NATIONAL PETROLEUM COUNCIL

Draft Report

Prudent Development:

Realizing the Potential of North America's Abundant Natural Gas and Oil Resources

September 15, 2011

This is the working draft reviewed and approved on September 15 by the members of the National Petroleum Council, subject to final editing. A report in final form will be available both electronically and in print later this year.

The Honorable Steven Chu
Secretary of Energy
Washington DC 20585

Dear Mr. Secretary:

In response to your letters of September 16, 2009 and April 30, 2010, the National Petroleum Council (NPC) conducted a comprehensive study to reassess the character and potential of North American natural gas and oil resources and the contribution that natural gas can make in a transition to a lower carbon energy mix while achieving objectives of environmental protection, economic growth and energy security.

This charge demanded a study that assessed environmental, operational, technology, supply, demand, and infrastructure considerations. The effort involved over 400 participants from diverse backgrounds and organizations, 58% of whom are employed by organizations outside of natural gas and oil companies.

Extraordinary events have affected energy markets in the years since the NPC reported on the "Hard Truths" about energy in 2007. That study concluded that the world would need increased energy efficiency and all economic forms of energy supply. This is still true today, but since then, significant technology advances have unlocked abundant natural gas and oil resources. These greatly expanded resources have already benefited our country economically. Increased supplies of natural gas have resulted in lower prices and helped revitalize many U.S. industries. Further, increased use of natural gas can reduce emissions and improve America's energy security.

While there have been significant positive outcomes, there have also been tragic accidents such as the Macondo oil spill in the deepwater Gulf of Mexico and the natural gas pipeline explosion in San Bruno, California. These accidents, although rare, have raised public interest in developing North America's oil and gas resources in an environmentally responsible and safe manner. Additionally, the environmental impacts of oil sands and shale gas extraction have been the subject of much public debate and scrutiny. Industry and governments have taken action, and will continue to do so, to elevate operational performance and protect public health, safety, and the environment.

With an understanding that the positive outcomes of increased North American natural gas and oil resources can only be realized if developed prudently, the study participants charted a course that resulted in policy recommendations that were based on careful analysis of several hundred existing studies as well as a proprietary survey of select organizations and institutions.

This study reached four conclusions. First, the potential supply of North American natural gas is far bigger than previously thought. It is now understood that the natural gas resource base is enormous and that its development, if carried out in acceptable ways, is potentially transformative for the American economy, energy security, and the environment, including reduction of carbon and other emissions. These resources could meet high projections of demand.

Second – and surprising to many – North America's oil resources are also much larger than previously thought. These oil resources offer substantial supply for decades and could help the United States reduce, though not eliminate, its reliance on imported oil.

Third, natural gas and oil resources will be needed even as energy efficiency reduces demand and lower-carbon alternatives become more economically available on a large scale. Moreover, the natural gas and oil industry is vital to the U.S. economy, generating millions of jobs, widely stimulating economic activity, and providing significant revenues to governments.

Fourth, realizing the benefits of natural gas and oil depends on environmentally responsible development. The nation can realize the benefits of these larger resources by ensuring they are developed and delivered in a safe, responsible, and environmentally acceptable manner in all circumstances.

As described more fully in the report, the NPC recommends five core strategies for governments and companies:

- Support prudent development and regulation of natural gas and oil resources, through such measures as councils of excellence covering environmental, safety, and health practices; corporate and regulatory commitment to advancing environmental performance; engaging affected communities; reducing methane emissions; and structuring policies to support prudent development of and access to resources.
- Better reflect environmental impacts in markets and fuel/technology choices, by recognizing that the United States will find it difficult to reduce greenhouse gas emissions further without a mechanism for putting a price on greenhouse gas emissions that is economy-wide, market-based, predictable, transparent, and part of a global framework; keeping options open for carbon capture and sequestration; and developing information and methodologies on environmental footprints and full fuel cycle impacts.
- Enhance the efficient use of energy, through policies that support continued progress to adopt cost-effective efficiency standards for buildings and appliances; remove the disincentives for utilities to deploy efficiency measures; and eliminate barriers to combined heat and power as a way to increase the efficiency of electricity production.
- Enhance the functioning of energy markets through policies and regulations that improve mechanisms for utilities to manage the impacts of price volatility; harmonize market rules and service arrangements between the wholesale natural gas and wholesale electric markets; and increase environmental regulatory certainty affecting investments and fuel choices in the power sector.
- Support the development of a skilled workforce, through increased public and private financial support for educational and training activities.

The attached report, *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources,* details findings and recommendations based on comprehensive analyses developed by the study teams.

The NPC looks forward to sharing this study and its results with you, and broader government and public audiences.

Respectfully submitted,

James T. Hackett
Chair

Aubrey K. McClendon
Vice Chair, Operations & Environment

Marvin Odum
Vice Chair, Resource & Supply

Daniel H. Yergin
Vice Chair, Demand

Phil Sharp
Vice Chair, Policy

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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

By letter dated September 16, 2009, Secretary of Energy Steven Chu requested the National Petroleum Council to conduct studies on two topics: 1) Future Transportation Fuels; and 2) Prudent Development of North American Natural Gas and Oil Resources. The Secretary stated that the Council is uniquely positioned to provide advice to the Department of Energy (DOE) on these important topics.

In the Fuels Study request, Secretary Chu asked the Council to "conduct a study which would analyze U.S. fuels prospects through 2030 for auto, truck, air, rail, and waterborne transport" with advice sought on "policy options and pathways for integrating new fuels and vehicles into the marketplace including infrastructure development." Expanding on his September 2009 request, in a supplemental letter dated April 30, 2010, Secretary Chu further asked that the Fuels Study examine actions industry and government could take to stimulate the technological advances and market conditions needed to reduce life-cycle greenhouse gas emissions in the U.S. transportation sector by 50 percent by 2050 relative to 2005 levels while enhancing the nation's energy security and economic prosperity. That study is now underway, with an anticipated completion in the first half of 2012.

This North American Resources Study report is the Council's response to the second study request, in which Secretary Chu asked the NPC to "reassess the North American natural gas and oil resources supply chain and infrastructure potential, and the contribution that natural gas can make in a transition to a lower carbon fuel mix." He further expressed his interest in "advice on policy options that would allow prudent development of North American natural gas and oil resources consistent with government objectives of environmental protection, economic growth, and national security." In his supplemental letter of April 2010, Secretary Chu stated that "the United Sates sees a future in which valuable domestic energy resources are responsibly produced to meet the needs of American energy consumers consistent with national, environmental, economic and energy security goals, … [and the United States] has the opportunity to demonstrate global leadership in technological and environmental innovation. Accordingly, I request the Council's advice on potential technology and policy actions capable of achieving this vision." Appendix A contains full copies of both letters from the Secretary.

Study Organization

In response to the Secretary's requests, the Council established a Committee on Resource Development to study this topic and to supervise preparation of a draft report for the Council's consideration. The Committee leadership consisted of a Chair, Government Cochair, and four subject-area Vice Chairs. The Council also established a Coordinating Subcommittee, three Task Groups, and three Coordinating Subcommittee level analytical Subgroups to assist the Committee in conducting the study. These study groups were aided by four Coordinating Subcommittee level support Subgroups and twenty-one Task Group level Subgroups focused on specific subject areas. Table 1 lists those who served as leaders of the groups that conducted the study's analyses and Figure 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, environmental nongovernmental organizations (NGOs), other public interest groups, financial institutions, consultancies, academia, and research groups. More than 400 people served on the study's Committee, Subcommittee, Task Groups, and Subgroups and while all have relevant expertise for the study, fewer than 50% work for natural gas and oil companies. Appendix B contains rosters of these study groups and Figure 2 depicts the diversity of participation in the study process. In addition to these study group participants, many more people were involved through outreach activities. These efforts were an integral part 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 policy 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.

Table 1
North American Resource Development Study Leaders

Chair – Committee
James T. Hackett
Chairman and Chief Executive Officer
Anadarko Petroleum Company

Government Cochair – Committee
Daniel P. Poneman
Deputy Secretary of Energy
U.S. Department of Energy

Vice Chair – Resource & Supply
Marvin E. Odum
President
Shell Oil Company

Vice Chair – Operations & Environment
Aubrey K. McClendon
Chairman of the Board and Chief Executive Officer
Chesapeake Energy Corporation

Vice Chair – Demand
Daniel H. Yergin
Chairman
IHS Cambridge Energy Research Associates, Inc.

Vice Chair – Policy
Philip R. Sharp
President
Resources For the Future

Chair – Coordinating Subcommittee
D. Clay Bretches
Vice President, E&P Services and Minerals
Anadarko Petroleum Company

Government Cochair – Coordinating Subcommittee
Christopher A. Smith
Deputy Assistant Secretary for Oil and Natural Gas
U.S. Department of Energy

Chair – Resource & Supply Task Group
Andrew J. Slaughter
Business Environment Advisor – Upstream Americas
Shell Exploration & Production Company

Chair – Operations & Environment Task Group
Paul D. Hagemeier
Vice President, Regulatory Compliance
Chesapeake Energy Corporation

Chair – Demand Task Group
Kenneth L. Yeasting
Senior Director, Global Gas and North America Gas
IHS Cambridge Energy Research Associates, Inc.

Chair – Policy Subgroup
Susan F. Tierney
Managing Principal
Analysis Group, Inc.

Chair – End-Use Emissions & Carbon Subgroup
Fiji C. George
Carbon Strategies Director
El Paso Corporation

Chair – Macroeconomic Subgroup
Christopher L. Conoscenti
Executive Director, Energy Investment Banking
J.P. Morgan Securities LLC

Figure 1. Structure of the North American Resource Development Study Team

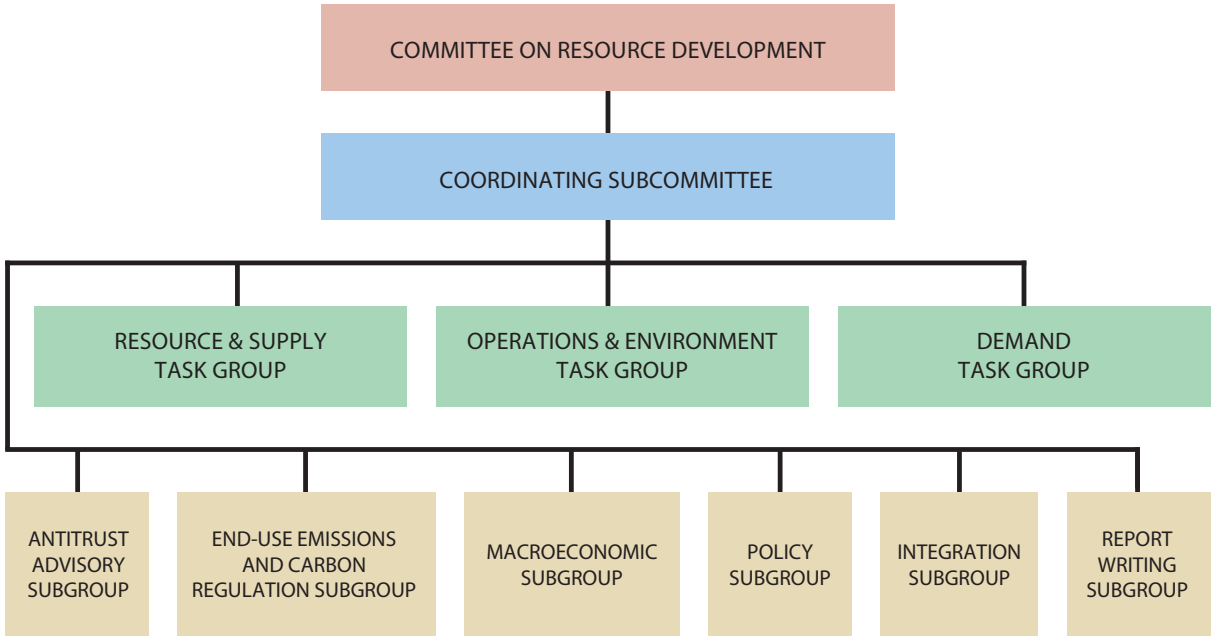
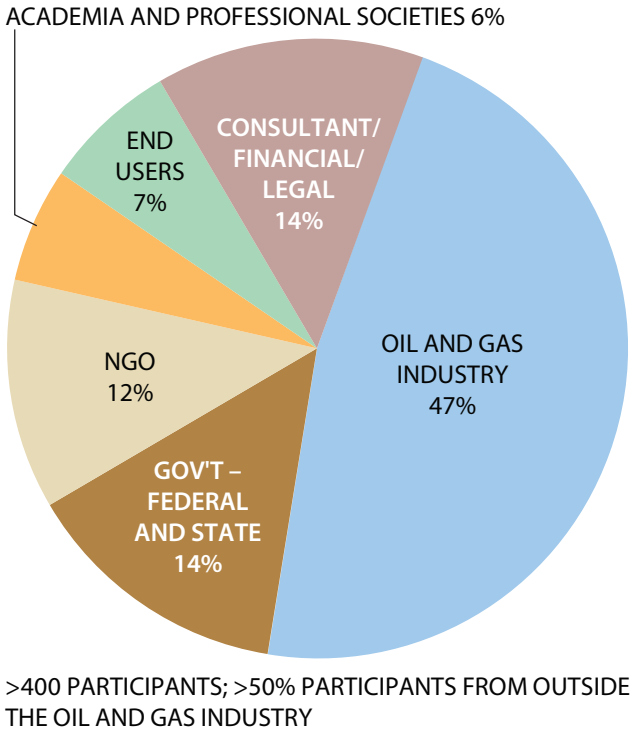


Figure 2. Study Participant Diversity



>400 PARTICIPANTS; >50% PARTICIPANTS FROM OUTSIDE THE OIL AND GAS INDUSTRY

Study Approach

A central goal of the study was to 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 does not include a direct evaluation of commodity prices despite the extremely important role these play in balancing supply and demand.

After careful thought, the Council decided upon the following principles to guide the study:

1. Identify and involve a broad and diverse set of interests to participate in the study
2. Utilize consensus-based leadership to produce the best results
3. Provide a broad review of current research and conduct new studies only as needed
4. Consider the evolutionary path of technology and the ability of the United States to demonstrate technological leadership
5. Develop policy recommendations following and deriving from the development of facts
6. Provide and adhere to clear objectives and a detailed scope of work
7. Set clear expectations for study participants – commitment level and duration
8. Communicate regularly with leadership, team members, and external stakeholders.

As part of providing a broad review of current knowledge, the study groups examined available analyses on North American oil and gas resources, supply, demand, and industry operations. The main focus of the analysis review was on the United States and Canada, as both countries are very large oil and natural gas producers and both have very large future supply potential in those resources. Mexico is geographically part of North America and is recognized as an important crude oil supplier to the U.S. as well as a current importer of approximately 1 Bcf/d of natural gas. These linkages are discussed in more detail in the Demand and Resources and Supply Chapters. The study team did not, however, attempt to undertake an in-depth review of future resources and supply potential from Mexico.

The varied analyses reviewed during the study included those produced by the Energy Information Administration, International Energy Agency, and National Energy Board, among others. In addition, the study incorporated the January 2011 Report of the Presidential Oil Spill Commission, the National Academy of Engineering Macondo Study, and the (as then incomplete) Joint Investigation Team study by the Bureau of Ocean Energy Management (BOEM and U.S. Coast Guard) and other studies.

The NPC also conducted a broad survey of proprietary energy outlooks. As an integral part of this process, the public accounting firm Argy, Wiltse & Robinson, PC received, aggregated, and protected the proprietary data responses.

Using these datasets, both public and private, the study groups organized the material to compare and contrast the views through 2050, the period selected in the request from Secretary Chu. Most of the outlooks evaluated, however, extended only through 2035 and a number ended before that date. For that reason, the material framing many aspects of the study for the 15 years between 2036 and 2050 are more qualitative than quantitative in nature.

To avoid overlap and leverage resources, both the Fuels Study and North American Resources Study teams created Integration Subgroups to coordinate work within and between the two parallel projects. The Resources Study thus evaluated the petroleum resource base and the infrastructure necessary to bring petroleum to the refinery while the Fuels Study focused on refinery capacity, upgrading, and downstream infrastructure. The Fuels Study also examined the demand for petroleum motor transportation fuels as well as natural gas demand for transportation. With regard to the latter, the Resources Study received access to the Fuels Study's initial view on high potential natural gas vehicle demand and the effect of electric vehicles on natural gas consumption but the Resource Study advanced timeline did not allow for inclusion of the final Fuels Study analysis in these areas. By addressing these potential overlaps and establishing firm means of communication, the results of both studies were significantly improved and the time necessary for completing each of the Council's studies was shortened.

The Resources Study Task Groups and Subgroups carefully evaluated the numerous studies available within their respective areas using the grounded perspective resulting from their combined hundreds of years of experience. They determined the key drivers for each outlook and developed a fact-based understanding of the key issues within demand and supply as well as end-use emissions, the economy and prudent environmental operations. From this background, the Committee on Resource Development brought important findings to the attention of the Council. These findings led to the creation of recommendations on government policy that could favorably affect the ability of natural gas to manage the country's "transition to a lower carbon fuel mix."

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 Integrated Report and supporting details 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 policy recommendations. It describes the significant increases in estimates of recoverable natural gas and oil resources and the contributions they can make to the nation's economic, security, and environmental well being if properly produced and transported.

- *Report Chapters* provide a more detailed discussion of the data, analyses, and additional background on the findings. These individual chapters of the Integrated Report are titled by subject area, i.e. Demand, Macroeconomics, etc. These chapters provide supporting data and analyses for the findings and recommendations presented in the *Executive Summary*.

- *Appendices* are at the end of the Integrated Report to provide important background material, such as Secretary Chu's request letters and rosters of the Council and study groups' membership. These sections also contain unit conventions and conversion

factors used by all study groups in the creation of the report as well as a glossary of terms used.

- *Topic Papers* provide a final level of detail for the reader. These topic papers, developed by the study's Task Groups and Subgroups, are included on the CD provided with each hardcopy report. These topic papers formed the base for the understanding of each study segment, such as Onshore Gas and Industrial Demand, and were heavily utilized in the development of the chapters of the Integrated Report. A short abstract list of the topic papers appears as Appendix E.

  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 papers were reviewed by the Task Groups and Subgroups but are essentially stand-alone analyses of the studies used by each group. As such, statements and suggested findings that appear in these topic papers are not endorsed by the NPC unless they were incorporated into the Integrated Report.

The Integrated Report and the topic papers may be individually downloaded from the NPC website. The website is located at: http://www.npc.org and the public is welcome and encouraged to visit the site to download the entire report or individual sections for free. Also, published copies of the report and the CD can be purchased from the NPC.

Executive Summary

Extraordinary events have affected energy markets in the years since the National Petroleum Council (NPC) reported on the *Hard Truths* about energy in 2007.[1] That study concluded that the world would need increased energy efficiency and all economic forms of energy supply. This is still true today, but in the few years since then, significant technology advances have unlocked vast natural gas and oil resources. The newly and greatly expanded North American natural gas and oil resources are already benefiting our country economically and increasing employment. Growing supplies of natural gas have resulted in lower prices, helping to revitalize many U.S. industries and, in some parts of the country, lower the cost of producing electricity. The increased competitiveness of natural gas could lead to greater use for power generation, helping to further reduce emissions from electricity production. Technological advances and the expansion of economically recoverable natural gas and oil reserves can substantially improve America's energy security. North America has also become much more integrated in energy terms; Canada provides a quarter of America's total oil imports, almost double that of the next largest source.

The great expansion of economically recoverable natural gas is central to meeting America's overall needs, as natural gas is one of the cornerstone fuels on which the nation's economy depends. Natural gas provides a quarter of America's overall energy and is used to generate a quarter of the nation's electricity. It provides the heat for 56 million homes and apartments and delivers 35% of the energy and feedstocks required by America's industries. What happens to natural gas supplies affects all Americans.

Other events have detracted from these positive developments. Consumers have been coping with the effects of high petroleum prices. There have been tragic accidents, such as the Macondo oil spill in the deepwater Gulf of Mexico and the natural gas pipeline explosion in San Bruno, California. Concerns have been raised about the environmental impacts of oil sands and shale gas extraction. Some are questioning the industry's ability to develop North American oil and gas resources in an environmentally acceptable and safe manner.

All this sets the context for this study, highlighting the need to continue to develop America's natural gas and oil resources in a manner that will balance energy, economic, and environmental security needs as part of a transition to a lower carbon energy mix.

In his letter asking the NPC to conduct this study, the Secretary of Energy requested that the assessment concentrate on two tasks: developing an up-to-date understanding of the potential natural gas and oil supply opportunities in North America[2]; and examining the contribution that natural gas could make in a transition to a lower carbon fuel mix. He focused the NPC's attention on interrelated national objectives of enhancing the nation's energy security and

[1] National Petroleum Council, *Hard Truths: Facing the Hard Truths about Energy*, July 2007 ("*Hard Truths*").

[2] This study generally focuses on resources in the United States and Canada.

economic competitiveness while minimizing environmental impacts, including climate change. He instructed the NPC to use a study process to "venture beyond business-as-usual industry and government assessments."

I. AMERICA'S ENERGY FUTURE

This study came to four conclusions about natural gas and oil. These findings can help guide the nation's actions.

First, **the potential supply of North American natural gas is far bigger than was thought even a few years ago.** As late as 2007, it was thought that the United States would have to become increasingly dependent on imported liquefied natural gas, owing to what appeared to be a constrained domestic supply. That is no longer the case. It is now understood that the natural gas resource base is enormous and that its development – if carried out in acceptable ways – is potentially transformative for the American economy, energy security, and the environment, including reduction of air emissions. These resources have the potential to meet even the highest projections of demand reviewed by this study.

Second – and **perhaps surprising to many – America's oil resources are also proving to be much larger than previously thought.** The North American oil resource base offers substantial supply for decades ahead and could help the United States reduce, but not eliminate, its requirements and costs for oil imported from outside of North America. The United States and Canada together produce 4% more oil than Russia, the world's largest producer. However, as *Hard Truths* stated, "energy independence is not realistic in the foreseeable future," although economic and energy security benefits flow from reducing imports through efficiency and increasing domestic production. Realizing the potential of oil, like natural gas, in the future will depend on putting in place appropriate access regimes that can allow sustained exploration and development activity to take place in resource-rich areas.

Third, **we need these natural gas and oil resources even as efficiency reduces energy demand and alternatives become more economically available on a large scale.** Even presuming that the United States uses energy much more efficiently, diversifies its energy mix, and transitions to a lower carbon fuel mix, Americans will need natural gas and oil for much of their energy requirements for the foreseeable future. Moreover, the natural gas and oil industry is vital to the U.S. economy, generating millions of high-paying jobs and providing tax revenues to federal, state, and local governments.

Fourth, **realizing the benefits of natural gas and oil depends on environmentally responsible development.** In order to realize the benefits of these larger natural gas and oil resources, safe, responsible, and environmentally acceptable production and delivery must be ensured in all circumstances. Many natural gas and oil companies are committed to such goals and work hard to achieve them. 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. Recognizing that access to available resources can be undermined by safety and environmental incidents, all industry participants must continuously improve their environmental, safety, and health practices, preserving the benefits of greater access for the industry, consumers, and all other stakeholders.

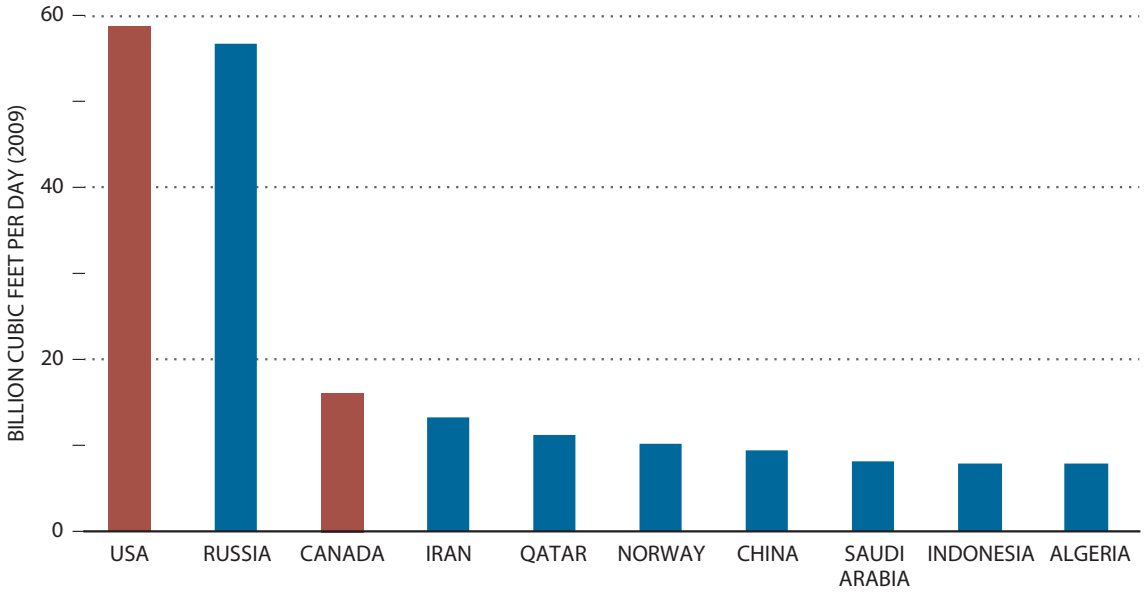
In making these core findings, the NPC examined a broad range of energy supply, demand, environmental, and technology outlooks through 2050. The study participants addressed issues relating to public health, safety, and environmental risks associated with natural gas and oil production and delivery practices, as well as opportunities for natural gas to reduce emissions from energy use. The NPC's findings and recommendations are summarized below and explained in detail in the report chapters.

1. NATURAL GAS IS A VERY ABUNDANT RESOURCE

America's natural gas resource base is enormous. It offers significant, potentially transformative benefits for the U.S. economy, energy security, and the environment. Thanks to the advances in the application of technology pioneered in the United States and Canada, North America has a large, economically accessible natural gas resource base that includes significant sources of unconventional gas such as shale gas. This resource base could supply over 100 years of demand at today's consumption rates. Natural gas, properly produced and delivered, can play an important role in helping the United States reduce its carbon and other emissions. But these potentially transformative benefits cannot happen without access to resource-rich basins and the consistent application of responsible development practices.

The United States is now the number one natural gas producer in the world and together with Canada accounts for over 25% of global natural gas production (Figure ES-1). While shale and other unconventional gas resources are the new game changers, significant conventional resources are being produced in onshore and offshore areas. Lower and less volatile prices for natural gas in the past two years reflect these new realities, with benefits for American consumers and the nation's competitive and strategic interests, including the revitalization of several domestic industries.

Figure ES-1.
United States and Canada Are among Leading Natural Gas Producers



Source: BP Statistical Review of World Energy.

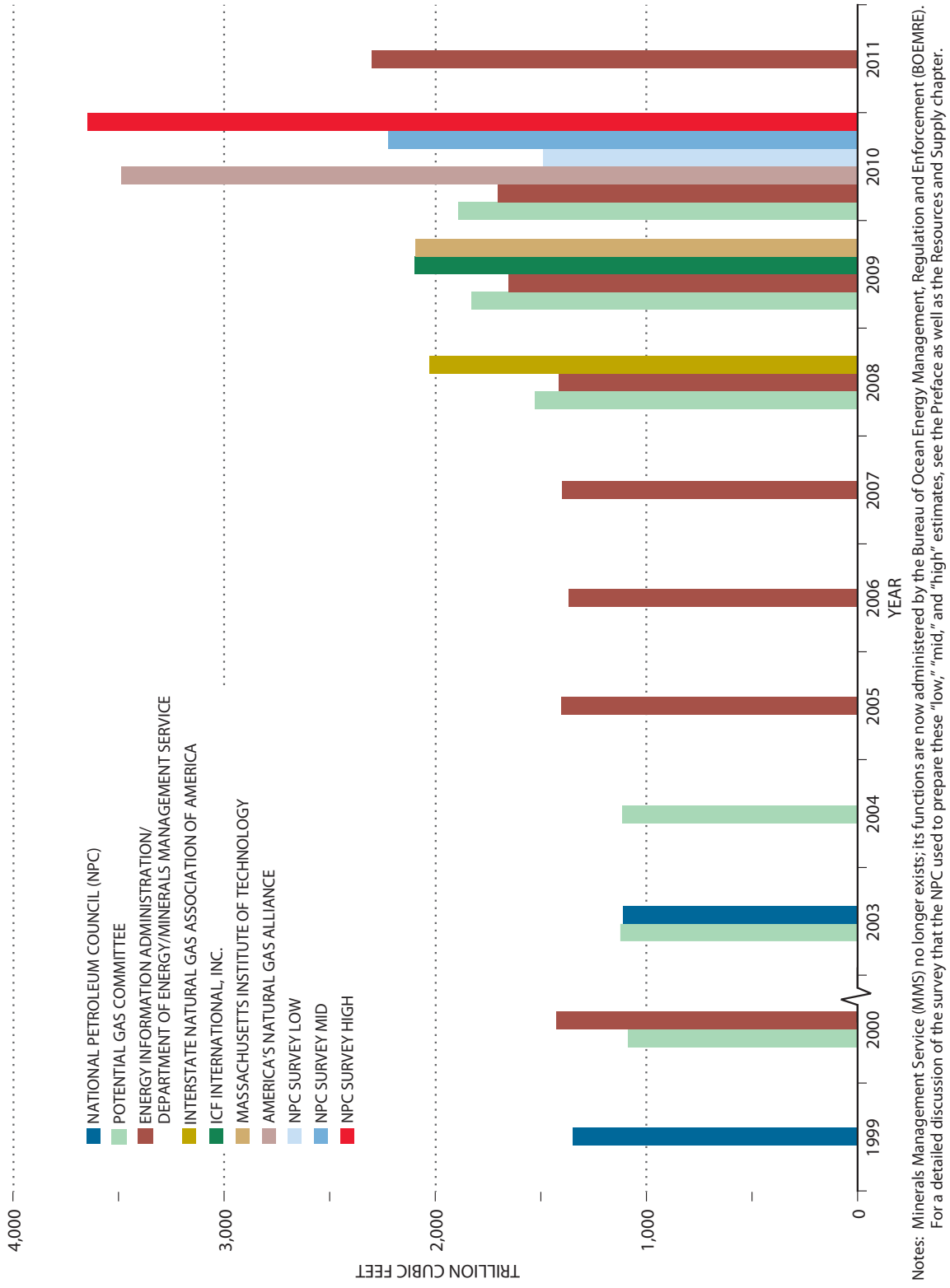
New applications of technologies such as horizontal drilling and hydraulic fracturing have brought about this recent increase in natural gas production and the reassessment of the size of the U.S. recoverable natural gas resource base. Figure ES-2 shows how the estimates of U.S. technically recoverable resources have greatly increased over the past decade, with estimates of recoverable shale gas being the most striking reason for changes over the decade.[3] The natural gas resource base could support supply for five or more decades at current or greatly expanded levels of use. Figure ES-3 shows estimates of the wellhead development cost from three estimates of future natural gas resources derived from the recent MIT study[4] on natural gas, along with low and high estimates of cumulative, total demand from 2010 to 2035.[5] The wellhead development cost, as estimated by the MIT study, should not be read as an expected market price, since many factors determine the price to the consumer in competitive markets. In the longer term, there are additional potential major resources in Arctic and other offshore regions, or with advances in technology from methane hydrate deposits in various locations, mainly offshore. These opportunities could allow natural gas to continue to play a central role in the North American energy economy into the next century.

[3] Technically recoverable resources are resources that can be produced using current technology, as defined by the Energy Information Administration ("EIA").

[4] MIT Energy Initiative, "The Future of Natural Gas: An Interdisciplinary MIT Study," Massachusetts Institute of Technology, 2011 ("MIT 2011 Gas Report"). As presented on Figure ES-3, the MIT "Mean Resource Case" shows the mean resource estimate, based on 2007 technology levels; the "Advanced Technology Case" shows the mean resource estimate based on advanced technologies; and the "High Resource Technology Case" shows the high resource estimate using advanced technologies, as defined in that study.

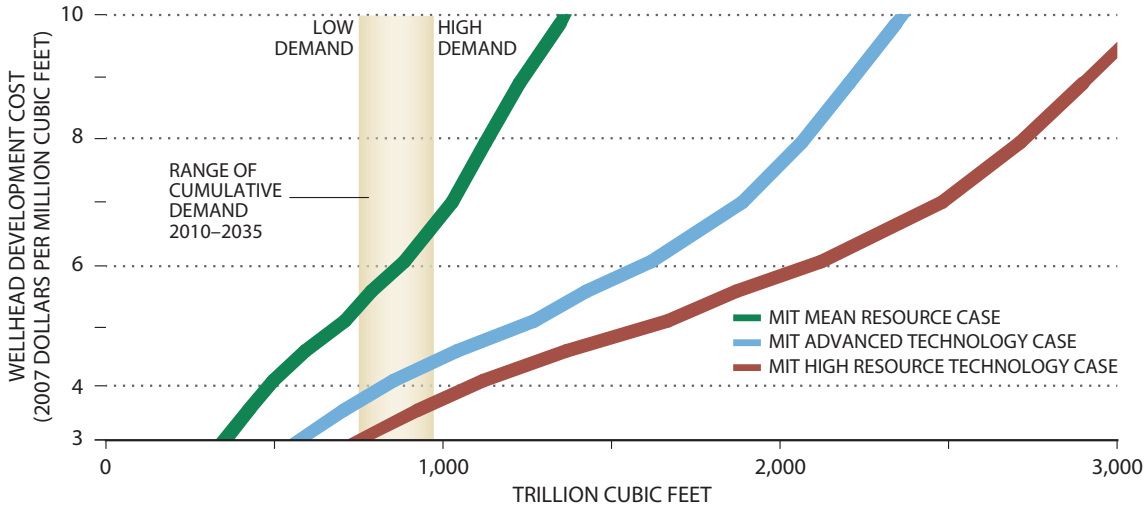
[5] Figure ES-3 also shows the range of cumulative natural gas demand for 2010 through 2035. The range is based on the NPC Demand Task Group estimate that North American natural gas demand for 2035 could range from 25 to 45 trillion cubic feet per year, with a 2010 beginning point of 26 trillion cubic feet per year.

Figure ES-2.
U.S. Natural Gas Technically Recoverable Resources Are Increasing



Notes: Minerals Management Service (MMS) no longer exists; its functions are now administered by the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE).
For a detailed discussion of the survey that the NPC used to prepare these "low," "mid," and "high" estimates, see the Preface as well as the Resources and Supply chapter.

Figure ES-3.
North American Natural Gas Resources Can Meet Decades of Demand



Note: The y-axis represents estimated wellhead cost of supply. The cost of supply can vary over time and place in light of different regulatory conditions, different technological developments and deployments, and other different technical conditions. In none of these cases is "cost of supply" to be interpreted as an indicator of market prices or trends in market prices, since many factors determine prices to consumers in competitive markets.

Source of MIT information: *The Future of Natural Gas: An Interdisciplinary MIT Study*, 2011.

Development of these natural gas resources will require timely investment in the expansion of delivery infrastructure. To date, market signals and existing regulatory structures have worked well in bringing about new natural gas delivery and storage infrastructure.

The technological success in the United States opens up significant new opportunities for global technological leadership and an expanded global role for U.S. natural gas and oil companies.[6] Many countries around the world – ranging from China to Poland, Ukraine, and South Africa – are now assessing their own shale gas resources and development potential. U.S. companies are playing an important role in these activities.

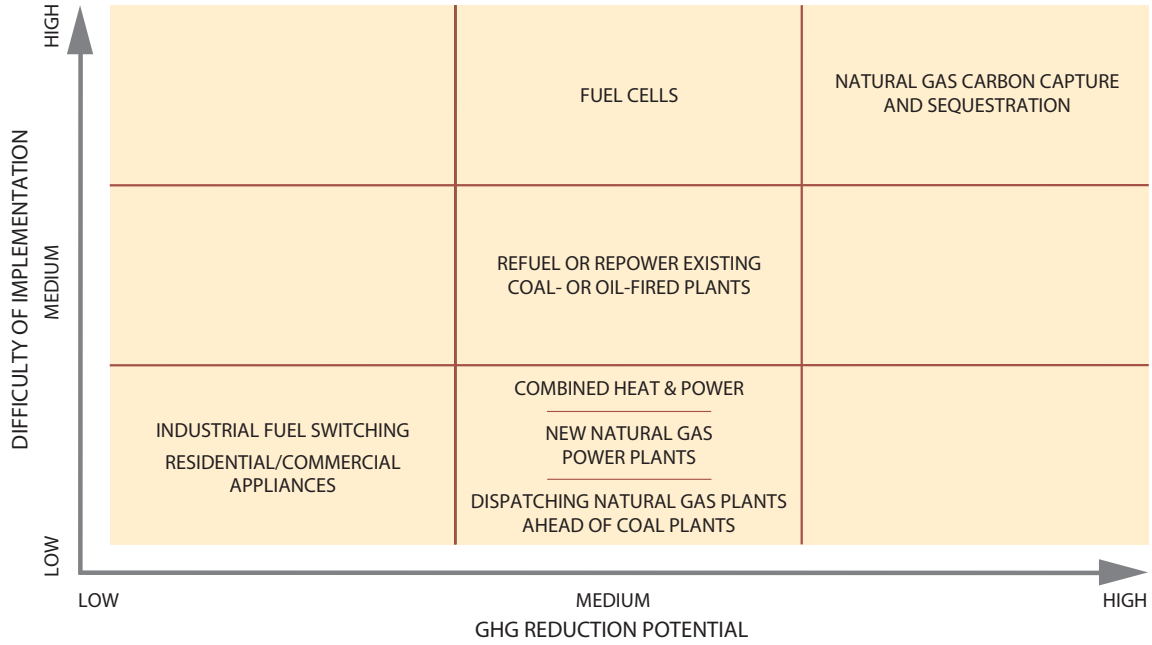
Natural gas can also help the United States reduce greenhouse gas[7] (GHG) and other air emissions in the near term, especially if methane emissions from gas production and delivery are reduced. The biggest opportunity is in the power sector, but there are also opportunities in the industrial, commercial, and residential sectors (Figure ES-4). In recent years, relatively favorable prices for natural gas have displaced some coal-fired generation. More natural gas use will likely result from the electric industry's response to upcoming federal environmental regulations that may encourage retirement of some of the nation's coal-fired power plants. In the long term, if the nation desires deeper reductions in GHG emissions, it will need to address the GHG emissions of all fossil fuels, including natural gas, by putting a price on carbon[8] and advancing other technologies, including those that can capture and sequester carbon dioxide (CO_2).

[6] Unless specifically described in context below, the term "natural gas and oil companies" used in this report includes not only exploration or production companies, but also service companies that support drilling and operations, as well as companies that transport oil and gas.

[7] The major GHG emissions of concern in this report are carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4).

[8] See http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-annex1.pdf. Generally, the term "price on carbon" refers to an assessment of the negative externalities of GHG emissions and the associated economic value of

Figure ES-4.
Natural Gas Technologies Can Help Reduce Greenhouse Gas Emissions



[Note: This will be a text box for final report]

Foundational Concepts

Based on the request from the Secretary of Energy, the NPC used four key concepts to evaluate potential policy recommendations that arose in the study: economic prosperity, environmental sustainability, energy security, and prudent development.

"Economic prosperity" means not just the level of wealth of a country, but also its economic growth, economic security, and economic competitiveness. This goal also includes the notion of balancing the interests of today's society against those of tomorrow's.

"Environmentally sustainable" means allowing for the maintenance of environmental quality and resource protection over time. Environmental sustainability encompasses impacts such as air and water pollution that directly affect public health, as well as these and other impacts affecting ecosystem vitality, biodiversity, habitat, forestry and fisheries' health, agriculture, and the global climate. It is related to the concept of sustainable development as defined by the *Brundtland Commission,* formerly known as the World Commission on Environment and Development: "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

"Energy security" means minimizing vulnerability to energy supply disruptions and the resulting volatile and disruptive energy prices. Since most of the U.S. energy supply is domestic, energy security is affected by the development of domestic resources, as well as the security of delivery and production systems such

reducing or avoiding one metric ton of GHG in carbon dioxide equivalent. Discussions in this report do not differentiate between an explicit carbon price (e.g., under a cap and trade or carbon tax policy) and an implied carbon cost (e.g., specific regulatory limitations on the amounts of emissions).

as natural gas pipelines, refineries, power plants, and electric power transmission. Likewise, as some of the U.S. energy supply comes from other countries, energy security also involves geopolitical considerations associated with protecting and enhancing U.S. strategic interests internationally. Potential disrupters of energy security cover a range, among which are turmoil in foreign supplier countries; the disruption of a major supply source or delivery infrastructure; assaults on the supply chain; natural disasters; and global environmental issues and extreme weather events, as characterized by the 2010 Quadrennial Defense Review Report of the U.S. Department of Defense.

The concept of "prudent development of North American natural gas and oil resources" means 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. Consideration of the distribution of costs and benefits is a key part of prudent development.

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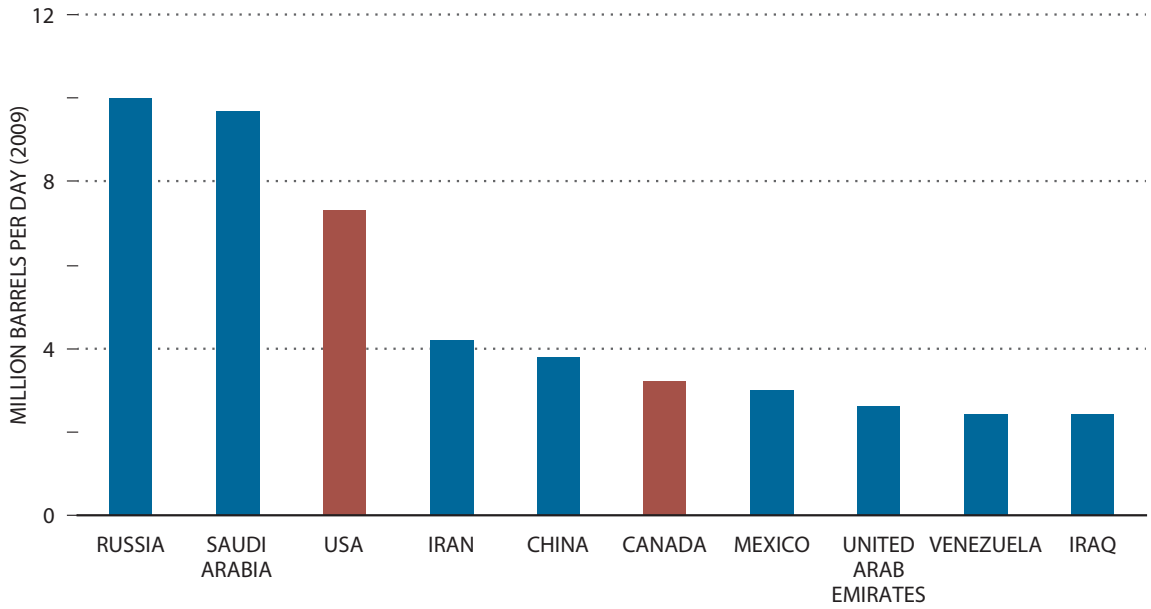
2. SURPRISINGLY, OIL IS ALSO AN ABUNDANT RESOURCE

Contrary to conventional wisdom, the North American oil resource base also could provide substantial supply for decades ahead. Through technology leadership and sustained investment, the United States and Canada together now constitute the largest oil producer in the world. We have world-class resource basins, some of which are located in remote areas offshore and in the Arctic. Going forward, access to these resources depends upon responsible development practices being consistently deployed.

After declining in recent years, North American oil production rose in 2009 and 2010 due to advances in technology and significant investment in exploration and development by companies over a number of preceding years. As a result, the United States and Canada have several already-producing world-class basins – in particular in the deepwater Gulf of Mexico and the Alberta oil sands. These areas contribute substantially to North American oil production, and could sustain and grow current production beyond 2030. In addition, onshore conventional oil is a large supply source, although made up of a multitude of small developments. The long-term decline of production from onshore conventional fields has reversed in recent years through techniques such as enhanced oil recovery (EOR) and hydraulic fracturing. The United States is the third largest oil producer in the world, after Russia and Saudi Arabia (Figure ES-5).

Figure ES-5.
United States and Canada Are Leading Oil Producers



Source: BP Statistical Review of World Energy.

Longer-term growth in oil production can come from several new and emerging North American supply sources. One source is tight oil, found in geological formations where the oil does not easily flow through the rock, such as in the Bakken formation of North Dakota, Saskatchewan, Montana, and Manitoba. Tight oil has also benefited from technologies similar to those used for shale gas, including hydraulic fracturing. Over the next 20 years, tight oil production could continue to grow. A second potentially large supply source is in new offshore areas, particularly in the Gulf of Mexico and the Atlantic and Pacific coasts of the United States and Canada. Access to and potential development of these new U.S. areas would require an Executive Branch level directive to include such areas in the 2012–2017 Leasing Program. New offshore areas could provide both natural gas and oil in significant quantities to supplement the continuing strong production in the Gulf of Mexico. Third, new Arctic oil and natural gas supply have a potential of the equivalent of over 200 billion barrels of oil. This is in addition to existing oil supply and proven natural gas reserves on the Alaska North Slope. The new Arctic resources could yield significant supply after 2025. Fourth, another very large long-term oil supply source lies in the shale oil deposits of Colorado, Utah, and Wyoming. The development of these billions of barrels of oil from these new resource areas will require sustained investment, substantial advances in technology, and environmental risk management systems and approaches.[9] In many instances, there will be the need for new pipelines and other infrastructure.

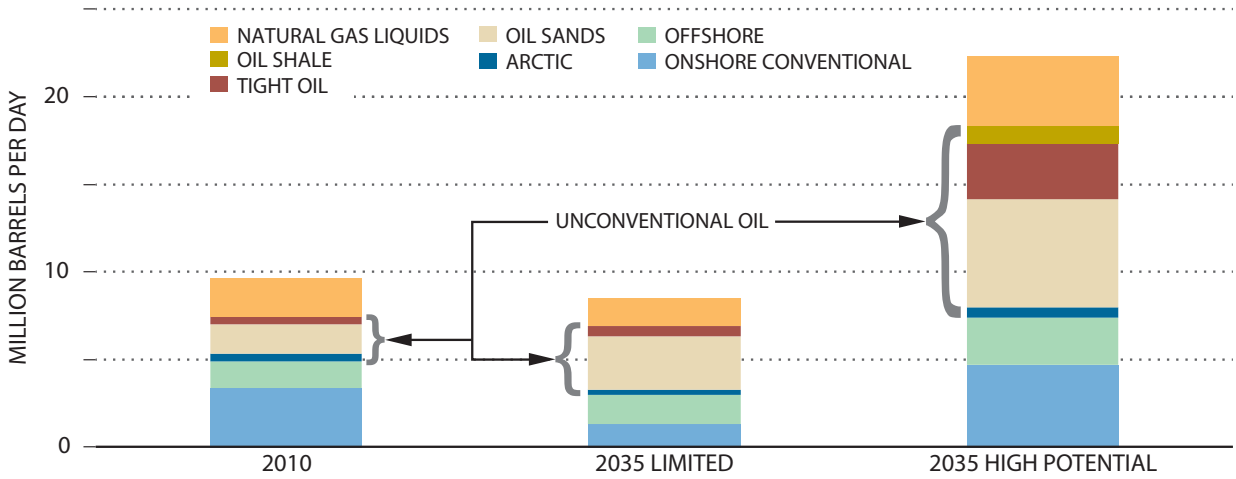
Continuing significant technological advances could extend North American oil production for many decades in various areas, such as other offshore areas, other unconventional oil opportunities, and eventually, oil shale. In recent years, there has been rapid learning and deployment of new production techniques to unlock higher actual and potential natural gas supply,

[9] There are several trillion barrels of "oil-in-place." How much can be extracted will greatly depend on the technology and economics.

particularly from tight and shale gas reservoirs. Such learnings have not yet been fully applied to new and emerging oil opportunities. As the emerging oil opportunities develop both onshore and offshore and with application of some of the technologies now enabling access to unconventional natural gas, similar upward re-appraisal of potential oil supply will likely follow. Such appraisals are an ongoing process as new resources are brought into the development phase.

Figure ES-6 shows the various sources of current supply as well as projected supply in 2035 under a "constrained" scenario and "unconstrained" scenario. The "constrained scenario" is characterized by limited resource access, constrained technology development, as well as greater regulatory barriers. The "unconstrained" scenario is characterized by more access, substantial advances in technology, and regulatory burdens that are not significantly different than today. Even under the unconstrained scenario, the United States will still need to import oil for the foreseeable future.

Figure ES-6.
More Resource Access and Technology Innovation Could Substantially Increase North American Oil Production



Source: Historical data from Energy Information Administration and National Energy Board of Canada.

Notes: The oil supply bars for 2035 represent the range of potential supply from each of the individual supply sources and types considered in this study. The specific factors that may constrain or enable development and production can be different for each supply type, but include such factors as whether access is enabled, infrastructure is developed, appropriate technology research and development is sustained, an appropriate regulatory framework is in place, and environmental performance is maintained.

Note that in 2010, oil demand for the U.S. and Canada combined was 22.45 million barrels per day. Thus, even, in the unconstrained case, 2035 supply is lower than 2010 demand, implying a continued need for oil imports and participation in global trade.

Enhanced access is also a key enabler that could move North American oil production towards the higher potential pathway indicated here. Resource rich areas such as the eastern Gulf of Mexico, the Atlantic and Pacific continental margins, and the Arctic are capable of delivering new volumes of oil supply, potentially extending over several decades. Indeed, in the Arctic, unless new oil production can be developed as a consequence of sustained exploration, the key infrastructure link currently operating (the TAPS pipeline from the Alaska North Slope to the crude oil loading terminal at Valdez, Alaska) will have to be decommissioned when the declines from existing Alaska North Slope production cause pipeline flows to fall below

minimum operating levels. Such an outcome could leave a huge resource stranded with deleterious consequences for the economy and for energy security.

This current and future development of U.S. and Canadian oil can translate into energy security benefits through reducing oil imports. Other potential benefits include improved balance of trade, jobs, and economic multiplier effects from domestic drilling, production, and delivery.

3. AMERICA NEEDS NATURAL GAS AND OIL EVEN AS ALTERNATIVE RESOURCES BECOME AVAILABLE

Even as the United States uses energy much more efficiently and diversifies its energy mix, Americans will need natural gas and oil for the foreseeable future. Natural gas can enable renewable power through management of intermittency. Natural gas and oil are currently indispensable ingredients in the American economy and Americans' standard of living. A vibrant domestic natural gas and oil industry has the potential to add much-needed domestic jobs and revenues for federal, state, and local governments. In a competitive global business environment, where companies have the ability to move capital around the world, a dependable and affordable supply of natural gas and oil is important for creating economic growth, investment, and jobs in the United States. Abundant supplies of natural gas are vital to improving the competitiveness of domestic industries that use natural gas as a fuel and feedstock. Though North America has abundant natural gas and oil resources, these resources must still be used wisely; and energy efficiency measures should be developed and implemented wherever they are cost effective.

Together, natural gas and oil make up nearly two-thirds of U.S. energy use.[10] Even with increasing energy efficiency, buildings, motor vehicles, industrial facilities, and other energy-using equipment will remain highly dependent on natural gas and oil for many years to come. Thus, these fuels are critical in the U.S. economy, particularly as part of a strategy to transition towards a low-carbon energy mix in the future. There is enough supply to meet a range of demand levels for decades – from business as usual, to scenarios with much greater penetrations of natural gas in the power, industrial, and transportation sectors. And, using these resources much more efficiently will strengthen the nation's economic resiliency, reduce environmental impacts, and enhance energy security. As noted in *Hard Truths* and other studies, investment in and deployment of energy efficiency measures is frequently cost effective and will reduce demands for fossil fuels and the impacts of their associated emissions. Energy efficiency deserves continued and increased efforts.[11]

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[10] Source: AEO2011 Reference Case for data for 2010.

[11] *Hard Truths* recommended that the U.S. moderate demand by increasing energy efficiency through improved vehicle fuel economy and by reducing energy consumption in the residential and commercial sectors. *Hard Truths* concluded that:

- "… anticipated energy use in the residential and commercial sectors could be reduced by roughly 15 to 20 percent through deployment of cost-effective energy-efficiency measures that use existing, commercially available technologies. Assuming that all these measures are put in place over the next decades and that all other factors such as level of services are held constant, U.S. residential/commercial energy consumption could be reduced by 7 to 9 quadrillion Btu. Technologies to accomplish savings of these magnitudes are indicated to be available in the marketplace" (page 43).

At the same time, in meeting the needs of U.S. consumers, the American natural gas and oil industry plays an essential role in the U.S. economy. Companies directly engaged in the oil and natural gas industry employ over 2 million Americans who earn over $175 billion in labor income. The employment figure jumps to over 9 million Americans with $533 billion in labor income when including the jobs created by the spending on goods and services of natural gas and oil companies and their employees. PricewaterhouseCoopers has estimated that the domestic oil and natural gas industry directly generated approximately $464 billion in combined operational expenses and capital investment in 2009 – equivalent to over 3% of America's gross domestic product (GDP).[12] In the United States, federal, state, and local governments also benefit from the substantial amount of taxes and royalties paid by natural gas and oil companies. Taking into account all corporate income taxes, severance taxes, royalties on federal lands, sales taxes, payroll taxes, property and use taxes and excise taxes, natural gas and oil companies generate over $250 billion in government revenue annually.

Although natural gas and oil have long been viewed as related fuels, their uses are quite different. Natural gas is especially important for heating, power generation, and industrial uses such as chemical manufacturing. By contrast, around 97% of all energy used in the transportation sector comes from oil. The import picture differs as well. Nearly all of the natural gas consumed in North America is produced within the same continental boundaries, while about half of the crude oil processed in North American Refineries is imported. Within North America, Canada is a net exporter of crude oil and the United States is a net importer.[13]

Low natural gas prices make U.S. manufacturers and farmers more competitive. U.S. firms rely on natural gas- and oil-derived chemicals as building blocks for the production of electronics (including computers and cell phones), plastics, medicines and medical equipment, cleaning products, fertilizers, building materials, adhesives, and clothing. When manufacturers use natural gas as a fuel and feedstock, they create a variety of products that are used every day. These products are valued at greater than eight times the cost of the natural gas used to create them, providing significant benefit to the nation's economy.[14]

- "… a doubling of fuel economy of new cars and light trucks by 2030 is possible through the use of existing and anticipated technologies, assuming vehicle performance and other attributes remain the same as today…. Depending upon how quickly new vehicle improvements are incorporated in the on-road light duty vehicle fleet, U.S. oil demand would be reduced by about 3-5 million barrels per day in 2030. Additional fuel economy improvements would be possible by reducing vehicle weight, horsepower, and amenities, or by developing more expensive, step-out technologies" (pages 14-15).

[12] PricewaterhouseCoopers, "The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy in 2009: Employment, Labor Income, and Value Added," May 2011.

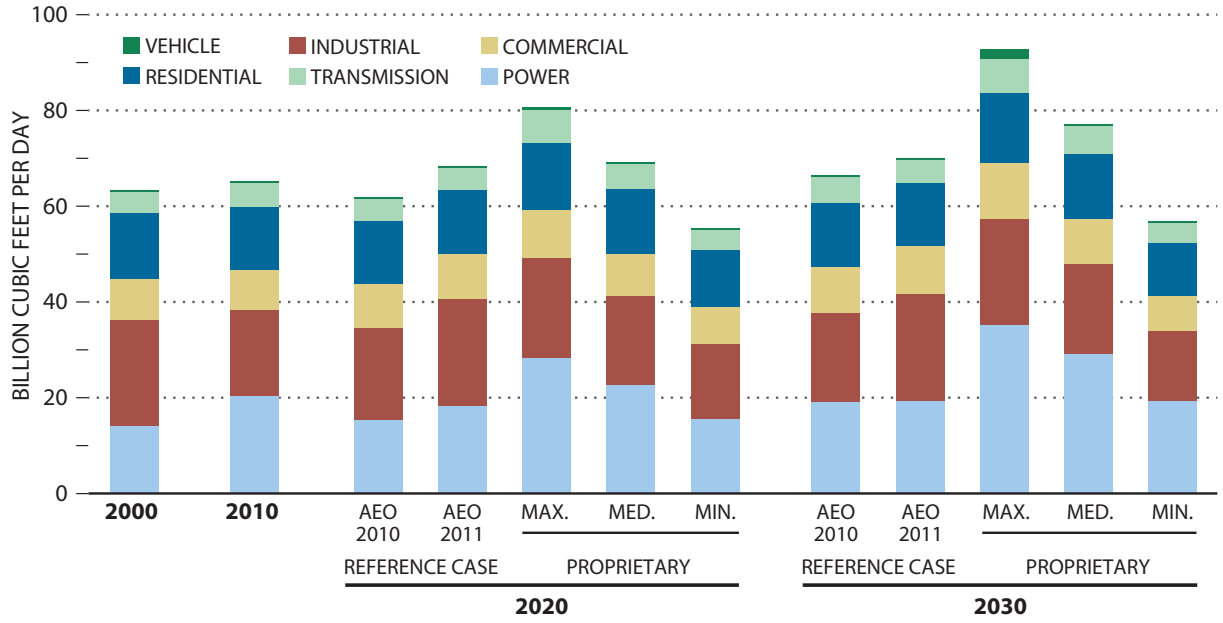
[13] In 2010, U.S. net crude oil imports were 9.1 million barrels per day, which was about 62% of its total refinery crude oil inputs. Canada, in contrast, is a net crude oil exporter, as it imports crude oil into eastern Canadian refineries but exports crude oil to the United States from western Canadian production. On a net basis, Canada exports 1.4 million barrels per day, but its crude oil exports to the U.S. total 1.99 million barrels/day, 22% of U.S. crude oil imports. So, for both countries together, net crude oil imports total 7.7 million barrels per day, or about 47 percent of combined refinery crude oil runs. Source: BP and EIA.

[14] Based on information in the American Chemistry Council, *Guide to the Business of Chemistry,* 2011; and American Chemistry Council, *Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing*, Economics & Statistics, March 2011.

Observers of natural gas markets forecast a wide range of future natural gas demand for the United States and a narrower range for Canada.[15] For the United States, most of the variation in natural gas demand comes from the power sector; for Canada, it comes from the industrial sector. Figure ES-7 shows demand in 2010, along with several projections for 2020 and 2030.[16] Over 120 gigawatts (GW) of natural gas combined cycle capacity was added from 2000 to 2008. The power sector has already substituted the use of natural gas for some coal because of low natural gas prices. The increased use of these new and efficient natural gas units decreased the GHG emissions from U.S. power plants by about 83 million metric tons of CO_2, or about 1% of total U.S. emissions in 2005.[17] Compared to 2000, natural gas use for power generation has grown by over 25% from 2000 to 2010. It is projected to increase as much as another 75% by 2030.[18]

The availability of abundant low cost natural gas is helping to revitalize several industries, including petrochemicals, leading to several billions of dollars of new investment in domestic industrial operations that would not been anticipated half a decade ago.

Figure ES-7.
The Power Sector Shows the Most Variation in Projected U.S. Natural Gas Demand



Notes: AEO2010 = EIA's Annual Energy Outlook (2010); AEO2011 = EIA's Annual Energy Outlook (2011).

[15] The NPC assessed the numerous recent forecasts of demand for U.S. and Canadian natural gas that exist in the public domain. Additionally, the NPC studied a number of proprietary forecasts and conducted a survey. The study subgroups also examined aggregated proprietary data collected via a confidential survey of private organizations, primarily gas and oil companies and specialized consulting groups. The proprietary data were collected by a third party and aggregated to disguise individual responses.

[16] The AEO cases are from the Annual Energy Outlook, prepared by the EIA. The proprietary cases are aggregated third-party forecasts.

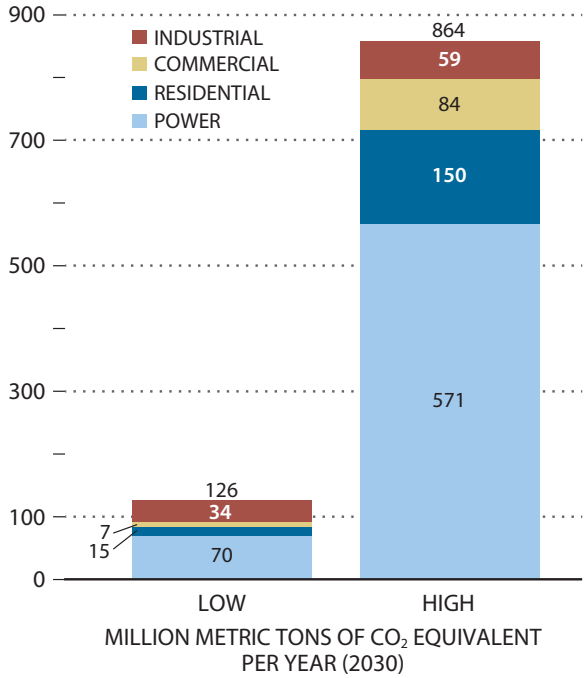
[17] Based on EIA, *U.S. Carbon Dioxide Emissions in 2009: A Retrospective Review,* http://www.eia.doe.gov/oiaf/environment/emissions/carbon/ and NPC analysis of EIA, *Monthly Energy Review*, April 2011.

[18] Compared to 2000, natural gas use for power generation has grown from 14 billion cubic feet per day (Bcf/d) in 2000 to 20 Bcf/d in 2010, and is projected to be between 19 and 35 Bcf/d by 2030 (see Figure ES-7).

Upcoming environmental regulations affecting power plants, combined with expectations for future natural gas prices informed by published forecasts, will have an impact on the use of natural gas in the power sector. Relatively old and inefficient coal-fired power plants with limited emission controls will likely retire, with various studies estimating retirements ranging from 12 to 101 GW of capacity by 2020. The study average of 58 GW of coal-fired capacity retirements represents about 6% of total U.S. generating capacity, or around 18% of coal-fired capacity. This will likely increase demand for natural gas at power plants, lead to new investment in natural gas-fired generation, and lower GHG emissions from the power sector (on average, around 3.5% of the 2005 U.S. total by 2020).

In the longer term, increased natural gas supplies, along with the possible introduction of policies to reduce GHG emissions, could yield more substitution of natural gas for other fossil fuels, mainly coal. According to studies reviewed as part of this NPC study, natural gas could help reduce emissions in the long term (such as a 50% reduction from a 2005 baseline by 2050). A steeper emissions reduction target, such as 80% or more by 2050, will likely also require more aggressive emission control technologies like carbon capture and sequestration (CCS) for both coal and natural gas power plants, if these fossil fuels were to remain a significant energy source for power generation. Excluding transportation, the potential reduction in GHG emissions from natural gas use ranges from an equivalent of 126–864 million metric tons of CO_2 per year by 2030, or about 2%–12% of total 2005 U.S. GHG emissions (Figure ES-8). This broad range of GHG reductions reflects the potential application of diverse natural gas technologies across the end-use sectors, including appliances, power infrastructure, and infrastructure retrofits in applications within the residential, commercial, and industrial end-use sectors.

Figure ES-8.
Estimated GHG Emission Reductions from the Use of Natural Gas Vary Widely



In addition to emissions of CO_2 at the point of natural gas combustion, there are emissions of methane into the atmosphere that result from the production and delivery of natural gas.[19] Some emissions occur in normal operations through venting for safety reasons such as to relieve pressure. Other emissions occur because of leaks in equipment such as compressor seals and connections. Because methane is a GHG that is significantly more potent than CO_2 in its global warming potential,[20] it is vital to minimize these emissions. In the April 2011 annual national GHG inventory update, the Environmental Protection Agency (EPA) estimated that fugitive methane emissions by natural gas companies accounted for approximately 4% of U.S. GHG emissions in 2009. There is, however, a very high degree of uncertainty around estimates of methane emissions and, therefore, better data are needed while efforts continue to reduce such emissions.

Taking into account EPA's recently revised estimates of methane emissions during production and delivery, the life-cycle emissions for natural gas are about 35% lower than coal on a heat-content (British thermal unit [Btu]) basis.[21] In terms of the production of electricity, for efficiencies typical of coal- and natural gas-fired plants, natural gas has about 50%–60% lower GHG emissions than those of a coal-fired plant (Figure ES-9).[22]

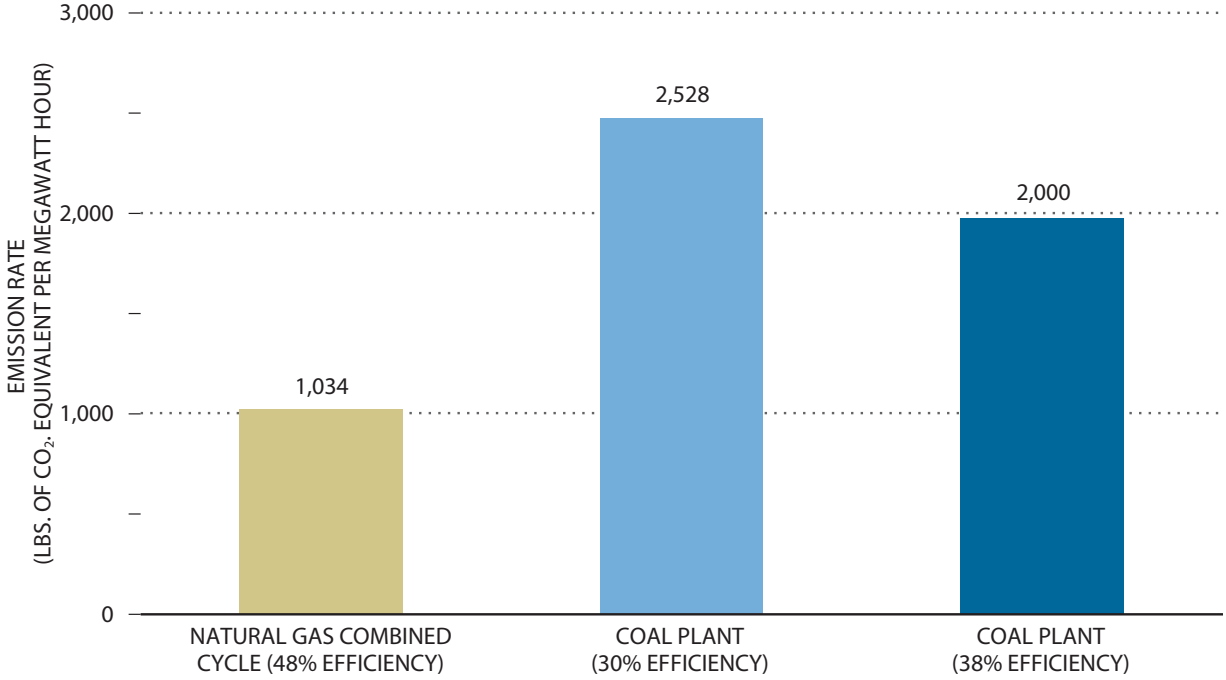
[19] Methane is a chemical compound that is the primary component of natural gas.

[20] See a more detailed discussion in Chapter Four about the issues surrounding the relative potency of methane and CO_2 from a global warming potential.

[21] Life-cycle emissions include those from the direct combustion of natural gas, as well as methane emissions from the production and delivery of natural gas.

[22] The natural gas combined cycle (NGCC) turbine unit has a heat rate of 7,000 Btu/kWh, while the coal plant at 30% efficiency has a heat rate of 11,377 Btu/kWh and the coal plant at 38% efficiency has a heat rate of 9,000 Btu/kWh.

Figure ES-9.
Life-Cycle GHG Emissions for Natural Gas Are about One-Half of Coal



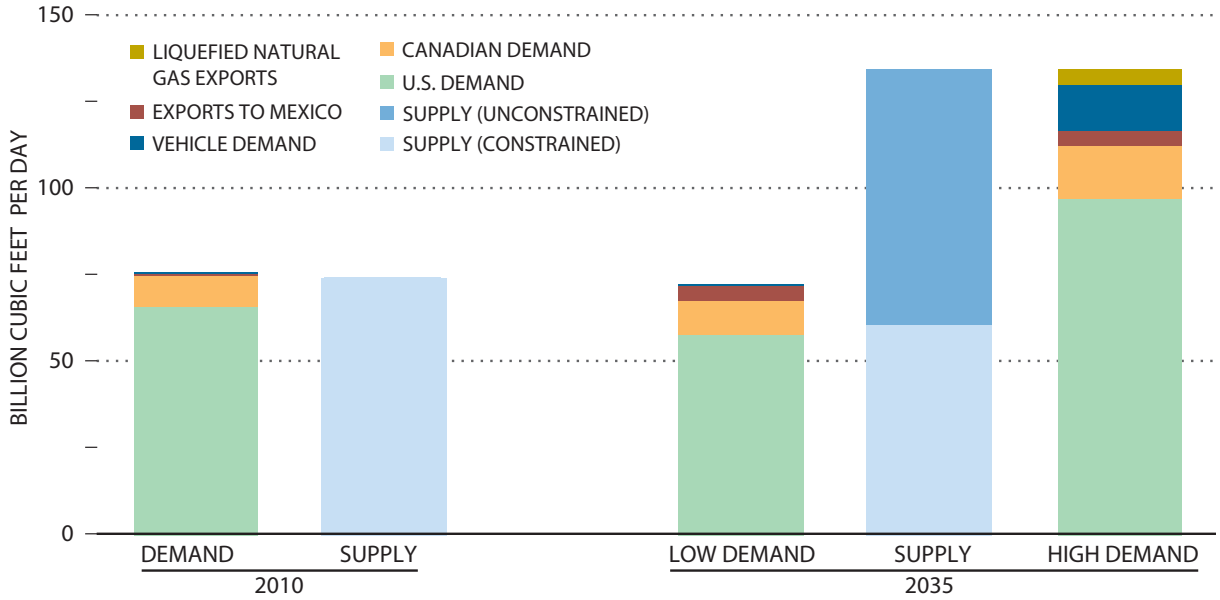
Beyond the power sector, there is potential for increased use of natural gas to displace oil in the transportation sector. The NPC Future Transportation Fuels (FTF) study is examining the implications for gasoline and diesel demand of Natural Gas Vehicles (NGVs) and Plug-in Electric Vehicles (PEVs) that could create some natural gas demand for power generation, as well as Fuel Cell Electric Vehicles (FCEVs) using hydrogen reformed from natural gas. Since the FTF study will be completed after this study, the final results of the FTF study cannot be incorporated here. Consequently, the NPC's study of natural gas and oil resources examined high-potential-demand cases for NGVs, PEVs, and FCEVs from published sources. For example, in 2035, U.S. and Canadian transportation could potentially consume 13 billion cubic feet per day (Bcf/d) of gas.

There is a wide range in the estimates of future demand for natural gas. The most aggressive estimate of total natural gas demand, including transportation, is 133 Bcf/d by 2035, an 85% increase from 2010 natural gas requirements of 72 Bcf/d.[23] The low-end estimate of total natural gas demand for 2035 is 72 Bcf/d (Figure ES-10). It appears that even a 2035 potential demand requirement of up to 133 Bcf/d could be supplied. And based on the 2011 MIT gas study, *The Future of Natural Gas*, this high potential demand could be supplied at a current estimated wellhead production cost range in 2007 dollars of $4.00 to $8.00 per million Btu (MMBtu), as shown by comparing the information in Figure ES-10 and Figure ES-3, and based on current expectations of cost performance and assuming adequate access to resources for

[23] U.S. and Canadian demand for 2035 is based on an extrapolation of 2020–2030 Proprietary Maximum and Minimum cases.

development.[24] This wellhead development cost should not be read as an expected market price, since many factors determine the price to the consumer in competitive markets.

Figure ES-10.
North American Natural Gas Production Could Meet High Demand



Notes: 2035 – Development facilitated by access to new areas, balanced regulation, sustained technology development, higher resource size.
2035 – Development constrained by lack of access, regulatory barriers, low exploration activity, lower resource size.

While natural gas and oil bring many benefits, they come with mixed impacts, as do other sources of energy. Production and delivery of energy involves real health, safety, and environmental considerations and risks. Using natural gas and oil resources much more efficiently, producing them with lower environmental impacts, and diversifying U.S. energy mix are essential. The nation should adopt energy efficiency measures wherever economically attractive, and government policies should address impediments to that objective.

4. REALIZING THE BENEFITS OF NATURAL GAS AND OIL REQUIRES ENVIRONMENTALLY RESPONSIBLE DEVELOPMENT

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, such as deepwater offshore basins or onshore areas with shale gas resources in populated 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

[24] 2011 MIT gas study, page 31.

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.

Risk to the environment exists with oil and natural gas development, as with any kind of energy production. Natural gas and oil companies have drilled for and delivered energy in the United States and Canada for a century and a half. Through that time, much has changed in how natural gas and oil are produced, and how drilling and production are regulated. In general, exploration and production occur in a far safer and environmentally responsible fashion than in generations past, in no small part as a result of changes in public environmental awareness, government regulation, technological innovations, and companies' actions. In spite of the exploration and production improvements, there will undoubtedly be areas that remain off limits, based on unique environmental attributes.[25] The key is that as environmental considerations evolve, both natural gas and oil companies and the government continue to work to improve environmental performance.

Many, if not most, natural gas and oil companies have committed themselves to operating at high levels of performance with respect to environment, safety, and health impacts. Oil and gas industry occupational injury statistics from 1994 to 2009 show significant reductions compared to all of private industry.[26] As an example of improvements in environmental performance, on Alaska's North Slope, the surface footprint of drill pads has been reduced from 65 acres to 9 acres[27] and the volumes of waste generated from 100 barrels of oil equivalent of reserve additions has shrunk from 7.5 to 3.4 barrels.[28] Advances in water use management practices have resulted in reduced demands on freshwater sources and many operators are pursuing reuse of produced water in fracture operations. According to the 2011 MIT gas study, which reviewed three reports of publicly reported incidents related to gas well drilling, there were only 43 "widely reported" incidents related to gas well drilling in the past decade (to 2010)[29] during which time, there were about 20,000 shale gas wells drilled with almost all of them being hydraulically fractured.[30]

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[25] The most obvious examples are resources located in national parks.

[26] The oil and natural gas industry had an injury and illness incidence rate of 5.4 per 100 full-time workers in 1994 (compared to 8.4 per 100 for all private industry that year), and improved the rate to 1.6 per 100 in 2009 (compared to 3.6 per 100 in that year for all private industry). Source: U.S. Department of Labor, Bureau of Labor Statistics, "Survey of Occupational Injuries and Illnesses," Table 1, Incidence rates of nonfatal occupational injuries and illnesses by case type and ownership, selected industries, 1994, 2009.

[27] American Petroleum Institute, *Examples of Technology at Work in the Arctic*, Autumn 2008 (http://www.api.org/policy/exploration/upload/Technology_at_Work_Arctic.pdf)

[28] U.S. DOE, *Environmental Benefits of Advanced Oil and Gas Exploration and Production Technology*, DOE-FE-0385 (October 1999).

[29] Of these, 47% of the incidents involved groundwater contamination by natural gas or drilling fluids; 33% involved on-site surface spills; 9% involved off-site disposal issues; and the remaining 10% involved water withdrawal issues, air quality issues, and blowouts. "With over 20,000 shale wells drilled in the last 10 years, the environmental record of shale gas development has for the most part been a good one – but it is important to recognize the inherent risks and the damage that can be caused by just one poor operation…. In the studies surveyed, no incidents are reported which conclusively demonstrate contamination of shallow water zones with fracture fluids." 2011 MIT gas study, Appendix 2E.

[30] 2011 MIT gas study, pages 39-40.

Unfortunately, accidents have occurred in operations of even the most committed companies. Efforts by all industry members to achieve and sustain high environment, health, and safety performance are essential. Many in and outside of the natural gas and oil industry worry that accidents or inferior practices of some companies could undermine public trust in the entire industry. Consistent use of responsible practices to protect the environment and public health are important on their own, and will also help avoid additional restrictions on access to resources and support access to additional resources that could help meet future energy needs.

[Note: This will be a text box for final report]

Hydraulic Fracturing

Hydraulic fracturing is the treatment applied to reservoir rock to improve the flow of trapped oil or natural gas from its initial location to the wellbore. This process involves creating fractures in the formation and placing sand or proppant in those fractures to hold them open. Fracturing is accomplished by injecting water and fluids designed for the specific site under high pressure in a process that is engineered, controlled, and monitored.

Fracturing Facts

- Hydraulic fracturing was first used in 1947 in an oil well in Grant County, Kansas, and by 2002, the practice had already been used approximately a million times in the United States.[31]
- Up to 95% of wells drilled today are hydraulically fractured, accounting for more than 43% of total U.S. oil production and 67% of natural gas production.[32]
- The first known instance where hydraulic fracturing was raised and addressed as a technology of concern was when it was used in shallow coalbed methane formations that contained freshwater (Black Warrior Basin, Alabama, 1997).
- In areas with deep unconventional formations (such as the Marcellus areas in Appalachia), the shale gas under development is separated from freshwater aquifers by thousands of feet and multiple confining layers. To reach these deep formations where the fracturing of rock occurs, drilling goes through the shallower areas, with the drilling equipment and production pipe sealed off using casing and cementing techniques.
- The technology and its application are continuously evolving. For example, testing and development are underway of safer fracturing fluid additives.
- The Interstate Oil and Gas Compact Commission (IOGCC), comprised of 30 member states in the United States, reported in 2009 that there have been no cases where hydraulic fracturing has been verified to have contaminated water.[33]
- A new voluntary chemical registry (FracFocus) for disclosing fracturing fluid additives was launched in the spring of 2011 by the Ground Water Protection Council (GWPC) and the IOGCC. Texas operators are required by law to use FracFocus.
- The Environmental Protection Agency concluded in 2004 that the injection of hydraulic fracturing fluids into coalbed methane wells poses little or no threat to underground sources of drinking water.[34] The EPA is

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[31] Interstate Oil and Gas Compact Commission, Testimony Submitted to the House Committee on Natural Resources, Subcommittee on Energy and Mineral Resources, June 18, 2009, Attachment B.

[32] IHS Global Insights, *Measuring the Economic and Energy Impacts of Proposals to Regulate Hydraulic Fracturing,* 2009; and EIA, Natural Gas and Crude Oil Production, December 2010 and July 2011.

[33] [34]Interstate Oil and Gas Compact Commission, Testimony Submitted to the House Committee on Natural Resources, Subcommittee on Energy and Mineral Resources, June 18, 2009, Attachment B.

currently studying hydraulic fracturing in unconventional formations to better understand the full life-cycle relationship between hydraulic fracturing and drinking water and groundwater resources.

- The Secretary of Energy's Advisory Board is also studying ways to improve the safety and environmental performance relating to shale gas development, including hydraulic fracturing [35]

Natural gas and oil resources in North America are developed in a wide variety of settings, each of which has a variety of environmental challenges. For instance, in offshore development, the response to a major oil spill incident is complicated by conditions in the marine location, with drilling occurring up to several thousand feet below sea level. Onshore natural gas and oil development takes place in a wide range of locations, including arid deserts and coastal wetlands, wildlife habitats, rural and urban settings, and pristine landscapes and industrial parks. The various locations pose different issues in areas such as water sourcing, effluent disposal, site preparation and reclamation, and reduced fragmentation and protection of wildlife habitat. Specific standards and regulations that may be appropriate for production in some areas may not be effective in others.

[Note: This will be a text box for final report]

Environmental and public health concerns associated with oil and natural gas development vary according to location and type of resource, whether the resource is onshore versus offshore, and the methods employed to extract and deliver the resource. The following issues are addressed in the chapters of this report:

- **Hydraulic fracturing** – consumption of freshwater (volumes and sources); treatment and/or disposal of produced water returned to the surface; instances of naturally occurring radioactive material (NORM) in produced water; seismic impacts; chemical disclosure of fracture fluid additives; potential ground and surface water contamination.
- **Onshore operations** – wellbore integrity; air emissions from combustion, venting, or leaks; methane migration into drinking water; community impacts including noise, odors, proximity to residential areas, and volume of truck traffic; fragmentation of and impacts on wildlife habitats; water contamination; waste management; and human health and safety.
- **Offshore operations –** the marine environment brings different concerns than for onshore; pressures and temperatures at remote wellheads make prevention and response to a major release more challenging; and seismic noise associated with exploration and drilling activities is recognized as a concern for whale populations and other marine life, including fish.
- **Arctic ice environments** – responding to an oil spill in low temperatures with the presence of broken sea ice, potential threats to sensitive habitat, and seismic noise.
- **Oil sands –** volumes of water needed generate issues of water sourcing; removal of overburden for surface mining can fragment wildlife habitat and increase the risk of soil erosion or surface run-off events to nearby water systems; GHG and other air emissions from production.

The different types of natural gas and oil resources and geologic formations also pose different development and environmental challenges. The variations among coalbed natural gas,

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[34] U.S. EPA, Office of Water, Office of Ground Water and Drinking Water, *Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs*, (4606M) EPA 816-R-04-003, June 2004.

[35] Secretary of Energy Advisory Board (SEAB), Natural Gas Subcommittee, 90-Day Interim Report, Safety of Shale Gas Development, May 5, 2011, http://www.shalegas.energy.gov/

tight sands, shale gas, oil sands, shale oil, and conventional opportunities can differ widely and require different approaches for production and delivery and different risk management practices to manage environmental impacts. Regulations and operating practices need to be tailored for the specific setting.

The number and variety of companies engaged in natural gas and oil development differ dramatically depending on the location and type of resource. In offshore development, because of the large capital investments and financial risk, generally the companies are fewer in number and larger in size than onshore. Onshore, around 7,000 companies are involved in natural gas and oil exploration and production, including 2,000 drilling operators and hundreds of service companies. The size of these firms ranges from those with very few employees to major integrated international oil companies with tens of thousands of U.S. employees.

Oil and gas activity has increased dramatically, and development is now occurring in some areas where there has not been significant activity for decades. In those circumstances, regulatory capability may have to be – and in some states,[36] already has been – enhanced and companies need to engage with local communities. Regulators face the challenge of keeping up with increased activity and staying abreast of technological developments. Regulatory programs have to be administered effectively and with clarity during a time of extraordinary budget pressures.

[Note: This will be a text box for final report]

Environmental regulation of the natural gas and oil industry

State, federal, and in some cases, regional regulations are in place to govern oil and natural gas production for the purpose of achieving safety, public health, and environmental protection. The interaction of these many layers of regulation is complex and generally effective. However, regulation among jurisdictions is uneven and in some cases requires strengthening resources available for staffing, keeping abreast of changes in the industry, and enforcement.

In certain circumstances, there are federal legislative exemptions or special considerations afforded the oil and gas industry that some environmental advocates believe result in material deficiencies in environmental protection, particularly in relation to water and air quality. Others, including many in the natural gas and oil industry and in state governments, maintain that the special classifications under federal law are appropriate and supported by scientific or economic findings, addressed by state laws, and are parallel to special considerations that exist for many industries.

There is a range of views on whether outstanding regulatory issues are best addressed through state or federal regulatory action. Many state agencies have been involved in regulating oil and gas development for much longer than the federal government and have unique knowledge and expertise relative to the local geological, hydrological, environmental, and land use setting, and are responsible for regulation and development of private and state natural gas and oil resources, as well as for implementing certain federal laws and regulations.

Federal agencies have similar responsibilities for federal mineral development and environmental performance of companies where the federal government owns or controls such mineral rights or lands. Some entities believe states are generally more adept than federal agencies in their ability to adapt to changes in technology and new industry practices and more efficient. Others believe that only through federal regulation can there be assurance of a

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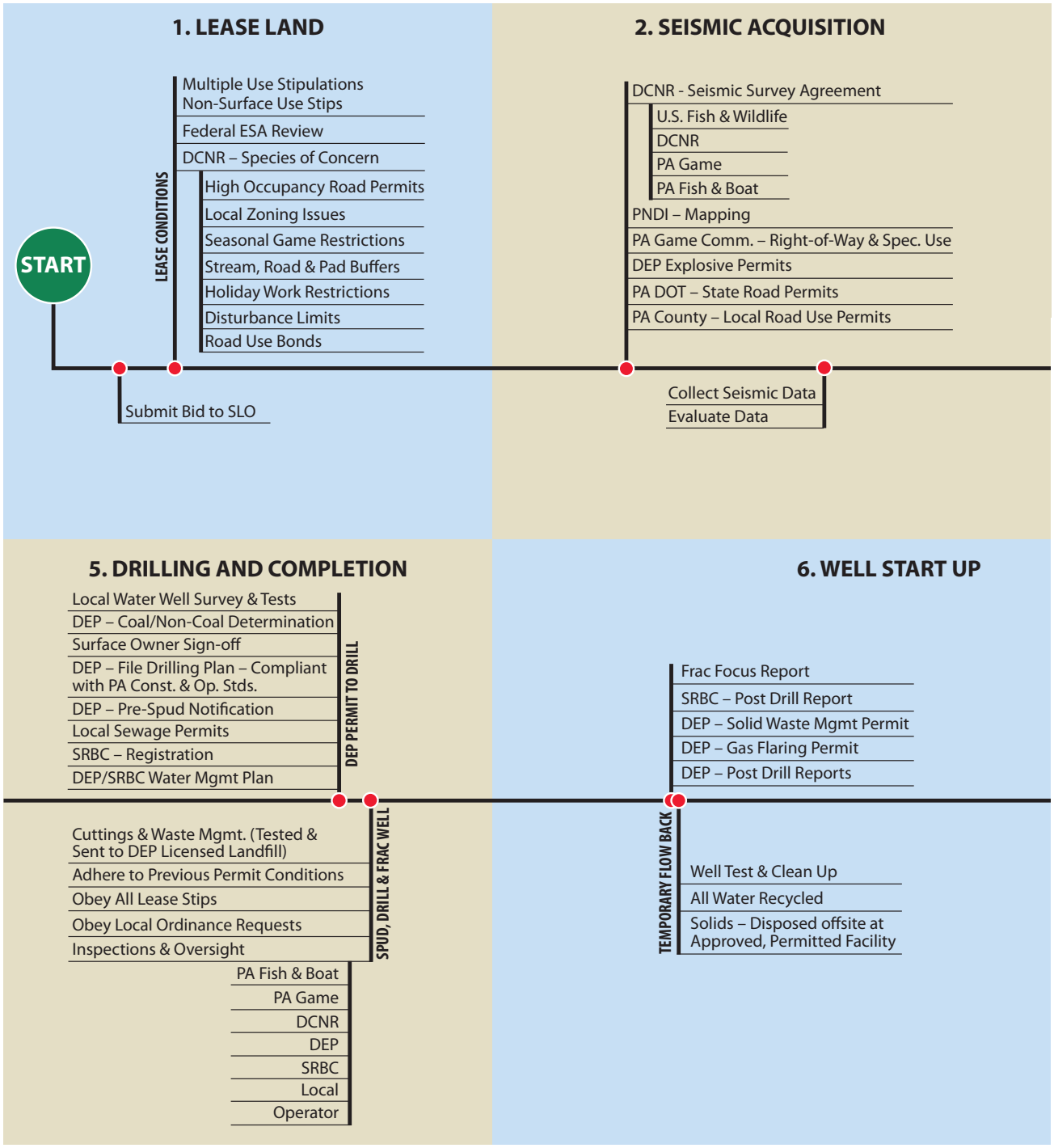
[36] For example, Colorado has recently updated its regulations, in part to address the intensity of development in parts of the state where less development has occurred historically; in 2010, Pennsylvania instituted a number of policies to update its regulations and regulatory capability, to address various issues relating to increased natural gas development in the state. See: Colorado Oil and Gas Conservation Commission, 2009 amended rules (http://cogcc.state.co.us/); and STRONGER, "Pennsylvania Hydraulic Fracturing State Review," September 2010.

reasonably consistent level of environmental and public health protection across the country, and on public and private lands.

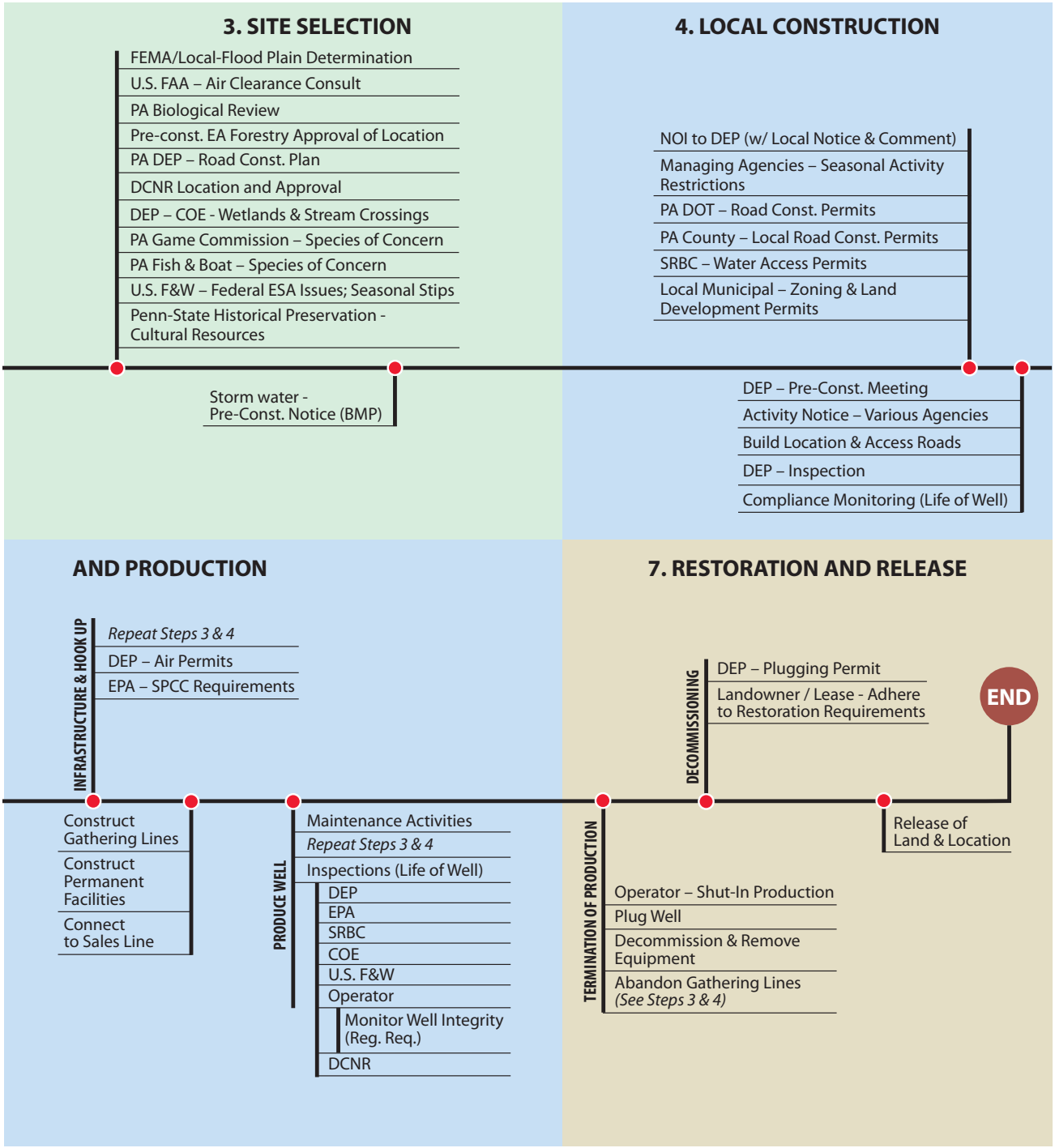
A complex regulatory framework governs operational requirements, drilling practices, land use, water use, and other environmental safeguards. These involve many agencies of the federal, state, and even local governments. Ensuring best regulatory practices means providing adequate resources for development and enforcement of regulations, ensuring that regulatory staff has the technical capabilities to make sound decisions, and creating a regulatory culture that embraces efficiency, innovation, and effectiveness. It also depends upon providing consistency of regulation and understanding the specific planning and practices required by the particular character of production and operating risks of different resource areas.

An example of the type of permitting and oversight that accompanies the development of a natural gas and oil project is illustrated in Figure ES-11. Not every development project is exactly the same, and in fact, there are significant differences between the Pennsylvania illustration and Deepwater Offshore development, as well as development on federal lands where the federal NEPA process is applied. However, the requirement for regulatory interaction at each stage of the process is common. Also, some of the state regulatory and oversight functions identified in this illustration are also delegated from federal regulatory programs. The federal programs are not highlighted on this illustration.



LEGEND:

BMP – Best Management Practice
COE – U.S. Army Corps of Engineers
DCNR – PA Dept. of Conservation & Natural Resources
DEP – PA Dept. of Environmental Protection
EA – Environmental Assessment
EPA – Environmental Protection Agency
ESA – Federal Endangered Species Act
FAA – Federal Aviation Administration
NOI – Notice of Intent
PA DOT – PA Dept. of Transportation
PNDI – PA Natural Diversity Inventory
SLO – State Lands Office
SPCC – Spill Prevention, Control & Countermeasure Plan
SRBC – Susquehanna River Basin Commission
U.S. F&W – U.S. Fish & Wildlife Service



Source: Adapted from "Governor's Marcellus Shale Advisory, Commission Report" by Jim Cawley, Lt. Governor, Commonwealth of Pennsylvania, July 22, 2011. Full Report Found at http://www.pa.gov. Also see Pennsylvania Public Records for Grugan development: Gathering Line - Permit #ESX10-035-0002, GP0518291004, GP0818291001; COP Tract 289 Pad E - Permit #ESX10-081-0076, API #37-081-20446 (Well #E-1029H); COP Tract 285 Pad C - Permit #GP0718291001, ESX10-035-0007. Additional reporting and oversight required for exceptions to permitted activity not shown.

II. CORE STRATEGIES

The NPC used the fundamental concepts of economic prosperity, environmental sustainability, energy security, and prudent development as lenses for viewing the potential of natural gas and oil as energy sources and the potential of gas to help reduce GHG emissions. In doing this, the NPC kept in mind that the United States generally relies on markets to produce efficient use of resources in the economy and on private entrepreneurs to innovate. Government policy plays an important role in helping markets function through setting the rules of the road, such as establishing the rule of law to support contracts, enforcing property rights, maintaining a regulatory regime, and through providing public goods (such as basic research and development [R&D]). Designing and implementing government policy in markets, however, should be done with care and consideration of possible unintended consequences.

As described more fully in this report, the NPC proposes a number of recommendations for adoption by governments and companies. These recommendations are organized around five core strategies:

- Support prudent natural gas and oil resource development and regulation
- Better reflect environmental impacts in markets and fuel/technology choices
- Enhance the efficient use of energy
- Enhance the regulation of markets
- Support the development of intellectual capital and a skilled workforce.

As policymakers consider the recommendations of this report and seek to create policies to implement them, they should rely to the greatest extent possible on market-based policies to provide signals and incentives to industry and consumers. These approaches have the best chance of providing cost-effective and creative solutions to responsibly meet the Nation's energy needs.

A. Support Prudent Natural Gas and Oil Resource Development and Regulation

The NPC found several key areas where more could be done to support prudent natural gas and oil resource development and regulation. Fundamental to all of these issues is that commitment to excellent environmental performance and continuous improvement must be maintained at both the leadership level of companies and throughout their organizations.

In support of these outcomes, the NPC recommends the establishment of industry-led, regionally based, "councils of excellence" for identification and dissemination of effective environment, health, and safety practices for natural gas and oil production and delivery.[37] The intention is to involve industry, government, academics, nongovernmental organizations, and other stakeholders in processes that are light on bureaucracy, dedicated to sharing technical information, and benefit from the substantive work of many existing industry and public-sector organizations such as the Society of Petroleum Engineers (SPE), the State Review of Oil and

[37] These exchanges of environmental, health, and safety practices (as well as other similar exchanges referenced elsewhere in this report) must be conducted in compliance with applicable laws and regulations, including federal and state antitrust laws.

Natural Gas Environmental Regulations (STRONGER), the Groundwater Protection Council (GWPC), the Interstate Oil and Gas Compact Commission (IOGCC), the standard-setting program of the American Petroleum Institute (API), and others[38]. Since there is lack of general information and awareness about what may be effective practices in a given region, and since companies vary in their access to the most-recent information about effective practices, such councils could address such deficiencies and provide for the more rapid dissemination of information.

Leaders in government should be committed to high-quality environmental supervision and outcomes by ensuring adequate resources for efficient and effective regulation and enforcement. Government officials should also ensure that their regulatory requirements evolve and keep pace with the development of new and highly effective practices. The NPC recommends cooperation between the councils of excellence and regulators. Community engagement needs to be a core value and fundamental practice of companies, and these councils may be ways to communicate constructive avenues to share information with communities and to listen to their concerns. Companies should also increase efforts to reduce emissions from their gas production and delivery activities. Finally, governments should structure policies to support prudent development of resources.

1. Establish Councils of Excellence for Sharing Effective Environmental, Health, and Safety Practices

Over many decades, natural gas and oil companies have made continuous and significant improvements in production processes and practices. These have resulted in energy production with lower environmental impacts. Although accidents, spills, and other problems have occurred, overall environmental protection has improved. This has occurred as companies have applied more sophisticated technologies to drilling and production practices.

In recent years, public confidence in natural gas and oil development and in some of the associated regulatory mechanisms has frayed. The tragic circumstances of the Macondo accident in the Gulf of Mexico in 2010 and community attention to real and perceived safety, water quality, and other environmental impacts of shale gas extraction in some parts of the country have heightened public awareness and concerns. In some cases, natural gas and oil production activity is increasing in populated areas and in closer proximity to residential areas.

Companies gain exposure to and adopt new technologies and operating practices in different ways and at different rates. More systematic mechanisms to identify, evaluate, and disseminate information to companies and regulators about effective environmental, health, and safety practices with a regional focus would improve information transfer. In light of the many existing organizations involved in one or another aspect of this work, the focus should be on developing mechanisms for information sharing, and not the establishment of new bureaucracies.

[38] STRONGER is a nonprofit organization whose purpose is to assist states in documenting the environmental regulations associated with the exploration, development and production of crude oil and natural gas; it uses a voluntary peer-review process of state regulatory approaches in order to share innovative techniques and environmental protection strategies, and to identify opportunities for program improvement. GWPC is a nonprofit organization whose members consist of state ground water regulatory agencies, which promote and ensure the use of best management practices and fair but effective laws regarding comprehensive ground water protection. IOGCC is a chartered multi-state government agency that promotes the conservation and efficient recovery of domestic oil and natural gas resources while protecting health, safety and the environment.

The goal would be to promote more consistently high-quality performance on environment, safety, and health issues across all companies. The concept is for the council(s) to be nimble, flexible, technically competent, and aimed at collecting and disseminating effective environmental, health and safety practices to all interested parties, rather than reinventing the wheel.

There are existing examples of mechanisms for sharing (and developing new) effective practices, including the recently formed Center for Offshore Safety under API, as well as activities by the SPE and the Petroleum Technology Transfer Council. Each has its own particular mission, structure that includes non-industry representatives, and programmatic activities with the goal of enhancing the performance of its members. Another example is the API's standards-setting organization – which is separate from API's advocacy organization and has responsibility for developing many standards and recommended practices for onshore and offshore operations through a standards-development process that encourages third-party participation.

Natural gas and oil companies should draw upon existing activities, as appropriate, and form "council(s) of excellence" that may be affiliated with or grow out of an existing organization. Their function would be to act as a centralized repository and more systematic mechanism to collect, catalog, and disseminate environmental, health, and safety standards, practices, procedures, and management systems that pertain to a region and resource play. Because development of natural gas and oil resources differs depending on factors such as the geology, water resources, geography, and land uses of the region, what constitutes effective practice may well be regionally defined. As such, there may be a need for multiple councils, each with a regional focus. The council(s) would be industry led, but should be open to companies, regulators, policymakers, NGO stakeholders, and the public. Their information would be publicly accessible to interested parties as well as government agencies. Experience in developing a first regional council (potentially in the Marcellus region) could provide insights for other subsequent councils.

A result of such council(s) of excellence should be continuous improvement by all company participants (and others, including other non-participating companies and regulators). Effective practices are not static. They must evolve with changing technology, and different effective practices will apply in different types of development areas.

There are many existing organizations that are already seeking to collect and disseminate relevant information and assist state regulators to have more effective environment, health, and safety regulatory approaches. These organizations include STRONGER, the GWPC, and the IOGCC. The proposed councils should benefit from their efforts and be useful to them as well. One of these existing multistate organizations should be considered as a possible vehicle for housing these councils.

Recommendation

The NPC makes the following recommendation **for more effective environmental performance of natural gas and oil production and delivery operations**:

- The leaders of companies set the expectations for their individual organizations and focus attention on the critical nature and importance of environmental safeguards and practices. While the leaders of many natural gas and oil companies are already committed to

excellent environmental performance and take action to ensure this at their firms, all leaders of natural gas and oil companies should commit and lead their firms to excellent environmental performance. These companies should consider more effective environmental, health and safety performance as critical success factors for their enterprises.

- Natural gas and oil companies should establish regionally focused council(s) of excellence in effective environmental, health, and safety practices. These councils should be forums in which companies could identify and disseminate effective environmental, health, and safety practices and technologies that are appropriate to the particular region. These may include operational risk management approaches, better environmental management techniques, and methods for measuring environmental performance. The governance structures, participation processes, and transparency should be designed to: promote engagement of industry and other interested parties; and enhance the credibility of a council's products and the likelihood they can be relied upon by regulators at the state and federal level.

2. Adopt Policies for More Effective Regulation of Natural Gas and Oil Production and Operations

Most regulation relating to natural gas and oil production in onshore areas occurs at the state rather than the federal level. In the 33 states where natural gas and oil resources are currently in development, state agencies establish most of the terms and conditions under which natural gas and oil production may occur. This is particularly true for mineral resources located on or under lands in private ownership. The federal government has jurisdiction over development on federal land, where federal mineral rights exist under privately owned lands, and in the offshore areas of the Outer Continental Shelf (OCS).

Within this context of natural gas and oil development on private and public lands, there are multiple and overlapping areas of regulatory jurisdiction. States are heavily involved in regulating the terms and conditions of access to and environmental impacts of resource development and extraction, while local governments often regulate land-use issues. The federal government regulates certain aspects of air pollution, water resource protection, and wastewater disposal. Where the federal government itself owns the land or mineral rights, the federal government also controls land use, terms and conditions of access and use, and many other issues.

For both state and federal regulation, it is important that regulatory requirements and oversight evolve to incorporate new technological developments and practices. This is necessary to identify new standards that may arise from the development of new science or technical information, and to keep up with the pace of industry activity.

While regulation of companies' access to and development of natural gas and oil resources exists in every state where such resources are located, states use different approaches and different standards in regulating the industry due to varying geologic, climate, environmental, institutional, and statutory factors. Over the years, the states have adopted tools to help each other do their jobs better. An example is the STRONGER organization, which provides peer reviews of state regulatory approaches. STRONGER is a nonprofit organization

comprised of environmental, state, and industry stakeholders. STRONGER's mission is to assist states by sharing innovative techniques and environmental protection strategies for exploration, development, and production of oil and natural gas. Another example is the IOGCC through which oil- and gas-producing states share information and tools to solve common problems, focus on model statutes and environmental stewardship, and acknowledge their differences.

Effective regulatory oversight should support the multiple objectives of prudent development and take into account different operating conditions for development and operations. Such oversight benefits not just the public, but also industry, by providing skilled regulatory personnel who can handle issues efficiently and effectively and keep abreast of technological developments. In addition, effective and credible regulatory oversight should take into consideration standards set by independent standards-setting organizations – and strengthen regulation consistent with evolving standards for prudent development. To achieve these goals, regulators require adequate resources, including sufficient staff, training, and technical expertise. A fee-based funding mechanism is one approach that could provide these resources in states where there are neither the resources nor adequate industry contributions to support this function, provided that such fees support the institutional mission of efficient and effective regulation and are not used solely to increase taxes for general budgetary support.

Recommendation

The NPC makes the following **recommendations for more effective regulatory programs:**

- Leaders of governments must be committed to efficient and effective oil and natural gas regulation; create organizational cultures aimed at that outcome; and ensure that their regulatory requirements evolve with improvements in scientific information, technology, and operational practices.
- State and federal agencies should seek a balance between prescriptive and performance-based regulations to encourage innovation and environmental improvements while maintaining worker and public safety.
- Federal agencies should undertake efforts to better coordinate and streamline permitting activities on federal lands and in the OCS.
- Regulators at the federal and state level should gain practical insights from the work of credible council(s) for excellence in effective environmental, safety, and health practices
- Regulators at the federal and state level should have sufficient funding to ensure adequate personnel, training, technical expertise, and effective enforcement to properly regulate natural gas and oil companies.
- STRONGER should be bolstered and increase the scope of its activities. All states with natural gas and oil production should actively participate in STRONGER and use its recommendations to continuously improve regulation. It should be adequately funded, including from the federal government.

3. Commit to Community Engagement

Every natural gas and oil company must be committed to community engagement. Even though a company may believe its environmental performance is at the highest level, maintaining transparency regarding issues is important to public stakeholders. Industry needs to explain its

production practices and environmental, safety, and health impacts in nonproprietary terms. The public should have the information necessary to have an understanding of the challenges, risks, and benefits associated with natural gas and oil production, including the cumulative impacts in a region of the development of multiple wells. Transparent reporting of comparable and reliable information can provide companies the tangible and intangible benefits of stronger relationships with communities, employees, and public interest groups. This is an essential part of earning and maintaining public trust and critical to establishing appropriate public policies and regulations.

While providing information is important, natural gas and oil companies should also work with communities and seek ways to reduce the tangible or perceived negative impacts of development. This should include predevelopment planning to identify issues such as noise and traffic and seek ways to mitigate them. Companies should ask for alternative views, and reflect stakeholders' positions in strategic objectives and communications.

One recent example of the natural gas and oil industry's community engagement is found in FracFocus, the hydraulic fracturing chemical registry website. A joint project of the GWPC and the IOGCC, FracFocus provides a place where companies can post information about the chemicals used in the hydraulic fracturing of oil and gas wells. Many natural gas and oil companies participate in FracFocus, but not all companies do so. Increasing the participation in FracFocus to all natural gas and oil companies that engage in hydraulic fracturing and adding into the system all wells currently in drilling or production would be an important step in raising the level of community engagement.

Another example is the practice of drilling multiple wells from a single pad, which can significantly reduce the truck traffic and minimize surface disturbance. Much effort is now going into innovations aimed at significantly reducing the water usage for hydraulic fracturing, and it is expected that the effects will be seen over the next few years.

Recommendation

The NPC makes the following **recommendations to increase community engagement by natural gas and oil companies and, in so doing, support prudent development practices:**

- Natural gas and oil companies should engage affected communities to establish shared understandings of expectations and awareness of issues and facts.
- Engagement should include sharing of information relevant to the community on a transparent and comparable basis.
- The industry and state and federal agencies must develop and disseminate science-based information on practices and risks to inform the public and build public confidence.
- All levels of the natural gas and oil industry should use appropriate and comprehensive predevelopment planning, risk assessment, and innovative applications of technology, which must be adapted to the variability of resource types and regional differences.
- Every natural gas and oil company that uses hydraulic fracturing should participate in FracFocus and comply with applicable state-mandated registries. The Department of the Interior should require every natural gas and oil company that uses hydraulic fracturing on federal lands to participate in FracFocus.

4. Actions to Measure and Reduce Methane Emissions

Since methane is a potent GHG, emissions should be minimized in production and delivery. The EPA Gas STAR program is a voluntary industry-government partnership that has helped to eliminate over 900 Bcf of methane emissions since 1993. However, Gas STAR lacks robust quantification protocols to document the reductions and does not fully account for reduction practices employed within the industry. Moreover, not all companies participate in Gas STAR. An enhanced Gas STAR industry-government partnership, or an alternative, could provide an improved forum to review the barriers to greater adoption of methane emission-reducing technologies, develop and fund research for a variety of new methane reduction technologies, and update processes and practices to improve emissions accounting and reductions protocols.

Compliance with the EPA mandatory reporting of GHG emissions should result in improved characterization of the emissions profile of the industry and enable identification and adoption of technologies to minimize the loss of natural gas.

Recommendation

The NPC makes the following **recommendations to reduce methane emissions**:

- Use industry-government partnerships to promote technologies, protocols, and practices to measure, estimate, report, and reduce emissions of methane in all cycles of production and delivery.
- Ensure greater adoption of these technologies and practices within all sectors of the natural gas industry, with a focus on significantly reducing methane emissions while maintaining high safety and reliability standards.

5. Other Policies to Support Prudent Development

Access to resources is a necessary condition for oil and gas development. The ability to develop subsurface areas with known or potential natural gas or oil resources often depends on decisions of owners of land and mineral rights and of policymakers. In circumstances of limited or contested access, even where there is a known natural gas or oil resource, exploration and development activities cannot be undertaken effectively. Access limitations can be explicit, such as recent moratoria applied to shale exploration and development in some areas. Limitations can occur less explicitly, resulting from ineffective or unpredictable permitting regimes, or public opposition. Recent advancements in technology and operating practices may be able to alleviate some environmental concerns that originally contributed to these access restrictions. Policy making on issues affecting access should reflect a balance of economics, energy security, and environmental protection.

In places, the term of leases can pose access problems. For example, offshore areas could make an important contribution to natural gas and oil supply over the next 20 to 30 years. Steps that could allow these areas to be considered for development, such as updated resource assessments and the development of environmental impact studies, are important to sustaining supply potential. Also, proposals that put into question the status of existing leases where drilling activity has not yet taken place (“use it or lose it”) are a threat to adequate access and resource development. It can take considerable time to develop lease exploration and drilling plans and receive requisite approvals, since drilling activity requires water and air discharge

permits and other environmental assessments. In some areas, such as the high-cost, financially risky offshore environment, 10-year lease terms are a minimum length of time for these processes and decisions to be made. Longer lease periods would be more effective in frontier areas such as the Arctic, which have shorter annual drilling windows, very limited processing and transport infrastructure, and more complex permitting procedures and environmental review processes.

A second necessary condition to enable development is predictable regulatory regimes. The public has a right to expect regulatory compliance by companies and proper government oversight. However, examples of overlapping or conflicting regulation that unreasonably impede development should be addressed. State or Canadian provincial regulations are usually more adapted to local subsurface and surface conditions, which can vary widely across regions of North America. Timely decision-making and regulatory clarity should also be objectives of government policy. Delays and "regulatory congestion" not only create uncertainty and draw out projects, but they can also negatively affect the economics of projects and add costs. Regulators should take care to ensure that they aim their regulatory processes on achieving meaningful outcomes, and minimize situations where long review periods produce diminishing returns to the public.

The third necessary condition to enable development is continued support for research and technology development. Much research and technology development is conducted by private companies, and it is important to not jeopardize this private enterprise system of innovation. However, sometimes the payoff period for such research is too long to attract private support. Therefore, private investment cannot be counted on to perform this work. In other cases, the intellectual property developed by research is better held as a public good rather than being held privately. This can occur when the benefits of the research would accrue to the United States as a whole, yet do not meet the criteria of any individual company to justify the investment.

Recommendation

The NPC makes the following **recommendations regarding other policies to support prudent development of natural gas and oil resources:**

- Policymakers on issues affecting access should reflect the balance of economic, energy security, and environmental issues, and consider technology and operational advancements that allow environmentally responsible development.
- Revise policies applicable to frontier areas with long lead times, challenging physical conditions, or new technology applications (e.g., deep offshore Gulf of Mexico and Arctic).
  - Allow the length of leases to correspond to the long development lead times necessary to allow for appropriate incentives for private-sector investments in exploration and prudent development.
  - Maintain tailored royalty relief targeted towards supporting pre-commercial investment by early adopters of new technology or entrants into new types of resources with potential for the long-term resource development.
- Congress should ensure adequate funding to EIA for the collection, analysis, and communication of data on natural gas, oil, and other elements of the energy system.

All are essential to support informed decisions by governments, private firms, and the public.

- Even as natural gas and oil companies continue to fund their own proprietary technology and other research, federal government agencies should also support the development of new technology. While different federal agencies may be appropriate homes for a range of research and technology development efforts, the DOE should lead in identifying, in some cases funding, and in other cases supporting public-private partnerships for research and development on energy and certain environmental issues of national interest (e.g., pre-commercial issues or issues where companies cannot retain intellectual property). Examples where federal involvement is needed include:
  - The environmental impact of oil spills and cleanup, including residual effects of chemical dispersants, and science-based risk assessments
  - Science and pre-commercial technology relating to methane hydrates
  - Technology and methods for understanding, quantifying, and mitigating the environmental impacts and other risks of natural gas and oil development to continue to improve the environmental performance of exploration and development activities
  - Assessments of resource base in areas currently off limits to exploration and production.

B. Better Reflect Environmental Impacts in Markets and Fuel/Technology Choices

1. Potential Policies for Internalizing the Cost of Carbon Impacts into Fuel Prices

In recent years, the substitution of natural gas for coal in electric power generation has decreased GHG emissions. Moreover, if the EPA's proposed non-GHG rules for power plants take effect, additional GHG emissions reductions are expected to occur.

In his letter asking the NPC to conduct this study, the Secretary of Energy asked the NPC to examine the contribution that natural gas could make in a transition to a lower carbon fuel mix. He did not ask the NPC to weigh in on the merits of adopting a climate policy. However, the NPC does believe that any consideration of climate policy should take into account the impacts on the national economy and competitiveness, the environment, and energy security, and be part of a global framework.

The NPC recognizes, however, that the United States, with its market-based economy, will find it difficult if not impossible to substantially further decrease its GHG emissions without introducing higher costs or regulatory controls associated with GHG emissions from development, delivery, or combustion of fossil fuels. Absent a price on carbon, energy efficiency, and those power sources with lower carbon intensity – such as renewables, nuclear, and natural gas – will tend to be undervalued as individuals, businesses, and governments make decisions. A price on carbon, implied or explicit, or similar regulatory action that prices the environmental costs of fossil fuel emissions, will help to accelerate shifts to lower carbon-intensity sources of electric power. Such policies could take the form of an explicit carbon price, such as a carbon tax, or other market mechanisms.

If policymakers were to adopt a carbon-pricing mechanism, the policy should ensure that the carbon price signal is not distorted to favor one energy source over another except with respect to carbon intensity. There should be a level playing field with regard to carbon-related attributes of energy alternatives. Designed appropriately, a carbon policy could provide the economic incentive for further improvements in energy efficiency; increased use of lower-carbon fuels such as natural gas; as well as for the development of other low- to zero-emitting technologies including renewables, nuclear, and technologies that allow for capture and sequestration of CO_2. Other policies can introduce an implied carbon price, such as through use of a performance standard, a clean energy standard (CES), or coal plant retirement incentives. If the United States were to proceed with a CES, then such a CES policy should include natural gas as a "qualified clean energy" source for both new and existing natural gas power plants. All energy resources included in a CES should be qualified on the basis of life-cycle analysis that reflects total emissions from the fuel, including production, delivery, and combustion.

A national carbon policy, incorporating the characteristics below, would help provide predictable signals for decisions about long-lived capital investments and allow for innovation and incremental steps toward a lower-carbon energy mix. Providing clarity on carbon policy would reduce regulatory uncertainty and help business investment decisions.

Recommendation

The NPC makes the following **recommendations with respect to potential policies for internalizing the cost of carbon impacts into fuel and technology choices:**

- As Congress, the Administration, and relevant agencies consider energy policies, they should recognize that the most effective and efficient method to further reduce GHG emissions would be a mechanism for putting a price on carbon emissions that is national, economy-wide, market-based, visible, predictable, transparent, applicable to all sources of emissions, and part of an effective global framework.
  - Should policymakers implement clean energy standards or other electric generation performance standards, such policies should allow natural gas to qualify as a clean energy source based on relative carbon-related emissions performance.
- Any policy should include consideration of the impacts on the national economy and industry and should provide a predictable investment climate. To minimize adverse impacts on energy security and affordability, implementation should address the need for phase-in of carbon prices and emission controls**.**

2. Policies for Keeping Options Open for Advanced Technology for CCS

Direct and indirect policies to set a price on carbon emissions from fossil fuel combustion and delivery would value natural gas' ability to provide energy with lower GHG emissions than other fossil fuels. However, if very deep reductions in GHG emissions are desired over the long run, fossil fuels, including natural gas, could play only a limited role in providing energy unless there is a means to capture and sequester the CO_2 emissions from burning fossil fuels. CCS could provide such a means.

Currently, CCS research is focused on coal-fired power production. However, all fossil fuels, including natural gas, would benefit from CCS; thus, CCS research, development, and

demonstration should be fuel neutral and include options that allow for potential applications in and out of the power sector. Therefore, CCS research and development funding should include natural gas. The petroleum refining and natural gas processing industries have been separating CO_2 from gas streams for decades and have invested significant research in developing technologies for making this separation. Even so, separating CO_2 remains expensive. Additional research might lower this cost. There is also a need for further research on aspects of long-term geological storage.

CO_2 separation from flue gas on the scale of a large electric power plant has not been demonstrated to date. Full-scale demonstration projects would provide the opportunity to learn how current CCS technologies might work on a large scale. Several demonstration projects are underway and more have been proposed. CCS demonstration projects will require government support in the near term, since they will be uneconomic without a significant price on carbon.

A way to reduce the cost of research and development of CCS is to combine it with commercial opportunities for using captured CO_2. Enhanced oil recovery is a technique currently in use for increasing the amount of oil that can be extracted from an oil field. When CO_2 is injected into certain types of oil fields for EOR, the CO_2 enhances oil mobility and can increase recovery from a reservoir. This use of CO_2 in EOR can be a method of geologic sequestration and it can provide first movers with repositories for scaled-up capture projects. CO_2 EOR production has been increasing for the last two decades and now amounts to about 10% of onshore conventional oil volumes.

There are various mechanisms to support funding for research, development, and demonstration programs, and policymakers should consider innovative methods to address support for CCS research and development. In addition, the need to "develop the legal and regulatory framework to enable CCS" remains as important today as it was when *Hard Truths* was published in 2007. These include policies that provide for a clear transfer of long-term responsibility for closed storage sites, after appropriate site integrity verification, to a government or other public entity for long-term management.

Recommendation

To keep the option open in the long run of using natural gas in a situation where deeper reductions in GHG emissions are desired or necessary, the NPC makes the following **recommendations regarding advanced technology for CCS:**

- The federal government should work with the states, universities, and companies in the electric, oil and gas, chemical, and manufacturing sectors to:
  - Fund basic and applied research efforts on CCS such as the cost of carbon capture, geologic issues, and the separation of CO_2 from combusted gases
  - Develop some number of full-scale CCS demonstration projects on a range of technologies and applications
  - Establish a legal and regulatory framework that is conducive to CCS
  - Find mechanisms to support the use of anthropogenic CO_2 without raising its cost to users in appropriate EOR applications
  - Strive to be fuel, technology and sector neutral, and include a range of geologic storage options.

3. Policies for Providing Information about Environmental Footprints and Full Fuel Cycle Impacts

All energy choices involve trade-offs of one form or another. Environmental footprint analyses incorporate the impacts that energy choices have on a variety of impact measures, including water and air quality, land and water resource use, human health, and wildlife health. Such footprint analyses provide a method for comparing the impacts of energy resources on different environmental outcomes. For example, a well-constructed footprint analysis would compare on a common basis the water use or land use associated with extraction of one energy resource such as shale gas development, with other energy resources such as coal or biofuels. In that example, water use could be measured in terms of energy content of the fuel or in terms of each fuel's ability to power a common unit of electricity.

In theory, an environmental footprint analysis is an objective, science-based assessment of the potential positive and negative impacts of each energy source. In practice, however, environmental footprint analyses are in early stages of development, with analyses exhibiting different techniques for measuring impacts and widely varying assumptions that often end up producing apples-to-oranges comparisons across fuels and energy resources. There are technical issues such as incomplete data and the lack of consensus around quantification of impacts and risks. This latter fact complicates the ability of this potentially important technique to provide policymakers with useful information to evaluate the relative importance of the different impacts. Moreover, the different resource types for the same fuel may have different impacts, such as with shale gas versus conventional gas. Environmental footprint results, however, are not intended to be a rationale for not mitigating the impacts of any fuel.

Policymakers should refine their understanding of the life-cycle and environmental footprint of energy sources including natural gas and oil, as part of providing a high-quality information base for making decisions about energy choices that reflect the different nature and intensity of impacts. Information from environmental footprint analyses could be incorporated into analyses used in making investment and purchasing decisions by consumers, producers, and state and federal governments.

Recommendation

The NPC makes the following **recommendations on environmental footprint analyses to enhance the evaluation of the environmental impact of energy resource choices:**

- The federal government should support the development of consistent methodologies for assessing environmental footprint effects such as impacts on water and land.
- As sound methodologies are established and vetted, regulators and other policymakers should use environmental footprint analyses to inform regulatory decisions and in implementing other policies where energy resource choices involve economic and environmental trade-offs.

In contrast to environmental footprint analysis, a full fuel cycle (FFC) analysis is a tool that can help inform choices about end-use technologies, such as a natural gas versus an electric water heater. Such FFC analysis incorporates information about both the impacts (e.g., CO_2 emissions) of energy consumption at the point of ultimate consumption, as well as those impacts

attributable to the energy consumed or vented as part of the fuel extraction, processing, and transportation. FFC can also account for impacts associated with energy losses from thermal combustion in power-generation plants and energy losses in transmission and distribution to homes and commercial buildings.

FFC analysis could inform energy-related policies at different levels and branches of government. FFC and footprint analyses are particularly useful in understanding the complete impact of energy-related decisions on total energy consumed and total emissions, especially when comparing two or more fuel options to achieve the same end-use result. FFC analysis could be applied in various decision-making settings, such as: development and implementation of appliance and building energy efficiency standards; comparisons of different technology choices such as a natural gas water heater to an electric water heater; home energy rating systems (HERS) index; and decisions about whether to approve power plant applications.

Continued development of FFC methodologies used to assess environmental benefits and costs of energy supplies would be instructive to policymakers, consumers, and the industry alike.

Recommendation

The NPC makes the following **recommendations for full fuel cycle analyses to enhance the evaluation of the environmental impact of energy choices**:

- The federal government should complete development of and adopt consistent methodologies for assessing full fuel cycle effects.
- As sound methodologies are established, regulators and other policymakers should use full fuel cycle analyses to inform regulatory decisions and implementation of other policies where fuel and technology choices involve energy and environmental trade-offs.

C. Enhance the Efficient Use of Energy

Given the importance of energy efficiency and the continuing availability of untapped economical efficiency opportunities, the NPC finds that stronger action is still needed:

- To enhance efficiency of energy use in buildings and appliances, through:
  - Continued progress to adopt stronger efficiency standards for buildings and appliances
  - Regulatory changes to remove the disincentives for natural gas utilities and electric utilities to deploy energy efficiency measures.
- To eliminate barriers to combined heat and power as a way to increase the efficiency of electricity production.

1. Enhance Efficiency of Energy Use in Buildings and Appliances

a. Building and Appliance Efficiency Standards

Buildings constitute a major source of demand for power, space heating and cooling, and lighting. In many situations, avoiding energy consumption through installation of more efficient

appliances or changes to the building shell can be the most cost-effective strategy for satisfying customers' energy needs. Compared to implementing energy efficiency, all other energy resources and technologies involve trade-offs among economic, environmental, and energy security objectives.

The 2007 NPC *Hard Truths* report identified many energy efficiency policy options, most of which are still applicable today. Implementing energy-efficient technologies can reduce the need to produce, deliver, and transform energy, thus avoiding emissions and resource use, mitigating environmental and health impacts, saving consumers money, and enhancing energy security. For instance, if the United States used energy at 1973 efficiency levels in all sectors of the economy, about 56% more energy would be consumed today – equal to another 52 quadrillion Btu that otherwise would have had to be extracted, delivered, combusted, or otherwise harnessed to produce usable energy for consumers' needs. Increasing energy efficiency can thus provide long-term benefits.

Significant energy savings have been achieved in the United States through building codes and appliance and equipment standards. Building codes are administered by the 50 states and by thousands of local authorities. To help state and local governments, the federal government can further support development and periodic update of national model energy codes, allowing and encouraging states to adopt the most recent of such codes.[39] These model codes are typically updated on a three-year schedule. The federal government can also provide technical assistance, training, and other measures to improve state and local ability to enact and enforce codes.

While building codes typically apply only to new structures or major renovations, appliance standards can reduce energy consumption in existing buildings. Efficient new appliances in the residential and commercial sectors could reduce energy consumption and, in turn, GHG emissions from these sectors by 12% and 7%, respectively. FFC analysis could provide the basis for these appliance standards.[40]

Recommendation

The NPC makes the following **recommendations to support the adoption of energy efficiency in buildings and appliances:**

- The federal government should continue to support the updating of national model building codes issued by existing institutions and to provide technical assistance, training, and other support for state and local enactment and enforcement of the updated codes.
- The federal government should continue to update energy efficiency standards for appliances and equipment over which it has statutory authority.

[39] The International Energy Conservation Code (IECC) issued by the International Code Council (ICC) develops national model energy codes for residential buildings. The American National Standards Institute (ANSI), the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), and the Illuminating Engineering Society of North America (IESNA) Standard 90.1 are national model energy codes for commercial buildings.

[40] See Chapter Four.

- Federal and state governments should consider incentives for products and buildings that are more efficient than required by laws and standards, such as Energy Star qualifying products.
- State and local governments should adopt programs to support cost-effective energy efficiency in buildings.

b. Utility Regulatory Policies to Support Greater Cost-Effective Energy Efficiency

Gas and electric utilities are natural entities to provide some types of energy efficiency programs, such as installing weather-proofing or distributing appliance rebates, because those utilities have information about the consumption patterns of their customers, have an ongoing relationship with them, and often have the expertise to implement energy efficiency programs. Moreover, treating energy efficiency as a resource in their portfolio of supply options can help utilities deliver supply for their customers at lower overall costs.

Under traditional ratemaking policies, however, utilities that sell electric power or natural gas to end-use consumers have the incentive to sell more of their product to consumers once rates have been set: higher sales means higher revenues and lower sales means just the opposite. To overcome this disincentive, ratemaking policies should align the financial interests of both electric and gas utilities with those of their customers in providing cost-effective energy efficiency measures.

Recommendation

The NPC makes the following **recommendation to remove the disincentives for natural gas utilities and electric utilities to deploy energy efficiency measures**:

- State and federal utility regulators should adopt for utilities:
  - Ratemaking policies to align utility financial incentives with the adoption of cost-effective energy efficiency measures
  - Goals and targets for the deployment of cost-effective energy efficiency so as to support the adoption of cost-effective energy efficiency measures on a timely basis.

2. Remove Barriers to Combined Heat and Power to Increase the Efficiency of Electricity Production

Another opportunity for energy savings comes from combined heat and power (CHP) facilities. Such facilities can function within industrial plants such as paper mills or chemical plants. CHP can also be found in large institutions such as universities or hospitals. These facilities produce steam for industrial purposes or heating and produce electricity as a secondary product for their own consumption or for sale. CHP can operate at nearly 70% energy-efficiency rates versus about 32% for base-load coal plants. Today CHP accounts for almost 9% of total electricity produced.

Greater use of CHP can provide a significant opportunity to lower energy costs and thus improve the competitiveness of manufacturing, while providing larger societal benefits such as

improving overall efficiency of power generation, lowering emissions, increasing reliability of the electric grid, and reducing transmission losses. CHP's power can be used internally or sold to the electricity grid.

In many areas, regulatory barriers prevent otherwise economic investments in CHP. These barriers include rules relating to interconnecting CHP facilities to the grid, policies limiting the sale of CHP power to the market, problems with pricing, and the ability to enter into long-term contracts for the power output from CHP. Greater flexibility, for instance, is needed to allow manufacturing facilities to sell power to one another, or in regulated states to wheel power from one facility to another. Additionally, typical environmental regulations also measure emissions of power combustion as a function of heat input (e.g., emissions per Btu consumed) rather than emissions associated with output (e.g., emissions per kilowatt-hour of output). This regulatory design disadvantages CHP units and other more-efficient technologies. Higher efficiency generally means lower fuel consumption and lower emissions of all pollutants.

Recommendation

The NPC makes the following **recommendations to eliminate the barriers to CHP and thus increase the efficiency of electricity production in the United States**:

- State and federal utility regulators should adopt policies for both natural gas and electric utilities that remove barriers to CHP in interconnection, power sales, and power transfers.
- Policymakers should include CHP and energy efficiency in any clean energy standard.
- The EPA should use output-based performance standards for emissions from power generation, including CHP, as a means to reflect inherent energy efficiency differences in power generation technologies.

D. Enhance the Regulation of Markets

In large part, the U.S. economy relies on open markets for goods and services that are influenced by government policy and regulation. Government regulation creates the rules of the road for markets. Accordingly, the design and implementation of regulations matter to accomplish desired results without introducing needless restrictions or costs. In this study, the NPC found three areas where changes to government regulation would enhance the functioning of energy markets and promote the goals of prudent development of natural gas and oil resources, and national economic prosperity, environmental sustainability, and energy security. These areas for improved regulation are:

- Mechanisms for utilities to manage the impacts of price volatility
- Harmonization of market rules and service arrangements between the wholesale natural gas and wholesale electric markets
- Environmental regulatory certainty affecting investments and fuel choices in the power sector.

1. Mechanisms for Utilities to Manage the Impacts of Price Volatility

Crude oil and natural gas price volatility poses a challenge to the natural gas and oil industry and the consumers of its products. Volatility is a measure of the pace and magnitude of price changes. Price changes send signals to consumers and producers that lead them to adapt their behavior to match market conditions. Consumers tend to consume more when prices are lower and less when prices rise. Higher prices tend to encourage the development of additional supply, while lower prices tend to discourage additional supply. Well-functioning and transparent commodities futures markets provide producers and consumers of crude oil and natural gas the ability to mitigate price volatility.

North American natural gas markets, with vast domestic supplies, have been relatively insulated from global supply and demand shocks. Despite this, there have still been fluctuations in U.S. natural gas prices due to supply and demand imbalances, especially in the past decade. The recent development of unconventional natural gas resources, however, is dramatically increasing supply relative to demand and dampening the expectation of future price volatility. Moreover, other factors provide further dampening on the potential for natural gas price volatility. First, substantial investments in LNG import capacity made over the past decade could now serve almost one-third of annual U.S. demand. Second, new investments have been made in natural gas storage. Third, some states use demand response and energy efficiency in order to manage price volatility.

Natural gas prices are currently low in comparison to recent history, making gas-fired generation attractive relative to coal in some situations. One form of risk faced by builders of new natural gas-fired power plants is the perception that natural gas prices are more volatile than the prices of competing fuels such as coal. This perception is grounded in historical experience when utilities made investments in (or purchases of power from) natural gas-fired power generation technologies only to have the prices unexpectedly rise. The price increases created difficulties, as these costs needed to be allocated between producers and consumers in states with traditionally regulated electric utilities and natural gas utilities. Some regulators and electric utilities may fear another spike in prices, and be reluctant to engage in another era of gas-fired power generation investments. Also, in many states, the regulatory legacy resulting from out-of-market, take-or-pay contracts from several decades ago creates regulatory risk and a barrier for electric and gas utilities, if they were to enter into long-term contracts for natural gas and then gas prices change in ways that introduce questions about the prudency of those original contract decisions. Even where various contract instruments were used more recently for price hedging purposes, some utilities have been subject to hindsight review by state utility commissions and more recently have had to refund some hedging costs to ratepayers. These experiences with regulatory risk have made investment in gas-fired generation less attractive for utilities.

Recommendation

The NPC makes the following **recommendations to allow natural gas utilities and electric power utilities to manage their natural gas price risk:**

- The NPC supports changes in regulatory policy that remove regulatory barriers from utilities managing their natural gas investment portfolios using appropriate hedging approaches, including long-term contracts. Any such rules should not impede the ability of utilities to appropriately hedge their price risk.

- Regulators (such as state utility commissions) and other policymakers should allow market participants such as utilities to use mechanisms to mitigate and manage the impacts of price volatility. These mechanisms include long-term contracts for natural gas, use of hedging instruments by regulated entities like utilities, and investment in storage facilities.

2. Harmonization of Market Rules and Service Arrangements between the Wholesale Natural Gas and Wholesale Electric Markets

From 2000 to 2010, the use of natural gas for power generation has increased from 16% to 24% of total electric sector generation. In terms of fuel use, the power sector's use of natural gas grew from 14 to 20 Bcf/d (rising from 22% to 31% of total gas demand). Natural gas use for power generation is expected to increase further in the future, in light of three factors:

- A change in expectations about North American natural gas supply and costs due to the economic viability of shale gas development. Concerns about high and volatile natural gas prices, flat production, and increasing LNG imports have changed to forecasts of lower and more stable natural gas prices and abundant North American natural gas supplies that could meet almost any natural gas demand requirement.[41]
- An expectation of strong growth in intermittent renewable generation capacity that increasingly requires backup by gas-fired generation to stabilize grid operations.
- An expectation of substantial retirements of coal-fired generation in the next few years as a consequence of implementation of EPA's proposed non-GHG regulations, combined with lower gas price expectations.

Further growth in natural gas use for power generation, however, should not be taken for granted. The increased use of natural gas for electricity production, especially during peak periods in regional gas and electric markets, is raising concerns about potential operational problems for both pipeline operators and power generators. Some power generators have identified some terms and conditions of natural gas services that are inhibiting them from building and operating gas-fired generation plants.[42] Conversely, some pipelines have stated that they are not being adequately compensated for providing service to gas-fired generators that are backstopping intermittent renewables.[43] Accordingly, federal and state regulators and industry leaders are calling for more formalized coordination between the electric and gas sectors.

This will not be an easy task. Both the natural gas pipeline network and the electric transmission grid operate under different complex systems of rules and regulations that have evolved independently over decades. For example, the natural gas industry uses a standardized definition of an operating day, but the power sector has multiple definitions of operating days.

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[41] See, for example, EIA, 2011 Annual Energy Outlook, Reference Case wellhead price forecast for 2030 declined from $7.80 (2007$) per MMBtu for the 2009 Reference Case to $5.66 (2009$) for the 2011 Reference Case.

[42] See Chapter Three for a more complete discussion of issues relating to the interaction of natural gas and electric wholesale markets.

[43] INGAA Foundation, *Firming Renewable Electric Power Generators: Opportunities and Challenges for Natural Gas Pipelines*, March 2011.

The scheduling rules and timelines for power generators (e.g., for day-ahead and real time markets) may not synchronize between electric control areas or with pipeline capacity nomination schedules or rights. Gas-fired generators not holding firm pipeline transportation frequently have to commit power to the regional electricity grid before they have the assurance of pipeline capacity. With the prospects that natural gas will become an even larger supply source for power generation, and with the increasing need for natural gas generation to backstop intermittent renewable generation, coordinating these respective operating and regulatory systems will become increasingly complicated.

As natural gas and electric markets become more entwined, greater coordination between the two will be required. One way to enhance this coordination and to minimize surprises is to increase the transparency of operations. The Federal Energy Regulatory Commission has done this for natural gas markets by requiring interstate pipelines to post on the web extensive data on their operations. Increasing the information about generation and transmission operations would increase transparency and would benefit the smooth functioning of the market.

Another interdependency issue that needs to be addressed is the recovery of costs incurred by pipelines in providing service to gas-fired generators and, in turn, the recovery of those costs by gas-fired generators from electric customers. The diversity of various organized and non-organized wholesale power markets requires different approaches.

Finally, there is an expectation that any retirement-related reduction in coal-fired generation can be met, to some extent, by existing gas-fired generation. However, none of the retirement studies examined whether there were any electric transmission bottlenecks to doing so.

Recommendation

The NPC **recommends continuing the efforts to harmonize the interaction between the natural gas and electric markets**:

- The Federal Energy Regulatory Commission, the North American Electric Reliability Corporation, the North American Energy Standards Board, the National Association of Regulatory Utility Commissioners, and each formal wholesale market operated by the Regional Transmission Organizations should undertake, with robust participation from market participants, to:
  - Develop policies, regulations, and standardized business practices that improve the coordinated operations of the two industries and reduce barriers that hamper the operation of a well- functioning market
  - Increase the transparency of wholesale electric power and natural gas markets
  - Address the issue of what natural gas services generators should hold, including firm transport and storage, and what services pipeline and storage operators should provide to meet the requirements of electricity generators as well as compensation for such services for pipeline and storage operators and generators
- Transmission operators should identify any transmission bottlenecks or power market rules that limit the ability of natural gas combined-cycle plants to replace coal-fired generation.

3. Environmental Regulatory Certainty Affecting the Power Sector

The EPA is in the process of finalizing a number of regulations that will affect the power sector over the next several years. These include the Clean Air Transport Rule (now finalized and called the Cross-State Air Pollution Rule); the proposed Air Toxics rule (also known as the "Maximum Achievable Control Technology" rule); and proposed regulations regarding cooling water intake structures (the "316(b) Rule" under the Clean Water Act); and coal combustion byproducts (coal ash). Compliance costs associated with these regulations may contribute to some power plant owners' decisions to retire some coal-fired power plants rather than retrofit them to comply with the new environmental rules. There is debate in the industry with respect to costs, benefits, and effects on reliability.

Economics suggest that natural gas generation will be a likely source of power to replace generation from retired coal units. According to studies reviewed by the NPC, the estimated amount of coal-fired capacity that will retire through 2020 ranges from 12 GW to 101 GW of capacity. Based on the study average of 58 GW, this represents about 6% of total U.S. generating capacity, or around 18% of coal-fired capacity. If this amount of coal-fired generation is replaced by gas-fired generation as a result of these regulations, there could be a decrease in power sector CO_2 emissions of 11% of total emissions by 2020. Other impacts would include lower electric power sector emissions of sulfur dioxide, nitrogen oxides, and mercury, with reductions of 19%, 16%, and 12%, respectively, below 2005 levels.

Current uncertainty regarding the timing and content of some of the pending EPA regulations contributes to some power plant owners and operators waiting to make decisions on affected power plants and on alternatives in the marketplace. These decisions may include whether and when to retire aging coal-fired power plants, as well as whether and when to build other generation types, including natural gas generation. Increasing the certainty with respect to the timing of new regulations would support timely investment decisions affecting an important amount of power generation capacity and regarding impacts on fuel markets. Resolution of the EPA rules, as well as compliance timelines and implementation decisions affecting individual plants, must take into consideration reliability impacts, recognizing that there are a variety of tools available to address location-specific reliability issues.

Recommendation

The NPC makes the following **recommendation to provide more regulatory certainty to the power sector:**

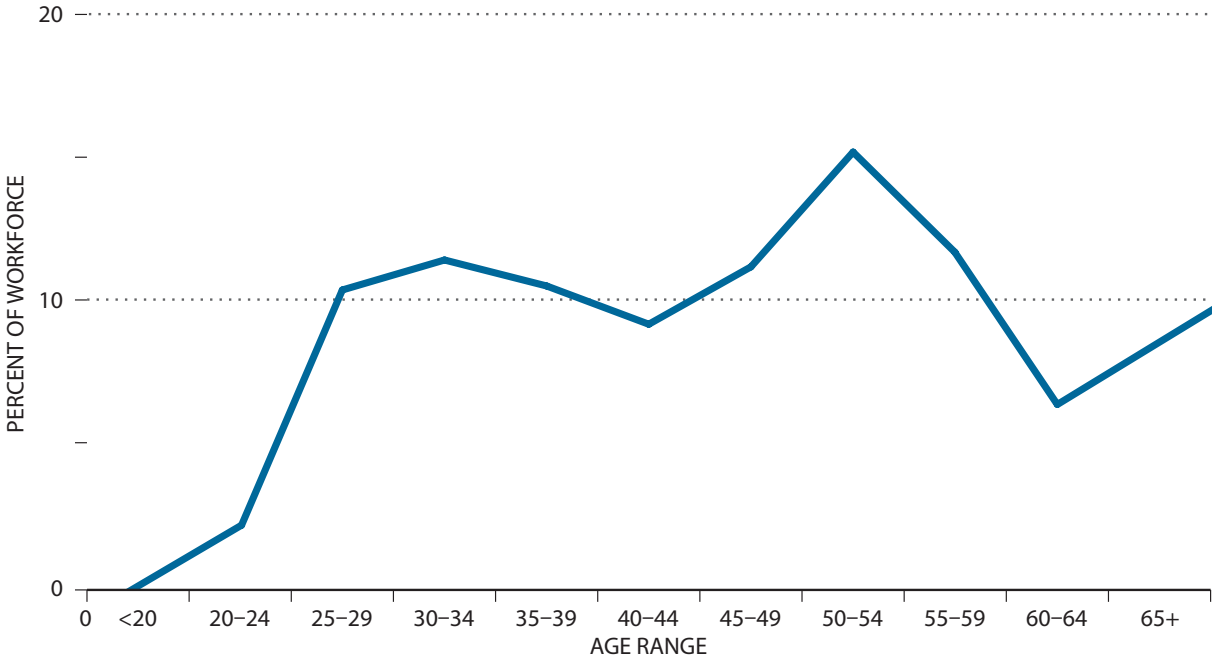
- Policymakers should take into account the benefits for market conditions from the finalization of EPA regulations affecting the power sector, especially those regulations not related to controlling GHG emissions. These benefits include reduced uncertainty in the market and provision of near-term investment signals, as well as the reduction of emissions of sulfur dioxide, nitrogen oxide, mercury, and particulates, along with collateral reductions of GHG emissions from power generation.

E. Support the Development of Intellectual Capital and a Skilled Workforce

Compared to other industries, the workforce in the natural gas and oil industry and the agencies that regulate them has an older average age. A large gap exists between the number of

retiring technical professionals and the number of graduates coming out of junior college, college, and graduate school with the knowledge and skills required to work in the industry. Figure ES-12 illustrates this for one segment. This leads to potential workforce challenges for the industry and its regulators.

Figure ES-12.
More Petroleum Engineers are Approaching Retirement (2010)



Source: Society of Petroleum Engineers.

Part of this is pure demographics, as the baby boomer generation has begun to retire from the workforce. But there also is not enough industry activity on university campuses. Moreover, government study grants to undergraduate and graduate-level engineering and geosciences projects often do not relate to the natural gas and oil industry. Despite a recent uptick in enrollments in petroleum engineering and natural gas and oil-focused geosciences programs, the prospective graduates will not have the experience or the raw numbers to replace the number of retiring, well-seasoned professionals.

Increased support for new faculty positions and research programs could address this problem at various levels of higher education: in community colleges, universities, graduate programs, faculty appointments, and in various fields (in the geosciences, in addition to other areas of earth sciences, engineering, below-surface-water hydrology, and environmental programs). In addition, there is evidence that support at the K-12 (kindergarten to 12th grade level) would also be helpful.[44] Because science literacy is important for public understanding of energy issues, energy science should be included in curricula at these levels.

[44] See, for example: National Academy of Sciences, *Rising Above the Gathering Storm, Revisited*, 2011.

Recommendation

The NPC makes the following **recommendations to increase the number of qualified natural gas and oil professionals:**

- Natural gas and oil companies should review and consider increasing their financial support for educational/training activities to support the development of the next generation of professionals with knowledge and skills in the fields necessary for prudent development of the nation's natural gas and oil resource base.
- Congress should provide financial support for higher-education programs, including faculty positions and research programs in areas of national interest related to energy resources.

The NPC also supports the recommendations of the National Academy of Sciences' *Rising Above the Gathering Storm* with respect to the need to "move the United States' K-12 education system in science and mathematics to a leading position by global standards."

III. CONCLUSIONS

The NPC reiterates the important findings of this study: The North American natural gas resource base is very large indeed, a size that has only become apparent over the last half decade. Natural gas plays a critical role in supplying a quarter of the United States' energy and what is likely to be a growing share of electric generation, including enabling renewable energy. Similarly, the oil resources are also very large, with major opportunities for development. The U.S. needs these resources to reduce oil imports even after continued efforts to improve energy efficiency, and even as the nation transitions to a lower-carbon energy system. Realizing the benefits of these natural gas and oil resources requires environmentally responsible development of them in all circumstances, continually taking advantage of new technologies and evolving effective practices. That is the route forward for advancing America's economic, environmental, and energy security objectives.