13038

A Collaborative Approach to Methane Hydrate Research and Development Activities

Brad Tomer, Hugh Guthrie, and Tom Mroz U.S. Department of Energy, National Energy Technology Laboratory and Ray Boswell, EG&G Services

Abstract

It is now clear that methane hydrates contain enormous volumes of natural gas and have the potential to play a major role in future global energy supplies. Recent developments indicate that the prospects for economic production of methane from hydrates are good, and could occur much sooner than previously thought. To ensure that the United States remains a leader in hydrates research and technology, the Department of Energy's (DOE) Strategic Center for Natural Gas (SCNG) at the National Energy Technology Laboratory (NETL) is charged with coordinating a comprehensive national research and development program in all aspects of methane hydrates. In advance of attempts at commercial exploitation, our program will support fundamental studies that will improve the understanding of the nature of hydrates, the impact of hydrates on the strength and stability of ocean-bottom sediments, and the interaction of the global hydrate reservoir with the world's oceans and atmosphere. This report outlines these key methane hydrate research and development (R&D) issues, reviews DOE's past and current hydrate programs, and outlines our plans for a coordinated and collaborative R&D program in which the nation's best minds are efficiently brought to bear on the challenge of maximizing the potential benefits of natural methane hydrates.

Introduction

At present, the United States is relying on the accelerated use of clean and affordable natural gas to simultaneously achieve aggressive economic and environmental goals. Fundamental to this strategy is an abundant and affordable supply of domestic natural gas. However, there are increasing concerns about the surety of this supply. In a recent workshop on post-2020 gas supplies held at the DOE's NETL, most organizations agreed that a new source of supply would most likely be needed by the year 2030. That new source will likely be methane hydrates.

Clearly, no one institution has the resources and the expertise to quickly resolve the many issues and technological challenges surrounding the possible exploitation of methane hydrates. Similarly, a series of parallel, duplicative, and uncoordinated efforts will inevitably delay results and may leave key questions unanswered. The NETL believes that a nationally coordinated, collaborative effort is needed, and is committed to supporting a program of allied and focused investigations by the nation's leading researchers on all fronts of the methane hydrate issue.

Methane Hydrate R&D Issues

Methane Hydrates are the most abundant natural form of *clathrate* - unique chemical substances in which molecules of one material (in this case, water) form an open solid lattice that encloses, without chemical bonding, appropriately-sized molecules of another material (in this case, methane). Recent investigations have revealed that the widespread occurrence of both methane and water allows methane hydrates to accumulate virtually everywhere pressures and temperatures are suitable. As a result, evidence of hydrates is being discovered at relatively shallow depths beneath arctic permafrost and within the fine-grained clastic sediments on the slopes and rises of continental shelves around the world. Of critical importance is the growing realization that, not only is the amount of methane held in this reservoir huge, but the reservoir itself is in constant flux, absorbing gas from below, releasing gas above, and continually equilibrating to changes in pressure, temperature and geochemical regimes. The implications of this vast, dynamic, and previously unnoticed methane reservoir on the global carbon cycle, long-term climate, seafloor stability, and global economics and energy policy, are only now being widely investigated.

DOE's Methane Hydrates program is driven by the need to better understand the nature of hydrates, hydrate-laden sediments, and the interaction between the global methane hydrate reservoir and the world's oceans and atmosphere. This effort will focus on two key-energy supply goals. First, we will support work that will enhance the safety of deep-water oil and gas E&P operations that require drilling through overlying marine hydrate deposits. Second, the DOE is committed to ensuring the long-term supply of natural gas by developing the knowledge and technology base to allow commercial production of methane from domestic hydrate deposits by the year 2015.

To achieve our goals, much must be learned. As a result, the DOE program supports work to improve the *characterization* of hydrates through laboratory study, direct observation, and remote sensing of hydrate deposits. This work will support both theoretical and field studies of the role of methane hydrates in both *sea-floor stability* and *global climate* phenomena. Ultimately, improved understanding of the hydrate reservoir will allow for development of effective and responsible methane hydrate *production technologies.*

Characterization: Characterization is a broad category of research intent on describing the basic nature of hydrates. Issues include natural hydrate forms, stability, and occurrence, as well as the nature and physical properties of hydrate-bearing sediments.

To date, the study of natural hydrates has been greatly complicated by two factors: 1) they are restricted to remote arctic and deep-water locations; and 2) hydrates quickly dissociate when removed from their natural temperature-pressure environment. Consequently, much is unknown about the variety of physical forms, levels of methane saturation, or the impacts various other chemical and physical parameters have on natural hydrates. Effective study will require a combination of controlled laboratory studies of pure hydrate and hydrate-sediment mixes, as well as coordinated expeditions to observe and collect hydrates in their natural settings. Better understanding of the physical and chemical process of hydrate formation, dissociation, and interaction with the natural environment will be the key first step to unlocking the role hydrates play in sea-floor stability, climate, and future energy supply.

Perhaps the key ongoing area of investigation in hydrate characterization is the refinement of the geophysical tools used to remotely sense the presence and discern the qualities of hydrate-bearing sediment sequences. Presently, the existence of bottom-simulating reflectors on conventional single-component seismic data is the primary tool in determining the presence/absence of hydrate. Advanced multi-component seismic that can detect the changes in the mechanical properties of marine sediments caused by hydrate presence will be the key to the allowing remote determination of hydrate volumes, concentrations, and modes of occurrence.

Sea-floor Stability: The presence of methane hydrate within the shallow sea floor greatly alters the physical character of the sediment. The crux of R&D in the area of sea-floor stability is to understand the role of natural or induced hydrate dissociation in increasing the instability and possible failure of ocean-bottom sediments. One area of immediate concern is the stability of the sea floor in the vicinity of oil and gas exploration facilities. Increasingly, exploration and production of oil and gas reservoirs in ultra-deep water will require operators to drill through hydrated intervals. Transit of produced fluids from deeper, hotter formations through boreholes transecting hydrate layers may promote hydrate dissociation and sediment instability. Resulting sea-floor movement can pose significant safety hazards and destroy sea bottom installations, pipelines, and production facilities.

On a larger scale, the natural periodic dissociation of hydrate, particularly at the margins of the deposit where the pressure-temperature conditions never stray far from the phase boundaries, can greatly weaken the strata of continental shelves. Studies along the Atlantic margin have shown a clear correlation between the up-dip termination of the zone of methane hydrate stability and the occurrence of submarine slope failure. It is likely that natural changes in sea-bottom temperatures and pressures may initiate the dissociation of hydrate, promoting such failures. More significantly, larger slides may trigger devastating tsunami. More needs to be known, including the impact that potential hydrate production may have on the stability of sea-floor sediments.

Global Climate: The global hydrate reservoir holds vast volumes of methane in close proximity to the sea floor. Many natural phenomena, including global temperature cycles, changes in sea level, and ongoing processes of erosion and deposition, continually alter the temperature and pressure profiles in the shallow sea-bottom sediments. As a result, there is a possibility of periodic, and perhaps massive, release of methane into the seawater, and eventually, the atmosphere. One current hypothesis is that sea-level drop during periods of glacial maxima results in sea-floor pressure reduction and dissociation of hydrates that contributes to the observed abrupt termination of ice ages through the massive input of the "greenhouse gases" methane and CO_2 (through methane oxidation) into the atmosphere. Clearly, more needs to be known on this important topic.

Resource Potential: The amount of energy trapped in natural gas hydrates is immense. The crystallization of the hydrate packs methane so efficiently that their energy density (btu/ft^3) is roughly 180 times that of conventional free gas deposits. Although only a handful of natural hydrate accumulations have been studied in any significant detail, it now appears certain that a global hydrate reservoir, dominated by methane, exists. Estimates of the volume of methane contained within hydrates have varied considerably, however, a rough median value on the order of 700,000 trillion cubic feet (Tcf) at standard temperatures and pressure persists. Domestically (within the U.S. Exclusive Economic Zone), the volume is generally considered to approximate 200,000 Tcf. Because most of the data thus far collected only indicate the presence, and not the concentration, of hydrate, further and perhaps significant refinement of these numbers will occur as tools are developed to allow more sites to be studied in detail.

R&D into the production potential of methane hydrates will focus on two issues; 1) the characteristics necessary of a hydrate accumulation to allow feasible production; and 2) production strategies that will be most effective in allowing safe, cost-effective recovery. No one doubts that the conversion of natural methane hydrates into a viable resource will pose enormous technical challenges. The most obvious difficulty is that the vast bulk of methane hydrate occurs as diffuse and widespread deposits located beneath deep waters. Therefore, economic recovery will probably require the identification of select areas ("sweet-spots") of unusually high hydrate concentration. In addition, certain minimum characteristics may also be required for the enclosing sediment. Initial research on hydrate production strategies will likely focus on the relatively less challenging permafrost accumulations. For the marine occurrences, however, advanced seismic imaging technologies will be needed for prospect delineation. Once sites are identified, complex strategies will likely be required to convert the solid hydrate to gas *in situ*. These efforts will require accurate models of hydrate dissociation and resulting methane flow tailored to either temperature increase or pressure decline. Extraction may rely on technologies utilizing multiple, branched horizontal drilling with some branches achieving dissociation and others collecting the produced methane. Other methods, including submarine mining, may also be feasible. Considerable work remains to be done.

In order to estimate the amount of methane that hydrate deposits may be capable of contributing to supply, one must estimate the likely percentage of the hydrate in-place resource that can be expected to be economically recoverable given likely advances in technology. For example, consider that the U.S. domestic natural gas *recoverable resource* of roughly 2,300 Tcf (1,400 Tcf remaining and 900 Tcf produced), is derived from an *in-place resource* that could easily range upwards from 25,000 Tcf if ever quantified. In the case of methane hydrates, if several large "sweet spots" can be located in US waters, the target hydrate resource base could exceed 5,000 Tcf (2.5% of the 200,000 Tcf total). Assuming technologies can be developed that will allow recovery of at even half the rate obtainable in "conventional" reservoirs, the ultimate recoverable hydrate resource could range from 1,500 to 2,000 Tcf. The allure of hydrates is that this volume, which may be less than 1 percent of the total in-place methane hydrates resource, would still more than double the nation's current estimated remaining recoverable domestic resource from all discovered and undiscovered natural gas reservoirs. This potential clearly calls for an accelerated and coordinated national R&D program.

Background to the Current DOE Methane Hydrates Program

First Phase of US DOE Methane Hydrates Research: 1982-1992. Before the 1980s, methane hydrates were only known to exist as a natural oddity beneath the permafrost of Siberia, as a nuisance in natural gas pipelines, and in the laboratories of chemists. That all changed in 1981 with the retrieval by *Glomar Challenger* of a seafloor core off the Guatemalan coast. Studies of the hydrate-bearing core conducted at the DOE's Morgantown Energy Technology Center, now part of the NETL, and other labs, prompted a new effort by DOE's Office of Fossil Energy to study the physical and chemical properties of hydrates, the mechanisms for their formation and dissociation, and the geological characteristics of marine and Arctic hydrate formations. From 1982-1992, DOE's methane hydrate program spent $8 million in developing a foundation of basic knowledge about the location and thermodynamic properties of gas hydrates. In particular, the DOE collaborated with many other organizations to:

- establish the existence of hydrates in the Kuparuk Field on the north slope of Alaska;
- complete studies of 15 offshore hydrate basins;
- develop alternative models for production of methane through both the depressurization and heating of hydrates;
- develop preliminary estimates of gas-in-place for hydrate deposits; and
- build the *Gas Hydrate and Sediment Test Lab Instrument,* a device that can simulate deep-sea conditions to allow testing of the properties of hydrate-bearing sediment.

DOE's initial phase of methane hydrate research ended as priorities temporarily shifted to more near-term exploration and production R&D. However, work continued at relatively small scales at the United States Geological Survey (USGS), universities, other laboratories, and overseas. Recently, the results of the Ocean Drilling Program (ODP) Leg 164 over the Blake Ridge indicated the potential for higher than expected hydrate accumulations. At the same time, expanding industry activity in the hydrate-prone areas of the Arctic and the deep-water continental shelves has made it immediately important to better understand the nature and dynamics of these deposits that must be drilled through and dealt with. Lastly, the U.S. research community has taken note of the significant spending on hydrate R&D that is occurring in Japan, India, and elsewhere, and is not willing to be merely a follower in this critically important exercise. As a result, the DOE hydrates program was re-started.

Preparation for Second Phase: Industry Workshops. In 1997, DOE initiated the planning for a multi-agency national gas hydrates program. Two workshops were conducted in 1998 to scope out the initial goals and activities of the program. These efforts produced *"A Strategy for Methane Hydrate Research and Development"* which was published in August 1998. This document was followed in June of 1999 with the *"National Methane Hydrate Multi-Year R&D Program Plan"*. The program focused on four areas: resource characterization, drilling safety and sea floor stability, global climate change, and production.

Funding for FY99 methane hydrate R&D efforts totaled approximately $500,000. Activities included resource characterization in the Arctic and Gulf of Mexico with the USGS and the Naval Research Lab (NRL), and membership in the gas hydrates consortium at the Colorado School of Mines.

Current Program – A Collaborative Effort

Funding for methane hydrates R&D grew to $2,960,000 for fiscal year 2000. With this funding, NETL continued sponsorship of the FY99 programs and initiated several new projects. Two rounds of proposals were received under program solicitation (PS) DE-PS26-00FT40759, entitled "Development of Technologies and Capabilities for Fossil Energy-wide Coal, Natural Gas, and Oil R&D Programs." Four methane hydrate projects were selected for funding out of those two rounds. In addition, the NETL selected four National Lab Projects under a National Lab Solicitation. Further, in FY00 NETL participated in the multi-country research well on the MacKenzie Delta in the Northwest Territories of Canada that provided an opportunity to drill, sample, and test a known hydrate reservoir located in an onshore environment. NETL will provide approximately $340,000 to the project directly and additional funds through Lawrence Berkley National Laboratory (LBNL). The following sections describe our current portfolio of projects which range from fundamental laboratory studies of pure hydrates to direct field observation and sampling, to modeling of potential hydrate production schemes.

Laboratory Characterization of Pure Hydrate: Description of the physical properties of pure gas hydrate is a critical first step in understanding the behavior of naturally occurring hydrate. The NETL supports the USGS's petrophysics laboratory (Menlo Park, California) in providing measurements of the composition, texture, thermal properties, stability, strength, and rates of gas-solid exchange in both porous and compacted hydrates. These efforts are being complimented by work at Brookhaven National Laboratory (BNL) to characterize the chemical bonding, structure, thermodynamics and kinetics of gas hydrates using both natural and synthetic samples. BNL is also working to track methane hydrate formation, observe the rate at which methane hydrates are formed, and estimate the amount of methane in typical hydrates. In addition, NETL's own on-site effort includes experimental work to obtain thermal conductivity information on pure hydrates and hydrate/sediment mixtures. Each of these studies will contribute to the basic understanding of hydrates and to the development of theoretical models that will improve the prediction of hydrate behavior over a wide range of conditions.

Laboratory Characterization of Hydrate-bearing Sediments: New data on the physical properties of pure hydrates are utilized in numerous studies supported by NETL that strive to uncover the composite properties exhibited by hydrate-bearing sediments. These efforts are key to 1) understanding the effect hydrates have on sediment strength and stability; 2) allowing correct interpretation of remote sensing data on hydrate sequences, and 3) improved modeling of potential hydrate production schemes. A key resource for these efforts is the GHASTLI (Gas Hydrate and Sediment Test Laboratory Instrument) System located at the USGS's laboratory in Woods Hole, Massachusetts. GHASTLI reproduces natural pressure/temperature conditions for testing of cores containing sediment, water, ice, and methane hydrate. The system allows measurement of key properties before, during and after hydrate formation or dissociation.

DOE's National Labs will conduct complimentary laboratory studies on a variety of issues involving sediment-hydrate properties. Lawrence Livermore National Laboratory will focus on the mechanical behavior of hydrates using synthetic hydrates and controlled mixtures of hydrates and sediment to simulate natural occurrences. Oak Ridge National Laboratory (ORNL) will use its Sea-floor Process Simulator (SPS) to simulate natural sea floor environments associated with gas hydrate occurrences. The SPS vessel will also be available for use by the other national laboratories involved in this cooperative research effort.

Finally, Clarkson University is contributing its multiphase flow laboratory to allow the physical characterization of gas hydrate and sediments during dissociation. Clarkson's experiments will help build a database of flow and pressure characteristics observed during hydrate dissociation.

Field Studies of Hydrate Occurrences: NETL supports a number of efforts to observe, sample, and characterize natural occurrences of hydrate in the Atlantic, Gulf of Mexico, Arctic Alaska, and Offshore Japan. In the Atlantic, we are working with the USGS's Woods Hole, Massachusetts's office on continued characterization of the Blake – Bahama Ridge hydrate accumulation. The work is utilizing a wealth of data accumulated over the last two decades through the Deep Sea Drilling Project and ODP and cooperative cruises to sample the structure. Currently, samples collected during the spring of 2000 are being analyzed to learn more about the dynamics of gas hydrate formation and dissociation in this area. Future work is planned as part of consortia research to date the geological features and define the structures in greater detail.

In the Gulf of Mexico, NETL will continue to work with the MMS and others to support direct sea-floor observations and sampling using the submersible *ALVIN*. Four dives conducted in late 2000 provided extensive reconnaissance of two potential sites for an upcoming Ocean Drilling Project leg, collected sea-floor samples, and provided direct observation of sea-floor hydrocarbon seeps. The data confirm both the presence of oil and shallow hydrate deposits at one of the locations and indicate the likely presence of both features at the other. Another ambitious project in the Gulf of Mexico will establish a remotely controlled station to monitor sea floor stability in the vicinity of known gas hydrate outcrops. This collaborative effort, co-funded by the MMS and NSF and coordinated by The University of Mississippi's Center for Marine Resources and Environmental Technology, will utilize 3–dimensional arrays of sensors that will monitor, record, and relay data from the sea floor to a rig platform where it will be transmitted to the participating researchers onshore. The station, which should be fully functional by 2004, will allow the continuous monitoring of temperature, pressure, currents, water chemistry and other parameters that can effect the formation and dissociation of hydrates in the near sea floor sediments. A live video feed is also planned for the site. The information will be invaluable in characterizing the shallow gas hydrate formation.

In Alaska, the NETL and the USGS have worked with industry partners to collect hydrates-related data from oil and gas wells drilled on the Alaska North Slope (ANS). This effort is a continuation of research funded and cooperatively run with the USGS Denver Office to characterize the gas hydrate bearing sediments first documented by industry drilling in the western Prudhoe Bay oil development activities in the 1970's. It is anticipated that these activities will continue as more of the ANS is developed over the next few years.

Finally, in Japan, NETL is sponsoring work by the Idaho National Engineering and Environmental Lab to collect in-situ samples of gas hydrate from the Nankai Trough. This deep ocean feature contains perhaps the most favorable reservoir quality and hydrates concentrations yet discovered, and may well be the first site for offshore production of methane from hydrates.

Remote Sensing of the Hydrate Reservoir: The key to widespread investigation, and ultimately, exploration of hydrates, is reliable and accurate means for remote sensing. The prime focus of these studies is to discern the presence, quantity, and characteristics of hydrates in sediments from measurement of the acoustic velocity of hydrated sediments. In the Atlantic, NETL and the NSF are co-funding work by the University of Wyoming and the University of Texas to collect new 3-D multi-component seismic data, and to use these data to map the distribution of hydrates and associated free gas. The study takes advantage of the uniform geologic character of Blake Ridge sediments to isolate the seismic response of hydrate zones. Early results from this effort show unique sedimentary structures and details of the dynamic nature of the hydrate/free gas interaction that has not been observed previously.

In the Gulf of Mexico, The University of Texas at Austin, Bureau of Economic Geology is working to test methods for reprocessing commercial, multi-component, seismic data to allow investigation of shallow subsurface layers. The capabilities of the advanced seismic to assess the impact of hydrate on the strength and stability of the enclosing sediment will be a key focus of the work. The Naval Research Lab is also working to evaluate the distribution of hydrates through acquisition of deep-tow seismic data. Success in these efforts will provide techniques for the widespread evaluation of hydrate resources and characteristics of vast areas of the Gulf of Mexico.

Modeling Hydrate Behavior: A key element in hydrates research will be the development of predictive computer models that will provide insight into the potential response of hydrate-sediment sequences to a variety of natural or man-made processes. As part of this effort, NETL has re-established the aggressive on-site modeling and simulation program that produced some of the earliest hydrate models in the 1980s. Our team will utilize the latest laboratory and field observations to produce new and improved model inputs and algorithms. Work will focus on potential production strategies, beginning with a simple case of production of free gas under a hydrate cap, then expanding to include production of gas from hydrates. In addition, LBNL will integrate geology, geophysics, and gas reservoir simulation with enhanced numerical codes to produce geological models of four different gas hydrate deposits representing permafrost and marine environments. The models are designed to improve the understanding of gas hydrate behavior in porous sediments, and emphasize operations or strategies for maximum resource recovery.

National Hydrates Databases*:* Critical to a massive collaborative effort such as this is the efficient widespread dissemination of information. The NETL has supported the USGS in development of a worldwide web site (http://walrus.wr.usgs.gov/globalhydrate) to provide details on all known gas-hydrate occurrences. In addition, NETL will be developing a web-site to provide current information on the status of all the efforts conducted within the program (the SCNG hydrates web-site). A second web-site will feature GIS products for various geological parameters affecting the hydrate resources of the Alaska and Gulf of Mexico regions.

Future Direction

Three significant events that occurred in FY00 have laid the groundwork for the future of NETL's hydrates program. In December 1999, the DOE established the Strategic Center for Natural Gas (SCNG) at NETL. On May 2, 2000, the President of the United States signed into law the Methane Hydrates Act of 2000. In August 2000, NETL and Chevron Petroleum Technology Corporation hosted an R&D planning workshop for hydrates in the Gulf of Mexico that help frame the priorities for NETLs FY2001 solicitation.

Role of the Strategic Center for Natural Gas: In December 1999 the Secretary of Energy established the SCNG at NETL. The purpose of the SCNG is to serve as a national focal point for all of DOE's natural gas programs "from borehole to burner tip." The Gas Exploration and Production program along with the methane hydrate program is part of the SCNG. In the upstream gas program, our goal is to coordinate all our efforts in order to remove redundancy and ensure that no important issues are ignored. This is true for all areas in the program including investigations into drilling, completion, and stimulation technologies, stripper well revitalization, secondary gas recovery, low-permeability resource development technologies, and methane hydrates. A key element in our work to coordinate an efficient and comprehensive national R&D effort in hydrates is to ensure that all relevant aspects of methane hydrates are well understood before commercial exploitation is attempted. This means full characterization of hydrate behavior, and an understanding of the roles hydrates play in areas like sea-floor stability, drilling safety, and global climate change.

Methane Hydrates Act of 2000: On May 2, 2000, Public Law 106-193 “Methane Hydrate Research and Development Act of 2000” was signed into law. The bill calls for the Secretary of Energy to commence a program of methane hydrate research and development. The bill authorizes a budget of $5M in FY01, $7.5M in FY02, $11M in FY03 and $12M each in FY 04 and FY05. In addition, the bill calls on the Secretary of Energy to coordinate with the Departments of Defense (NRL), Interior (MMS and USGS), Commerce (NOAA), and the National Science Foundation. Further, the bill specifies that an Advisory Panel of experts from industry, academia, and the Federal Government must be formed to advise on potential applications of methane hydrate; assist in developing recommendations and priorities for the methane hydrate research and development program; and, report to Congress.

In keeping with the requirements of the bill, DOE hosted the initial meeting with the named Federal agencies on January 19, 2001, and began charting a path forward. The purpose of these meetings is to discuss each agency’s hydrate program in order to minimize areas of duplication and identify opportunities to collaborate. This group will meet every 120 days as specified in the legislation.

In addition to coordinating with other agencies, DOE has established the Methane Hydrates Advisory Panel composed of industry, academia, and one national lab representative. The first meeting of this group is scheduled for April 2001. This group is charged with recommending research priorities for the program and for reporting to Congress after two years on the impact that hydrates have on global climate change.

***GOM Hydrates Workshop*:** In August 2000, the SCNG hosted a Gulf of Mexico Hydrates R&D Planning Workshop in cooperation with Chevron Petroleum Technology Company. Ninety-six people attended including an unprecedented number of industry participants from companies such as Marathon, Conoco, Chevron, Halliburton, Schlumberger, McDermott, Vastar (BP Amoco), Maurer Engineering, Exxon-Mobil, Unocal, Diamond Offshore Drilling, Total Fina ELF, Coastal and others. In addition, representatives from the Minerals Management Service, the United States Geological Survey, and the National Oceanic and Atmospheric Administration participated along with most of the National Labs and a host of Universities.

The purpose of the workshop was to develop a plan to address hydrate R&D needs in the areas of drilling safely, long-term production through hydrates, sea floor stability, resource characterization, and production technology in the Gulf of Mexico. In this workshop, participants were to define the major technical opportunities that can help achieve the vision and goals of the National Methane Hydrate Multi-Year R&D Program Plan with emphasis on the Gulf of Mexico. The workshop results will be used to guide the development of an action plan that will serve as a framework for industry and government in implementing collaborative R&D activities.

Workshop participants identified the following:

- Key barriers to meeting the hydrates program goals;
- R&D opportunities to overcome these barriers;
- Collaboration opportunities and an action plan; and
- Joint Industry Projects for potential funding over the next couple of years.

The resulting action plan allowed the development of a significant, industry-driven program including new R&D efforts selected through a solicitation which NETL plans to issue in early February 2001. In addition, DOE established a dialog within the industry on how to develop strategic alliances between industry, academia, and government. Several industrial members expressed interest in participating in the program with cash, in-kind contributions, and with personnel. The results of this workshop will improve the chance for success by providing a coordinated plan of action that should result in a Joint Industry Project in the area of hydrates

With the creation of the SCNG, the passing of the Methane Hydrates Act of 2000, and, the results of the GOM Hydrates R&D Planning Workshop, DOE is now prepared to continue moving forward with a large program that has participation and collaboration with government, industry and academia. To kick start the coordination, NETL is developing a database and a website for any organization working in hydrate research to use. The objective of this effort will be to:

- collect and organize hard-copy file of pertinent open file reports on gas hydrates;
- convert hard copy to PDF or other electronic format, and establish electronic databank of hydrate open file reports;
- create and update bibliography of outside publications on hydrates;
- create and update directory of hydrates researchers and their affiliations;
- create and update calendar of meetings on gas hydrates;
- create and update GIS index map of NETL hydrates projects, past and present and current.

In addition to the database and web site, NETL is planning to link all activities funded through the Lab. The goal is to have all researchers working together and communicating with each other in order to achieve common goals. To this end, NETL is developing new ways in which national labs can participate in solicitations with industry and universities, and allow industry representatives to review lab proposals and interagency work plans. In addition, NETL will host a yearly meeting similar to the GOM workshop which will afford everyone the opportunity to see what is going on in hydrate research and to input into the plan going forward. The goal is to foster communication between organizations.

Summary

In recent years, a consensus has emerged that a massive reservoir of methane housed in hydrates exists beneath the Arctic permafrost and along the slopes and rises of continental shelves around the globe. Research is now indicating that this global reservoir may profoundly impact both the stability of the sea floor and long-term climate. Furthermore, as conventional oil and gas production spreads into deeper waters, the necessity to drill through hydrate zones will also pose increasing safety hazards due to incidental hydrate dissociation and sediment movement. Nonetheless, ongoing R&D efforts in many nations are indicating that the commercial production of methane from hydrates is a real possibility, and may occur much sooner than previously thought. The immense benefits that a vast new methane source would have on the world economy require the full exploration of hydrate production technologies. In response, the DOE working to develop a coordinated and comprehensive national R&D effort to ensure that all aspects of natural methane hydrates are understood prior to attempts at commercial production. Through a program in which duplicative and isolated studies are discouraged in favor of complimentary and collaborative efforts, we can accelerate technical progress and ensure that no important questions are left unanswered.