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The Shale Gale turns 10: A powerful wind at America's back

What's ahead for the next decade

July 2018

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Vice Chairman

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Executive Commentary | **Strategic Report**

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The first in a series of reports by IHS Markit exploring the implications of the Shale Gale

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A decade ago, something dramatic—and largely unanticipated—began to emerge in the US natural gas industry. At the time, we dubbed it the "Shale Gale." What has transpired since then is both a dramatic surge in output and a wholesale turnaround, a veritable revolution in the industry. It has transformed the United States from an importer of natural gas into an increasingly important exporter. The impacts extend beyond the natural gas industry itself. The Shale Gale has also transformed the overall US energy industry, shifted company strategies, and dramatically changed global energy markets. It has proved to be a major positive for the US economy, what former Federal Reserve Chairman Ben Bernanke called "one of the most beneficial" economic developments since the Great Recession.[1] It continues to have a major effect on global geopolitics and on America's position and influence on the world stage.

This report uses the vantage point of a decade later to bring into perspective the extent of the shale gale. And it seeks to answer a fundamental question—what's ahead for US natural gas in the decade ahead in terms of output, markets, exports, and impacts?

The coming of the "Shale Gale"

Part of the explanation for shale's development lies in regulatory change and the freeing of markets. For many years, the price of natural gas sold in interstate markets had been set by the Federal Energy Regulatory Commission (FERC) and its predecessor, the Federal Power Commission. However, the prices were set so low that they discouraged investment in new supplies. As a result, in the second half of the 1970s, there were shortages of natural gas, which gave rise to one of the most divisive and contentious political issues of that era. The decontrol of natural gas prices was initiated under the then President Jimmy Carter and completed by former President George H. W. Bush. Market pricing, in place of administratively determined prices, stimulated drilling for new gas. The result was new supplies. These supplies, together with pipeline restructuring, opened an era of moderate prices—to the surprise of many who had opposed the lifting of price controls. Indeed, supplies became so ample that they created a decade-long oversupply that became known as the "gas bubble."

But, around the beginning of the twenty-first century, the market changed. The drill bit was producing declining amounts of gas, supplies were becoming tight, and prices were going up. There was a widely held assumption that the domestic supply base was being exhausted and that the United States would have to become a major importer of liquefied natural gas (LNG)—perhaps the world's largest. In response, plans and investment were initiated for the construction of receiving terminals that would regasify imported LNG from the liquid form in which it is shipped and inject it into the domestic pipeline system.

Yet, at the same time, although largely unobserved, advances in and yoking together of two technologies—horizontal drilling and hydraulic fracturing (fracking)—were beginning to access heretofore commercially unavailable gas that was trapped in shale rock and tight formations.[2] A growing band of independent producers seized upon the new technology to develop new gas resources. The relatively high natural gas prices of this

1. Comments by former US Federal Reserve Chairman Ben Bernanke at CERAWeek by IHS Markit in 2014.

2. Fracking in this report refers to the combined technologies of horizontal drilling and hydraulic fracturing.

period, reflecting the overall tight supplies, provided the incentive for experimentation and risk-taking by these independents. However, this new development went largely unnoticed or was regarded as something that was suited only for the business model of independents and the modern-day version of "wildcatters."

But then, in 2007, the bell rang. For that was the year production started to increase; the increase was even more striking in 2008.

The supply surge

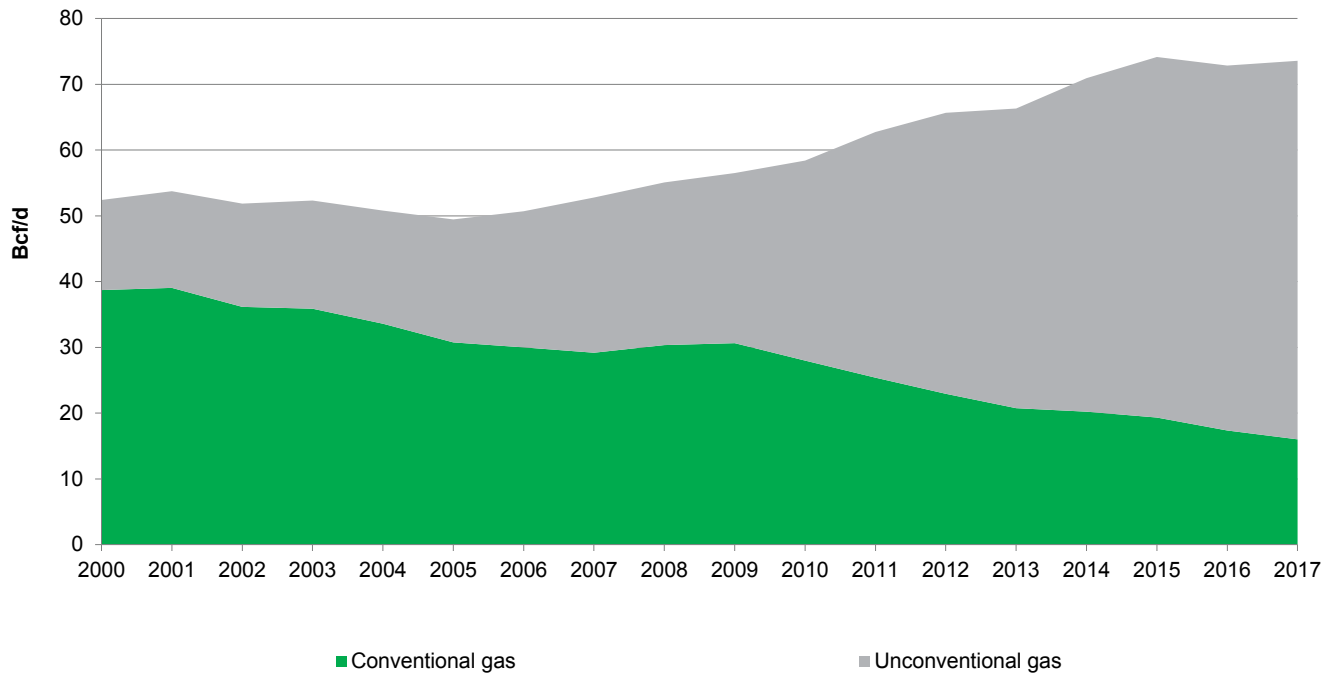
As the combined technologies were applied more widely, US gas production surged to such an extent that this turnaround in US gas supply was dubbed the "Shale Gale." IHS Markit coined the phrase in a February 2009 report entitled *The Shale Gale: The Implications for North American Natural Gas Pipeline Development*.[3]

The turnaround has been striking. For the eight-year period of 2000–07, total US natural gas production grew less than 1%. However, over the subsequent 10-year period of 2007–17, output grew by about 40% (see Figure 1). And the pace of growth is accelerating. For 2018, we expect natural gas production to be up 7 billion cubic feet per day (Bcf/d) relative to 2017. Altogether, we anticipate that US production could grow by about another 60% over the next 20 years.

The Potential Gas Committee has estimated that US recoverable resources have increased by 52%, from 2,074 trillion cubic feet (Tcf) in 2008 to 3,141 Tcf in 2016, and those numbers will likely increase as fracking technology improves and more associated gas gets added to the ledger.[4] In March 2010, IHS Markit issued its

Figure 1

US natural gas production: The evolution of shale



Source: IHS Markit, EIA

3. See the IHS Markit Strategic Report *The Shale Gale: The Implications for North American Natural Gas Pipeline Development*.

4. The Potential Gas Committee released its most recent assessment of the technically recoverable natural gas resource base of the United States on 19 July 2017.

first assessment of the North American *economic* shale resource, estimating more than 900 Tcf of economic resource that could be produced at $4 per million British thermal units (MMBtu) or less. Our current view, as of 2018, is that there is approximately 1,250 Tcf of resource that is economic below $4/MMBtu (see Figure 2). (The resource curve is quite flat near the $4/MMBtu Henry Hub price; and service sector cost inflation or productivity improvements can shift the estimates up or down around that number from year to year.)

In his 2012 State of the Union address, the then President Barack Obama recognized the innovation taking place in energy, stating

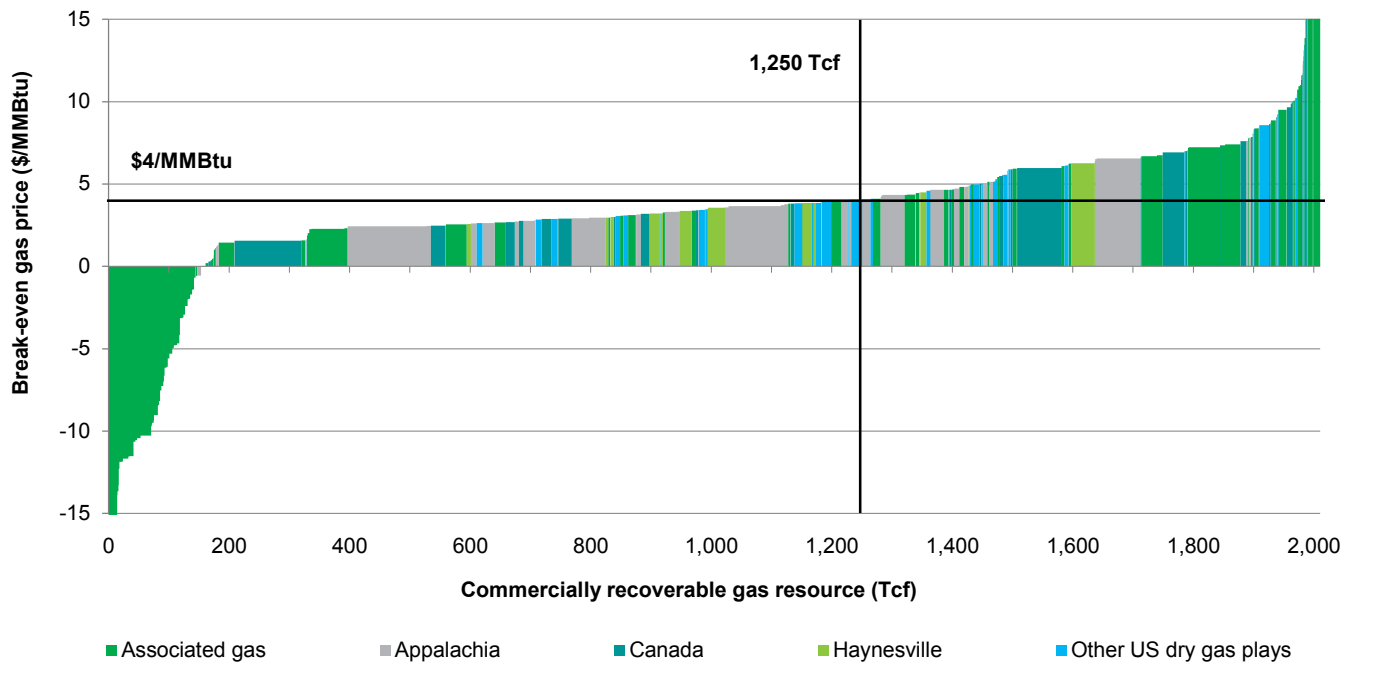
- "We have a supply of natural gas that can last America nearly 100 years."
- "Experts believe this will support more than 600,000 jobs by the end of the decade."
- "The development of natural gas will create jobs and power trucks and factories that are cleaner and cheaper, proving that we don't have to choose between our environment and our economy."[5]

With broad recognition of resource availability, supplies grew, and prices declined (see Figure 3). What had been expected to become an increasingly scarce and expensive resource was now abundant and inexpensive. Between 2007 and 2017, US natural gas production grew from 51.7 Bcf/d to 72.6 Bcf/d. Gas's share of total US energy consumption rose from 22% in 2006 to 29% in 2017.

But the most dramatic effect has been on the US electric power industry.

Figure 2

North American onshore cost gas curve

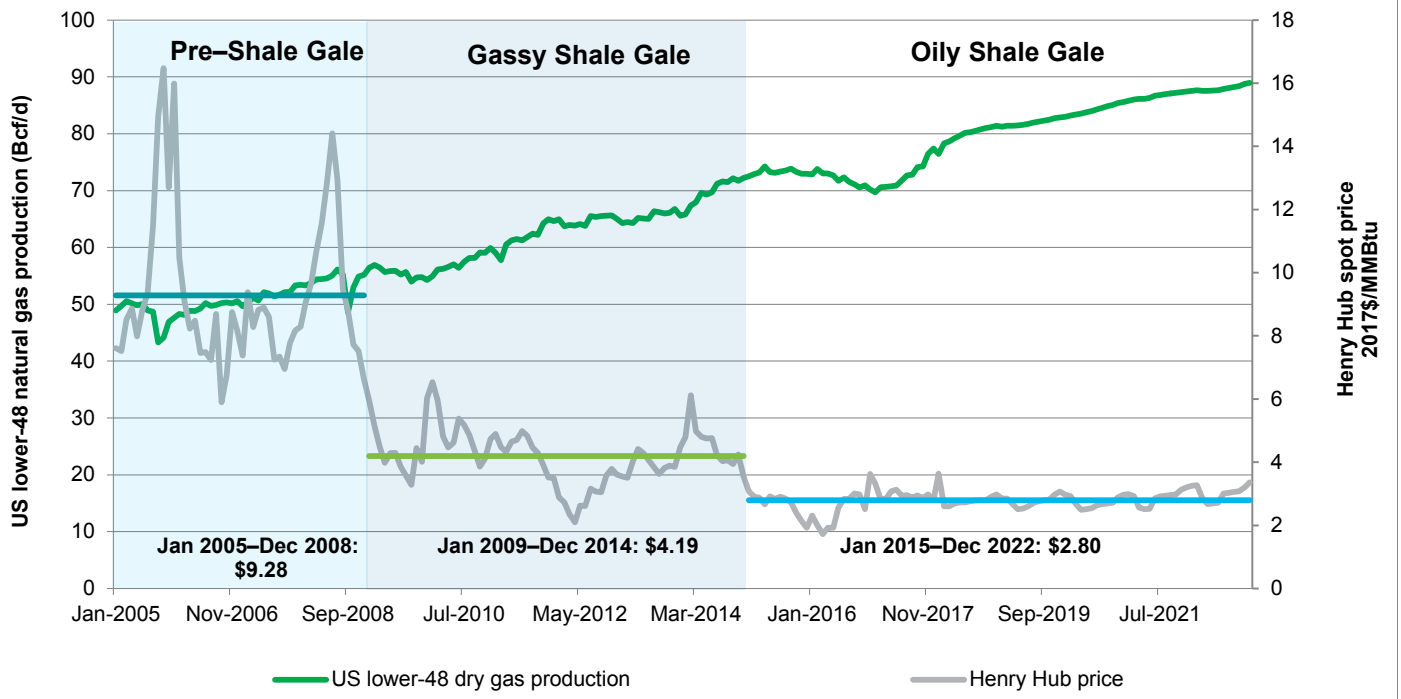


Source: IHS Markit

5. Source: "Remarks by the President in State of the Union Address," Obama White House, 24 January 2012, https://obamawhitehouse.archives.gov/the-press-office/2012/01/24/remarks-president-state-union-address.

Figure 3

Pricing eras of the Shale Gale



Source: IHS Markit, Energy Information Administration (EIA), Intelligence Press

The impact on the power industry

Prior to 1990, coal and nuclear dominated the growth in the share of US electric power generation capacity and energy. Coal was inexpensive and regarded as a secure domestic energy source. The start-up of nuclear power plants was the result of investment decisions largely made in the 1970s. Owing to the natural gas shortages of the late 1970s, the use of natural gas was banned in new electric generation. That ban was lifted in 1987. But coal still dispatched ahead of natural gas and limited gas's share of domestic electric generation to no more than 17% through the 1990s (see Figure 4a).

While the shale gas revolution seemed to imply a complete change in power generation economics, the electric power industry—remembering previous periods when abundant gas supplies had become tight—was cautious about shifting to gas. This reluctance was reinforced by what had happened to merchant power generators. Having bet on gas, these generators had overbuilt capacity and ran into extreme financial difficulties, including bankruptcy, following the rise in gas prices in the early 2000s.

As a consequence of that experience, the power industry initially greeted shale gas with skepticism. Additionally, there was a burgeoning coal capacity build and expectations of a nuclear renaissance. By 2010, about a dozen proposed nuclear plants, totaling 27 gigawatts (GW), had gone for licensing. But, as it became evident that gas supplies were abundant—and highly cost competitive—the industry put aside its skepticism and began to embrace natural gas in its portfolios. Natural gas had another competitive advantage: the culmination of several Clean Air Act initiatives contributed to retirements of many coal plants, and opposition to new coal build became very strong. In addition, natural gas–fueled generating facilities were less expensive, quicker to build, and easier to move through the regulatory process than coal facilities.

The shale gas revolution has transformed power generation economics, resulting in a rebalancing in fuel choice for electric generation (see Figure 4b). In 2007, coal provided 49% of US generation and natural gas provided

22%, and more than 10 GW of coal generation was under construction. In 2016, natural gas overtook coal for the first time and supplied 34% of total electric generation while coal supplied 31%. Gas has become a backbone of electric generation in the United States.

In terms of future generating capacity, the electric power industry will install new renewable and natural gas facilities, in contrast to the coal and nuclear additions that characterized the final decades of the last century. Given the incentives extended by federal legislation in December 2015, we expect that well over half of all new electric generation capacity entering service from 2016 to the early 2020s will be renewables. But, in terms of actual generation, we expect natural gas's share to grow from almost one-third currently to almost half of all electricity generated by 2040.

The impact on carbon emissions and the environment

The shift from coal to natural gas has, because of falling natural gas prices and confidence in long-term gas supply, along with the addition of renewables, contributed to the reduction in US carbon dioxide (CO_2) emissions from power generation. We estimate that in 2017, CO_2 emissions from power generation were down 30% from 2005. More than half of that emission decline was from gas replacing coal. In September 2016, President Obama pledged (in accord with the Paris Agreement) that the United States would reduce total greenhouse gas (GHG) emissions by 26–28% from 2005 levels by 2025.[6] The Shale Gale has been a major element in the power industry's contribution to the overall goal.

Figure 4a

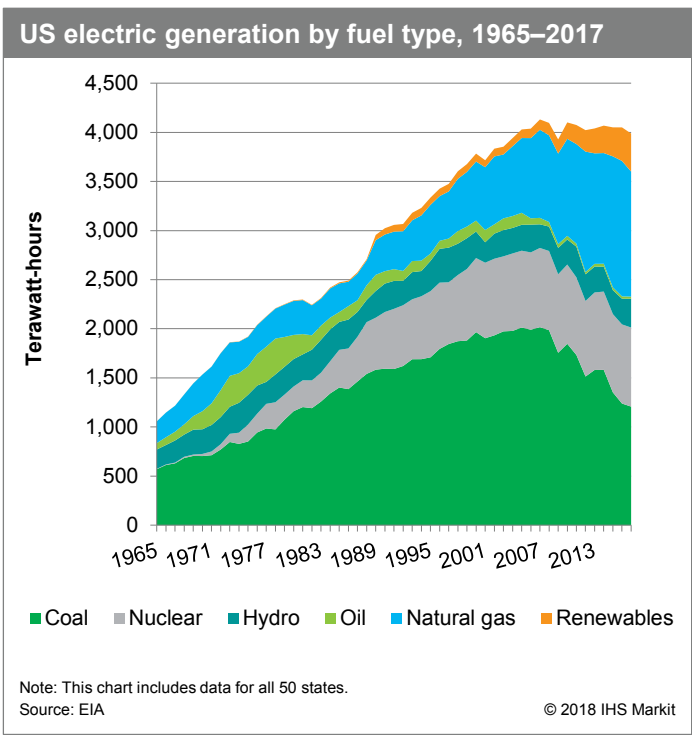
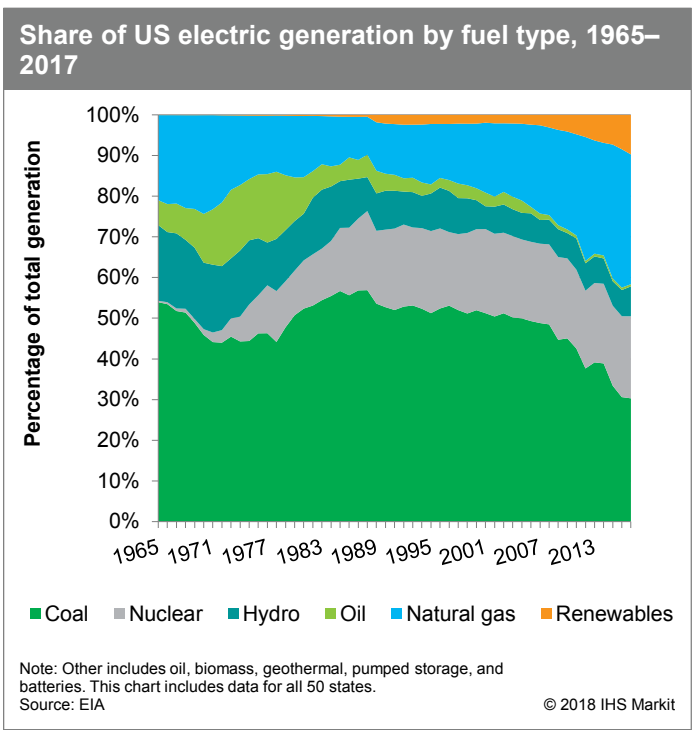


Figure 4b



6. Source: "FACT SHEET: U.S. Reports its 2025 Emissions Target to the UNFCCC," Obama White House, 31 March 2015, https://obamawhitehouse.archives.gov/the-press-office/2015/03/31/fact-sheet-us-reports-its-2025-emissions-target-unfccc; and Tanya Somanader, "President Obama: The United States Formally Enters the Paris Agreement," Obama White House, 3 September 2016, https://obamawhitehouse.archives.gov/blog/2016/09/03/president-obama-united-states-formally-enters-paris-agreement.

When the Shale Gale first appeared, criticism emerged over environmental consequences, much of which related to water issues. These concerns were addressed in a report that President Obama requested and was delivered in 2011 by the Secretary of Energy Advisory Board.[7]

The report concluded that, if properly managed and properly regulated, shale gas production was environmentally responsible. The study made specific recommendations on such issues as water, community impact, emissions, and best practices. It also observed that, although not well known, oil and gas production was largely regulated by the states and not the federal government. Since the report there has been increasing attention to methane emissions from natural gas production, the reduction of which has become an industry priority.

The new geography of natural gas

Prior to 2007, US natural gas production was predominantly from the Southwest and the Gulf of Mexico. Canadian imports accounted for about 16% of US consumption. Since producers first learned how to frack the shale source rock, there has been a continuous evolution in terms of new and prolific discoveries. The productivity of shale from fracking varies significantly among the different basins and there has been a learning curve on how to best frack the various shales. Production started with the Barnett Shale in Texas, then moved to the Haynesville play in Louisiana, followed by the Fayetteville in Arkansas, before reaching Appalachia—a key contributor to the current production trajectory.

Appalachia's vast economic resource base comprises the massive and prolific Marcellus and Utica plays, each of which is now estimated to be able to supply the United States with two decades of natural gas. Production from these plays, currently at more than 25 Bcf/d, is expected to grow to almost 50 Bcf/d by 2050—rivaling the entire US production level prior to the Shale Gale. But this monumental growth will require more infrastructure to move gas production from supply basins to consuming markets within North America and to liquefaction facilities for export.

And now there is another player, the Permian Basin in West Texas, which is the predominant source of growing shale oil and associated gas production.

Permian oil production grew by more than 750,000 barrels per day—more than 35%—in 2017 and is expected to exceed that year-to-year growth rate in both 2018 and 2019. Each million barrels per day of oil production growth is adding 2–3 Bcf/d of associated gas. This growing Texas oil production has helped boost the contribution of total associated gas to almost 30% of total US production. More than 8 Bcf/d of new pipeline capacity has been proposed to move this growing supply of Permian gas to market. However, the first 2 Bcf/d of expansion is not expected online until late 2019. It is likely that a significant portion of that gas will go to new industrial facilities on the Gulf Coast and to exports (of LNG and by pipeline to Mexico).[8]

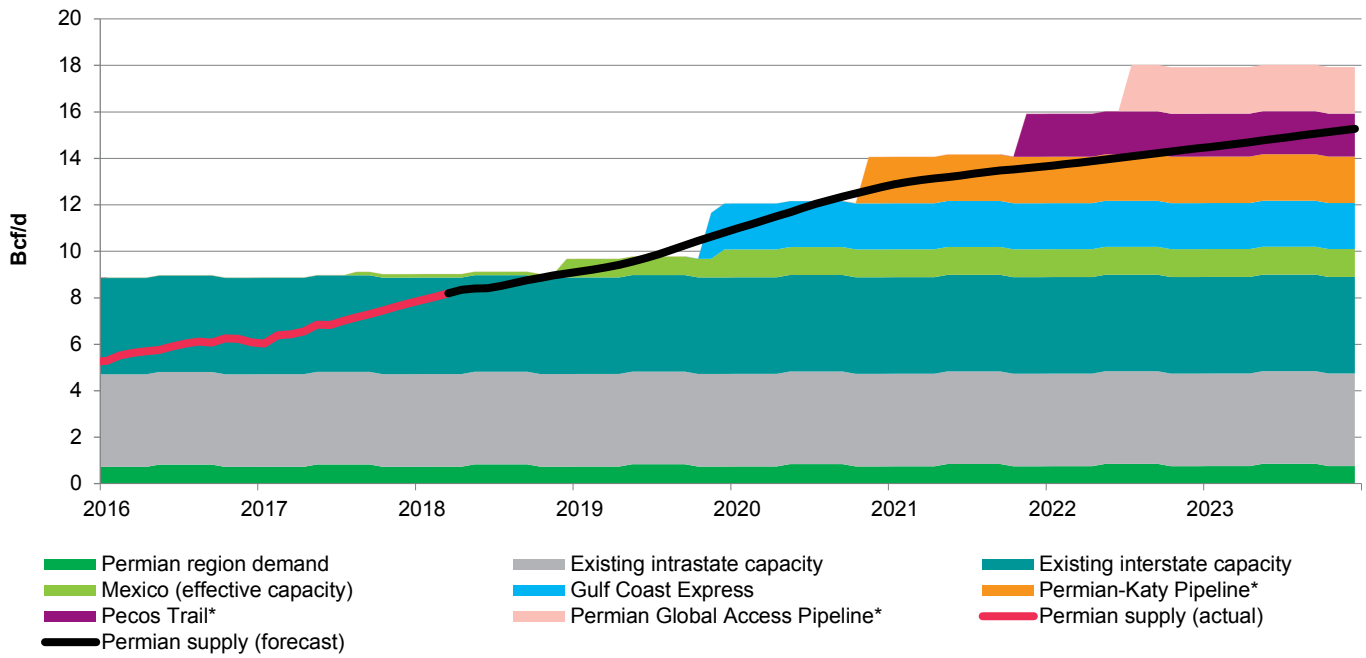
The pace of growth in the Permian Basin, much like the Marcellus before it, is outstripping the pace of infrastructure expansion (see Figure 5).

7. Source: US Department of Energy, *Shale Gas Production Subcommittee Second Ninety Day Report*, 18 November 2011, https://www.energy.gov/sites/prod/files/90day_Report_Second_11.18.11.pdf. The report was chaired by Professor John Deutch of the Massachusetts Institute of Technology (MIT), former deputy secretary of defense and undersecretary of science in the Department of Energy, and is often referred to as the "Deutch Report." Daniel Yergin was a member of the task force.

8. See the IHS Markit Strategic Report *The Permian: $308 billion, 41,000 wells, and other key ingredients in the IHS Markit outlook to 2023*.

Figure 5

Permian gas production and takeaway capacity



*These pipelines are proposed and in various stages of development. The pipeline expansion modeling assumptions for the IHS Markit outlook may differ from developers' proposed capacity.
Source: IHS Markit

The need for infrastructure

An unprecedented amount of incremental pipeline capacity (exceeding 30 Bcf/d) has been developed or proposed to connect supply from Appalachia and West Texas to growth markets throughout North America. However, pipeline projects in general, and specifically those of Appalachia, have faced growing challenges, such as more organized opposition, longer review times, and rising costs, resulting in the delay or even cancellation of many large-scale projects. With opportunities to reverse existing south-to-north lines having already been largely exploited, projects now involve new greenfield pipeline construction, which requires higher capital outlays and a more extensive review, authorization, and permitting process.

In one particularly dramatic case, the Sabal Trail pipeline into Florida, built to serve new gas-fired generation in Florida that is replacing retired coal and nuclear generation, has had its certification rejected by the US Court of Appeals for the District of Columbia Circuit. A three-judge panel sided with an assertion from the environmental group Sierra Club that an environmental impact statement FERC had issued for the proposed Southeast Market Pipelines project had failed to adequately consider the impact of GHG emissions. The court remanded the case to FERC and went further, by vacating all the existing permits that had been issued for the project. This has left an already-constructed pipeline at risk of being shut down. Yet, as it turned out, Sabal Trail was needed to operate at available capacity this past winter to meet Florida's gas demand during the "bomb cyclone" and has been deemed necessary by Florida utilities to ensure future power grid reliability. FERC has asserted, in its reply, that the agency "could not find a suitable method to attribute discrete environmental effects to GHG emissions" nor to quantify how a few gas-fired power plants in Florida will affect the climate of the entire globe.[9]

9. FERC issues Draft Supplemental Environmental Impact Statement on Southeast Market Pipelines Project (Docket Nos. CP14-554-002, CP15-16-003, and CP15-17-002), FERC, 27 September 2017, https://www.ferc.gov/industries/gas/enviro/eis/2017/09-27-17-DEIS.asp.

Overall, there is so much resource available in the United States and Canada that producers are competing to see which plays are the most economic and able to serve a demand-constrained market. This wealth of economic resource has led to the price of natural gas falling below $3/MMBtu. One major consequence is that gas at lower prices has turned around the prospects for energy-intensive manufacturing in the United States.

The impact on manufacturing

For years, energy-intensive manufacturing had been leaving the United States owing to high energy costs. But, as the reality of abundant and inexpensive natural gas came to be accepted, the direction of investment changed. The advantages in terms of thermal energy, feedstock, and electricity costs have driven a surge of new investment in US petrochemical and other industrial facilities. IHS Markit estimates that, from 2010 through 2020, more than $120 billion in new capital investments will be spent to expand petrochemical manufacturing capacity. Ancillary expenditures around the plant projects could double the total capital investment.

The economic benefits have not been limited to capital investments. Lower prices for raw materials and energy have increased industrial production. The United States has become competitive in energy-intensive products such as petrochemicals, fertilizers, iron, steel, and machinery. It has been estimated that, by 2025, as many as four million jobs—direct, indirect, and induced—could be supported by unconventional activity.[10]

The big flip: From imports to exports

As already noted, the informed assumption prior to 2007 was that the United States was going to be a major importer of LNG, perhaps the world's largest. On that basis, construction had already begun on several facilities for importing LNG, regasifying it, and distributing it to US consumers. But then, as the Shale Gale's intensity grew, it became obvious that higher-cost imported LNG would have no market in the United States. Not only were LNG imports not required, but US pipeline imports of natural gas from Canada declined from a peak of about 16% of domestic supply in 2005 to about 7% currently. Moreover, and contrary to what had seemed settled wisdom, it became clear that the growing volumes of gas were exceeding domestic demand and that the United States could sell natural gas into international markets while still easily meeting its own growing demand (see Figure 6).

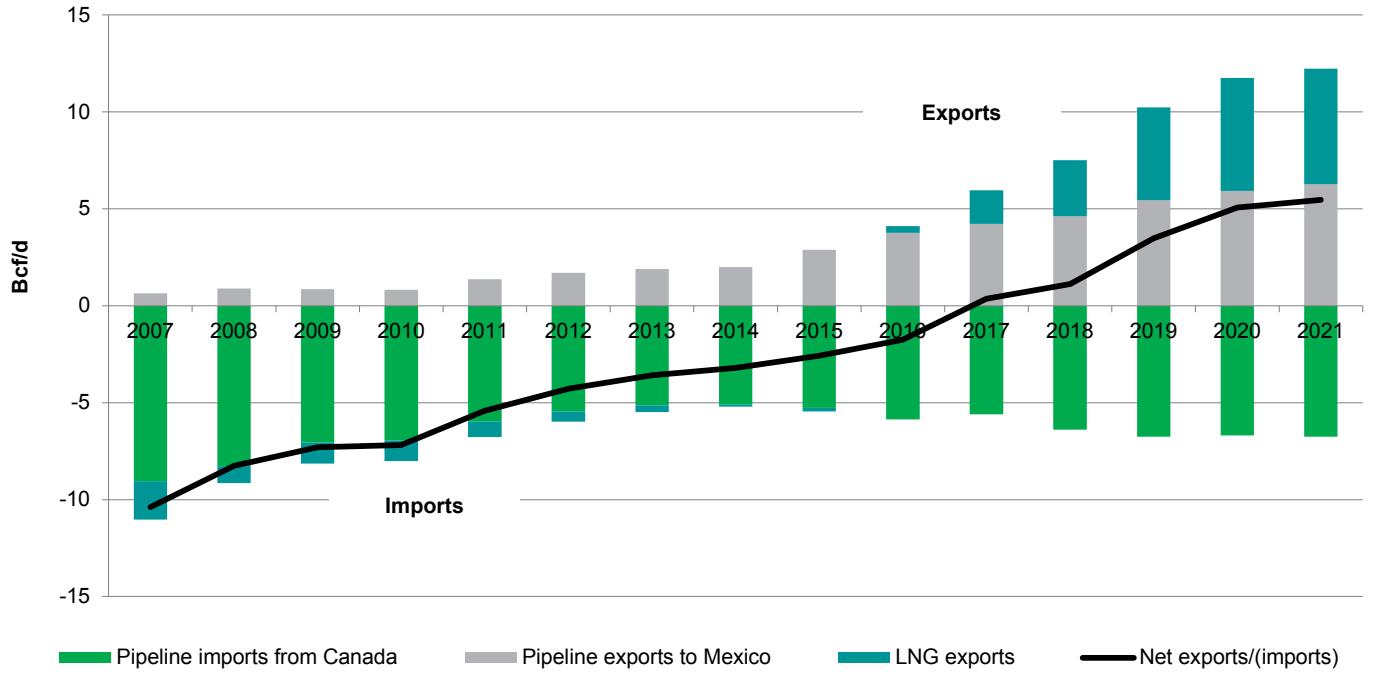
By the beginning of 2018, the United States was exporting 4.4 Bcf/d (worth about $5 billion per year) via new pipelines to Mexico—about 6% of domestic production but close to half of Mexican natural gas needs. For Mexico, this was the most immediate and tangible benefit of its own domestic energy reforms, because imported gas from the United States used in electric generation helped to bring down the cost of electricity for Mexican consumers, manufacturers, and voters.

In addition to Mexico, there is the growing global market. The dramatic expansion in US natural gas production has meant a 180-degree turn, enabling the United States to become an LNG exporter, rather than an LNG importer. Plants that were originally envisioned as LNG receiving terminals have been reconfigured as LNG liquefaction export terminals, at the cost of tens of billions of dollars. New greenfield projects have also been initiated. Some energy-intensive manufacturing companies expressed concerns about exporting LNG, fearing that this could crimp supplies for their own multibillion-dollar investment commitments. However, the continued growth in natural gas production allayed those fears.

10. See the IHS Markit study *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy, Volume 3: A Manufacturing Renaissance,* 2014.

Figure 6

US natural gas: From imports to exports



Source: IHS Markit, EIA

One small export terminal in Alaska had, since 1969, exported limited volumes of LNG. But the first new major US LNG export terminal dispatched its first cargo in February 2016. Since then, US LNG exports have ramped up to up to 3 Bcf/d and LNG has been delivered to a total of 26 countries by vessel: Argentina, Brazil, Chile, Malta, China, the Dominican Republic, Egypt, India, Italy, Japan, Jordan, Kuwait, Lithuania, Mexico, Portugal, South Korea, Spain, the Netherlands, Pakistan, Poland, Taiwan, Thailand, the United Arab Emirates, Britain, Turkey, and Colombia.

We expect that, over the next five years, the current nameplate liquefaction capacity of 3.1 Bcf/d of LNG exports will grow by another 6.9 Bcf/d. By 2025, the United States is expected to be producing 92 Bcf/d and will rank as one of the world's largest exporters of LNG. Investment in these plants will total an estimated $56 billion. Instead of being a gas-short LNG importer, the United States is now on track to rank among the world's major LNG exporters. By 2025, the global LNG market is anticipated to be more than 400 million metric tons per year, with the top suppliers—Qatar, Australia, and the United States—exporting 60% of total supply.[11]

The impact on oil

The Shale Gale may have begun with natural gas, but the shale revolution would be extended to oil, with enormous global impact. In the first several years of shale gas development, there had been skepticism about the applicability of the technology to oil. But around 2008, that applicability came to be proved. And oil output would quickly demonstrate the same kind of surge that had characterized natural gas. Between 2008 and 2018, US oil output more than doubled and exceeded the previous high set in 1970. On a net basis, the United States went from importing 60% of its liquid fuel at the peak to below 16% in March 2018, and the share is still falling.

11. See the IHS Markit Strategic Reports *Potential and risk: What could limit the growth of North American liquefaction capacity?* and *Next wave of US LNG seeks a competitive advantage*.

The change in Texas was particularly stark. In 2008, Texas had produced approximately 1 million barrels per day. By 2018, it was producing close to 4 million barrels per day. Owing to the mismatch between the typical quality of shale oil and America's existing refining capacity, the United States has become a significant exporter of oil (both crude and products), as well as an importer. The unexpectedly rapid buildup of US supplies was one of the major factors that, along with weak demand, created the imbalance in supply and demand that triggered the 2014 oil price collapse.

Overall economic impacts

The overall economic impacts of shale gas and shale oil cannot be separated because they involve the same companies, the same supply chains, and often the same wells. In March 2014, shortly after leaving the chairmanship of the Federal Reserve, Ben Bernanke said of the shale revolution, "It's clearly been one of the most beneficial—if not the most beneficial—developments" since the 2008 financial crisis and the onset of the Great Recession and "it's helping our economy in a number of ways."[12] In 2014, IHS Markit estimated that the full unconventional value chain (from upstream energy through energy-related chemicals) associated with unconventional oil and natural gas development had supported more than two million jobs (direct, indirect, and induced), had generated over $75 billion in federal and state tax revenues, and had contributed more than $283 billion to US GDP, representing an increase in real GDP for 2012–14 in the range of 2–3%. Per average household, disposable income was raised by more than $1,000.

Notably, the supply chains extended across the country, stimulating manufacturing (notably in the Midwest) and service and technological industries across the United States. The development of the Marcellus play provided major economic stimulus in Pennsylvania, including such support industries as real estate, lodging, food, vehicle sales, construction, and local commerce. The supply chains are even creating jobs in New York State, despite that state's ban on shale gas development. At the peak, shale was responsible for about 15% of all the capital investment in the fixed equipment and structures sector for the United States.

The oil price collapse that began in late 2014 led to a dramatic cut in investment. However, prices have rebounded since the OPEC/non-OPEC agreement of late 2016, accompanied by strong global oil demand growth and plummeting output from Venezuela. US capital investment is once again increasing, and producers have increased well productivity and reduced costs.

Conclusion: The impacts are wide ranging

In 2010, Professor John Deutch of MIT wrote that "every decision on a domestic energy matter has a foreign policy implication, and many foreign policy decisions have major impacts on domestic energy matters."[13] The domestic US power markets and overall economy would look significantly different without the shale revolution. Similarly, the outlook would be different in terms of the global economy and international relations—both for countries that produce oil and natural gas and for countries that import them.

Certainly, without the Shale Gale, the United States would be in a very different position. The Shale Gale and its consequent impact on oil have brought a new element of influence and independence for the United States. US LNG and oil exports are becoming a significant and positive factor in the relations with many countries and a key element in discussions about trade.

12. Source: Comments by former US Federal Reserve Chairman Ben Bernanke at CERAWeek by IHS Markit in 2014.

13. John Deutch, "Oil and Gas Energy Security Issues," National Energy Policy Institute Backgrounder, June 2010.

Subsequent papers in this series will explore in more detail the implications of the Shale Gale on topics including natural gas markets, oil markets, economics, geopolitics, and the infrastructure necessary to enable it. Overall, the unconventional revolution has dramatically altered the outlook for US natural gas over the past decade. Once considered to be in imminent danger of depletion, the US natural gas resource base is now widely agreed to be sufficient to last into the twenty-second century at current rates of consumption. Costs have also fallen, and natural gas prices are expected to increase very slowly over the next 20 years—remaining lower than prices for many other fuels.

The new outlook for natural gas cost and availability has created new possibilities for making progress toward national goals of energy efficiency, cost efficiency, environmental protection, and energy security. It is also contributing jobs and revenues to the economy at the national, state, and local levels. In short, the Shale Gale has put a powerful new wind at America's back.

About the authors

Daniel Yergin is Vice Chairman of IHS Markit and Chairman of CERAWEEK by IHS Markit. He received the Pulitzer Prize for his book *The Prize*. His most recent book is *The Quest: Energy, Security and the Remaking of the Modern World*. He chairs the new IHS Markit mobility service.

Samuel J. Andrus is an Executive Director at IHS Markit. He is an authority on North American gas markets with operational and trading experience in natural gas and power markets. He is responsible for the IHS Markit North American gas analytics practice, which covers modeling of natural gas supply, demand, storage, and price in support of short-, intermediate-, and long-term market outlooks.

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This paper is the first of an ongoing series exploring the global implications of the Shale Gale for the energy value chain, economies, and geopolitics. Contact craig.urch@ihsmarkit.com **for more information on these advisory services.**

Future events

India Energy Forum by CERAWeek, New Delhi, 14–16 October 2018

CERAWeek by IHS Markit, Houston, 11–15 March 2019

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