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New Energy, New Geopolitics

Background Report 1: Energy Impacts

MAY 2014

A Report of the CSIS Energy and National Security Program and the Harold Brown Chair in Defense Policy Studies

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ISBN: 978-1-4422-2849-8 (pb); 978-1-4422-2850-4 (eBook)

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Acknowledgments

This report is the result of a year-long project by the CSIS Energy and National Security Program and the Harold Brown Chair in Defense Policy Studies called the "The Geostrategic Implications of Unconventional Oil and Gas." Over the course of the past year, we were able—through workshops, in-depth sessions, and meetings—to illuminate the multiple dimensions and alternative outcomes of the shifting energy landscape. We are grateful for the valuable time and insights we received from a wide array of leaders in industry, government, academia, and nonprofits and to the Smith Richardson Foundation, whose generous support made this study possible.

We would like to thank and recognize Tatiana Mitrova, head of the Oil and Gas Department at the Energy Research Institute of the Russian Academy of Sciences (ERI RAS), and her staff for their insights, assistance in the formulation of the potential energy scenarios used in this report, and contribution to our Russia-specific analysis.

The authors also gratefully acknowledge the valuable assistance of their Center for Strategic and International Studies (CSIS) colleagues throughout this project and the production of this report: Edward Chow, David Pumphrey, Annie Hudson, Lisa Hyland, Andrew Gossett, and Scott Mann; and our studious interns Fernando Ferreira, William Hicks, Hong Yang, Chance Fowler, and Ariel Robinson.

Finally, we would like to thank our regional scholars at CSIS: Jon Alterman, Zbigniew Brzezinski Chair in Global Security and Geostrategy and director of the Middle East Program; Heather Conley, director and senior fellow with the Europe Program; Chris Johnson, senior adviser and Freeman Chair in China Studies; Andrew Kuchins, director and senior fellow with the Russia and Eurasia Program; and Murray Hiebert, deputy director and senior fellow with the Sumitro Chair for Southeast Asia Studies. Their insights and analyses on the geopolitical impacts of the unconventional energy revolution in each of their respective regions were a critical input into the report.

1 Introduction[1]

In the last 10 years, U.S. shale gas and tight oil production has skyrocketed, supplying not only national but global markets, to the benefit of many. Between 2005 and 2014 U.S. crude oil production rose nearly 65 percent and natural gas production was up 34 percent—both increases a result of tight oil and shale gas development.[2] The shale gas supplies from Pennsylvania alone equal the entire natural gas export capacity of Qatar, the world's second largest natural gas exporter.[3] And the increase from light tight oil production in places like North Dakota and Texas over the last five years is equivalent to that of Iraq's current production levels. All things being equal, this surge in supply has helped to suppress prices for both oil and natural gas that would likely have been higher due to other supply disruptions. (This effect has been most pronounced in North America, where gas prices in particular have been lower than elsewhere in the world.)

New production techniques have meant that resource deposits around the world previously considered uneconomic to access have become "technically recoverable," significantly adding to the global resource balance sheet. According to one preliminary assessment, 137 shale formations in 41 other countries, in addition to the United States, hold around 10 percent of technically recoverable global crude oil and 32 percent of global natural gas.[4] Deposits beyond the countries examined increase these recoverable amounts still further. For a world increasingly dependent on energy to drive economic growth and prosperity, this is a good news story.

For those who look at the world through a geostrategic lens, however, assessing the impact of these new resources is more complex. They raise a number of questions about who stands to gain, who stands to lose, and what opportunities for advantage might emerge

1. *New Energy, New Geopolitics: Balancing Stability and Leverage*, by Sarah O. Ladislaw, Maren Leed, and Molly A. Walton, was published by CSIS in April 2014. Related to that volume are three "background reports," providing greater detail on (1) energy impacts, (2) geopolitics and national security impacts, and (3) scenarios, strategies, and pathways. This is the first of those background reports.

2. Calculations based on U.S. Energy Information Administration (EIA). 2014 projections from EIA, *Short-Term Energy Outlook (STEO)* (Washington, DC: EIA, November 2013), http://www.eia.gov/forecasts/steo/archives/nov13.pdf; data for 2005 is from EIA, *Short-Term Energy and Summer Fuels Outlook (STEO)* (Washington, DC: EIA, April 2014), http://www.eia.gov/forecasts/steo/report/us_oil.cfm.

3. BP, *BP Statistical Review of World Energy 2013* (London: BP, 2013), http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf.

4. EIA, "Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States," June 13, 2013, 10, http://www.eia.gov/analysis/studies/worldshalegas/. Notably, this assessment includes only 41 countries around the world and does not include some of the most hydrocarbon-rich countries, such as those in the Middle East and the Caspian region.

in both the energy and geopolitical realms. Since the advent of the so-called "shale gale" or "unconventionals revolution," myriad energy analysts, geopolitical strategists, foreign policy experts, industry titans, and government officials, including heads of state, have offered their views on the potential strategic impact of the changing energy landscape on global economic and geopolitical relations. Some see limited significance, while others predict profound and radical change.

Given the scope and intensity of the discourse surrounding this new source of energy production and its potential effects, the Center for Strategic and International Studies (CSIS) believed its expertise in energy, regional affairs, and national security could provide a useful and unique synthesis of the complex interactions under debate. Assembling a broad multifunctional team, CSIS undertook a year-long exploration of the potential geostrategic implications of shale gas and tight oil, with the intention of providing policymakers with a structured way to consider the potential risks and rewards of the new shale gas and tight oil resources.[5] This analysis is not meant to be regionally comprehensive; rather it represents an overarching survey across categories of key international players, with deeper analysis in certain cases.[6]

This first background report outlines the changes that have taken place in U.S. and global energy markets thus far, including a description of U.S. tight oil and shale gas production and the domestic impacts, how the shifts in the U.S. energy posture (i.e., slowing consumption and increasing production) are affecting global energy markets, and the challenges faced by other countries that seek to replicate the U.S. experience.

The second background report, "Geopolitical and National Security Impacts," lays out some of the geopolitical adjustments being made around the world in response to energy changes (both actual and perceived), and what these adjustments—in terms of energy markets and geopolitics—have meant for U.S. national security. So far, perception is leading reality when it comes to the geopolitical and associated national security impacts that have resulted from tight oil and shale gas. Many countries and companies are acting on early interpretations of this trend. Some will be rewarded, while others may lose out (especially on the investment side).

The final background report, "Scenarios, Strategies, and Pathways," examines how the U.S. government is attempting to incorporate shale gas and tight oil developments into current U.S. energy and national security strategy. This strategy is still evolving and many

5. For the purposes of this report, when we discuss unconventional oil and gas in the context of the United States, we use the terms "shale gas" and "tight oil," as they are at the heart of the U.S. oil and gas production surge under examination, and are a key driver for many of the impacts analyzed in this report. When we discuss the potential for the production of unconventional resources outside of the United States, we use the term "unconventionals" because the authors recognize that oil sands, heavy oil, coal bed methane, and other types of unconventional oil and natural gas have significant potential around the world and are often included under the unconventional category. Similarly, when discussing the future trajectory of production, we use the term unconventionals because future assessments look at the global potential in addition to the United States.

6. This report focuses on North America, Asia, Europe, the Middle East, and Russia. Though it does not go into depth on Africa, Latin America, or Southeast Asia, these regions are touched on throughout the report.

view policy statements thus far as unevenly connected to actions. Going forward, U.S. policymakers face a choice between two strategic paths for managing shale gas and tight oil resources—what this report terms "energy stability" or "energy leverage." The energy stability pathway suggests that the United States' energy advantage should be used to enhance energy security around the world, on the theory that more stable energy markets will foster strong economies and enhance geopolitical stability. The energy leverage pathway views the energy advantages presented by U.S. oil and gas production as tools that can be employed in the service of broader geopolitical or economic objectives.

The difficulty in deciding on a way ahead is complicated by the uncertainty about the future of unconventionals themselves. This report posits a range of possible futures in that regard, in order to inform risk judgments associated with the potential strategic pathways. Ultimately, the report concludes that energy stability is most prudent and robust against a range of possible outcomes, and makes recommendations for how such a strategy could be implemented.

2 New Production in a Changing Landscape

The United States has always been a resource-abundant country and has successfully converted its ample energy, agriculture, water, mineral, and human capital resources to fuel its economic growth. Over the last several decades and until about 2010, the size of economically recoverable oil and gas resources available in the United States diminished, and the country relied increasingly on imported oil and natural gas. This growing import dependence and the reality of U.S. vulnerability to the often-volatile global oil markets (and the widely shared expectation that these two conditions would only deepen over time) resulted in a national view that the United States was a relatively resource-constrained and energy-insecure country.[1]

The Energy Landscape

Since the 1973 Arab oil embargo, the United States has been preoccupied both with its own and its allies' dependence on imported energy sources, especially in relation to the stability and interdependence of global energy markets. The United States and other major traditional Organization for Economic Co-operation and Development (OECD) energy-consuming countries have taken a number of steps to reduce their vulnerability. First, they created international energy institutions like the International Energy Agency (IEA), which was initially founded to "help countries co-ordinate a collective response to major disruptions in oil supply through the release of emergency oil stocks to the markets."[2] Second, as part of the IEA, they established a system of member country strategic stocks, including the U.S. Strategic Petroleum Reserve, in order to provide some degree of buffer against large and sudden supply disruptions. Third, they promoted free trade and open investment climates for energy goods and services, to include the removal of U.S. price controls. Fourth, the United States has protected sea lanes and trade routes in an attempt to set and enforce international norms and ensure the free flow of goods and resources. Fifth, they have encouraged integrated energy infrastructure where possible to increase overall efficiency and resiliency. And finally, they have created a system of policies and programs to drive greater levels of energy efficiency to decrease energy demand, and have taken steps to

1. Despite ample coal, nuclear, and renewable energy potential.
2. This mission has evolved over time, and now the primary function of the International Energy Agency is to ensure reliable, abundant, and clean energy to its 28 member countries (and others). International Energy Agency (IEA), "About Us," http://www.iea.org/aboutus/whatwedo/.

invest more systematically in new energy technologies and sources. These steps were initially promoted by traditional OECD energy-consuming countries, but have been picked up in large part by rapidly emerging developing economies like China and India.

Over the last decade the fundamental structure of the global energy landscape began to shift. Economic growth in the world's most developed economies was beginning to slow down, but the associated fall in energy demand growth was more than offset by the sudden onset of unforeseen growth rates in rapidly emerging developing economies (most notably China). The demand-side shock challenged the world's energy providers to develop new supplies, and prices for energy and other commodities rose across the board. This caused some analysts and policymakers to question both the adequacy of the resource base and the ability to get energy products to market in sufficient quantities to keep energy prices at a manageable level. Despite ample evidence that energy supplies were sufficient in terms of resources underground, the "above ground issues" (political instability, unwillingness of the world's major oil and gas resource holders to allow and provide timely investment into their sovereign resources, transit risks, technological complexity, difficult or inconsistent investment frameworks, etc.) continued to fuel the so-called "scarcity mindset" that has dominated energy discourse in the past. The fears among policymakers were further stoked by worry that the fastest growing consumers—mostly in Asia, and China and India in particular—might be less committed to the global energy norms and institutions that had emerged in the 1970s.

The changing demand picture also spurred state-owned oil and gas companies, not only in major producing countries like Saudi Arabia, Venezuela, and Russia, but also in China and India, to develop new strategies for investing in resources around the world. For example, several national oil companies (NOCs) developed investment strategies both in oil and gas producing but also refining ventures around the world. This introduced a new competitive dynamic for the large, privately owned, integrated oil and gas companies.

The growing concern over resource scarcity, relentless demand growth, and the resulting potential for a new and higher floor for global energy prices in combination with a growing awareness of the need to tackle the problem of climate change converged, creating an enabling environment for an increasingly mainstream acceptance of the need to transition to lower-carbon energy sources. At the time, fossil-based energy sources were seen as increasingly expensive and more unstable and unreliable. Thus the attractiveness of traditionally more costly low-carbon energy sources (more efficient technologies and systems, wind, solar, geothermal, biomass, and nuclear) rose, as they were seen as offering not only greater energy security, but also the potential to reduce greenhouse gas emissions.

Between 2007 and 2009 the geopolitical dynamics of energy took on a discernibly new tone. Traditional fossil-based energy producers became concerned about the apparent growth in global willingness to seriously consider alternative sources of energy. Among major consuming regions, including Europe, Asia, and even the United States, investing in new clean energy technology development and deployment was put forth as a major component of economic, environmental, and security strategies. The United States sought to

obtain energy self-sufficiency through increased use of biofuels and hybrid and electric vehicles, and by taking part in a global nuclear renaissance aimed at decarbonizing the power sector. U.S. politicians campaigned on lower U.S. reliance on places in the world like the Middle East, Venezuela, and Nigeria.

Yet even as new policies supporting renewable and low-carbon energy were developed, the energy landscape continued to evolve. Over the last five years the global financial crisis and economic downturn, combined with the subsequent perceived stalling of interest in international climate policy, an unprecedented nuclear disaster in Fukushima, Japan, and the worst deep-water oil spill in U.S. history have all changed energy priorities and market dynamics.

The U.S. Shale Gas and Tight Oil Experience

Perhaps the most fundamental change has related to unconventional energy. Success in unlocking the economic, technological, and commercial viability of the tremendous oil and natural gas resources within the United States, combined with lower demand and greater efficiency, has resulted in an entirely new energy posture for the United States. Though other countries have not yet succeeded to date in replicating the North American experience, there is still great interest in transferring this production of unconventional oil and gas to other parts of the world with similar resources.

WHAT IS UNCONVENTIONAL OIL AND NATURAL GAS?

According to the Energy Information Administration (EIA), unconventional oil and natural gas is "an umbrella term" for any oil and natural gas resource that is produced by a method other than drilling a well into a "geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore." EIA appropriately caveats that "what has qualified as 'unconventional' at any particular time is a complex interactive function of resource characteristics, the available exploration and production technologies, the current economic environment, and the scale, frequency, and duration of production from the resource. Perceptions of these factors inevitably change over time and they often differ among users of the term."[3]

Some organizations characterize oil sands in Canada, heavy oil in Venezuela, and deep-water oil and gas resources in many parts of the world as unconventional because of the processes used to produce those resources. For the purposes of this report, "unconventional oil and gas" refers to the shale gas and tight oil resources that are at the heart of the U.S. oil and gas production surge under examination.

Shale gas, one type of unconventional gas, is natural gas trapped in sedimentary rocks with low permeability. Shale gas is gas trapped in very tiny pores in the rock. To produce the gas, the rock must be fractured (broken apart) using water mixed with certain chemicals and bits of material (like sand) to prop open the fractures in the rock that then allow

3. EIA, "Glossary," http://www.eia.gov/tools/glossary/index.cfm.

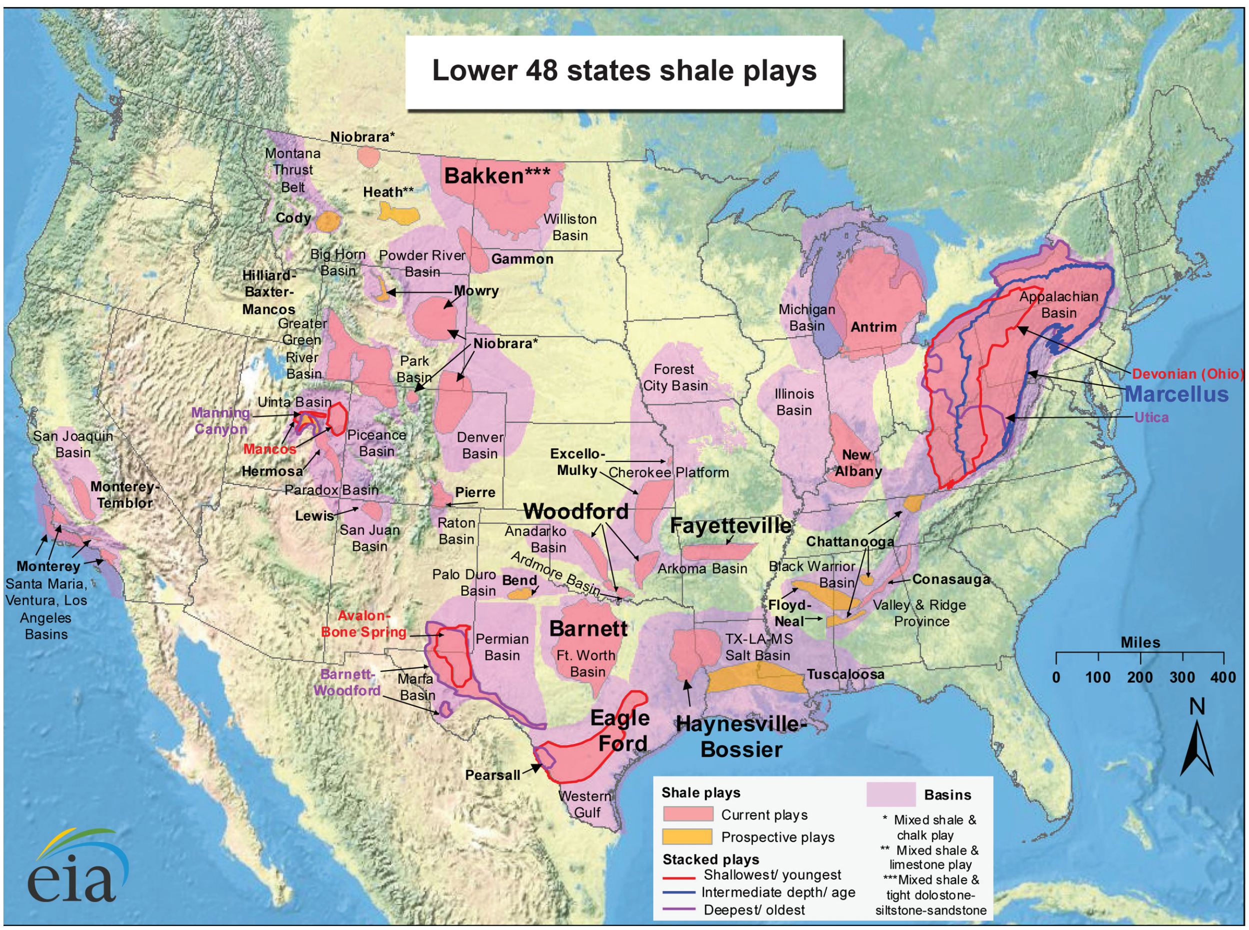
the gas to escape and be produced. Tight oil is oil embedded in low-permeable sandstone, carbonate, or shale rock and it is produced using similar techniques to shale gas. Due to the different physical characteristics of oil, it is often more difficult to produce.

As will be discussed in the next section, the surge of oil and gas production in the United States is a rapidly evolving and complex phenomenon. Since the commercial onset of these production techniques began in earnest in 2008, the new resources have been called many things—from shale gale to unconventional revolution to resource boom. The terminology confusion reflects a search for wording that accurately reflects the nature and significance of the newfound production growth.

RESOURCE ESTIMATES

The United States has both conventional and unconventional natural gas and oil resources (see Figure 1 for unconventional natural gas plays). Recent studies conducted by EIA have also demonstrated that unconventional resource potential exists outside of the United States. To date, however, the United States has been the epicenter of unconventional production and growth.

Figure 1: Continental U.S. Shale Plays



Source: U.S. Energy Information Administration (EIA), http://www.eia.gov/oil_gas/rpd/shale_gas.pdf.

Table 1. Technically Recoverable Shale Oil and Shale Gas Resources

	Crude Oil (billion barrels)	*Wet Natural Gas (trillion cubic feet)*
Outside the United States		
Shale oil and shale gas[1]	287	6,634
Non-shale[2]	2,847	13,817
Total	**3,134**	**20,451**
Increase in total resources due to inclusion of shale oil and shale gas	10%	48%
Shale as percent of total	9%	32%
United States[3]		
Shale/tight oil and shale gas	58	665
Non-shale	164	1,766
Total	**223**	**2,431**
Increase in total resources due to inclusion of shale oil and shale gas	35%	38%
Shale as percent of total	26%	27%
Total World		
Shale/tight oil and shale gas	345	7,229
Non-shale	3,012	15,583
Total	**3,357**	**22,882**
Increase in total resources due to inclusion of shale oil and shale gas	11%	47%
Shale as percent of total	10%	32%

1. Advanced Resources International, Inc. (ARI), 2013.
2. *Oil and Gas Journal*, Worldwide Report, December 3, 2012; Christopher J. Schenk, "An Estimate of Undiscovered Conventional Oil and Gas Resources of the World, 2012," fact sheet, U.S. Geological Survey, March 2012; Timothy Klett et al., "Assessment of Potential Additions to Conventional Oil and Gas Resources of the World (Outside the United States) from Reserve Growth, 2012," fact sheet, U.S. Geological Survey, April 2012.
3. EIA, various reports.

Source: EIA, "Shale oil and shale gas resources are globally abundant," January 2, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=14431.

Although the resource estimates of conventional resources are fairly well understood, understanding of the shale gas and tight oil resource geology continues to evolve. The most recent EIA-sponsored study estimated the United States' technically recoverable[4] shale oil resources at 58 billion barrels (17 percent of world totals) and the technically recoverable shale gas resources at 665 trillion cubic feet (tcf) (9 percent of global totals).[5] As Table 1

4. Defined as the volume of a resource that is recoverable using current exploration and production technology without regard to cost. This represents varying proportions of the estimated in-place resource.

5. EIA, "Shale oil and gas resources are globally abundant," January 2, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=14431.

illustrates, overall, U.S. shale oil and gas have increased total national oil and gas resources by 35 and 38 percent, respectively.

Domestically, a combination of factors has allowed U.S. oil and gas producers to develop and refine the previously uneconomic production processes now being used to unlock the abundant hydrocarbon resources.[6] The resulting transformation has been overwhelming and continues to this day. According to EIA, in 2012 tight oil made up 35 percent of total U.S. crude oil production, and shale gas made up 40 percent of total U.S. natural gas production.[7] The EIA's *AEO 2014 Early Release* reference case put total tight oil production at around 2.3 million barrels per day in 2012, with a projection that it will more than double to 4.8 million barrels per day by 2020 (see Table 2).[8]

Table 2. Projected U.S. Tight Oil and Shale Gas Production (per day)

	2011	*2012*	*2020*
Tight oil (million barrels)	1.31	2.25	4.79
Shale gas (trillion cubic feet)	7.94	9.72	13.33

Source: EIA, *Annual Energy Outlook (AEO): 2014 Early Release*, table A14.

U.S. SHALE GAS

The U.S. is home to a large number of geographically dispersed basins that contain shale gas (26 basins in 28 states). The resources contained in each basin vary a great deal in terms of geological complexity and hydrocarbon makeup: some are primarily dry gas (very few liquid hydrocarbons), while some are mostly wet gas. Wet gas generally has a higher value due to the oil-like value given to the liquid condensate produced with the gas. Shale gas production started to ramp up earlier than tight oil production; this longer production history offers a more advanced understanding of the production processes than tight oil. Producers have been able to rapidly exploit this knowledge, and shale gas production increased by almost 900 percent between 2006 and 2013 (see Figure 2).[9]

As shown in Figure 3, by 2040 shale gas is projected to comprise half of total U.S. gas production.

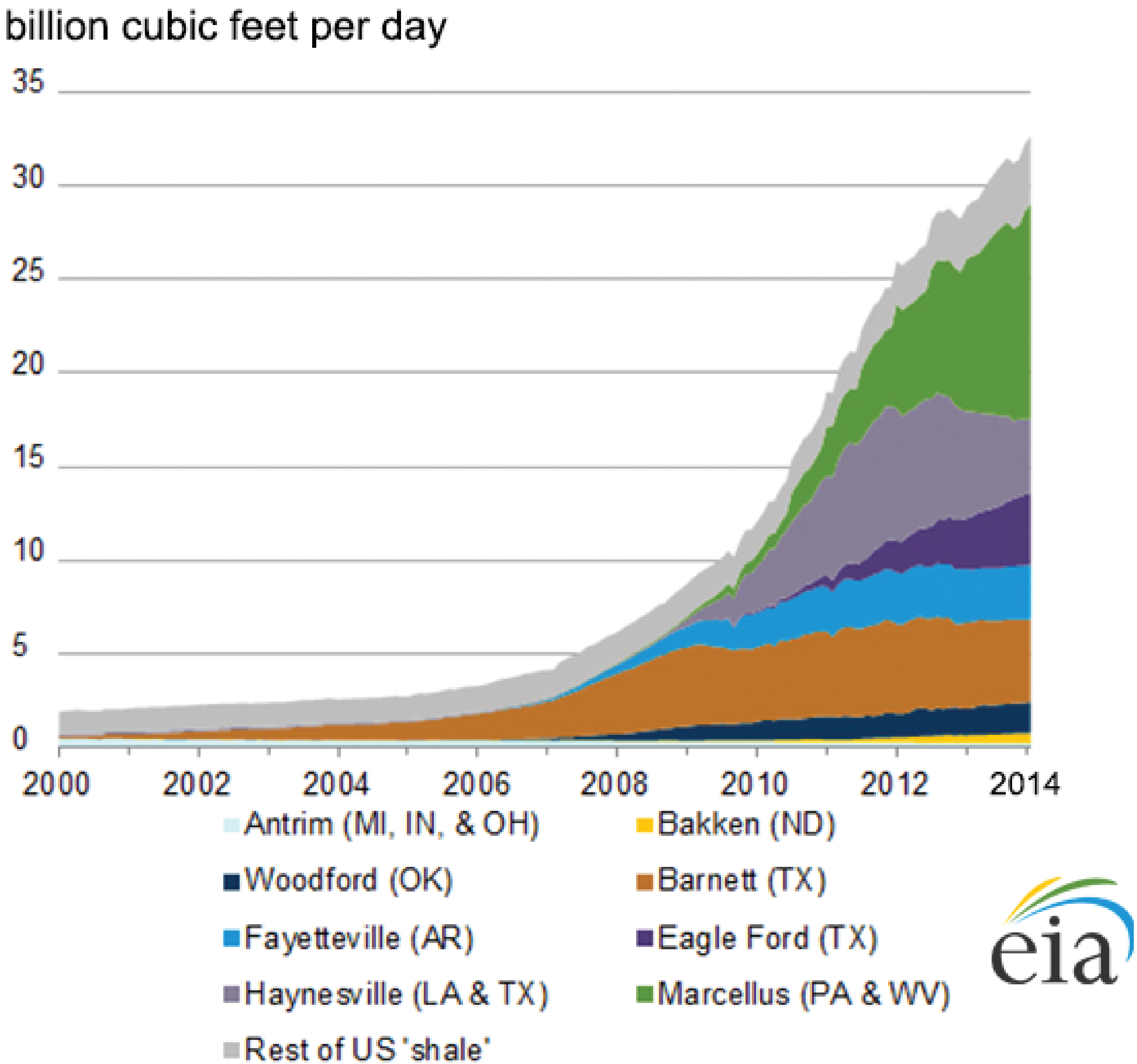
6. These include high natural gas prices, especially in the 2006–2008 time frame, a permissive regulatory and resource ownership structure, technological know-how, and the overall capabilities of the oil and gas industry.

7. Based on calculations from EIA data set. EIA, *Annual Energy Outlook (AEO): 2014 Early Release*, table A14.

8. Ibid.

9. Production levels rose from 3 billion cubic feet per day in 2006 to almost 27 billion cubic feet per day in 2013. Adam Sieminski, "Outlook for U.S. shale oil and gas" (presentation, Argus Americas Crude Summit, Houston, TX, January 22, 2014), 4, http://www.eia.gov/pressroom/presentations/sieminski_01222014.pdf.

Figure 2: Domestic Production of Shale Gas, 2000–2014



Source: EIA, "Natural Gas Weekly Update," data through January 2014, http://www.eia.gov/naturalgas/weekly/.

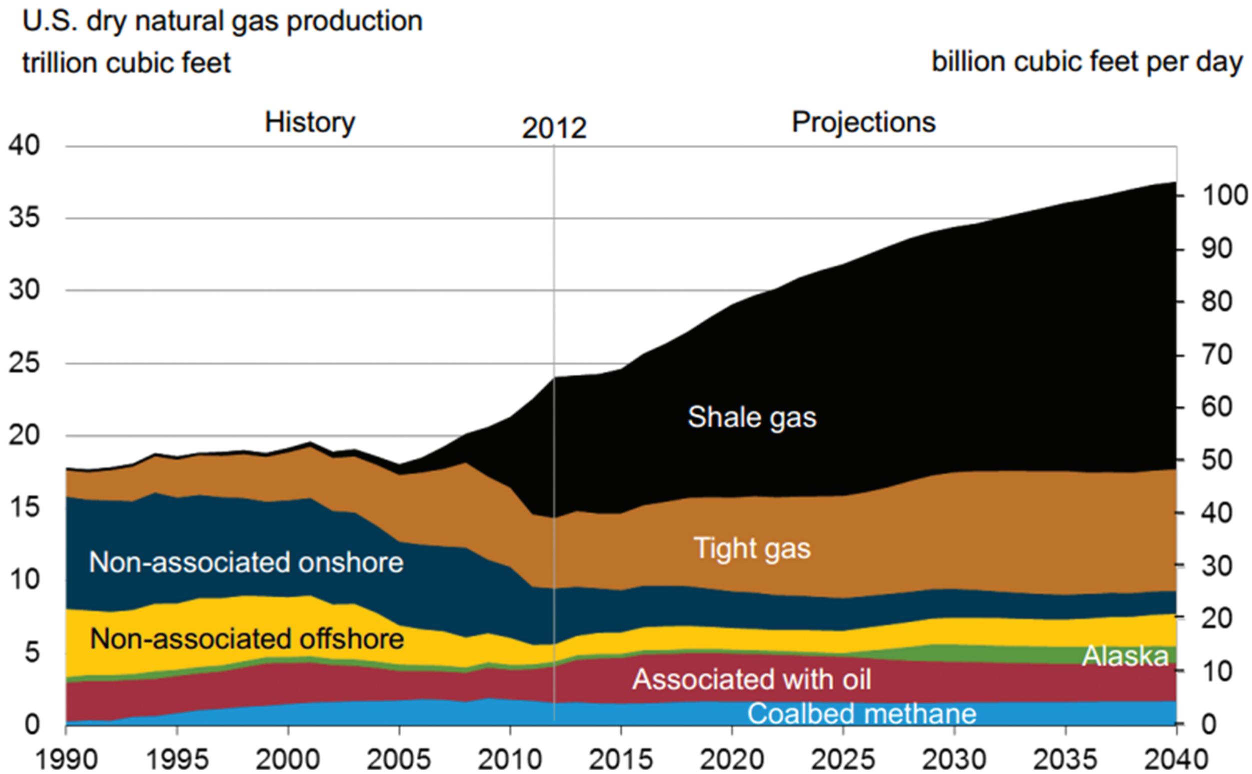
U.S. TIGHT OIL

U.S. tight oil has taken off more recently, primarily concentrated in North Dakota (the Bakken) and Texas (Eagle Ford and Permian) (see Figure 4).[10] In 2013 alone, U.S. crude oil production increased by nearly 1 million barrels per day—more than the combined increases in the rest of the world—and the largest annual increase ever observed in U.S. history.[11]

10. Three main areas for aggregation are the Permian, Williston, and Gulf Coast basins. The Bakken and the Eagle Ford and Permian are the major plays that are producing tight oil.

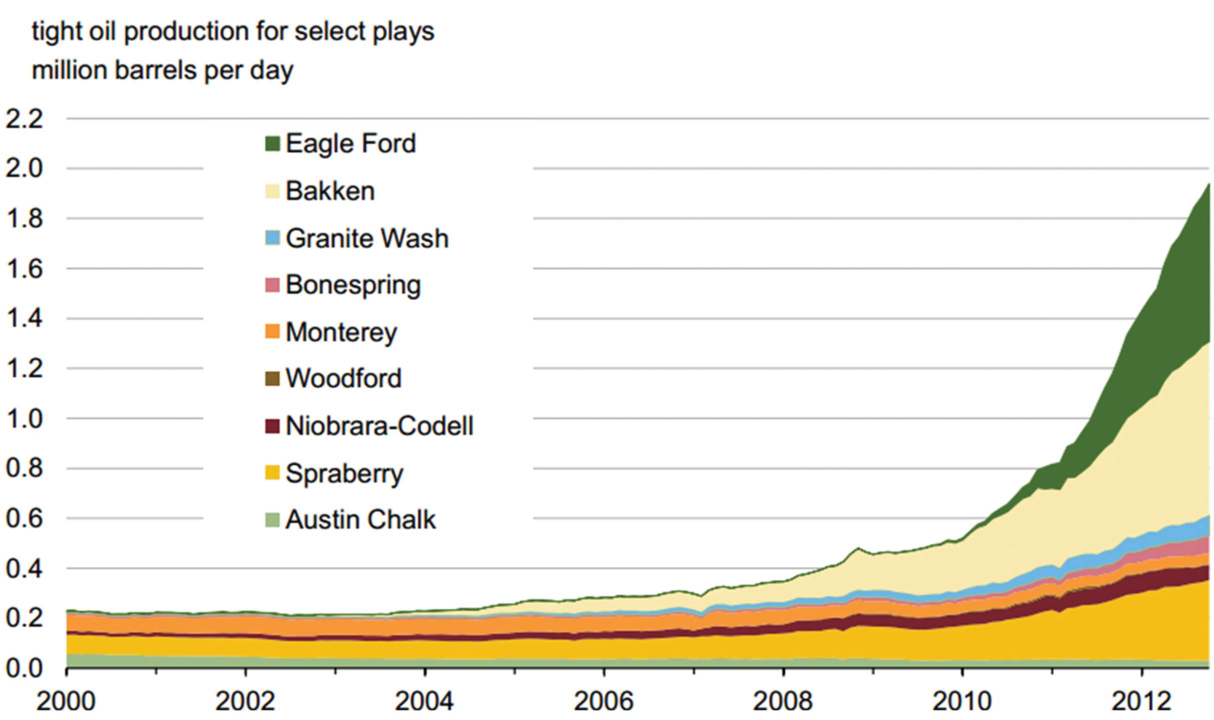
11. EIA, "U.S. crude oil production growth contributes to global oil price stability in 2013," January 9, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=14531.

Figure 3: U.S. Dry Natural Gas Production by Source, 1990–2040



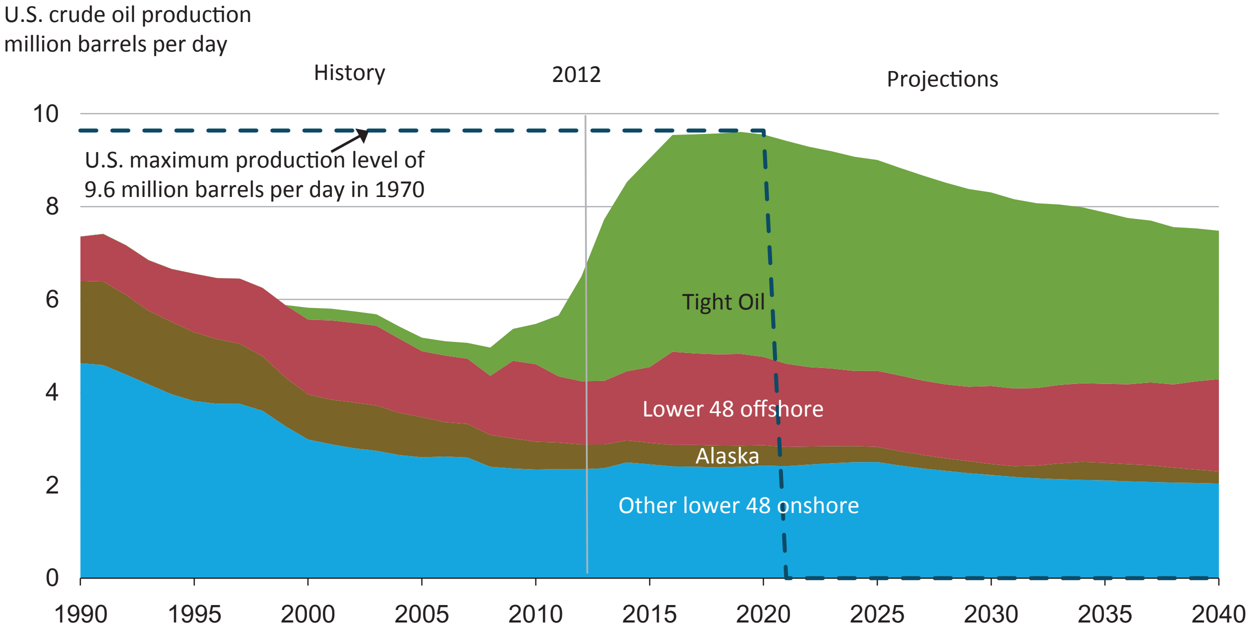
Source: EIA, *Annual Energy Outlook (AEO): 2014*, http://www.eia.gov/forecasts/aeo/.

Figure 4: U.S. Tight Oil Production, 2000–2013



Source: Adam Sieminksi, "Outlook for shale gas and tight oil development in the U.S." (presentation, American Petroleum Institute, Washington, DC, April 4, 2013), 12, http://www.eia.gov/pressroom/presentations/sieminski_04042013.pdf.

Figure 5: U.S. Crude Oil Production by Source, 1990–2040



Source: EIA, *Annual Energy Outlook (AEO): 2014*.

According to the BP Statistical Review of World Energy, the U.S. oil production increase in 2013 is the sixth largest of any country ever.[12] The EIA forecasts that production will increase by another million barrels per day in 2014 (from 7.5 million barrels per day in 2013 to 8.5 million barrels per day), and that U.S. production will total 9.3 million barrels per day in 2015. These levels approximate the highest ever annual average U.S. production level—9.6 million barrels per day—last achieved in 1970.[13]

As with shale gas, tight oil represents a rising proportion of total U.S. crude production. As illustrated in Figure 5, tight oil rose from negligible levels in the early 2000s to 35 percent in 2013, and is projected to provide almost one third of total U.S. crude production by 2040.

A NEW ENERGY POSTURE FOR THE UNITED STATES

The emergence of shale gas and tight oil has resulted in a drastic change in the U.S. energy mindset. According to the latest *World Energy Outlook 2013* from the International Energy Agency (IEA), the United States has been the largest producer of natural gas since 2012, is expected to become the world's largest oil (crude, unconventionals plus natural gas liquids

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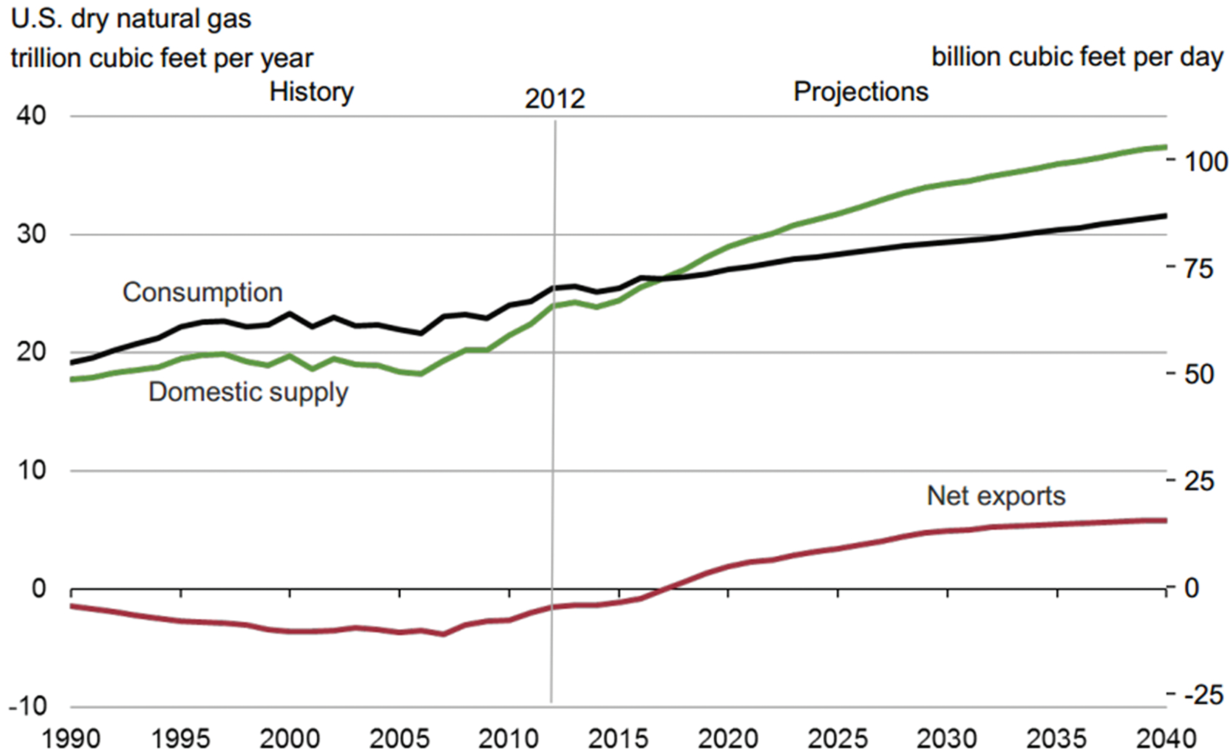
12. Christof Rühl, "Producing oil history in America," LinkedIn, February 12, 2014, http://www.linkedin.com/today/post/article/20140212113621-259060403-producing-oil-history-in-america?trk=mp-reader-card.
13. EIA, *Short-Term Energy and Summer Fuels Outlook (STEO)* (Washington, DC: EIA, April 2014), http://www.eia.gov/forecasts/steo/report/us_oil.cfm.

Figure 6: Domestic Natural Gas Production, Consumption, and Exports, 1990–2040



Source: EIA, *Annual Energy Outlook (AEO): 2014 Early Release Overview* (Washington, DC: EIA, 2014), http://www.eia.gov/forecasts/aeo/er/index.cfm.

[NGLs]) producer in 2015, and is expected to remain so through early 2030.[14] Even more conservative estimates from EIA recognize a substantial shift.[15] The EIA forecasts a future where the United States moves from a net importer of 50 percent of liquids (a combination of crude oil, oil products, and biofuels) in 2010 to between 32 percent by 2035. On the gas side, EIA estimates that (on the basis of resources alone) the United States will be a net gas exporter by 2018 (see Figure 6).[16]

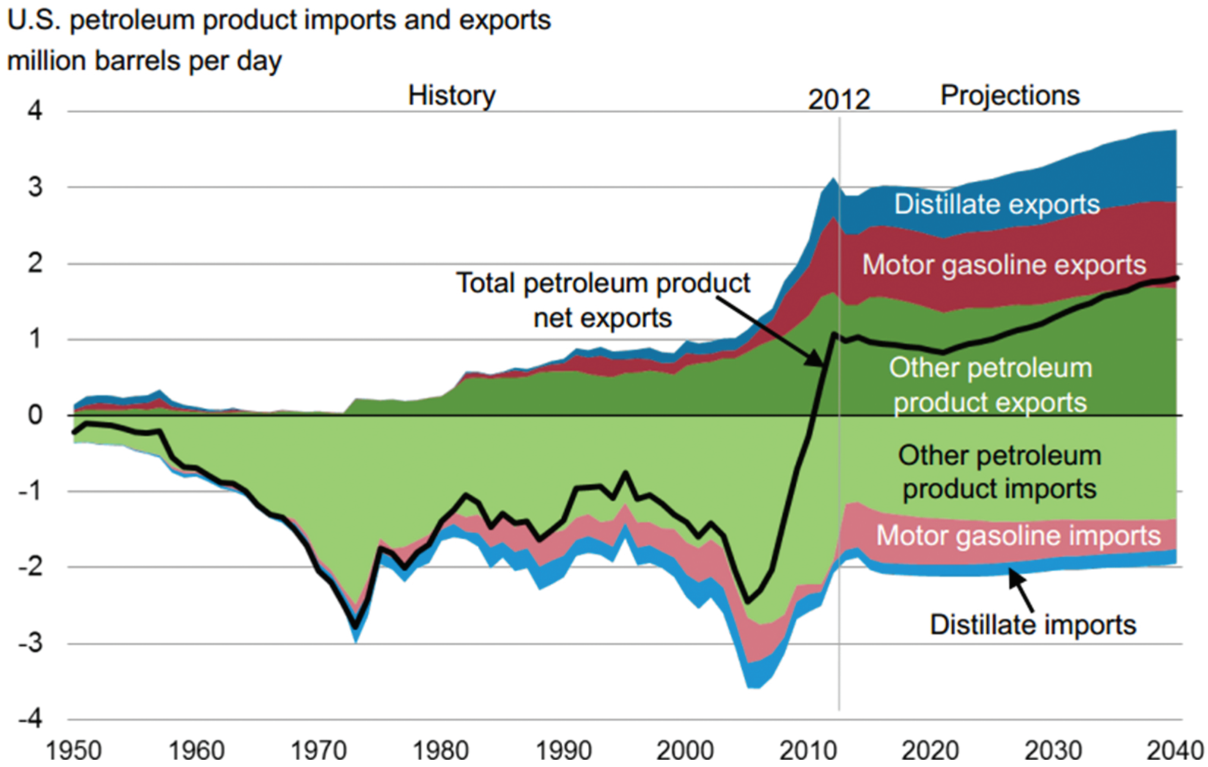
This represents a dramatic turnaround from previous projections of the United States as a primary destination for global natural gas exports (i.e., a major natural gas importer). In 2003 EIA forecast that U.S. gas imports would more than double from 3.7 trillion cubic feet in 2001 to 7.8 trillion cubic feet in 2025. Today, the U.S. Department of Energy is reviewing more than two dozen applications for natural gas export terminals.

14. IEA, *World Energy Outlook 2013* (Paris: IEA, 2013), 73, 480, and 76, http://www.worldenergyoutlook.org/publications/weo-2013/.

15. For example, EIA forecasts a future where U.S. imports of liquids (crude oil, oil products, and biofuel) fall from 50 to 32 percent by 2035 and where the United States becomes a net gas exporter by 2018. EIA, *Annual Energy Outlook (AEO): 2014 Early Release*, table A14.

16. Ibid.

Figure 7: U.S. Petroleum Imports and Exports, 1950–2040



Source: EIA, *Annual Energy Outlook (AEO): 2014*.

A similar transformation is happening on the oil side. In 2011 the export of refined petroleum products[17] exceeded imports for the first time in over six decades, and became the top U.S. export commodity (see Figure 7).

More fundamentally, the emergence of shale gas and tight oil has resulted in a drastic change in the U.S. mindset: not since before the energy shocks of the 1970s has the United States thought of itself as an energy-abundant nation.

Global Potential

Given the U.S. experience, there is global interest in determining whether others might be able to produce their own unconventional oil and gas resources. According to one preliminary assessment, 137 shale formations in 41 countries, in addition to the United States, hold around 10 percent of technically recoverable global crude oil and 32 percent of global natural gas (see Figure 8).[18]

17. Including but not limited to gasolines, kerosene, distillates (including No. 2 fuel oil), liquefied petroleum gas, asphalt, lubricating oils, diesel fuels, and residual fuels.

18. EIA, "Technically Recoverable Shale Oil and Shale Gas Resources," 10, http://www.eia.gov/analysis/studies/worldshalegas/. Note, this assessment includes only 41 countries around the world and does not include some of the most hydrocarbon-rich countries, such as those in the Middle East and the Caspian region.

Impact of the Shale Gas and Tight Oil Revolution

U.S. shale and tight oil:

- U.S. production is up 50 percent since 2005 (3 percent of the global market).
- Imports have fallen 16 percent since 2005 and are projected to further decline.
- The United States is projected to be a net oil exporter by 2030 (per IEA).

U.S. shale gas:

- U.S. production is up 40 percent since 2005 (50 percent of the global market).
- Imports have fallen by 28 percent since 2005.
- The United States is projected to be a net exporter by 2018.

Global shale gas and tight oil resources base estimates:

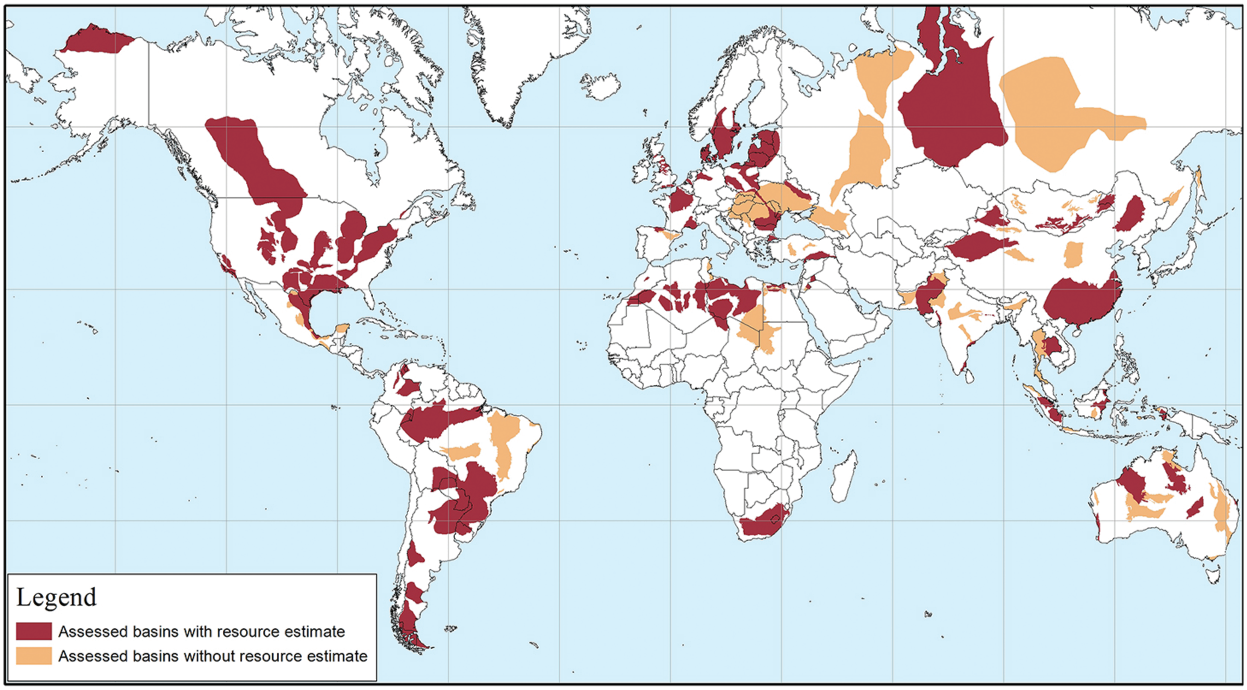
- Global oil resources have increased by 11 percent.
- Global gas resources have increased by 47 percent.
- Resources exist in 42 countries, though to date production has only occurred in the United States at significant volumes.

In EIA's ranking of countries by amount of technologically recoverable shale gas and tight oil potential (see Table 3), the United States does not rank at the top of the list for either, though production of both of these resources exists primarily in the United States. The EIA's global estimates are further limited by the omission of the hydrocarbon-rich Middle East. Saudi Arabia, for example, claims to have enough technically recoverable shale gas to place fifth in the global list.[19]

There is significant uncertainty about future shale gas and tight oil production elsewhere around the world for a number of reasons. First, while many other countries have technically recoverable shale gas and oil reserves, resource quality and geologic distribution matters. Second, mineral rights and land ownership have provided strong incentives for development and community buy-in in the United States; these factors do not exist in many other countries. Third, the availability of independent operators, equipment, and

19. Charles Kennedy, "Saudi Arabia to Use Shale Gas for Domestic Power Generation," *OilPrice*, October 14, 2013, http://oilprice.com/Latest-Energy-News/World-News/Saudi-Arabia-to-Use-Shale-Gas-for-Domestic-Power-Generation.html#.

Figure 8: Global Basins with Shale Oil and Gas Formations



Source: EIA, "Shale oil and shale gas resources are globally abundant."

Table 3: Top 10 Countries with Technically Recoverable Shale Oil and Shale Gas

Top Ten Countries with Technically Recoverable Shale Oil Resources			*Top Ten Countries with Technically Recoverable Shale Gas Resources*		
Rank	*Country*	*Shale Oil (billion barrels)*	*Rank*	*Country*	*Shale Gas (trillion cubic feet)*
1	Russia	75	1	China	1,115
2	United States[1]	58 (48)	2	Argentina	802
3	China	32	3	Algeria	707
4	Argentina	27	4	United States[2]	665 (1,161)
5	Libya	26	5	Canada	573
6	Australia	18	6	Mexico	545
7	Venezuela	13	7	Australia	437
8	Mexico	13	8	South Africa	390
9	Pakistan	9	9	Russia	285
10	Canada	9	10	Brazil	245
	World Total	**345 (335)**		**World Total**	**7,299 (7,795)**

1. EIA estimates used for ranking order. ARI estimates in parentheses.
2. EIA estimates used for ranking order. ARI estimates in parentheses.
Source: EIA, "Shale oil and shale gas resources are globally abundant."

service companies with the technical knowledge, access to capital, and the right technology has played an instrumental role in U.S. production. While many NOCs are investing in U.S. plays in an attempt to gain such experience and knowledge, it is not clear whether such technical expertise will be replicable elsewhere. Fourth, U.S. producers benefited from a large amount of preexisting infrastructure (pipelines, as well as gathering and wastewater treatment facilities) that was capable of supporting early production. Countries without a history of oil and gas development lack this key enabling feature, which will likely hamper production. Finally, public and community buy-in is a crucial element. As has been evident in the United States, such community support is not guaranteed. Nor are such battles confined to the United States; lack of public support in various countries in Europe, for example, has led to bans and delays of unconventional development. The ability to overcome public fears, explain and manage production risks, and continually improve operations is a key component of unconventional gas production in most places.[20]

It is also unclear whether other countries can (or would want to) replicate the evolving business model that facilitated shale gas and tight oil's rise in the United States. Early on, small entrepreneurial independent exploration and production companies were the ones discovering and producing. They operated under a different business model than the big companies that came into the picture later. Many of the independent companies had to drill to produce in order to generate and secure enough capital to move to the next well. Conversely, larger companies had sufficient reserves to drill and hold leases, waiting to produce until more favorable price conditions emerged. Many other nations lack this type of interplay, which will almost certainly result in a different evolutionary path than was the case in the United States. Another key factor was the dynamic U.S. energy service industry,[21] which also does not exist in many of the other countries with a large unconventional resource base. In many countries price controls at the wellhead for domestic gas are a real impediment for investment in production, including for shale gas.

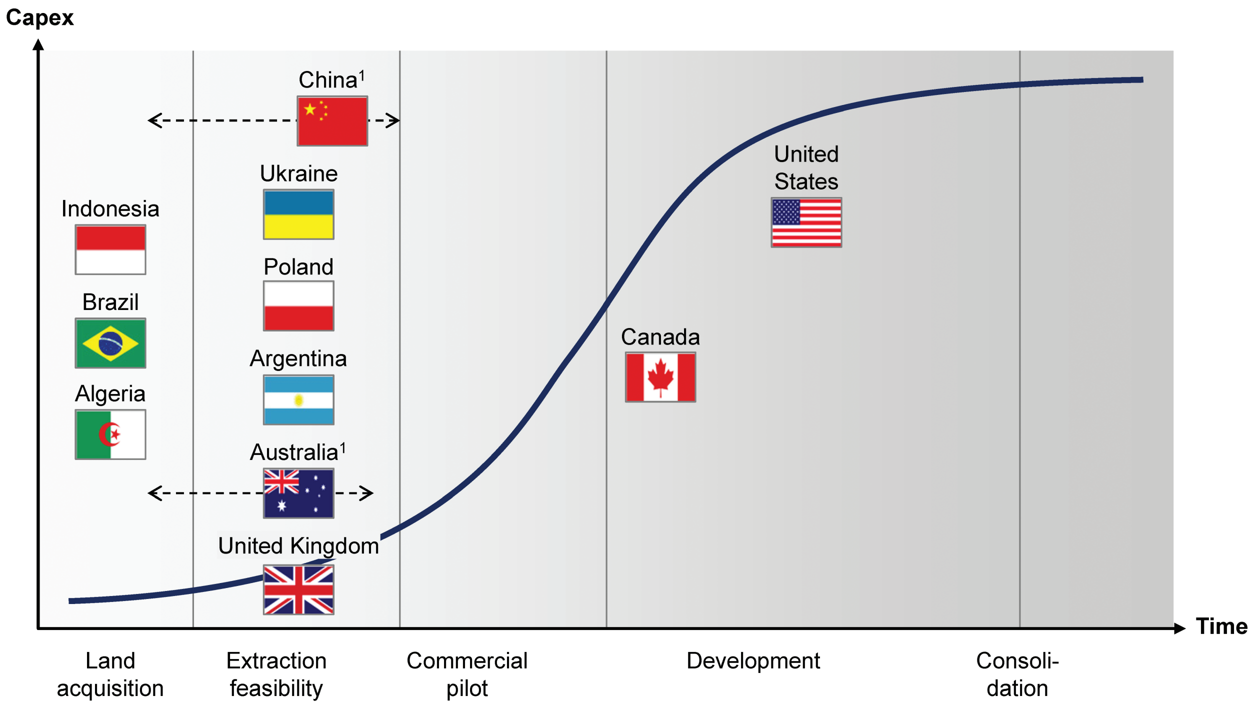
Finally, the maturity of the business model in the United States (which begins with acreage acquisition, experimentation with respect to practices and fracturing methods, lessons learned from core development and then applied to achieve better optimization, etc.) takes years to work through, even under favorable conditions. In this regard, the United States is years—maybe a decade or more—ahead of other nations, many of which are still experiencing the early land acquisition and testing phases (see Figure 9). Even under assumptions of accelerated technology transfer, training personnel and providing services at scale will take a while.

Despite this daunting list of obstacles, countries around the world have started to pursue exploration and development of their resources. Australia, China, Poland, the United Kingdom, Turkey, Mexico, Argentina, and Russia have begun exploration, launched

20. Howard Gruenspecht, "Global Energy Developments with Possible Geopolitical Implications" (presentation, International Security Advisory Board, Washington, DC, September 20, 2013).

21. For example, companies such as Baker Hughes, Halliburton, and Schlumberger, which provide services to the petroleum exploration, and production industry but do not typically produce petroleum themselves.

Figure 9: Current Position of Select Countries on Shale Gas and Oil Production

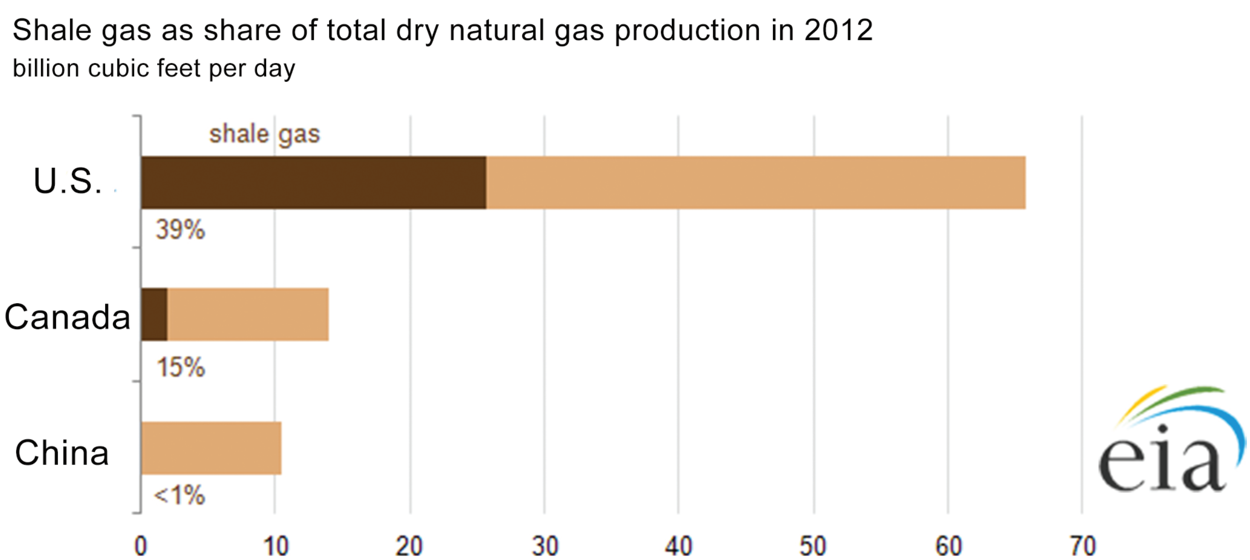


Note: Capex, Capital Expenditure.

1. Flags based on most advanced basins in China (Sichuan basin) and Australia (Cooper basin). Other basins are still at the land acquisition stage.

Source: Susan Lund et al., *Game changers: Five opportunities for US growth and renewal* (New York: McKinsey Global Institute, July 2013), 26, http://www.mckinsey.com/insights/americas/us_game_changers.

Figure 10: Dry Natural Gas Production in the United States, Canada, and China, 2012



Source: EIA, "North America leads the world in production of shale gas," October 23, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=13491.

bid rounds, or expressed interest in domestic shale gas development. So far, none except for Canada has moved into mature phases of development (and others have experienced significant setbacks), but progress continues. In 2012 Canada averaged 2 billion cubic feet per day of dry gas production from two shale-producing regions in British Columbia and Alberta, less than 10 percent of the average daily dry gas production in the United States. China too has begun to attempt shale gas production but, as Figure 10 illustrates, has thus far met with limited success to date.

Overall, the U.S. unconventional experience has been extraordinary, prompting a major shift in its energy position and in the mindset of U.S. policymakers. It has also created the possibility for others to achieve similar or even greater production, raising the potential for even more dramatic shifts in the world's energy markets going forward. The market has already begun to adjust, and state actors are beginning to respond to both the realities of changes in the U.S. market and in anticipation of future repositioning.

3 Energy Impacts to Date

There is no question that the shale revolution has profoundly shifted the energy production profile within the United States. But the effects of this production has extended around the world. U.S. unconventional production has prompted major adjustments in energy trade flows, markets, and investment patterns. It has added an additional impetus for many nations to reconsider their energy strategies for the future. And it has reconfigured the international conversation about climate change and how best to address it.

Considerable changes have already taken place, despite the fact that the ultimate magnitude and longevity of those changes are highly uncertain. Significant questions exist about how shale gas and tight oil might evolve in the United States, where production is already well under way. As discussed in the previous chapter, there is even greater ambiguity about whether the U.S. experience can be replicated elsewhere, and, if so, to what degree and over what time frame. This chapter describes the impact of shale gas and tight oil to date in the international energy landscape, but concludes by highlighting why great caution is warranted when considering further developments.

Shifting Energy Markets, Trade Flows, and Investment Decisions

Unconventional oil and gas are helping shift trade flows, and these new supplies and the associated infrastructure have altered the basic contours of the energy system. Most fundamentally, energy supplies that were previously destined for the United States are now servicing other markets.

To date, the most immediate impacts are already being evidenced in global gas markets where rising U.S. production has reduced reliance on imported liquified natural gas (LNG)—thereby freeing up supplies to go elsewhere.[1] In addition, by replacing domestic coal with natural gas in U.S. power plants, America coal exports have found their way to Europe and elsewhere. The market would shift further should the United States begin exporting LNG, though this too requires changes to infrastructure. Terminals that were originally built to receive LNG are being repurposed in order to accommodate potential

1. Qatar, Western Africa, and Trinidad LNG all initially destined for the United States are now free to service other markets.

exports.[2] Given the state of gas markets, in which demand growth continues most strongly in Asia, the extra supplies on the global market and the potential for U.S. exports to give consumers additional leverage in contract negotiations are welcome developments.

But the shifts are not just occurring in gas markets: the emergence of unconventional oil (specifically light tight oil) is impacting oil markets and trade as well. While tight oil production is not as established in the United States as is gas, the existing production and potential for more are already causing adjustments. Increased production of U.S. tight oil has increased the global supply of crude.

U.S. tight oil production and Asia's rapid demand growth have been the two major influences reshaping oil trade flows.[3] The surge in U.S. tight oil production has displaced imports of light oil into the Gulf and East coasts from places like Nigeria, Angola, Libya, and Algeria. U.S. imports from the Middle East have also declined, although not to the same degree. The U.S. still requires the Middle East's heavier and medium grade crudes. Further, many long-term contracts and special industrial relationships remain in place. These two factors suggest that U.S. imports from the Middle East will not diminish entirely in the foreseeable future. African and Middle Eastern oil previously destined for the United States is now going to Europe and Asia. Given that European demand is projected to remain weak, it is an unlikely destination for oil previously slated for the U.S. market. Latin America and the former Soviet Union (FSU) must also look for alternative markets to export their crude. This has given Asian consumers a range of potential suppliers, and Middle Eastern exporters have become more aggressive in their pricing to Asian refineries in order to retain market share.[4]

At the same time that U.S. energy imports are falling, its exports are on the rise. As natural gas displaces coal in the power generation sector, for both economic and environmental reasons, the United States is exporting more coal to places in the world where coal demand continues to increase and prices are more attractive.[5]

Another key area being impacted by altered oil production centers and shifting trade is the refining sector, which is also influencing products trade flows. Unrelated to the unconventional revolution, new refining capacity being built in Asia and the Middle East—in addition to advantages currently held by U.S. refineries—has meant that margins and markets for traditional refiners in places like Europe are shrinking.

European refineries have long been in economic trouble because of overcapacity, low conversion rates, and low demand, a situation exacerbated by the economic downtown in 2008 and the subsequent Libya supply disruption in 2011. They were originally built to

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2. Permits for about 9.3 cubic feet per day (as of April 2014) have been approved by the Department of Energy but have not yet begun exporting. Additional approvals are required to certify that environmental standards associated with terminal modifications can be satisfactorily met.

3. Amrita Sen, *US Tight Oils: Prospects and Implications* (Oxford: Oxford Institute for Energy Studies, September 2013), http://www.oxfordenergy.org/wpcms/wp-content/uploads/2013/10/WPM-51.pdf.

4. Ibid.

5. Keisuke Sadamori, "Medium Term Coal Market Report 2013" (presentation, CSIS, Washington, DC, January 29, 2014), http://csis.org/event/medium-term-coal-market-report-2013.

meet domestic gasoline demand, but as diesel increased in use, Europe has experienced gasoline surpluses and diesel deficits. The United States used to be the outlet for European gasoline, but declining demand has meant that U.S. refineries can adequately meet domestic demand. With the emergence of shale gas and tight oil, U.S. refineries have increased runs and are now exporting significant volumes of oil products, including gasoline. Low U.S. natural gas prices have provided U.S. refineries a competitive advantage, especially over their European counterparts.

Projections of stagnant or declining U.S. demand for petroleum products means U.S. refiners will continue to focus on exports, which will increasingly reach traditional European market strongholds in Africa and Latin America, causing Europe to seek out new markets for their exports, primarily in Asia.[6]

Increasingly, Europe is turning east, exporting large amounts of naphtha[7] to Asia for use in making plastics and to blend with gasoline. However, many analysts expect U.S. naphtha to head to Asia as well, squeezing European markets still further.[8] The impacts of the shifts in the refining and products sectors are still evolving, and it is unclear what, if any, the major ramifications might be. There is, however, potential for important effects on product supply and pricing driven by shale gas and tight oil and the demand side of the market.

U.S. Natural Gas Prices

The long-term effects of cheap natural gas prices in the United States remain unclear and depend on a number of policy and economic factors. Changes in export policies and emissions targets, technological breakthroughs, interest rate changes, and numerous other variables will ultimately determine the magnitude of the economic effect. Ultimately, the global implications will be heavily dependent on price and price stability.

Source: Sarah O. Ladislaw et al., *Realizing the Potential of U.S. Unconventional Natural Gas* (Washington, DC: CSIS, April 2013), http://csis.org/publication/realizing-potential-us-unconventional-natural-gas.

CHANGING INVESTMENT PATTERNS

New sources of energy are altering commercial competitiveness and investment decisions as well. The hierarchy of energy projects is being reordered, at least temporarily shifting capital investments to the U.S. energy sector and away from more expensive and/or risky

6. Sen, *US Tight Oils*.

7. "Refined or partly refined light distillates with an approximate boiling point range of 27 degrees to 221 degrees Centigrade. Blended further or mixed with other materials, they make high-grade motor gasoline or jet fuel. Also, used as solvents, petrochemical feedstocks, or as raw materials for the production of town gas." EIA, "Glossary: Naphtha," http://www.eia.gov/tools/glossary/index.cfm?id=naphtha.

8. Lin Noueihed and Jonathan Saul, "European Refiners, Desperate for Markets, Look to Asia," Reuters, December 11, 2013, http://www.reuters.com/article/2013/12/11/europe-naptha-idUSL6N0JP2IC20131211.

locations. The unconventional oil and gas boom has caused revisions not only to upstream investment priorities, but also to associated infrastructure, both for countries and companies. They have been forced to reevaluate the commercial viability of several development projects. Projects in locations as diverse as the Arctic, deep-water Brazil, Australia, Turkmenistan, and offshore east Africa are being reexamined, and, at a minimum, may have longer commercial time frames than previously thought.[9] As a result, some countries that depend on the investment and income generated by oil and gas production are beginning to rethink domestic policies and economic reforms.

The production of U.S. shale gas and tight oil is affecting more than just oil and gas investment decisions. Industries such as petrochemicals and energy-intensive manufacturing are modifying decisions on production locations and supply chains. The sudden surge in U.S energy supply and consequent reduction in prices has made North America among the most attractive and competitive places in the world to locate such energy-intensive endeavors.

These realities have had clear economic benefits for the United States. Low energy prices have raised the prospect of revitalizing or strengthening the industrial sector and lowered costs for consumers. Between 2010 and 2020 the chemical industry will invest $71.7 billion in the United States because of unconventional gas.[10] According to the latest analysis by the Boston Consulting Group (BCG), the United States is becoming one of the lowest-cost countries for manufacturing among the members of the OECD due to three main factors: natural gas, electricity, and labor. Much of this is attributed to cheap natural gas, which impacts manufacturing in two ways. First, natural gas and natural gas liquids are an important feedstock for chemicals and plastics, and can be a high-cost component of production in a range of products including metals, paper, and synthetic textiles, to name just a few.[11] Second, low-cost natural gas decreases the cost of electricity. According to IEA's estimates, lower-priced gas and electricity resulted in nearly $130 billion in total savings for the U.S. manufacturing industry compared to Europe.[12]

The comparative advantage afforded the United States by low cost, domestic unconventional resources is a source of real concern in several countries, particularly in Europe. It is a mixed picture though. Several studies have shown that increased oil production can lead (all things being equal) to lower global oil prices.[13] These in turn improve the overall gross domestic product (GDP) and balance of payments for oil-importing countries, and generally harm oil exporters. In addition to concerns over the flow of investment dollars for certain

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9. Sylvia Pfeifer, "Exploration: Rising cost of complex projects hits majors," *Financial Times*, September 8, 2013, http://www.ft.com/intl/cms/s/0/99622e42-13cd-11e3-9289-00144feabdc0.html#axzz2v0vBhFdx.

10. American Chemistry Council, *Shale Gas, Competitiveness, and New US Chemical Industry Investment: An Analysis Based on Announced Projects* (Washington, DC: American Chemistry Council, May 2013), 23, http://chemistrytoenergy.com/sites/chemistrytoenergy.com/files/shale-gas-full-study.pdf.

11. Harold L. Sirkin, Michael Zinser, and Justin Rose, "The U.S. as One of the Developed World's Lowest-Cost Manufacturers: Behind the American Export Surge," *BCG Perspectives*, August 2013, 8, https://www.bcgperspectives.com/content/articles/lean_manufacturing_sourcing_procurement_behind_american_export_surge/.

12. IEA, *World Energy Outlook 2013*, 276.

13. Trevor Houser and Shashank Mohan, *Fueling Up: The Economic Implications of America's Oil and Gas Boom* (Washington, DC: Peterson Institute for International Economics, January 2014).

energy-intensive industries, countries' overall economic positions are also likely to be affected (either positively or negatively) by lower energy prices that could result from production increases.[14]

U.S. Shale Gas and Tight Oil Production Is Adding Urgency to Many Countries' Already-Ongoing Reexaminations of Energy Policy

Not surprisingly, unconventional oil and gas resource potential is prompting many countries to rethink their energy policies to either take advantage of their own unconventional resource base or respond to some of the changes brought about by the impact of the U.S. oil and gas production surge.

Nowhere is this more evident than in the United States, where a sudden surge in production has reignited talk about energy independence, a manufacturing renaissance or more meaningful industrial policy, and LNG and (more recently) crude oil exports. U.S. energy policy's historical (for the last 40 years) basis in the dual notion of resource scarcity (to include concern over undue import reliance) and ever-rising demand has been turned on its head within the last five years. At some point in the not too distant future, export policy with respect to crude oil is likely to be revisited, as will numerous other issues; these include the permitting of large infrastructure projects, as well as the size, composition, and logistics associated with the strategic petroleum reserve. Policymakers will also likely be called upon to reevaluate the continued utility of the current Jones Act restrictions on which vessels are eligible to transport U.S. oil between domestic ports.

While production of unconventional oil and gas has yet to materialize outside of North America, other countries are also evaluating the potential of their own domestic shale gas and oil resources. In most countries there are compelling reasons to seek to develop potential unconventional oil and gas. Some European countries are looking for cheaper energy alternatives (either to contractually high gas prices or traditionally higher renewable energy prices) to help restore competitiveness and salvage environmental policies. In China, energy demand continues to rise, and environmental and social pressures are increasingly prodding Beijing to explore cleaner avenues of energy production than the traditional widespread use of domestic coal. Given the sheer amount of energy China will require, its leaders are also wary of finding themselves overly dependent on the market, and are seeking a greater sense of energy security by developing domestic resources. Finally, energy demand in oil-exporting countries across the Middle East is projected to rise. This reality places a new impetus behind finding ways to satisfy that demand without sacrificing exports, the revenues from which comprise major portions of regional economies and government budgets.

14. PricewaterhouseCoopers (PWC), "Shale Oil: the Next Energy Revolution," February 2013, https://www.pwc.com/en_GX/gx/oil-gas-energy/publications/pdfs/pwc-shale-oil.pdf; and Houser and Mohan, *Fueling Up*.

Other countries are more conflicted about whether or not to pursue these resources, mostly on environmental grounds. Members of the European Union, for example, are divided on the issue of whether to pursue shale gas development. France has imposed a ban on hydraulic fracturing, and the new German coalition government has an effective ban in place until more studies are conducted.[15] Protests in places like Romania have dampened some governments' enthusiasm for shale gas production. But Poland and the United Kingdom, on the other hand, are aggressively trying to develop their respective shale gas resources.

The Prospect of Abundant Oil and Gas Supplies Has Reordered Options to Deal with Climate Change

The emergence of abundant and economically recoverable unconventional gas (and oil) came at a time when global energy dialogue and policy was at a crossroad. Many, both individuals and governments alike, assumed that fossil resources were limited and becoming increasingly more expensive to discover and produce, that climate change and carbon dioxide emissions were increasingly pressing issues, and that the decarbonization of the economy was the best path to meeting the dual goals of carbon reduction and energy security. The discovery of an affordable and plentiful supply of natural gas and oil challenged part of this narrative. Many in the public and private sector are now seeking ways to prioritize the role that abundant natural gas supplies can play in the energy economy. Proponents of the "green agenda" have split over whether to endorse or resist natural gas as a possible "bridge fuel" that promotes near-term emissions reduction but eventually leads to cleaner energy solutions.[16]

From an environmental perspective, shale gas can play a role in a transition to a low-carbon economy. Natural gas emits fewer greenhouse gases (GHG) than does coal (half the carbon dioxide of coal when used in power generation, for example), reduces conventional pollution,[17] and is compatible with the intermittency of renewables.[18] Natural gas has already taken market share from coal in the United States power sector (though coal temporarily

15. Dan MacGuill, "France Upholds Ban on Shale Gas Fracking," *The Local*, October 11, 2013, http://www.thelocal.fr/20131011/breaking-france-upholds-ban-on-fracking; Stefan Nicola, "No Fracking in Germany for Now Backed in Merkel Coalition," Bloomberg, November 8, 2013, http://www.bloomberg.com/news/2013-11-08/no-fracking-in-germany-for-now-backed-in-merkel-coalition.html.

16. Natural gas can lead to near-term reduction of greenhouse gas emissions through use in the power sector (by switching from coal to gas or by building new natural gas power–generation facilities in lieu of coal power); thus, it can start "bridging" the world onto a lower-carbon pathway. The bridging idea has become quite popular.

17. For example, nitrogen oxides, sulfur oxides, sulfur dioxide, and mercury. U.S. Environmental Protection Agency (EPA), "Air Emissions," http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html.

18. Many sources of renewable energy, such as solar or wind, do not generate energy continuously. Given the current lack of battery storage that might help mitigate this problem, natural gas is often considered a compatible baseload source of energy for renewable sources, as it can quickly be scaled up when the wind is not blowing or the sun is not shining. Molly A. Walton, "Environmental Concerns: How Clean Is Clean?," CSIS, September 2012, http://csis.org/files/publication/120918_Walton_EnvironConcerns.pdf.

Methane Emissions from Natural Gas Production

While natural gas has the lowest carbon content of any fossil fuel, its production, including exploration, drilling, venting/flaring, equipment operation, gathering and the associated truck traffic does emit volatile organic compounds (VOCs), particulates, and greenhouse gases (GHG) including methane. Methane is the second most common greenhouse gas emitted in the United States and is emitted from both natural and human activities. The lifetime of methane in the atmosphere is much shorter than other GHGs. However, it has a much higher global warming potential (GWP) and is 21 times more potent than carbon dioxide (CO^2) over a 100-year time span. The Intergovernmental Panel on Climate Change (IPCC) recently put that figure at 34 times more GWP.[1]

There has been a particular focus placed on methane emissions from natural gas production because of its climatic impact; however, there remains considerable uncertainty regarding the actual amount of emission rates along the value chain. Methane can be released during well completion (specifically the amount released during flowback), wellbore cleaning, liquids unloading, and throughout the supply chain as a result of leaks. Reduced emissions completion technologies already exist, and along with green completions, can dramatically reduce the amount of methane released.

Methane emission rates remain an area of uncertainty. They have become a focus for many organizations and there have been a slew of studies released or announced with a goal of increasing the body of literature to increase understanding and weigh in on the controversy. In April 2013 the EPA released its annual "Inventory of U.S. Greenhouse Gas Emissions and Sinks," in which it revised its estimates of greenhouse gas emissions from natural gas production, citing the effective natural gas emissions rate per unit of natural gas production to be 1.5 percent, lower than previous EPA estimates of 2.2 to 2.4.[2]

On September 16, 2013, the University of Texas (UT), in partnership with the Environmental Defense Fund (EDF) and industry members, released the first of 16 studies that will assess methane emissions from the natural gas supply chain.[3] Nine participating natural gas companies allowed the university access to their production equipment and facilities to measure emissions at the source. The study found that on average, wells emitted roughly 20 percent less GHG than EPA's estimates. The biggest divergences from EPA's greenhouse gas inventory came from emission rates associated with well completion flowbacks and pneumatic pumps and controllers. UT's study also found that well completion flowbacks only represented 1 percent of emissions, compared to the 26 percent reported by EPA, and that pneumatic pumps and controllers accounted for more emissions (29 percent) than stated in EPA's annual inventory (15 percent).

More recently the journal *Science* published "Methane Leaks from North American Natural Gas Systems," results of a study that found the EPA has vastly underestimated the amount of methane leaked, by nearly 50 percent, from all sources (including but not limited to natural gas systems).[4] The amount contributed by the production of natural gas remains unknown, but the study concluded that switching from coal to natural gas still provided a net positive reduction in emissions. While the study did not estimate the total leakage rate from the natural gas industry, nor isolate the location of cause of the leaks, it noted that evidence suggested that hydraulic fracturing accounted for a minimal amount.

These three studies highlight the range of uncertainty regarding methane emissions from natural gas production. Thus, there remains much work to be done in terms of data collection, technology assessments, and regulatory developments in order to advance current understanding of the methane emissions rates associated with shale gas production, and to respond and minimize the climatic implications of the shale gas boom.

1. Note: Includes climate-carbon feedbacks. "Climate Change 2013: The Physical Science Basis," Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, eds. Stocker, Thomas F et al., (Stockholm, Sweden: Intergovernmental Panel on Climate Change, September 2013), 714, http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf.

2. EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2011," April 12, 2013, http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf.

3. David T. Allen et al., "Measurements of Methane Emissions at Natural Gas Production Sites in the United States," Proceedings of the National Academy of Sciences of the United States of America, August 19, 2013, http://www.pnas.org/content/early/2013/09/10/1304880110.

4. A. R. Brandt et al., "Methane Leaks from North American natural Gas Systems," *Science* 343 no. 6172 (February 14, 2014): 733–735, https://www.sciencemag.org/content/343/6172/733.summary.

regained its position in 2013), for both economic and environmental reasons. Coupled with lower energy demand during the prolonged economic slump, in 2012 U.S. carbon dioxide emissions had fallen to pre-2005 levels.[19] A vantage point from which reaching the U.S. goal of reducing emissions 17 percent below 2005 levels by 2020 is not implausible.

Despite its potential to reduce emissions in the near-term, some environmentalists note that cheap natural gas disadvantages renewable, nuclear, and clean coal energy sources by making them less price competitive. The notion that the United States has well over a 100-year supply of natural gas (at the current consumption level), coupled with the potential for global production, has many clean energy advocates uncomfortable with the notion of restructuring the energy economy around what still remains a fossil resource. This, they fear, would effectively lock in a fossil fuel–based infrastructure for the next 100 years. This potential for near-term emissions reduction, paired with concern over the perpetuation of a fossil-based energy system, has led to the popular "bridge fuel" terminology intended to

19. EIA, *Annual Energy Outlook 2013 with Projections to 2040* (Washington, DC: EIA, April 2013), http://www.eia.gov/forecasts/aeo/pdf/0383%282013%29.pdf.

cast natural gas as an interim step toward a new energy system. In many ways the size, scale and nature of this bridge is the focus of one very active component of the current climate change debate. Several studies point to possible limits for the use of natural gas for long-term climate benefits. While switching from coal to gas in the power sector can reduce emissions, limiting methane emissions (refer to text box on methane emissions) in the natural gas production and distribution process is an important part of realizing those benefits. While this debate continues, a stronger strain in the "bridge" conversation centers on whether switching from gasoline or diesel to natural gas for transportation purposes is a more meaningful way to achieve a cleaner climate.[20]

Even if such a path were universally deemed desirable, the shale gas and tight oil revolution may make it less likely. The emergence of an economic way to produce greater supplies of oil, which is the most efficient and energy-dense source of energy, makes diversification of the transportation sector more difficult. It could also extend the time frame for implementation or diminish the economic attractiveness of technologies, research, and investment in alternative transport fuels and vehicles. Some in the environmental community in the United States have sought to capitalize on the fact that the U.S. tight oil production boom yields high volumes of light sweet crude oil, which is arguably less carbon intensive than other types of unconventional oil like oil sands or heavy oil. These environmental groups have started to argue that the United States should find policy mechanisms to drive greater use of lighter oil.[21] Some in the oil and gas industry counter that this would lead to a host of unintended consequences for both climate change and energy policy.

In general, less focus on the resource-scarcity imperative to switch away from fossil fuel use has meant attention is now more squarely on other reasons to address climate change—namely its economic, national security, health, and other societal impacts. Of course, this debate will likely unfold differently outside the United States.

In places like China that are experiencing increasingly severe air pollution, for example, greater use of natural gas as a substitute for coal, or even as a way to limit coal's share in total energy mix, could become a major policy priority. Globally, the potential for widespread production of natural gas, combined with an environment of high oil prices, might encourage greater penetration of natural gas into a wide range of end uses, including greater use in power generation, and potentially, into oil's traditional stronghold: transportation. Such switches would in turn have implications for global carbon emissions. Overall, while the outcomes remain unclear, at a minimum, the rapid emergence of shale gas and tight oil has challenged existing climate policies and redrawn coalitions.

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20. Laura Barron-Lopez, "Study: Natural Gas May Not be 'Bridge Fuel' to Fight Climate Change," *The Hill*, February 13, 2014, http://thehill.com/blogs/e2-wire/e2-wire/198392-study-natural-gas-may-not-be-bridge-fuel-to-combat-climate.

21. Deborah Gordon, *The Carbon Contained in Global Oils* (Washington, DC: Carnegie Endowment for International Peace, December 2012), http://carnegieendowment.org/files/global_oils.pdf.

What Does Climate Change Have to Do with Geopolitics?

Climate change, energy, geopolitics, and national security are linked in a number of ways. The most obvious is the link between the effects of climate change and the impact on the natural environment and people. Climate change could also have a growing impact on global stability, increasing the frequency of extreme weather events.[1] One 2012 report on extreme weather events found, with medium confidence, that there have been increases since 1950 in extreme precipitation, droughts, and floods that can be attributed to humans. It also concluded that rising mean sea level is the result of climate change, and it is very likely that this "will contribute to upward trends in extreme coastal high water levels."[2]

These climatological changes are exacerbated by socioeconomic trends. Population growth in littoral areas and coastal deltas, especially in increasingly dense urban environments, will place more people at risk from extreme weather events, especially in Asia. Estimates that control for frequency and severity find that population factors alone will drive the number of people exposed to tropical cyclones per year in Asia to 126 million by 2030 and the number of people exposed to floods per year to 77 million, a more than two-fold increase from 1970 levels.[3] The greater impact of storms and floods will increase the humanitarian burden of such disasters, presenting complex challenges for developed nations and potentially crippling problems for states without strong governance regimes and robust civil societies. At minimum, trends suggest there will be an increased need for humanitarian and disaster relief assistance.

1. National Intelligence Council, *Global Trends 2030: Alternative Worlds* (Washington, DC: Office of the Director of National Intelligence, December 2012), 32, http://www.dni.gov/files/documents/GlobalTrends_2030.pdf.
2. S.I. Seneviratne et al., "2012: Changes in Climate Extremes and their Impacts on the Natural Physical Environment," in *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, ed. C.B. Field et al. (Cambridge: Cambridge University Press, 2012), 119–120.
3. J. Handmer et al., "2012: Changes in Impacts of Climate Extremes: Human Systems and Ecosystems," in *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, 240–241.

Caution about the Future Is Warranted: It Is Risky Business to Extrapolate Long-term Conclusions from a Resource with Such a Short Production History

While the changes described above are nascent, they are by no means set in stone. The unconventional resource base is undoubtedly enormous. However, when put in perspective, shale gas production is in its early stages, and even earlier for tight oil. Regulators, producers, and end users are all still learning how to best optimize the value of the resources.

Early on, this unanticipated and fast-moving resurgence in domestic gas production gave rise to questions about the long-term viability of the resource base and the production potential. In the United States, markets and infrastructure had to adjust to large and geographically dispersed production increases. This reorientation was further complicated by a very dynamic commercial environment in which price fluctuations, industry mergers and acquisitions, continual technological and production improvements, and changing regulatory frameworks made the task of assessing the production dynamics of unconventional oil and gas very difficult to discern.

Despite the continual upward revision of shale gas and tight oil resource estimates, there remains considerable uncertainty regarding any given reservoir's ultimate production. Unlike conventional oil and gas development, shale gas and tight oil wells typically have very high decline rates. This means that production from a given well decreases very rapidly a short time after initial production. In order to keep production levels high, companies must increase resource recovery rates, improve drilling efficiencies, and keep drilling. According to EIA, many publicly available estimates are based on assumptions about the production profiles and ultimate recovery rates for wells that have only been in production for a few years (see Figure 11). Estimates that do not take into account the variability in the recovery rates and production profiles in different parts of the same formation are limited still further. Such underlying assumptions can be immensely significant: EIA has stated, for example, that production rates for different wells in the same formation can vary by as much as a factor of 10.[22]

A number of factors can influence estimates of recoverable shale gas resources. Some early drilling may have taken place in areas that were more productive, which would bias estimates upward. On the other hand, estimates that exclude consideration of evolving technologies and allow for more cost-effective drilling and better fracturing and development practices would underestimate the recoverable resource.[23]

Price has proven to be another key variable in natural gas development rates. The differential between oil and gas prices has prompted drillers to shift rigs toward areas with greater quantities of more valuable natural gas liquids (NGLs). (The price of NGLs—ethane, propane, butane and natural gasoline—tracks more closely with crude oil.) The development of gas in these "wet gas" areas has helped to offset the potential price-related production declines in primarily dry gas areas.

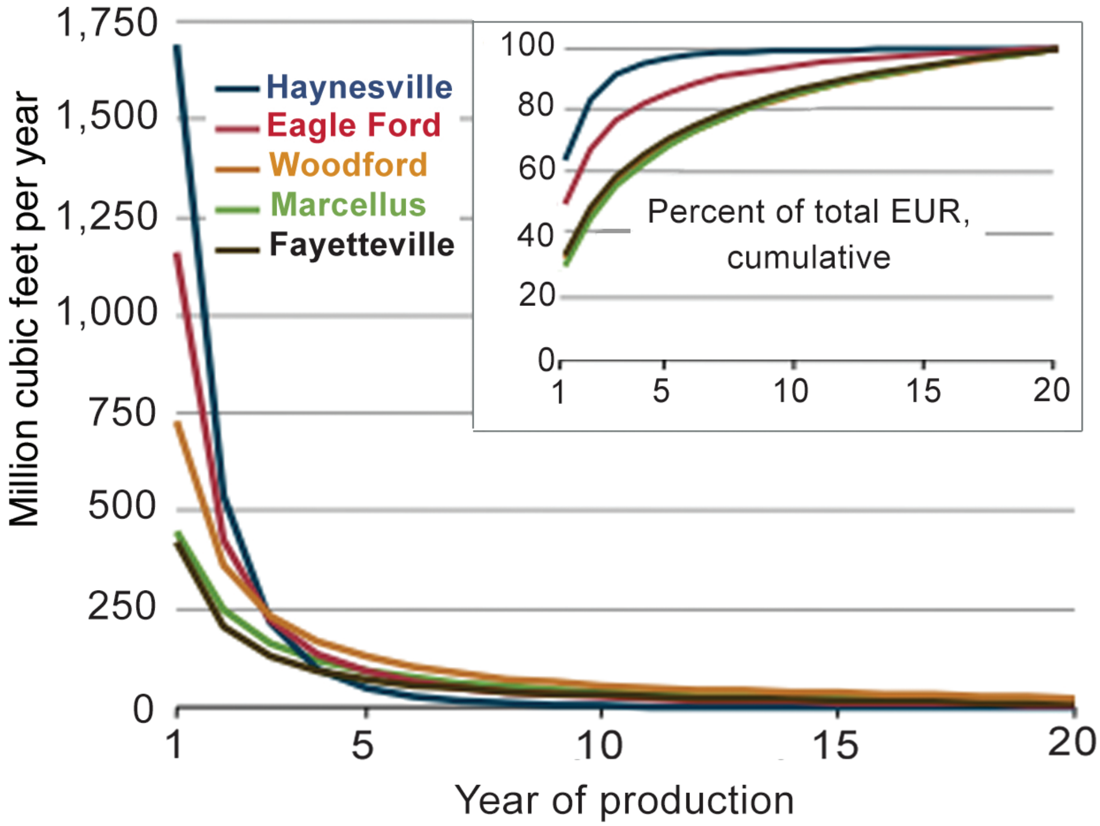
In 2013 EIA published its first "Drilling Productivity Report" that estimates the changes in oil and gas production in six key fields based on the number of operational drilling rigs, estimated drilling productivity, and production changes.[24] The data show that despite a declining rig count, production growth is continuing due to higher drilling efficiency and

22. EIA, "Geology and Technology Drive Estimates of Technically Recoverable Resources," July 20, 2012, http://www.eia.gov/todayinenergy/detail.cfm?id=7190.

23. EIA, *Annual Energy Outlook 2011* (Washington, DC: EIA, 2011), http://www.eia.gov/forecasts/archive/aeo11/IF_all.cfm#prospectshale.

24. EIA, "Drilling Productivity Report," February 10, 2014, http://www.eia.gov/petroleum/drilling/.

Figure 11: Average Shale Gas Production Profiles, by Play



Note: EUR, Estimated Ultimate Recovery.
Source: EIA, Annual Energy Outlook (AEO): 2012, 59, http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf.

the productivity of new wells.[25] Moreover, oil and gas are increasingly being produced from the same well.

The productivity study also shows that legacy decline rates are accelerating in all U.S. oil plays, including the Bakken, Eagle Ford, Niobrara, and Permian Basin.[26] The aforementioned improvements in process and technology are at present able to overcome this challenge. In various plays, between 70 and 77 percent of active rigs are being used to offset natural decline rates and keep production flat or growing. It is too early to tell whether these trends will continue. Thus far, however, technology and production practices have exceeded expectations, resulting in higher production estimates as experience grows.

These experiences highlight that while the global resource potential for unconventional oil is large, a host of uncertainties remain regarding a reservoir's ultimate potential. Given

25. Adam Sieminski, "EIA Drilling Productivity Report" (presentation, Center for Global Energy Policy, Columbia University, New York, NY, October 29, 2013), http://www.eia.gov/pressroom/presentations/sieminski_10292013_drilling.pdf.

26. EIA, "Drilling Productivity Report: Year-over-year Summary," March 2014, http://www.eia.gov/petroleum/drilling/pdf/summary.pdf.

the limited data (five years or so), it is difficult to extrapolate long-term trends in decline rates for unconventional oil. According to one expert, the natural decline rate for most tight oil wells can be as high as 50 to 70 percent per year.[27] Thus far, they have been high not only for oil but also for natural gas—69 percent and 73 percent, respectively,[28] with production falling drastically absent continuous hydraulic fracturing.[29] The costs associated with such high perishability are compounded by large upfront capital costs such as those for holding acreage and adding infrastructure.

Uncertainty exists not only for total production volumes, but also in its timing. Even where the resource base is large, increased production is constrained by commercial markets and infrastructure. In the United States, some have mistaken slowdowns in rig activity or production as a sign of resource inadequacy. Instead, many are natural delays resulting from time taken to build the right mid-stream and end-use infrastructure, or are driven by periods of lower prices that are simply curtailing production for the time being.

In the near-term, low natural gas prices and infrastructure lags are the biggest barriers to more expansive U.S. natural gas production. The rapid development of shale gas in areas that have not historically been major suppliers requires the development of new pipelines and processing facilities to ensure that supply reaches the demand centers. What will complicate this effort is that much of the necessary infrastructure build-out needs to occur in areas of high population density.[30]

What about Prices?

Even if analysts could correctly anticipate future unconventional production, this would still be just one component of anticipating the effects of production on global prices. As has been alluded to above, one of the most direct ways that energy influences governments, both at home and in dealings abroad, is its price effects on individual economies. Lower relative gas prices in the United States, for example, have driven the significant reallocation in both energy and energy-intensive sectors from elsewhere in the world to the United States. And comparatively stable oil prices in the face of new shale gas and tight oil supplies have distributed benefits and costs to various countries, depending on the role oil plays in their respective economies.

Just as shale gas and tight oil have influenced trade, investment, and the climate change debate in unforeseen ways, so too have they influenced the price formulation for natural gas and oil. And just as countries with unconventional basins look to unlock that potential, they and every other country around the world are anticipating how potential production might additionally influence overall prices, which will have widespread effects.

27. Sen, *US Tight Oils*.

28. Sieminski, "EIA Drilling Productivity Report."

29. Ibid.

30. National Petroleum Council (NPC), *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Reserves* (Washington, DC: NPC, 2011), 52, http://www.npc.org/reports/NARD-ExecSummVol.pdf.

PERCEPTION OF FUTURE GAS PRICE IMPACT RESULTING FROM SHALE GAS PRODUCTION

The prospect of a world with abundant gas resources raises a number of lofty expectations with regard to the overall price of gas and for expected changes to global gas markets. Positioning relative to the evolution of regional gas markets and gas pricing dynamics has become an important area to watch in understanding the context for energy-related geopolitical tension between a number of producing and consuming countries in the world. It is important to understand the differences between how oil and gas are used within the global and regional economies and how each commodity is priced. Where oil is generally traded on the global market with various crude oils discounted depending on quality characteristics, natural gas markets are regional in nature. The three major markets for gas trade are North America, Europe, and Asia.[31] Within each market, the gas price is based to varying degrees on oil-linked pricing, regulated pricing or gas-on-gas pricing (also referred to as competitive market pricing). Natural gas that is traded via oil-linked prices is often traded through 20-year contracts set by prices derived from a formula that includes a discount off some mix of oil and oil product pricing. Regulated prices are set by governments and are based on a mix of costs and subsidies. Several markets include competitively priced natural gas that is traded at a hub and based off the price of other gas sold into the market—thus the term, gas-on-gas pricing.

Even before the onset of shale gas development in the United States, global gas markets were changing and there was speculation about how and when these markets might evolve to look more like global oil markets (i.e., more widely traded with more competitive pricing and development of a spot market even if the total traded volume remained much smaller than for oil). The shale gas revolution in the United States has accelerated this conversation and encouraged widespread theorizing over how the introduction of a North American export market for low-priced gas would impact gas markets elsewhere in the world both structurally and in terms of overall price level.

U.S. natural gas prices are deregulated and natural gas is sold through a series of pricing points or hubs, most notably Henry Hub in Louisiana. In Europe, natural gas prices are largely deregulated but hub-based pricing has not yet been universally adopted.[32] Natural gas continues to be sold on both the spot market at hub-based prices and through long-term contracts under oil-linked prices. In Asia, natural gas is traded primarily under long-term contracts with oil-linked prices. Asian markets generally lack the infrastructure and contract flexibility of North American and European markets though volumes of LNG bought and sold on the spot market have increased over the last several years.

All three markets have undergone significant change in recent years. In the North American markets prior to 2010, natural gas prices that were formally delinked from oil markets still tended to move in concert with one another in North America. They have now

31. Often referred to by market analysts as the Pacific and Atlantic basin markets.

32. The hub pricing is most advanced in the United Kingdom. Even within the continental Europe, deregulation is generally more advanced in the northern part than in the southern part.

become much more independent.[33] In Europe long-term oil linked contacts have shifted toward gas-on-gas pricing and the volume of spot trading is on the rise. Moreover, as recently as 2005, natural gas prices in Europe were less expensive than in the United States, whereas gas prices in Europe are now considerably higher than in the United States. Even within Asia LNG contracts are being renegotiated to include greater flexibility between oil and natural gas pricing, shorter-term contracts, and more destination flexibility. Several recent contracts for U.S. gas that have recently been signed have presumably included some element of the Henry Hub–linked price.[34] It is important to note that sustained high natural gas prices in the United States would erode any price advantage of shipping U.S. LNG to Asia.

Should shale gas continue to increase natural gas supplies globally, the transition away from oil-linked natural gas markets is likely to continue. The move toward few longer-term oil-linked contracts is already under way; while it will take time to emerge, it seems to be accelerated by the onset of shale gas production in the United States, but is obviously price dependent as well.

PERCEPTIONS OF FUTURE OIL PRICE IMPACT RESULTING FROM TIGHT OIL PRODUCTION

Despite early speculation that U.S. tight oil production would bring prices down or even precipitate a price collapse, the price impact has been relatively muted thus far. There have been some significant price differences, however, resulting from temporary oversupply situations in parts of the United States.

Most analysts concede that oil prices have remained lower than they likely would have been otherwise given multiple supply outages (e.g., Nigeria, Libya, Sudan, and Iran) and historically low global spare capacity.[35] These price effects occurred despite the fact that U.S.-based West Texas Intermediate (WTI) and other U.S. benchmark crudes were severely discounted relative to European-based Brent crude (shown in Figure 12 on page 36), as markets accounted for insufficient infrastructure to move this new supply to market.

Nonetheless, the onset of tight oil production in the United States has raised interest in the prospect of an oil price downturn due to oversupply. While the following analysis suggests the onset of tight oil production alone will not likely lead to a significant reduction in oil prices, the reaction of major global oil producers to the perceived risk of an oversupplied global oil market provides much of the geopolitical context for big oil producers.

33. EIA, *International Energy Outlook 2013* (Washington, DC; EIA, 2013), http://www.eia.gov/forecasts/ieo/nat_gas.cfm.

34. U.S. Department of Energy, "Applications Received by DOE/FE to Export Domestically produced LNG from the Lower-48 States (as of March 10, 2014)," http://energy.gov/sites/prod/files/2014/03/f9/Summary%20of%20LNG%20Export%20Applications.pdf.

35. Sen, *US Tight Oils*; and Conway Irwin, "Sieminski: US Tight Oil Growth Bolsters OPEC Spare Capacity," Breaking Energy, May 15, 2013, http://breakingenergy.com/2013/05/15/sieminski-us-tight-oil-growth-bolsters-opec-spare-capacity/.

Oil Price Formulation

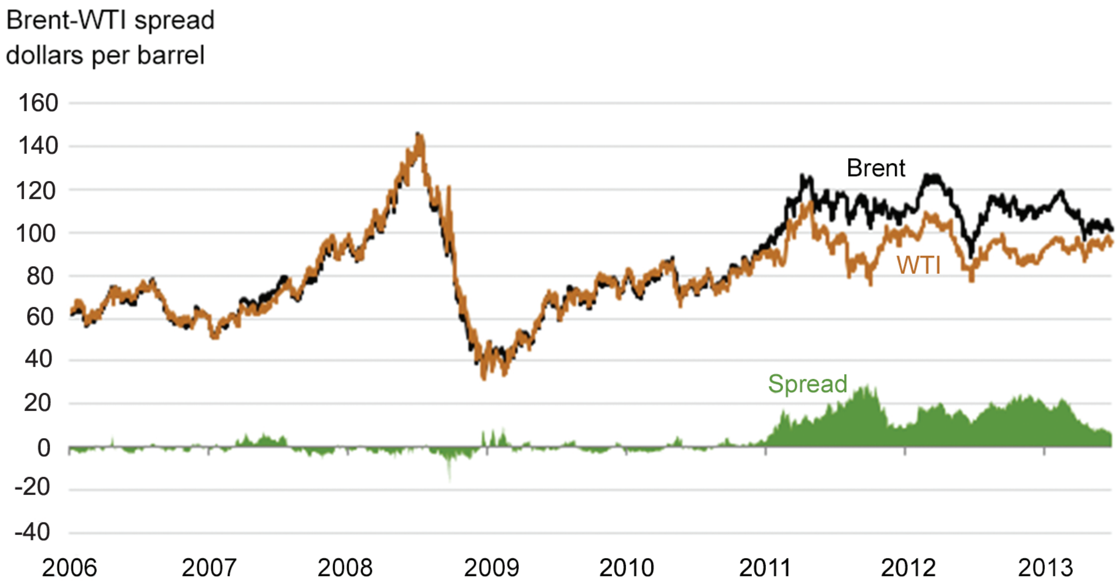
The issue of global oil prices is an important one. Oil is one of the world's most widely traded commodities, is an important part of the revenue stream for a variety of countries around the world, and is an important economic input for the global economy. In a geopolitical sense, global oil prices—both high and low—raise a host of concerns. High prices can tax the economies of oil-consuming nations and strain the public finances of countries with high oil subsidies. They can also fund the domestic and foreign policy prerogatives of governments experiencing windfalls, for good or for ill. Low prices can be a boost for global consumers, but can undermine the economies of oil revenue–dependent countries and tighten the purse strings for those who use oil-derived wealth to shore up domestic and international support.

The EIA offers a helpful primer on oil price formulation through factors affecting oil supply and demand:

> Oil demand is sensitive to the rate at which economic activity grows, particularly in developing countries. It also responds to a sustained change in oil prices that encourages those replacing or adding oil-using equipment to choose options that either use oil more efficiently or run on other fuels. In the short run, the stock of oil-using equipment is largely fixed, and oil demand is affected by price changes only to the extent that utilization rates of oil-using equipment are reduced due to substitution and income effects.
>
> Oil supply depends on resources, technology, prices, and producer behavior. Decisions about the use of existing production capacity and investments in additional capacity are made by national governments, acting through national oil companies or various policy mechanisms, as well as by investor-owned companies. Suppliers who act as so-called price takers, including but not limited to investor-owned oil companies, typically seek to use their available production capacity fully unless prices fall below their operating cost, which occurs rarely if ever for most of them. Price-taking suppliers also tend to increase their capacity investments in response to the expectation of sustained higher prices, which allow more candidate projects to meet or exceed their investment criteria. Suppliers that do not act as price takers, including key OPEC [Organization of the Petroleum Exporting Countries] member countries, base their capacity utilization and investment decisions on a variety of factors related to oil market conditions, geopolitical considerations, and national revenue needs.[1]

1. EIA, *International Energy Outlook 2013* (Washington, DC: EIA, July 2013), 32, http://www.eia.gov/forecasts/ieo/pdf/0484%282013%29.pdf.

Figure 12: Brent and West Texas Intermediate Crude Prices, 2006–2013



Source: EIA, "Price difference between Brent and WTI crude oil narrowing," June 28, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=11891.

So what are the chances of a precipitous decline in oil prices resulting from U.S. tight oil production? Oil market analysts evaluate this question based on several variables: (1) projected oil demand; (2) projected tight oil production; and (3) projected oil supply.[36] To account for a range of outcomes, oil market modelers usually develop low, reference, and high demand/supply cases to inform sensitivity analyses (they usually assume moderate levels of economic growth into the future).

Perhaps the most important variable in projections about future oil prices is the availability of other production sources. Oil market outlooks suggest that additional U.S. supply growth will outpace global demand growth as early as 2014–2015. In theory, this would prompt OPEC producers to reign in production in order to support global prices, though whether they would share the same interests or have the internal discipline needed to constrain production is an open question.

Based on historical case studies, EIA has concluded that significant changes in oil prices over the next 10 years are unlikely. While EIA acknowledges that the global oil market may be imbalanced, its basic characteristics are not likely to resemble two preceding periods of time in which there were precipitous global oil price changes. In the first instance, which occurred between 1973 and 1985, global supply significantly outpaced demand. Saudi Arabia

36. A fourth variable is economics. It is, of course, impossible to know whether or precisely when a global or regional economic downturn will occur and, if so, what its impact on demand for oil would be. Sources include BP, *BP Statistical Review of World Energy 2013*; EIA, *International Energy Outlook 2013*; and Bassam Fattouh, "Shifting oil and oil product markets and the impact on the Middle East" (presentation at Centre international d'études pédagogiques, The Hague, November 5, 2013), http://www.clingendaelenergy.com/inc/upload/files/2._Oxford_Middle_East_presentation_secured.pdf.

did not act as the global swing producer to defend global prices, which correspondingly fell. The second instance occurred between 2000 and 2012, when global demand significantly outpaced supply. Producers could not respond in time to bring down price pressure, resulting in record high prices by the late 2000s. The analysis suggests that, absent other unforeseen supply or demand changes, even the high oil and gas production scenario is not enough to throw global oil prices out of whack.

BP's *Energy Outlook 2035* offers a similar explanation for why, despite less global need for increased OPEC oil supplies, oil markets may still avoid a significant price decline. BP projects that while OPEC members will be forced to cut production over the coming decade, global spare capacity will be far lower as a percentage of the global oil market (7 percent versus 17 percent in the oil price collapse of 1985), and that oil demand will be robust enough to support prices. Moreover, the BP *Outlook* notes that by the end of 2013, supply disruptions had effectively removed 2 million barrels per day from the market. History suggests that these losses will not be easily recovered, as they can take years to return to the market.[37]

So, if oil market analysts are relatively sanguine about the prospect for softer, yet still reasonably balanced oil markets over the coming decade, is a discussion of possible oil prices still important? The answer is absolutely, but it is perhaps no more useful than it has ever been. Oil prices are notoriously hard to predict and subject to a host of factors from weather, to economic downturns or upticks, technology changes, and political unrest. Here are a few key points for consideration, however.

- *Reversal of market psychology*. As noted by EIA, BP and a number of other analysts, the period leading up to and, in fact, including part of the tight oil production surge in the United States was one of the most dramatic periods of oil price rises in history. For much of that decade (2000s), oil market analysts, governments, and companies saw very little easing in global prices. The predominant question was about how high prices would go, how long they would stay there, and whether the world had indeed reached a natural limit to oil development. In an amazingly short period of time, demand decreased, supply rapidly increased, and the entire psychology of the market reversed itself. This about face on global oil market and oil price predictions has a significant impact on anyone investing in oil-producing assets, governing oil resources, or purchasing significant amounts of oil and oil-derived products.
- *Even small price movements matter*. For some countries, even a small decrease in price on a sustained basis (say to a $70 to $80 per barrel range) puts pressure on domestic finances. Despite that reality, the loss of market share is viewed by some countries as a vulnerability to be avoided; this mindset could enhance pressure on major producers not to cede ground even in the face of better-supplied markets.
- *Structural changes to the market*. Tight oil may be affecting the market structure in a number of ways less obvious than daily price levels. Some have argued that the tight

37. BP, *BP Energy Outlook 2035* (London: BP, January 2014), 31–35, http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/Energy_Outlook_2035_booklet.pdf.

> oil phenomenon has effectively set a floor on global oil prices. Differences in cost structures (during exploration, development, and production phases) between conventional and unconventional production and natural decline rates may mean tight oil production levels will adjust to price more than the boom-and-bust cycles that typify previous periods. Secondly, previously U.S.-destined light crudes such as Nigerian Bonny Light must now sell at a steep discount to other customers mostly in Asia. As more West African crude makes its way into Asian markets, Middle Eastern suppliers will face growing competition there. Compensating for those revenue losses may mean a weakening of the traditional discounts afforded to U.S. customers.[38]

While the onset of tight oil production alone will not likely lead to a significant reduction in oil prices, it (along with demand suppression from the economic downturn) suggests a much softer oil market outlook over the next 10 to 15 years than had previously been expected. The reaction of major global oil producers to the perceived risk of an oversupplied global oil market is significant, and is a key factor in much of the geopolitical context for major oil producing and consuming countries alike.

Change Is Everywhere

The oil and gas production surge in the United States impacts global energy markets in a number of different ways including altering patterns of trade and investment, reordering the climate change debate, and potentially increasing oil and gas production in other countries. Markets are adjusting based on projections about both production levels and the resulting effects on prices, despite widespread appreciation for the significant limitations associated with those prognostications. Even if unconventional production in the rest of the world results from a slow spread rather than a rapid ramp-up as witnessed in the United States, the emergence of this opportunity has created a swell of technological optimism that has fundamentally altered the psychology around hydrocarbon resource development. Instead of asking if the world will run out of oil and gas, many people are starting to wonder what other frontier energy sources we will be able to access as technology progresses. The flip side of this optimism among consumers is the potential for a psychology shift among producers, who may see their markets, influence, and power undercut.

This perceived gas abundance has many countries looking for ways to incorporate natural gas into their economies. Natural gas is now a more pivotal part of global climate change negotiations and, within that context, countries are looking for ways to incorporate gas into a low carbon outlook. While much of the international energy dynamic was previously based on the notion of driving technology advancement in the face of resource scarcity, the shift is now toward making the most of newfound abundance and scrutinizing more carefully the technological horizons where new surprises may occur.

38. Sen, *US Tight Oils*.

In sum, U.S. shale gas and tight oil has changed the U.S. and global energy picture. It has shifted the mix of energy sources around the globe, adjusted the economic calculations governing investments both for energy itself and in energy-intensive industries, modified energy trade flows, added another variable for governments to consider when reexamining their overall energy strategies, and injected a new variable into the already thorny challenge of addressing global climate change. These changes have already taken place. The facts, coupled with humans' natural predilection to anticipate and try to shape the future, have created ripple effects in the broader realm of geopolitics, which is explored more deeply in the "Geopolitical and National Security Impacts" background report written to further elucidate topics discussed in *New Energy, New Geopolitics: Balancing Stability and Leverage*.[39]

39. Ladislaw et al., *New Energy, New Geopolitics*.

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ISBN 978-1-4422-2849-8
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