieval, and transport at controlled pressures; and pressure core characterization tools for analyzing acoustic, geomechanical, and hydrological properties of samples in a laboratory setting.

- Advances in understanding methane hydrate properties, owing to experimental laboratory work on pressurized core specimens from domestic and international hydrate research expeditions.

Modeling and Analysis:

- Expansion of numerical modeling capabilities to enable the first simulations of field-scale production of gas from hydrates; simulations for predicting geomechanical stability of hydrate-bearing sediment and hydrate-bearing reservoirs; and simulations of gas hydrate-climate interactions.

- Confirmation of the ability to reliably map and characterize gas hydrate accumulations prior to drilling, using seismic and well log information.

International Collaboration:

- Ongoing development of collaborative agreements with leading global gas hydrate research programs—primarily with international hydrate programs in Japan, India, South Korea, and China.

Based on these critical results and ongoing research activities, the Gas Hydrates Program is working to advance the science and technologies necessary to fully understand the energy resource potential and environmental implications of naturally-occurring gas hydrate.

NATIONAL ENERGY TECHNOLOGY LABORATORY

Contacts

Jared Ciferno
Technology Manager
Oil & Gas Program
Jared.Ciferno@netl.doe.gov

Gabby Intihar
Program Manager
DOE Office of Fossil Energy (FE-30)
gabby.intihar@hq.doe.gov