Energy & Infrastructure Program

Energy Project

BPC Discussion Series: The New Geopolitics of Petroleum and Natural Gas

Issue Brief and Event Summaries

Summer 2014

BIPARTISAN POLICY CENTER

ABOUT THE BIPARTISAN POLICY CENTER

Founded in 2007 by former Senate Majority Leaders Howard Baker, Tom Daschle, Bob Dole, and George Mitchell, BPC is a nonprofit organization that drives principled solutions through rigorous analysis, reasoned negotiation, and respectful dialogue. With projects in multiple issue areas, BPC combines politically balanced policymaking with strong, proactive advocacy and outreach.

DISCLAIMER

This document was prepared by BPC staff to summarize the questions and key insights arising from BPC's Discussion Series on the New Geopolitics of Petroleum and Natural Gas. The perspectives and conclusions reached in this document do not necessarily reflect the views of the project's leadership, BPC, its founders, or its board of directors.

Foreword

Over the last year, the Bipartisan Policy Center (BPC) has been privileged to host a series of highly productive discussions on the emerging trends in global oil and natural gas production and how they impact energy markets, diplomacy, the environment, and economic growth.

The discussion series brought together a remarkable group of expert participants from industry, government, academia, and the NGO community. Together, participants approached the topics from a wide range of perspectives, but with a common interest in working to understand how surging U.S. production of petroleum and natural gas are creating significantly different prospects for the future.

It is clear now, as it was when the discussion series began one year ago, that the United States has far more abundant petroleum and natural gas resources than was previously known. In other words, good news rather than concern over scarcity provided the inspiration and backdrop for deliberations.

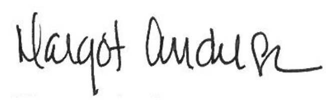
But the world has also changed in many unforeseen ways since this inquiry began. Conversations on the implications of U.S. liquefied natural gas (LNG) and crude oil exports on global energy security have taken on new significance. The crises unfolding in the Ukraine and in Iraq have prompted a vigorous discussion among policymakers about what role U.S. energy exports can play to quell volatile global energy markets, as well as what the limits of U.S. energy exports will be. If anything, current events have only underscored the urgent need for greater diversity in global LNG and crude oil trade, and in particular the need for greater international oil and gas supplies from stable countries—a long-standing goal of U.S. energy policy.

Global energy markets also face a long-term supply challenge in order to meet growing demand in the developing world for crude oil, which is projected to increase by 25 million barrels per day between now and 2040. Over the medium term, tight oil can and will supply the incremental demand from global oil markets. But tight oil is not a panacea; BPC's discussion experts see a point in the future when production from onshore tight oil plays in the United State will decline. The United States will need to look to new frontiers—including shale formations outside U.S. borders as well as ultra-deep water and Arctic resources—to meet demand and to ensure global energy security and diversity of supply. This will require careful planning and preparation, as well as refinement of the technologies and practices needed to access these resources in a manner that is both cost-effective and environmentally sound. Achieving these goals will take an inordinate amount of time and planning, and there is a pressing need to start today.

An additional theme from the discussions centered on the interconnections among growing use of natural gas, efforts to deploy emerging clean energy technologies, and policies to mitigate climate change. While natural gas has lower air emissions than coal and the ability to aid in the integration of intermittent energy sources into the grid, there is the potential for friction in the dynamic between natural gas and other low-carbon energy technologies, such as carbon capture and storage, nuclear power, and renewables. Many low-carbon energy technologies are relatively less economic in light of abundant natural gas supplies, though the nation's long-term success in tackling climate change still hinges on keeping energy options open—and those options require investment in low-carbon technologies at the same time that policymakers are seeking significant discretionary spending cuts.

Therefore, the United States must continue to invest in research and development for the most promising energy technologies, even if those technologies are currently uneconomic in light of the natural gas boom. It will be important to balance budget concerns with the need to fund energy R&D in pursuit of the technologies that expert scientists tell us are the most imperative.

BPC is proud to be on the leading edge of the debate around the implications of North American energy abundance. It is our hope that this document will provide the foundation for a new way of thinking about geopolitical energy issues. And we look forward to working with you, the reader, as this important debate evolves in the months ahead.



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Acknowledgements

The Bipartisan Policy Center (BPC) would like to express its thanks for the strong support of its funders.

Special appreciation is due to David L. Goldwyn for moderating the discussion series as well as to Leigh Hendrix of Goldwyn Global Strategies, LLC for the substantial guidance, research, and support that they offered throughout the course of this effort.

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Introduction

The Bipartisan Policy Center's (BPC) Energy Project held a series of four moderated discussions over the course of 2013 and 2014. The discussions focused on recent and emerging trends in global oil and natural gas production, and on how they impact energy markets, energy diplomacy, and economic growth. The discussion series was hosted by BPC Senior Fellow and former Senator Pete V. Domenici and was moderated by David L. Goldwyn of Goldwyn Global Strategies, LLC.

The first two of these discussions, titled "The Geopolitical Impacts of the U.S. Tight Oil Boom: Implications for OPEC and the U.S. Strategic Posture" and "U.S. Shale Gas Boom: Implications for the U.S. Economy, Trade, and Geopolitics," were held in June and July of 2013, respectively. The first session focused on the significant increase in U.S. tight oil production and its impact on domestic oil infrastructure, geopolitical ramifications, and the possibility for U.S. oil exports. The second session concentrated on the U.S. shale gas boom and addressed a similar set of economic, geopolitical, and trade-related themes.

The third and fourth discussions, titled "Expanded Natural Gas Production: Impacts on New Pathways for Climate Change Mitigation," and "Navigating the Oil Frontier: The Implications of the Tight Oil Boom on Arctic and Ultra-Deepwater Oil Development," were held in October 2013 and April 2014, respectively. The third session investigated how growing natural gas production is likely to affect global greenhouse gas emissions as well as investments in competing low-carbon energy technologies. The fourth and final session explored the impact of the surge in tight oil production on the prospects for "frontier" energy resources, such as those found in the Arctic or ultra-deepwater, and explored the scientific, technical, environmental, and social challenges associated with accessing frontier energy resources.

Session 1 Summary

The Geopolitical Impacts of the U.S. Tight Oil Boom: Implications for OPEC and the U.S. Strategic Posture

Recent growth in U.S. oil production has led to an unexpected energy boom. Although this is a definite positive for the United States, there are challenges that may prevent the boom from reaching its full potential. Among the expert panelists at this event, there was consensus that the U.S. tight oil boom is sustainable, but that it will require infrastructure investment and upgrades, supportive policy, and an energy outlook based not on scarcity but abundance. This new mindset will have major impacts on U.S. domestic and foreign policy decisions.

Participants

Keynote: The Impact of Tight Oil and U.S. Strategic Posture

U.S. Senator Lisa Murkowski (R-AK)

Panel 1: How Sustainable Is the Tight Oil Boom?

Edward Morse
Global Head of Commodities Research, Citibank

Katherine Spector
Head of Commodities Strategy, CIBC World Markets

Paul Sankey
Managing Director, Deutsche Bank

Panel 2: Geopolitical Impacts of Tight Oil

Luis Giusti
Senior Adviser, Center for Strategic and International Studies

Ambassador Carlos Pascual
Special Envoy and Coordinator for International Energy Affairs, U.S. Department of State

Daniel Yergin
Vice Chairman, IHS

Panel 3: The Likelihood and Implications of Crude Oil Exports

Former Senator Bennett Johnston
Chairman, Johnston & Associates

Robin West
Chairman, PFC

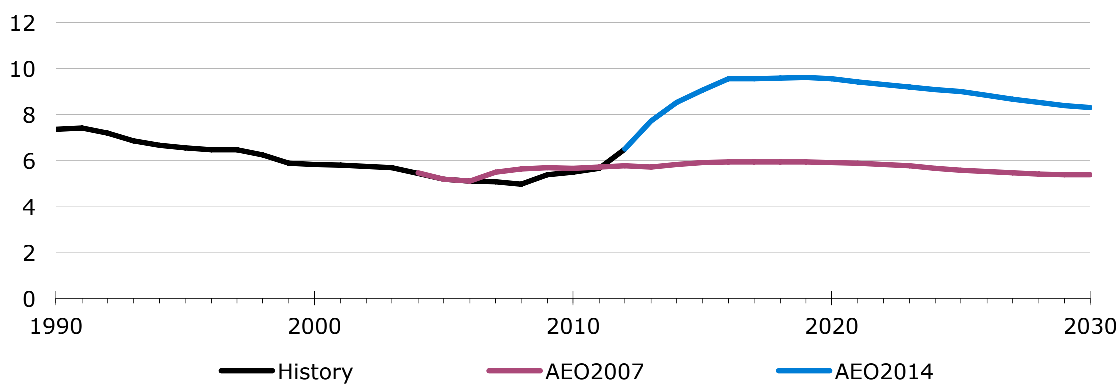
Adam Sieminski
Administrator, U.S. Energy Information Administration

Background and Context

Only a few years ago, the United States was projected to be increasingly dependent on foreign sources of oil, and domestic production was entrenched in a long and slow decline. However, these trends are in the midst of a dramatic reversal. Horizontal drilling and hydraulic fracturing technologies have been applied not only to the production of shale gas, but also to produce crude oil from shale formations. The results have been spectacular and were wholly unpredicted: in 2012, U.S. oil production grew more than in any other year since the first commercial well was drilled in 1859.[1] Over the next decade, the country is projected to increase its domestic crude oil production to 9.6 million barrels per day—a level not seen since 1970.[2,3]

U.S. Total Crude Oil Production in Three Resource Cases, 1990-2040

million barrels per day

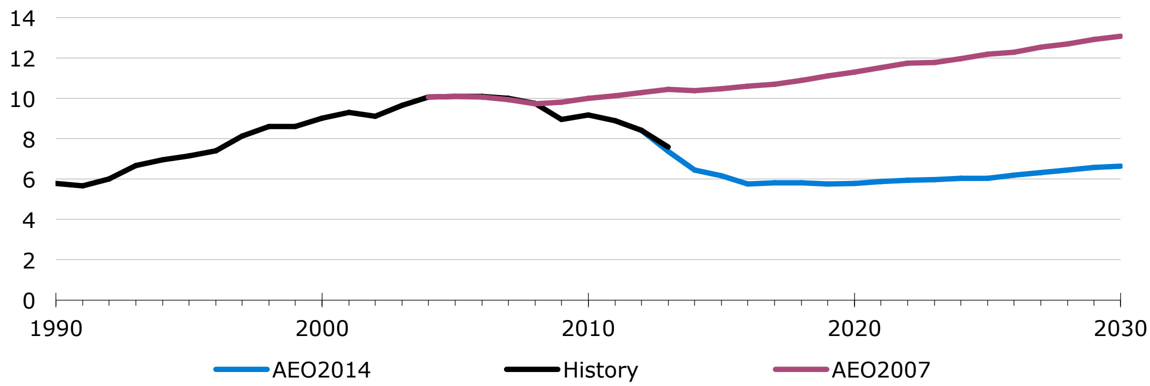


Source: U.S. Energy Information Administration, Annual Energy Outlook 2007, Reference Case (available at: http://www.eia.gov/oiaf/archive/aeo07/excel/aeotab_11.xls); U.S. Energy Information Administration, Annual Energy Outlook 2014, Reference Case (available at: http://www.eia.gov/forecasts/aeo/excel/figmt52_data.xls).

On the demand side, changing demographics and consumer preferences, along with ambitious investment in efficient use of energy, leads forecasters to believe that the future will be in stark contrast to the past. Although for most of the last three decades the United States' demand for petroleum seemed insatiable—presenting a likely future of greater consumption for years to come—the U.S. Energy Information Administration (EIA) now estimates that growth in energy demand will lag behind both population and GDP growth rates through 2020.[4,5] From 1983 to 2005, U.S. petroleum consumption grew by more than 35 percent, peaking at 20.8 million barrels per day in 2005.[6] From 2005 to 2012, however, the United States reduced petroleum consumption by almost 10 percent to 18.9 million barrels per day in 2012.[7] This decrease can largely be attributed to high oil prices, an economic recession, improved fuel economy, and competition from alternative fuels. U.S. crude oil imports have followed a similar trajectory, dropping 25 percent from 2005 to 2013.[8] EIA estimates that U.S. liquid fuels consumption will remain below 20 million barrels per day through the year 2040, due in large part to continuing progress on fuel economy and the production of alternative transportation fuels.[9]

U.S. Net Imports of Crude Oil

thousand barrels per day



Source: U.S. Energy Information Administration, Annual Energy Outlook 2007, Reference Case (available at: http://www.eia.gov/oiaf/archive/aeo07/excel/aeotab_11.xls); U.S. Energy Information Administration, Annual Energy Outlook 2014, Reference Case (available at: http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=0-AEO2014&table=11-AEO2014&region=0-0&cases=ref2014-d102413a); U.S. Energy Information Administration, U.S. Net Imports of Crude Oil (available at: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRNTUS2&f=A).

Key Questions and Insights from the Discussion

Domestic Oil Infrastructure

What transportation options are available to handle increased U.S. oil production, and how do the options differ? What safety concerns surround current and future oil transportation infrastructure?

The boom in oil production is already reshaping U.S. energy infrastructure. In some cases, oil from shale formations is being produced in regions that have aging infrastructure and in regions that have not historically been major producers. In other cases, the type of oil being produced is itself driving changes in infrastructure. Over the last 30 years, the U.S. crude mix has become significantly heavier as U.S. production of light oil fell and imports of heavy oil increased. Major investments were made to configure U.S. refineries to upgrade heavier crudes. In contrast to these infrastructure developments, however, much of the new shale oil is light sweet crude. Today, the imbalance in supply has created transportation bottlenecks and resulted in regional price differences across the United States.

Investment in oil pipeline carrier property (a proxy for pipeline capacity) has increased significantly over the past several years, from $39.1 billion in 2008 to $54 billion in 2012.[10] Similarly, Federal Energy Regulatory Commission (FERC) data shows that total oil pipeline capacity expanded more than 2,000 miles between 2011 and 2012.[11] Growth in pipeline infrastructure has been paralleled by rapidly expanding rail transportation. According to the Association of American Railroads, rail transport of crude oil rose to about 400,000 carloads in 2013—a 71 percent increase from 2012, and more than a thirteenfold increase compared with all such rail shipments in 2010.[12] Statistics for the Bakken region are similarly striking: nearly 60 percent of North Dakota's crude oil production is now transported by rail.[13]

As mentioned above, current U.S. oil transportation infrastructure has struggled to keep pace with increased oil production levels, leading to periods of mid-continent glut and corresponding crude oil price differentials.[14] Throughout much of 2012, the price of Bakken crude was less than that of West Texas Intermediate (WTI), with the difference reaching $28 per barrel in February of that year.[15] In addition to issues surrounding transportation capabilities, government policies on energy infrastructure and exports will also be an important determinant of future price differences, and in turn may impact who captures the profits from these price differentials. Note that U.S. consumers will not experience a direct benefit from such price differentials, given that oil is a globally traded commodity and U.S. producers are able to charge global market prices for their products.

Expansion of both pipelines and rail transportation is needed and likely. The degree to which each is developed depends on a number of factors, including the economic, permitting, environmental, and safety challenges that surround both options.

Rail transportation of crude oil, though sometimes more expensive than comparable pipeline transportation, has a number of unique advantages. One of these is flexibility, allowing both for quick expansion and for sourcing variation based on market conditions.[16] For this reason and others, companies view rail not only as a short-term alternative to pipelines, but also as part of a longer-term strategy to bring their products to market. Infrastructure expansion will face continuing challenges specifically with regards to building pipelines, although economic drivers will ultimately bring oil to markets through one mode or another.

Regardless of the challenges, transportation infrastructure will adapt to changing market dynamics and, over time, the glut that is currently seen in the midcontinent will shift to the Gulf Coast, where refineries will also have to make changes to their configurations and crude sources in order to absorb the increased domestic production.

In a broader sense, the possibility of a significant adverse environmental or public safety incident—not just in transportation, but at any point in the supply chain—must be taken seriously, as it could impact the longevity, and hence the benefits, of the production boom. This is particularly important in the wake of a recent rail incident in Canada.[17]

"It has become more difficult and expensive to build pipelines … but the market usually finds a way. Partly rail, partly pipeline … sooner or later those barrels will find homes." *Katherine Spector, CIBC World Markets*

"So far, the record [on hydraulic fracturing] has been better than the record with other extractive technologies. … But nonetheless, environmental risk remains. It is muting over time, but lurks in the rhetoric around the debate." *Ed Morse, Citibank*

"We will have more and more problems with pipes in the United States. ... Every weld of a U.S. pipeline [built] before 1970 is suspect." *Paul Sankey, Deutsche Bank*

Geopolitical Implications

How has the geopolitical situation changed in light of increased U.S. oil production? Does increased production allow the United States to become less engaged than it previously has been?

U.S. policy, both foreign and domestic, has operated under an assumption of energy scarcity for the past three decades. Today, the rules of U.S. diplomacy are being rewritten for a future less dependent on foreign oil, with significant implications for the country's strategic posture and relationships with trading partners and allies alike.

The boom in tight oil is currently unique to North America, but, at some point in the future, may expand to other countries such as China, Mexico, Saudi Arabia, and Russia. Increased domestic production—and the resulting decline in dependence on foreign oil imports—would appear to provide the United States with the ability to withdraw from its global role and become more insular. However, increased U.S. supplies will not diminish the need for the United States to maintain its strategic engagement for geopolitical, economic, and logistical reasons. Oil remains a global commodity, and supply disruptions elsewhere in the world will still affect prices and economic stability, both domestically and abroad.

Increased U.S. supplies—combined with growing international production and the potential transfer of new extraction technologies—will have long-term ramifications for the Organization of Petroleum Exporting Countries (OPEC), though the immediate effects are not yet clear. Over time, it has become increasingly difficult for OPEC to make cohesive, strategic decisions, in part because its members have differing goals and needs. Many OPEC nations rely heavily on oil revenues to support their governments and to keep their populations satisfied, while others are unable to meet their production targets due to political, technical, or geological realities. Additionally, Saudi Arabia now plays a pivotal role in OPEC decision-making, as it is the only OPEC country that still has significant spare production capacity. Although the future of oil production in Iraq and Venezuela could be game-changers for OPEC, the organization's declining influence allows more flexibility for the United States in its global engagement.

Increased U.S. production will also be important in the context of expanding and diversifying worldwide oil production, given that increased production from stable regions is almost always associated with lower and more stable global oil prices. With a finely balanced market for crude oil, an expectation emerges that a future supply disruption would have a significant price impact. For these reasons, higher levels of U.S. production are likely to have a unique role in the global market as an additional source of stable capacity.

U.S. oil production interacts with the global balance of supply and demand to influence a variety of factors. Additional geopolitical impacts include the fact that increased U.S. supply (equivalent to Nigeria's entire oil output) has helped to balance international oil markets and has also enabled the successful implementation of Iranian sanctions without creating additional market instabilities. In this way, the supply-side impacts of additional U.S. oil production can reinforce U.S. foreign policy goals. Global demand-side variables—such as rising consumption in developing countries—will also increasingly play an important role and will require a new way of thinking about the global oil landscape.

"A better-supplied world is a safer world, but it doesn't mean there still aren't above-ground and below-ground risks." *Daniel Yergin, IHS CERA*

"Two million barrels a day more production in the U.S. means, in a sense, two million barrels a day more spare capacity around the world and EIA has shown … that there is a very direct relationship between spare capacity and prices. And higher global spare capacity is almost always associated with lower and more stable pricing." *Adam Sieminski, U.S. Energy Information Administration*

"Can we change our foreign policy and our posture and simply retreat from parts of the world that have been in the past critical to us for energy supplies? And the answer to that is a resounding no." *Carlos Pascual, U.S. Department of State*

"Let's say that the U.S. continues to increase the production of oil, which is likely to happen. Should the United States forget about the rest of the world? I would guess that the answer to that would be no." *Luis Giusti, Center for Strategic and International Studies*

U.S. Oil Exports

What are the prospects for future U.S. oil exports? Are there benefits to allowing exports?

Most new U.S. shale oil production consists of light sweet crude, creating a mismatch with current Gulf Coast refining capacity, which has evolved over the years to process heavier oils like those imported from Saudia Arabia, Canada, Mexico, and Venezuela. Markets have responded to increased domestic supply by decreasing imports of light sweet crude that U.S. East Coast refiners have historically obtained from foreign suppliers. However, the reduction in U.S. imports of light sweet crude oil will ultimately be insufficient to compensate for rapidly expanding domestic supplies.

As such, refiners will increasingly look to other solutions. Potential results of greater U.S. oil production include the following: (1) exports to Canada could increase; (2) refineries could process more light sweet crude oil, displacing more imported crude oil; (3) more Bakken crude could be moved to the East and West Coasts via rail; (4) the United States could utilize crude oil swaps more than it does currently; and (5) the United States could turn to crude oil exports. One potential approach—falling under the second option—is blending, where U.S. light sweet crude is mixed with heavier crude from foreign sources; however, this in itself may cause a bottleneck, as investment must be made in tanks and other infrastructure to handle the extra processing associated with blending.

Given these trends, future U.S. supply of light sweet crude will likely overwhelm domestic refining capacity and Canadian demand within as little as two years, leading to the possibility for increased U.S. oil exports—though with significant political hurdles. Crude oil exports are generally not permitted under U.S. federal law, as stipulated primarily in the Mineral Leasing Act of 1920, the Energy Policy and Conservation Act of 1975, and the

Export Administration Act of 1979.[18] The Bureau of Industry and Security within the Department of Commerce, which regulates crude oil exports through its Export Administration Regulations, does in some cases allow crude oil exports.[19,20]

However, from an economic perspective, some analysts believe that the projected increase in U.S. supply and flattening of demand growth indicates that this import-export balance may need to be reversed, or at least reconsidered, which is at odds with the current licensing process. At the same time, there is limited east-west pipeline capacity, and only American-built, -owned, and -crewed ships are legally permitted to transport goods between U.S. ports (per the Jones Act), effectively limiting the movement of oil from the U.S. Gulf Coast to the U.S. East Coast (due to historically limited Jones Act shipping capacity and higher prices).[21,22] In general, laws and regulations would need to be changed to facilitate greater U.S. exports to global oil markets.

Overall, if U.S. policy does not permit exports, the tight oil boom could be constrained. However, there currently appears to be little appetite in Washington for taking on crude oil exports as a policy issue. In general, free trade is viewed as the most efficient method for bringing crude oil to market, and if projections are correct, there will be too much domestically produced oil for the U.S. market to absorb without additional oil export outlets.

"If we don't allow exports, the North American boom is not sustainable and the geopolitical impacts will be enormous on the United States." *Robin West, PFC Energy*

"[R]efineries are taking oil, whether it's from the Bakken or from Canada or from other places in North America, and processing it into petroleum products. As I mentioned before, we are now a net exporter in this area and that's great news for our trade balance. Diesel, gasoline, jet fuel—exports of these products are enormous and increasing." *Senator Lisa Murkowski, Ranking Member, U.S. Senate Committee on Energy and Natural Resources*

"The notion that the United States may have so much light, sweet crude oil that it might make sense to export some would have been heretical only a few short years ago." *BPC Senior Fellow and former Senator Pete V. Domenici*

"If we're going to be preaching free trade abroad, then we shouldn't be resource nationalists here." *Former Senator Bennett Johnston*

"When exports are limited, or when some exports are limited but others are not, that is simply policy deciding who gets the rents from this boom. In other words, policy so far has decided that … refiners in the midcontinent get the rents from this boom." *Katherine Spector, CIBC World Markets*

"The likelihood of crude oil exports is 100 percent, because we are already exporting 120,000 barrels a day to Canada." *Adam Sieminski, U.S. Energy Information Administration*

Session 2 Summary

The U.S. Shale Gas Boom: Implications for the U.S. Economy, Trade, and Geopolitics

In the wake of increased natural gas production in the United States, natural gas has taken center stage in a number of different policy arenas. Debates have focused on the environmental impacts of producing shale gas, the efficacy of exporting this new domestic resource, and the long-run impact of increased natural gas use on climate change. One of the primary takeaways from this event was that, although important questions remain with regards to these environmental and policy issues, none of these challenges will be a showstopper for the responsible production, use, or export of U.S. natural gas if the appropriate policies and practices are implemented.

Participants

Keynote: Process and Policy of Exporting Natural Gas

Melanie Kenderdine
Energy Counselor to the Secretary of Energy, U.S. Department of Energy

Keynote: The Economic and Geopolitical Impact of Natural Gas Exports

U.S. Senator Ron Wyden (D-OR)

Panel 1: U.S. Natural Gas Exports—Process and Policy Issues

Gary Hufbauer
Reginald Jones Senior Fellow, Peterson Institute for International Economics

David Montgomery
Senior Vice President, NERA Economic Consulting

Scott Moore
Vice President, Marketing, Anadarko Petroleum Corporation

Panel 2: Geopolitical Impacts of Shale Gas

Francis O'Sullivan
Executive Director, Energy Sustainability Challenge, MIT Energy Initiative

Robert Johnston
Director, Global Energy & Natural Resources, Eurasia Group

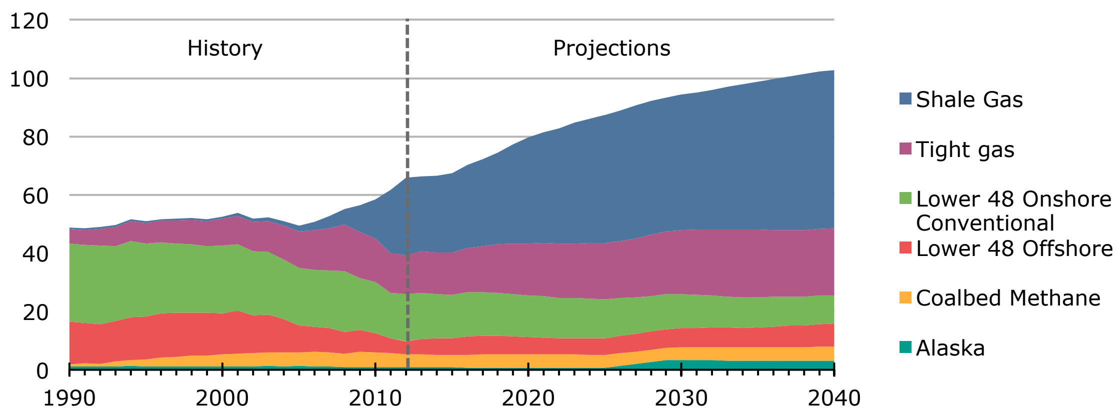
Kenneth Medlock
James A. Baker III and Susan G. Baker Fellow in Energy and Resource Economics, Rice University

Background and Context

The United States is in the midst of a boom in unconventional natural gas production. Less than a decade ago, the United States was forecasted to be a growing market for liquefied natural gas (LNG) imports, as falling domestic production resulted in high natural gas prices. It is now recognized that the United States has extraordinarily large natural gas resources, and the long-held perception of natural gas as a constrained resource has changed dramatically. The story of the boom in natural gas runs parallel to that of crude oil, which was described in the preceding event summary. The combination of hydraulic fracturing and horizontal drilling to economically extract natural gas from shale formations spread rapidly during the years between 2005 and 2010, and these technologies are now ubiquitous.

U.S. Domestic Natural Gas Production, 1990-2040

billion cubic feet per day

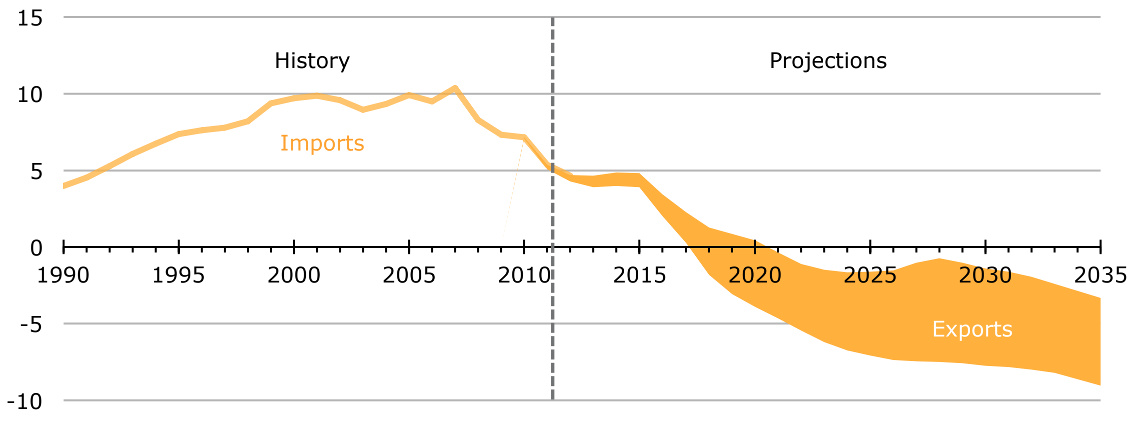


Source: U.S. Energy Information Administration, Annual Energy Outlook 2014, Reference Case (available at: http://www.eia.gov/forecasts/aeo/excel/figmt44_data.xls).

LNG trade provides a striking example: by 2006, there were a total of 43 applications pending at FERC for permits to build LNG *import* facilities.[23] The situation is completely reversed today, however, with 43 applications to the U.S. Department of Energy (DOE) to export—rather than import—LNG from the United States.[24] Moreover, pipeline exports of natural gas, which have increased more than eightfold since 2000, have been growing under the radar and are expected to rival the volume of potential LNG exports.[25] The boom in shale gas production is anticipated to transition the United States from a net importer to a net exporter of natural gas sometime between 2017 and 2021.[26]

U.S. Net Imports of Natural Gas, 1990-2035

billion cubic feet per day



Source: Bipartisan Policy Center, New Dynamics of the U.S. Natural Gas Market, p. 35 (available at: http://bipartisanpolicy.org/library/report/new-dynamics-us-natural-gas-market).

Key Questions and Insights from the Discussion

The Economics and Domestic Politics of U.S. Natural Gas Exports

What are the potential economic implications of U.S. natural gas exports, and specifically, how might gas prices be affected? What are some of the political aspects of the possibility for exports?

DOE is responsible for approving permits to export LNG, and under Section 3 of the Natural Gas Act of 1938, the department must make a determination that exporting LNG is in the national interest.[27] For countries with which the United States has a free-trade agreement (FTA), exports are presumed to be in the national interest. However, for projects seeking permission to export to countries that do not have FTAs—many of which represent the most lucrative markets for U.S. LNG—this determination must be made on a case-by-case basis by DOE. To date, the department has approved seven permits to export LNG from the United States to non-FTA countries—totaling 9.27 billion cubic feet per day (bcf/d)—and has 26 applications left to consider.[28] In all, approved and pending applications for export to non-FTA countries represent a total export capacity of just over 35 bcf/d.[29]

Although the pending applications represent a large quantity of natural gas exports, it is unlikely that more than a handful of projects will ultimately be constructed in the United States, given the substantial capital costs of building facilities, the limited global market for additional LNG, and competition from other LNG-exporting countries.[30] Recent modeling analyses estimate that U.S. exports of LNG will range from 2 bcf/d to 6.4 bcf/d by 2030.[31] A number of these analyses have also assessed the potential impact of U.S. LNG exports on domestic prices. The consensus among these studies is that LNG exports are likely to have modest impacts on domestic natural gas prices and that LNG exports will adjust as domestic prices rise or fall, because U.S. LNG exports also compete in a global market based on price.

Nonetheless, these plans have raised concerns among stakeholders that natural gas exports will drive up the price of domestic natural gas. For instance, industrial consumers are concerned that if natural gas prices increase, their products, which depend on natural gas as both a feedstock and a process fuel, could become relatively less competitive in the global marketplace. Similarly, U.S. consumers are worried that higher domestic prices will result in higher utility bills.

The NERA Economic Consulting analysis, which was commissioned by DOE, concluded that LNG exports from the United States would create net benefits for the United States at all considered export levels, due to global market fundamentals that combine to limit future exports and potential price increases.[32] The NERA analysis also shows that natural gas exports only make sense within a certain price band, and if U.S. gas were to become too expensive, the global market would no longer support those exports. As a result, the general consensus in the NERA study is that there would be net economic losses if the United States were to limit its natural gas exports at this time.

Both producers and consumers need to have some certainty about the long-term supply, demand, and price of LNG shipments as potential LNG consumers are concerned not only about price of potential LNG imports, but also about the reliability of supply.

DOE, now under Secretary Ernest Moniz's lead, is comfortable with NERA's modeling results and is prepared to move forward with the kind of analysis already in place for the previous export authorizations. The department will continue to evaluate projects on a case-by-case basis and will seek to process permits as expeditiously as possible.

Although there is significant worldwide demand for natural gas, international oil companies and analysts note that there is a competitive environment that favors early entrants into the global LNG market. LNG export projects are moving forward in Africa, Australia, Canada, and the Middle East, and those projects will compete with U.S. LNG exports. From this viewpoint, U.S. applicants facing longer permit approval times are at a relative disadvantage to competing projects.

From a political perspective, actions taken by the United States that delay or prohibit LNG exports—either purposefully or inadvertently—are in opposition to many open-market policies that the United States has advocated for decades. (Although it is worth noting that U.S. crude oil exports remain prohibited, as discussed in the previous session.) Some believe that the provisions in existing statutes calling for explicit export approval may not be consistent with international trade rules. It is also important to consider whether any potential restrictions may encourage other countries, such as China, to take a similar approach with their own valuable domestic resources.

Overall, the panelists' sense was that the U.S. natural gas resource base is robust enough to support both domestic consumption and increased exports, with a limited effect on domestic natural gas prices.

"At DOE's request, we investigated the potential impacts on the U.S. economy of various different levels of natural gas exports. … We found that under all of these conditions … there were net benefits to the U.S. economy from all of the scenarios we looked at." *David Montgomery, NERA Economic Consulting*

"The United States … has had a consistent position of open markets. ... [But] we do have one exception, which has been energy … where we have natural gas and petroleum legislation that requires an affirmative decision to allow exports." *Gary Hufbauer, Peterson Institute for International Economics*

"We have the resources to support [both export and domestic demand] of our product. Will we increase our activity to support LNG exports? Yes, we will, and the good news is the shape of the supply curve … is relatively flat." *Scott Moore, Anadarko Petroleum Corporation*

Potential Challenges

What are some of the environmental considerations relating to increased U.S. natural gas production and potential exports, from both a domestic and international perspective?

Panelists identified two broad categories of challenges related to hydraulic fracturing and natural gas production that must be addressed in order to realize the full potential of shale gas resources: public opinion and environmental impacts.

Public opinion. Public perception is important both as a potential catalyst and as a possible barrier to expanded natural gas production. Many observers have noted that public acceptance of hydraulic fracturing and the infrastructure that accompanies production must extend into many parts of the country not already familiar with the oil and gas industry. Additionally, a catastrophic event or accident could have long-term impacts on the future growth potential of the industry.

Assuring the public that the regulatory system is capable of protecting human health and environmental health in the area immediately affected by production will be very important. In particular, the standardization of reporting for hydraulic fracturing fluids and spills could be a key contributor to public confidence. Similarly, effective regulation, including environmental regulation, could yield a financial return for producers, as they enable producers to bring more of their product to market. At the same time, care should be taken not to create disincentives to further development, and flexibility in rules can help to accomplish that goal.

Environmental impacts. U.S. LNG exports are expected to have a neutral effect on global carbon-dioxide emissions; although more research needs to be conducted to make a definitive determination. Coal and natural gas are substitutes at the global level, and future studies can help to quantify this interaction in the context of increased U.S. LNG exports. In addition, coal combustion results in significantly higher carbon-dioxide emissions than burning natural gas; though research continues to investigate the potential magnitude of greenhouse gas emissions throughout the entire natural gas life cycle. In particular, more research is needed to determine what amount of methane "leakage" is consistent with preservation of the climate benefits of natural gas as compared with coal.

Local environmental concerns are closely linked to the public opinion discussion above. In particular, transparency, even across state lines in border areas, could go a long way toward alleviating concerns about environmental impact issues, such as water quality and the effects of a potential accident.

"I want to explore the idea of giving the states a really broad berth, a really key role, in what happens below ground, while the federal government could have a leadership role on a number of the key issues above ground, such as disclosure and spill reporting." *Senator Ron Wyden, Chairman, U.S. Senate Committee on Energy and Natural Resources*

"Things like *Gasland*, whether they're true or not, are putting pressure on firms to be the best operator using the best practices. … They affect public opinion, which can influence regulations." *Dr. Kenneth B. Medlock III*

"I regard this as one of the biggest threats to this great opportunity. So, I hope the top executives are meeting and doing everything they possibly can." *Gary Hufbauer, Peterson Institute for International Economics*

The Geopolitical Implications of U.S. Natural Gas Exports

How does the increase in U.S. natural gas production affect gas contracts in other parts of the world? Which countries will be most affected by U.S. exports and in what ways?

Growth in U.S. natural gas exports will put pressure on oil-linked natural gas contracts. Some panelists suggested that once such de-linking begins, it will happen rapidly as buyers leverage hub-indexed deals to negotiate better contracts with their other potential suppliers. At the same time, modeling and analysis has shown that—aside from linkages with oil—increases in natural gas production will lead to decreases in price volatility.

There is still, and will likely continue to be, a significant price difference between natural gas and oil. Such price differences may stimulate the substitution of natural gas for oil in the transportation sector, with potential implications for OPEC in the longer-term. It is also important to note that shale gas production costs vary significantly around the world. Thus, while shale gas reserves are widely dispersed around the globe, not all countries will necessarily have their own shale gas booms on the scale of the current U.S. boom.

The shifting international natural gas landscape will particularly impact Russia, Iran, and Venezuela; although it will also affect many countries around the world.

Russia has felt the ramifications of decreased U.S. demand, which has re-routed LNG exports destined for the United States to Europe, thereby weakening Europe's long-standing dependency on Russian gas. This has put pressure on existing contracts, and Gazprom has already engaged in contract discussions and negotiations. Although Russia is not the most reliable gas supplier today—due to political and other issues—the situation may change with the potential development of its shale resources and new transportation infrastructure to serve emerging markets, such as China and India.

With continued increases in relatively inexpensive U.S. gas supply, the cost of production in Iran and Venezuela might be too high to be competitive in global LNG markets. Nevertheless, future geopolitical changes may allow these countries to become exporters, as regulations and politics—more so than the resource base—have been the greatest hindrances to energy development in these countries.

China has significant shale resources, but the degree to which they will be developed remains uncertain. If developed, Chinese shale gas would likely be more expensive than gas from the United States, although still cheaper than current oil-indexed gas in Asia. Substantial production of Chinese shale gas could have an important impact on world markets.

Qatar is in a strong position because its investments are already producing a return, and it has the ability to seek the best price for its product. Given the significant decrease in U.S. import demand, the Qataris will increasingly focus their export efforts toward buyers in Asian markets. This changes the U.S.-Qatari relationship from one of trade partners to competitors.

Mexico is expected to experience significant growth in gas demand in coming years, both for gas-fired electricity generation and for its industrial and manufacturing sectors. Long an importer of U.S. natural gas, Mexico could import increased volumes of piped gas or could also become an LNG importer. Mexico could also develop its own resources, contingent on the attraction of sufficient investment.

On the erosion of the gas-oil price linkage: "I think when it happens, it's going to happen like a waterfall. It's not going to be long and dragged out." *Dr. Kenneth B. Medlock III, Rice University*

"[W]e're seeing the emergence of what I describe as a 'self-contracting' arrangement. … It's helping to shift a lot of the risk to the buyers. Now what you're seeing is those people who are purchasing that gas in the market, … which I think is a good thing for the issue of volatility management here in the United States." *Francis (Frankie) O'Sullivan, MIT Energy Initiative*

"This debate about the foreign policy impact of gas exports is a challenging one, in large part because we have at least 30, and arguably 50 or 60, years of foreign policy and energy policy institutions that are built around the concept of scarcity. And now they're shifting towards, not independence—probably not even not self-reliance—but relative abundance. So how do we re-think all the architecture of U.S. foreign policy and energy policy as we shift towards relative abundance of domestic energy resources?" *Robert (RJ) Johnston, Global Energy & Natural Resources*

“I expect that the technology development in countries with large shale basins will in the next 10, 15 years or so will dramatically alter both the geopolitics of shale gas and the geopolitics of LNG.” *Melanie Kenderdine, Energy Counselor to the Secretary of Energy, U.S. Department of Energy*

“Expanded North American production of natural gas contributes towards a more stable, transparent, and competitive global natural gas market. This will improve energy security and support U.S. foreign policy goals.” *BPC Senior Fellow and former Senator Pete V. Domenici*

Session 3 Summary

Expanded Natural Gas Production: Impacts on New Pathways for Climate Change Mitigation

The development of abundant, low-cost natural gas supplies in the United States has facilitated a significant reduction in U.S. greenhouse gas emissions. But there are concerns that growing use of natural gas could crowd out investments in other low-carbon energy technologies, such as renewables, carbon capture and storage, and nuclear energy. Panelists agreed that natural gas is likely to play an important role in reducing greenhouse gas emissions in the near term, but that we must remain vigilant to preserve the options embodied in other energy resources that will be critical in a low-carbon future despite being uneconomical today. Looking globally, a world that possesses a newfound abundance of energy resources is one where comparative advantages must be leveraged in order to achieve climate policy goals. In this context, it is likely that a series of different optimal approaches will deliver the greenhouse gas reductions called for in any future multilateral agreement on climate change mitigation.

Participants

Panel 1: The Scientific and Technological State of Play

The Honorable David Garman
Principal, Decker Garman Sullivan and Associates, LLC

Joseph Aldy
Assistant Professor of Public Policy, Harvard University

Ethan Zindler
Head of Policy Analysis, Bloomberg New Energy Finance

Panel 2: Leveraging Comparative Advantages to Deploy Low-Carbon Energy Technologies

William Ramsay
Senior Advisor at the Center for Energy, Ifri

The Honorable William Reilly
Senior Advisor, TPG Capital, LP

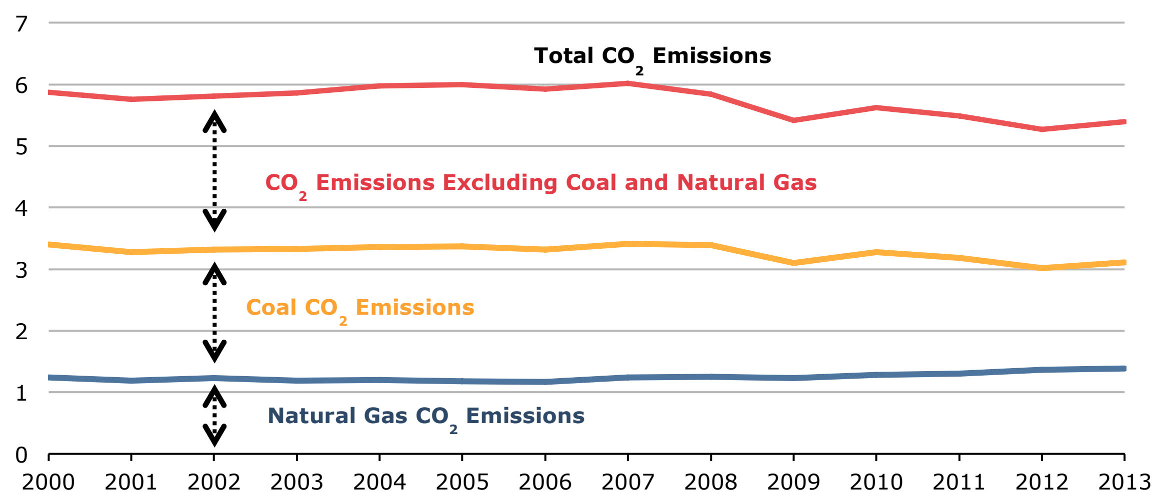
Jason Bordoff
Director, Center on Global Energy Policy, Columbia University School of International and Public Affairs

Background and Context

Natural gas from shale formations, along with improvements in energy productivity and macroeconomic factors, has facilitated an unprecedented and unexpected reduction in U.S. greenhouse gas (GHG) emissions. Carbon dioxide (CO_2) emissions from energy consumption have declined approximately 10 percent in the past several years, from just over 6 billion metric tons in 2007 to about 5.4 billion metric tons in 2013—a level not seen since 1995.[33] Although the reduction in GHG emissions is welcome news, there are concerns that the proliferation of natural gas has the potential to displace investments in other competing, low-carbon energy technologies, which in turn could result in a lesser degree of fuel diversity in the U.S. electric power sector.

U.S. CO_2 Emissions from Energy Consumption, Selected Categories, 2000–2013

billion metric tons of carbon dioxide



Source: U.S. Energy Information Administration, May 2014 Monthly Energy Review, Table 12.1.
Notes: Coal includes coal coke net imports. Natural gas excludes supplemental gaseous fuels.

The timing of these trends coincides with declining congressional support for energy technology research, development, and deployment (RD&D). According to data from the American Association for the Advancement of Science, federal outlays for energy research and development totaled \$3.82 billion, \$3.08 billion, and \$2.53 billion over fiscal years 2011, 2012, and 2013, respectively.[34] These values were approximately five percent of total non-defense research and development outlays during those years.[35] As such, a material change to the level of federal government support could dramatically affect the prospects for these technologies and the diversity of the U.S. energy mix, both now and in the future.

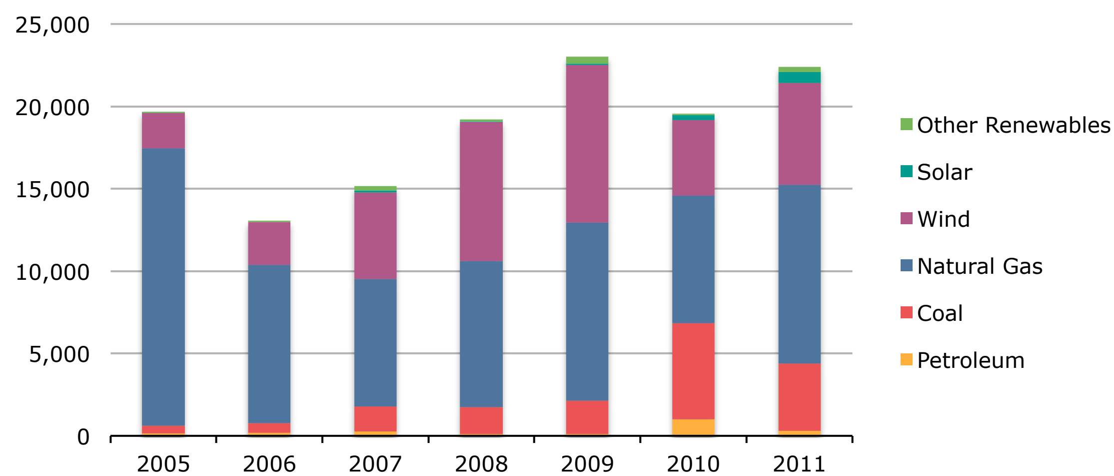
As noted by BPC's Strategic Energy Policy Initiative, a diversity of energy resources is critical to ensuring America's economic and energy security:[36]

An energy system that relies on a varied mix of fuels and technologies from diverse geographic sources, as well as continued progress in energy-efficiency improvements, is inherently more robust and resilient than one that is heavily dependent on a limited number of sources. Energy diversity helps to insulate the U.S. economy from the supply shocks and price volatility that can affect the market for a particular energy source.

This sentiment was shared by the panelists, though several noted that—given the trends described above—the United States may currently be reducing energy diversity rather than strengthening it. Over the years 2005 to 2011, more than 80 percent of nameplate capacity additions in the electric power sector were natural gas and wind—while just 12 percent of additions were coal, and none were nuclear.[37]

U.S. Generating Unit Additions, 2005–2011

nameplate capacity in megawatts



Source: U.S. Energy Information Administration, "Electricity Generating Capacity," http://www.eia.gov/electricity/capacity/.

Notes: This graph excludes purchased steam, tires, black liquor, municipal solid waste, and waste heat. "Other renewables" is agriculture crop byproducts/straw/energy crops, geothermal, energy storage, other biomass gases, other biomass liquids, hydroelectric (conventional and pumped), and wood/wood-waste solids. "Natural gas" is blast-furnace gas, landfill gas, natural gas, other gas, and propane. "Petroleum" is distillate fuel oil, jet fuel, kerosene, and petroleum coke.

Key Questions and Insights from the Discussion

The Scientific and Technological State of Play of Low-Carbon Energy Technologies

How has abundant natural gas impacted low-carbon energy technologies, both in the near term and in the long term? What are the emissions implications of current trends in energy use? What near-term opportunities exist to improve the environmental performance of the current energy system, and similarly, what are the technology pathways, politics, and economics of technologies that will yield long-term GHG emissions reductions?

Looking forward, the panelists expressed varying levels of optimism regarding the security of America's energy future. These differences in opinion were, at least in part, a product of different views regarding the future prospects for a number of technologies; particularly, the feasibility of deploying low-carbon technologies at reasonable cost to provide for the nation's future baseload power needs. These technologies include fossil fuels paired with carbon capture and sequestration (CCS), nuclear power, and renewable energy complemented by utility-scale electricity storage. The extent to which each of these technologies will be—or can be—deployed has significant implications for U.S. future energy options and therefore for America's energy security.

In many ways, all of these low-carbon energy technologies face a similar set of challenges. One is the low price of natural gas, which not only reduces the economic competitiveness of other technologies, but can act as a disincentive to continued research and development on alternatives. Some of this effect will be felt immediately in the marketplace, but much of it will occur later—as research and development often takes place over years or even decades.

Another challenge is flattening demand for new generation, as growth in U.S. electricity consumption continues to slow. Energy infrastructure is generally long-lived, and with a reduced need for new generation, electric utilities are experiencing difficulty in securing the capital they need. This may pose a particular challenge for large, capital-intensive CCS and nuclear projects. In addition, utilities face the challenge of an eroding customer base as homeowners continue to adopt distributed generation technologies, such as rooftop solar photovoltaic (PV) systems that are being deployed at a rate of 140,000 installations per year.[38]

A third important factor for the potential deployment of low-carbon energy technologies is the uncertainty surrounding policies to price GHG emissions. Each of the technology combinations described above will be affected differently by such a policy, depending on a number of economic, policy, and other factors.[39, 40]

"[I]t would be a tragedy if we settled into a state of complacency because of what appears today to be reasonably priced gas for years to come. [A]s a consequence of that we shortchanged the innovation and investment we need to do on new nuclear, carbon capture, and other technologies that we need over the long term." —The Honorable David Garman, Principal, Decker Garman Sullivan and Associates, LLC

"[I]f we don't have any kind of policy signals—whether it's an explicit price signal, whether it's some kind of regulatory framework that will create the demand for these technologies in the marketplace—then I don't think that the public-sector R&D will be sufficient." —*Joseph Aldy, Assistant Professor of Public Policy, Harvard University*

"[T]here is a challenge for trying to raise the private capital to go into a new CCS project, for instance, or even a new nuclear project. It's just very hard to raise the money these days for these big, new, experimental technologies. Part of that definitely has to do with gas—gas and the fact that our economy is not demanding a whole lot of new power generation overall." —*Ethan Zindler, Head of Policy Analysis, Bloomberg New Energy Finance*

FOSSIL FUELS AND CARBON CAPTURE AND SEQUESTRATION

There was general consensus that CCS research and development is an important focus for the country as part of a diverse energy strategy. To the extent that future energy demand cannot be met by renewable energy alone, or by the combination of renewables and natural gas, future supply sources will need to include coal and gas—supplemented with CCS—as well as nuclear power.

Despite its importance, however, there were differing perspectives regarding the timing and prospects for future deployment of CCS. One central challenge is the design of policies to best incentivize related RD&D. Some panelists were optimistic, stating that with the right actions today, the United States may have at-scale CCS within the next decade; other panelists agreed that while CCS may be economically developed, it will require a clear economic value to capturing CO_2 beyond enhanced oil recovery applications.

NUCLEAR POWER

Although nuclear power has been a significant part of America's generating mix for decades, it faces several of the same challenges as other low-carbon energy technologies. These include the comparatively low price of substitute energy sources—impacting both near-term economic competitiveness and longer-term research efforts—as well as flattening demand for new generation. Several panelists also noted a need to reform the licensing process for new nuclear power plants, as well as safety and public perception concerns that have emerged following the nuclear incident at Fukushima.

RENEWABLE ENERGY

The effect of natural gas on renewable energy sources can be considered from several perspectives: one is the potential for low-priced natural gas to crowd out renewable resources, in a manner similar to that for CCS and nuclear; another is the possibility for natural gas to complement the deployment of wind and solar generation, to the extent that gas can provide backup power during periods of intermittency.

One panelist noted that wind energy, more so than solar PV, is in direct competition with natural gas for market share, though there have been periods in recent years where both wind and natural gas have seen strong growth. Unlike wind, the deployment of residential solar PV may be less sensitive to competition from natural gas, given that homeowners have unique economic and policy incentives to install these systems.

"We must accommodate the growth of renewables. We're not going to get where we need to get to manage the climate without them. … Natural gas can be a godsend in helping us achieve our 2020 objectives, and we already see emissions coming down in the United States. … But to the extent that you lock in another fossil fuel … you may impede the achievement of your 2030 objectives. So at some point you're going to have to manage that problem." —*The Honorable William Reilly, Senior Advisor, TPG Capital, LP*

ENERGY EFFICIENCY

Energy efficiency should be considered as a resource in its own right and can directly reduce the need for the other primary energy resources. Although energy efficiency generally draws broad support, several panelists noted that it can be, and has been, controversial at times. Nevertheless, there are new opportunities to promote energy efficiency and continued opportunities for efficiency to reduce the energy intensity of economic activity. As the nation continues to push new technologies into the market, it will also have to contend with diminishing marginal returns and thermodynamic limits, which again serve as a catalyst for continued research and development.

Research, Development, and Deployment of Clean Energy Technologies

How do you manage energy R&D spending in a flat or declining budget environment?

A recurring theme throughout the discussion was the need for strong research and development to ensure the availability of a diverse portfolio of low-carbon energy options for the future—not only to maintain diversity in the United States, but also to ensure that other countries have access to technologies that will allow them to realize their own emissions reductions. However, there is considerable uncertainty over how to incentivize this innovation, especially in light of reduced discretionary spending and the price gap between new technologies and conventional energy sources being driven by low natural gas prices. Panelists pointed to the need for supportive policy in promoting research and development. In doing so, they discussed how policy can harness the power of industry to drive innovation in critical areas. These policies can take many forms, including subsidies, taxes, and mandates.

In general, incentives for low-carbon energy technologies should be determined in the context of market conditions and natural resource endowments in the target areas. For example, in a country where electricity prices are high, solar PV is competitive without subsidies, provided that capital can be accessed to build the project. In contrast, deploying low-carbon energy technologies in a country with significant, low-cost fossil energy resources will likely require some form of policy support.

Natural Gas and the Environment

How should the risks from natural gas production be managed? What are the GHG implications of expanded trade in fossil energy?

The environmental aspects of U.S. natural gas production and use range along multiple dimensions. They include local concerns regarding water quality and safety, broader issues of public perception, and national—and even international—ramifications for GHG emissions.

Overall, panelists were optimistic regarding the sustainable development of shale gas resources in the United States. There was a sense that companies, perhaps more now than previously, understand both the economic and "public license to operate" benefits that accompany adoption of best operating practices. From an investment and development perspective, it does not seem that environmental risks are meaningfully slowing the domestic production of natural gas.

There was general agreement that increased domestic production and use of natural gas would significantly benefit the U.S. GHG emissions profile in the near term, despite any uncertainty associated with lifecycle methane emissions. In addition, natural gas also emits lower levels of conventional air pollution (such as particulate matter, sulfur dioxide, or nitrogen oxides) and is likely to provide significant public health benefits in comparison with coal.

Panelists saw U.S. exports of liquefied natural gas (LNG) as positive to the extent they displace foreign electricity generation from coal or oil. At the same time, it is unclear how and to what degree this substitution occurs, and so the global GHG impacts of increased U.S. natural gas exports remain uncertain.

Global GHG emissions could also be affected through the development of shale resources elsewhere in the world, particularly if done on a scale comparable to that of the United States. Many other countries possess significant shale resources—including Canada, Mexico, Argentina, Russia, China, parts of Africa, and Eastern Europe. The extent to which future development of these shale resources allows natural gas to displace coal at the global level could have a significant impact on GHG emissions. At the same time, panelists noted there is substantial uncertainty surrounding when and how these shale resources will be developed, and so their ultimate impacts remain unclear. There was an acknowledgement, however, that these resources would likely be developed at some point in the future, due to a strong motivation in all countries to harness their domestic energy resources.

"Industry is remarkably competent at figuring out to how to extract new hydrocarbons when there's an economic incentive to do so. What that tells me is we need policies in place that create the right incentives for people to change the mix of fuel consumption in the world." —Jason Bordoff, Director, Center on Global Energy Policy, Columbia University School of International and Public Affairs

"Best practices do two things over the long term. Number one, they save you money. And two, they enhance your license to operate. A production company without a license to operate in the public's mind is broke, and I think the responsible operators—they get this. … [B]est production and best practices are taking root and taking hold, and I think we need to encourage that." —The Honorable David Garman, Principal, Decker Garman Sullivan and Associates, LLC

"We just follow the economic impact, and there's yet to be a study that's seriously, in any way, slowed down the boom in gas development." —*Ethan Zindler, Head of Policy Analysis, Bloomberg New Energy Finance*

International Agreements on Climate Change Mitigation

How effective are efforts that seek to reach a formal agreement to reduce greenhouse gas emissions? Does the likelihood of success change with the number of parties included in the negotiation?

There was a broad sense that policy to reduce GHG emissions is critical in making progress on global climate mitigation. Rather than selectively restricting supply from one location or another, a comprehensive policy that targets energy demand will better move the nation toward its climate goals, given the strong relationship between market drivers and the development of fossil fuel resources. And although innovation and technology are lowering the prices of both renewables and natural gas—which may in turn reduce the cost of climate mitigation—these economic developments will not replace the need for policy.

There are a number of efforts underway seeking to reach a formal agreement to reduce GHG emissions. These include bilateral, minilateral ("the smallest possible number of countries needed to have the largest possible impact on solving a particular problem," as defined by Moisés Naím[41]), and multilateral discussions to achieve both voluntary and binding reductions in GHG emissions.

The most well-known multilateral effort has proceeded under the United Nations Framework Convention on Climate Change. Countries have met annually in Conferences of the Parties (COPs), though their progress has been limited due to the high number of countries involved and the corresponding differences in perspectives and priorities.

An alternative approach may be negotiations among smaller numbers of countries. For instance, the United States and China agreed in June 2013 to phase down the production and use of potent hydrofluorocarbons (HFCs). This opened the door to further discussions, and at the G20 conference in September 2013, the G20 countries issued a similar agreement regarding HFCs. Under both agreements, the existing institutions and expertise of the Montreal Protocol will be an important tool for achieving results. These efforts—between the United States and China, and among countries in the G20—may serve as models for future bilateral and minilateral action, respectively.

Regardless of the form of talks, another issue is the potential leadership role of the United States. Some speakers asserted that the United States must take this role if any meaningful agreements are to be reached. Otherwise, countries are left to consider their individual circumstances in isolation, pursuing only the climate actions that are sensible for their own objectives. At the same time, one panelist noted that there needs to be better "policy surveillance" in the climate arena, to ensure that if one country—such as the United States—is taking serious action on climate change, then its partners will be as well. The primary concern in this case is the loss of competitive advantage.

In all, some countries have taken meaningful steps, but the global community is still far from meeting the target concentration levels of GHGs laid out by scientists studying the issue (for instance, the 450 parts per million target).[42] Panelists were mixed with regards to future prospects for an agreement. One panelist believes that the United States is in the process of moving from a strategy of climate mitigation to one of adaptation; from this perspective, the International Energy Agency's "450 Scenario" may be seen more as a general political motivator than as a roadmap for achievable goals. Other panelists believe that while there is still substantial room for mitigation and that we should pursue the actions we can, adaptation will be a significant part of any future climate change strategy.

"I looked at the issue of how effective these talks have been going up until now on the macro scale, and I think we've all had the same observation: when you get 200 countries around the table, it's pretty hard to reach any kind of a conclusion on anything." —*William Ramsay, Senior Advisor of the Center for Energy, Ifri*

"You have a number of very positive initiatives taken by companies which, 20 years ago, had never heard of a vice president for sustainability, all of whom now have one; who had not published annual sustainability reports, and most of the good ones do now; who really had not measured their emissions. In some ways, it's ahead of governments in various parts of the world. … This is something we have to build on. When the time comes, when the politics catches up with the culture—I would say at the moment it's lagging that, and there are a lot of public opinion polls that would suggest that—I think we'll be ready." —*The Honorable William Reilly, Senior Advisor, TPG Capital, LP*

International Approaches to the Deployment of Low-Carbon Energy Technologies

How will strategies to deploy low-carbon energy technologies vary depending on geopolitics, natural resource endowments, and domestic politics? Which technologies are likely to be deployed in different regions?

EUROPE

Europe's economy-wide carbon policies can sometimes interact with layered requirements and the market in unexpected ways. For instance, although large amounts of wind and solar have been installed throughout the continent, a significant share of European generation continues to come from natural gas, and more recently from coal, as a backup to those renewables and to satisfy the need for baseload power.

Increased U.S. production of natural gas has had mixed effects for Europe. On one hand, Europe has already benefited from increased U.S. natural gas production through displaced LNG shipments that are no longer needed in the U.S. market; these increased supplies have also led to the renegotiation of European contracts, though the continent continues to experience high natural gas prices. On the other hand, Europe may see itself at a competitive disadvantage given the much lower price of natural gas in the United States, which has begun to spur reindustrialization in many parts of the country.

CHINA

Much of the panelists' discussion on China revolved around the potential for natural gas to replace coal-fired generation in the country. There was some sense that China's coal use may peak within the foreseeable future, though significant declines are unlikely given the lack of an immediate substitute.

More so than climate, conventional air pollution is a significant driver in switching from coal to other fuel sources in China, though there are several challenges. One is a lack of electric and natural gas transmission infrastructure. Another issue is price and what happens to natural gas markets around the world, which are not yet as integrated as the global market for oil. In the future, there may be a change in how natural gas is priced in markets in Asia, similar to the transition that has already started in Europe. One panelist noted that if gas prices in China were to come down into a range of $9–11 per thousand cubic feet (mcf)—versus current levels of $15/mcf—then new power plants may be natural gas-burning instead of coal-burning. This view is not universally accepted, however. Some analysts believe that, while growth in Chinese coal demand is slowing significantly, the fuel that will be most substituted by gas is not coal, but diesel, which is considerably more costly than coal and has a higher emissions profile than natural gas. Nevertheless, these market prices are not sufficient to drive coal completely out of the generation mix in China, so policy mechanisms will also be needed to achieve environmental and other goals.

AFRICA

Electrification in Africa is badly needed, but regional macroeconomic projections do not anticipate growth in per capita GDP at levels that would support additional investment. Multiple panelists agreed that public investment would not be enough on its own, arguing that in addition to market demand, regulatory structures must overcome political risk premiums in order to bring in private investment. Part of the needed certainty is a guarantee that when the leadership of a country changes, the rules won't change. There was also mention of President Obama's "Power Africa" initiative, which aims to attract private investment to the region.[43] Potential baseload power sources for the region would include hydroelectricity, natural gas, and coal.

Panelists also highlighted resource wealth in Africa, including natural gas currently being developed and other resources that may be developed offshore. This natural gas is presently being exported due to lack of economic incentives to generate electricity on the continent, leading some panelists to point out the potential negative effects of resource wealth in general.

Session 4 Summary

Navigating the Oil Frontier: The Implications of the Tight Oil Boom on Arctic and Ultra-Deepwater Oil Development

Today, energy companies have more options to invest capital than at almost any time in recent history. The dramatic increase in the ability to extract tight oil and shale gas has created a myriad of new exploration and production opportunities; at the same time, improvements in deepwater drilling technology and reductions in Arctic sea ice have opened vast new “frontier” areas for production. The proliferation of investment opportunities has resulted in many companies taking a hard look at the high-cost, high-risk, ultra-deepwater, and Arctic plays to see where they stand among the other options for investment.

There are significant scientific, technical, environmental, and social challenges associated with accessing frontier energy resources—especially those located in the Arctic—and these challenges must be addressed prior to moving forward with energy production in these areas. The combination of growing global energy demand and the present lack of viable alternatives for liquid transportation fuels will ultimately drive frontier development, and the onus is on leaders in government and industry to pursue the policies and practices that will enable prudent development of these resources.

Participants

Keynote: The Current State of "Frontier" Oil Development

Christopher A. Smith
Principal Deputy Assistant Secretary for Fossil Energy, U.S. Department of Energy

Panel 1: Assessing the Need for Frontier Oil in an Unconventional World

Rebecca Fitz
Senior Director, Upstream Strategy & Competition, IHS Energy Insight

Oliver Moghissi
VP Technology, DNV GL North America Oil & Gas

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Research Geologist, U.S. Geological Survey

Panel 2: Navigating the Frontier—Science and Safety Concerns

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Background and Context

With the onset of the tight oil boom in the United States and the growth of oil sands production in Canada, expectations about future oil supply are shifting. The rapid growth in the production of unconventional oil has major implications for the development of all oil sources, particularly high-cost, high-risk "frontier oil" such as that found in the ultra-deepwater or Arctic. Some industry observers question whether the market needs this oil, given the unconventional boom, while others question the safety of exploring new frontiers such as the ultra-deepwater or Arctic.

Comparison of Minimum Extent of Arctic Sea Ice: 2012 Minimum Versus 30-year Sea Ice Minimum

Source: United States Department of the Navy, "The United States Navy Arctic Roadmap for 2014 to 2030," February 2014, P. 10, http://www.navy.mil/docs/USN_arctic_roadmap.pdf.

Nevertheless, high global oil prices, the reduction of Arctic sea ice, and the development of deepwater exploration technology have combined to open up new frontiers for oil exploration.[44] In the past 100 years, average Arctic temperatures have increased at almost twice the global average rate, and in 2012, Arctic sea ice reached its smallest extent in recorded history, 1.3 million square miles.[45] Oil and natural gas from Arctic regions and from ultra-deepwater locations, taken in conjunction with other new sources of energy, could provide a boon for global energy security and diversity of supply. Combined, global deepwater and Arctic resources are estimated at more than 380 billion barrels of crude oil.[46]

Arctic Oil and Natural Gas Resources by Continental Land Mass

Region	Crude Oil (billion barrels)	Natural Gas (trillion cubic feet)	Natural Gas Liquids (billion barrels)	Total Resources, Oil Equivalent (billion barrels)
Eurasia	30.70	1,219.39	27.55	261.49
North America	58.09	435.40	16.20	146.85
Indeterminate	1.20	13.87	0.31	3.82
Total	89.98	1,668.66	44.06	412.16
Eurasia	34.1%	73.1%	62.5%	63.4%
North America	64.6%	26.1%	36.8%	35.6%
Indeterminate	1.3%	0.8%	0.7%	0.9%
Total	100.0%	100.0%	100.0%	100.0%

Source: U.S. Energy Information Administration, "Arctic Oil and Natural Gas Potential," October 19, 2009, http://www.eia.gov/oiaf/analysispaper/arctic/.
Notes: "Resources" are estimated, undiscovered technically recoverable resources. The column totals may not equal the sum of the rows due to rounding. Per the original source, "indeterminate" regions are those that could not conclusively be assigned to either continent.

"[When] we think about the regulatory and the technical environment, the goal posts truly are moving. We are not in a static environment, we're in a very dynamic environment in which the objectives change, the challenges change, and they're evolving literally day by day. As technology evolves, you've got different opportunities, which means you've got different challenges you have to evaluate and mitigate through smart research and smart regulation." —*Christopher A. Smith, Principal Deputy Assistant Secretary for Fossil Energy, U.S. Department of Energy*

Key Questions and Insights from the Discussion

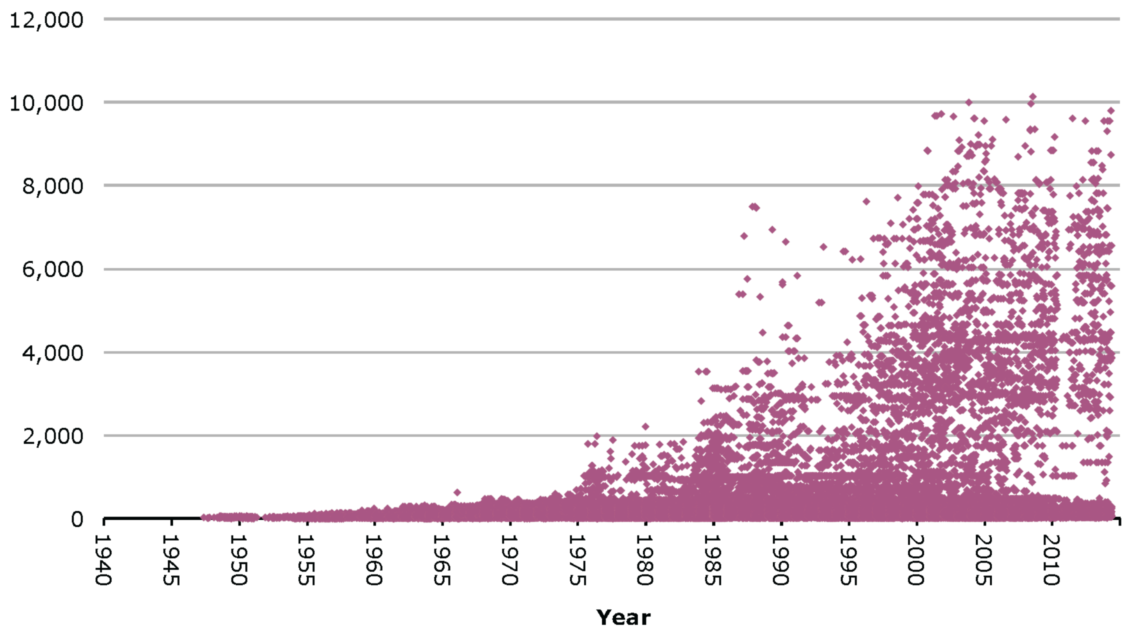
Competition from the Shale Boom

Why do companies want to invest in ultra-deepwater and Arctic production opportunities when the price outlook for oil might be uncertain, and how will competition from unconventional oil influence the prospects for Arctic and ultra-deepwater oil production? How would a future potential carbon price affect development? What is the lead time on Arctic production?

From the company perspective, development choices involve a number of factors, including balancing risks and seeking a diversified portfolio of exploration and production opportunities. For example, one panelist noted that in the Gulf of Mexico, production is shifting into riskier, deeper areas with higher costs, which must be taken into account as part of a company's larger strategy. In contrast, unconventional resources in the United States have lower geological risk; that is, the formations and the presence of oil and natural gas are well understood and the cost in comparison with a deepwater well is small. This shifts the risk borne by the operator to the environmental and technological aspects of production.

Wells Drilled in the Gulf of Mexico by Water Depth, 1940–2014

feet



Source: Bureau of Ocean Energy Management, "Well Information, Borehole," June, 2014, https://www.data.boem.gov/homepg/data_center/well/well.asp.

On the other hand, panelists noted that there are few companies globally that have both the appetite and capabilities for pursuing Arctic energy development. That observation also holds for the ultra-deepwater, with the exception of the Gulf of Mexico. There are key geologic and operational differences between the Gulf of Mexico and the Arctic. For instance, the continental shelf in the Gulf of Mexico has largely been fully developed, and the deepwater areas—where development has increasingly shifted—exhibit substantial overpressure conditions. The significant overpressure and water depth in the deepwater Gulf combine to make exploration technically challenging, while the significant experience that operators have amassed in turn makes these challenges easier to surmount. In contrast, there are Arctic shelves that are still largely unexplored, that are at shallower depths, and that have relatively limited overpressure conditions. These geologic conditions, according to the panelists, make Arctic exploration less technically challenging, while the lack of operator experience, extreme weather conditions, lack of infrastructure, and remoteness in turn contribute to different types of challenges for an operator.

In the near term, phenomenal growth in tight oil and natural gas production has created challenges in the market. For instance, according to some panelists, a substantial number of companies are struggling with profitability at current natural gas and crude oil prices. One panelist noted that if some companies' returns are challenged with an oil price of $110, then the situation would be exacerbated with prices of $75; in fact, such a situation would be concerning for producers in many areas other than the frontier.[47] Such an assessment is not supportive of the U.S. resource production forecasts from a variety of agencies, particularly if the current restrictions on U.S. crude oil exports remain in place, given that domestically produced light tight oil is already sold at a discount to world prices.[48]

In the long term, it is likely the world will need to access deepwater and Arctic resources in order to meet the growing global demand for crude oil, which is projected to increase by 25 million barrels per day by 2040.[49] Over the near- to medium-term, unconventional oil will likely be an integral source of supply for the incremental demand from global oil markets. But unconventional oil is not a panacea: some analysts see a point in the future when production from onshore unconventional oil formations in North America will decline, and there is uncertainty about the long-term role for unconventional oil and gas from unexplored tight formations outside of North America in the energy supply mix.[50]

The timing of future exploration and production in the Arctic is difficult to predict, though panelists believe that it is expected to play an important role by the end of this decade. Some areas, such as those in Eastern Canada and the Barents Sea, are already seeing some movement. The U.S. Arctic is at a different scale, however, and a lack of infrastructure, in addition to other factors, will contribute to a significant lead time of ten or more years until production could conceivably make its way to market.

"We have roughly 130 billion barrels of undiscovered oil in the United States. If you break that down, about 10 percent is so-called unconventional (tight oil), about 30 percent is Arctic, and about 30 percent is relatively deepwater [in the] Gulf of Mexico—that is, beyond the shelf edge. So really what we're looking at is 70 percent of the undiscovered resource in the United States being unconventional, Arctic, or deepwater." *—David Houseknecht, Research Geologist, U.S. Geological Survey*

"If you compare the best wells in the Eagle Ford or the Bakken to, let's say, the best wells in Prudhoe Bay, it would take 60 to 80 bore holes in the Eagle Ford or Bakken to equal one bore hole at Prudhoe Bay. That shifts the risk to the footprint on the landscape and all the associated things that come with that." *—David Houseknecht, Research Geologist, U.S. Geological Survey*

"Large companies challenged with unconventional business models ultimately need large, diversified portfolios. So I would say instead of unconventionals versus Arctic, the core question is, in a large company, what role does exploration play in global strategy execution? And if the choice is that exploration plays a fundamental role in doing what we need to do, what [is the] role for the Arctic within the exploration strategy?" —*Rebecca Fitz, Senior Director, Upstream Strategy & Competition, IHS Energy Insight*

The Arctic

Is the United States ready for development in the Arctic? What are the largest risks and how are they being mitigated? What are the specific challenges associated with the Arctic's unique geology and environment, and how will these challenges be impacted by climate change adaptation?

According to the panelists, the principal risks associated with energy production in the Arctic are environmental and technical. Two key technical risks are the presence of sea ice and the potential for extreme weather events. On the environmental side, one speaker noted that the impacts of human activities on Arctic ecosystems are highly uncertain at present. The U.S. government has identified science gaps and areas for additional research and understanding with regards to these challenges.[51] These areas include improving disaster-response and spill-cleanup capabilities, Arctic climate change adaptation, and the specific challenges of operating in the Arctic's unique geology and environment.[52] In addition, Arctic biological populations have dependencies on an international ecosystem that spans maritime boundaries, prompting the need to work with other governments to devise schemes that protect ecosystems from externalities associated with energy development. Finally, in the United States, events taking place during the 2012 Arctic drilling season raised questions about the adequacy of safety systems and emergency response.[53]

Climate change is happening faster in the Arctic than anywhere else on Earth. There has been a temperature increase of four degrees in Alaska; spring comes earlier, and fall comes later.[54] Climate change is also having a significant impact on the onshore and offshore environment, where development is increasingly subject to a shorter operating window onshore (where melting permafrost makes ice road transportation difficult) and a longer window offshore (where reductions in sea ice are increasing access). Both inside and outside of the Arctic, increased storm, wave, and flooding activities related to climate change will have impacts on energy production and subsea pipelines. As ice melts, it will also create new shipping and transit routes. Although more is being learned each year, research is still needed.

Finally, there are complex societal issues as well. As one speaker noted, indigenous peoples often take a vastly different approach to risk and development than do outsiders.

"I think there's a tendency sometimes for us to look at high-consequence threats as being high risk. … I think that in reality, rather than asking whether deepwater or Arctic is riskier, we should look at both the consequence and the probability side." —*Oliver Moghissi, VP Technology, DNV GL North America Oil & Gas*

"The present is not what the past was, and the future will not be what the present is today. So you can pick your projections about how rapidly things will continue to change, but the reality is, how we build ports, docks, airports, and buildings—[they are all] changing right now because of permafrost thawing. … So it's very dynamic." —*The Honorable Fran Ulmer, Chair, U.S. Arctic Research Commission*

Post-Deepwater Horizon Reforms, and Areas for Future Research

What do we know about responding to a potential oil spill? What is the current state of disaster response and spill cleanup in both Arctic and ultra-deepwater oil production areas? How have oil-spill prevention and response capabilities changed over the four years that have passed since the Macondo spill in the Gulf of Mexico? Which topics should be priority areas for ongoing and future research?

It is almost impossible to clean up an oil spill in any location. In general, a cleanup operation will recover less than ten percent of the oil.[55] The Gulf of Mexico is relatively well equipped to deal with an oil spill, given a spectrum of regional assets that includes ships, airports, and other infrastructure. Even with these capabilities, however, only a limited amount of oil can be recovered. The Arctic's geographical isolation and relative lack of development compounds these challenges further.

Panelists agreed that Macondo has had a lasting impact on both the government and industry practices with respect to drilling safety and disaster response. In the aftermath of the accident, more resources are being devoted to improve disaster response technologies and practices. This research encompasses organization-wide efforts, such as those by the Coast Guard, as well as technology-specific research into measures such as in-situ burning and dispersants. The National Research Council has recently released a report indicating priorities for future research.[56]

Prevention, containment, and spill response technologies and practices are all very important, but are still underdeveloped. The panelists noted that special emphasis should be placed on prevention, not just in the Arctic, but everywhere. Identifying technology research and development priorities is also important. During the Deepwater Horizon incident, some panelists noted that only a primitive level of response options was available to the United States and that relatively little research and development into spill response was occurring at that time.

All panelists agreed that research and continuous improvement in process safety will be an ongoing need and that regulation and prevention will have to keep pace with industry's technological advancements. Prevention has to be the subject of continuing review and dialogue; otherwise, we risk falling back into the same complacency seen before Macondo.

More coordination of research and findings would also be helpful. This includes both an integrative effort that brings together research within individual countries—across companies, government, and academic institutions—but also a better perspective on the safety and prevention research that is happening in different countries.

One specific suggestion for science research was an Arctic observation network, which does not currently exist. In addition to information collection regarding ice cover, this type of network would collect data on variables such as the location of marine mammals/fish and ocean conditions (such as acidification). Such an effort would include industry's ongoing research, domestic agencies such as NOAA, NASA, and others, as well as foreign government organizations. This kind of comprehensive observation network would also be an important legacy for the U.S. chairmanship of the Arctic Council that is starting next year.

"I think we're significantly better at preventing accidents than we were before. We have a much-enhanced set of drilling safety regulations, which—although done in a hurry-up fashion—incorporated a lot of learning from industry and from government that should have been incorporated years, if not decades, before. So I think we're in a much better place. But we have to look at things squarely and recognize that we will never, ever reduce the risk to zero." *—Michael R. Bromwich, Founder and Managing Principal, The Bromwich Group*

"Prevention has always got to be where we put our money, as opposed to spill response. Not to say we don't need to do more research in spill response, or training, or positioning of assets—don't get me wrong; but that will never be the answer. The answer is prevention and risk reduction." *—The Honorable Fran Ulmer, Chair, U.S. Arctic Research Commission*

"The Gulf of Mexico is probably a good place from the standpoint of readiness. You have a lot of capacity in that region to deploy assets to recover oil. You have numerous Coast Guard bases, airports, ports, harbors, and vessels of opportunity that could be deployed. In comparison to the Arctic, where there is very little infrastructure, it's day and night." *—The Honorable Fran Ulmer, Chair, U.S. Arctic Research Commission*

"[What] could have happened before Macondo that didn't happen, but that might have avoided [the accident]? I think the answer is many things. But first and foremost, the biggest evils: complacency and over-confidence. The complacency and over-confidence of thinking you know all of the answers to the question 'Are you ready?' as opposed to continually looking for ways to improve." *—The Honorable Fran Ulmer, Chair, U.S. Arctic Research Commission*

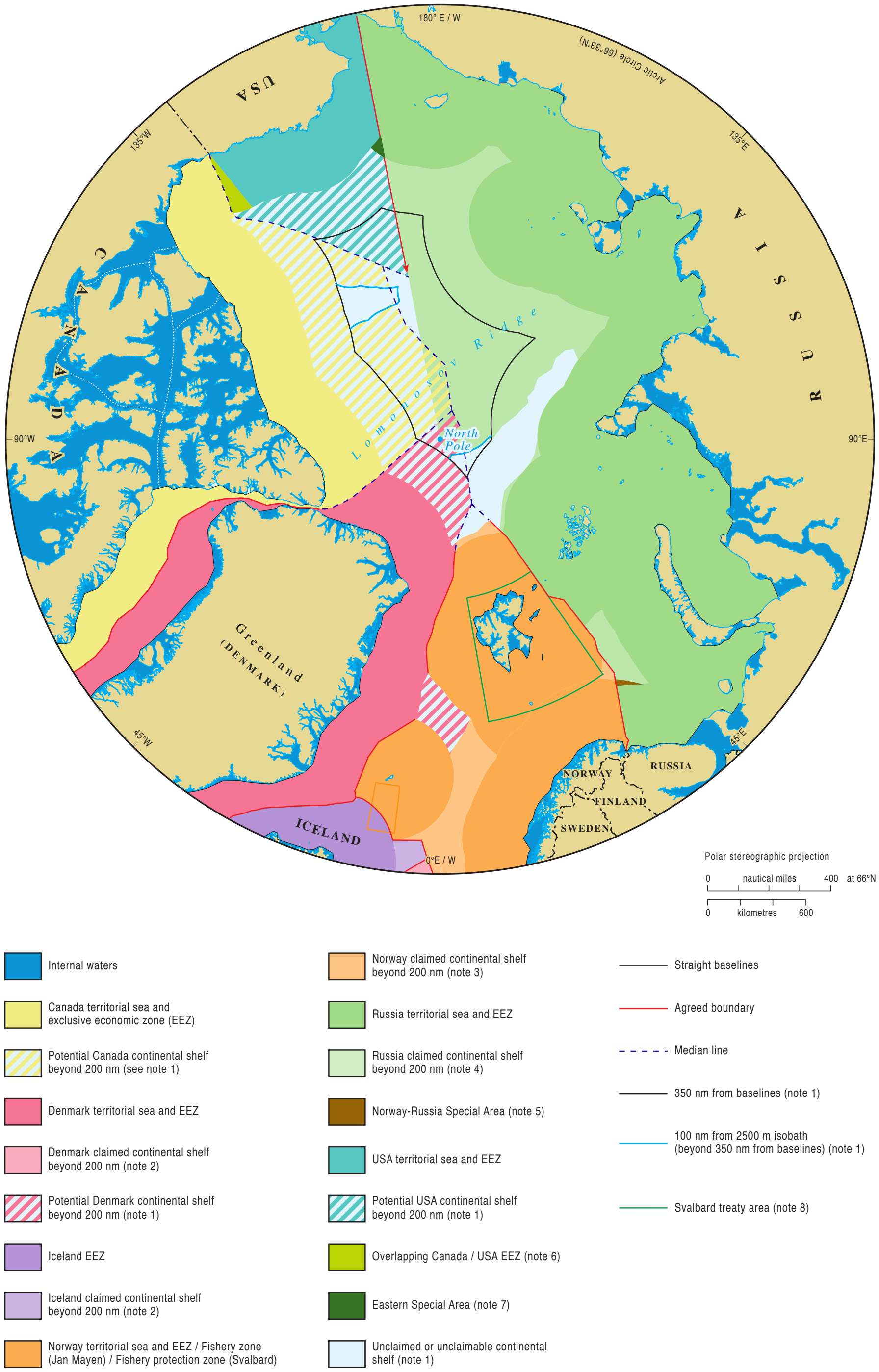
"I completely agree that the fatal flaw—of both industry and government—that produced Macondo was complacency and over-confidence. I don't think we had that in the immediate aftermath of the accident; I don't think we have it now. [But] I'm very worried that in a couple of years, it will descend on us again, and we will be [where] we were back in 2010." *—Michael R. Bromwich, Founder and Managing Principal, The Bromwich Group*

Geopolitics, a Look Abroad, and Strengthening Developing Country Energy Production Oversight

What are the geopolitical ramifications of Arctic and ultra-deepwater oil development? How is the conflict in Russia likely to impact offshore oil and gas governance in the Arctic?

One panelist noted that the Law of the Sea Treaty is not critical for the development of resources on the Beaufort Shelf, given that the Exclusive Economic Zone (EEZ) already extends well beyond the toe of the slope, and production will likely not move past that point within the foreseeable future. On the Russian side, however, the resources extend significantly past the EEZ.

Arctic Boundaries



Source: International Boundaries Research Unit, Durham University, “Maritime jurisdiction and boundaries in the Arctic region,” http://www.durham.ac.uk/ibru/resources/arctic.

Russia has invested tens of millions of dollars in collecting high-resolution seismic data in their areas of interest, while only a small amount of the data collected by the Canadians is on the Alaska margin.[57] Overall, the panelists believe that the United States is not in a strong position to compete with the knowledge that has been collected by other countries. Panelists agreed that while current tensions in Eastern Europe have strained U.S.-Russian relations in some areas, it is imperative that all Arctic countries remain engaged and cooperative on Arctic governance issues.

For countries new to frontier energy development, several steps are important. First, the regulatory framework must be consistent with the country's political, cultural, and other norms; a foreign system will not work. Once a system has been designed, there are also implementation challenges. For instance, in many cases activities will exceed the boundaries of the regulatory structure, which poses its own safety and other difficulties.

Countries in this position can take several steps to promote the safety and efficiency of their operations. One is to ensure the technical competence of the operators, as well as of the suppliers and contractors. Another path is to seek third-party oversight, which can help to lend credibility to a project when there may be opposition from one or more stakeholders.

The regulator's main challenge is to determine: if the country is ready to conduct these operations; if the correct regulations are in place to ensure prevention, containment, and spill response; and if the operator can effectively handle the unusually challenging conditions of the proposed project.

It is also important for countries to build economic incentives into regulatory regimes, by either increasing monetary incentives or increasing penalties, so that companies have reason to act. In other words, regulators have to change the balance so a company's internal risk analysis gives more weight to avoiding a disaster.

"I still think international efforts are extremely important, extremely meaningful. We learned a lot as we were developing our new regulations from a variety of different countries that had very different regulatory regimes—from the UK, from the Norwegians, from the Australians, from others. So I think the continuation of those kinds of interchanges and exchanges are extremely valuable. And I think setting baseline international standards is a worthwhile project, but people should not underestimate the challenges to getting there, because I think they're very, very substantial." *—Michael R. Bromwich, Founder and Managing Principal, The Bromwich Group*

Alternatives to Ultra-Deepwater and Arctic Energy Development

Is it plausible to imagine a future where there is no development in the ultra-deepwater and Arctic, and if so, what do the alternatives look like?

Although there have been calls from some not to pursue Arctic and other frontier resources, the panelists agreed that, at present, such a strategy is not feasible. Domestic energy demand is significant, and although it is no longer growing quickly, world energy demand is expected to rise rapidly in the coming decades. These challenges are particularly relevant for the transportation sector, where alternatives to conventional liquid fuels have been slow to enter the market.

At the same time, panelists acknowledged that Arctic areas with particularly high biodiversity or environmental importance should be considered for protection. Through effective planning, it is possible to steer companies away from these areas and toward others; but given the need for resources, it is not possible to place every area off-limits.

The world is changing fairly rapidly and, while in the future new technologies are likely to make up a major share of the energy mix, the conventional energy industry will still play a large role for years to come.

"Are there some places that should be off-limits [to drilling]? Yes, there are. But realistically, can we put everything off-limits? No we can't. … Meanwhile, as a nation and as a species, we should be investing in the research [of alternatives] that would allow us the luxury of making the decision that we're simply not going to drill at all in places like the Arctic. We're not there yet." —*The Honorable Fran Ulmer, Chair, U.S. Arctic Research Commission*

"We should not necessarily look to the conventional energy industries to lead us into the wilderness of this new sustainable/renewable energy future. That isn't necessarily what an oil and gas company is good at. … Maybe they will be the discoverers and the implementers of the new energy technologies, or maybe they won't and somebody else will. But to sit back and look at [these companies] and say, 'You have to take us there,' is a little misguided. Let them do what they're good at, do it as efficiently as possible, and incent new energy industries to develop and create new technologies to take us into the next century." *—Richard Sears, Consulting Professor, Stanford University*

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[50] U.S. Energy Information Administration, Annual Energy Outlook 2014, May 7, 2014, Table 14: Oil and Gas Supply, http://www.eia.gov/forecasts/aeo/data.cfm#summary.

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[53] U.S. Department of the Interior, Review of Shell's 2012 Alaska Offshore Oil and Gas Exploration Program," March 2013, http://www.doi.gov/news/pressreleases/upload/Shell-report-3-8-13-Final.pdf.

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