NATIONAL PETROLEUM COUNCIL

Dynamic Delivery

America's Evolving Oil and Natural Gas Transportation Infrastructure

Summary Report

December 12, 2019

This is a working document as approved by the National Petroleum Council on December 12, 2019. This document is subject to final editing and preparation of graphics for publication.

National Petroleum Council

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

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December 12, 2019

The Honorable Dan R. Brouillette
Secretary of Energy
Washington, DC 20589

Dear Mr. Secretary,

In response to Secretary Perry's September 21, 2017 request, the National Petroleum Council conducted a comprehensive study analyzing the changing dynamics of U.S. oil and natural gas transportation infrastructure. The U.S. energy landscape has undergone dramatic changes in the past decade. Of particular note—the United States has recently become the largest oil and natural gas producing country in the world and since 2008 the United States has transitioned from net importing the majority of the petroleum it consumes to rapidly approaching self-sufficiency, and from being a net importer of natural gas to a net exporter. America's vast energy resources and infrastructure to deliver them to market are vital to the nation's energy security. In 2015, U.S. oil and natural gas operations and capital investments directly and indirectly generated $1.3 trillion of value added to the national economy, accounting for 7.6% of U.S. gross domestic product and 10.3 million American jobs.

The Council found that even in energy scenarios designed to meet climate change targets, the largest energy sources will continue to be oil and natural gas through at least 2040. The nation faces the dual challenge of providing affordable energy to support economic growth and human prosperity while addressing the environmental effects of that development, including the risks of climate change. The United States has a vast oil and natural gas infrastructure network, but existing infrastructure has been modified and adapted to near maximum capacity. To connect America's abundant energy supplies with domestic and global demand, significant public and private investment in new and existing pipelines, ports, rail facilities, and inland waterways will be essential.

The permitting and construction of numerous energy infrastructure projects have been challenged, delayed, or stopped as a result of litigation by stakeholders concerned about climate change and the associated policy debate. The public's concern about climate change is a serious issue that must be addressed and litigation of individual projects to address climate concerns is an ineffective approach. The Council makes several recommendations to overcome these challenges, including clarifying greenhouse gas assessments under the National Environmental Policy Act and enacting a comprehensive national policy to reduce greenhouse gas emissions.

The Council found that several critical infrastructure bottlenecks exist, such as natural gas pipeline access to New England/New York, channel capacity in the port of Houston, and insufficient oil and natural gas export capability. Congress should fully appropriate the revenue coming into the Harbor Maintenance Trust Fund and ensure those funds are used to properly maintain waterways.

Overlapping and duplicative regulatory requirements, inconsistencies across multiple federal and state agencies, and unnecessarily lengthy administrative procedures have created a complex and unpredictable permitting process. While there have been bipartisan actions by Congress and the Executive Branch to expedite the permitting process, more improvements are necessary. The Council recommends that states be incentivized to participate in permitting reform efforts and adopt a single point of contact for permit coordination. Industry should collaborate with state organizations to develop a master model structure for state permitting. The Council also makes several recommendations for the U.S. Army Corps of Engineers, including recommendations to provide procedural consistency among nationwide permit programs, improve the efficiency of the Corps' regulatory process, and create consistent approaches to permit interpretation among the Corps' field offices.

The Council also found that crude oil, petroleum products, and natural gas moved by the nation's infrastructure reach their destinations with a high degree of safety, resiliency, and environmental performance. Advancements in new technologies have been an important contributor to this performance. The Council found that cyber threats to energy infrastructure control systems are increasing and security protections are being challenged due to increasing connectivity and growing malicious cyber activity.

The Council makes recommendations to address these issues in the following areas:

- Increase the efficiency, effectiveness, and predictability of permitting processes for siting, construction, operation, and maintenance of infrastructure projects
- Enhance recent regulatory reform efforts
- Improve stakeholder engagement
- Promote economic development of oil and natural gas resources to provide societal benefits
- Promote more rapid development and implementation of technology to increase transportation safety and integrity
- Demonstrate excellent industry safety and environmental performance.

The attached report, *Dynamic Delivery – America's Evolving Oil and Natural Gas Transportation Infrastructure,* provides additional detail and recommendations. The Council looks forward to sharing this study with you, your colleagues and broader government and public audiences.

Respectfully submitted,

Greg L. Armstrong, Chair
National Petroleum Council

Attachment

REPORT OUTLINE

Appendices

Preface

I. NATIONAL PETROLEUM COUNCIL

The National Petroleum Council (NPC) is an organization whose sole purpose is to provide advice to the federal government. At President 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 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 supplies that fueled the Allied victory. President Truman's goal was to continue the 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.

Council members, about 200 in number, 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 American nations, 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.

II. STUDY REQUEST AND OBJECTIVES

By letter dated September 21, 2017, Secretary of Energy Rick Perry requested that the National Petroleum Council conduct a study analyzing the changing dynamics of U.S. oil and natural gas transportation infrastructure. This request was referred to the Agenda Committee for review and recommendation as to whether the study should be undertaken by the Council. The Agenda Committee recommended, and the Council agreed to undertake, a study on U.S. Oil and Natural Gas Transportation Infrastructure.

In the Transportation Infrastructure study request, Secretary Perry asked the Council to conduct a study that would explain the extent of the transportation infrastructure today and the United States' infrastructure needs under varying demand assumptions. The study should include a review of any constraints to growing domestic oil and natural gas production caused by infrastructure limitations that reduce domestic demand or energy exports. In addition, the study should evaluate technology and policy options for improving infrastructure siting and related permitting processes, which in turn could improve safety, environmental performance, and resilience of the system.

The Secretary posed the following questions to consider in the study:

- What are the important changes in future supply and demand patterns, and what transportation infrastructure improvements are required to leverage the regional and national opportunities offered by these changes?
- What advances in technology could improve the U.S. oil and natural gas transportation system, in terms of safety, reliability, efficiency, and environmental performance? In what new technology areas should research be progressed?
- How can state and federal governments leverage efforts to support U.S. petroleum and natural gas supply and transportation infrastructure capacity improvements?
- Are there regulatory requirements or policies that may be causing unintended consequences on energy system resilience? If so, what solutions can accomplish the regulatory objective more effectively?
- What emerging issues should policy makers be aware of and what actions should be considered to address these issues?

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

III. STUDY ORGANIZATION

In response to the Secretary's request, the Council established a Committee on U.S. Oil and Natural Gas Transportation Infrastructure to study this topic and to supervise the preparation of a draft report for the Council's consideration. The Committee was led by a Steering Committee that consisted of the Committee's Chair, Government Cochair, and seven members representing a cross section of the Committee. A Coordinating Subcommittee and four analytical Task Groups were also established to assist the Committee in conducting the study. The study organization and leadership are shown in Figure P-1. These study groups were aided by multiple study teams focused on specific subject areas and supplemented by outreach sessions focused on important stakeholder groups.

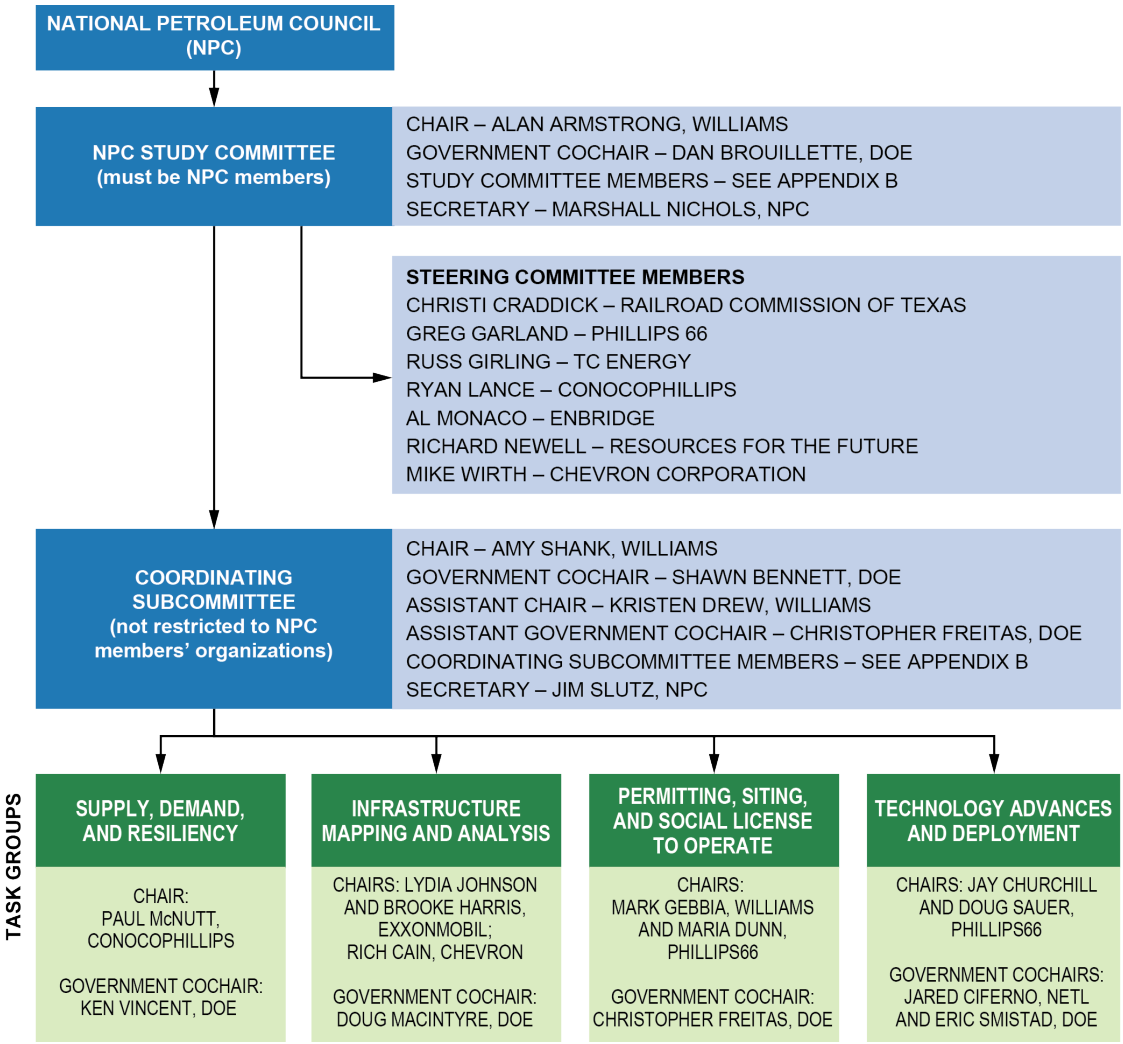

Figure P-1. Infrastructure Study Organization

The members of the various groups were drawn from NPC members' organizations as well as from many other industries, state and federal government agencies, Native American Tribes, nongovernmental organizations (NGOs), other public interest groups, consultancies, and academia. More than 306 people served on the study's Committee, Subcommittee, and Task Groups or participated in outreach sessions and workshops. While all have relevant expertise for the study, approximately 44% do not work for oil and natural gas companies or within the oil and natural gas value chain. This broad support and input into the study process is a critical component of the study. Appendix B contains rosters of the study groups and Figure P-2 depicts the diversity of participation in the study process. In addition to these study group participants, many more individuals representing communities such as Native American Tribes, environmental groups, conservation groups, and agriculture representatives were involved through outreach activities. These efforts were an integral part of the study, with the goal of informing and seeking input from a 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 a participant's or their organization's endorsement or agreement with all statements, findings, or recommendations in this report. Additionally, while U.S. government participants provided significant assistance in the identification and compilation of data and other information, they did not take positions on the study's recommendations. As a federally appointed and chartered advisory committee, the NPC is solely responsible for the final advice provided to the Secretary of Energy. However, the Council believes that the broad and diverse study group and outreach participation has informed and enhanced its study and advice. The Council is truly appreciative of the commitment and contributions from all who participated in the process.

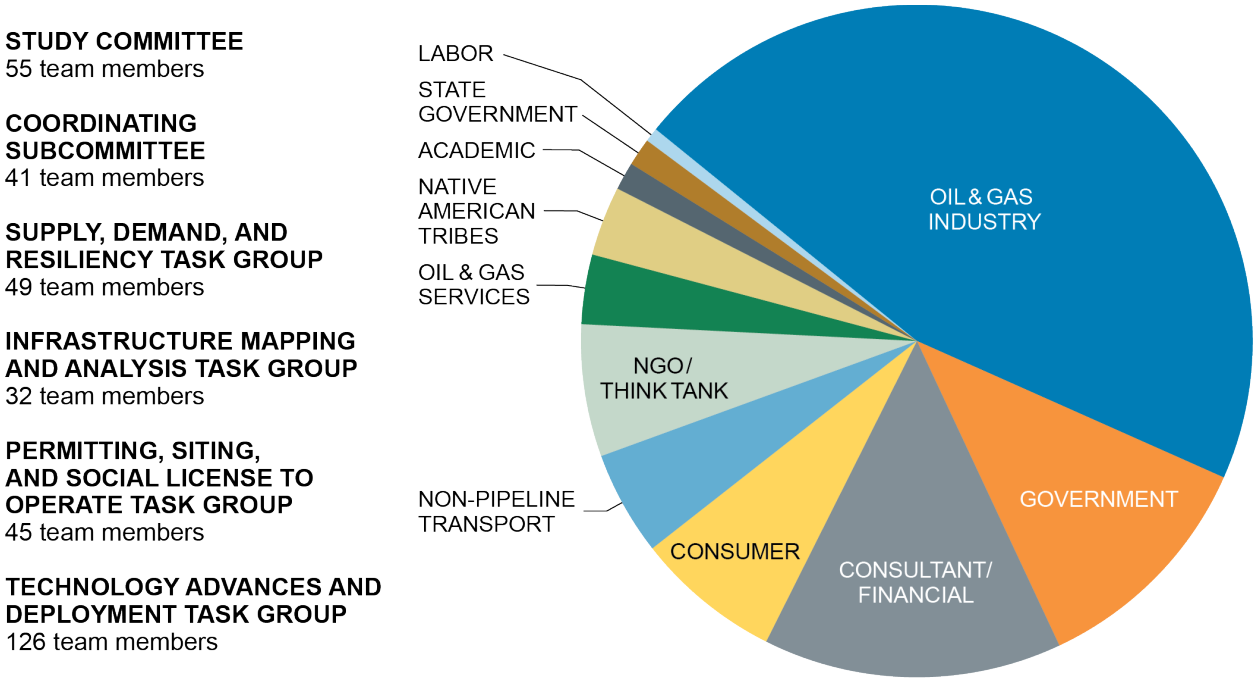

Figure P-2. Infrastructure Study Participation

IV. STUDY SCOPE

At the outset of the study in early 2018, the study leadership formed the core of the Coordinating Subcommittee to develop a proposed work plan for the study that would define the study scope, organization, and timetable. This step was to guide the study process and to ensure that the study plan was aligned with and designed to meet the Secretary's request. This initial work plan formed the base for the study and help identify the specific expertise and representation on the Coordinating Subcommittee and Task Groups. The work plan identified the fourth quarter 2019 as the time frame for completing the study.

The objective of the study is to provide the Secretary of Energy with the Council's perspective on the present and future state of oil and natural gas transportation infrastructure. The study plan was organized around four key areas:

1. The changes to supply and demand with the energy markets and how traditional U.S. energy flows have changed with shale development.

2. The state of the U.S. oil and natural gas infrastructure today, including associated assets such as refineries, liquified natural gas terminals, and storage. This section includes analysis of energy delivery challenges and constraints caused by current or insufficient future physical infrastructure.

3. The role of the government and regulatory agencies play in permitting, and identifying changes needed to create a predictable and efficient regulatory environment. This includes the challenges to permitting and siting, the efficiency of the National Environmental Policy Act (NEPA) evaluation process, and the process for replacing aging infrastructure as well as the challenges to modernization. Public and stakeholder engagement is a critical component of the permitting process and is addressed.

4. The impacts of emerging and future technologies and which nascent technologies merit additional research and development investment.

The first component of the report addresses the supply and demand outlook, including the evaluation of lower carbon future energy scenarios. These outlooks are the basis of demonstrating the continuing need for oil and natural gas in the U.S. energy mix for the foreseeable future. The second component, infrastructure resiliency, mapping, and analysis, provides the historical and present oil and natural gas infrastructure system. This report component also evaluates current and developing infrastructure constraints and challenges, as well as developing methodology to appreciate the value of the existing oil and natural gas transportation infrastructure to the individuals and to the economy as a whole. The third component, permitting, siting, and community engagement, is the most complicated portion of the study. This section undertakes three primary areas: understanding the regulatory processes, analyzing key issues underlying public concerns and opposition, and finally, identifying opportunities to improve the regulatory processes. The fourth component of the report looks at technology advancement and deployment across the oil and natural gas transportation infrastructure value chain with a focus on technology that improves safety or environmental performance. In addition, this section reviews the key technology challenges around cybersecurity, focusing on the interface with operating systems technology. Figure P-3 provides a high-level overview of the scope of work and the task groups, organized to provide the detailed analysis.

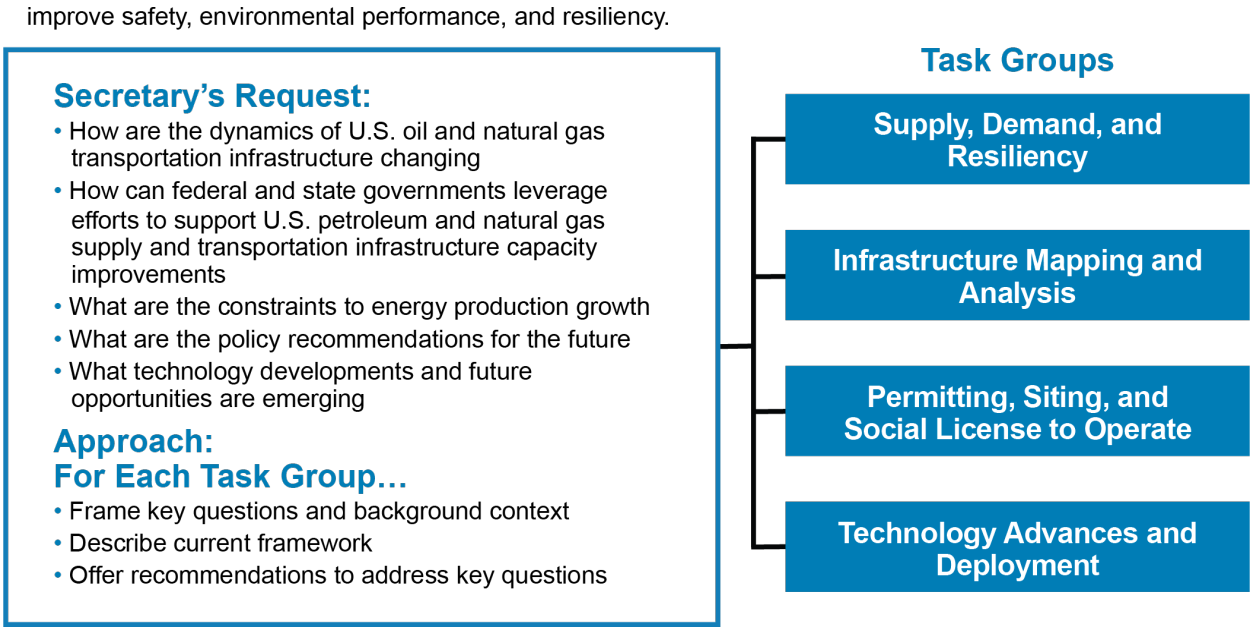

Figure P-3. Overview of Study Scope

V. STUDY APPROACH

The study was conducted with a fundamental expectation that all parties would fully comply with regulations and laws that cover a project of this type. Every effort was made to conform to all antitrust laws and provisions as well as the Federal Advisory Committee Act. As part of this compliance effort, this study did not include evaluations of commodity prices. In addition, processes were put in place to ensure that any information on various industry outlooks, projections, and specific data (including geospatial attributes) were handled to protect any proprietary information between competitors.

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

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

VI. REPORT STRUCTURE

In the interest of transparency and to help readers better understand this study, the NPC is making the study results and many of the documents developed by the study groups available to all interested parties. To provide interested parties with the ability to review this report and supporting information 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 principle findings and resulting recommendations. It describes future U.S. oil and natural gas needs and the growing domestic supply to meet that demand and for export. The report looks at the oil and natural gas transportation infrastructure and how that infrastructure has evolved over time. The report describes the regulatory and public interest issues that have impacted time frames for permitting and siting new projects. Finally, the report reviews technological innovations that can improve safety and reliability, as well as reduce the environmental impact of oil and natural gas transportation infrastructure.
- Report Chapters provide more detailed discussion and additional background on the study analyses. These chapters are grouped into four parts: Supply and Demand; Infrastructure Resiliency, Mapping, and Analysis; Permitting, Siting, and Community Engagement; and Technology Advancement and Deployment. These chapters provide supporting data and analyses for the findings and recommendations presented in the Executive Summary. The chapters also provide additional, secondary findings and recommendations that were not included in the Executive Summary.
- Appendices of the Full Report provide background material, such as Secretary Perry's request letter, rosters of the Council and study group membership, and a list of topic papers. This section also contains a list of acronyms and abbreviations used in the report.
- Topic Papers provide a final level of detail for the reader. These papers, developed or used by the study's various task groups, are included on the NPC website. These papers may include greater detail and background information than was useful to include in the study report or helped the study team with specific analyses. A list of the topic papers appears at the end of this report.

  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 the topic papers but, rather, to approve the publication of these materials as part of the study process. The topic papers were reviewed by study participants but are essentially stand-alone analyses. As such, statements and suggested findings that appear in these topic papers are not endorsed by the NPC unless they were incorporated into the Full Report.

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

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Executive Summary

I. INTRODUCTION

Americans depend on reliable and affordable energy without always being aware of the vital role that oil and natural gas play in maintaining their way of life. Assuring that way of life requires a resilient and growing energy transportation system so that energy can be moved from supply points and delivered to consumers safely. Even scenarios designed to meet climate change targets estimate that this will be the case for decades to come.

Americans expect readily available gasoline at their local gas station, continuously available electricity, and reliable natural gas, heating oil, and propane for heating and cooking. American businesses and industry also depend upon reliable and affordable supplies of oil and natural gas in the form of fuels, feedstocks, petrochemicals, and electricity to produce and deliver the goods and services that Americans depend upon every day. Oil and natural gas are essential building blocks for scores of manufactured goods such as plastics, packaging, textiles, paint, fertilizer, and even solar panels and light-weight electric automobile components. The scale of the oil and natural gas industry is illustrated by its contribution to the U.S. economy. In 2015, U.S. oil and natural gas operations and capital investments directly and indirectly generated $1.3 trillion of value added to the national economy, accounting for 7.6% of U.S. gross domestic product and 10.3 million American jobs.[1]

Oil and natural gas are delivered via a vast infrastructure network in the United States. This transportation infrastructure is dynamic and complex, uses multiple modes of transport, and is in a constant state of evolution. The U.S. infrastructure supporting oil and natural gas includes:

- 300,000+ miles of natural gas transmission lines
- 210,000+ miles of pipelines for crude oil, refined oil products, and natural gas liquids (NGLs)[2]
- 4,000,000+ miles of public roads
- 135,000+ miles of freight railroads
- 12,000+ miles of inland waterways
- 388 active natural gas storage facilities
- 1,499 crude oil and products terminals
- 777 marine oil terminals
- 5 operating liquified natural gas (LNG) export terminals.

One might think that with all of this infrastructure in place, the United States does not need any more. After all, gasoline demand has plateaued as automobile efficiency continues to increase. However, the volumes of oil and natural gas consumed by Americans will continue to be large, even in forecasts

[1] PriceWaterhouseCoopers, "Impacts of the Oil and Natural Gas Industry on the US Economy in 2015," July 2017.https://www.api.org/news-policy-and-issues/american-jobs/economic-impacts-of-oil-and-natural-gas

[2] Natural gas liquids include ethane, propane, butane, and natural gasoline, and are commonly used to produce plastics and petrochemicals, as fuel blending components, and for space heating.

that project the effects of policies to reduce greenhouse gas emissions. Therefore, the existing infrastructure needs to be maintained and expanded.

Demands on energy infrastructure are continuously changing, requiring modifications and additions. While domestic gasoline demand has been generally flat, jet fuel demand is projected to increase. Natural gas demand is also projected to increase, as electricity generators rely on natural gas to replace coal and to provide backup for increasing supplies of intermittent wind and solar power. Furthermore, supply sources of crude oil and natural gas have been undergoing a significant geographic shift, requiring realignment of infrastructure to move these supplies to consumers. For example, Appalachia has become one of the top producing regions of natural gas, growing from almost nothing in 2009 to more than 30% of U.S. production in 2018. The Permian Basin in west Texas and southeast New Mexico has displaced the Gulf of Mexico as the top crude oil producing region, and the Eagle Ford in south Texas grew from producing nearly nothing in 2005 to 16% of U.S. production in 2018. Abundant supply of domestic natural gas has supported announcement of 334 petrochemical projects since 2010.

The United States has recently become the largest oil and natural gas producing country in the world, providing benefits to the domestic economy and enhanced domestic and global energy security. As the September 2019 attacks on Saudi Arabia demonstrated, the ability of the United States to reduce oil imports and withstand OPEC production cuts protected the U.S. economy from what could have been a major oil price shock. Additionally, export of growing excess capacity can further benefit the U.S. economy. More than 13 million barrels per day (MMB/D) of new crude oil export capacity and 16 billion cubic feet per day (BCF/D) of new LNG export capacity have recently been announced. For these exports and projects to come to fruition, new transportation infrastructure in the form of pipelines, deepened waterways and ports, and export facilities must progress. All of this activity stands to benefit the country through job growth and investment in local communities.

The U.S. Congress and individual states have passed numerous laws to ensure that oil and natural gas are delivered safely, with protections for other societal priorities, from the assurance of clean air and water, to the protection of species, to the preservation of culture and history. The resulting framework of regulations is comprehensive and complex. The challenge for companies is to maintain, modify, and expand infrastructure in a way that balances all priorities: job creation, economic development, reliable and affordable energy supplies, environmental protection, national security, and other social priorities.

The vast majority of energy infrastructure projects are completed successfully.[3] However, there are rising levels of opposition to permitting and siting of new and modified infrastructure. The concerns driving this opposition range from worries about leaks and spills of hydrocarbons from accidents, to concerns about the disruption and environmental impacts caused by construction, to the government's power to seize land using eminent domain, to concerns about climate change or doubts about the need for new supply of hydrocarbons. Some major projects have been delayed or impeded, and the trend is concerning.

This report first reviews recent history and forecasts for future oil and natural gas supply and demand, including scenarios designed to produce reductions in greenhouse gas emissions. Next, the report reviews the evolution of the interdependent transportation system that moves crude oil, refined products, natural gas, and NGLs from supply areas to demand centers, and the need for future infrastructure

[3] EIA database; between 2012-2019, 144 liquid pipelines and 239 natural gas pipelines have been completed (new construction, reversals, conversions and lateral pipelines). U.S. Energy Information Administration, natural gas pipelines: https://www.eia.gov/naturalgas/data.php#pipelines, accessed August 23, 2019. U.S. Energy Information Administration, petroleum & other liquids pipelines, https://www.eia.gov/petroleum/data.php#movement, accessed August 23, 2019.

changes and additions. The report describes the processes for and challenges to obtaining federal and state permits to maintain and modify existing infrastructure and build new infrastructure. Opportunities to address stakeholder concerns and improve the predictability and timeliness of permitting are identified. The report discusses the reliability, resiliency, safety, and environmental performance of existing infrastructure, including cybersecurity. Opportunities and technology developments that could enhance the safety and environmental performance of energy transportation infrastructure are identified.

This study concludes that oil and natural gas will continue to be needed, even in scenarios designed to produce reductions in greenhouse gas emissions. The United States needs to both maintain existing energy infrastructure and build new infrastructure to adapt to changing needs. The individual chapters that follow this Executive Summary provide greater detail. Additional detail can be found in the topic papers on the National Petroleum Council website (www.npc.org) and a list of those topic papers can be found at the back of this report.

II. KEY FINDINGS OF THIS STUDY

1. The United States has become the largest producer of both oil and natural gas in the world, which has provided the nation with increased employment and economic growth, reduced energy imports, and reduced greenhouse gas emissions. Increased natural gas use replacing coal to generate electricity has been the single largest contributor to reducing U.S. carbon dioxide (CO_2) emissions by 15% since 2005.
2. Even in energy scenarios designed to meet climate change targets, the largest energy sources continue to be oil and natural gas through at least 2040 to provide reliable and affordable energy.
3. The benefits of the unprecedented increase in oil and natural gas production could not have come about without the significant expansion and adaptation of transportation infrastructure capacity.
4. The U.S. economy can benefit even further from increased export of oil and natural gas.
5. Existing infrastructure has been modified and adapted to near-maximum capacity. To connect America's abundant energy supplies with domestic and global demand, significant public and private investment in new and existing pipelines, ports, rail facilities, and inland waterways will be essential**.**
6. Several critical infrastructure bottlenecks exist: natural gas pipeline access to New England/New York, Port of Houston channel capacity, and oil and natural gas export capability.
7. It is becoming increasingly challenging to keep pace with hiring and developing a well-qualified workforce to build and maintain existing and future infrastructure. A skilled labor shortage exists in the United States and will continue to grow as the current workforce continues to retire.
8. An interdependent infrastructure system of pipelines, truck, rail, and marine transport working together with storage ensures the delivery of reliable and affordable energy.
9. Overlapping and duplicative regulatory requirements, inconsistencies across multiple federal and state agencies, and unnecessarily lengthy administrative procedures have created a complex and unpredictable permitting process.
10. Bipartisan actions by Congress and the Executive Branch, including mechanisms to expedite the permitting process for large infrastructure projects represent positive steps; however, more improvements are necessary.

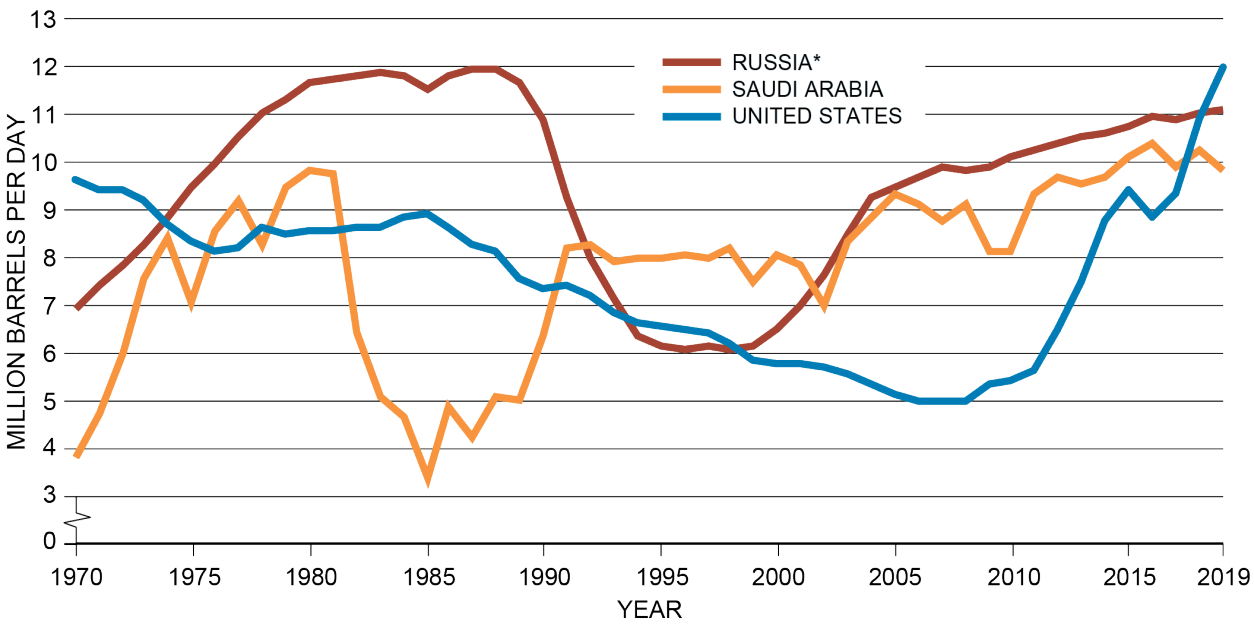
11. Successful infrastructure projects depend upon early, effective, and continuous stakeholder engagement and collaboration.
12. The nation faces the dual challenge of providing affordable energy to support economic growth and human prosperity while addressing the environmental effects including the risks of climate change. Industry shares the public's concerns that climate change is a serious issue that must be addressed. Litigation of individual projects to address climate concerns is an ineffective approach.
13. The permitting and construction of numerous energy infrastructure projects have been challenged, delayed, or stopped as a result of litigation by stakeholders concerned about climate change and the associated policy debate.
14. Crude oil, petroleum products, and natural gas moved by the nation's infrastructure reach their destinations with a high degree of safety, resiliency, and environmental performance. However, incidents have occurred, and oil and natural gas companies are committed to continuous improvement.
15. Advancements in new technologies have been an important contributor to industry's safety, reliability, and environmental performance. Overcoming challenges and barriers to new technology development and deployment would accelerate these improvements.
16. Cyber threats to energy infrastructure control systems are increasing and security protections are being challenged due to increasing connectivity and growing malicious cyber activity.

III. U.S. OIL AND NATURAL GAS PRODUCTION

Key Finding 1: The United States has become the largest producer of both oil and natural gas in the world, which has provided the nation with increased employment and economic growth, reduced energy imports, and reduced greenhouse gas emissions. Increased natural gas use replacing coal to generate electricity has been the single largest contributor to reducing U.S. CO_2 emissions by 15% since 2005.

A. Crude Oil Production

Recent growth in U.S. crude oil production has been extraordinary. Until 1974, the United States was the world's largest producer of crude oil. But in 1974, as Russia's crude oil production increased and U.S. production declined, Russian production surpassed U.S. production. U.S. production continued to decline, hitting a 62-year low in 2008. Since then, hydraulic fracturing and directional drilling technology have enabled U.S. oil production to more than double, gaining 5.9 MMB/D by 2018. This increase represents an economic gain for the United States of $130 billion per year at $60 per barrel of crude oil. In late 2018, the United States once again became the largest crude oil producer in the world, as shown in Figure ES-1.



Note: Includes crude oil and condensate. *1970-1990 figures are for for Soviet Union; 1991 onward is Russia only.
2019 figures are IHS Markit May 2019 projections. 2019 is January-June average.
Sources: IHS Markit; EIA, *International Energy Statistics;* and International Energy Agency.

Figure ES-1. Crude Oil Production from 1970 to 2018 for the United States, Russia, and Saudi Arabia

B. Future Oil Production

This study examined a wide range of forecasts for potential future U.S. oil production, including scenarios assuming existing policies and technologies and scenarios assuming substantial future changes. Terms such as "forecast" or "outlook" are used throughout this report to describe estimates of possible energy futures. They do not imply any specific probability or likelihood of outcome. All forecasts or outlooks make assumptions about future uncertainties. These assumptions may be calibrated to existing policies or to potential new policies, technology developments, or geopolitical changes. The assumptions may be outcome-agnostic, or they may be made to drive the forecast or outlook to a particular outcome. For example, the International Energy Agency's (IEA) Sustainable Development Scenario makes assumptions to reduce greenhouse gas emissions consistent with limiting global warming to 1.5ºC to 2ºC. Forecasts are useful to provide a perspective on future possibilities, but their underlying assumptions must be considered. A detailed discussion of each forecast or outlook's assumptions is included in Chapter 1, "Supply and Demand."

Projections for domestic crude oil production through 2040 range from a high of nearly 20 MMB/D to a low of 7.1 MMB/D, as shown in Figure ES-2. Most forecasts examined by this study show increasing production through the mid-2020s, followed by generally flat to slightly declining production.

Growing world demand, as projected by several scenarios and discussed in a following section, will support continued growth in production as U.S. exports play an increasingly important role in satisfying world energy demand.

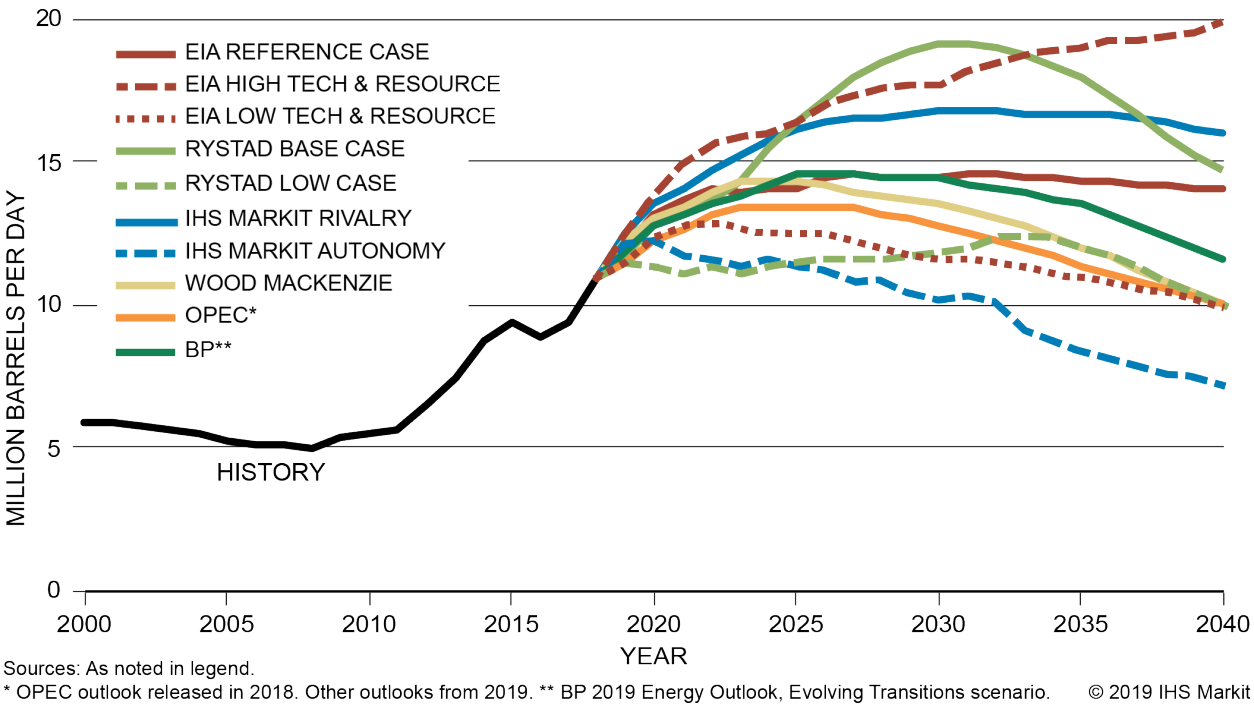


Figure ES-2. U.S. Crude Oil Production Forecasts to 2040
Sources: EIA *Annual Energy Outlook 2019*, Rystad Energy, IHS Markit, BP, OPEC, and Wood Mackenzie Q1 2019.

C. Natural Gas Production

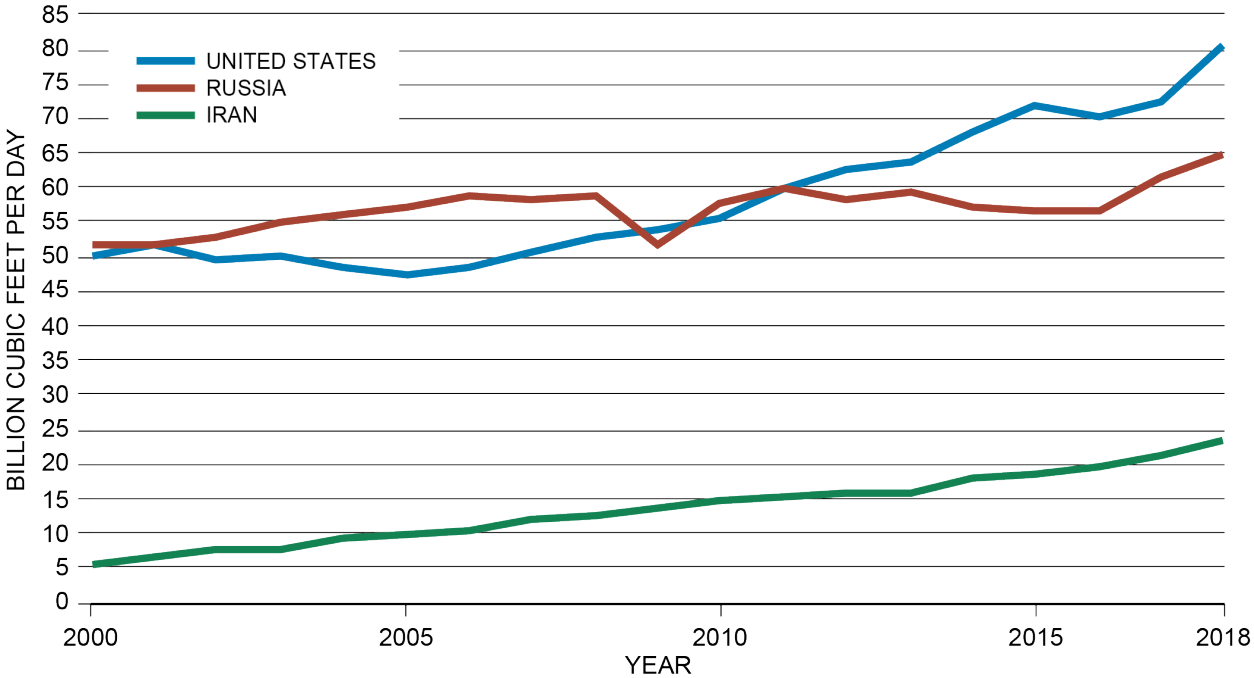
Natural gas production began an upward climb in 2006, aided by technology that unlocked production from tight and shale formations.[4] Growth in natural gas supply has been propelled by development in Appalachia—the Marcellus and Utica formations in Pennsylvania, West Virginia, and Ohio—and from increased associated natural gas production[5] in the Bakken, Eagle Ford, and Permian Basin formations in North Dakota, Texas, and New Mexico. In 2012, the United States became the largest natural gas producer in the world, overtaking Russia, as shown in Figure ES-3.

D. Future Natural Gas Production

Forecasts generally project increasing U.S. natural gas production, as shown in Figure ES-4. Much of the projected growth is in the Appalachian Basin, where some forecasts project production to double from 2018 to 2040. Production in the Permian Basin is also expected to grow substantially through about 2030; after that, forecasts of Permian Basin production tend to level off.

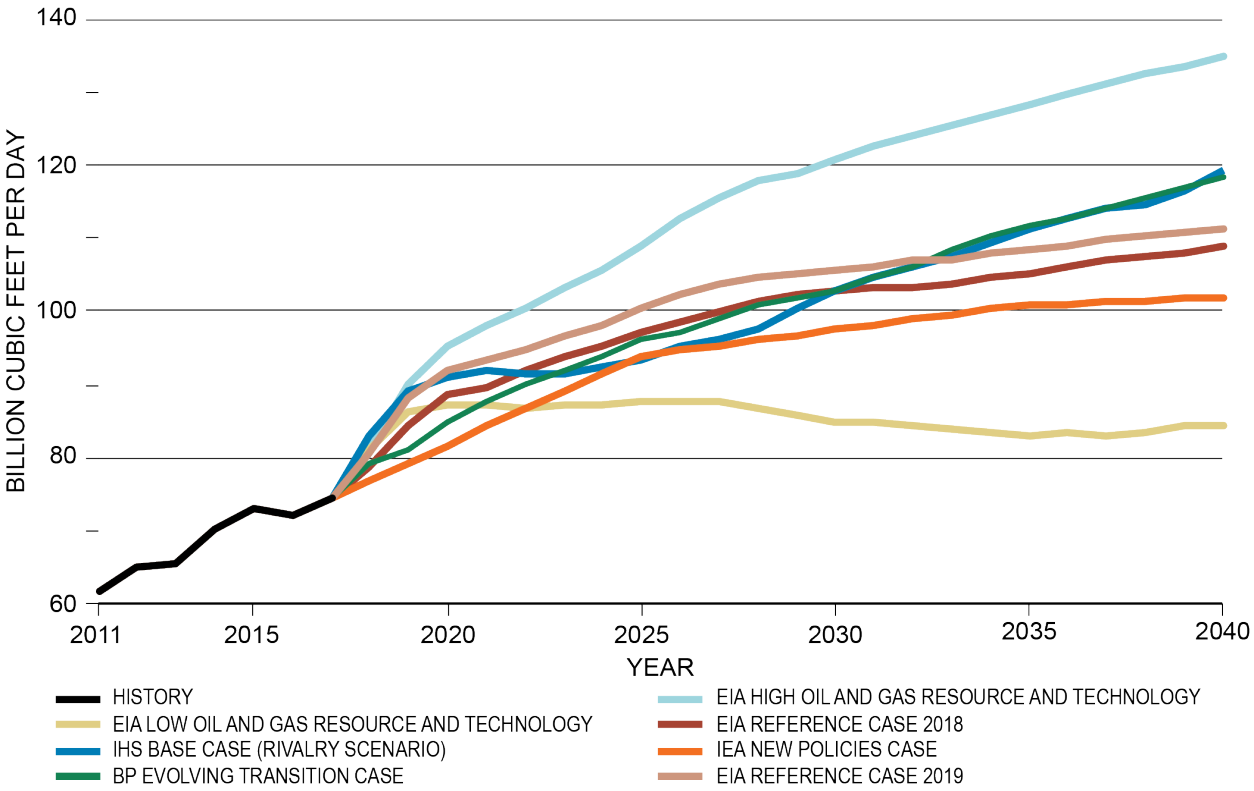
[4] Tight formations are ones that have low permeability, such that oil or gas will not easily flow without some form of stimulation, such as hydraulic fracturing. Shale is a specific type of rock that generally has low permeability.

[5] Associated gas is natural gas that is produced with crude oil.



Source: 2018 BP Statistical Review.

Figure ES-3. Top Three Natural Gas Producing Countries



Sources: EIA *Annual Energy Outlook* 2018 and 2019; IHS Markit; and *BP Energy Outlook* 2019.

Figure ES-4. U.S. Natural Gas Production Forecasts to 2040

E. Value of the U.S. Oil and Natural Gas Industry

Infrastructure is a critical component of efficient production and delivery of affordable, reliable energy to businesses and consumers, unlocking the enormous value of the energy sector for the U.S. economy. The U.S. oil and natural gas industry's operations directly or indirectly generated $1.1 trillion of value in the national economy in 2015, and its capital investment added an additional $220 billion. Combining both operational and capital investment impacts, the industry's total value added at the national level was $1.3 trillion, accounting for 7.6% of U.S. GDP in 2015. The U.S. oil and natural gas industry's economic impact reaches all 50 states and the District of Columbia.[6]

The U.S. oil and natural gas industry's total employment in 2015, combining operations and capital investment, amounted to 10.3 million full-time and part-time jobs and accounted for 5.6% of total U.S. employment. In 2015, the oil and natural gas industry directly provided 2.8 million jobs for American workers, paid $290 billion in wages, salaries and fringe benefits, and proprietors' income, and it generated $603 billion in GDP.

The total number of jobs directly or indirectly attributable to the oil and natural gas industry's operations as a percentage of each state's total employment in 2015 ranged from 1.3% in the District of Columbia to 16.6% in Oklahoma. The oil and natural gas industry directly or indirectly supported 5% or more of the total employment in 13 states in 2015.[7]

U.S. consumers have benefited from reduced retail energy prices that paralleled the increased oil and natural gas production over the past decade:

- Increased supplies of low-cost natural gas enabled average retail electricity prices to grow at only about 8% from 2008 to 2018, a significant reduction from the 40+% increase over the prior decade.
- Consumers have benefited from a 15+% decline in motor gasoline prices.
- Energy expenditures as a share of GDP have fallen from about 10% to 6 to 8%.
- These consumer impacts have resulted in an average reduction in household energy cost of $800 to $2,500 per year.

The expansion in the U.S. energy supply and its associated infrastructure has also benefited the economy in the form of direct and indirect employment and increased expenditures from ancillary industries, ranging from pipeline and equipment manufacturers to retail clothing and food. Since 2010, 334 petrochemical projects valued at $204 billion have been announced.[8]

Increased domestic energy production reduces the need for imports and supports exports, benefiting the domestic economy and enhancing both the country and world's energy security. IHS Markit estimates that increased domestic petroleum production from 2007 to 2017 reduced the U.S. trade deficit by nearly $250 billion.

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[6] American Petroleum Institute. (2019). "State of American Energy," https://powerpastimpossible.org/state-of-american-energy/.

[7] Oklahoma, Wyoming, North Dakota, Texas, Louisiana, Alaska, New Mexico, West Virginia, Kansas, Colorado, Nebraska, Montana, and Mississippi.

[8] American Chemistry Council, press release May 2019, U.S. Chemical Investment Linked to Shale Gas: $204 Billion and Counting, https://www.americanchemistry.com/Shale_Gas_Fact_Sheet.aspx.

Using natural gas to generate electricity produces only about half of the greenhouse gas emissions as using coal. From 2005 through 2017, CO_2 emissions from U.S. power generation declined by 28%. An analysis by the U.S. Department of Energy's (DOE's) Energy Information Agency (EIA) concluded that a substantial portion of this reduction resulted from switching from coal and oil to natural gas for power generation.[9]

IV. U.S. OIL AND NATURAL GAS DEMAND

Key Finding 2: Even in energy forecasts designed to meet climate change targets, the largest energy sources continue to be oil and natural gas through at least 2040 to provide reliable and affordable energy.

U.S. electricity production from wind and solar has grown nearly six-fold over the past decade. Fuel ethanol and biodiesel use have grown 60% over the same period. Some groups and policymakers advocate for ending fossil fuel use within the next few decades. However, wind, solar, and biofuels provided less than 6% of U.S. energy demand in 2018. Numerous forecasts of future energy consumption show substantial continuing growth in renewables, but these forecasts still project that oil and natural gas will continue to be the two largest sources of U.S. energy consumption in 2040—the final year in many detailed publicly available energy forecasts.

Figure ES-5 compares the U.S. 2018 energy consumption by type to three energy forecasts for 2040: the EIA AEO 2018 Reference Case, IEA WEO 2018 New Policy Scenario (IEA NPS),[10] and IEA WEO 2018 Sustainable Development Scenario (IEA SDS).[11]

The EIA Reference Case assumes a continuation of current U.S. policies. The Reference Case projects U.S. energy demand in 2040 about the same as in 2018, with oil declining slightly and natural gas increasing. The IEA NPS, which includes energy policies likely to stem from governments' announced intentions, projects oil declining further than EIA's forecast and natural gas staying about the same. The IEA SDS scenario forecasts a further decline in oil, near elimination of coal, and increasing renewables. Even in the SDS, natural gas and oil remain the first and second largest providers of U.S. energy in 2040.

A. U.S. Petroleum Liquids Demand

Most of the forecasts examined by this study project that total U.S. demand for petroleum liquids will be flat to slightly declining between 2017 and 2040. Forecasts that include additional policies to limit greenhouse gas emissions moderately reduce liquids demand. For individual refined transportation fuels, forecasts generally show flat-to-declining demand, with the majority of the demand decline in gasoline. The exception to this declining trend is jet fuel, which increases over the period to 2040 in many forecasts.

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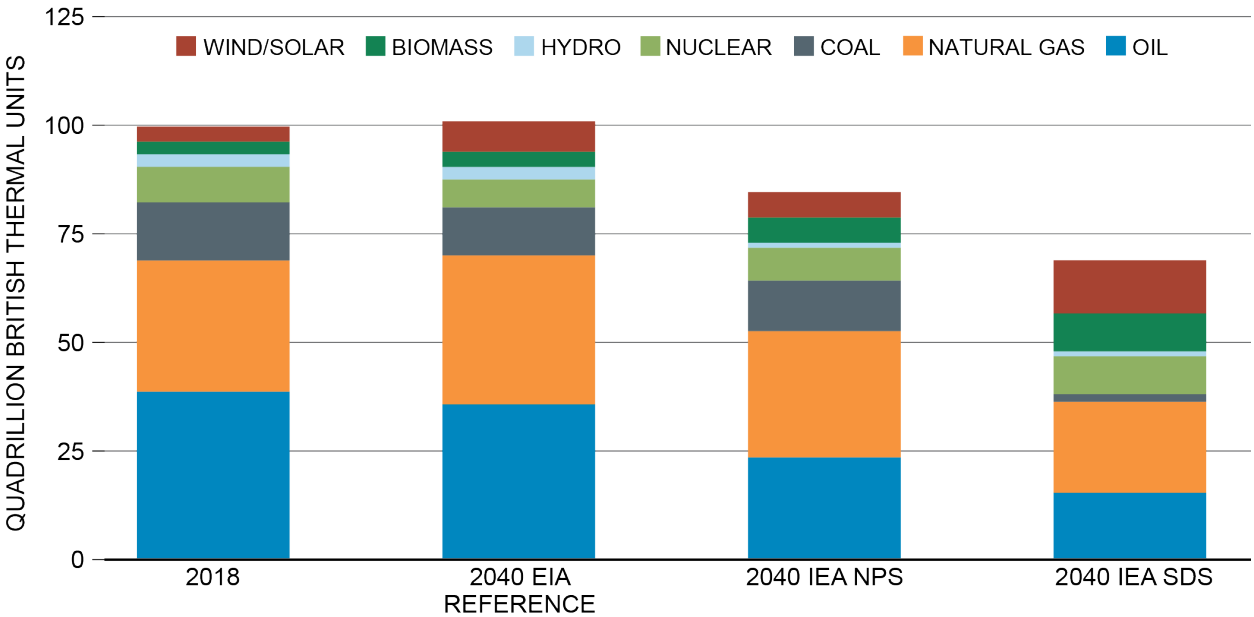
[9] Based on EIA's "Today in Energy," October 29, 2018.

[10] The IEA New Policy Scenario incorporates existing energy policies as well as an assessment of the results likely to stem from implementation of announced policy intentions.

[11] The IEA Sustainable Development Scenario is fully aligned with the Paris Agreement's goal of holding the increase in the global average temperature to well below 2°C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5°C, https://www.iea.org/weo/weomodel/sds/.



Note: "Consumption" as used here does not include net exports, such as export of LNG.

Source: The IEA New Policy Scenario and Sustainable Development Scenario are based on IEA data from IEA (2018) *World Energy Outlook*, all rights reserved; as modified by the National Petroleum Council.

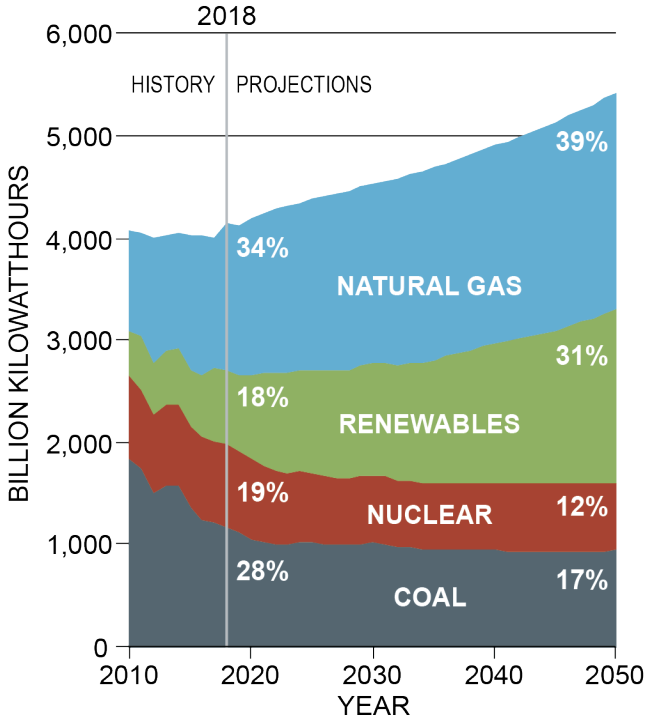
Figure ES-5. U.S. Energy Consumption by Type

B. U.S. Natural Gas Demand

Natural gas demand is generally projected to increase over the period as electricity generators rely on natural gas to replace coal and to provide backup for increasing supplies of intermittent wind and solar power, with the exception of the IEA SDS scenario, which shows that total primary energy demand for natural gas declines. However, under the SDS, natural gas still comprises 32% of U.S. primary energy demand in 2040. Natural gas-fired generators can quickly ramp up and down, allowing natural gas to complement increasing supplies of intermittent wind and solar power, assuring electrical grid stability and reliable supplies of electricity. More than 60% of U.S. electricity generating capacity installed in 2018 was fueled by natural gas. In 2018, natural gas was the single largest domestic electricity generation source, comprising 34% of total U.S. generation, as shown in Figure ES-6.

In the 10 years from 2007 to 2017, overall natural gas use increased by 17%. However, methane[12] emissions from the natural gas production and distribution were down over the same period by about 3%. Emissions from the natural gas transportation and storage sector, the subject of this study, were down about 18%. The transportation and storage sectors continue to focus on making further reductions.

[12] Methane is the primary component of natural gas.



Source: EIA *Annual Energy Outlook 2019* Reference Case.

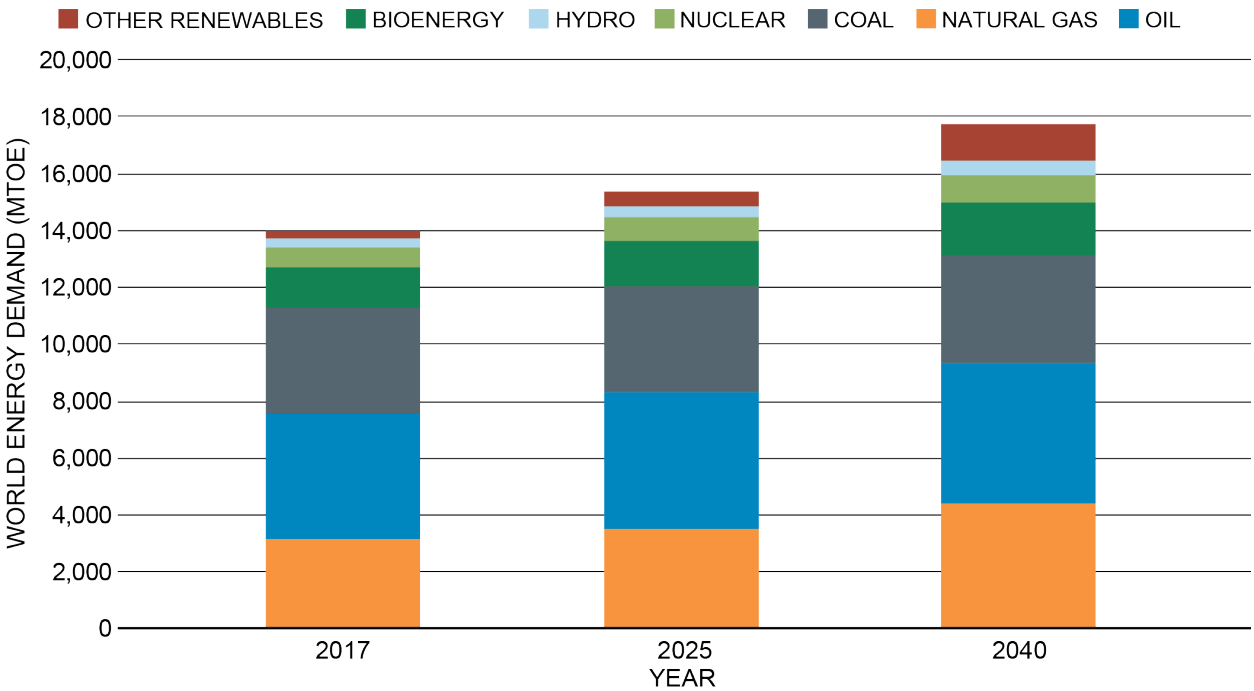
Figure ES-6. U.S. Electrical Generation Capacity by Fuel
Source: EIA, *Annual Energy Outlook 2019* (Reference Case).

C. Global Energy Demand

In its 2018 NPS, the IEA forecasts that the world will need 27% more total energy in 2040 versus 2017, as shown in Figure ES-7. The IEA projects that nearly half of this growth will come from oil and natural gas. The IEA projects that natural gas will provide the largest amount of energy growth, slightly outpacing renewables, with oil being the third largest source of energy growth. Compared to 2017 world demand, natural gas demand will grow by 43% and oil demand will grow by 10%.

The IEA forecast aligns directionally with forecasts from the U.S. EIA, which projects in its 2017 International Energy Outlook Reference Case that total world demand for energy will grow by 25% through 2040. The EIA projects that natural gas will be the largest growing source of energy, with demand growing by 41% over 2017 levels. The EIA also forecasts that there will be an increasing need for oil, which grows by 15% and remains the single largest source of energy, providing 31% of all energy consumed in 2040.

Even in scenarios with stringent greenhouse gas constraints, demand for natural gas remains robust. The IEA SDS projects that total global energy demand will drop only slightly by 2040. Over this same time period, global natural gas demand actually increases by 11%, to replace coal and provide reliable backup for intermittent wind and solar power. Natural gas is the single largest source of energy by 2040 in this scenario.



Source: The IEA New Policy Scenario is based on IEA data from IEA (2018) *World Energy Outlook*, all rights reserved; as modified by the National Petroleum Council.

Figure ES-7. World Energy Demand, per the IEA New Policy Scenario

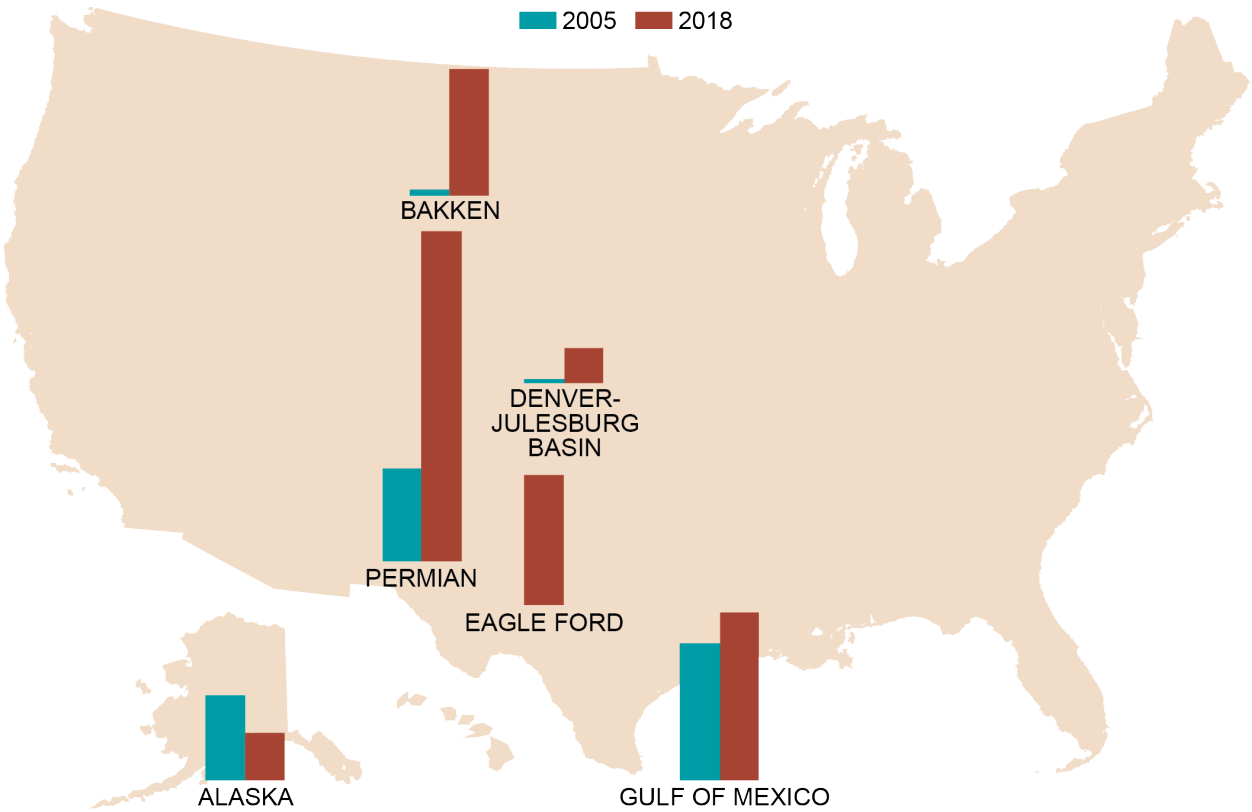
U.S. exports will play a vital role in supplying oil, natural gas, and chemical feedstocks into this growing world demand. U.S. exports will support global energy security, improve the balance of trade, and create economic value for the United States. Growing exports will require continuing improvements and expansion of U.S. infrastructure.

V. NECESSITY OF ADEQUATE INFRASTRUCTURE

Key Finding 3: The benefits of the unprecedented increase in oil and natural gas production could not have come about without the significant expansion and adaptation of transportation infrastructure capacity.

A. Oil Production Geographic Shifts

The geography of oil production has changed with rising output. Recent oil production growth has been led by tight oil development in the Permian Basin of west Texas and southeast New Mexico, and two new areas of major U.S. shale oil production—the Eagle Ford formation in south Texas and the Bakken formation in North Dakota. At the same time, production in some traditional areas such as Alaska has been declining, as shown in Figure ES-8.



Source: U.S. Energy Information Administration.

Figure ES-8. Significant Regional Crude Oil Production Volume Changes, 2005 to 2018

From 2010 through 2018, crude oil transportation capacity was increased and modified with expansion, flow reversal, and greenfield[13] projects adding more than 7 MMB/D of capacity to accommodate the change in historical crude oil flow patterns. Most significantly, oil imports into the U.S. Gulf Coast and flows toward the Great Lakes area have reversed, with oil now flowing from Canada and North Dakota toward the Great Lakes area and on to Oklahoma and Texas, backing out imports.

The exceptional rate of crude oil production growth in the Permian Basin of west Texas and southeast New Mexico has resulted in pipeline capacity additions struggling to keep up with production, as shown in Figure ES-9. The blue area shows pipeline takeaway capacity growing, and the black line shows crude oil production growth. During 2012, 2014, 2017, and 2018, takeaway capacity was strained, as indicated by the red dashed ovals. When this happens, demand rises for additional transportation by rail or truck, and some production can become uneconomic. This demonstrates the importance of allowing infrastructure to adapt and grow as necessary.

[13] "Greenfield" refers to industrial development on land not previously used for industrial development; for example, laying a new pipeline along a route without existing pipeline easements.

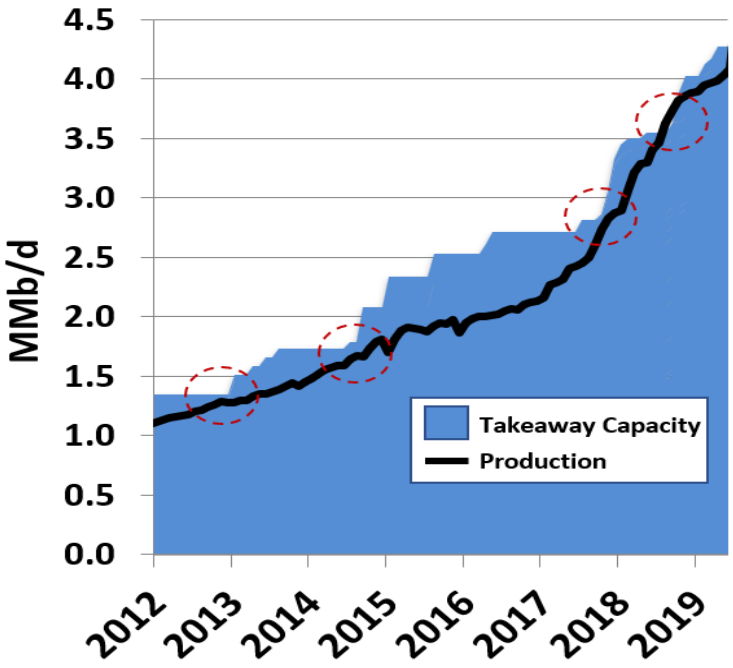


Figure ES-9. Permian Basin Crude Oil Production and Pipeline Takeaway Capacity
Source: RBN Energy LLC.

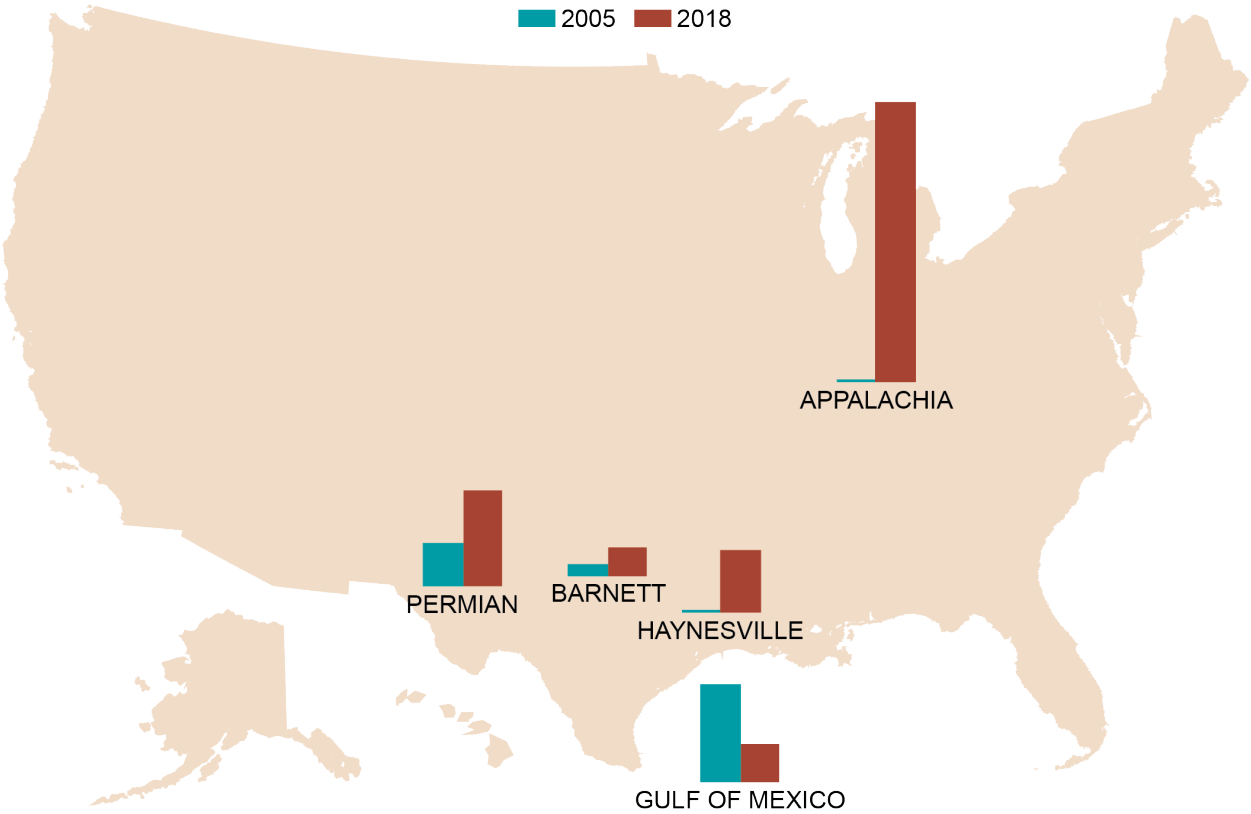
B. Natural Gas Production Geographic Shifts

Natural gas production geographies have also changed dramatically in recent years, as shown in Figure ES-10. Production in the Marcellus and Utica formations in Pennsylvania, West Virginia, and Ohio has grown from essentially zero in 2009 to about 31% of total U.S. production in 2018. On the other hand, natural gas production in the Gulf of Mexico declined from 13.6 BCF/D in 2001, about 25% of total U.S. production, to less than 4 BCF/D in 2018, less than 5% of total U.S. production.

These shifts have resulted in significant changes in domestic natural gas flows. Prior to natural gas production from new shale fields, pipelines delivered natural gas from Texas and Louisiana to the Northeast. Large production increases in the Northeast have resulted in natural gas flowing south and west, supporting multiple new LNG export facilities on the Gulf Coast. This was achieved initially by flow direction reversals and expansions of existing pipelines. The Rockies and Bakken gas typically flows east to the Midwest. Permian gas flows west and south, also supporting Gulf Coast LNG exports. From 2010 through 2018, natural gas transportation projects added 23.8 BCF/D of transportation capacity. These projects were a combination of expansions or extensions of existing pipelines, flow direction reversals, and new pipelines.

C. Crude Oil, Natural Gas, and NGL Takeaway Capacity Limitations

The ability to produce crude oil is frequently dependent on the ability to take away the natural gas and NGLs that are produced with crude oil. For example, Permian Basin takeaway capacity for crude oil, natural gas, or NGLs has occasionally been constrained, leading to situations in which producers may have needed to defer drilling until new capacity is built. A lack of natural gas takeaway capacity led to increased flaring of natural gas in 2019. Flaring waivers have allowed for temporary flaring, but this may not be allowed long term. If natural gas and NGL takeaway capacity does not develop in line with associated gas and liquids production, it could hinder oil production growth in the Permian Basin or elsewhere, such as the Bakken Formation.



Source: U.S. Energy Information Administration.

Figure ES-10. Significant regional natural gas production geography shifts, 2005 to 2018

VI. U.S. OIL AND NATURAL GAS OPPORTUNITIES

Key Finding 4: **The U.S. economy can benefit even further from increased export of oil and natural gas.**

Key Finding 5: **Existing infrastructure has been modified and adapted to near-maximum capacity. To connect America's abundant energy supplies with domestic and global demand, significant public and private investment in new and existing pipelines, ports, rail facilities, and inland waterways will be essential.**

Key Finding 6: **Several critical infrastructure bottlenecks exist: natural gas pipeline access to New England/New York, Port of Houston capacity, and oil and natural gas export capability.**

Key Finding 7: **It is becoming increasingly challenging to keep pace with hiring and developing a well-qualified workforce to build and maintain existing and future infrastructure. A skilled labor shortage exists in the United States and will continue to grow as the current workforce continues to retire.**

The shifting sources and increasing production of oil and natural gas discussed previously will necessitate new and modified infrastructure to ensure reliable and affordable delivery to customers. Over the past decade, existing infrastructure has been significantly expanded, modified, and repurposed to meet changing needs. However, oil and natural gas production in the Permian Basin has dramatically increased recently, and new takeaway capacity has struggled to keep up. Similarly, natural gas production in Appalachia has grown from near zero in 2009 to more than 30% of U.S. production; new infrastructure will be required to enable the substantial continued growth envisioned in many forecasts.

Most publicly available forecasts show U.S. oil demand flat to declining to 2040. This combined with increasing production means that oil exports are projected to increase. The net of supply and demand for natural gas in most forecasts also results in projections of increased exports of natural gas. Increased infrastructure will be necessary to support these increased exports and the economic and energy security benefits that they can bring to the United States.

A. Oil Exports

The production forecasts discussed previously generally assume unrestricted global trade in oil and natural gas. U.S. light oil, natural gas, and refined product supplies currently exceed domestic demand. This surplus has supported growth in exports, providing benefits to the United States, including jobs, revenue, economic activity, reduced trade deficits, and lower cost of supply of domestic energy.

Future supply and demand changes will require new greenfield pipelines, additional expansion of existing pipelines, and increased marine terminal and waterway capacity. Nearly 8 MMB/D in crude oil pipeline capacity is expected to be added over the next 2 to 4 years. The EIA Reference Case forecasts a net increase of 5.6 MMB/D of oil exports from 2018 to 2040. The value of 5.6 MMB/D of oil exports would be $120 billion per year at $60 per barrel. Figure ES-11 shows more than 13 MMB/D of new crude oil export projects announced for the Gulf Coast area.

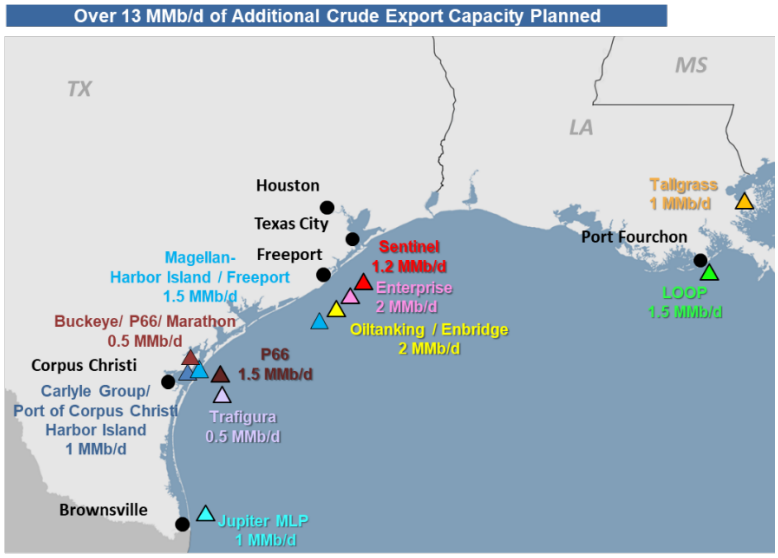


Figure ES-11. Planned New Gulf Coast Crude Oil Export Capacity Projects
Source: RBN Energy.

The EIA forecasts modest growth in U.S. refining capacity of 500,000 barrels per day over the period to 2040. Refinery equipment and the type of crude oil processed dictate the relative amounts of gasoline, jet fuel, and diesel produced; major new refining investment would be required to change these relative yields significantly. As a result, just maintaining supplies of domestically manufactured jet fuel and diesel in the face of declining domestic gasoline demand will require increased exports of gasoline to allow the nation's existing refinery capacity to operate efficiently. If gasoline exports cannot be increased, refining jobs and economic value will be lost.

B. Natural Gas Exports

Natural gas is currently exported by pipeline to Mexico and Canada and by marine shipments of LNG. Forecasts show substantial growth in LNG exports, principally from the U.S. Gulf Coast. LNG exports will require not only additional liquefaction, terminal, storage, and waterway capacity, but also increased pipeline capacity from producing fields to the new export terminals. Natural gas pipeline capacity and NGL pipeline capacity are expected to grow by 18 BCF/D and 3.5 MMB/D, respectively, over the next 2 to 4 years. Approved projects expected to export LNG are shown in Figure ES-12 and total 16 BCF/D capacity; another 23 BCF/D have been proposed to the Federal Energy Regulatory Commission (FERC). The value of 16 BCF/D increased LNG exports is about $29 billion per year at $5.00 per million BTUs.

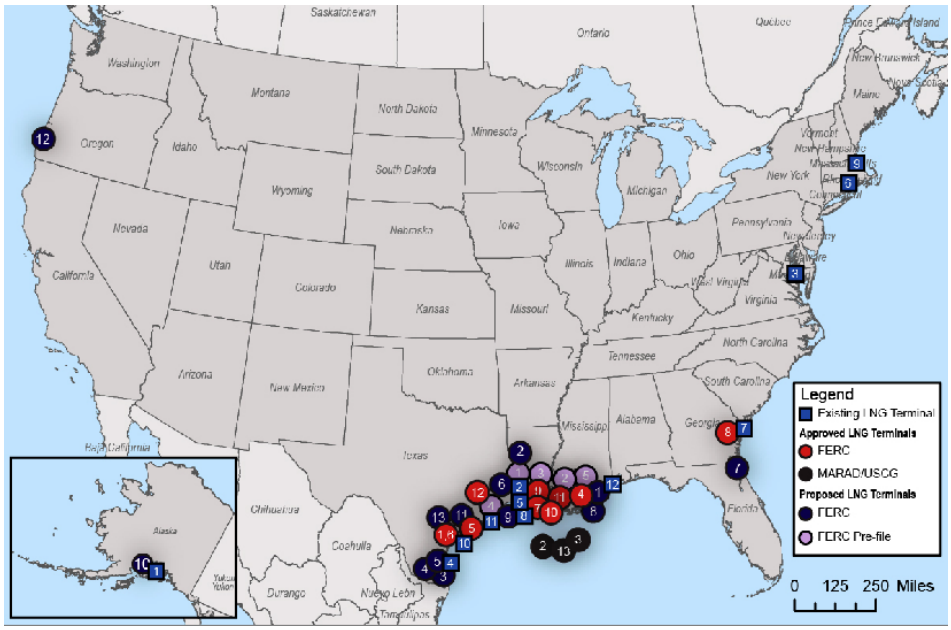


Figure ES-12. Recent and Announced LNG Export Projects
Source: Hart Energy, with underlying data from FERC.

Natural gas exports can deliver not only increased jobs and value to the United States but also global greenhouse emissions reduction benefits. The IEA NPS forecasts that global coal demand will increase by nearly 5% from 2016 to 2040, driven primarily by a 200+% increase in India. U.S. LNG

exports could help stem an increase in global coal use for power generation, as power generation from natural gas typically results in only half the greenhouse gas emissions of power generation from coal.

C. Port and Waterway Capacity

On a national level, the U.S. port system can be viewed as having adequate capacity, but the recent oil production increase and development of LNG export capacity has had significant impacts on a few key energy ports. The Port of Houston is home to the largest petrochemical and refining complex in the United States. Its proximity to the NGL infrastructure in Mont Belvieu, Texas, makes it the largest exporter of NGLs in the United States. The port is also a very active container port and receives steel and other bulk cargoes. Congestion is becoming a significant issue in the port, and the need to restrict the channel to one-way traffic when very large ships enter or leave has exacerbated the issue. The U.S. Army Corps of Engineers is currently studying alternatives to deepen and widen the channel.

D. Skilled Labor Required

Constructing and maintaining America's energy infrastructure requires an army of highly trained and skilled career professionals. A chronic skilled labor shortage continues to overwhelm the construction industry as retirements outpace new trainees. As the energy sector market expands, an acute skilled labor shortage is taking a toll on the oil and gas sector. A 2018 industry-wide survey by the Associated General Contractors of America[14] determined that 80% of construction firms were having a hard time filling hourly craft positions. The Commercial Construction Index indicates that the skilled labor shortage will have a great impact on businesses over the next 3 years. Eighty-eight percent of contractors expected a moderate impact from the workforce shortages and 57% expected the impact to be high in the next 3 years.

In their first-quarter 2019 Commercial Construction Index report,[15] USG Corp. and the U.S. Chamber of Commerce reported that 70% of contractors are struggling to meet project deadlines due to a chronic skilled labor shortage. More than half of the respondents expressed concern about their workers having adequate skills. More than 80% of the contractors reported that the workload for their existing employees has increased significantly. The skilled labor shortage has increased the cost of new work for 63% of respondents, resulting in 40% of them having to turn down project opportunities.

There is also a lack of skilled labor training of workers on the community level.[16] In the absence of adequate supply of skilled workers in the community, projects must use transitory labor to meet their needs, which increases the unpredictability of labor availability and limits direct economic benefits to the communities from job creation. Skilled trades training and apprenticeship programs will not only help build a skilled workforce on the community level, but they will also maximize the economic earning potential for those communities.

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[14] "Eighty Percent of Contractors Report Difficulty Finding Qualified Craft Workers to Hire as Association Calls for Measures to Rebuild Workforce" Associated General Contractors of America, August 29, 2018. https://www.agc.org/news/2018/08/29/eighty-percent-contractors-report-difficulty-finding-qualified-craft-workers-hire-0.

[15] USchamber.com. (2019). USG Corporation + U.S. Chamber of Commerce, Construction Index Q1 2019, Available at: https://www.uschamber.com/sites/default/files/cci_q1_2019_3-12-2019_for_release_0.pdf

[16] Npr.org. (2018). "High Paying Trade Jobs Sit Empty While High School Grads Line Up for University," NPR Choice page. Available at https://n.pr/2ORLDPb. Accessed August 27, 2019.

Accredited apprenticeship programs add highly trained and skilled apprentices with on-the-job training to the workforce every day. For example, the building trades invest over $1.5 billion annually in apprenticeship and journeymen training, and they operate more than 1,600 training centers in the U.S. Registered Apprenticeship Programs that help fill the skills gap resulting from a wave of current workforce retirements.[17]

E. Consequences of Limits on Infrastructure Development

If infrastructure companies cannot respond to changing supply and demand, consumers will have fewer energy choices, more volatile energy prices, and lost opportunities to save money and reduce greenhouse gas emissions. For example, the northeastern United States has severe capacity constraints in its natural gas pipeline system that supply electricity generation and heat for homes and buildings. An ISO New England report studied 23 scenarios and found that in all but the most optimistic cases, without new natural gas pipeline capacity, households would need to curtail energy use or would experience rolling blackouts in 2024-25 during extended winter periods.[18]

Some areas of New York State have been denied access to natural gas service due to projected lack of supply because of insufficient pipeline infrastructure. This impacts some households that are denied the choice to use natural gas for home heating.

State and local policies, state denials of infrastructure projects, and state restrictions on the movement of energy limit and fragment the infrastructure network. In the last 5 years, 12 energy infrastructure projects were denied permits by state or local agencies, 15 projects were delayed due to permitting, and 12 were cancelled due to regulatory delay or change in the project economics.[19] Fragmentation has consequences for interstate commerce by restricting the ability to transport energy from one state to another. Delay, denial, and cancellation of infrastructure projects impact job opportunities, economic activity, and tax revenue. Solutions are difficult, complex, and involve competing interests including governments.

The NPC recommends:

- To mitigate negative impacts on interstate commerce, all levels of government should have constructive dialogue about the overall economic benefits from the nation's energy resources and effectively engaging stakeholders and minimizing local impacts and risks.
- Congress should fully appropriate the revenue coming into the Harbor Maintenance Trust Fund and the Inland Waterways Trust Fund funds to restore and fully maintain all U.S port and waterways infrastructure at their authorized dimensions.
- The U.S. government, states, local communities, secondary schools, and industry should promote vocational career education and technical training of their constituents, members, and communities.
- Industry, along with secondary and technical schools, should advocate for and support registered and accredited apprenticeship programs to ensure an adequate supply of skilled industrial construction, operations, and maintenance workers.

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[18] ISO New England, Grid Resilience in Regional Transmission, Organizations and Independent System Operators. Response of ISO New England Inc. (Docket No. AD18-7- 000), https://www.iso-ne.com/static-assets/documents/2018/03/ad18-7_iso_response_to_grid_resilience.pdf.

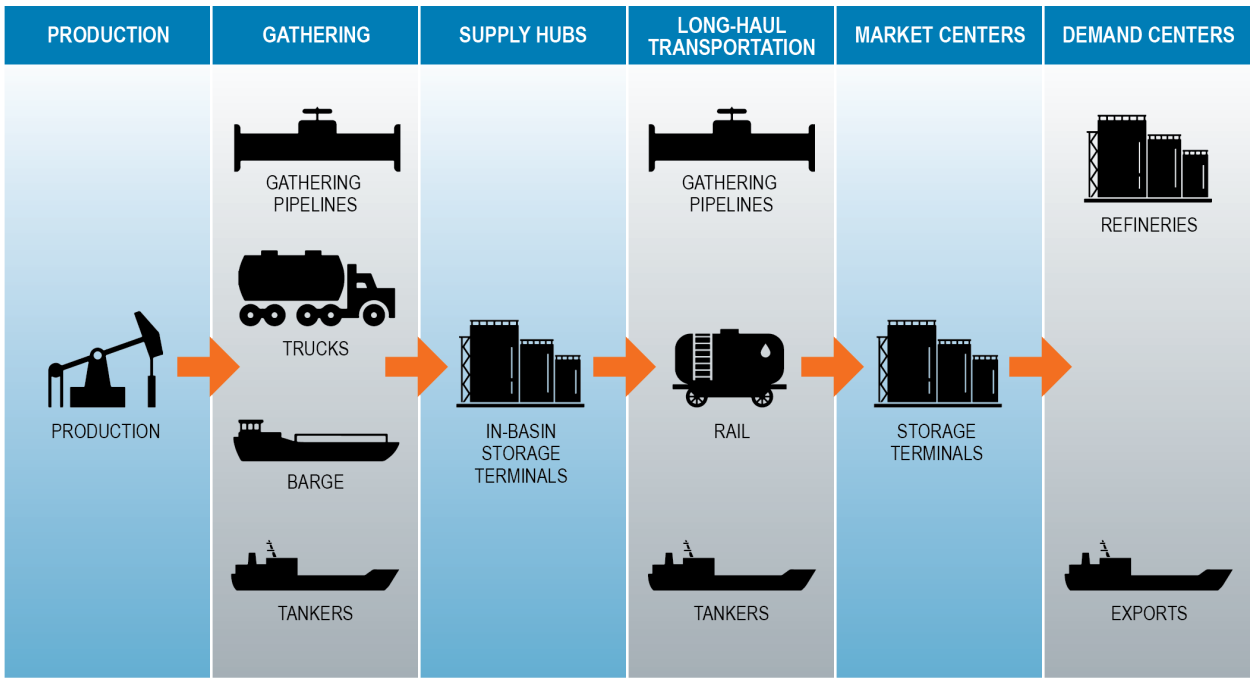
[19] This list is from a survey of public information and is not exhaustive.

VII. ENERGY SYSTEM RESILIENCY

Key Finding 8: An interdependent infrastructure system of pipeline, truck, rail, and marine transport working together with storage ensures the delivery of reliable and affordable energy.

A. Oil and Liquids Transportation

Crude oil and petroleum liquids have multiple options for transport from wellhead to consumer, as shown in Figure ES-13. Pipelines are typically the most economic option for moving large volumes of liquids over land. Railcars and trucks move smaller quantities, although they have much more flexibility in pickup and delivery options than pipelines. Nearly all retail gasoline and diesel make the final leg of their journey to retail stations by truck. Marine movement of liquids offers economical transportation between locations on inland and coastal waterways.



Source: Plains All American, adapted by NPC.

Figure ES-13. Liquids Transportation Options

B. Natural Gas Transportation

Within the United States, natural gas is primarily moved by a network of pipelines from the wellhead to the ultimate consumer. Natural gas pipelines can be divided into three general categories:

- Gathering lines – generally short, smaller-diameter pipelines carrying gas from individual wells to a central collection point for processing and transport.
- Transmission lines – generally long, large-diameter pipelines transporting gas from production areas to demand areas. Transmission pipelines are the focus of this study.
- Local distribution systems – generally short, smaller-diameter lines distributing gas to individual consumers within demand centers.

For import or export, natural gas can be liquefied to become LNG for transport by specialized ships. LNG can also be moved by special trucks and rail cars to domestic users, though the applications are specialized and the volumes are small compared to pipeline movements. A simplified view of natural gas distribution is shown in Figure ES-14.

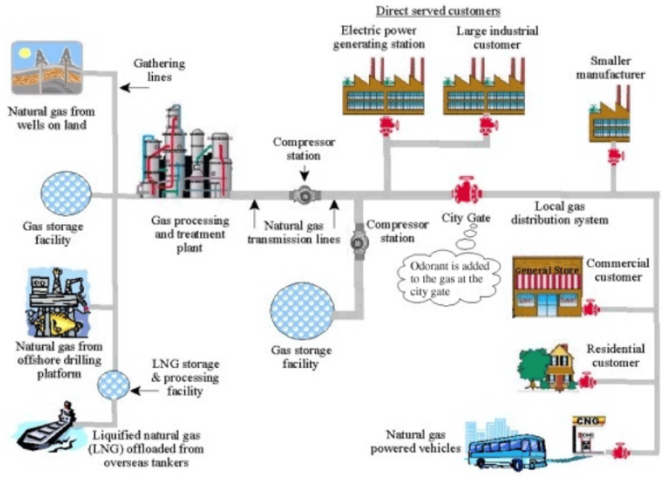


Figure ES-14. Natural Gas Transportation System
Source: Pipeline and Hazardous Materials Safety Administration.

Natural gas storage is a necessary part of the U.S. natural gas transmission and distribution system due to the large variations in seasonal demand. Generally, lower summer demand months provide an opportunity for operators to fill storage, allowing for natural gas to be withdrawn from storage to meet higher winter heating demand. Natural gas storage is primarily underground, in depleted oil and gas reservoirs and salt caverns.

C. Resiliency

Energy transportation resiliency is the ability of an infrastructure network to continue meeting demand even when portions of the network have been disrupted. Resiliency results from having multiple transportation and storage options, enabled by allowing the infrastructure to build and adapt to ever-changing supply and demand dynamics.

In connecting production to demand, resiliency can be provided in various ways:

Multiple Routes. An example would be two pipelines, one moving crude oil directly from West Texas to the Texas Gulf; and the other moving crude oil from West Texas to the large oil terminal in Cushing, Oklahoma, and joined to a pipeline moving crude oil from Cushing to the Texas Gulf. In the event of interruption to the first pipeline, crude oil supply could reach its destination via the second pipelines assuming the alternative pipelines have sufficient available capacity.

Multiple Modes. For the same example of crude oil moving from West Texas to the Texas Gulf, secondary modes could include rail, trucking, or a pipeline normally used for transporting a different commodity. In any of these cases, responsiveness can be expected to be slower than for a parallel infrastructure pathway of the primary mode, because a new supply chain must be established with time and cost involved in securing shipper commitments, building physical assets, and, in many cases, permitting.

Storage. Storage provides resiliency at production centers, market centers, and demand centers. Storage is also an indispensable component of an economically efficient energy distribution system. At demand centers, storage provides resiliency for consumer supply. Near the point of production, storage guards against having to shut in production should a problem occur with the transportation infrastructure. Since a short-term production shut-in can degrade the long-term performance of a well, producers have an incentive to plan for resilient offtake.

Throughout the United States, there are more than 2.3 billion barrels of storage capacity for crude oil and refined products at private bulk terminals and tank farms. Additionally, the U.S. Strategic Petroleum Reserve contained 645 million barrels of crude oil as of June 30, 2019, for deployment in the event of a disruption in global oil supply. There are 4.3 trillion cubic feet of company-owned underground storage capacity for natural gas, which provides storage during periods of low demand and is drawn down during periods of high demand.

VIII. COMPLEXITY OF THE PERMITTING PROCESS

Key Finding 9: Overlapping and duplicative regulatory requirements, inconsistencies across multiple federal and state agencies, and unnecessarily lengthy administrative procedures have created a complex and unpredictable permitting process.

A. Federal Requirements

Federal laws aimed at achieving interstate commerce, energy security, environmental protection, and human health and safety have evolved for more than a century. The Rivers and Harbors Act of 1899 is considered the nation's first environmental law, and with amendments since then, sets conditions for how oil and natural gas infrastructure can alter civil works along waterways built or maintained by the U.S. government. Congress passed the Natural Gas Act in 1938 to regulate the natural gas industry; now FERC uses authorities in the Natural Gas Act to oversee rates, permitting, construction, and operation of interstate natural gas pipelines.

The regulatory framework for oil and natural gas transportation infrastructure is also shaped by a series of environmental laws enacted in the 1970s, including the National Environmental Policy Act (NEPA) and Clean Air Act in 1970, the Clean Water Act in 1972, and the Endangered Species Act in 1973. These federal laws, along with at least 15 other federal and state laws, created processes for conducting reviews of infrastructure projects and federal standards for potential impacts of infrastructure development.

NEPA created a government-wide mandate to consider the environmental impacts of major agency decisions. The law directs all agencies of the federal government to evaluate:

> "(i) the environmental impact of the proposed action,
>
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
>
> (iii) alternatives to the proposed action,
>
> (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
>
> (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."[20]

[20] Sec. 102 [42 USC § 4332]

NEPA established the Council on Environmental Quality (CEQ) within the Executive Office of the President to ensure that federal agencies meet their obligations under NEPA. CEQ oversees NEPA implementation, principally through issuing guidance and interpreting regulations that implement NEPA's procedural requirements. CEQ also reviews and approves federal agency NEPA procedures, approves alternative arrangements for compliance with NEPA for emergencies, and helps to resolve disputes between federal agencies and with other governmental entities and members of the public. Each federal agency is required to develop NEPA procedures that implement the CEQ regulations. Federal agencies' NEPA procedures must meet the standards in the CEQ regulations while also reflecting each agency's unique mandate and mission. As a result, NEPA procedures vary from agency to agency, creating a potential for conflict.

Further procedural differences may arise from other statutory requirements, agency-specific regulations and guidance, and the extent to which federal agencies use NEPA analyses to satisfy other review requirements. These include environmental requirements under statutes such as the Endangered Species and National Historic Preservation Acts, the Executive Order on Environmental Justice, and other federal, state, tribal, and local laws and regulations. Figure ES-15 depicts the complexities of the NEPA process.

There have been several attempts over the years to improve the NEPA environmental review process. Over the past four decades, CEQ has issued numerous guidance documents but has amended its regulations substantively only once.

B. Permitting Challenges

NEPA has become a leading basis for challenging agency decisions affecting energy infrastructure. Despite Supreme Court precedent on key issues such as the purpose of NEPA and the limiting principles governing NEPA review, new NEPA interpretations by agencies and the courts, changes in CEQ guidance on NEPA interpretation, and updated CEQ NEPA regulations have led to legal challenges.

Courts continue to review NEPA-based challenges in litigation. In 2016, the various U.S. Courts of Appeals issued 27 decisions involving implementation of NEPA by federal agencies. The 27 cases involved 7 different departments and agencies. Overall, the federal agencies prevailed in 21 of the cases, partially prevailed in 3 cases, and did not prevail in 3 cases.

The uncertainty over the authoritative interpretation of NEPA delays permitting. The risk of litigation encourages agencies to expand their NEPA reviews as a defensive measure rather than to aid decision-making. CEQ has the authority to ensure that revisions to the implementing regulations address common issues that are frequently litigated.[21]

[21] From 2006 to 2016, the U.S. Courts of Appeals issued 238 decisions in NEPA cases. See National Association of Environmental Professionals NEPA Practice, Annual NEPA Report 2016 at 32. In 2016, the U.S. Courts of Appeal issued 27 decisions involving implementation of NEPA by federal agencies. FERC was involved in three of these cases. Although FERC was not the agency with the largest number of cases, FERC's three cases rank it high among agencies with NEPA cases in 2016. Since 2016, FERC has been involved in several notable NEPA decisions issued by U.S. Courts of Appeals. See, e.g., Sierra Club v. FERC, 867 F.3d 1357 (D.C. Cir. 2017); Delaware Riverkeeper Network v. FERC, 857 F.3d 388 (D.C. Cir. 2017); City of Boston Delegation, et al. v. FERC, Nos. 16-1081, et al. (D.C. Cir. July 27, 2018).

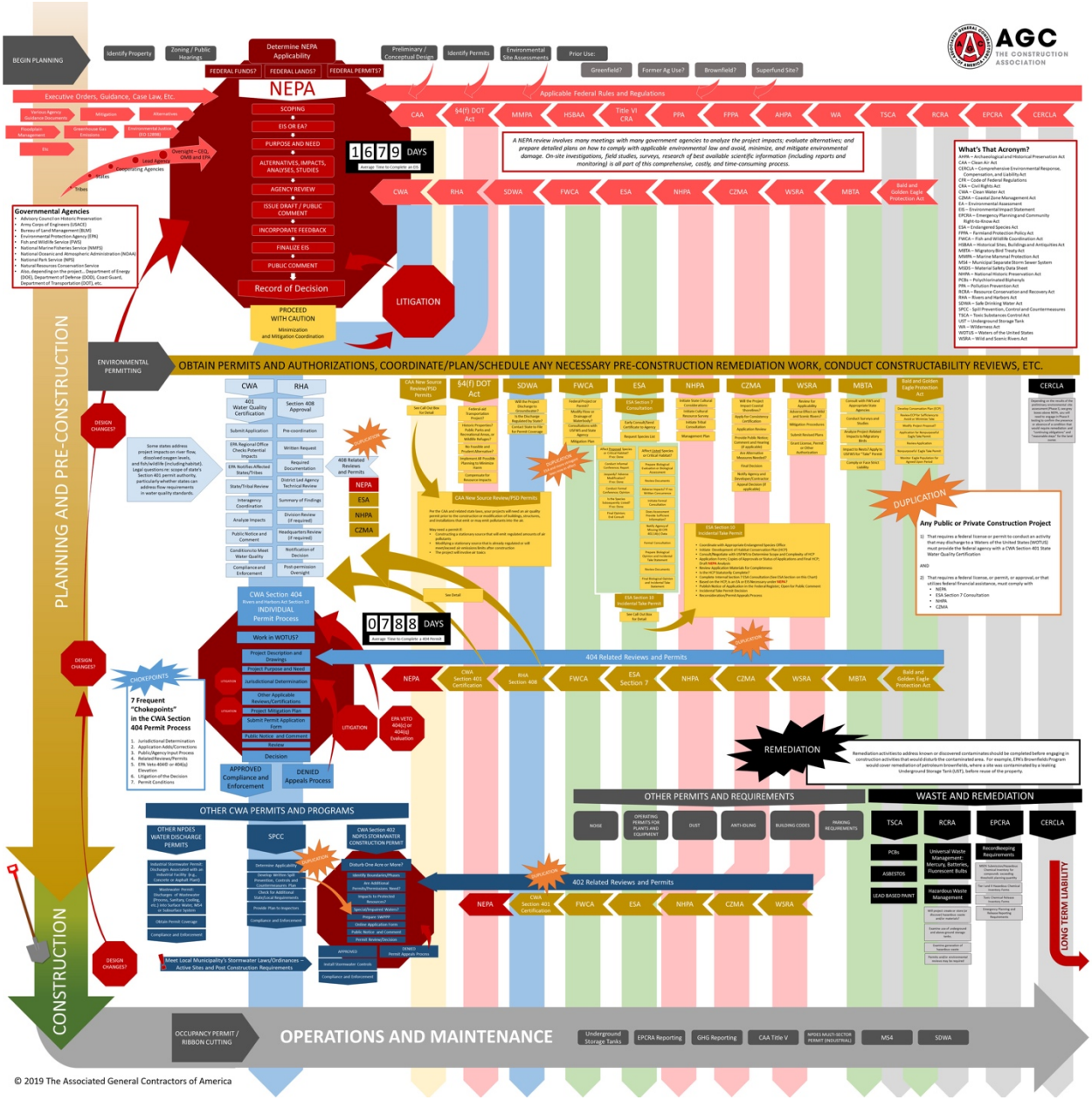


Figure ES-15. Depiction of a NEPA Permitting Process by the Associated General Contractors of America

Although originally expected to be concise, NEPA environmental assessments and environmental impact statements have grown in length and corresponding agency review time. Original NEPA regulations, which are still in effect, suggest that an environmental impact statement (EIS) "normally be less than 150 pages and for proposals of unusual scope or complexity shall normally be less than 300 pages" plus appendices. A 2019 CEQ study analyzed the length of all EISs in a recent 5-year period across all federal agencies. The study found that final EISs averaged 669 pages and final appendices

averaged more than 1,000 additional pages.[22] An EIS prepared in 2019 to modify existing intracoastal waterways, floodgates, and locks in Texas contained more than 2,600 pages and 27 appendices.[23] There is an opportunity for simplification of the EIS requirements.

C. State and Local Government Role

The states' role in regulating oil and natural gas infrastructure is defined by specific provisions in federal statutes that create requirements for consultation or that delegate federal authorities to the states. States' authority for some regulatory action also comes about by virtue of the absence of a national law, and states can enact their own policies and programs. State legal challenges and statewide ballots can also create development and operational uncertainties for developers and operators of energy infrastructure.

In addition to federal regulatory review of infrastructure projects and state exercise of federally delegated authority, state statutes and regulations apply to the permitting of infrastructure projects. Twenty states have promulgated state environmental policy acts (SEPAs). Furthermore, most other states have forms of environmental regulation and oversight that are substantive but not analogous to the federal NEPA. These SEPA statutes and regulations share a similar objective to NEPA but vary widely in their requirements and implementation, creating additional potential for conflict.

In some cases, a state will allow the federal NEPA review to substitute for completion of the state review. This process is similar to when federal agencies adopt a lead federal agency's NEPA analysis. In others, the federal and state reviews run concurrently, and the state agencies cannot issue any permits until their state review is completed. As a result, these state reviews can add time to a project schedule, and sequential or duplicative state reviews can create inefficient regulatory review.

The wide variation in state-level environmental statutes and regulations is a concern. Generally, states have adopted environmental policy acts that do not align with each other or with federal laws and regulation, and it is incumbent on operators to comply with such acts.

Permitting for interstate oil or liquids pipelines is governed primarily by the states. FERC is responsible for regulating rates, charges, and rules for transporting oil by pipeline under the Interstate Commerce Act (ICA), but the ICA does not mandate regulation of permitting, siting, or constructing these pipelines; that authority rests with the states. Individual states retain broad authority to permit and regulate oil pipelines for eminent domain, pollution control, and natural resource and environmental protections along any proposed route. An interstate oil pipeline must therefore obtain permits on a state-by-state basis, with processes and even government agency structures differing by state.

The role of local governments in regulating oil and natural gas transportation infrastructure differs from state to state depending on how much the state constitution or law delegates authority and how active the local government is in enacting relevant policies. Some states, such as Alaska and Pennsylvania, designate a lead agency for permit review; this is an efficient approach. State organizations and councils, such as the Environmental Council of the States and the Interstate Oil and Gas Compact Commission, which champion conservation and efficient recovery of oil and natural gas resources while

[22] Council on Environmental Quality, *Length of Environmental Impact Statements (2013-2017),* July 22, 2019, https://ceq.doe.gov/docs/nepa-practice/CEQ_EIS_Length_Report_2019-7-22.pdf. This document presents federal government-wide and agency-specific data but does not subdivide EISs by sector or project type.

[23] See Gulf Intracoastal Waterway, Brazos River Floodgates, and Colorado River Locks, Texas, EPA Environmental Impact Statement Database, accessed August 5, 2019.

protecting health, safety and the environment, are avenues to share regulatory best practices and efficient permitting regimes.

Counties and cities may pass local zoning or other ordinances to protect local citizens' safety and the environment. Since the local government provides the first level of response to emergencies, preparedness and response issues are important to local officials, and infrastructure operators partner with emergency response teams to address these concerns. Local ordinances that may overlap with federal and state law often relate to waters and wetlands crossings; for example, even the smallest municipalities may have zoning, conservation, or wetlands commissions, building officials, or a health officer that have been granted authority to issue local permits for activities that affect land and water resources.

Some local governments and states have been delaying or denying permits for projects intended to improve infrastructure that would provide their citizens with improved access to oil and natural gas products. States and local governments must abide by the federalism within the U.S. Constitution and Commerce Clause protections against impermissibly discriminating against or regulating interstate or foreign commerce.

D. U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) plays a large role in the permitting process, including coordination among governments, agencies, and companies. The agency's varied responsibilities include operation of more than 600 dams and 12,000 miles of inland navigation channels and maintenance of 926 harbors on coasts, the Great Lakes, inland waterways, and reservoir lakes. Today, the USACE has more than 20,000 employees at its headquarters in Washington, D.C. and 38 district offices.

The USACE has the authority to issue permits to discharge dredged or fill material into waters of the United States under Section 404 of the Clean Water Act. The USACE also has jurisdiction over structures or work in navigable waters of the United States under Section 10 of the Rivers and Harbors Act. If any activity could affect a federal project, such as a levee, dam, or navigation channel, permission from the USACE is required.

The USACE can issue general permits for activities that have minimal impacts provided certain conditions are met. Pipelines fall under one of these nationwide permits (NWP12); however, states can modify or supplement nationwide permits as they deem appropriate. Additionally, guidance from the 38 USACE district offices who do not share common implementation standards leads to inconsistent requirements and internal disagreements on policy, as well as disagreements with states. The result is that the nationwide permit program, intended to have a single, predictable set of standards, has variations and additional conditions.

The USACE, along with states, is also involved with Section 401 of the Clean Water Act (CWA) water quality certificates. CWA 401 regulates pollutant discharges into the waters of the United States and requires state certification of compliance with applicable water quality standards. Federal agencies may not issue permits for activities that could result in discharges into waters of the United States unless the state certifies that the activity will comply with state water quality standards or waives certification. Because states can condition their Section 401 water quality certificates or impose conditions on regional or other general permits to be issued by the USACE under Section 404, conditions can vary from state to state or within a water shed. As a result, there is no predictable nationwide set of standards.

In fiscal year 2018, the 38 USACE district offices issued 56,000 permits and finalized more than 76,000 permit-related activities. Its decentralized decision-making creates a high degree of subjectivity and little opportunity for administrative appeal up the chain of command.

The NPC recommends:

- States should consider utilizing the Environmental Council of the States' relationships with state officials and knowledge of the federal process, to facilitate a common agreement between federal and state jurisdictions when there are potential conflicts between a NEPA review and a SEPA review to avoid delay, confusion, and legal vulnerability.
- A national organization made up of state regulatory agencies, such as the Interstate Oil and Gas Compact Commission or the Environmental Council of the States, and representatives of local governments, communities, interested nongovernmental organizations (NGOs), and industry should collaborate to develop a model master structure for state permitting and coordination of approvals for infrastructure, to provide for efficient collaboration with operators and better coordination with federal agencies.
- States should adopt a single point of contact for permit coordination.
- The U.S. Army Corps of Engineers should:
  - Implement rulemaking to provide procedural consistency among nationwide permit programs, potentially requiring pre-application to identify Lead Districts, points of contact, and variations in requirements across watershed and political boundaries.
  - Continue working and implementing One Federal Decision process initiatives to improve the efficiencies of the USACE regulatory processes, including a lead district for projects crossing multiple districts and a single point of contact for One Federal Decision and any project crossing District boundaries.
  - Clarify when the pre-construction notifications requirements for use of NWP12 are required, e.g., when there are public water supply intakes downstream of the activity, or when the activity may affect listed species or officially designated critical habitat.
  - Implement consistent approaches to permit interpretation among its field offices to minimize variation of nationwide permit programs.

IX. PERMITTING IMPROVEMENT INITIATIVES

Key Finding 10: Bipartisan actions by Congress and the Executive Branch, including mechanisms to expedite the permitting process for large infrastructure projects, represent positive steps; however, further improvements are necessary.

In the past two decades, there have been multiple efforts to improve the regulatory process. In 2015, the Fixing America's Surface Transportation Act (FAST) was signed into law.[24] Title 41 of the FAST Act (FAST-41) created a new governance structure, a set of procedures, and funding authorities to improve the federal environmental review and permitting process for eligible infrastructure projects within the structure of existing federal environmental reviews and permits. FAST-41 promotes early consultation and enhanced interagency coordination through the development of a project-specific plan and deadlines

[24] The current administration has demonstrated its support for the FAST-41 process through Executive Order 13807, which called for the designation of cross-agency priority goals, use of the One Federal Decision Process, and coordination with the FAST-41 created Federal Permitting Improvement Steering Council. Executive Order 13807 (Aug. 15, 2017), https://www.energy.gov/nepa/downloads/eo-13807-establishing-discipline-and-accountability-environmental-review-and.

for completing environmental reviews and permits. Eligible projects' environmental review and permitting completion date targets are required to be posted online to track the status of federal permitting and reviews and improve coordination, transparency, and accountability.

FAST-41 provides new funding authority for governance, oversight, and processing. The Act established the Federal Permitting Improvement Steering Council (FPISC) composed of agency Deputy Secretary-level members and chaired by an executive director appointed by the President. FPISC oversees FAST-41 implementation, interagency coordination, and dispute resolution.

Further developments in the federal permitting processes come from several executive orders (EOs) issued to address specific issues. EO 13807 establishes an approach called One Federal Decision for use in evaluating major infrastructure projects. The goal of EO 13807 is for the federal government to make efficient and effective infrastructure decisions and to change the way federal agencies process environmental reviews and permit decisions. The EO states:

> "Inefficiencies in current infrastructure project decisions, including management of environmental reviews and permit decisions, have delayed infrastructure investments, increased project costs, and blocked the American people from enjoying improved infrastructure that would benefit our economy, society, and environment."

One Federal Decision requires the identification of a lead federal agency that will be responsible for navigating the project through the federal environmental review and permitting process. Involved federal agencies "shall all agree to a permitting timetable" and agencies shall record their individual decisions in a single record of decision, unless certain conditions specified in the EO apply. The EO also requires agencies to establish an accountability and tracking system to ensure that project review schedules are met, the guidance for which will be issued in consultation with the FPISC. The Federal Infrastructure Permitting Dashboard tracks the federal government's environmental review and permitting processes for covered major infrastructure projects.

More time is needed to tell whether these legislative and executive branch efforts to reform the permitting process will result in greater efficiency and certainty. However, the reforms are already improving the transparency of federal processes by requiring regular reports to Congress on progress and by creating dashboards that track the permitting process across agencies.

The NPC recommends:

- A federal agency should consult with FAST-41 project sponsors and other stakeholders to obtain feedback to improve FAST-41 before reauthorization.
- Congress should reauthorize FAST-41 for an additional 7 years and include the following improvements:
  - Expand FAST-41 to include eligibility for all federal energy infrastructure projects and continuing staffing of FPISC.
  - For federal permits or decisions delegated to the states (CZMA, CWA, CAA), states should be incentivized to comply with FAST-41 and One Federal Decision and make decisions in conjunction with federal NEPA process timeline.
  - FPISC should be leveraged to drive concurrent review by the states during federal permitting processes.
- Further reauthorizations by Congress of FAST-41 should consider eliminating sunset provisions.

X. STAKEHOLDER ENGAGEMENT

Key Finding 11: Successful infrastructure projects depend upon early, effective, and continuous stakeholder engagement and collaboration.

A critical element of successful siting and operation of energy infrastructure is productive engagement with all stakeholders. Throughout the history of infrastructure development, there have been episodes of successes and failures. Transparent and consistent land and right-of-way acquisition practices, sufficient communication about project implementation plans, and effective community engagement practices can help avoid project delays.

Stakeholders include individuals, state and local governments, and organizations that can affect or be affected by infrastructure development and operation. Private citizen stakeholders may include affected landowners, farmers and ranchers, small business owners, and local community leaders and individuals. States have their own environmental protection plans, and communities can have concerns about the impact of infrastructure on local culture or economies. Local and national public interest groups and NGOs advocate as stakeholders for a number of issues, including the environment, wildlife, historic preservation, and public safety. There is a wide range of NGOs, covering myriad concerns and interests, with diverse membership. Stakeholders also include federal, state, and local government officials, and even federal and state legislators.

Stakeholders regularly express concerns about the siting, permitting, construction, operation, maintenance, and abandonment of pipelines, rail, LNG facilities, and other facilities to transport and store oil, natural gas, and NGLs. Stakeholder concerns include safety, climate change, air and water quality, noise, traffic, wear and tear on roads and bridges, impacts on wildlife, environmental justice, loss of property use, eminent domain, historical and cultural preservation, promotion of local jobs and economic benefit, treaty rights, and protection of sacred sites. Companies and government should respond to these concerns, including emphasizing the construction, maintenance, and environmental protection measures to be taken.

The footprint of the oil and natural gas industry has experienced a period of significant growth in the past decade, some in areas that have not previously experienced development of large energy infrastructure projects. This has increased public awareness and heightened controversy over infrastructure projects, resulting in greater public involvement in the permitting process.

Regulatory processes at all levels of government provide opportunities for stakeholders to provide input to the permitting process, recognizing the importance of public involvement in and transparency of regulatory decisions. Stakeholder acceptance can influence if a project goes forward or gets delayed. Agencies and project developers typically develop proactive strategies for identifying and communicating with stakeholders to educate them on the details of the project, alert them on where and how to participate in the process, and understand and address their concerns early.

A. American Indian and Alaska Native Tribes

The sovereign nation status of American Indians, Alaska Natives, and Native Hawaiians (tribes) is constitutionally recognized, with Congress having the power to regulate commerce with foreign nations, among the several states, and with the tribes. Tribal governments may enact their own regulations to protect tribal members and lands, although Congress has the ultimate authority to enact laws concerning tribes. The federal government has an obligation to consult with tribes on a government-to-government basis in implementing those laws as they relate to tribal lands and people.

Tribes have interests in the development of energy infrastructure on tribal lands, not only in protecting their land, water, treaty rights, and sacred sites, but also in sharing in the economic benefits of new infrastructure. Any decisions with implications for tribes, such as the siting of infrastructure, must be made in consultation with the affected tribe.

CEQ regulations for implementing NEPA require agencies to consult with tribes during the preparation of environmental reviews. Section 106 of the National Historic Preservation Act concerning historic, religious, or culturally important sites requires consultation when activities will occur on historic properties either on or off tribal lands. Federal agencies have developed extensive regulations and guidelines, although different at each agency, for meaningful consultation. Now that some federal agencies have created more effective stakeholder engagement protocols, tribes are using the federal courts to enforce them. This provides tribes an opportunity to delay energy infrastructure projects if tribes feel their interests have not been considered in the siting and permitting process.

B. Community Engagement

Effective community engagement to develop and maintain public support helps a company engender customer loyalty, keeps employees in tune with stakeholder priorities, and educates regulators and communities on performance and compliance. Lack of community engagement can result in negative public input to the regulatory agency, protests, or litigation to challenge an agency decision. Public support is influenced by the company's approach to and quality of interaction with stakeholders. Judgments are made more quickly and spread more rapidly than ever before with the plethora of social media and viral videos that can be instantly uploaded and distributed globally.

The public's perception of an energy company and how it operates, both within and outside of the community, can lead to either acceptance and approval or ongoing controversy and conflict. In the energy industry, one energy company's behavior can influence the public's perception of the entire industry. If one company does not take local community and stakeholder concerns and issues seriously and does not address them honestly and expeditiously, that company's missteps influence public opinion for all companies within the energy industry, including infrastructure providers.

Many companies have demonstrated models of successful best practices for community engagement. These companies seek to understand and respect the culture, norms, and concerns of each local community, communicate with local stakeholders effectively by tailoring their methods to the unique needs of their local audiences, and validate stakeholder concerns through respect and empathy. The desired goal of best practices for community engagement is to create an environment in which trust exists and the community comes to support and even promote the infrastructure development.

Many landowners are concerned about the loss of the use of their property, just compensation, and the degree of land restoration after the project is complete. Restoration is an important and often

overlooked element of landowner agreements and is an opportunity for an infrastructure company to create goodwill with stakeholders.

Industry and all levels of government agencies should inform stakeholders from the earliest engagement on planned safety and environmental measures. These measures frequently exceed those imposed on operators by federal and state regulations. Most infrastructure operators understand that compliance with regulations is a baseline expectation and that a culture focused on "performance beyond compliance" is necessary to engender public trust. Industry must maintain the infrastructure and operate safely.

The NPC recommends:

- Infrastructure companies should:
  - Implement existing best practices (e.g., FERC, INGAA, API, AOPL) for early and effective engagement with local governments, communities, private citizens, public interest groups, and American Indian and Alaska Native Tribes to understand and address stakeholder concerns. Infrastructure companies should strive to incorporate stakeholder input into a proposed action wherever practicable and collaborate on finding solutions or conveying reasons in those circumstances where an interest is difficult to accommodate.
  - Engage in educational and awareness efforts with communities and stakeholders to increase understanding of the need for infrastructure, the steps to be taken to construct and operate it safely, and how they will be engaged throughout the siting and development process.
  - Work collectively toward more effective engagement practices regarding energy, environmental, and related public policies that encourage responsible energy development and transport.

XI. PERMITTING AND CLIMATE CHANGE

Key Finding 12: The nation faces the dual challenge of providing affordable energy to support economic growth and human prosperity while addressing the environmental effects including the risks of climate change. Industry shares the public's concerns that climate change is a serious issue that must be addressed. Litigation of individual projects to address climate concerns is an ineffective approach.

Climate change concerns have substantially increased since the 1992 UN Framework Convention on Climate Change, which stated that addressing climate concerns requires "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system…". Since then, increasing numbers of companies and organizations and a significant portion of the public have developed concerns about climate change and the need for effective measures to reduce greenhouse gas emissions.

The fourth U.S. National Climate Assessment, released in 2018, notes that U.S. greenhouse gas emissions have been declining as a result of changes in the energy sector and policy actions across all levels of government and also notes, "While mitigation and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, and human health over the coming decades."

The 2019 EIA Annual Energy Outlook projects that U.S. economy-wide carbon emissions will essentially stay flat through 2050 under existing policies. That level is substantially above the levels of emissions contemplated by various emissions reductions scenarios to avoid the negative impacts of climate change.[25]

The United States has been a global leader in CO_2 reductions with the largest total tonnes of reduction since 2005,[26] primarily as a result of the economic fuel switching from carbon intensive fuels to the less carbon intensive natural gas, mostly in power generation. Natural gas also supports the expansion of intermittent renewable power generation. Moreover, energy companies have taken multiple collaborative actions and set up public-private programs to address greenhouse gases, including reducing greenhouse gases from the operation of energy infrastructure, funding and leading research to abate greenhouse gases, advancing technology deployment, and improving transparency of actions to address emissions. In recent years, much of industry has worked in concert with the government and advocates on programs to reduce greenhouse gas emissions from oil and natural gas infrastructure. Reducing methane emissions across the natural gas value chain further improves the greenhouse gas reduction benefit of fuel switching to natural gas.

The NPC recommends:

- All infrastructure companies should strive for an outstanding environmental compliance record and to reduce the intensity of greenhouse gas emissions from their operations. Emissions reduction programs, such as One Future, The Methane Challenge, The Environmental Partnership, and Environmental Protection Agency's (EPA's) Natural Gas Star Program are all means of demonstrating a company's efforts to reduce methane emissions.

Key Finding 13: The permitting and construction of numerous energy infrastructure projects has been challenged, delayed, or stopped as a result of litigation by stakeholders concerned about climate change and the associated policy debate.

Stakeholders are increasingly raising climate change concerns and the need for governmental action to address greenhouse gas emissions in the siting and permitting processes for new energy infrastructure. Comments filed by citizens in opposition to many infrastructure projects suggest that many who contest new infrastructure do so out of the belief that the nation will not take other effective measures to achieve greenhouse gas emissions reductions.

A 2019 study found NEPA to be the most frequent statutory basis for litigation against natural gas and oil pipelines.[27] For pipeline projects, the most frequently claimed NEPA errors have been insufficient analysis of direct and indirect effects and insufficient review of upstream greenhouse gases, downstream greenhouse gases, and cumulative impacts. Federal agencies' NEPA reviews are typically thorough and generally upheld—agencies have a more than 80% success rate in litigation. Although FERC is not the

[25] IEA World Energy Outlook 2018, p 537, Annex A Tables for Scenario Projections, United States: Current Policies and Sustainable Development Scenarios

[26] BP Statistical Review of Energy 2019. The U.S. reduced emissions 706 million metric tonnes per year in 2018 versus 2005. The second largest reduction was the United Kingdom at 182 million tonnes per year. On a percentage basis, the U.S. had the third largest reduction of the 10 largest 2005 emitters, behind the U.K and Italy.

[27] Analysis by ClearView Energy Partners, LLC, based on court data through July 12, 2019.

agency with the largest number of cases, it ranks high among agencies with NEPA cases and in recent years has had mixed results.

The main NEPA interpretation issue in the litigation is whether FERC, in assessing the environmental impacts of a particular project, must include (1) greenhouse gas emissions upstream of a project, from an increase of production to support an infrastructure project, or (2) emissions downstream of a project, from the use of the fuel transported by the energy infrastructure. The legal dispute is whether these emissions are or are not reasonably foreseeable and causally related to the project. This dispute can lead to costly and time-consuming litigation over the environmental review of infrastructure projects. Litigation consumes public and private resources, can delay the construction, maintenance, and operation of sited and approved projects, creates uncertainty for communities and project developers, and can reduce the resiliency of U.S. energy infrastructure.

The lack of specific guidance or regulations under NEPA for agencies to make this greenhouse gas assessment in their review of energy infrastructure projects results in uncertainty and confusion in the evaluation to be conducted. The NEPA statute and regulations are not well suited for evaluating the relative significance of the environmental impact caused by an individual project's greenhouse gas emissions in a national or regional context, particularly due to the global aspects of climate change. The lack of clarity on conducting emissions evaluations creates uncertainty for both the regulated community and regulators alike.

Congressional action adopting a comprehensive policy to reduce economy-wide greenhouse gas emissions could help alleviate the concerns of environmental stakeholders, thus minimizing the need for litigation as a forum for addressing their climate concerns and the delays to the construction, operations, and maintenance of infrastructure. The patchwork of local, state, regional, and sector-specific greenhouse gas policies is affecting the resiliency of the national energy infrastructure and leads to inefficiencies in meeting the dual challenge of supplying affordable and reliable energy to the nation while reducing greenhouse gas emissions. Defining by law the appropriate environmental review process would limit the scope of legal challenges by clarifying what should or should not be included in a NEPA greenhouse gas assessment.

While some opponents do not see a path forward that allows for both new oil and natural gas infrastructure and national measures to mitigate the impacts of climate change, others would support new oil and natural gas infrastructure if the nation adopts policies to reduce greenhouse gas emissions

Concurrent Congressional action to reduce carbon emissions across the economy and to address how greenhouse gas emissions are treated within the siting and permitting process would both greatly improve the permitting certainty of energy transportation infrastructure and set the nation on a course to simultaneously address climate change concerns.

Beyond voluntary measures, economists generally agree that a market-based approach is a much more economically efficient way of reducing CO_2 emissions than inflexible standards and mandates or subsidies. A well-designed pricing system would be an efficient way to build upon the emission reductions that have occurred over the past decade as a result of the market, technology, and policy changes that drove the U.S. energy renaissance.

The NPC recommends:

- Congress should:
  - Clarify that greenhouse gas assessments under NEPA, for oil and natural gas infrastructure projects, are confined to emissions that are (1) proximately caused by the federal action (see

Department of Transportation v. Public Citizen, 541 U.S. 752 (2004)), and (2) are reasonably foreseeable.

- Enact a comprehensive national policy to reduce greenhouse gas emissions and seek to harmonize federal, state, and sectoral policies to enhance efficiency and effectiveness. Congress should ensure that the enacted national policy is economy wide, applicable to all sources of emissions, market-based, transparent, predictable, technology agnostic, and internationally competitive.

XII. TECHNOLOGY ADVANCEMENTS TO IMPROVE TRANSPORTATION SAFETY

Key Finding 14: Crude oil, petroleum products, and natural gas moved by the nation's infrastructure reach their destinations with a high degree of safety, resiliency, and environmental performance. However, incidents have occurred, and oil and gas companies are committed to continuous improvement.

Oil and natural gas transportation companies have improved their performance over time in delivering its products with safety and environmental care and are committed to continuing to improve safety and environmental performance across every mode of transportation. Transportation of crude oil, petroleum products, and natural gas is performed with a high degree of safety, reliability, and environmental performance. More than 99.999% of volumes safely reach their destination. In addition, oil and natural gas transportation companies focus on workplace safety and achieve safety results better than most industries. However, incidents have occurred, and companies are committed to the elimination of such incidents. Analysis shows that the majority of incidents result in part from human and organizational factors. Strengthening safety management systems, advancing and deploying technologies, and creating a more adaptive and performance-based regulatory framework could accelerate safety performance improvements.

A. Oil and Natural Gas Pipelines

Liquid pipeline incidents impacting people or the environment have declined by 20% in the past 5 years, while pipeline mileage has grown by 12% in the same period. Natural gas transmission pipeline incidents have been reduced by 17% in the past 5 years, while pipeline capacity has increased through modifications to the existing network. Natural gas transportation volumes since 1990 have increased by more than 40%, while in the same time frame, pipeline transportation and storage facilities have reduced methane emissions by 43%.

The primary reasons for recent improvement of pipeline safety and environmental performance are technology advancements in leak detection systems and pipeline inspection technologies, coupled with industry's implementation of safety management systems. These management systems focus on both preventative and mitigating safeguards, as shown in Figure ES-16.

Technology advancements have included a focus on in-line pipeline inspection capability to more reliably identify cracks and corrosion for proactive repair. Pipe inspection technologies are now capable of identifying defects that were not previously detectable. Leak detection technologies and programs have advanced to improve detection accuracies. Improved surveillance technology provides advance warning of external operations integrity concerns, such as geological hazards (e.g., land movement, washout from flooding) or encroachments in pipeline right-of-way easements. Emphasis has also been placed on improving the sensitivity of leak detection systems for more rapid response to mitigate public and environmental impact in the event of a loss-of-containment incident. Examples of pipeline integrity technologies are shown in Figure ES-17.

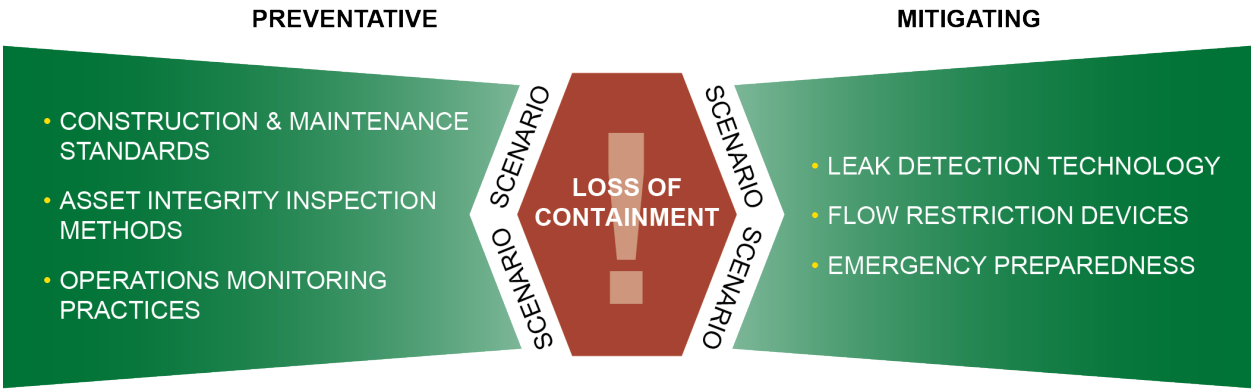


Figure ES-16. Key Safeguards for Managing Pipeline Integrity

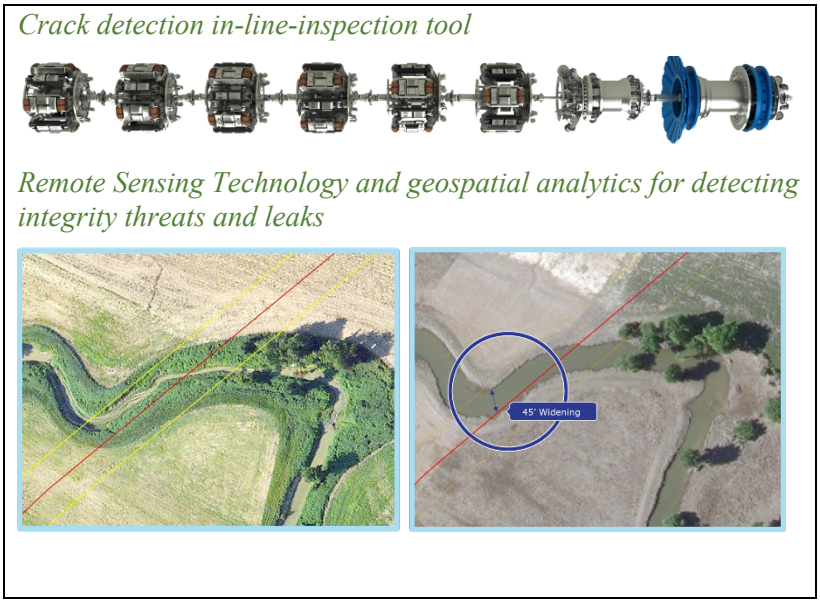


Figure ES-17. Examples of Pipeline Integrity Technologies
Sources: Baker Hughes Company and Satelytics Company.

Opportunities also exist in advancing and deploying data analysis technologies that offer the potential to identify multiple threats in a predictive and timely manner. A key challenge is applying sophisticated analytics to translate inspection and sensor data into actionable insights.

The oil and natural gas transportation industry shares with the public and environmental agencies a desire to continue reducing emissions of methane, which is the main component of natural gas. Advancements in new technology, consistent implementation of best practices, and revisions to regulations are important to help accelerate the adoption of new technologies to achieve additional reductions in methane emissions. The best opportunities to reduce methane emissions from the natural gas

pipeline sector are reducing compressor station leaks, decreasing uncombusted fuel in reciprocating engine exhaust, and reducing pipeline blowdowns.[28]

B. Underground Natural Gas and Gas Liquids Storage Facilities

Important aspects of safely operating underground storage include: (1) well, reservoir, and cavern integrity, (2) natural gas inventory control, and (3) maintaining and monitoring well, reservoir, and cavern performance. Identifying deterioration in well casing and the cement surrounding the casing is critical to maintaining well integrity. Additional downhole casing inspection tools capable of analyzing multiple casing strings and the cement behind the casing help identify potential issues before they become a problem. Companies are pursuing research and testing in these areas to further improve safety and environmental performance, including development of coatings, treatments, cements, and other materials that could be used to make new and existing wells more durable under typical operation conditions.

C. LNG Shipping and Terminals

LNG has been commercially produced, stored, and transported in the United States to meet customers' winter needs since the 1960s. The United States safely exported LNG from Alaska for decades. Since its inception, the LNG shipping industry has operated without loss of LNG containment from a marine vessel.

LNG storage tanks are unique in that they have multiple layers of structural elements together with different types of insulating materials to maintain cryogenic conditions. The regulations that govern the design and operations of domestic LNG terminals and storage facilities have served the U.S. market well. Considering expected growth of the LNG export business, it is prudent to reexamine and update these regulations to better address the development of world-class LNG liquefaction and export facilities in the United States.

Port rules and regulations related to LNG traffic management include limits on the size and type of LNG carriers allowed to call, establishment of safety and security zones around the vessel, the possible imposition of night-only transits into and out of port, as well as other conditions. Regulations should be aligned with the best operating standards employed by the worldwide LNG industry and based on risk analyses.

D. Marine

Marine companies have made continued improvements in vessel safety and environmental performance. The volume of oil spilled from tankers and barges in the U.S. Coast Guard's jurisdiction has declined over the past decade. Improvements are largely attributed to companies' adoption of formal management systems, commitment to operating excellence, and improvements in international maritime safety standards. Human factors are the leading cause of marine navigational accidents.

An opportunity for further improvement is to strengthen navigational technologies that can better inform vessel captains of approaching hazards and accident threats so that they can take proactive measures to avoid accidents. Advancements in route planning, integrated navigational system technologies, mapping, and detection technologies offer the potential for maximizing channel capacity while making marine operations even safer. Training of personnel and updating of management systems

[28] Pipeline blowdown entails the planned venting of gas to depressurize a pipeline segment for repair, integrity testing, or for new pipeline connections.

will be essential to effective adoption of new technologies. An example of a marine navigation training simulator is shown in Figure ES-18.

Figure ES-18. Marine Training Simulator
Source: Wärtsilä Corporation

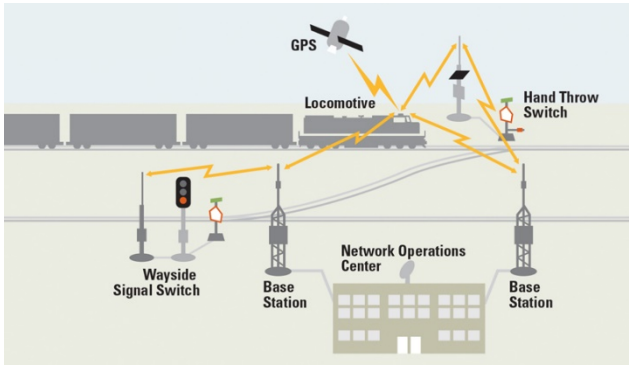
E. Rail

The U.S. rail industry has a long history of safely transporting hazardous commodities. Federal Railroad Administration safety statistics show that train accidents have declined by 37% since 2000.

Rail companies are focusing on addressing the leading causes of accidents: track, equipment, and human error. Track and equipment-related safety can be improved by aggressively implementing defect detection technologies. These state-of-the-art systems can improve flaw detection through the use of various ultrasonic, laser, optical, and infrared technologies. Equipment-related improvements will be supported by enhanced tank car standards promulgated by the Pipeline and Hazardous Materials Safety Administration in 2015. These updated standards require new and retrofitted tank cars to meet strict design specifications, which will translate into a 50% to 70% lower probability of release in the event of a train accident.

Additionally, the Rail Safety Improvement Act of 2008 mandated implementation of positive train control (PTC) technology, which is designed to reduce incidents caused by human error. This technology is designed to prevent train-to-train collisions, derailments caused by excessive speed, and the movement of a train on the wrong track due to a track switch left in the wrong position. Implementation of PTC technology is underway throughout the industry and is expected to be complete in 2020. Examples of rail safety technologies are shown in Figure ES-19.

Positive Train Control



Track Geometry Defect Detection

Figure ES-19. Examples of Rail Safety Technologies
Source: BNSF.

F. Trucking

Trucking provides the most flexible means of transporting oil products because it can mobilize on short notice and go where other transport options are not available. Commercial trucking safety performance improvements may be realized through deploying recently proven collision-avoidance technologies. According to a 2017 study by AAA Foundation for Traffic Safety, approximately 90% of all accidents result from driver error. Anecdotal evidence from companies that have installed advanced collision-avoidance technologies shows that they can reduce at-fault crashes by more than 50%. These technologies provide valuable alerts and responses to help reduce forward collisions and lane departures, intervene to prevent fatigue-related distracted driving, and record incidents and near-miss driving information to improve driver training and competency assurance.

Data sharing across industry and government stakeholders may support collision-avoidance investments, thus accelerating deployment and implementation. In addition, it will take time for the existing trucking fleet to convert to new trucks.

Key Finding 15: Advancements in new technologies have been an important contributor to industry's safety, reliability, and environmental performance. Overcoming challenges and barriers to new technology development and deployment would accelerate these improvements.

A strong collaborative framework for research programs across the Department of Transportation, the Department of Energy, and industry is necessary to ensure that the highest priority needs for new safety technology are funded and supported throughout the entire technology development cycle. Without this collaboration, new technologies can fail to complete sufficient field validation to gain market acceptance. In addition, federal agencies need the flexibility to adopt updated standards as a result of technology advances. Regulations need to keep up with technical developments.

Companies face challenges with respect to research, development, commercialization, and adoption of new technologies. The inherent challenges to deploying new technologies include time and cost to develop and deploy, adequate acceptance testing, and regulatory impediments. Most of these challenges translate into higher risks, costs, and uncertainty in the benefit-cost evaluation of new technology investments. These challenges can be overcome with the proper level of collaboration among government and industry organizations and from a regulatory framework that promotes the use of advanced technologies to help enable continued improvements in safety and environmental performance.

More efficient pathways for field testing new technologies could reduce deployment time and accelerate quality and reliability improvements. Prescriptive, rules-based regulations, which can lock in old technology solutions and be slow to adopt more effective and often less costly practices, can stifle rather than foster innovation. For example, technology demonstrations of in-line inspection technologies for use in pipeline integrity management programs should be treated as trial runs as long as all other compliance programs remain in place, and not be subject to prescriptive repair requirements while the technology accuracy is still being proven. Advancements of in-line inspection technologies can now identify smaller defects than previously possible. Through engineering assessment processes, some of these smaller defects can be proven not to be a risk to the integrity of the pipeline; however, prescriptive regulations can require actions that are not needed for continued safe operation, such as repairing minor defects regardless of risk. Performance-based regulations where appropriate may provide technology developers and industry operators additional opportunity to continue to drive improvements in safety performance and operational integrity.

Investment in R&D is occurring across the oil and natural gas transportation industry. Research investments by individual operating companies, research consortiums, or suppliers can be limited by competing priorities, slowing the developmental timeline leading to widescale adoption by industry. Strong investment levels are necessary from across the industry to accelerate technology innovations that provide promising opportunities for industry-wide improvements in safety, security, and environmental protection.

The NPC recommends:

- While working with DOE, EPA, and the U.S. Coast Guard, Department of Transportation (DOT) should lead creation of an agile pathway for evaluation and regulatory acceptance of new technologies that can improve transportation safety and shorten the research, deployment, and adoption cycle time.
- Congress should authorize DOT to lead a collaborative effort, with support from industry, to develop and prioritize pilot programs that can accelerate pipeline, storage, and LNG technology adoption based on performance-based rules with a goal of enhancing public safety. Upon successful

completion of pilot programs, regulators should promptly update their regulations to allow use of new technology.

- Oil and natural gas transportation companies should establish a collaborative effort with participation from DOT, DOE, EPA, and industry research consortiums to prioritize promising, risk-based research opportunities, establish consistent technical readiness processes, and prioritize field validation testing needs.
- FERC and state regulatory agencies should work with DOT, DOE, and others to promote laws, regulations, and public-private partnerships that support cost recovery for natural gas and oil pipeline safety research.

XIII. CYBERSECURITY

Key Finding 16: Cyber threats to energy infrastructure control systems are increasing and security protections are being challenged due to increasing connectivity and growing malicious cyber activity.

Over the past 20 years, growth in internet access and the proliferation of internet-connected devices and systems have enabled real-time access to large amounts of data to elevate productivity, obtain efficiencies, and make informed decisions across all major industries. This extraordinary level of connectivity has also introduced progressively greater cyber challenges to the energy distribution system due to the increased connection of business information technology networks with operational technology (OT) systems. The growing number of connected devices within OT systems and the further reliance on global supply chains has complicated the risk of exposure. Long-standing threats have evolved as nation-states, terrorists, individual criminals, transnational criminal organizations, and other malicious actors move their activities into the digital world. Motivations include espionage, political and ideological interests, and financial gain.

In March 2015, the Department of Homeland Security (DHS) issued a report listing the energy sector, which includes electrical power and transmission, nuclear, and oil and natural gas, as one of the U.S. sectors most under threat of cyberattacks. In December 2015, Russian hackers triggered outages at three Ukrainian utilities, resulting in hundreds of thousands of customers losing electricity service. This attack spread around the world, costing companies $11 billion in economic losses worldwide.[29] In 2017, an unplanned shutdown of a plant in the Middle East was caused by malware designed to attack safety instrument systems. The impact was contained due to a programming error within the malicious code, and two systems within the refinery entered a failsafe mode.[30] There have been no reported cyberattacks on energy OT systems in the United States that have resulted in significant safety incidents or disruption of energy supplies.

This report does not address the cybersecurity threats relating to business information systems. Business systems and OT systems have very different goals and risk profiles. Business systems focus on financial or other informational aspects and enable broad connectivity; OT systems are dedicated to maintaining safe and reliable operation of industrial systems and typically have less connectivity and

[29] U.S. Department of Homeland Security, CISI, ICS Alert, *Cyber-Attack Against Ukrainian Critical Infrastructure,* last revised August 23, 2018, https://www.us-cert.gov/ics/alerts/IR-ALERT-H-16-056-01
[30] U.S. Department of Homeland Security, *Energy Sector-Specific Plan,* 2015, https://www.dhs.gov/sites/default/files/publications/nipp-ssp-energy-2015-508.pdf

fewer access points. However, OT system connectivity is increasing with new sensors and control devices provided by multiple vendors and broader deployment of increasingly integrated control systems.

Industry has measures in place to identify and mitigate risks to health, safety, and the environment. However, the adoption of increasingly interconnected digital systems is introducing cyberattack vulnerabilities that could lead to security risks not predicted by traditional safety analysis methods. Stakeholder support of efforts to improve digital security through technological innovation as well as adoption of improved operational and policy frameworks will strengthen cybersecurity defenses. Partnerships between information technology groups, communications providers, cybersecurity services, industry operators, and government entities are essential to strengthen cybersecurity and enable outcomes to minimize vulnerabilities and supply chain risks.

DOE and FERC cohosted a Security Investments for Energy Infrastructure Technical Conference in 2019 to discuss current cyber and physical security practices used to protect energy infrastructure and how federal and state authorities can provide incentives and cost recovery for security investments, particularly the electric and natural gas sectors. FERC reaffirmed that its 2001 Policy on "Extraordinary Expenditures Necessary to Safeguard National Energy Supplies" supports cybersecurity investment and flexibility for pipeline companies to address cost recovery.

Companies are continuing to adopt risk-management cybersecurity frameworks. The private and public sectors are collaborating to align and improve cybersecurity frameworks and responses to cybersecurity incidents. Expanding adoption of risk-management frameworks is important to improve protection from cybersecurity threats. Performance-based standards will allow for more rapid and efficient adoption of new practices that are largely driven by technological advancement, emergence of new threat actors, and the resulting risk landscape.

The NPC recommends:

- Cybersecurity protections should be advanced through:
  - Industry, in collaboration with trade associations and federal government agencies, should adopt and maintain up-to-date performance-based Cyber Security Management Standards.
  - Increased DHS and DOE capabilities and resources to support independent and secure cyber security assessments and audits prioritized on critical infrastructure.
  - DOE, working with industry, DOD, DHS, and DOT, to establish a collaborative process to identify and prioritize research and development aimed at sector-wide protection against nation-state and advanced persistent threat actors.

XIV. SUMMARY OF EXECUTIVE SUMMARY RECOMMENDATIONS

The National Petroleum Council recommends the following:

Increase the Efficiency, Effectiveness, and Predictability of the Permitting Processes for Siting, Construction, Operation, and Maintenance of Infrastructure Projects

- Congress should:
  - Clarify that greenhouse gas assessments under NEPA, for oil and natural gas infrastructure projects, are confined to emissions that are (1) proximately caused by the federal action (see

Dep't. of Transportation v. Public Citizen, 541 U.S. 752 (2004)), and (2) are reasonably foreseeable.

  - Enact a comprehensive national policy to reduce greenhouse gas emissions and seek to harmonize federal, state, and sectoral policies to enhance efficiency and effectiveness. Congress should ensure that the enacted national policy is economy wide, applicable to all sources of emissions, market-based, transparent, predictable, technology agnostic, and internationally competitive.

- States should consider utilizing the Environmental Council of the States relationships with state officials and knowledge of the federal process, to facilitate a common agreement between federal and state jurisdictions when there are potential conflicts between a NEPA review and a SEPA review to avoid delay, confusion, and legal vulnerability.
- Industry, a national organization made up of state regulatory agencies such as the Interstate Oil and Gas Compact Commission or the Environmental Council of the States, and representatives of local governments, communities, and interested nongovernmental organizations should collaborate to develop a model master structure for state permitting and coordination of approvals for infrastructure, to provide for efficient collaboration with operators and better coordination with federal agencies.
- States should adopt a single point of contact for permit coordination.
- The U.S. Army Corps of Engineers should:
  - Implement rulemaking to provide procedural consistency among nationwide permit programs, potentially requiring pre-application to identify Lead Districts, points of contact, and variations in requirements across watershed and political boundaries.
  - Continue working and implementing One Federal Decision process initiatives to improve the efficiencies of the USACE regulatory processes, including a lead district for projects crossing multiple districts and a single point of contact for One Federal Decision and any project crossing District boundaries.
  - Clarify when the pre-construction notifications requirements for use of NWP12 are required, e.g., when there are public water supply intakes downstream of the activity, or when the activity may affect listed species or officially designated critical habitat.
  - Implement consistent approaches to permit interpretation among its field offices to minimize variation of nationwide permit programs.

Enhance Recent Regulatory Reform Efforts

- A federal agency should consult with FAST-41 project sponsors and other stakeholders to obtain feedback to improve FAST-41 before reauthorization.
- Congress should reauthorize FAST-41 for an additional 7 years and include the following improvements:
  - Expand FAST-41 to include eligibility for all federal energy infrastructure projects and continuing staffing of FPISC.

  - For federal permits or decisions delegated to the states (CZMA, CWA, CAA), states should be incentivized to comply with FAST-41 and One Federal Decision and make decisions in conjunction with federal NEPA process timeline.
  - FPISC should be leveraged to drive concurrent review by the states during federal permitting processes.
- Further reauthorizations by Congress of FAST-41 should consider eliminating sunset provisions.

Improve Stakeholder Engagement

- Infrastructure companies should:
  - Implement existing best practices (e.g., FERC, INGAA, API, AOPL) for early and effective engagement with local governments, communities, private citizens, public interest groups, and American Indian and Alaska Native Tribes to understand and address stakeholder concerns. Infrastructure companies should strive to incorporate stakeholder input into a proposed action wherever practicable and collaborate on finding solutions or conveying reasons in those circumstances where an interest is difficult to accommodate.
  - Engage in educational and awareness efforts with communities and stakeholders to increase understanding of the need for infrastructure, the steps to be taken to construct and operate it safely, and how they will be engaged throughout the siting and development process.
  - Work collectively toward more effective engagement practices regarding energy, environmental, and related public policies that encourage responsible energy development and transport.

Promote Economic Development of Oil and Natural Gas Resources to Provide Societal Benefits

- To mitigate negative impacts on interstate commerce, all levels of government should have constructive dialogue about the overall economic benefits from the nation's energy resources and effectively engaging stakeholders and minimizing local impacts and risks.
- Congress should fully appropriate the revenue coming into the Harbor Maintenance Trust Fund and the Inland Waterways Trust Fund funds to restore and fully maintain all U.S port and waterways infrastructure at their authorized dimensions.
- The U.S. government, states, local communities, secondary schools, and industry should promote vocational career education and technical training of their constituents, members, and communities.
- Industry, along with secondary and technical schools, should advocate for and support registered and accredited apprenticeship programs to ensure an adequate supply of skilled industrial construction, operations, and maintenance workers.

Promote More Rapid Development and Implementation of Technology to Increase Transportation Safety and Integrity

- DOT should lead, while working with DOE, EPA, and the U.S. Coast Guard, creation of an agile pathway for evaluation and regulatory acceptance of new technologies that can improve transportation safety and shorten the research, deployment, and adoption cycle time.
- Congress should authorize DOT to lead a collaborative effort, with support from industry, to develop and prioritize pilot programs that can accelerate pipeline, storage, and LNG technology adoption based on performance-based rules with a goal of enhancing public safety. Upon successful

completion of pilot programs, regulators should promptly update their regulations to allow use of new technology.

- Oil and natural gas transportation companies should establish a collaborative effort with participation from DOT, DOE, EPA, and industry research consortiums to prioritize promising, risk-based research opportunities, establish consistent technical readiness processes, and prioritize field validation testing needs.
- FERC and state regulatory agencies should work with DOT, DOE, and others to promote laws, regulations, and public-private partnerships that support cost recovery for natural gas and oil pipeline safety research.
- Cybersecurity protections should be advanced through:
  - Industry, in collaboration with trade associations and federal government agencies, should adopt and maintain up-to-date performance-based Cyber Security Management Standards.
  - Increased DHS and DOE capabilities and resources to support independent and secure cyber security assessments and audits prioritized on critical infrastructure.
  - DOE, working with industry, DOD, DHS, and DOT, to establish a collaborative process to identify and prioritize research and development aimed at sector-wide protection against nation-state and advanced persistent threat actors.

Demonstrate Excellent Industry Safety and Environmental Performance

- All infrastructure companies should strive for an outstanding environmental compliance record and to reduce the intensity of greenhouse gas emissions from their operations. Emissions reduction programs, such as One Future, The Methane Challenge, The Environmental Partnership, and EPA's Natural Gas Star Program are all means of demonstrating a company's efforts on reducing methane emissions.

The individual chapters contain additional recommendations.