ARCTIC POTENTIAL

Realizing the Promise of U.S. Arctic Oil and Gas Resources

National Petroleum Council
2015

National Petroleum Council

An Oil and Natural Gas Advisory Committee to the Secretary of Energy

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March 27, 2015

The Honorable Ernest J. Moniz
Secretary of Energy
Washington, D.C. 20585

Dear Mr. Secretary:

In response to your October 25, 2013 request, the National Petroleum Council conducted a comprehensive study considering the research and technology opportunities to enable prudent development of U.S. Arctic oil and gas resources. Today, there is both increasing interest in the Arctic for economic opportunity, and concern about the future of the culture of the Arctic peoples and the environment in the face of changing climate and increased human activity. Other nations, such as Russia and China, are moving forward with Arctic economic development. Facilitating exploration and development in the U.S. Arctic would enhance national, economic, and energy security, benefit the people of the north and the U.S. as a whole, and position the U.S. to exercise global leadership. Despite these benefits, there are diverse views on how to balance this opportunity with environmental stewardship. In April 2015, the U.S. will assume chairmanship of the Arctic Council, and during 2015, the Administration will complete its first quadrennial energy review. In this context, your request required a study that included the following:

- To put the U.S. opportunity and experience in global context, the study provides an integrated review of U.S. and global onshore and offshore Arctic oil and gas potential, Arctic environments, operating history, policy and regulatory practices, and development challenges
- An in-depth assessment of available offshore oil and gas technology, ongoing research, and research opportunities, in six areas: ice characterization; oil and gas exploration and development; logistics and infrastructure; oil spill prevention and response; ecology; and the human environment
- A broad group of participants with input from diverse backgrounds and organizations.

The Council found that the U.S. has large Arctic oil and gas potential that can contribute significantly to meeting future U.S. and global energy needs. The majority of the U.S. Arctic potential is undiscovered and offshore, in relatively shallow water depths of less than 100 meters. The technology to explore for and develop the majority of this U.S. potential is available today, based on a long history of technology development and extensions already applied in the U.S. and global Arctic. After decades of research, much is known about the physical, ecological, and human environment, and sufficient information is available to pursue exploration. However, the environment is changing, and additional information could facilitate future development. Developing the U.S. oil and gas potential requires an economically viable discovery. Current U.S. regulatory practices, adapted from other non-Arctic U.S. regions where activities can occur year-round, are limiting Arctic exploration activity. Realizing the promise of U.S. Arctic oil and gas resources requires public confidence that the opportunity can be safely pursued while ensuring environmental stewardship. Industry and government share the responsibility of securing and maintaining this public confidence. There have been significant recent technology advances in oil spill prevention and response. Application of these technologies in the U.S. Arctic could improve environmental stewardship and reduce cost, by safely extending the time available for exploration drilling.

Although the technology exists today to explore and develop the majority of U.S. offshore oil and gas potential, the Council recommends additional research to both validate recently developed technology for use in the U.S. offshore, and to pursue technology extensions that could lead to improved safety, environmental, or cost performance. Pursuing this research is predicated on an economically viable framework for oil and gas exploration and development, and effective coordination and implementation of U.S. Arctic policy. Therefore, this study also includes recommendations for policy and regulatory improvements, where such improvements enable the application of technology and best practices from other jurisdictions that could improve safety, environmental, and cost performance. The Council's recommendations have been grouped into three themes.

Considering **environmental stewardship**, the Council recommends the following:

- Industry and regulators should work together to perform the analyses, investigations, and any necessary demonstrations to validate technologies for improved oil spill prevention and source control.
- Government agencies should participate in ongoing and future Arctic oil spill industry collaborative research programs, such as the Arctic Oil Spill Response Technology Joint Industry Programme, currently underway.
- Regulators should continue to evaluate oil spill response technologies in Arctic conditions, and all spill response technologies should be pre-approved to enable use of the appropriate response technology to achieve the greatest reduction in adverse environmental impacts.
- Long-term population estimates and understanding of the interactions of key species with oil and gas activities should be improved, to improve efficiency of exploration and environmental stewardship.
- Collaboration and coordination of ecological/human environment research should be improved.

Considering **economic viability**, the Council recommends the following:

- Industry, government, and regulators should perform the analysis, investigations, and any necessary demonstrations to validate technologies and capabilities to safely extend the drilling season.
- The Department of Energy and the Department of the Interior should assess the timelines necessary to progress an offshore exploration and development program, compared with current U.S. lease durations and practices in other jurisdictions.
- Policies and regulations should encourage innovation and enable use of technology advances.

Considering **government leadership and policy coordination**, the Council recommends actions for:

- The Arctic Executive Steering Committee and the Department of Energy.
- The Department of State, as the U.S. assumes the chairmanship of the Arctic Council.

The attached report, *Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources*, provides additional detail and recommendations. The Council looks forward to sharing this study with you, your colleagues, and broader government and public audiences.

Respectfully submitted,

Charles D. Davidson – Chair

Attachment

Outline of Full Report

Executive Summary

Part One — Prudent Development

Part Two — Technology and Operations

Part Three — Ecological and Human Environment

List of Study Topic Papers (Web Only)

Preface

National Petroleum Council

The National Petroleum Council (NPC) is an organization whose sole purpose is to provide advice to the federal government. At President Harry Truman's request, this federally chartered and privately funded advisory group was established by the Secretary of the Interior in 1946 to represent the oil and natural gas industry's views to the federal government: advising, informing, and recommending policy options. During World War II, under President Franklin Roosevelt, the federal government and the Petroleum Industry War Council worked closely together to mobilize the oil supplies that fueled the Allied victory. President Truman's goal was to continue that successful cooperation in the uncertain postwar years. Today, the NPC is chartered by the Secretary of Energy under the Federal Advisory Committee Act of 1972, and the views represented are considerably broader than those of the oil and natural gas industry.

About 200 in number, Council members are appointed by the Energy Secretary to assure well-balanced representation from all segments of the oil and natural gas industry, from all sections of the country, and from large and small companies. Members are also appointed from outside the oil and natural gas industry, representing related interests such as states, Native Americans, and academic, financial, research, and public-interest organizations and institutions. The Council provides a forum for informed dialogue on issues involving energy, security, the economy, and the environment of an ever-changing world.

Study Request and Objectives

By letter dated October 25, 2013, Secretary of Energy Ernest Moniz requested that the National Petroleum Council conduct studies on three topics: (1) Emergency Preparedness (Natural Gas and Oil Infrastructure Resilience); (2) Methane Emissions (Maximizing the Climate Benefits of Natural Gas); and (3) Arctic Research. These requests were referred to the NPC Agenda Committee for review and recommendation as to whether they should be undertaken by the Council. The Agenda Committee recommended and the Council agreed to undertake studies on Emergency Preparedness and on Arctic Research and to defer the request on Methane Emissions because the basic data needed for such a study was still being collected and analyzed.

In the Emergency Preparedness study request, Secretary Moniz asked the Council to conduct a study that would provide advice on how the oil and gas industry and government at all levels can better prepare for, respond to, and recover from energy emergencies resulting from natural disasters. That study was completed, and its final report was approved and submitted to Secretary Moniz in December 2014.

This Arctic Research report is the Council's response to the study request, in which Secretary Moniz asked the NPC to advise him on Arctic Research. Specifically the Secretary noted that:

> A core component of the Administration's National Strategy for the Arctic Region released in May 2013 includes responsibly developing Arctic oil and gas resources to ensure energy security. In 2015 the United States will assume chairmanship of the

multination Arctic Council. The National Petroleum Council's input would be invaluable to assist us as we explore:

- What research should the Department of Energy pursue and what technology constraints must be addressed to ensure prudent development of Arctic oil and gas resources while advancing U.S. energy and economic security and ensuring environmental stewardship?

(Appendix A contains a copy of the Secretary's request letter and a description of the NPC.)

In further discussions with Department of Energy (DOE) leaders regarding the objectives of the study, it was agreed that the study would provide the DOE with the National Petroleum Council's perspective on research and technology pursuits that support prudent development in the Arctic. It was recognized that energy security from Arctic oil and gas development is a core component of the administration's National Strategy for the Arctic Region. Further, it was agreed that the NPC study would:

- Comment on implementation of the U.S. National Strategy for the Arctic Region

Chair – Committee Rex W. Tillerson Chairman, President and Chief Executive Officer Exxon Mobil Corporation	**Government Cochair – Committee** Elizabeth Sherwood-Randall[1] Deputy Secretary of Energy U.S. Department of Energy
Members – Steering Committee	
Paal Kibsgaard Chief Executive Officer Schlumberger Limited	Mark D. Myers Commissioner Alaska Department of Natural Resources[2]
Marvin E. Odum President Shell Oil Company	David T. Seaton Chairman and Chief Executive Officer Fluor Corporation
Frank A. Verrastro Senior Vice President and James R. Schlesinger Chair for Energy and Geopolitics Center for Strategic & International Studies	John S. Watson Chairman of the Board and Chief Executive Officer Chevron Corporation
Chair – Coordinating Subcommittee Carol J. Lloyd Vice President, Engineering Department ExxonMobil Upstream Research Company	**Government Cochair – Coordinating Subcommittee** Paula A. Gant Deputy Assistant Secretary for Oil and Natural Gas U.S. Department of Energy
Chair – Prudent Development Subgroup Bill Scott General Manager, Chevron Arctic Center Chevron Canada Resources	**Chair – Technology & Operations Subgroup** Jed M. Hamilton Senior Arctic Consultant, Offshore and Environment ExxonMobil Upstream Research Company
Chair – Ecology & Human Environment Subgroup A. Michael Macrander Science Team Lead Shell Alaska Venture	

1 Replaced Daniel B. Poneman.

2 Vice Chancellor, Research, University of Alaska Fairbanks, until mid-January 2015.

Table P-1. *Arctic Research Study Leaders*

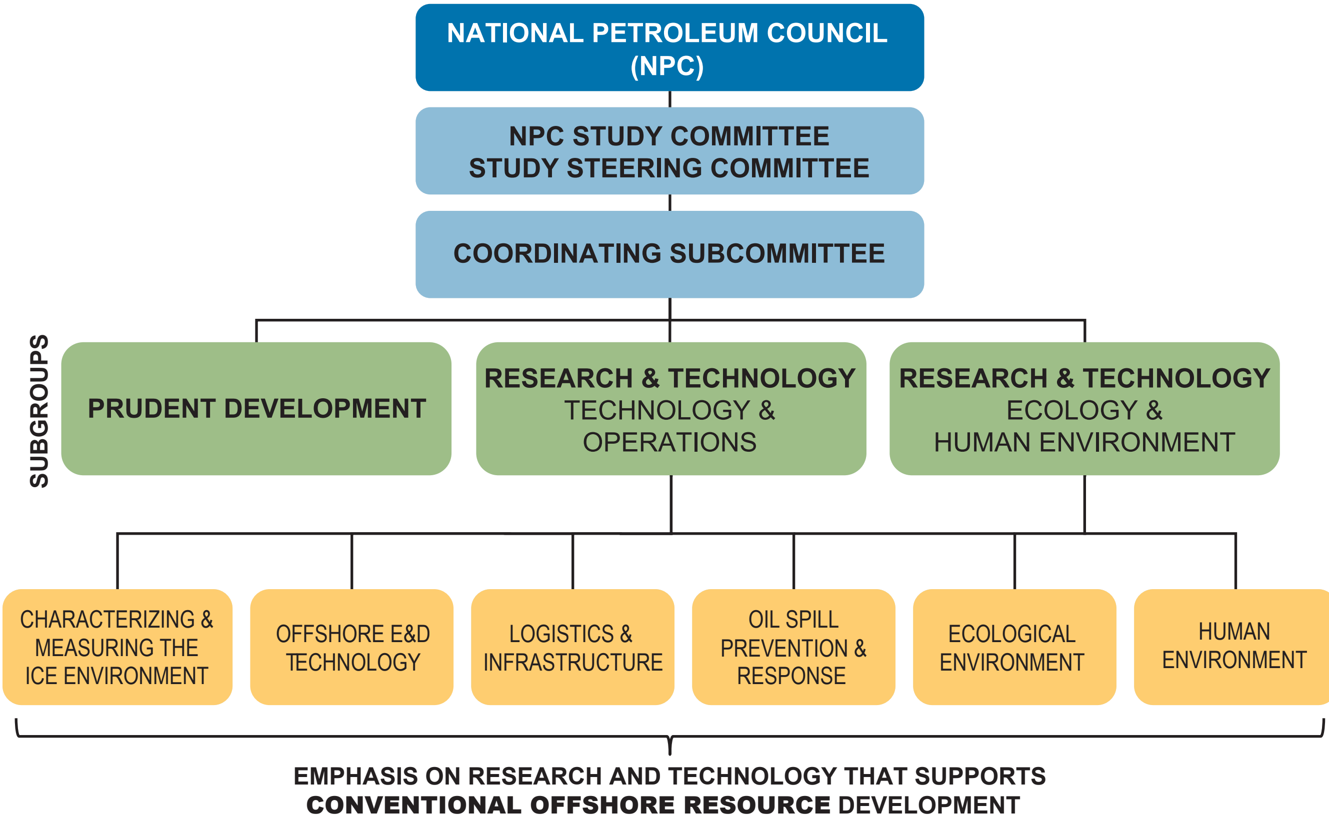


Figure P-1. *Structure of Arctic Research Study Team*

- Provide input to the Quadrennial Energy Review and the Quadrennial Technology Review by DOE in 2015

- Provide context to the administration as the United States assumes chairmanship of the multination Arctic Council in 2015

- Provide additional perspectives that would support prudent development of oil and gas in the U.S. Arctic offshore.

Study Organization

In response to the Secretary's requests, the Council established a Committee on Arctic Research to study this topic and to supervise preparation of a draft report for the Council's consideration. The Committee was led by a Steering Committee that consisted of the Committee's Chair, Government Cochair, and six members representing a cross section of the Committee. A Coordinating Subcommittee and three analytical Subgroups were also established to assist the Committee in conducting the study. These study groups were aided by multiple Study Teams focused on specific subject areas supplemented by workshops and other outreach. Table P-1 lists those who served as leaders of the groups that conducted the study's analyses, and Figure P-1 provides an organization chart for the study.

The members of the various study groups were drawn from NPC members' organizations as well as from many other industries, state and federal agencies, nongovernmental organizations (NGOs), other public interest groups, financial institutions, consultancies, academia, and research groups. More than 250 people served on the study's Committee, Subcommittee, and Subgroups or participated in the Technology Workshop. While all have relevant expertise for the study, less than 45% work for oil and natural gas companies. Appendix B contains rosters of these study groups as well as participants in the study's workshops, and Figure P-2 depicts the diversity of participation in the study process. In addition to these study group and workshop participants, many more people were involved through outreach activities. These efforts were an integral part

Study Committee
30 team members: 18 industry, 9 non-industry, 3 government

Coordinating Subcommittee
23 team members: 8 industry, 9 non-industry, 6 government

Prudent Development Subgroup
47 team members from 20 different organizations

Technology & Operations Subgroup
110 team members from 53 different organizations

Ecology & Human Environment Subgroup
22 team members from 14 different organizations

Federal & Alaska Technology Workshops
111 participants from industry, government, NGO, native, consultant, and academic organizations

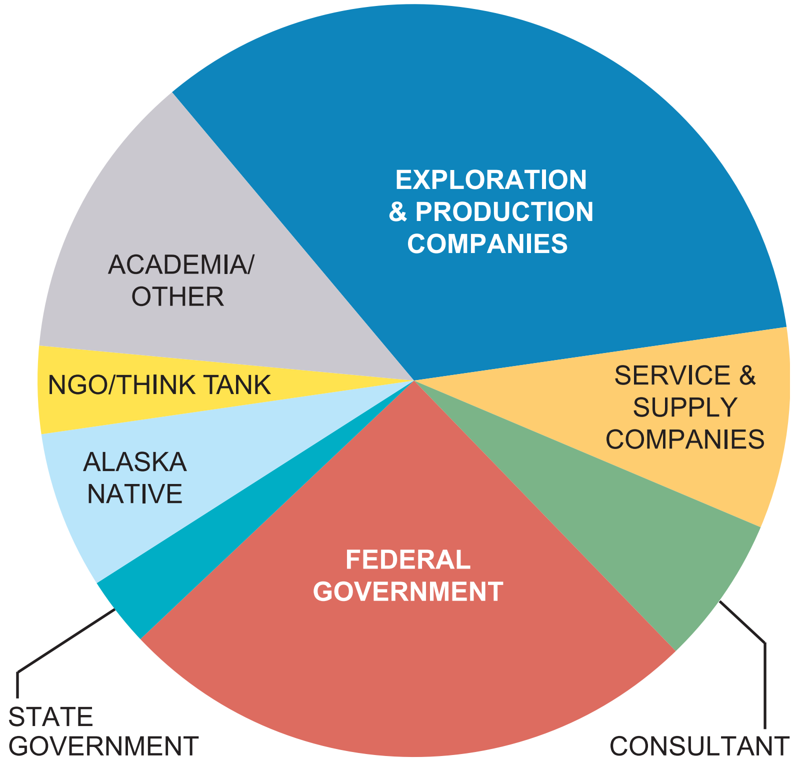


Figure P-2. *Study Participant Diversity*

of the study with the goal of informing and soliciting input from an informed range of interested parties.

Study group and outreach participants contributed in a variety of ways, ranging from full-time work in multiple study areas, to involvement on a specific topic, to reviewing proposed materials, or to participating solely in an outreach session. Involvement in these activities should not be construed as endorsement or agreement with all the statements, findings, and recommendations in this report. Additionally, while U.S. government participants provided significant assistance in the identification and compilation of data and other information, they did not take positions on the study's recommendations. As a federally appointed and chartered advisory committee, the NPC is solely responsible for the final advice provided to the Secretary of Energy. However, the Council believes that the broad and diverse study group and outreach participation has informed and enhanced its study and advice. The Council is very appreciative of the commitment and contributions from all who participated in the process.

STUDY SCOPE

At the outset of the study in February 2014, the study leadership formed a Scoping Subcommittee to develop a proposed work plan for the study that would define the study scope, organization, and timetable. This step was to ensure that there was alignment on the study scope in order to meet the Secretary's request for completion of the final report in early 2015. The Scoping Subcommittee deliberated over a 2-month period to develop a proposed work plan for the study.

The study plan was organized around two key themes: (1) Prudent Development in the Arctic and (2) Arctic Research and Technology. The first theme provides context on Arctic development experience, resource potential, regulatory practices, and the ice and sea environment in general. The scope of the Prudent Development section is broad and includes a discussion of both global and domestic ice environment, experience, practices, and development potential and challenges. This section also provides insight as the federal government takes on global leadership roles in the Arctic. The Prudent Development theme provides the necessary foundation for the more forward-looking Arctic Research and Technology chapters on emerging research opportunities, technology development, and collaborative approaches applicable to prudent development in the Arctic. The scope of the Research and Technology chapter analyses also includes important assessments of the human and ecological environments. A key element of the plan was the recommendation that the study's research and technology analyses would focus on the needs for exploration and development of conventional offshore resources. This recommendation was made because onshore technologies and experience were more mature and, in light of the tight study timeframe, the focus should be in the area with the greatest needs and opportunities.

Once the proposed work plan was completed, the Committee Chair met with Secretary Moniz and other senior DOE leaders to ensure that the study scope and report outline summarized in Figure P-3 were consistent with their objectives. The work plan was then submitted to the NPC Committee on Arctic Research for its review and approval. It served as the guiding document for the Coordinating Subcommittee and its Subgroups in conducting the study analyses and drafting a final report.

Consistent with the emphasis on "prudent development" in Secretary Moniz's study request, the study team reviewed and decided to adopt the definition drawn from the NPC 2011 report, *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources,* as follows:

> The concept of prudent development of North American natural gas and oil resources means the development, operations, and delivery systems that achieve a broadly acceptable balance of several factors: economic growth, environmental stewardship and sustainability, energy security, and human health and safety. Prudent development necessarily involves tradeoffs among these factors.

The text box on the next page outlines the roles of government and industry in research. It is important to understand that various aspects of research

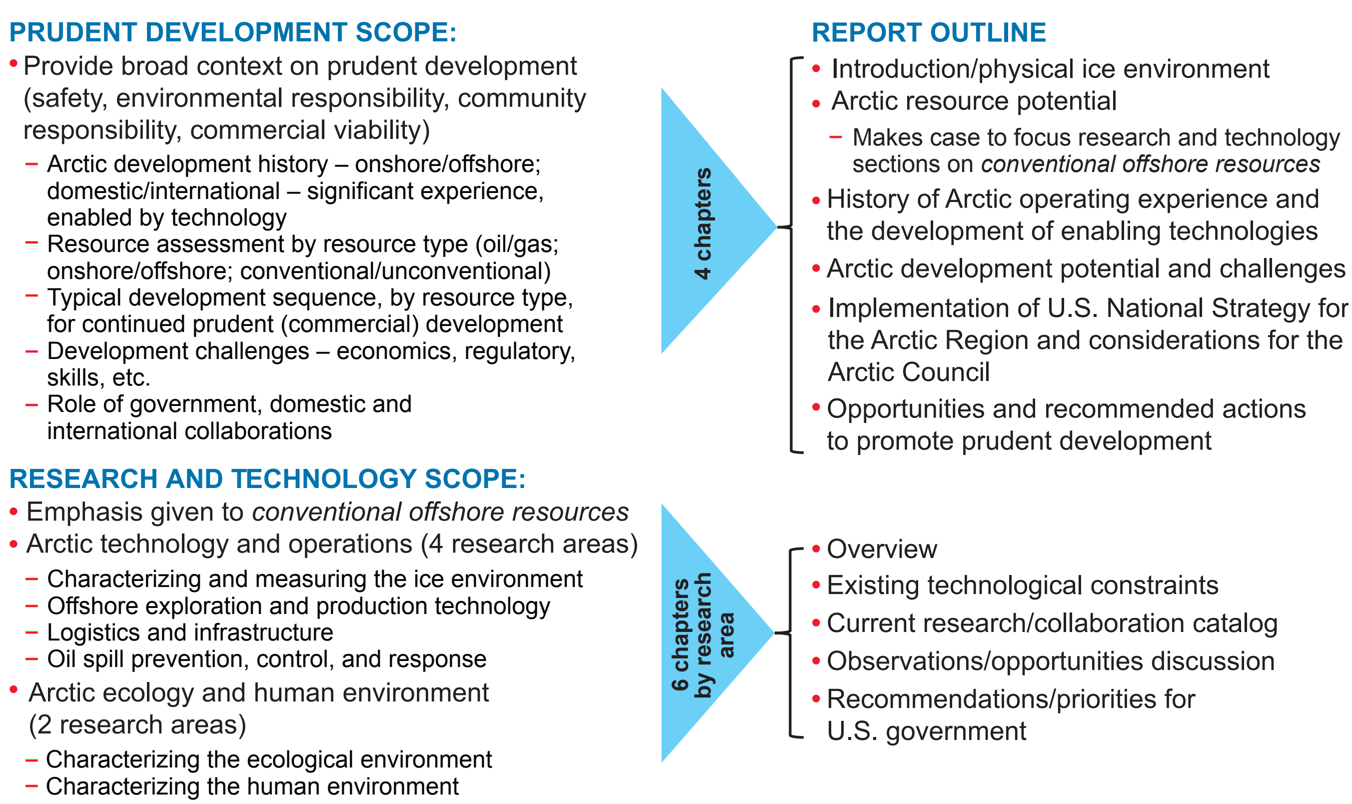


Figure P-3. *Study Scope and Outline* to advance scientific knowledge and technology are performed by multiple entities: governments, private companies, manufacturers, academia, and consortiums of these entities.

STUDY APPROACH

The study was conducted with a fundamental expectation that all parties would fully comply with all regulations and laws that cover a project of this type. For that reason, every effort was made to conform to all antitrust laws and provisions as well as the Federal Advisory Committee Act. As part of this compliance effort, this study did not include evaluations of commodity prices despite the extremely important role these play in encouraging research and technology investments and the exploration and development of frontier resources.

The Roles of Government and Industry in Research

Research to advance scientific knowledge and technology is performed by governments, companies, academia, and consortiums of these entities. In general, companies pursue research to develop knowledge and advance technologies with some expectation of producing commercial value within the planning time frame of the company. Some type of expected opportunity usually drives company research, such as the availability of a resource that is not economically producible with current technology. Companies also pursue research and technology improvements to reduce risk and improve performance (e.g., safety, protection of the environment, reduction of costs) of existing operations. Permitting and permit compliance may also require research, in particular when impacts of a potential operation or development will impact the environment. In addition, companies may pursue the advancement of basic science either directly or through grants to academia; such efforts support the development and retention of scientific capabilities. The U.S. government has traditionally conducted research that:

- Examines areas of science and technology in long-term areas where private companies may not see sufficient opportunity to monetize the research in a foreseeable time frame. Examples of such government research include: advancing fundamental scientific understanding, pursuing nonmonetary objectives such as defense research and space exploration, and developing challenging opportunities with potential long-term societal value such as controlled nuclear fusion.
- Accelerates the deployment of technology and infrastructure to support national policy objectives such as economic competitiveness, energy security, and environmental protection. Examples include research to support advanced manufacturing and modernization of the electric grid.
- Develops or maintains a talent pipeline to further scientific discovery and innovation.
- Takes advantage of government-owned assets, such as supercomputers, advanced modeling and simulation centers, and particle accelerators.
- Provides scientific and technological data and tools to support informed policy decision-making or resource management.
- Provides government regulators with the technical expertise to effectively oversee private sector operations.
- Facilitates public acceptance of industry research and technologies as an independent regulating body.

Both governments and industry pursue some research through targeted programs with academic institutions, and academic institutions also pursue research using their own funds or with nonspecific funding from governments or companies. In addition to increasing scientific understanding, academic research supports the development of future science and technology personnel, skills, and capabilities. Some academic institutions have progressed technology development to the point of commercialization, sometimes resulting in financial benefits to the institution.

Based on lessons learned from recent Council studies, the following principles were used to guide the study process:

- Well-defined study scope and execution plan, understood by all participants
- Front-end alignment of team leads on scope, resources, and schedule
- Identification and involvement of a broad and diverse set of interests to participate in the study starting with the leadership
- Consensus built among study participants
- Principle of analysis, discussion, and then recommendations in order to build consensus on the facts
- Comprehensive communication of the report's assumptions and conclusions via tailored presentations delivered to multiple interested parties.

Study Report Structure

In the interest of transparency and to help readers better understand this study, the NPC is making the study results and many of the documents developed by the study groups available to all interested parties. To provide interested parties with the ability to review this report and supporting materials in different levels of detail, the report is organized in multiple layers as follows:

- *Executive Summary* is the first layer and provides a broad overview of the study's principal findings and resulting recommendations. It describes the significant estimates of recoverable oil and natural gas resources in the Arctic and the experience and technologies available for their prudent exploration and development.
- *Report Chapters* provide more detailed discussion and additional background on the study analyses. These 10 individual chapters of the Full Report are grouped into three parts: Prudent Development, Technology and Operations, and Ecological and Human Environment. These chapters provide supporting data and analyses for the findings and recommendations presented in the Executive Summary.
- *Appendices* of the Full Report provide background material, such as Secretary Moniz's request letter, rosters of the Council and study group membership, and a table categorizing the study's recommendations by type (Appendix C). This section also contains a list of acronyms and abbreviations used in the report.
- *Topic Papers* provide a final level of detail for the reader. These papers, developed or used by the study's Technology & Operations Subgroup, are included on the NPC website. They formed the base for the various study segments, such as Ice Characterization and Arctic Exploration and Development Technologies, and were heavily used in the development of the chapters of the Full Report. A list of the topic papers appears in Appendix D.

  The Council believes that these materials will be of interest to the readers of the report and will help them better understand the results. The members of the NPC were not asked to endorse or approve all of the statements and conclusions contained in these documents but, rather, to approve the publication of these materials as part of the study process. The topic papers were reviewed by the Subgroup but are essentially stand-alone analyses. As such, statements and suggested findings that appear in these topic papers are not endorsed by the NPC unless they were incorporated into the Full Report.

The Executive Summary, Report Chapters, Appendices, and Topic Papers may be individually downloaded from the NPC website at: http://www.npc.org. The public is welcome and encouraged to visit the site to download the entire report or individual sections for free. Also, printed copies of the report can be purchased from the NPC.

Executive Summary

INTRODUCTION

The Arctic is home to distinct indigenous peoples and provides habitat for large numbers of birds, mammals, and fishes. While some areas of the Arctic, such as the central North Slope of Alaska around Prudhoe Bay, have seen decades of economic activity, much of the region remains largely unaffected by human presence. Today, there is increasing interest in the Arctic for tourist potential, and reductions in summer ice provide an increasing opportunity for marine traffic. At the same time, there is concern about the future of the culture of the Arctic peoples and the environment in the face of changing climate and increased human activity.

Internationally, other countries such as Russia are moving forward with increased Arctic economic development during this time of change. Russia is drilling new exploration wells in the Kara and Pechora Seas and is expanding its naval and transportation fleet. While China does not have Arctic territory, it is investing millions of dollars in Arctic research, infrastructure, and natural resource development. The United States has developed a national strategy for the Arctic region that recognizes the importance of integrating national security, foreign policy, and energy policy, stating that "we seek an Arctic region that is stable and free of conflict, where nations act responsibly in a spirit of trust and cooperation, and where economic and energy resources are developed in a sustainable manner that respects the fragile environment and the interests and cultures of indigenous peoples."

The United States has large offshore oil potential, similar to Russia and larger than Canada and Norway. Facilitating exploration in the U.S. Arctic would enhance national, economic, and energy security, benefit the people of the north and the United States as a whole, and position the United States to exercise global leadership. Despite these benefits, there is a wide diversity of views on how to balance this opportunity with environmental stewardship. In April 2015, the United States will assume chairmanship of the Arctic Council, the most prominent multination Arctic institution. In this context, Energy Secretary Moniz asked the NPC for guidance on potential research and technology to support prudent development of Arctic oil and gas resources.

This report reviews, from a global perspective, the relevant research, technology, and ecological and human environment opportunities in the Arctic region, as well as Arctic resource potential, the challenges of operating in the Arctic, and the experience of the oil and gas industry in Arctic conditions. Much is known about the Arctic's physical, ecological, and human environments after decades of research. Sufficient information to pursue exploration is available. However, the environment is changing, and additional information would be helpful to facilitate development and secure public confidence. After a discussion of key findings, the report presents recommendations for opportunities for additional research and technology development.

A key finding of this report is that the technology to develop U.S. offshore oil and gas is available today, but additional research could validate technology that has been used in other areas and offer improvements. Pursuing these research opportunities is predicated on an economically viable framework for oil and gas exploration and development, and effective coordination and implementation of U.S. Arctic policy. Therefore, this study also includes recommendations for policy and regulatory improvements, where such improvements enable the application of technology and best practices from other jurisdictions that could improve safety, environmental, or cost performance. Recommendations are grouped into three key themes: environmental stewardship, economic viability, and government leadership and policy coordination.

KEY FINDINGS

1. Arctic oil and gas resources are large and can contribute significantly to meeting future U.S. and global energy needs.
2. The arctic environment poses some different challenges relative to other oil and gas production areas, but is generally well understood.
3. The oil and gas industry has a long history of successful operations in arctic conditions enabled by continuing technology and operational advances.
4. Most of the U.S. Arctic offshore conventional oil and gas potential can be developed using existing field-proven technology.
5. The economic viability of U.S. Arctic development is challenged by operating conditions and the need for updated regulations that reflect arctic conditions.
6. Realizing the promise of Arctic oil and gas requires securing public confidence.
7. There have been substantial recent technology and regulatory advancements to reduce the potential for and consequences of a spill.

1. Arctic Oil and Gas Resources Are Large and Can Contribute Significantly to Meeting Future U.S. and Global Energy Needs

Arctic oil and gas resources can play a substantial role in meeting future global energy needs, given their significant potential. The United States is currently benefiting from resurgence in oil production fueled largely by the development of tight oil opportunities in the U.S. Lower 48. Production profiles for these oil opportunities will eventually decline and, in its Annual Energy Outlook 2014, DOE's U.S. Energy Information Administration (EIA) estimates that U.S. oil production will drop one million barrels per day by 2040 compared to 2014. Given the resource potential and long timelines required to bring Arctic resources to market, Arctic exploration today may provide a material impact to U.S. oil production in the future, potentially averting decline, improving U.S. energy security, and benefitting the local and overall U.S. economy.

The Arctic can be defined as areas north of the Arctic Circle (see Figure ES-1). The United States, Canada, Russia, Kingdom of Denmark (Greenland), and Norway all have coastlines within this region, and these countries possess the majority of the resource potential. Other Arctic countries have recognized the significant potential of the Arctic oil and gas endowment and are pursuing Arctic oil and gas exploration and development with an integrated national security, foreign policy, and economic perspective. To remain globally competitive and to be positioned to provide global leadership and influence in the Arctic, the United States should facilitate exploration in the offshore Alaskan Arctic now.

Resource potential estimates are inherently uncertain given the methods used for their estimation and the fact that many accumulations are yet to be drilled or produced. For simplicity, statistical mean values[1] are provided in this executive summary with details available in Chapter 1, "Arctic Resource Potential and History of Arctic Operations." Despite the uncertainty, it is expected that there is a high potential for large accumulations of oil and gas yet to be discovered in the Arctic. Furthermore, despite the high potential, the economic viability of these accumulations has yet to be determined and depends on many factors discussed later in this summary.

Oil and gas activities in the Arctic have resulted in the production of over 25 billion barrels of liquids[2] and 550 trillion cubic feet of natural gas.[3] Additionally, an existing reserve base of 38 billion barrels of liquids and 920 trillion cubic feet of natural gas is estimated.[4] The Arctic is also estimated to contain an additional

1 Undiscovered potential volumes are based on USGS 2008, Circum-Arctic Resource Appraisal. Discovered potential, reserves, and production values are provided by IHS and are approximate as of the end of 2013.

2 "Liquids" refers to crude oil and natural gas liquids.

3 IHS, International E&P Database, September 3, 2014, http://www.ihs.com/products/oil-gas/ep-data/sets/international.aspx.

4 Ibid.

Figure ES-1. *Arctic Circumpolar Map Highlighting the Arctic Circle and Key Regions and Sea Routes*

525 BBOE[5] of conventional resource potential,[6] 426 BBOE of which is undiscovered conventional liquids and gas as shown in Figure ES-2. This 426 BBOE represents about 25% of the remaining global undiscovered conventional resource potential. The majority of the Arctic resource potential is expected to be gas with about 30% estimated to be liquids as shown in Figure ES-3.

Russia is estimated to have by far the largest Arctic resource potential as shown in Figure ES-4 and will continue to be a dominant player in Arctic oil and gas development. When considering only Arctic oil potential, however, the United States and Russia are assessed to have approximately equal portions of the conventional resource potential with approximately 35 billion barrels of oil each. For the United States, this represents about 15 years of current U.S. net oil imports.[7]

It is estimated that approximately 75% of the total global Arctic conventional resource potential is offshore and 25% onshore, as shown in Figure ES-5. As shown in Figure ES-6, the U.S. Arctic is estimated to have 48 BBOE of offshore undiscovered conventional resource potential, with over 90% of this in less than 100 meters of water. Furthermore, the Chukchi and Beaufort Sea Outer Continental Shelf (OCS) combined represent over 80% of the total U.S. Arctic offshore conventional potential. Limited exploration in both the Chukchi and Beaufort Seas has resulted in some discoveries. However, the only U.S. Arctic OCS development to date is the Northstar development, which straddles both federal and state waters in the Beaufort Sea.

5 Billion barrels of oil, or oil equivalent for gas; 6,000 cubic feet of gas is equivalent to 1 barrel of oil.

6 "Conventional oil" refers to oil found in liquid form flowing naturally or capable of being pumped without further processing or dilution.

7 Calculated based on data from U.S. Energy Information Administration at http://www.eia.gov/dnav/pet/pet_move_wkly_dc_NUS-Z00_mbblpd_w.htm. Accessed January 13, 2015.

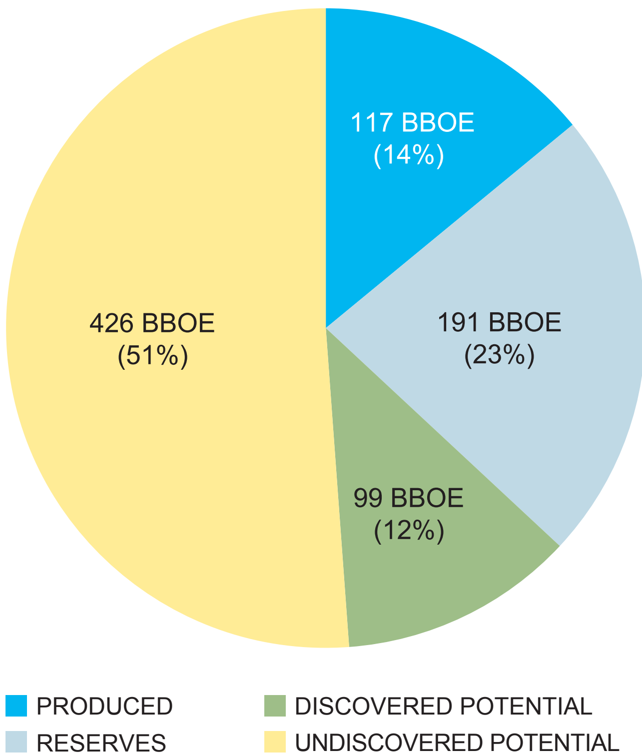


Figure ES-2. *Global Arctic Conventional Endowment*

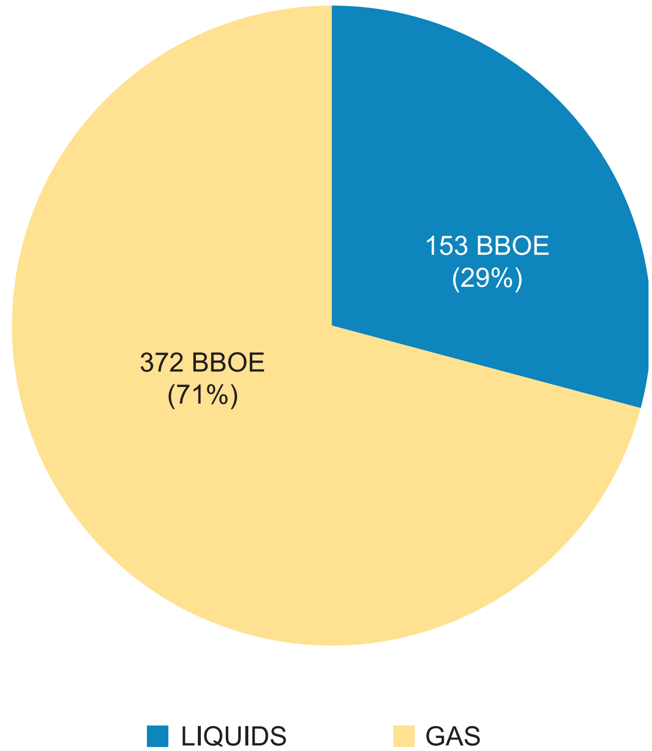
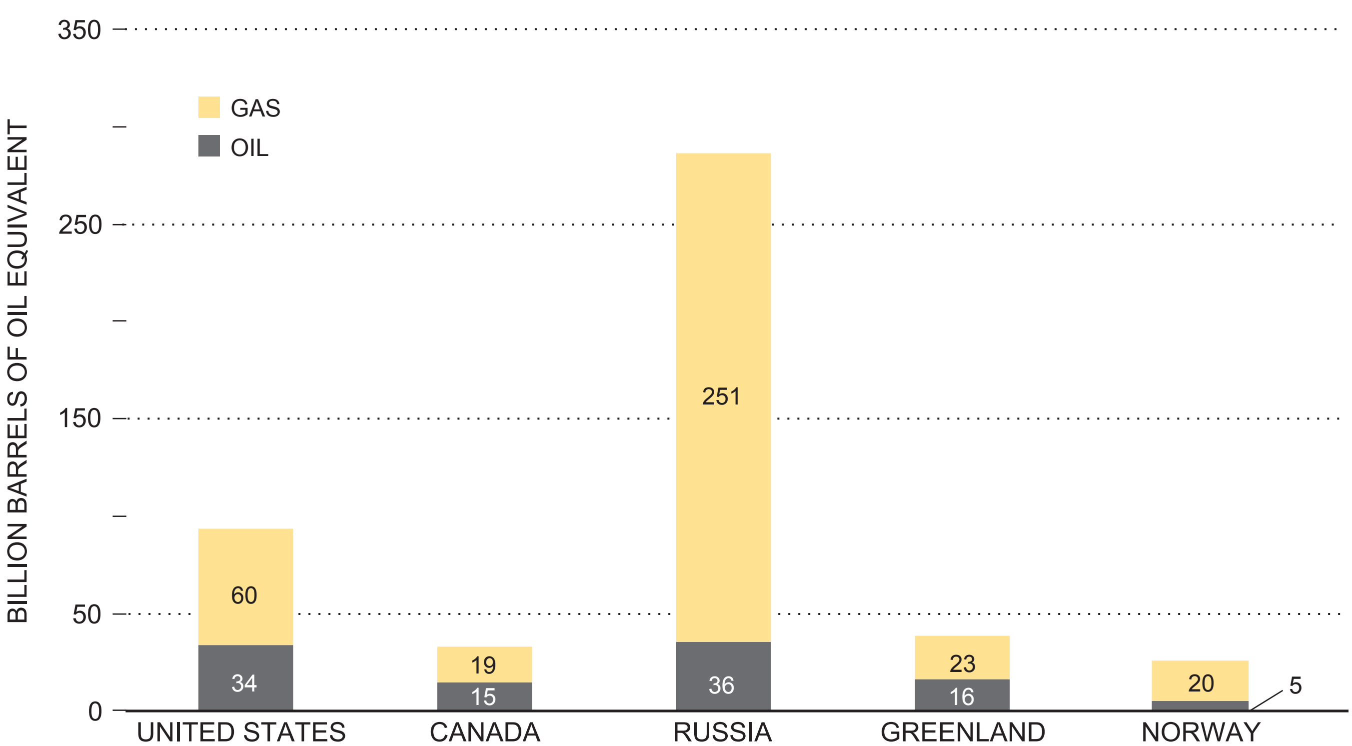


Figure ES-3. *Global Arctic Conventional Resource Potential by Hydrocarbon Type*



Note: Natural gas liquids are not included here.

Figure ES-4. *Global Arctic Conventional Oil and Gas Resource Potential by Country*

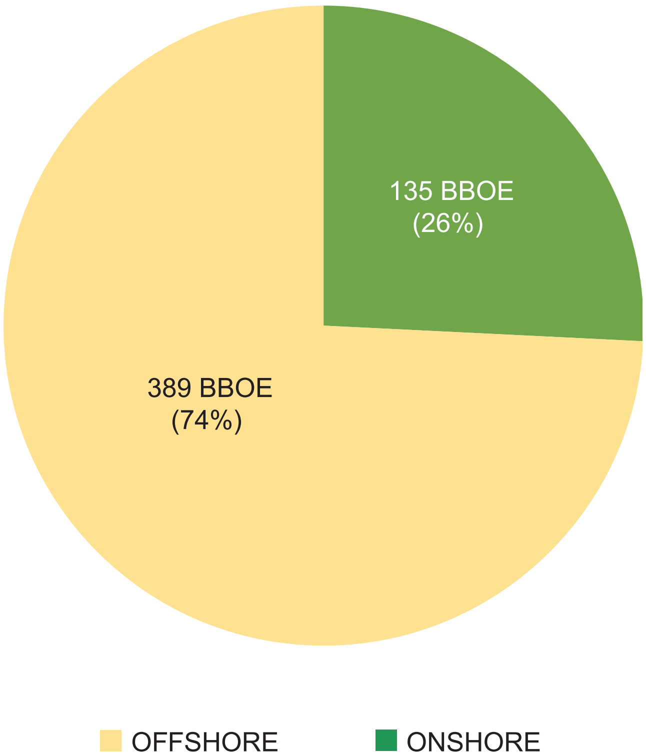


Figure ES-5. *Global Onshore and Offshore Arctic Conventional Resource Potential*

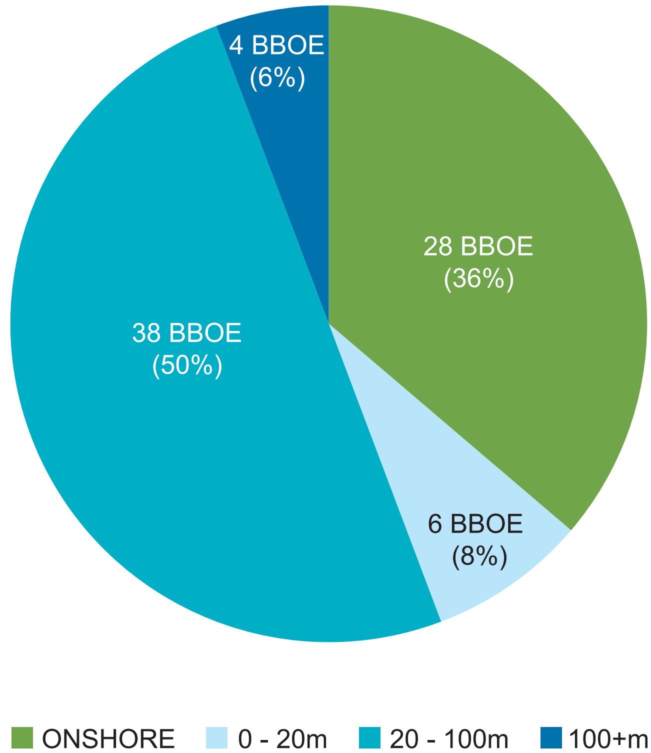


Figure ES-6. *U.S. Arctic Conventional Resource Potential by Water Depth*

The Arctic Region—Why Now?

In recent years, the success of unconventional drilling in the U.S. Lower 48 has revitalized U.S. oil production, changing the picture from one of declining U.S. production and increasing import dependency to one of increasing production and decreasing import requirements. The benefits to the overall economy, trade balances, and energy security have been significant. U.S. and world oil prices have dropped significantly during the course of this study. In this current context of increasing oil supply and declining oil prices, one might ask: Why pursue Alaskan exploration and development now?

The answer to this question lies in the long lead times involved in exploration and development in Alaska, compared with other sources of U.S. oil production, and the potentially transitory nature of the current world oil supply/demand situation. If development starts now, the long lead times necessary to bring on new crude oil production from Alaska would coincide with a long-term expected decline of U.S. Lower 48 production. Alaskan opportunities can play an important role in extending U.S. energy security in the decades of the 2030s and 2040s.

The cycle of leasing, exploration, appraisal, development, and production, shown in Figure ES-7, takes longer in the Arctic than in other offshore regions. For instance, Northstar, the only U.S. offshore OCS Arctic project, took 22 years from lease sale to start of production, while recent Gulf of Mexico deepwater projects such as Mars and Atlantis took 11 and 12 years respectively. The longer time frame required for U.S. Arctic projects is the result of remoteness, long supply chains, short exploration seasons due to ice, regulatory complexity, and potential for litigation. The time frame for developing any significant offshore Arctic opportunity would likely be between 10 to 30+ years. With a sustained level of leasing and exploration drilling activity over the next 15 years, offshore Alaska could yield material new production by the mid-2030s and sustain this level of production through mid-century and beyond.

Figure ES-8 provides background to understand the Alaskan development opportunity in

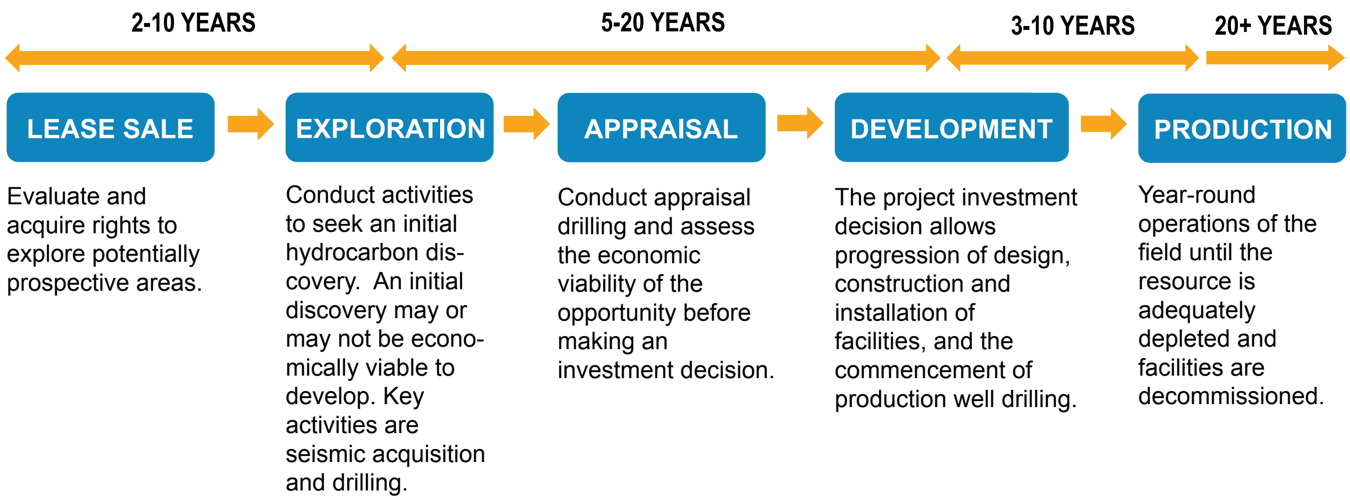


Figure ES-7. *Typical U.S. Arctic Project Cycle*

the context of the total U.S. demand in the coming decades. Figure ES-8 shows the 2014 U.S. EIA Reference Case outlook for U.S. crude oil production. Driven by onshore tight oil production, total U.S. crude oil production increased from 5 million barrels per day in 2008 to 8.5 million barrels per day in 2014, and is projected to increase to a maximum of 9.6 million barrels per day in 2019.[8] Crude oil imports are expected to decline from 9.8 million barrels per day in 2008 to a minimum of 5.8 million barrels per day in 2019. But in the Reference Case after 2019, U.S. crude oil production is expected to decline to about 7.5 million barrels per day and imports rise to 7.7 million barrels per day by 2040. U.S. domestic crude oil production is 57% of domestic demand in 2014, but declines to 49% in 2040, reversing the improvements in the economy and energy security from the recent production increase.

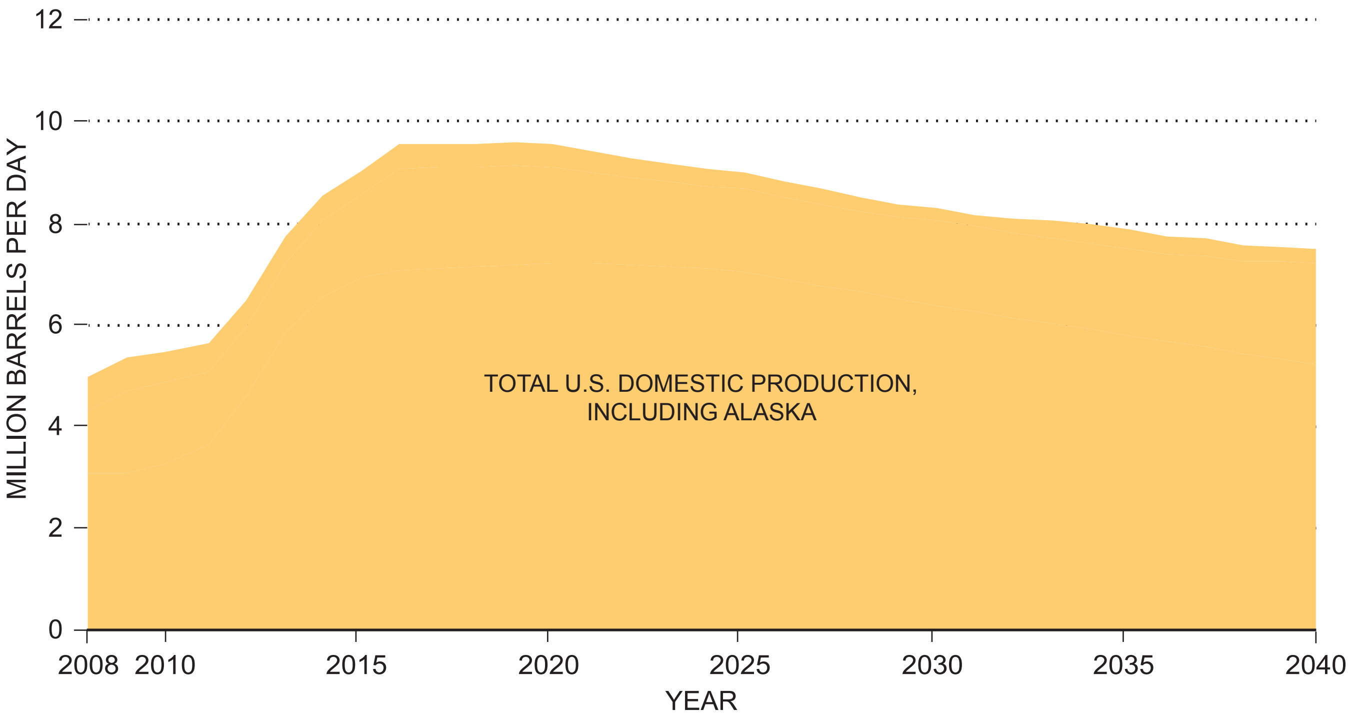
In this Reference Case, the EIA includes only minimal future Alaska OCS activity and assumes decline of Alaskan fields from about 0.5 million barrels per day in 2014 to under 0.3 million barrels per day in 2040. Such a decline would mean that the operational viability of the Trans-Alaska Pipeline System (TAPS) could be challenged, potentially resulting in the loss of an additional 0.3 million barrels per day of oil production.

8 U.S. Energy Information Administration, *Annual Energy Outlook 2014*.

The EIA also assessed an alternative outlook to the 2104 Reference Case, assuming higher oil and gas resource development. In this alternative outlook, the “High Resource Case,” Alaska production doubles from 2014 to 1.0 million barrels per day by 2040, instead of declining as in the Reference Case. This higher contribution from Alaska would require sustained exploration and development activity over the next two decades. In this alternative outlook, the contribution of U.S. crude oil production to total U.S. demand rises to 85% by 2040, instead of declining to 49% as in the Reference Case.

Thus, the U.S. Arctic can make an important contribution to sustaining overall U.S. crude oil supplies at a time when Lower 48 production is projected to be in decline, and extend the energy security benefits that the United States is currently enjoying. ***However, these new sources of crude oil production in the 2030s and 2040s will only be available if new offshore exploration drilling can ramp up in Alaska during this decade.***

In addition to these energy security benefits, development of oil and gas resources in Alaska would benefit U.S. national security. Additional industrial activities in the region would promote a strong and lasting U.S. presence. The oil and gas development activity would expand navigational aids in the Bering Sea and the Bering Strait, and enhance search and rescue capabilities. Additional oil and gas development could support improved infrastructure and logistics in the region, potentially spurring development of



Source: U.S. Energy Information Administration, Annual Energy Outlook 2014.

Figure ES-8. *U.S. Crude Oil Production, 2014 Reference Case Outlook Per EIA*

ports and communications facilities by governments, industry, or both.

Finally, the economic benefits to the U.S., state, and local economies of continued Alaskan development would be significant. Today oil and gas development is one third of the state of Alaska's economic activity and provides about 90% of the state's general revenue. The North Slope Borough oil and gas property taxes have exceeded $180 million annually since 2000, representing about 60% of their annual operating budget.[9] One-third of Alaska's jobs—127,000—are oil-related and depend on oil production.[10] (See Figure ES-9.)

Similarly, development of Alaska's OCS will increase economic activity and jobs. Northern Economics in association with the University of Alaska-Anchorage assessed that OCS development would add approximately $145 billion in new payroll for U.S. workers and $193 billion or more in new local, state, and federal government revenue combined over 50 years.[11] The projected net revenues to the state of Alaska from OCS development could be about $6.6 billion (2007$). The report goes on to say:

> Opportunities would be created throughout the state in both high paying, long-term, year-round jobs and in seasonal and short-term jobs. Of the 6,000 oil and gas sector jobs, about 3,900 could be long-term, year-round jobs. It is estimated that total national annual average employment from OCS development—including all the direct, indirect, and induced employment—could be about

9 Alaska Department of Commerce Community and Economic Development (2013).

10 University of Alaska's Institute for Social and Economic Research.

11 *Economic Analysis of Future Offshore Oil and Gas Development: Beaufort Sea, Chukchi Sea, and North Aleutian Basin*, by Northern Economics in association with the Institute of Social and Economic Research at the University of Alaska-Anchorage. The scenarios used for this study are based in part on the scenarios discussed by the Minerals Management Service (MMS) in published Environmental Impact Statements (EIS) and other materials. The recent draft environmental impact statement for the *Beaufort and Chukchi Sea Planning Areas, Oil and Gas Lease Sales 209, 212, 217, and 221* was issued after the analysis for this report was completed. The scenarios used in this report are based on earlier scenarios and other material that are broader in scope and duration than the November 2008 draft EIS.

Photo: ExxonMobil

Figure ES-9. *Oil Industry Workers Celebrating a Safe Work Milestone on the North Slope*

35,000 per year on average through 2057, with a peak employment of over 50,000 in 2038. Total wages and salaries associated with OCS development over the 50-year period are estimated to be about $72 billion (2007$).

2. The Arctic Environment Poses Some Different Challenges Relative to Other Oil and Gas Production Areas, But Is Generally Well Understood

The Arctic is a vast, remote, and integrated system, with a challenging and variable climate. The key characteristic that distinguishes the Arctic from other oil and gas production areas is the presence of ice. The ice environment varies substantially throughout the Arctic depending on the season and the location.

The Arctic environment has been studied for many years by industry, government, and academia, and much is known about the physical, biological, and human environments. The Arctic is host to a rich fabric of aquatic and land species, each dependent on the environmental niches in which they thrive. There is a significant population of indigenous peoples who live and draw sustenance from the land and sea.

Many aspects of the Arctic pose challenges similar to other oil and gas production areas, and experience and technologies from these other areas can be applied to the Arctic development. For example, the design practices, technology, and safety systems for deepwater and subarctic regions are adaptable to the Arctic. Logistical challenges associated with long distances and lack of infrastructure are similar to recent projects in Africa and Papua New Guinea.

Multiple Arctic Offshore Physical Environments

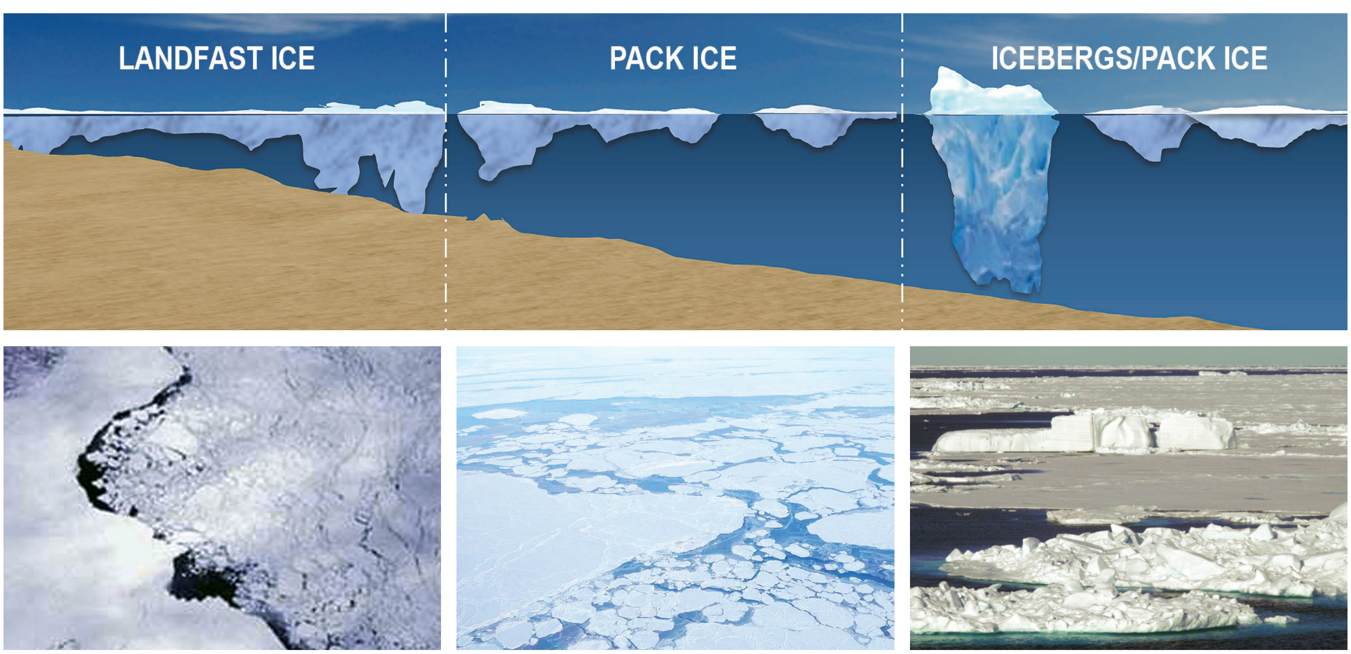
To those not living or working in the Arctic, the offshore Arctic physical environment may appear to be uniformly remote, harsh, and challenged by ice and long periods of darkness. From the perspective of potential oil and gas development, the challenges associated with the offshore Arctic physical environment vary widely from country to country, basin to basin, and even year to year. There are three key physical characteristics of offshore Arctic environments that play a large role in determining the technologies that are required and the degree of complexity of operations. The dominant physical characteristic is ***ice type and abundance***, but ***water depth*** and ***length of open water season*** also play key roles in differentiating one Arctic location from another in terms of the technology needed and the economic prospects for development.

Ice Type and Abundance

Since as early as the 1940s, a wealth of scientific information has been acquired to characterize the nature and morphology of ice conditions across the Arctic. This information has been gained through concerted efforts by governments, academia, and industry using ship expeditions, scientific on-ice surveys, ice drift buoy programs, ice reconnaissance using airborne and satellite measurements, and navigational charting of ice conditions. These studies have demonstrated that the extent of summer sea ice coverage has declined significantly over the past several decades. They also indicate that although summer ice coverage has decreased, winter ice coverage remains robust. Hence, ice interactions will continue to be the dominant consideration for design of offshore Arctic oil and gas facilities.

In areas of the global Arctic that experience seasonal ice, Figure ES-10 depicts the gradation of ice conditions typically encountered from the shoreline to about 100 meters water depth. Landfast ice can extend from the shoreline out to a depth of about 15 to 20 meters. Landfast ice freezes fast to the shoreline and is relatively stable throughout the winter until the summer break-up occurs. With thicknesses approaching 2 meters, it can provide a stable platform for drilling exploration wells, transporting materials and equipment, or supporting equipment to lay pipelines to shore for shallow water developments. Beyond the edge of the landfast ice zone is floating pack ice of varying concentrations, which, depending on the season, might range from sparse coverage near the edge to complete coverage further into the pack.

Mobile pack ice mass consists of sea ice of varying age and thickness. Depending on location, there may also be inclusions of icebergs or drifting fragments of thick, multi-year shelf ice known as ice islands. The new ice that forms over the open water each winter is called first-year ice. It typically reaches a thickness of 1.5 to 2 meters over the winter season. Wind forces compress and break the ice sheet, forming thickened ridges and rubble fields. When these thickened areas refreeze, they can become the dominant features that impede icebreaker transit and exert large forces on stationary platforms. Second-year ice is thickened



Schematic: Chevron; Photos: NASA, ExxonMobil, ION Geophysical

Figure ES-10. *Typical Arctic Ice Regimes* ice that results from refreezing of surviving first-year ice from the previous season. Similarly, multi-year ice is built up from multiple freeze cycles of previous years of second-, third-, etc.-year ice. Multi-year ice can range in thickness from approximately 3 meters to more than 6 meters. Figure ES-11 shows ice ridges.

Icebergs are large pieces of freshwater ice that break off from glaciers and drift with sea currents. Icebergs are nearly nonexistent in the U.S. Arctic due to the lack of large glaciers terminating in the nearby ocean. While relatively rare, the U.S. Arctic does contain ice island features, which are thick tabular masses of ice that break off from Canadian ice shelves and drift with the pack.

Water Depth

Water depth within the world's prospective Arctic oil and gas basins varies from zero to more than a thousand meters. As mentioned previously, most of the U.S. Arctic offshore oil and gas potential lies in water depths of less than 100 meters. The Russian Arctic shelf is broad and shallow, with a large fraction of the area lying in water depths less than 100 meters. Water depths offshore Arctic Canada and Greenland, on the other hand, fall off to more than 100 meters closer to shore. Water depth predominantly impacts the type of drilling and production platforms that can be used and whether offshore wellheads and pipelines require burial to protect them from being damaged by moving ice keels that extend to the seafloor. Developments in ice-prone water depths less than about 100 meters are amenable to well-established technology of structures resting on the seafloor ("bottom-founded"). Beyond about 100 meters, a technology transition from bottom-founded to floating platforms may be required because the overturning forces of the floating ice become too large for practically sized bottom-founded structures. Unlike for temperate waters, where floating drilling facilities are routinely used in thousands of meters of water, suitable technology to allow year-round floating drilling in Arctic pack ice will require additional research and development before commercial use.

Open Water Season

In addition to ice conditions and water depth, the length of the open water season—the time without ice coverage—has a significant impact on the types of technologies that can be used for exploration and development. The length of the open water season can vary considerably from year to year. Over most of the U.S. Chukchi Sea lease area, the average open water season is about 3 to 4 months long, but has been as short as 1 to 2 months. Mid-season incursions of pack ice from the north can occur, potentially interrupting operations. In the correspondingly shallow shelf areas of the U.S. Beaufort Sea, the open water season is typically 1 to 1.5 months shorter than in the Chukchi, and can also be interrupted by pack ice intrusions. Access into the Beaufort Sea at the start of the open water season may be impeded by high ice concentrations at Point Barrow, restricting the usable operating window in some years.

First-year ice with numerous pressure ridges

Multi-year ice ridge in the Canadian Beaufort Sea

Iceberg, ~200 meters across, in open water

Photos: ExxonMobil

Figure ES-11. *Ice Features*

If the open water season is 3 months or more, it may be possible to complete the drilling of an exploration well in a single season using conventional technology that would be used in any open water setting. Shorter open-water seasons or deeper reservoirs may require multiple seasons to complete a single well, resulting in much higher costs for exploratory drilling. Likewise, development technology requirements become more challenging and costs increase with decreasing open water season. For example, 3 months may provide sufficient time for installation of platforms and pipelines, while shorter open water periods may necessitate special measures for platform installation and pipeline construction.

On either side of the open water season, there are periods of summer breakup/melting and fall–early winter freeze-up where some ice may be present at a drilling location. These periods are often referred to as the "shoulder" seasons, because ice coverage is reduced and the ice is either receding or newly forming. The satellite images of early summer and late fall ice conditions shown in Figure ES-12 illustrate the shoulder seasons in the U.S. Chukchi Sea. Past Arctic exploration drilling programs have successfully extended operations into the shoulder seasons by using ice management to break or guide away approaching ice that might otherwise interfere with the rig's ability to stay in place over the well ("stationkeeping"). The photographs in Figure ES-13 show a Canmar drillship working in thin ice during the fall and the Arctic-class drilling rig *Kulluk* drilling in much thicker summer ice. Operating in the shoulder season depends on the capability of the drilling rig and ice management vessels to safely contend with ice. In previous Canadian Beaufort Sea drilling programs using the *Kulluk*, the summer shoulder season could begin as early as late June or early July, and the winter shoulder season could extend into November or even early December. Beyond about mid-December, the ice cover becomes essentially continuous and thickness exceeds 0.7 meter. Extending the drilling season beyond mid-December would require robust station-keeping and ice management capability.

Ecological Characterization

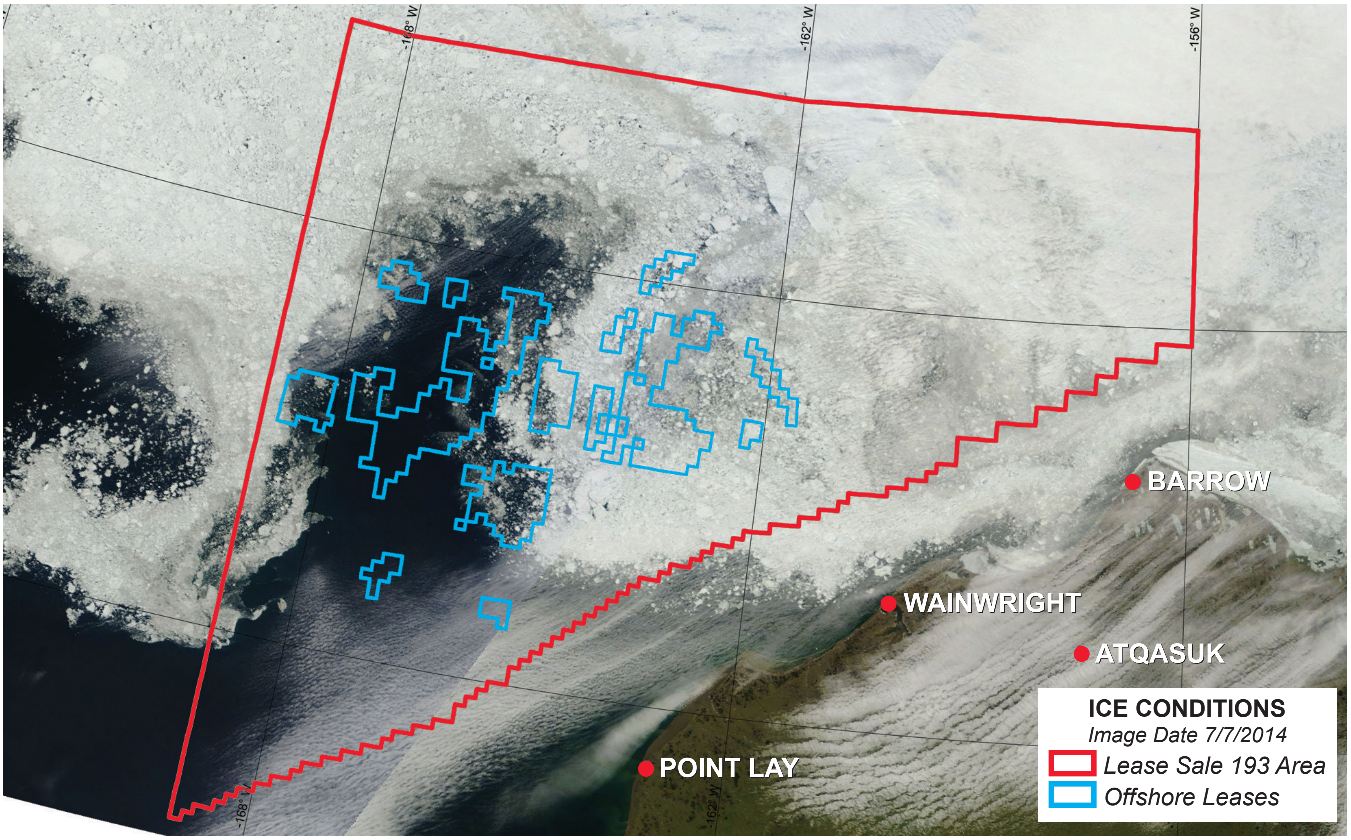
A number of government and international bodies have conducted assessments of the science available to inform decisions in the Arctic. These assessments conclude that there is a substantial amount of information available for Arctic ecological resource management and pursuit of resource development while protecting the environment.

Current Availability of Information

Humans have observed and studied the seasonal patterns of the physical environment and the biological inhabitants of the Arctic for thousands of years. Current ecological understanding of the Alaskan Arctic, aided by Alaska Native traditional knowledge, has been driven by basic scientific inquiry supported through academia, government institutions, nongovernmental organizations, and by various commercial endeavors, particularly oil and gas exploration and development. Alaska Native traditional knowledge is a practical knowledge base founded upon personal experience and observation of the environment. Traditional knowledge among the Inupiat population has been handed down for millennia; early western knowledge was derived from the scientific curiosity of members of exploration teams looking for new global travel routes and potentially useful natural resources.

Early observations by explorers grew into formal research initiatives by the late 1800s. The discovery of economically recoverable oil in 1968 in Prudhoe Bay focused research on topics relevant to environmental stewardship during development and operation of oilfields. This research included efforts such as the Outer Continental Shelf Environmental Assessment Program, the Arctic Nearshore Impact Monitoring in the Development Area program, more than three decades of fish sampling in the Beaufort Sea, and 15 years of acoustic and bowhead whale monitoring directly assessing the effects of offshore development. Most recently, beginning in 2006, an industry-supported integrated ecosystem study known as the Chukchi Sea Environmental Studies Program investigated a wide range of physical and biological components of arctic marine systems. Additional recent efforts supported by local, state, and federal government agencies include bowhead whale, seal, and walrus tagging studies as well as the Chukchi Offshore Monitoring in the Drilling Area program. Collectively, these studies are providing a comprehensive and detailed understanding of various physical and biological processes and components.

The species present in the U.S. Arctic continental shelf are well known, and the ecosystem processes that determine habitat characteristics and species distribution are increasingly well understood. For many



Source: NASA/USGS

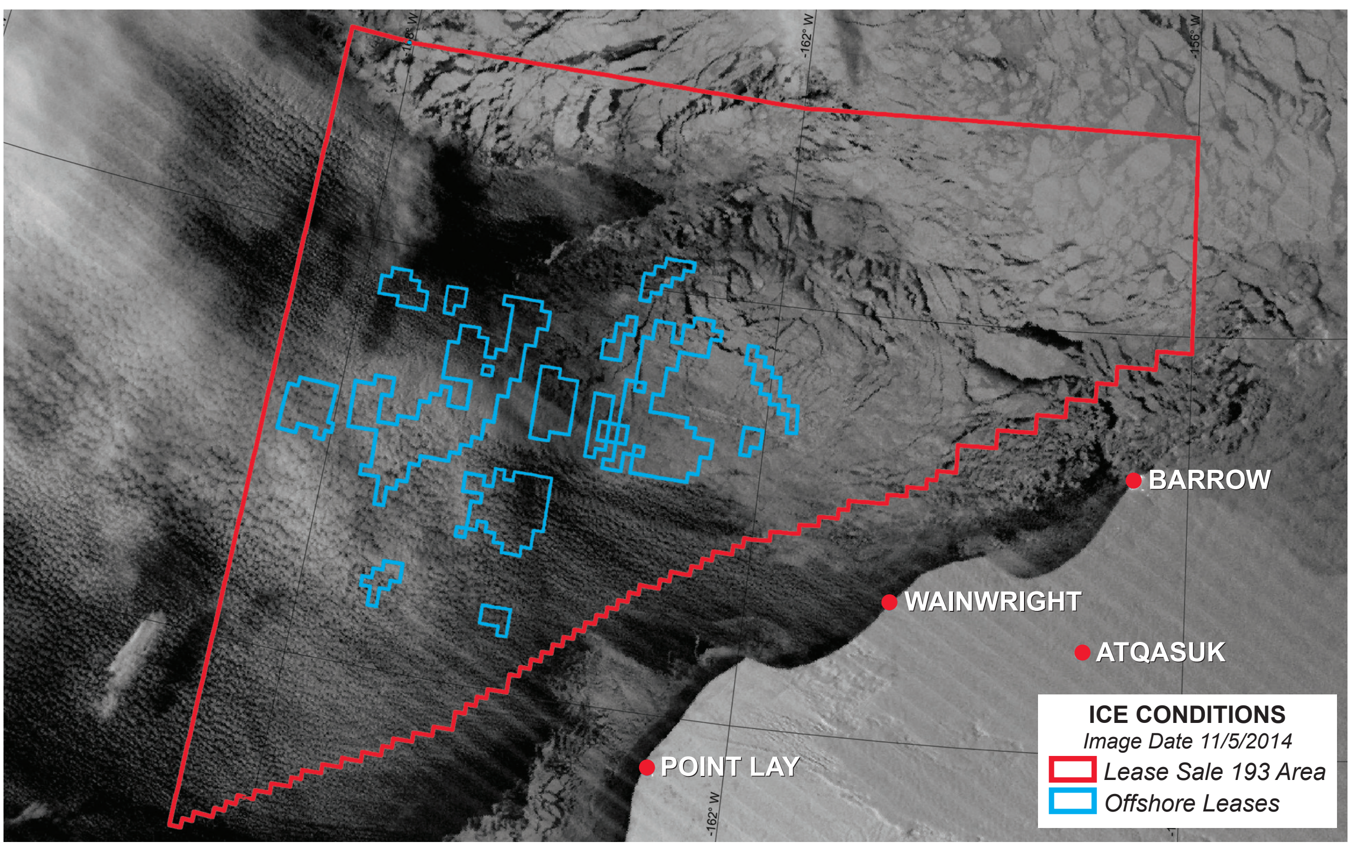


Figure ES-12. *Satellite Photos Showing Typical Chukchi Sea Ice Conditions Summer and Fall Shoulder Ice Seasons*

Photo: R. Pilkington

Photo: Shell

Figure ES-13. *Canmar Drillship and* Kulluk *Rig Operating in Canadian Beaufort Sea in Ice Conditions Typical of the Shoulder Seasons During Arctic Drilling Programs of the 1980s*

key species, the populations, habitats, and migration patterns are also very well understood. For example, abundance and habitat use of birds in terrestrial areas of the North Slope are well documented. Aerial surveys in the Beaufort Sea have documented widespread use of the nearshore and offshore waters along most of the coastline and into the northern Chukchi Sea during the open water period. Marine mammal populations of the Alaskan Arctic are some of the most intensively studied populations in the world, primarily because of interest in oil and gas resources and because of the importance of these species to Alaska Native cultures and subsistence activities. As a result, a great deal is known about the life history, distribution, and behavior of marine mammals in the Alaskan Chukchi and Beaufort Seas.

Information Opportunities

Decadal-scale fluctuations in the Arctic climate over the past 25 years have led to significant loss of thick, multi-year sea ice cover, which has rendered the ice pack thinner and more vulnerable to summer melting. As sea ice cover recedes, ice loss due to melting is being accelerated by increased heat absorption into the exposed ocean surface. This multi-decade trend of retreating summer sea ice area results in decreased availability of ice as habitat for Arctic species. It is important to understand the impacts of these changing physical parameters. Numerous monitoring programs have been under way over the last decade, but the collective body of research could be improved if it were better coordinated, continuous, and systematic.

Additional information would improve the ability of trustee agencies (resource managers including U.S. Fish and Wildlife Service and U.S. National Marine Fisheries Service) to establish more effective management policies and to issue focused permits that protect ecological resources while accommodating exploration and development activities. For example, population estimates could be improved for a number of species, including the Arctic cod and other forage fish, Pacific walrus, four species of ice seals, polar bears in the Chukchi Sea, and beluga whale stocks (Figure ES-14). Without detailed population estimates and growth/decline trends, agencies are ill equipped to establish policies based on sound population biology and to respond to litigation challenges.

Interactions between key species and industry operations have been studied extensively through a combination of traditional knowledge and western science for more than 30 years. Populations of Arctic marine species have not shown long-term negative impacts related to oil and gas activities. For example, the population of bowhead whales has continued to grow at a healthy rate of more than 3% per year during periods of exploration and development activity in close proximity to migratory pathways and feeding areas.

Source: Chukchi Sea Environmental Studies Program

Source: Shell Alaska

Figure ES-14. *Walruses and Whaling*

Localized and temporary behavioral changes have been documented in several species. For example, bowhead whales are known to alter their migration routes and deflect around oil and gas drilling platforms in the Beaufort Sea. It has also been observed that bowheads may alter the rate at which they call when exposed to sound levels from oil and gas activity. However, there is no evidence of measurable harm to the bowhead population based on extensive studies. Population growth of the bowhead stock indicates that oil and gas activities since the 1980s have not had a negative impact.

Mitigation measures that protect both populations and subsistence hunting of marine resources have been generally successful, but can be improved to continue to protect populations and subsistence hunting while accommodating oil and gas activities. Some of these mitigation measures include expansive time/area closures that significantly limit availability of the OCS to oil and gas operations during periods when physical access is most available. Improved ability to detect and resolve interactions between marine resources, resource use, and industry activities would yield benefits both to species protection and to expanded opportunity.

Considering offshore oil spill research in the Arctic regions, physical parameters (currents, oceanographic conditions, and ice movements) of the Chukchi and Beaufort Seas are relatively well understood and improving with recent studies and monitoring capacities largely driven by energy exploration. Numerous studies exist on the fate and effects of oil, dispersants, and dispersed oil on ecological systems. The ecological impacts related to a number of releases that have occurred nationally and internationally over the past 30 years have been and are being closely studied, adding to the knowledge base of fate and effects related to oil spills. Toxicity assessments of oils, dispersants, and response-related constituents have been conducted under a variety of conditions, with results for Arctic species and conditions generally within the range of fate and effects in other areas. However, additional information would help address stakeholder concerns regarding the ecological impacts of oil under ice, including through the winter, and oil in Arctic waters.

Characterization of the Human Environment

The term "human environment" as used in this study means the physical, social, economic, and cultural aspects of local communities and how these aspects may be positively or negatively affected by oil and gas and other activities. Indigenous subsistence cultures of the North, such as the Inuit (Inupiat), Yu'pik, and Chukchi, possess individual and community identities that are closely connected to hunting, distribution, and consumption of subsistence foods. The harvest of the bowhead whale by many coastal communities is a well-established example. Caribou, birds, fish, and plants are also valuable subsistence resources. Local stakeholders have concerns related to their ability to continue to utilize their environment sustainably.

The oil and gas industry has partnered with the local communities for many years to maximize the positive benefits and minimize the negative impacts of oil and gas exploration and development. Positive economic impacts are significant, and in many cases, have enhanced subsistence practices by providing jobs and income, with a flexible work schedule to promote subsistence hunting and fishing. These are intertwined because cash is necessary to purchase equipment, supplies, and fuel for harvesting subsistence resources. Oil and gas development in the Arctic is a major source of economic activity that supports the local economy.

The oil and gas industry has coordinated its activities with the whaling associations in North Slope villages to minimize disruption of subsistence activities. The Conflict Avoidance Agreement is one tool for communication and negotiation on topics such as subsistence hunt window, timing of operations, participation in communication centers, and other topics such as discharges. This negotiation and communication process is a conduit for bringing both western science and traditional knowledge together for the common purposes of protecting subsistence use while accommodating industry activities. While it is generally agreed by North Slope residents that oil and gas activity has improved their quality of life in many respects, the potential social effects of additional economic development in the region are a common concern. These concerns include how increased economic development could impact subsistence lifestyles, change the cultural and demographic makeup of villages, and increase reliance on outside resources. There is concern that a significant oil release could substantially affect subsistence lifestyles. A focus on safety and prevention of major spill in Arctic is the top priority for the oil and gas industry. Understanding of the fate and effects in the unlikely event of a spill in the Arctic is integral to an informed understanding of preventive measures, response measures, and mitigation strategies.

3. The Oil and Gas Industry Has a Long History of Successful Operations in Arctic Conditions Enabled by Continuing Technology and Operational Advances

The oil and gas industry has a long history of environmental stewardship and successful operations in the Arctic, including exploration, development, production, and transport, enabled by continuous technology advances and learnings from experience. Approximately 440 exploration wells have been drilled in Arctic waters,[12] including 35 in the Alaskan OCS.[13] Figure ES-15 highlights some of the key developments in offshore arctic conditions. Oil and gas activities in the global Arctic, onshore and offshore combined, have produced more than 25 billion barrels of liquids and 550 trillion cubic feet of natural gas.

Exploration drilling in Arctic conditions began just below the Arctic Circle at Norman Wells in the Canadian Northwest Territories in 1920, with production beginning in 1932. Most of the Norman Wells Field is under a 2-mile-wide portion of the Mackenzie River. In 1985, the development was expanded to include six artificial islands designed to withstand seasonal water level changes and loads from ice floes. This field continues to produce today, with a long record of operations integrity while contending with challenges such as seasonal flooding, ice jams, ice scouring, and permafrost.

In 1962, Pan American Petroleum Corporation discovered the first offshore oil field in the Cook Inlet of Alaska. In addition to long, dark, and cold winters, the Cook Inlet has tides as high as 30 feet and currents that reach up to 8 knots. From November to April, the Inlet's waters are filled with ice that moves with the tides. The first production platform was installed in 1964 using a steel platform concept adapted from Gulf of Mexico experience to withstand the harsh conditions and strong tidal forces and resist the forces of ice on the platform legs. In all, 16 platforms were installed in the inlet, with the last installed in 2000.

Most of the oil already produced from Alaska has come from the onshore North Slope Prudhoe Bay field, which was discovered in 1968 and began producing in 1977. Specialized design and construction allowed drilling through permafrost and operating production facilities under extreme climatic conditions. Oil from Prudhoe Bay is transported through the 800-mile Trans-Alaska Pipeline System, which incorporates multiple advancements including an innovative passive refrigeration system to avoid melting the permafrost and a zigzag configuration to allow for expansion and for movement in case of

12 Provided by IHS, International E&P Database.

13 Bureau of Ocean Energy Management Website (http://www.boem.gov/), "Exploration Wells Beaufort Sea.pdf" and Exploration Wells Chukchi Sea.pdf."

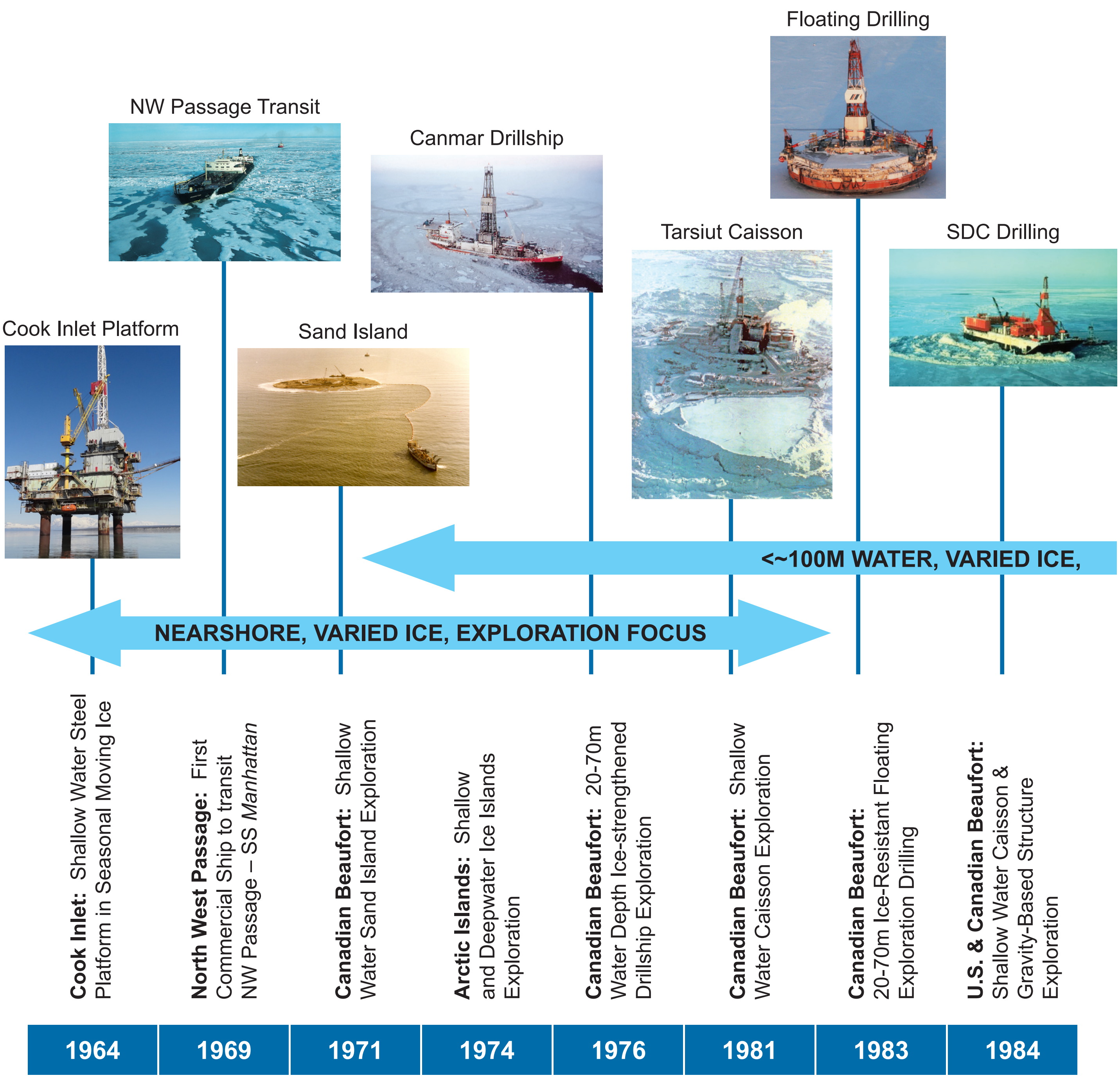


Figure ES-15. *Offshore Technology Development in Arctic Conditions*

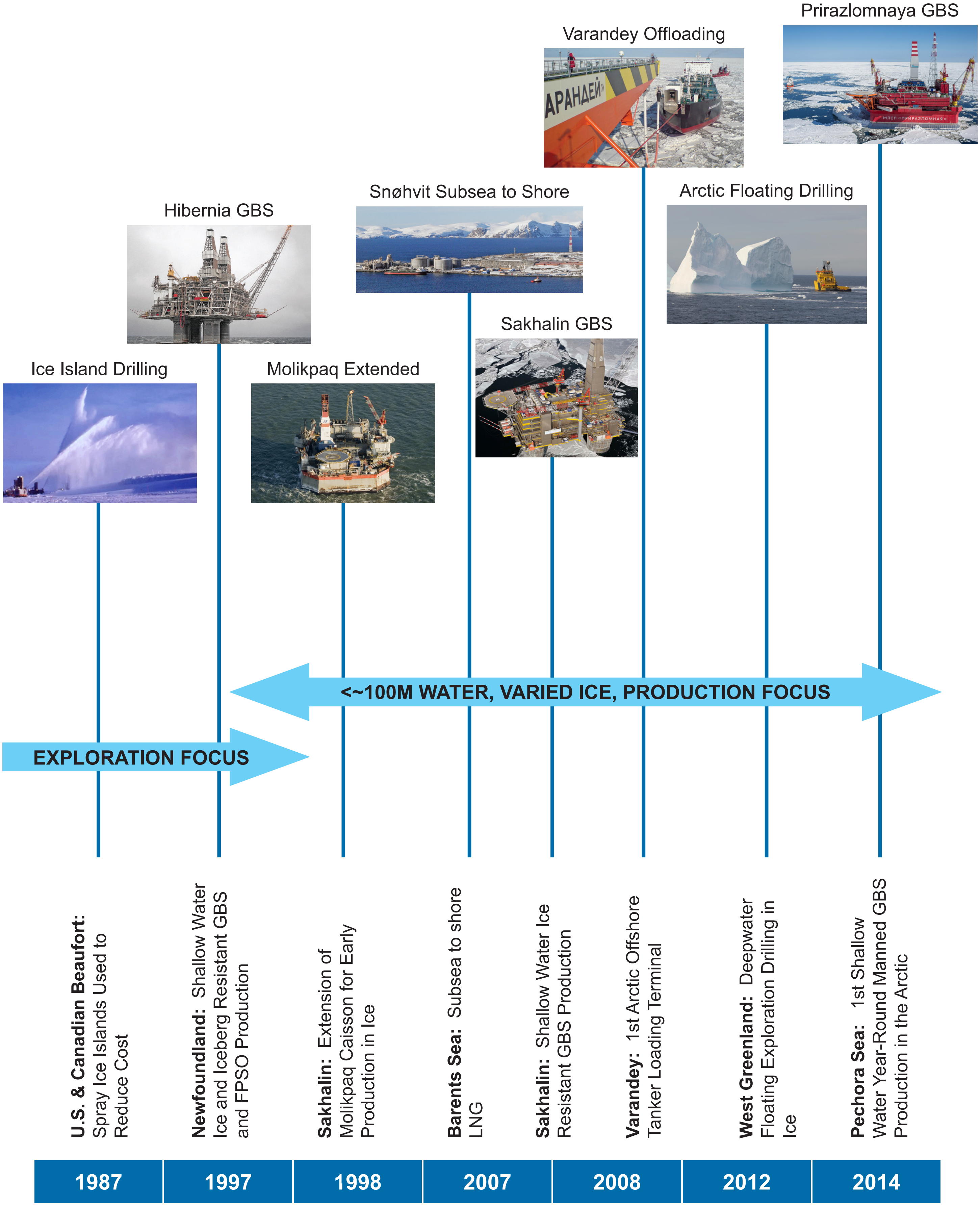


Figure ES-15. *Offshore Technology Development in Arctic Conditions (continued)* earthquakes. As onshore development progressed, technology advancements such as horizontal and extended reach drilling allowed development from fewer and smaller pads, reducing the environmental footprint, as described in the text box on the Prudhoe Bay Case Study.

In addition to the technical hurdles to develop Prudhoe Bay and construct TAPS, several permitting, legal, and political barriers had to be overcome. Unsettled Alaska Native land claims from as far back as 1867, the permitting process for TAPS, plus lengthy legal challenges from the environmental community all required a comprehensive congressional approach to developing Prudhoe Bay. The first congressional action was the passage of the Alaska Native Claims Settlement Act in 1971, which settled all Native land ownership. The second was the passage of TAPS Act in 1973 to facilitate construction of the pipeline due to the urgent national interest to ensure energy security. The key elements of the TAPS Act were to mandate that government studies to date were sufficient for permits and to set judicial review limits on challenges to the issuance of necessary rights-of-way, permits, leases, and other authorizations for construction and initial operation of the pipeline system.

Early offshore exploration drilling in the U.S. and Canadian Beaufort and Chukchi Seas began in 1969 with the first gravel islands built in shallow water. Shell's Sandpiper Island in 15 meters of water was the deepest man-made gravel island built at that time. In the mid-1970s, the first well was drilled from an ice island in U.S. state waters 3 kilometers offshore. As experience grew and gravel and ice island technology developed, exploration drilling progressed to the deeper federal OCS waters with additional technology developments. Ultimately, the water depth limitations of ice and gravel islands necessitated a move to bottom-founded structures. The first wells from bottom-founded structures were drilled in 1984 from Exxon's concrete island drilling structure. Canmar's single steel drilling caisson was used between 1986 and 2003.

The Northstar development, located about 12 miles northwest of Prudhoe Bay in about 14 meters of water, began production in 2001 and employed a gravel island concept. Self-contained drilling, production, and housing are located on a 5-acre artificial island, protected from sea ice and wave erosion by concrete armor, a steel sheet pile wall, and an underwater bench and berm system. A 6-mile subsea oil pipeline to shore was installed at a depth several feet below the deepest ice gouges ever recorded in order to protect against possible ice damage.

Moving further offshore into deeper water required using floating drill rigs, and the first floating rig wells were drilled by the Shell-Amoco-Union consortium at Camden Bay in 1985. Ultimately nine wells were drilled in the U.S. Beaufort Sea by two ice-resistant floating rigs, the *Canmar Explorer II* and the *Kulluk*.

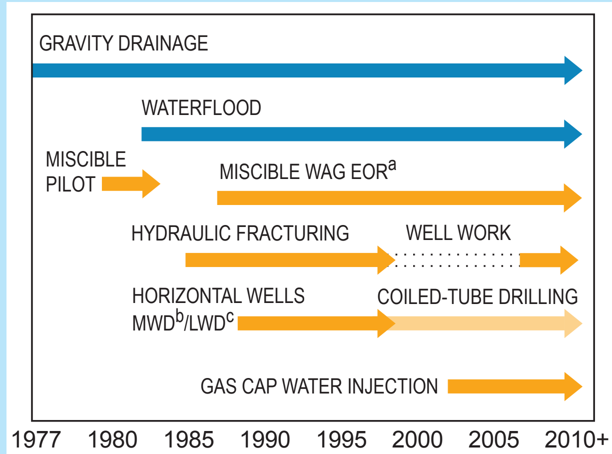
The Hibernia field was discovered offshore Newfoundland in 1979 and is one of the largest fields ever discovered in Canada. While there is little sea ice that reaches the Hibernia location, there is threat of iceberg collisions, which created unique design considerations for the production facilities. In the 1990s, the field was developed with a gravity-based structure, extended reach wells, and offshore tanker loading. The Hibernia gravity-based structure (GBS) was built using high-strength steel reinforced concrete with pre-stressed tendons to withstand a 6-million-ton iceberg impact. A sophisticated ice management program is employed to monitor for approaching icebergs. Support vessels are then used to divert any icebergs using ropes or water cannons.

The Molikpaq steel GBS mobile offshore drilling unit was deployed in the Canadian Beaufort Sea from 1984 through 1988 and was subsequently redeployed to offshore Sakhalin Island as an early production facility where it continues to be in operation today. The Molikpaq was an important early exploration structure since it provided measurements of full-scale, multi-year ice loads on a fixed platform. The results from these ice interactions formed the basis of the design ice load requirements contained in both API and ISO Arctic Standards.

Although south of the Arctic Circle, Russia's Sakhalin Island located north of Japan has been home to several developments in Arctic-like ice conditions over the past 20 years. The Sakhalin developments use a combination of offshore drilling platforms and extended-reach wells from onshore drill pads to reach the offshore reserves. The offshore platforms are among the largest ice-resistant concrete platforms ever constructed. Extended-reach wells drilled from shore out to a distance of 13 kilometers have set multiple world records for horizontal reach. The Sakhalin offshore platforms operate continuously through the

Prudhoe Bay Case Study—Technology to Prudently Develop Alaska's Largest Arctic Oil and Gas Field

TAPS Pipeline (Enabling Technology)



Enhanced Drilling and Recovery Technologies (Continuous Improvement)

Technology plays an important role in oil and gas resource development from the perspective of both enabling the initial development and in the continued improvement of operations to ensure fields continue to be prudently produced. The Prudhoe Bay field, discovered in 1968, is the largest oil field in North America and is located on the North Slope of Alaska. This field is an example of such technology development and continuous improvement.

The most notable use of technology to enable the Prudhoe Bay development was the Trans-Alaska Pipeline System (TAPS). To export oil, a purpose-built 800-mile pipeline from the field to the Valdez Terminal was designed and constructed using the latest technology to ensure safe operations and protection of the environment. Below are some of the major technology feats:

- Passive refrigeration system consisting of 140,000 heat pipes[d] along the pipeline to prevent permafrost melting and ensure the soil remains stable.
- Zigzag design to allow for pipeline expansion and contraction given that air temperatures along the pipeline can range from minus 80 to 95 degrees F. This design also allows for movement during earthquakes with no significant damage experienced in as high as magnitude 7.9 earthquakes.[d]
- Elevated pipeline to allow for wildlife migration, including Caribou and Moose.[d]

As production has continued, practices and technologies have been continually developed and improved to ensure that prudent development continues. Examples of these include:

- Directional, horizontal, and multilateral drilling have allowed greater reservoir access and drilling pad environmental footprints have been reduced by 70%.
- 3D and 4D seismic imaging have provided a greater understanding of the subsurface, and coiled tubing unit drilling has allowed smaller oil accumulations to be targeted at much lower cost.
- Several enhanced oil recovery techniques have been employed to increase oil recovery, including gas cycling, miscible gas injection, and a technique called water alternating gas injection.

The use of these and other technologies has helped increase the field's recoverable oil from 9.6 billion barrels of oil at the time of discovery to well over 13 billion barrels of oil today. Additionally, most of the original 26 trillion cubic feet of gas has been retained in the reservoir and is planned to be produced and sold as part of the currently proposed Alaska LNG project.

Today, Prudhoe Bay field development consists of six major processing facilities, one of the world's largest gas handling facilities, 38 well pads, more than two thousand wells, a seawater treatment plant, and more than a thousand miles of gathering lines. Technology development is expected to continue and improvements will facilitate additional economic and environmental benefits for both existing fields and other new Arctic development.

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a WAG EOR = Water Alternating Gas Enhanced Oil Recovery

b MWD = Measurements While Drilling

c LWD = Logging While Drilling

d Alyeska Pipeline Service Company website (http://www.alyeska-pipe.com/TAPS/PipelineFacts) and Alyeska Fact Book.

winter ice conditions where they must resist forces from ice ridge features more than 30 meters in thickness. The produced oil flows back to onshore processing facilities before being carried via pipeline to export terminals. In the case of Sakhalin-1, tankers are loaded year-round at the Dekastri Terminal and are escorted by icebreakers when ice is present. In 2009, this terminal was named Terminal of the Year at the Oil Terminal Conference in St. Petersburg by industry and experts for its economic, environmental, and social aspects.

The Snøhvit gas field in Norway was the first offshore Arctic development without any offshore surface structures. It is located 140 kilometers from shore in water depths of about 300 meters and began producing in 2007 with gas from the subsea wells flowing through pipelines to Melkøya, where the first LNG export plant in Europe processed the gas.

From the installation of the first platform in Cook Inlet in the 1960s, to the construction of the Trans-Alaska Pipeline System, and to the more recent development of Sakhalin, there has been a long track record of progressive accomplishments. Industry has benefited from the local knowledge of indigenous people as well as the know-how and experience from preceding developments, both Arctic and non-Arctic, and has advanced engineering design, technology, and operating practices.

4. Most of the U.S. Arctic Offshore Conventional Oil and Gas Potential Can Be Developed Using Existing Field-Proven Technology

The technical ability to explore and develop in the offshore Arctic is governed by a number of key factors: water depth, ice conditions, and the length of the open water season. Drilling rigs that rest on the seafloor have a maximum usable depth of about 100 meters in ice; deeper water requires floating rigs. Exploration can be carried out in waters with a short ice-free season using floating drilling rigs in waters deeper than about 20 meters, but development and production generally requires year-round operation to be economic, which means using facilities that rest on the seafloor and are resistant to ice forces in ice-prone areas.

The length of the open water season impacts the ability to carry out seismic acquisition and to conduct exploration and appraisal drilling with floating rigs. Nearshore, where landfast ice can be used to drill in the winter, the length of the landfast ice season is the primary variable that controls the ability to explore and appraise opportunities in that region. Figure ES-16 shows how the combination of these factors impacts the ability to explore and develop in various Arctic and some subarctic basins.

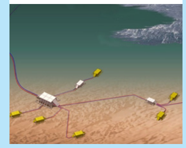
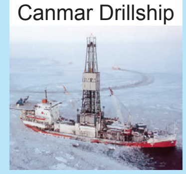
Most of U.S. Arctic offshore resources are in less than 100 meters of water and have some open water season. As a result, exploration is possible during summer and shoulder seasons with floating drilling rigs, and development and production are technically possible using conventional bottom-founded drilling facilities with numerous support vessels including oil spill response vessels. Such technology has been field-proven.

5. The Economic Viability of U.S. Arctic Development Is Challenged by Operating Conditions and the Need for Updated Regulations That Reflect Arctic Conditions

Technical feasibility is not the only consideration for successful development of oil and gas resources. Ultimately, an opportunity must be both technically and economically feasible to warrant pursuit. For development to progress, a resource opportunity of sufficient size and quality of producible oil and gas must be found. Thus, the ability to explore is the first critical step in a successful development process. Arctic exploration and development is more costly than in other areas due to remoteness, lack of infrastructure, challenging climate, and short operating seasons. Finding large, high-quality resources will be key to economically viable Arctic development. Additional factors that influence the economic feasibility of an opportunity include:

- *Infrastructure*. Availability of existing infrastructure to enable development and production increases the attractiveness of an opportunity. Lack of existing infrastructure increases cost and thus the economic burden on a potential development.
- *Stakeholder Alignment*. Alignment of local residents and other affected parties, regulators, and operators in the resource development process provides the operators with a social license to operate.

Increasing Complexity to Explore & Develop

Physical Ice Environment and Water Depth		Technology to Explore & Develop
Description	**Examples**	
Typically ice free, any water depth • Minor first-year ice intrusions, icebergs possible	• South Barents Sea • Newfoundland	**Exploration & development proven** (Various drilling rigs, floating solutions, GBS, subsea tieback) Snøhvit Subsea  Hibernia GBS 
Any ice conditions, nearshore & shallow water • <~15m water	• Globally, near shore (including U.S. Beaufort and Chukchi Seas)	**Exploration & development proven** (Ice & gravel islands, concrete & steel structures, extended reach drilling from onshore) Spray Ice Island  Northstar 
Open water >~2 months, any water depth • Mainly first-year ice, potential for combination of multi-year ice, icebergs, and ice islands • Water depth determines development concept (greater or less than ~100m is key)	• Sea of Okhotsk • Pechora Sea • Labrador Sea • U.S. Chukchi & Beaufort Seas • South Kara Sea	**Exploration proven; development proven mainly in <~100m water** Ice management required <~100m development by GBS >~100m development by floating drilling & subsea tieback Canmar Drillship  Sakhalin-2 GBS 
Open water <~2 months, any water depth • Likely to encounter multi-year ice and/ or icebergs, and in some locations ice islands • Water depth determines development concept (greater or less than ~100m is key)	• Deepwater Beaufort Sea • Deepwater Northern Russian Arctic Seas	**Exploration & development possible with technology improvements** Increased ice management capability and possible new technology
Limited to no open water • Frequent multi-year ice with embedded icebergs, and ice islands	• Northeast Greenland • Deepwater Northern Russian Arctic Seas	**Technology extensions or new technology required** Floating, robust ice managed solutions GBS/Subsea technology extensions or new technologies Difficult to mobilize equipment without open water season

Sources: Snøhvit Subsea - Statoil (Even Edland); Hibernia GBS - ExxonMobil; Spray Ice Island - BP – Amoco; Northstar - BP p.l.c.; Canmar Drillship - R. Pilkington; Sakhalin-2 GBS - Sakhalin Energy

Figure ES-16. *Exploration and Development in Various Arctic Conditions*

- *Regulatory Efficiency and Predictability.* An efficient regulatory framework with a clear process and a predictable timeline would support investment in challenging exploration activities. Two particular factors—drilling season length and lease length—currently have substantial negative implications for oil and gas exploration in the Alaska OCS.

Exploration Drilling Season Length

The limited time available each year for exploratory seismic data gathering and drilling is a major factor affecting the economic feasibility of offshore U.S. Arctic development. Beyond nearshore landfast ice and water shallow enough for constructing artificial islands, offshore exploratory drilling will usually need to be conducted using some form of mobile offshore drilling unit. Current regulations and permit conditions only allow exploratory drilling activity during the open water season. The U.S. Arctic open water season is typically only 3 to 4 months long and can be much shorter in a given year or be shortened by mid-season ice intrusions. The useful drilling period is further shortened by restrictions in recent permits requiring the ability to drill a same season relief well[14] before the onset of ice. It can take more than a month to drill a relief well in the Arctic. The useful drilling season may be even further shortened by voluntary agreements or regulations requiring an operator to cease operations to accommodate subsistence harvesting and marine mammals. Combining these factors, the practical drilling season in parts of the U.S. Arctic could be as little as 40 to 60 days each year.

For example, in the western area of the U.S. Chukchi Sea, the accessible season for drilling is July 1 to November 1, a total of 124 days. Assuming 7 days

14 A relief well is a separate well that is drilled, in the unlikely event of a loss-of-well-control incident or blowout, to intercept and permanently stop the flow from a blown-out well.

are needed to mobilize the drilling rig and supporting vessels to the site, and 38 days is reserved at the end of the season for drilling a relief well should one be necessary, there are only 79 days actually available in a calendar year for exploratory drilling (Figure ES-17). This may not be sufficient to complete one well in a single season. Multiple expensive mobilizations over several years would therefore likely be necessary to complete exploration of a prospect, substantially reducing the feasibility of offshore Arctic development.

There are technologies available to substantially extend the useful annual drilling season while maintaining operational safety and enhancing environmental protection. These technologies fall into two broad categories:

- *Advanced Well Control and Oil Spill Response.* As discussed in Key Finding 7 on oil spill prevention and response, technologies have been developed that can offer superior protection with shorter implementation time than a relief well. These technologies include subsea isolation devices and capping stacks. Furthermore, there have been advances in oil spill response techniques designed for operations in ice.
- *Ability to Operate in Ice.* Drilling rigs and the associated support vessels, including those for oil spill response and emergency evacuation, would be designed and strengthened to operate in water where ice is present and accompanied by ice monitoring and ice-management vessels. The ability to work safely and effectively in ice-covered waters has been demonstrated since the 1980s.

Applied to the previous Chukchi Sea example, substituting either a subsea isolation device that could be activated immediately or a capping stack,[15] which might take up to 14 days[16] to implement in place of the 38-day relief well requirement, would add 24 to 38 additional days to the useful drilling season. Allowing operations to extend into early ice season conditions within the demonstrated capability of an ice-capable drilling system would add an additional 30 to 45 days to the useful drilling season, extending it from an end date of November 1 to December 15 (Figure ES-17). The combined result would nearly double the available drilling season each year, enabling the drilling of an exploration well to its target depth in a single season and improving the economics of developing offshore Arctic prospects without compromising safety or environmental protection.

Lease Length

The Outer Continental Shelf Lands Act limits the primary term of any OCS lease to a maximum of 10 years. If oil or gas is discovered but cannot be shown to be commercially developable within this time, the lease must be relinquished, leaving the operator

15 Subsea isolation devices and capping stacks are discussed in more detail in Key Finding 7 of this executive summary.

16 14 days is an estimate and a single number is used in the example for simplicity. Depending on the plans specific operators submit, this duration may be days to weeks.

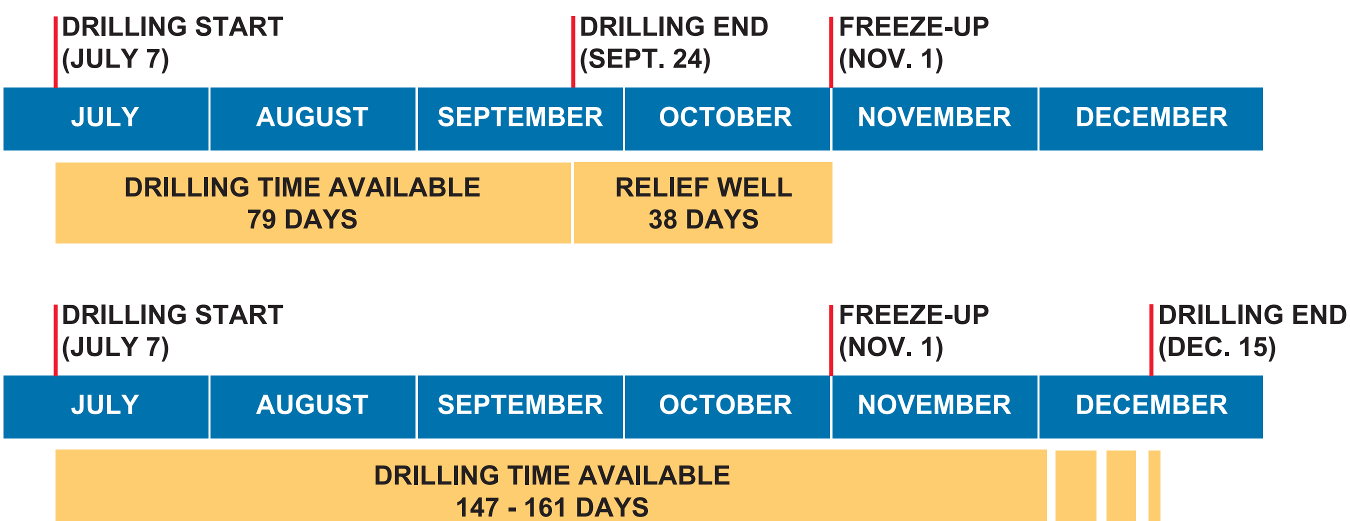


Figure ES-17. *Exploration and Development in Various Arctic Conditions* with no return on their exploration investment. Lessees in the U.S. Lower 48 have access to their leases 12 months of the year. This is not the case in the Arctic, where access is limited to 3 to 4 months a year. There are no specific allowances made in the lease terms for time lost on a lease due to ice cover.

The extent of exploration in the Arctic will be greater and the total time required will be longer than in other areas such as the U.S. Gulf of Mexico. This is because Arctic resources are expected to be larger, but less dense and spread over broader areas than in the Gulf of Mexico, and hence require more exploratory wells to gain sufficient definition of the resource to proceed to development. Also, the resource uncertainty in frontier areas such as the Alaska OCS means that subsurface knowledge gained from each well has a great impact on future drilling decisions, compelling serial rather than concurrent exploration drilling, as the results from each well affect decisions on where and how the next should be drilled. Given the severe limitations on the length of the useful annual exploration season, the greater time required for Arctic exploration programs, and the extremely high costs of drilling in remote, icy Arctic conditions, the current 10-year lease term is inadequate to support developing Alaska's OCS potential.

Other Arctic countries address the need for longer lease terms for Arctic frontier areas in various ways. The U.S. lease system is development based; to retain a lease, the operator must have gained enough information to be able to move into the commercial development phase by the end of the 10-year lease term. As described in the previous section, the short drilling season can make this difficult. Other countries have regulations that provide extra time to determine technical or commercial viability. Canada offers an exploration license with a 9-year term that can be extended if an operator is diligently pursuing drilling. If a discovery is made, the operator receives a Significant Discovery License that allows the operator to hold the lease indefinitely until the discovered field can be economically developed. Norway provides for an initial exploration license of 4 to 6 years that can be extended up to 10 years with commitment to a work program. If oil or gas is found, the operator can apply for an extension of up to 30 years. Table ES-1 summarizes these differences.

In addition to extending the lease time available for exploration, holding more frequent and predictable lease sales would also improve the ability to plan and execute exploration programs, particularly important in an area with a short working season. The inherent uncertainty in prospective frontier areas such as the Alaska OCS means that the subsurface knowledge gained from seismic surveys and the geological information from each drilled well significantly impacts on future drilling decisions. In the Alaska OCS, exploration and appraisal activities will proceed serially because the results of the first well in each area will determine where and how the next well should be drilled.

6. Realizing the Promise of Arctic Oil and Gas Resources Requires Securing Public Confidence

Exploration and development of Arctic offshore oil and gas resources will require securing and maintaining public confidence that the resources will be developed responsibly. Industry and government

Country	Lease/License System	Typical Well Count to Retain License/Lease*	Lease/License Duration
Canada	Exploration Based	1 to 2	9 years
Greenland	Exploration Based	1 to 2	Up to 16 years
Norway	Exploration Based	1 to 2	Up to 30 years
Russia	Exploration Based	1 to 2	10 years
United States	Development Based	6 to 7†	10 years

* The number of wells shown is estimated based on 1 to 2 wells needed to establish an exploration discovery.

† The number of wells shown includes exploration and appraisal wells. Based on practices used in the Lower 48, securing a lease extension beyond the primary term requires a firm commitment to develop requiring multiple appraisal wells, engineering studies, and funding. One appraisal well per 200 million barrels of recoverable volume, and a field size of 1 billion recoverable barrels was assumed.

Table ES-1. *Lease/License Comparison by Country* have a shared responsibility to gain and maintain the public trust:

- Industry must operate responsibly, bringing appropriate technology and operating practices to bear and continuously improving technologies and operations.
- Government must maintain and continuously improve effective policies and regulation that support development while ensuring protection of people and the environment.
- Both industry and government must engage the local communities.

The fourth and final recommendation of the NPC 2011 study *Prudent Development: Realizing the Potential of the North American's Abundant National Gas and Oil Resources* stated:

> Achieving the economic, environmental, and energy security benefits of North American natural gas and oil supplies requires responsible approaches to resource production and delivery. Development in different geographic areas requires different approaches and continued technological advances. But in all locales and conditions, the critical path to sustained and expanded resource development in North America includes effective regulation and a commitment of industry and regulators to continuous improvement in practices to eliminate or minimize environmental risk. These steps are necessary for public trust.

The NPC continues to support this recommendation.

"Prudent development" as used in this report encompasses oil and gas development, operations, and delivery systems that achieve a broadly acceptable balance of several factors: economic growth, environmental stewardship and sustainability, energy

Industry Risk Management

The Oil and Gas Industry has a rich, deeply ingrained safety and risk management culture that is backed by extensive training and mature management systems specifically designed to manage the risks inherent in oil and gas production. These management systems have different names among different companies, but they typically include the following elements:

- Management commitment to safe operations and leadership in establishing a culture of effective risk management
- Hazard identification and mitigation
- Maintaining integrity of facilities—design and maintenance
- Management of change
- Preparation for response to incidents should they occur
- Training of employees
- Inclusion of third party workers and suppliers in the same culture of risk management
- Community engagement
- Learning from near or actual incidents and continuous improvement of management systems.

Hazard identification and mitigation is at the heart of all risk management systems and typically consists of the following processes:

- Hazard identification by anyone ranging from experienced professionals conducting structured hazard and operability studies of proposed new operations to a new employee questioning a routine procedure as part of a daily job safety analysis
- Quantification of the probability and potential consequence of a hazard once identified
- Identification of mitigation steps to reduce the probability and/or consequence
- Application of the appropriate mitigation steps or stopping the activity if sufficient mitigation is not achievable.

Systematic management of risk is not only part of industry's culture, it is at the heart of its commitment to prudent operations and underpins industry's license to operate.

Source: ExxonMobil

Figure ES-18. *Simulated Incident Response Exercises*

security, human health and safety, and compatibility with the interests of the local communities. Prudent development necessarily involves trade-offs among these factors. It is incumbent on all stakeholders in the Arctic to apply the least intrusive, most technically appropriate, and safest means of assuring the continued balance of this ecosystem while producing the natural resources that bring economic and social vitality to the region and enhance U.S. long-term energy security.

Local Engagement and Traditional Knowledge

Securing public confidence also requires engaging with local communities to understand their issues and concerns. In the Alaskan Arctic, local stakeholders have concerns about the effect of development on their traditional culture and about the security of subsistence food resources. The potential effects of industry activity are both cause for concern and a source of economic benefit. To secure public confidence for development, these effects must be understood with any negatives minimized.

Over many generations, the indigenous peoples of the Arctic have developed a practical knowledge base founded upon personal experience and observation of their environment, referred to as traditional knowledge. The integration of traditional knowledge into western science has resulted in better understanding of ecological resources and improved regulatory and management policies. For example, traditional knowledge conflicted with conventional thought about the bowhead whale population, leading to an acoustic monitoring program that aided in the lifting of the International Whaling Commission ban on subsistence hunting of this resource. Application of traditional knowledge can improve understanding of the potential impacts of oil and gas development, leading to regulatory requirements that are more efficient at protecting the environment while promoting development of valuable resources.

Industry Role

The oil and gas industry strives to continuously improve its safety and environmental performance. Risks exist in any human endeavor, and oil and gas companies use extensive systems to identify, minimize, and manage the risks of oil and gas development. An overview of the key concepts of risk management is included in the text box entitled "Industry Risk Management."

An important aspect of risk management is advance preparation to respond effectively should an incident occur. Advance preparation includes providing response materials and equipment readily accessible should an incident occur, training personnel in effective response, and conducting simulated responses to reinforce training. The photographs in Figure ES-18 show response exercises being conducted to reinforce an incident command structure that promotes an effective, coordinated response.

Unfortunately, there have been incidents of varying sizes in global operations. Industry and governments have learned from these experiences and used those learnings to improve practices and regulatory requirements. Some key examples are shown in the text box entitled "Safety Improvements in the Oil and Gas Industry."

Throughout industrial history, advances in capabilities and technologies have started from experimentation, research, and first-of-a-kind activity. As these initial activities proved successful, they have been improved in economic, safety, environmental, and other ways through further research and experimentation, while the understanding of the activities' impacts has also grown. The oil and gas industry is no exception, with a long history of technology development and improvement. Advancements in technology and operational practices play a key role

Safety Improvements in the Oil and Gas Industry

Safety is the highest priority for all stakeholders and a core value for industry. However, over the last several decades, a small number of major incidents have had significant consequences, including in some cases the tragic loss of life. The industry and regulators have responded with reforms that substantially improved safety and environmental performance of the industry. Some examples of major incidents during exploration, development, and production include:

1988 – Production platform *Piper Alpha* in the North Sea off of the United Kingdom was destroyed by an explosion and resulting fire, with a loss of 167 crew members. Key reforms include:

- Stringent design requirements including wind tunnel testing and explosion simulations and improved and multiple escape route to helicopters and lifeboats during evacuation
- Clear identification of a person in charge who has the ultimate decision-making authority with regards to safety and the environment
- New regulations mandate operators must demonstrate that an effective safety management system is in place.

2010 – While drilling in the Gulf of Mexico, the *Deepwater Horizon* rig experienced a blowout and explosion that killed 11 workers. The well was capped 87 days later. Key reforms include:

- Enhanced drilling safety regulations including new standards for well design, casing, and cementing as well as independent certification
- Subsea containment devices as a requirement of spill response plans
- Increased emergency response preparedness requirements including worst-case discharge planning.

In addition, examples of maritime incidents that occurred during oil and gas exploration, development, or production include:

1989 – The *Exxon Valdez* ran aground in Alaska's Prince William Sound. Despite efforts to stabilize the vessel, more than 250,000 barrels of oil were spilled. Key reforms include:

- Passage of landmark legislation to improve American oil spill prevention and response
- New requirements for contingency planning, both by government and industry
- Establishment of new tanker design and tug escort criteria
- Development of an integrated operations integrity management system by the operator.

2012 – During towing of the drilling rig *Kulluk* from Dutch Harbor, Alaska, to Seattle, Washington, the towline parted and the *Kulluk* ultimately ran aground in rough weather on Sitkalidak Island near Kodiak, Alaska, on December 31, 2012. There were no serious injuries or environmental damage. Key reforms include:

- U.S. Coast Guard and Towing Safety Advisory Committee task group set up to assess strengthening global guidelines for towing offshore drilling rigs and harsh weather risk assessment, due spring 2015
- U.S. Coast Guard recommendations for all operators to reevaluate towing procedures and consider new criteria for tow planning in the Arctic.

in improving the safety and efficiency of operations while reducing negative impacts. These advances can support public confidence in industry activity, provided that the public believes that the advances will be applied responsibly. The government also has a role in research and gaining support for technology advances.

Government Role

The government's responsibilities in securing public confidence include:

- Establishing high-level policy and promoting alignment and consistency among agencies
- Developing and maintaining regulatory processes to ensure public health and safety and take advantage of advances in science, technology, and processes
- Increasing the availability of scientific and technological data and tools to support informed policy decision-making and resource management.

Over many years, the federal government, state of Alaska, and local Alaskan communities have developed a comprehensive regulatory structure to protect the environment, human health, and safety and to collect revenues for governments and its citizens. The renewed interest in the Alaska OCS has triggered a review of the present federal regulations to ensure that these regulations will adequately address the conditions of the Alaskan OCS. Federal, state, and local agencies all have a role in the exploration and development processes through issuance of permits to obtain seismic and geological data, secure leases, and through to development, production, and decommissioning.

Figure ES-19 provides an overview of the number and scope of these regulations and highlights the permits required at various stages of the prudent development process. This study has confirmed the conclusions of previous studies, including the 2011 NPC *Prudent Development* report, that multiple, overlapping regulatory agencies with, in some instances, conflicting regulatory objectives, bring a high level of uncertainty, additional cost, and delay to permitting processes and reduce the predictability of regulatory oversight. Securing permits for oil and gas projects in Alaska can typically consume 10 to 30% of the duration of the lease, which further reduces the probability of achieving successful exploration programs. In addition, the complexity of the system exposes multiple opportunities for legal challenge, which can cause further delays.

Domestic Policy

The specifics of the extensive federal and state regulatory process for the Arctic ultimately reflect the policy of the federal and Alaska governments. In addition to guidance on potential research to support prudent development of Arctic oil and gas resources, Secretary of Energy Moniz also requested the NPC's input on implementation of the U.S. National Strategy for the Arctic Region (NSAR) and considerations as the United States assumes leadership of the Arctic Council in 2015.

Since President Nixon's National Security Decision Memorandum in 1971, the United States strategy for the Arctic has continued to evolve. Common themes have centered on national security, economic development, and science. On May 10, 2013, President Obama released a new NSAR articulating the vital linkages between events in the Arctic and enduring U.S. interests. The strategy makes a case that changes in the Arctic are affecting U.S. national security. The strategy defines strengthening international cooperation as one of the principal ways to support new commercial opportunities while providing environmental stewardship. In January 2014, the White House issued an Implementation Plan for the National Strategy for the Arctic Region (IPNSAR) identifying details on how to achieve the strategy's major objectives regarding hydrocarbon development: promotion of Arctic oil pollution preparedness, prevention, and response internationally, and advancement of U.S. interests in the region.

The national strategy was supported by the Coast Guard's Arctic Strategy release in May 2014, the Department of Defense's in November, and the Navy's in early 2015. All three highlight the importance of the Arctic region to U.S. national and energy security and all three documents emphasize the significance of Arctic hydrocarbons to the U.S. national interest:

- They reduce oil and gas imports from less secure sources.
- Alaskan crude oil and natural gas will contribute positively to the nation's balance of trade.
- Development of Alaskan crude oil could provide important foreign policy benefits in allowing the

1. Lease Land

- BOEM – OCSLA – Lease Sale
- Lease Stipulations[1]
- NEPA review[2] (conducted by agency)
  - Includes review of multiple applicable laws
- Reviewed by State of Alaska for consistency with state laws
- Reviewed by BSEE for technical and safety content

2. Seismic Acquisition

- BOEM – OCSLA – A&A
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – G&G
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – NTLs for seismic acquisition
- BOEM – OCSLA – Lease stipulations[1]
- EPA – CWA – NPDES Vessel General Permit
  - Vessel discharges
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2] (conducted by agency)
  - 4MP
  - IHAs / LOAs (as appropriate)

3. Site Selection

- BOEM – OCSLA – A&A and SHS[3] (On-Lease Activities)
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – G&G and SHS[3] (Off-Lease Activities)
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – Lease stipulations[1]
- EPA – CWA – NPDES General Permit
  - For geotechnical activities
- EPA – CWA – NPDES Vessel General Permit
  - Vessel discharges
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2] (conducted by agency)
  - 4MP
  - IHAs / LOAs (as appropriate)
- ADEC – CWA – APDES General Permit
  - For geotechnical activities in State of Alaska waters

4. Local Considerations

- ADNR – LUP
- NSB – Title 19 Zoning
- NWAB – Title 9 Zoning
- Industry – Local Stakeholder Engagement Methods
  - AEWC – CAA
  - Subsistence mitigation
  - Marine mammal co-management meetings
  - POC meetings
- Native allotment owners

5. Exploration Drilling

- BOEM – OCSLA – EP/EIA
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – Lease stipulations[1]
- BSEE – OCSLA – APD
- BSEE safety regulations
  - NTLs
  - OSRP
  - COCP
  - BOP certification/recertification
  - WCD
  - DIMP
- EPA – CWA – NPDES General Permit
  - Drilling activities
- USACE – NWP #8
- USCG – Safety and Security Zones
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2]
  - 4MP
  - IHAs/LOAs (as appropriate)

6. Development and Production Plan

- BLM – Certificates of Public Convenience
  - NEPA review[2] (conducted by agency)
- BOEM – OCSLA – Development and Production Plan
  - NEPA review[2] (conducted by agency)
- BSEE – OCSLA
  - APDs
  - OSRP
  - DOCD
- EPA – CWA – NPDES General Permit
  - Development activities
- USACE – Section 404 Permit
  - NEPA review[2] (conducted by agency)
- JPO-SPCO – ROW
  - ADNR – LUP
  - NSB – Title 19 Zoning
- NOAA/NMFS, USFWS – MMPA – Authorizations
  - NEPA review[2] (conducted by agency)
  - 4MP
  - IHAs / LOAs (as appropriate)
- Disposal and Injection Well Permits (APD from BSEE; UICS, NPDES from EPA)

NOTES

[1] OCS Lease Stipulations include:
1. Protection of Biological Resources
2. Orientation Program
3. Transportation of Hydrocarbons
4. Industry Site-Specific Bowhead Whale Monitoring Program
5. Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence Harvesting Activities
6. Pre-Booming Requirements for Fuel Transfers
7. Lighting of Lease Structures to Minimize Effects to Spectacled and Steller's Eider

[2] The NEPA review process for each agency involves:
- EIS/EA and ESA review
- Section 7 Biological Opinion and ITS for ESA species
- EFH assessment

[3] SHS includes:
- Clearance of potential hazards for placement of anchors
- Includes clearance of archaeological features

ACRONYMS

4MP	Marine Mammal Monitoring and Mitigation Plan
A&A	Ancillary Authorization
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
APD	Application for Permit to Drill
APDES	Alaska Pollutant Discharge Elimination System
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CAA	Conflict Avoidance Agreement
COCP	Critical Operations and Curtailment Plan
CWA	Clean Water Act
DIMP	Drilling Incident Management Plan
DOCD	Development Operation Coordination Document
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EP	Exploration Plan
EPA	Environmental Protection Agency
ESA	Endangered Species Act
G&G	Geology & Geophysics
IHA	Incidental Harassment Authorization
ITS	Incidental Take Statement
JPO-SPCO	Joint Pipeline Office-State Pipeline Coordinator's Office
LOA	Letter of Authorization
LUP	Land Use Permit
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSB	North Slope Borough
NWAB	Northwest Arctic Borough
NTL	Notice to Lessees
NWP	Nationwide Permit
OCSLA	Outer Continental Shelf Lands Act
OSRP	Oil Spill Response Plan
POC	Plan of Cooperation
ROW	Right of Way
SHS	Shallow Hazard Survey
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish & Wildlife Service
WCD	Worst Case Discharge

Majority of requirements included, list may not be exhaustive

Figure ES-19. *Alaska OCS Oil and Gas Project Exploration and Development Requirements*

United States to supply energy to vital Pacific allies such as Japan, Korea, and Taiwan in the event of a supply disruption.

- Oil and gas development encourages vitally needed infrastructure in a region with increasing tourist and trade activities.

The Department of the Interior, which is responsible for leasing and regulation of U.S. Arctic oil and gas development, is likely the agency with the most influence over Arctic oil and gas policy, but it is by no means the only agency. The U.S. Coast Guard and the Environmental Protection Agency have jurisdiction over oil spills, offshore and onshore respectively, with the assistance of the other federal agencies that make up the U.S. National Response Team. The National Oceanic and Atmospheric Administration and the Department of Energy maintain roles related to scientific research and technology development. The Department of State maintains jurisdiction over diplomatic efforts, including those related to energy, with the assistance of the agencies that lead delegations to Arctic Council Working Groups and Task Forces. In total, there are 39 federal agencies participating in the Arctic Policy Group, 27 agencies and working groups identified in the IPNSAR, and seven interagency policy coordination bodies. Given the breadth of federal government involvement in Arctic policy and the numerous agencies, committees, and working groups involved, implementing a cohesive national strategy and coordinating activities across the multitude of agencies will continue to be a significant challenge.

On January 21, 2015, President Obama issued an Executive Order, "Enhancing Coordination of National Efforts in the Arctic," that created an Arctic Executive Steering Committee to "provide guidance to executive departments and agencies and enhance coordination of federal Arctic policies across agencies and offices, and, where applicable, with state, local, and Alaska Native tribal governments and similar Alaska Native organizations, academic, and research institutions, and the private and nonprofit sectors." The chair of the Steering Committee will be the head of the Office of Science and Technology Policy or designee. The vice chair of the Steering Committee will be the U.S. National Security Adviser or designee. The other members of the Steering Committee are listed in a nearby text box. The Executive Steering Committee member roles are still in the formative stage.

On February 24, 2015, as this study was in final review, the Department of the Interior proposed new regulations for U.S. Arctic OCS drilling to continue to ensure that operations are conducted in a safe, responsible, and culturally sensitive manner. The proposal refers to many technologies and practices that have been extensively studied by the NPC for this

Arctic Executive Steering Committee Members

- Office of Science and Technology Policy
- Council on Environmental Quality
- The Domestic Policy Council
- National Security Council
- Department of State
- Department of Defense
- Department of Justice
- Department of the Interior
- Department of Agriculture
- Department of Commerce
- Department of Labor
- Department of Health and Human Services
- Department of Transportation
- Department of Energy
- Department of Homeland Security
- The Office of the Director of National Intelligence
- The Environmental Protection Agency
- The National Aeronautics and Space Administration
- The National Science Foundation
- The Arctic Research Commission
- The Office of Management and Budget
- The Assistant (or designee) to the President for Public Engagement and Intergovernmental Affairs
- Other agencies or offices as determined appropriate by the chair of the Steering Committee.

report. Ice characterization and ice management are discussed in Chapters 5 and 6. Oil spill prevention, control, and response, including kick detection, blowout preventers, well control and containment technologies, and oil spill response in ice, are discussed in Chapter 8. Some of the proposed new regulations are aligned with this study and some could benefit from progressing the research recommended in this study. Specifically, this study has new information and recommends additional research and analyses that may be helpful in developing the final rule and future actions in the areas of oil spill prevention and source control, oil spill response in ice, and technologies to safely extend the drilling season. Pursuing this research is critically important to assess technology that has been advanced in other regions for potential acceptance in the United States to ensure environmental stewardship and promote exploration drilling that is more cost effective.

State of Alaska

The state of Alaska has a long history of proactively working to address energy, economic opportunity, and other issues that affect the state and the Alaskan people. When Alaska became a state in January 1959, crude oil was being produced from Cook Inlet and the first major gas discovery had been made. Under the Statehood Act, the new state was entitled to 100 million acres of land, and it focused on selecting lands that were highly prospective for oil, gas, and minerals. The state established the necessary regulatory regime and began holding predictable lease sales, which enabled the discovery of the Prudhoe Bay oil field in 1968. The state's leaders sought to increase their ability to interest investors in Alaska opportunities by taking active roles in the Energy Council and the Interstate Oil and Gas Compact Commission.

In the 1990s, the state of Alaska created a one-stop permit coordination office to provide project applicants, agencies, stakeholders, and the general public the necessary resources to promote a transparent, consistent, and predictable state permit process for proposed resource development projects. The Office of Project Management in the Alaska Department of Natural Resources offers coordinated state permit support for large oil and gas, mining, transportation, and renewable energy projects located throughout the state. The Office of Project Management's permit coordination model is unique to Alaska.

In advance of the U.S. Chairmanship of the Arctic Council and in response to the growing global interest in the Arctic, the Alaska State Legislature in 2012 established the Alaska Arctic Policy Commission to develop an Arctic policy and implementation plan for the state that reflects the values of Alaskans. The Commission's report, released on January 30, 2015, identifies four priority lines of effort:

- Promoting economic and resource development
- Addressing the infrastructure and response capacity gap in the Arctic
- Supporting healthy communities
- Strengthening a state-based agenda for Arctic science.

The Arctic Council

Established in 1996 through the Ottawa Declaration, the Arctic Council has been built on a foundation of environmental stewardship of the Arctic environment and sustainable development. The Arctic Council has become the most prominent and visible multilateral Arctic institution. Today, the Arctic Council consists of eight Arctic states (the United States, Canada, the Russian Federation, Norway, Kingdom of Denmark, Sweden, Finland, and Iceland), six permanent participant groups, twelve observer states, and a multitude of other governmental and nongovernmental organizations.

The permanent participants represent approximately 500,000 Arctic indigenous inhabitants and have made the protection of their cultural heritage and rights to subsistence living a priority, while also improving the health, well-being, and economic stability of indigenous communities. The primary role of observer states is to observe the work of the Arctic Council and make relevant contributions at the level of the working groups.

Through six primary working groups, guidelines are prepared on various topics relating to the sustainable development of the Arctic. The Emergency Prevention, Preparedness, and Response Working Group was instrumental in developing a set of operational guidelines that support the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic that was signed at the Kiruna Ministerial meeting in 2013. The Arctic Council's Task Force on Pollution Prevention is progressing an

Action Plan that establishes a framework for cooperation on oil spill prevention across Arctic states. Additionally, the Arctic Economic Council has been created to provide a forum to discuss economic development of the Arctic region and allow inclusion of the business community in those discussions.

The United States held the Chairmanship of the Arctic Council from 1998 to 2000 and will resume the chairmanship in April 2015. The proposed agenda for the U.S. chairmanship centers around addressing: Arctic Ocean safety, security, and stewardship; improving the economic and living conditions of the people of the North; and addressing the impacts of climate change. Prudent development of U.S. offshore Arctic oil and gas would be consistent with these strategies and offers significant benefit to economic and living conditions of the people of the North, as described in Key Finding 1.

7. There Have Been Substantial Recent Technology and Regulatory Advancements to Reduce the Potential for and Consequences of a Spill

Prudent development of the offshore U.S. Arctic is contingent on being able to prevent major oil spills and to respond effectively should any spills occur. Over the past four decades, the oil industry has made significant advances in being able to prevent, contain, and mitigate impacts of spills in Arctic environments. Even so, concerns remain regarding industry's capability to prevent spills and to promptly deal with spills in Arctic waters, especially in the presence of ice. Addressing these concerns will be central to the acceptance of extended season drilling operations, which is key to conducting economic exploration and development in areas where open water seasons are severely limited.

Industry's primary focus is on spill prevention; however, the risk of a spill can never be completely eliminated, so effective oil spill response capability is also critical. The "bow-tie" diagram in Figure ES-20 illustrates the spectrum of measures industry employs to protect the environment from oil spills due to loss-of-well-control incidents. On the left hand side of the bow tie are preventative measures aimed at reducing the risk of an incident in the first place. Prevention is accomplished through a set of primary and secondary barriers.

The primary barriers maintain control against backward flow of formation fluids during the drilling process. These begin with well planning and design based on knowledge of the subsurface formations and fluid pressures gained from seismic exploration. Steel casing and wellheads are designed to withstand formation pressures, and specially formulated cement seals the steel casing to the borehole. The weight of the drilling fluid column is designed and monitored to offset subsurface formation pressures. Careful control of the drilling process is facilitated by having a crew of well-trained personnel who constantly monitor well stability. This includes the use of sensors located near the drill bit that continuously measure downhole conditions and transmit them to the drilling control room and surface measurements of the drilling fluid volume and flow rates, as well as geoscientists onsite who analyze the rock cuttings from the well.

Secondary barriers include procedures to detect and control deviations from normal operating conditions and the blowout preventer (BOP). An example of a deviation is an influx of formation fluids into the wellbore, also called a "kick." Kicks are detected using equipment located on the deck of the drilling rig. If formation fluid flows into the wellbore, an increase in the volume of returning drilling fluid can be detected in the mud tanks and/or by gas detectors. A trained drilling crew will detect this and take the necessary action, which normally involves closing the BOP or pumping heavier mud into the wellbore.

The BOP has multiple, redundant, powerful sealing components that can be remotely activated to close around or shear through pipe and seal the wellbore to provide containment of fluids before they can escape in the event of a loss of well control. The Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE) has numerous requirements for BOP tests. The BOP stack must be fully pressure tested every 14 days for subsea BOPs and every 21 days for surface BOPs, and a function test must be conducted every week. Also, the BOP stack must be pressure tested upon initial hook-up to the wellhead and after each casing string is set. Additional regulations implemented post-Macondo for BOPs include requirements for recertification by the original

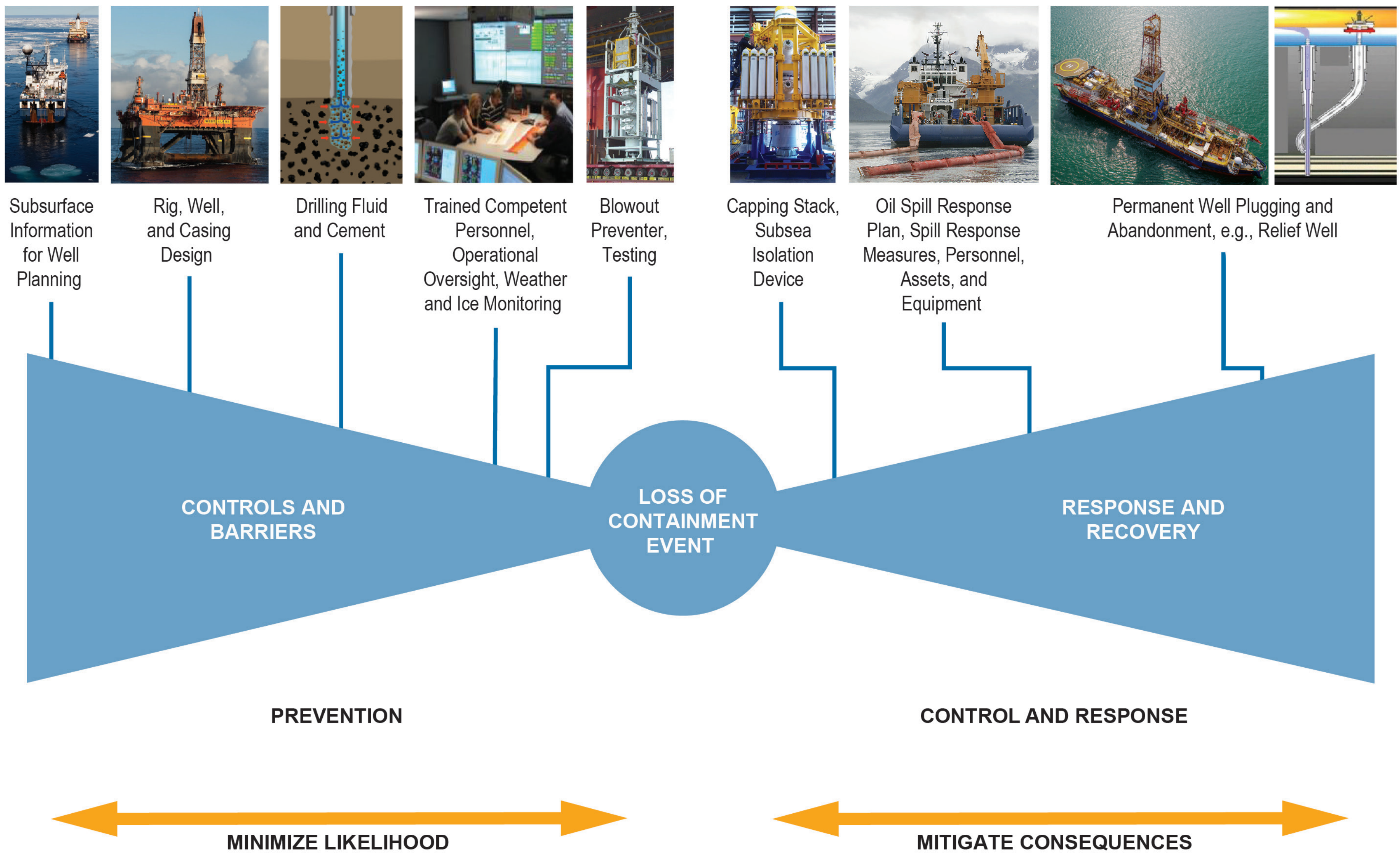


Figure ES-20. *Well Control and Barriers Leading to Response in the Worst Case* equipment manufacturer every five years, additional functionality such as at least five ram preventers with a minimum of one annular ram, two pipe rams, and two shear rams of which one must be a sealing type, and additional redundancy such as two control stations, one located near the rig floor and the other distant from the rig floor.

At the center of the bow tie is a loss-of-well-control incident, which means that primary and secondary barriers have been breached and there is loss of containment of wellbore fluids. The right-hand side addresses limiting the size of a spill once containment is lost and responding to any spill. Flow-stoppage measures on the right-hand side are employed to stop the outflow of a well to the environment through the use of shut-in devices such as a capping stack or a pre-installed shut-in device at the seafloor whose operation is totally independent of the BOP. These tools are designed to stem the uncontrolled flow of oil as rapidly as possible to minimize damage to the environment. The final available flow-stoppage measure is a relief well, which is a separate well drilled to intercept and permanently stop the flow from a blown-out well. Depending on the circumstances, the well may be plugged from the wellhead, which would eliminate the need for a relief well to accomplish final plugging and abandonment.

On the right side of the bow tie is the variety of spill response measures that can be used to remove spilled oil from the environment and minimize environmental damage. These would include tracking spilled oil, mechanical recovery using booms and skimmers, in-situ burning of the oil, and use of dispersants. The potential for encountering sea ice, cold temperatures, and potentially limited shore infrastructure are key features that differentiate Arctic spill response from others. While challenging in many respects, research has shown that cold temperature and ice can slow the spreading rate of spilled oil.

There have been substantial recent technology and regulatory advancements in oil spill prevention and response capability. These include advances in well design, spill prevention measures and practices, and spill response methodologies. Continued advancement of these technologies, coupled with building of public confidence in their capabilities, are essential elements in the acceptance of future U.S. Arctic drilling activities. Collaborative work with the public and regulators can be an effective mechanism for gaining stakeholder confidence in the use of these improved control and mitigation technologies.

The following concepts provide context for appreciating technology achievements to date and to help determine future technology needs surrounding the issue of Arctic oil spill prevention and response:

- Role of prevention as the primary defense against loss of well control
- Recent technical advances in source control
- Long history of research into oil behavior and spill response in ice
- Selecting and executing the most effective response strategy.

Role of Prevention

The greatest reduction of environmental risk comes from preventing any loss of well control. This is achieved through adherence to established codes/standards and operations integrity management systems, combined with a culture of safety and risk management. Industry's primary approach to prevention is guarding against loss of well control. A major well-control event is extremely unlikely, and recently upgraded U.S. regulations, standards, and practices make the likelihood of a major well control event even less likely. Recent steps taken to improve safety include certification by a licensed professional engineer that there are two independently tested barriers across each flow path and that the casing design and cementing design are appropriate and independent third-party verification of the BOP. These engineering safeguards are backed up by requiring strict adherence to operations integrity management systems as part of an overall culture of safety and risk management. The multiple spill prevention measures and barriers that are designed into the wells are defined and specified in U.S. and international standards and U.S. offshore regulations. Arctic well design and construction follows these standard offshore well practices.

Recent Technical Advances in Source Control

Additional well control devices and techniques are now available that are independent of the controls on the drilling rig. Examples of these devices are capping stacks that are deployed after an incident to stop the flow from the well and subsea isolation devices installed before the well encounters potential hydrocarbon-bearing zones in addition to standard BOP. These systems offer a dramatic reduction in worst-case discharge volumes because they are designed to stem the flow of oil in a matter of minutes, hours, or days versus weeks or months. Consequently, they can provide a superior alternative to the requirement for same season relief well and/or oil spill containment systems.

Arctic Spill Response Research

Over the past four decades, the oil industry and government have made significant advances in being able to detect, contain, and clean up spills in Arctic environments. Many of these advances were achieved through collaborative international research programs with a mix of industry, academia, and government partners. Much of the existing knowledge base in the area of Arctic spill response draws on a long history of experiences with a number of key field experiments, backed up by laboratory and basin studies in the United States, Canada, Norway, and the Baltic countries.

The ongoing Arctic Oil Spill Response Technology Joint Industry Programme (ART JIP) is a comprehensive research initiative bringing together the world's leading Arctic scientists and engineers. This program was initiated in 2012 as a collaboration of nine international oil and gas companies: BP, Chevron, ConocoPhillips, Eni, ExxonMobil, North Caspian Operating Company, Shell, Statoil, and Total. These companies have come together to further enhance industry knowledge and capabilities in the area of Arctic spill response as well as to increase understanding of potential impacts of oil on the Arctic marine environment. Such collaborative projects, in a noncompetitive technology arena wherein all stakeholders stand to gain from mutual advancement of capabilities, have been the hallmark of industry's oil spill response research.

In addition to substantial industry-sponsored research, there has been a long and effective research effort led by government organizations. For more than three decades, MMS/BSEE has funded programs for open water and in ice. The National Oceanic and Atmospheric Administration (NOAA) is involved in a variety of oil spill research projects in conjunction with academia and other agencies that includes development of an Arctic version of its oil spill trajectory model GNOME (General NOAA Operational Modeling Environment). The U.S. Environmental Protection Agency is conducting tests of dispersant efficacy and toxicity at low temperatures.

A long history of intensive research into oil spill behavior and response in ice-covered waters provides a strong foundation for Arctic oil spill contingency planning today. As with oil spill response in temperate environments, there will always be a need to advance capabilities and knowledge. The ongoing research exemplified by the ART JIP recognizes the critical importance of this issue to all key stakeholders concerned with protecting the Arctic environment.

Selecting and Executing the Most Effective Response Strategy

There is extensive knowledge on oil spill response and behavior in ice and cold water based on at least four decades of research. Industry and government agencies continue to put significant resources into technology enhancements through collaborative research that will further improve the operability and effectiveness of different response systems in ice. Defining and gaining acceptance of existing technology and technology enhancements requires integrating a diverse set of stakeholder groups, including Arctic community residents and regulators, into a collaborative effort to resolve uncertainties and agree in advance on the most effective oil spill response options.

The overall goal of spill response is to control the source as quickly as possible, minimize the potential damage caused by an accidental release, and employ the most effective response tools for the incident. Promoting mutual understanding of the benefits, limitations, and trade-offs of different response tools would facilitate achieving this goal. Response options that are highly effective under certain conditions may be ineffective in others depending on spill size, location, oil type/weathering, and environmental conditions.

Response strategies for spills in ice use the same general suite of countermeasures, modified and adapted for use in ice, that are used elsewhere in the world, including:

- Mechanical containment and recovery with booms and skimmers in open water and open pack ice

Advanced Technologies for Prevention of Blowouts and Major Spills

Source: Cameron

BOP

Source: Shell

Capping Stack

Source: Trendsetter Engineering Inc.

Subsea Isolation Device

Blowout Preventers (BOP). Blowout preventers are standard equipment for drilling wells. Blowout preventers typically have multiple rams designed to seal around or cut through any drill pipe and casing strings in the well to prevent or stop flow from a well if other preventative measures fail. Blowout preventers are part of the drilling rig's equipment and are removed when the well is completed and the rig departs. Bureau of Safety and Environmental Enforcement regulations and notice-to-lessees require frequent testing and maintenance of BOPs.

Capping Stacks. Subsea well capping operations were widely publicized during the Macondo incident in 2010; however, the well capping technique has been used by industry to shut in surface well blowouts for many decades. Capping stacks are designed to mechanically connect to a BOP or wellhead and shut-in and/or contain and divert the flow from the well until control can be regained. Since Macondo, capping stacks have become a standard part of the subsea drilling operations and specially designed and maintained units are strategically located near many offshore drilling areas such as Alaska and the Gulf of Mexico.

Subsea Isolation Devices (SID). Subsea isolation devices are essentially permanent blowout preventers installed on the wellhead below the drilling rig's blowout preventer. SIDs have their own independent control system and do not rely on the drilling rig. The SID's control system and shearing/sealing rams include enhanced levels of redundancy and capability, and provide additional protection in the event that the drilling risers are damaged, such as in the case in Macondo. These devices can be located below the seafloor in an excavated trench to provide protection from deep ice keels in the event they need to remain in place over the ice season.

and skimmers extended from vessels directly into trapped oil pockets in heavier ice

- Dispersants applied from the surface or subsea
- In-situ burning of thick, burnable oil by using containment against natural ice edges without booms, fire resistant booms in open water or very open drift ice, or herding agents in open water and intermediate ice concentrations
- Detection and monitoring while potentially planning a later response
- Natural attenuation through evaporation and dispersion.

In a spill in open water, the oil usually spreads quickly to form a very thin layer on the water surface. Ice and cold temperatures can decrease or eliminate oil spreading, weathering, and shoreline stranding, providing additional response time for an Arctic oil spill response.

Containment and mechanical recovery is generally regarded as the preferred strategy for responding to marine oil spills in open water and is mandated by regulations as the primary techniques in many jurisdictions. Mechanical recovery will always be a critical tool for contingency planning—including in the Arctic—because the vast majority of historical spills have been small. Containment and recovery of oil is effective when responding to small spills and spills that are rapidly contained in relatively calm waters and close to the spill source. Larger and more remote spills may be better remediated using dispersants and in-situ burning.

Dispersants are an important response option that should be considered for Arctic contingency planning. Dispersants work by breaking up oil into tiny droplets that rapidly dilute in the water column, thus speeding biodegradation to reduce the toxic effects of the oil. Dispersants have a significant advantage: the ability to be applied by aircraft or directly to a subsea release point. Aircraft application allows response operations in remote locations to occur much faster than response by boat. Subsea dispersant injection has the advantage of treating oil before it can form a slick at the surface that can rapidly thin and break apart, and subsea injection is not affected by darkness, extreme temperatures, strong winds, rough seas, or the presence of ice. A large body of research demonstrates that dispersants can be used over a wider range of conditions than other response options, and studies have shown that cold temperatures do not hinder the dispersion of many oils.

In-situ burning is especially suited for use in the Arctic where ice can provide a natural barrier to contain and thicken oil without the need for booms. Thick, cold oil contained by ice will remain fresh and un-emulsified longer, improving the efficiency of response options. Decades of research has demonstrated the ability to use controlled in-situ burning in cold water and the Arctic. Research conducted at several scales including in the field has demonstrated that when conducted in accord with established guidelines, in-situ burning is safe and poses no risk to human populations or responders and no unacceptable risk to the environment. In-situ burning minimizes or eliminates the logistical challenges of collecting, storing, transferring and disposing of oil.

An important aspect of preparing for an effective response, should the need for one arise, is practicing response techniques. Practice provides useful feedback into research of and planning for more effective techniques. Photographs of practicing techniques in the field are shown in Figure ES-21.

Even under the best of conditions, one can never expect to recover all of the oil from a large spill on water. A successful response limits damage to the environment by using the full range of available countermeasures in the most effective manner. An important means to enable success in an emergency

Source: Shell

Source: Shell

Figure ES-21. *Oil Spill Response Practice Exercises*

Dispersants and In-Situ Burning

Dispersants are designed to enhance natural dispersion by reducing the surface tension at the oil/water interface, making it easier for waves to create small oil droplets that are rapidly diluted below acute toxicity thresholds. The dilution to low concentrations allows naturally available nutrients and oxygen to sustain effective microbial degradation in Arctic as well as temperate waters. All marine and terrestrial environments contain naturally occurring micro-organisms capable of using petroleum compounds as a food source to degrade oil and gas primarily to carbon dioxide and water. In situations where rapid containment and recovery of spilled oil is not possible, facilitating the natural degradation processes by applying dispersants is beneficial to minimize the environmental impact.

Some have expressed concern about the rate and extent of oil biodegradation in Arctic waters. Studies by industry, government, and academic groups have found that indigenous Arctic microorganisms are able to degrade both fresh and weathered oil with and without using dispersants. One of these studies determined that Arctic organisms were no more sensitive to the acute toxic effects of both chemically and naturally dispersed oil than temperate organisms.

An important consideration for dispersant use is assessing the net benefit of short-term, transient exposure of dispersed oil to water-column organisms versus allowing unrecovered oil to drift at sea and potentially strand onshore. There is often a net benefit because effective dispersion and biodegradation of oil in the water results in oil in the environment for periods of days to a few weeks versus allowing oil to strand on shorelines and persist for much longer.

Controlled in-situ burning (ISB) is another important response option. ISB in ice and Arctic environments is a safe, environmentally acceptable, and fully proven technique with numerous successful Arctic field validations over the past 40 years. ISB is especially suited for use in the Arctic, where ice often provides a natural barrier to maintain the necessary oil thicknesses for ignition without the need for containment booms, and oil remains fresh and unemulsified for a longer period of time. The process of burning tends to destroy the toxic components of oil because they are generally more volatile. This leaves burn residue that is less toxic than the original oil. Results demonstrated that when conducted in accord with established guidelines, ISB is safe and poses no unacceptable risk to humans, wildlife, or responders.

Industry is developing a method to thicken oil suitable for burning using herding surfactants without using fire-resistant booms. This technology will enable in-situ burning using only aerial access, allowing rapid implementation of this response option. Once fully proven, herding will be a significant advance for oil spill response in all areas including the Arctic because of the rapid aircraft deployment capability.

is to review and update federal and state planning standards and regulations to make sure they reflect the latest technologies, realistic operational and environmental constraints, and practical levels of response capability.

There has been and continues to be research and technology development on all aspects of oil spill response. Maximizing the value of these efforts and transferring the knowledge and understanding gained from more than 40 years of research requires working collaboratively with local stakeholders and researchers from government agencies, academia, private organizations, and industry.

RECOMMENDATIONS

The view of this study is that the essential technology and knowledge currently exist to explore and develop oil and gas resources in the U.S. Arctic while protecting the environment and benefiting local populations. That said, there have been recent technology advancements that still need assessment and demonstration to gain acceptance by regulators and key stakeholders, and opportunities for further technology and knowledge can and should be developed to improve safety, environmental, and/or cost performance.

The National Petroleum Council makes the following recommendations, grouped into three broad themes:

Environmental Stewardship

1. Oil spill prevention and source control
2. Oil spill response in ice
3. Increasing knowledge of Arctic ecology and human environment

Economic Viability

4. Technologies to safely extend the drilling season
5. Lease terms appropriate to Arctic conditions
6. Effective policies and regulations
7. Enabling infrastructure

Government Leadership and Policy Coordination

8. Domestic leadership and policy coordination
9. U.S. chairmanship of the Arctic Council

Recommendations are discussed by subject areas. There are 32 recommendations in this executive summary, made up of 13 research, 3 regulatory, and 16 leadership/policy recommendations. In addition to these recommendations, there are an additional 60 research recommendations in the research chapters. These are summarized at the beginning of each of the technology chapters in Parts 2 and 3 of the report.

Environmental Stewardship

Continued prudent development in the Arctic requires the public's trust that companies are able to prevent oil spills and to effectively respond should a spill occur. The potential effects of oil and gas development are both a source of economic benefit as well as cause for concern about the effect of development on traditional cultures and the security of subsistence food resources. Obtaining higher confidence in ecological and human environment conditions and interactions would support improvements in science-based regulation and development.

1. Oil Spill Prevention and Source Control

The greatest reduction of risk to safety and the environment comes from preventing or limiting loss of well control. Current Department of the Interior (DOI) BSEE regulations (30 CFR 250.141) and procedures allow alternative and equivalent technology to be proposed in a drilling operations plan for the Arctic. There have been major recent advancements in well control technologies.

- Industry and regulators should work together with government agencies and other stakeholders to synthesize the current state of information and perform the analyses, investigations, and any necessary demonstrations to validate technologies for improved well control. Canada is using an approach described in the text box entitled "Evaluating Same Season Relief Well Equivalency."
  - The benefits and risks of advanced control technologies should be assessed relative to the current practice of a same season relief well. Alternatives include subsea shut-in devices independent of the standard blowout preventer. These alternatives could prevent or significantly reduce the amount of spilled oil compared to a relief well, which could take a month or more to be effective. This assessment should consider the benefits and risks of leaving the well secured using these technologies over the winter season.

    DOE should work with industry and DOI to perform this assessment, engaging the National Laboratories, the National Academies, and other stakeholders as appropriate. Assessment techniques could include those used in the nuclear, aviation, and petrochemical industries, such as precursor analysis and quantitative risk assessment, where the DOE already has expertise.
  - Future regulation and permit requirements should be informed by the results of this analysis including required demonstrations and testing. DOI, DOE, and the National Laboratories should witness these demonstrations of improved well control devices and include appropriate observers from the stakeholder community.

2. Oil Spill Response in Ice

While oil spill prevention is industry's primary focus, the probability of a spill can never be reduced completely to zero. Therefore, effective oil spill response capability will be critical to Arctic development. Over the past four decades, BSEE, other domestic and international agencies, and industry have conducted significant research on oil spill response techniques in Arctic conditions.

Evaluating Same Season Relief Well Equivalency

The Canadian Experience

National Energy Board (NEB) Same Season Relief Well Hearing

In 2010, the Canadian National Energy Board (NEB), the government body responsible for regulating offshore drilling in the Canadian Arctic, initiated a public process to review the long-standing Same Season Relief Well Policy and provide operators an opportunity to propose alternative technology approaches that would meet or exceed the intended outcome of the Policy. Following the Macondo incident, the NEB cancelled the Same Season Relief Well Hearing process and replaced it with a more broadly scoped review of all components of drilling activities in the Canadian Arctic Offshore. This process was initiated as the NEB Arctic Offshore Drilling Review.

NEB Arctic Offshore Drilling Review (AODR)

The objective was to provide a comprehensive review of Arctic offshore drilling preparedness including:

- Drilling safely while protecting the environment
- Responding effectively when things go wrong
- Learnings from past incidents
- Filing requirements for applicants seeking an authorization to drill.

The NEB conducted the review as a fully public process. All interested parties within Canada were given an opportunity to provide input into the review design and process. The NEB released a comprehensive written request for information on the above topic areas, and all written submissions were made publicly accessible via the NEB website. After the written review period, a week-long workshop was conducted to discuss the content of the Review.

The NEB held community meetings across Yukon, Northwest Territories and Nunavut to hear residents' views. All interested parties within Canada were invited to provide written comments. Inuvik workshop attendance included more than 200 representatives from government, communities, industry, academia, ENGOs, the general public, and government representatives from Alaska and Greenland.

The NEB released two final reports following the review:

- *Review of Offshore Drilling in the Canadian Arctic: Preparing for the Future*
- *Filing Requirements for Offshore Drilling in the Canadian Arctic.*

The Filing Requirements outlined the necessary components a proponent must provide in a submission for a drilling program. The NEB reaffirmed the Same Season Relief Well Policy, but stated they would consider proposals that would meet or exceed the intended outcome of the Policy on a case-by-case basis.

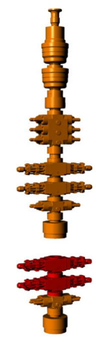
NEB Advance Ruling on or Same Season Relief Well Policy

The AODR proceedings clearly demonstrated the benefit of applying the most current proven technology to planned drilling programs. Two separate industry applications were initiated requesting an advance ruling on proposed alternative methods for a same season relief well.

The National Energy Board has yet to determine the final format of the process to provide the advance rulings. The NEB is expected to continue its commitment to public involvement in the process. As of March 2015, the review process is underway.

Case Study: Evaluating Same Season Relief Well Equivalency Related Technology Development

The Chevron/Cameron Alternative Well Kill System (AWKS)



- In 2008, Chevron identified the need for and initiated an R&D project that would meet or exceed the required Same Season Relief Well Policy in the Canadian Arctic offshore.
- Technology selection criteria included consideration of a tangible technology that could be demonstrated to, and understood by, local stakeholders who were involved directly in the project team.
- Project initiated in 2008 as a technology joint venture between Chevron and Cameron, with the goal of developing a step change in best available BOP technology.
- Developed the concept of a fully independent safety package including two shear rams capable of simultaneously shearing and sealing heavier wall, larger diameter tubulars and casing than was currently possible.
- A proof of concept testing video distributed to local stakeholders and regulators with the intent of educating interested parties on the project scope and objectives.
- Consultation was conducted with local stakeholders on equipment testing criteria.
- Held numerous engagement and education sessions with local community stakeholders, including equipment demonstrations.
- Joint representation with local stakeholders at major conferences discussing both industry and community perspectives on the SSRW Equivalency issue.
- Successfully completed internal testing of AWKS in May 2014, thereby making AWKS ready for commercial deployment.

Industry currently has the capability to respond quickly and effectively to an oil spill in Arctic conditions, in part by having oil spill response vessels and key response assets stationed at the drilling site, but many stakeholders remain concerned, underscoring the need for further collaborative work.

- Government agencies should participate in the ongoing and future oil spill response Joint Industry Programs. As an example, the ongoing ART JIP (2012-2016) includes projects to:
  - Conduct field testing, using relatively small amounts of oil, to further test the efficacy of tactics and strategies for spill response
  - Advance remote sensing technology for tracking of spilled oil
  - Improve and enhance fate and effects models and model inputs for varying sizes of oil spills
  - Advance research in support of other options to mechanical recovery, including dispersants, in-situ burning, and chemical herders.
- Regulators should continue to evaluate oil spill response technologies in Arctic conditions, considering past and ongoing research. Future regulations and oil spill response plans should consider this evaluation such that other technologies could be used as primary response options.
  - A Net Environmental Benefits Assessment (NEBA)-based decision process should be used collaboratively by government decision-makers with industry assistance to assess and approve all available oil spill response technologies to achieve the greatest reduction of adverse environmental impacts.

- Preapproval options should be reviewed and provided to facilitate rapid response for dispersants and in-situ burning where supported by NEBA.

- Consistent with the Oil Pollution Act of 1990, the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) should play a stronger role in conducting, coordinating, prioritizing, and supporting oil spill response research and technology development, across federal and state agencies, with industry and academia, and internationally.
- Recognizing the importance of field trials and the need to coordinate timely permits across multiple agencies (federal, state, local), ICCOPR or the new Arctic Executive Steering Committee could facilitate a collaborative process to conduct Arctic field oil release experiments.
- The National Laboratories should pursue development of oil simulants to facilitate field testing of oil spill response technologies in lieu of using crude oil.
- Industry and the federal government, including the National Laboratories, should collaborate to determine if any existing military technology or other research in the area of remote sensing, including satellite access, can be made available and commercialized for oil spill response.

3. Increasing Knowledge of Arctic Ecology and Human Environment

Research has been conducted by industry, government, and academia for decades, and much is known about the Arctic ecology and native peoples. Obtaining higher confidence in ecological and human environment conditions and interactions would support improved science-based decision-making. Key study areas include enhancing the ability to determine impacts, better defining special status species listings and critical habitats, and improving ecological resource management. This research would promote prudent development.

- Trustee agencies, such as U.S. Fish and Wildlife and U.S. National Marine Fisheries, could execute multi-year population assessment and monitoring of key Arctic species, including the Pacific walrus, ice seals, polar bears, and beluga whales.
- Under its legislative mandate to coordinate scientific data that will provide a better understanding of the ecosystems of the North Slope of Alaska, the North Slope Science Initiative (NSSI) should work with trustee agencies, industry, and other stakeholders to define, develop, and maintain an ecological monitoring program to detect and interpret change in the Arctic ecosystem.
- DOE, other governmental entities, the National Laboratories, and industry should execute additional studies of fate and effects of oil under Arctic conditions and upon Arctic species: toxicity of oil, oil residue, and dispersants to key Arctic species, including Arctic cod and plankton, the rate and extent of biodegradation of oil in Arctic environments, and the interactions of oil with under-ice communities.
- The federal government, namely the National Marine Fisheries Service, should work collaboratively with industry and other stakeholders to develop a coordinated strategy for industry and government research on interactions between energy development and key species.
  - Specifically, the improved understanding of the response of ice-dependent species to specific industry activities (ice management, seismic, drilling, etc.) would inform operational planning and permitting as well as designations and management of critical habitats.
  - The National Marine Fisheries Service should join the Bureau of Ocean Energy Management (BOEM) in participation as an observer in the Sound and Marine Life joint industry program.
- An updated Social Impacts Assessment protocol is needed to improve consistency and ability to integrate baseline data across agencies, industry, and communities.
  - The Department of State, via the Senior Arctic Official and the Arctic Council Sustainable Development Working Group, should update the Social Impacts Assessment protocol, leveraging the state of Alaska's coordinated framework for a Health Impact Assessment, recently developed by the Alaska Department of Natural Resources and Department of Health, in partnership with federal agencies, the Alaska Native Tribal Health Consortium, and local boroughs.
  - The Council for Environmental Quality could include this updated protocol in the

existing EIA protocol under the National Environmental Policy Act (NEPA).

- The NSSI's mandate is to provide scientific information on both environmental and social science to its 14 federal, state, and local government members and to the public. Recognizing the importance of improved collaboration and coordination of human environment research activities, enhancement of NSSI capacity and capability in social science should be pursued to enable the NSSI to deliver on its mandate.
- The NSSI should work with the Interagency Arctic Research Policy Committee and other stakeholders to establish appropriate protocols and gather best practices for the effective collection and integration of traditional knowledge, existing science, community engagement, and resource management.
- Industry, government, and academia should work to establish data sharing agreements and promote use of platforms such as the Alaska Ocean Observing System and the University of Alaska Fairbanks/NSSI catalog.

Economic Viability

Prudent development in the offshore Arctic requires exploration activity and success to find an oil accumulation of sufficient size and quality to justify the substantial investments required to develop in a remote location. This section includes recommendations that could enable economically viable exploration and development.

4. Technologies to Safely Extend the Drilling Season

Extending the drilling season available for exploration in the U.S. offshore Arctic is vital to economic exploration and subsequent development. In addition to the limitations on the drilling season posed by the physical Arctic conditions, concerns regarding oil spill response in ice and the requirement for a same season relief well in ice-free conditions further limit the time available to drill exploration wells.

- Industry and regulators should work together with other government agencies and stakeholders to synthesize the current and evolving state of knowledge and perform the analysis, investigations, and any necessary demonstrations to validate technologies and capabilities that could safely extend the useful drilling season length.
  - These technologies include recent advancements in source control and containment and improvements in oil spill response in ice discussed earlier.
  - The capabilities include the drilling rig, ice management vessels, and emergency and oil spill response capability.

5. Lease Terms Appropriate to Arctic Conditions

The short useful working season in the U.S. Arctic offshore makes it difficult to develop an opportunity within the same time frame achievable with the lease terms applied in other parts of the United States that experience year-round working seasons. This challenge reduces the competitiveness of Alaskan OCS opportunities compared to other global Arctic regions.

- The Department of Energy, working in collaboration with the Department of the Interior and with input from other stakeholders, should conduct an assessment of the timelines required to progress an offshore exploration prospect from lease through a decision to proceed to development. This assessment should be completed before the next lease sale.
  - These timelines should include the time to plan, permit, and safely execute seismic surveys, exploration drilling, and any necessary appraisal wells, as well as conduct and interpret results from these activities. The time required to complete engineering studies, including an economic feasibility assessment, to enable a development decision should also be included.
  - The assessment should consider the season length limitations imposed by the Arctic operating environment and ecological/subsistence considerations, as well as approaches used by other Arctic nations with similar geological and operating environments.
  - If warranted based on this assessment, congressional action to amend the Outer Continental Shelf Lands Act to reflect the lease term for Arctic operations could be pursued. For existing leases, the Department of the Interior could clarify suspension authority.

6. Effective Policies and Regulations

Oil and gas exploration and development in the Arctic is extensively regulated. Drilling an offshore exploration well in the Arctic currently requires permitting from at least 12 principal state and federal agencies; progressing offshore development in the Arctic would require about 60 permit types through 10 federal agencies. Regulations should be adaptive to reflect advances in technology and ecological research, and achieve an acceptable balance considering safety, environmental stewardship, economic viability, energy security, and compatibility with the interests of the local communities. Prescriptive regulation may inhibit the development of new, improved technologies by suppressing the potential opportunity that drives advancement.

- Policies and regulations should encourage innovation by providing for incorporation of technological advancements.
  - Where authority already exists to consider industry proposals that provide for equivalent or better levels of safety and environmental protection, such as that already established in 30 CFR 250.141, use of that authority should be encouraged.
  - BSEE should continue to review existing and new regulations to identify candidate areas for implementation of performance-based regulation, considering lessons from other jurisdictions.
  - Staff development in Arctic-specific operational and regulatory requirements should be pursued within regulatory agencies.
- Policies and regulations should reflect improved ecological understanding from ongoing research and monitoring. Regulators could use their authority to designate or update appropriate mitigations based on more recently developed science.
- Regulators should identify, prioritize, coordinate, and communicate permit information requirements to the operators in a timely manner.
- The Administration should champion policies that enable effective and efficient logistics and infrastructure. Examples of current requirements that unnecessarily constrain Arctic development include:
  - Limited access to federal lands for oil and gas transportation systems where no practical alternative exists
  - Presupposing oil transport solutions for potential new discoveries
  - The Jones Act rules on tankers and support vessels mandate largely unavailable and noncompetitively priced ships, unduly increasing the cost of operations in the U.S. Arctic.

7. Enabling Infrastructure

The Arctic is characterized by its climate, remoteness, sparse population, and long distance between population centers. This has resulted in limited infrastructure development including ports, airfields, roads, rail, communication networks, and fuel and electricity delivery systems compared with other regions. To promote prudent development, additional capacity is needed.

There are many synergies between the types of infrastructure that would facilitate Arctic oil and gas exploration and development and the infrastructure needs of local communities, the state of Alaska, and elements of the U.S. Armed Forces such as the Coast Guard and Navy. Investments by any party in new or upgraded airfields, ports, roads, navigational aids, satellites, radars, and communication facilities could confer wider benefits. The Coast Guard and Navy, which play key roles in the areas of safety, search and rescue, and national defense, are subject to many of the same resupply and support requirements in the Arctic as the oil and gas industry.

- Local, state, and federal government agencies should coordinate infrastructure planning by carrying out, where possible, joint scenario planning to identify the intersection of mutual needs such as airfields, ports, roads, and communications to identify opportunities for investment synergies. Planning needs and considerations should include those from the oil and gas industry, Navy, Coast Guard, and local stakeholders, and include options to extend the life of the TAPS pipeline.
- Recognizing the potential for increasing needs in the Arctic from all industries, the U.S. Coast Guard icebreaker fleet and presence should be expanded

and extended into the shoulder season to promote transportation safety, national security, and a longer exploration season.

- Recognizing the potential for increased vessel traffic in the Bering Strait in the future, actions should be taken now to improve vessel safety:
  - The United States should support implementation of the International Maritime Organization Polar Code to ensure that vessel traffic traversing the Bering Strait is suitably designed and constructed per the requirements of the code.
  - NOAA should complete hydrographic mapping of the region.
  - The U.S. Coast Guard should improve regional navigational and communication aids and continue development of comprehensive Arctic marine traffic awareness systems.
- NOAA should maintain at least the current capability of polar observing weather satellites and evaluate the merits of a new publicly accessible synthetic aperture radar satellite.
- Recognizing the potential of unmanned aircraft to significantly improve current monitoring and sensing capabilities, all stakeholders should work with the Federal Aviation Administration (FAA) Investigative Program to support permitting the use of unmanned aircrafts in the Arctic. This technology is currently available and would improve safety and efficiency of logistics support, oil spill response, ice characterization, and environmental monitoring.

Government Leadership and Policy Coordination

The specifics of the extensive federal and state regulatory process for the Arctic ultimately reflect the policy of the federal and Alaska governments. In addition to guidance on potential research to support prudent development of Arctic oil and gas resources, Secretary of Energy Moniz also requested the NPC's input on implementation of the U.S. NSAR and considerations as the United States assumes leadership of the Arctic Council in 2015.

8. Domestic Leadership and Policy Coordination

There are 39 federal agencies participating in the Arctic Policy Group and 27 agencies and working groups listed in the IPNSAR. Most of these organizations are engaged in the conduct of Arctic-oriented research that could be applicable in some way to oil and gas exploration and development. However, despite the critical economic and national and energy security importance of oil and gas activities to a wide range of stakeholders, there is no clear advocate for Arctic oil and gas development at the federal level. Central leadership and collaboration and coordination of activities would improve the potential for prudent development. A January 2015 Executive Order formed a new Arctic Executive Steering Committee to provide overall coordination.

- The Arctic Executive Steering Committee should:
  - Reaffirm U.S. commitment to prudent Arctic oil and gas development and U.S. leadership in the region.
  - Assess alignment across federal agencies in advancing prudent Arctic oil and gas development.
  - Request DOE and Department of Commerce to partner to inform U.S. policymakers across federal departments and agencies about the economic, energy, and national security benefits of prudent Arctic oil and gas development, consistent with the DOE's mandate and the Department of Commerce's recently announced Arctic Affinity group.
  - Clarify the process by which it will collaborate with the state of Alaska, Alaska Native tribal governments, and other stakeholders.
- The Arctic Executive Steering Committee as part of its mandated gap analysis should:
  - Request regulators to compile a comprehensive and integrated inventory of regulatory requirements for offshore Arctic oil and gas exploration and development.
  - Recognizing the significant progress by the Interagency Working Group on coordination of permitting in Alaska, the Arctic Executive Steering Committee should, as part of its gap analysis:
    - Review lessons learned for application to broader coordination of opportunities and identify areas for improvement.
    - Recalibrate the existing Interagency Working Group to refine its mission and enhance its

capabilities to coordinate Arctic activities and permitting.

  - Review the effectiveness of DOE participation in the working group.

- The Department of Energy should designate a senior advisor to support its representative on the Arctic Executive Steering Committee and be a focal point for Arctic policy, including:
  - Producing a department-wide Arctic strategy that clarifies its implementation of the NSAR
  - Advancing prudent Arctic oil and gas development
  - Coordinating with the U.S. Arctic Council Chairman
  - Coordinating the department's Arctic science and technology, integrated analysis, and research agenda and effecting full coordination and engagement of the National Laboratories.

- The Department of Energy should engage Alaska institutions including the state of Alaska in the planning and conduct of its Arctic initiatives and consider public-private partnerships and data sharing platforms similar to the Alaska Ocean Observing System.

9. U.S. Chairmanship of the Arctic Council

One of the government's key priorities proposed for the Arctic Council Chairmanship is to improve the economic and living conditions of the people of the North. Consistent with benefits realized from onshore Arctic development since the 1970s, prudent development of U.S. offshore Arctic potential would help accomplish this. With the United States assuming chairmanship of the Arctic Council in April 2015, there is an opportunity for the U.S. government to internationally promote its objectives as stated in the U.S. NSAR, which is to develop energy resources in a sustainable manner that respects the environment and the interests and cultures of indigenous peoples.

- As Arctic Council members implement the two internationally legally binding agreements on search and rescue (2011) and on oil pollution preparedness and response (2013), the U.S. government should encourage engagement and participation with the international energy industry in the conduct of its search and rescue table top exercise in May 2015 and the full-scale exercise in the summer of 2016.

- The U.S. government should seek to strengthen the Arctic Economic Council's formal interaction and engagement with the Arctic Council as well as to promote its business advisory role.

To assist readers with a particular interest in research, regulatory improvement, or leadership/policy opportunities, Appendix C duplicates the recommendations above with color coding to reflect recommendation type.

The Secretary of Energy
Washington, DC 20585

October 25, 2013

Mr. James T. Hackett
Chairman
National Petroleum Council
1625 K Street, NW
Washington, DC 20006

Dear Mr. Hackett:

Building the foundation for a clean energy economy will require unprecedented actions by industry and government to strengthen the nation's oil and natural gas infrastructure, tackle the issues of climate change, and protect our environment. To provide useful input into upcoming policy decisions, I request that the National Petroleum Council undertake strategic, short term studies on three topics: *Natural Gas and Oil infrastructure Resilience, Maximizing the Climate Benefits of Natural Gas,* and *Arctic Research.*

Natural Gas and Oil Infrastructure Resilience. Superstorm Sandy, wildfires and floods have underscored the importance of having resilient oil and natural gas infrastructure and effective ways for industry and government to communicate to address energy supply disruptions. Key questions to be addressed on this topic include:

- What vulnerabilities have recent storm activity exposed in US energy infrastructure?
- What legal, procedural, and physical gaps need to be addressed by industry and government to improve response to disruptions?
- What strategies should be pursued to increase energy system resilience to storms and other potential disruptions?
- What actions can be taken to address the interdependencies between oil and natural gas systems and other critical infrastructure?

Maximizing the Climate Benefits of Natural Gas. The vital role that domestic natural gas resources are poised to serve in a clean energy economy will hinge on maximizing the climate benefits of increased natural gas use. Key prerequisites will include gaining a better understanding of the extent of methane leakages in the natural gas value chain from the well head to the consumer, as well as focusing attention on reducing these leakages. Key questions to be addressed on this topic include:

- What technologies and practices can be adopted or further developed to improve the detection and measurement of methane emissions from natural gas systems?
- What technologies and practices can accelerate reductions in methane leakage in natural gas systems?

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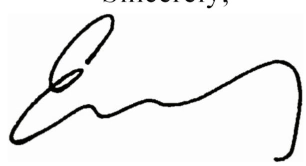
Arctic Research. A core component of the Administration's National Strategy for the Arctic Region released in May 2013 includes responsibly developing Arctic oil and gas resources to ensure energy security. In 2015 the United States will assume chairmanship of the multi-nation Arctic Council. The National Petroleum Council's input would be invaluable to assist us as we explore:

- What research should the Department of Energy pursue and what technology constraints must be addressed to ensure prudent development of Arctic oil and gas resources while advancing U.S. energy and economic security and ensuring environmental stewardship?

For the purposes of these studies, I am designating Deputy Secretary Daniel Poneman to represent me. He will provide the necessary coordination between the Department of Energy and the National Petroleum Council and oversee the Department's engagement. Acting Assistant Secretary Christopher Smith is the Designated Federal Official for this advisory committee and he will work with Deputy Secretary Daniel Poneman and the Council staff to identify leads for each of the studies. I understand that dialogue between the Department and the Council may be necessary to further define the scope of the studies.

Sincerely,



Ernest Moniz

DESCRIPTION OF THE NATIONAL PETROLEUM COUNCIL

In May 1946, the President stated in a letter to the Secretary of the Interior that he had been impressed by the contribution made through government/industry cooperation to the success of the World War II petroleum program. He felt that it would be beneficial if this close relationship were to be continued and suggested that the Secretary of the Interior establish an industry organization to advise the Secretary on oil and natural gas matters. Pursuant to this request, Interior Secretary J. A. Krug established the National Petroleum Council (NPC) on June 18, 1946. In October 1977, the Department of Energy was established and the Council was transferred to the new department.

The purpose of the NPC is solely to advise, inform, and make recommendations to the Secretary of Energy on any matter requested by the Secretary, relating to oil and natural gas or the oil and gas industries. Matters that the Secretary would like to have considered by the Council are submitted in the form of a letter outlining the nature and scope of the study. The Council reserves the right to decide whether it will consider any matter referred to it.

Studies undertaken by the NPC at the request of the Secretary include:

- *Industry Assistance to Government – Methods for Providing Petroleum Industry Expertise During Emergencies* (1991)
- *Petroleum Refining in the 1990s – Meeting the Challenges of the Clean Air Act* (1991)
- *The Potential for Natural Gas in the United States* (1992)
- *U.S. Petroleum Refining – Meeting Requirements for Cleaner Fuels and Refineries* (1993)
- *The Oil Pollution Act of 1990: Issues and Solutions* (1994)
- *Marginal Wells* (1994)
- *Research, Development, and Demonstration Needs of the Oil and Gas Industry* (1995)
- *Future Issues – A View of U.S. Oil & Natural Gas to 2020* (1995)
- *U.S. Petroleum Product Supply – Inventory Dynamics* (1998)
- *Meeting the Challenges of the Nation's Growing Natural Gas Demand* (1999)
- *U.S. Petroleum Refining – Assuring the Adequacy and Affordability of Cleaner Fuels* (2000)
- *Securing Oil and Natural Gas Infrastructures in the New Economy* (2001)
- *Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy* (2003)
- *Observations on Petroleum Product Supply* (2004)
- *Facing the Hard Truths about Energy: A Comprehensive View to 2030 of Global Oil and Natural Gas (2007). One Year Later: An Update On Facing the Hard Truths About Energy* (2008)
- *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources* (2011)
- *Advancing Technology for America's Transportation Future* (2012)
- *Enhancing Emergency Preparedness for Natural Disasters* (2014).

The NPC does not concern itself with trade practices, nor does it engage in any of the usual trade association activities. The Council is subject to the provisions of the Federal Advisory Committee Act of 1972.

Members of the National Petroleum Council are appointed by the Secretary of Energy and represent all segments of the oil and gas industries and related interests. The NPC is headed by a Chair and a Vice Chair, who are elected by the Council. The Council is supported entirely by voluntary contributions from its members.

Additional information on the Council's origins, operations, and reports can be found at www.npc.org.

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David M. McClanahan	Special Advisor to the Chief Executive Officer	CenterPoint Energy, Inc.
Aubrey K. McClendon	Founder	American Energy Partners, LP
M. Kevin McEvoy	President and Chief Executive Officer	Oceaneering International, Inc.
James T. McManus, II	Chairman, President and Chief Executive Officer	Energen Corporation
Rae McQuade	President	North American Energy Standards Board
Cary M. Maguire	President and Chief Executive Officer	Maguire Oil Company
William V. Maloney	Executive Vice President, Development and Production North America	Statoil ASA
Kenneth B. Medlock, III	James A. Baker III and Susan G. Baker Fellow in Energy and Resource Economics and Deputy Director, Energy Forum, James A. Baker III Institute for Public Policy Adjunct Professor, Economics Department	Rice University
Augustus C. Miller	Chairman and Chief Executive Officer	Miller Oil Co., Inc.
David B. Miller	Partner	EnCap Investments L.P.
Merrill A. Miller, Jr.	Executive Chairman	DistributionNOW
John C. Mingé	Chairman and President	BP America Inc.
Al Monaco	President and Chief Executive Officer	Enbridge Inc.
Jack B. Moore	President and Chief Executive Officer	Cameron
Alicia E. Moy	President and Chief Executive Officer	Hawai'iGas
Steven L. Mueller	Chairman of the Board and Chief Executive Officer	Southwestern Energy Company
David L. Murfin	President	Murfin Drilling Co., Inc.
Mark B. Murphy	President	Strata Production Company
Mark D. Myers	Commissioner, Alaska Department of Natural Resources	State of Alaska
Richard S. Neville	President	Western Petroleum Company
J. Larry Nichols	Executive Chairman	Devon Energy Corporation
Patrick F. Noonan	Chairman Emeritus	The Conservation Fund
John W. B. Northington	Principal	Northington Strategy Group
Thomas B. Nusz	President and Chief Executive Officer	Oasis Petroleum, LLC
Marvin E. Odum	President	Shell Oil Company

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C. R. Palmer	Chairman Emeritus	Rowan Companies, Inc.
Mark G. Papa	Director of the Board	EOG Resources, Inc.
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Robert L. Parker, Jr.	Retired Chairman	Parker Drilling Company
Donald L. Paul	Executive Director of the USC Energy Institute, William M. Keck Chair of Energy Resources and Professor of Engineering Viterbi School of Engineering	University of Southern California
Jeffrey M. Platt	President and Chief Executive Officer	Tidewater Inc.
Allan G. Pulsipher	Executive Director and Marathon Professor of Energy Policy Center for Energy Studies	Louisiana State University
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June Ressler	President and Chief Executive Officer	Cenergy Companies
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Philip M. Rykhoek	President and Chief Executive Officer	Denbury Resources Inc.
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Philip R. Sharp	President	Resources for the Future Inc.
R. Gordon Shearer		New York, New York
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Thomas E. Skains	Chairman, President and Chief Executive Officer	Piedmont Natural Gas
Eric S. Slifka	President and Chief Executive Officer	Global Partners LP
Carl Michael Smith	Executive Director	Interstate Oil and Gas Compact Commission

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Jeffrey B. Spath	2014 President	Society of Petroleum Engineers
Charles B. Stanley	Chairman, President and Chief Executive Officer	QEP Resources, Inc.
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William Paschall Tosch	Managing Director	J.P. Morgan Securities LLC
H. A. True, III	Partner	True Oil LLC
Robert B. Tudor, III	Chairman and Chief Executive Officer	Tudor, Pickering, Holt & Co., LLC
William P. Utt	Former Chairman	KBR, Inc.
W. Bruce Valdez	Executive Director	Southern Ute Indian Tribe Growth Fund
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Vaughn O. Vennerberg, II	President	MorningStar Partners LP
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Frank A. Verrastro	Senior Vice President and James R. Schlesinger Chair for Energy and Geopolitics	Center for Strategic & International Studies
Bruce H. Vincent	Chief Executive Officer	Vincent and Company
John B. Walker	President and Chief Executive Officer	EnerVest, Ltd.
R. A. Walker	Chairman, President and Chief Executive Officer	Anadarko Petroleum Corporation
Cynthia J. Warner	Executive Vice President Strategy & Business Development	Tesoro Corporation
Michael D. Watford	Chairman, President and Chief Executive Officer	Ultra Petroleum Corp.

John S. Watson	Chairman of the Board and Chief Executive Officer	Chevron Corporation
J. Robinson West	Senior Advisor, Energy & National Security Program	Center for Strategic & International Studies
Craig E. White	President and Chief Executive Officer	Philadelphia Gas Works
William H. White	Chairman	Lazard Freres & Co. LLC
David W. Williams	Chairman of the Board, President and Chief Executive Officer	Noble Corporation
Mary Jane Wilson	President and Chief Executive Officer	WZI Inc.
Patrick H. Wood, III	Principal	Wood3 Resources
Karen Buchwald Wright	President and Chief Executive Officer	Ariel Corporation
George M. Yates	President and Chief Executive Officer	HEYCO Energy Group, Inc.
John A. Yates	Chairman Emeritus	Yates Petroleum Corporation
Daniel H. Yergin	Vice Chairman	IHS Inc.
John F. Young	President and Chief Executive Officer	Energy Future Holdings Corp.