

SHALE REALITY CHECK

Drilling Into the U.S. Government's Rosy Projections for
Shale Gas & Tight Oil Production Through 2050

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Executive Summary

Shale gas and tight oil from low permeability reservoirs have provided a new lease on life for U.S. oil and gas production. Tight oil has allowed U.S. oil production to double from its 2005 lows, and shale gas has similarly allowed a major increase in U.S. gas production. However, the nature of these reservoirs is that they decline quickly, such that production from individual wells falls 70–90% in the first three years, and field declines without new drilling typically range 20–40% per year. Continual investment in new drilling is therefore required to avoid steep production declines. Older fields like the Barnett, where drilling has nearly ceased, are in terminal decline. Shale plays also exhibit variable reservoir quality, with “sweet spots” or “core areas” containing the highest quality reservoir rock typically comprising 20% or less of overall play area. In the post-2014 era of low oil prices drilling has focused on sweet spots which provide the most economically viable wells.

How sustainable is shale production in the long term given optimistic government and industry forecasts of robust production through 2050 and beyond? This report endeavors to answer that question by assessing the viability of the projections of the U.S. Energy Information Administration (EIA), which are widely used by policymakers, industry, and investors to make long-term plans. The report is based on an analysis of well production data for all major shale gas and tight oil plays in the U.S. These plays make up 88% of the EIA’s *Annual Energy Outlook 2017* (AEO2017) reference case cumulative production forecast for shale gas and tight oil for the period 2015–2050. The data source is Drillinginfo,¹ a commercial database of well-level production data which is utilized by the EIA and most major oil and gas companies.

For each play, this report assesses:

- Current and historical production.
- Total- and producing-well count by county, well type and vintage.
- Well- and field-declines by county, well type and vintage.
- Distribution of wells in terms of quality, as defined by production of oil or gas in the highest month (initial productivity), in order to delineate sweet spots.
- Density of wells in sweet spots.
- Cumulative oil and gas production by county.
- Average productivity of all wells drilled in each year from 2012 to 2017 by county, well type and play average, in order to determine the impact of enhanced technology.
- Production history in sweet spot counties and in the remainder of the play area.
- Prospective drilled area to determine the area which might reasonably contribute to future production.
- The optimism bias for the EIA AEO2017 play-level forecast based on play fundamentals determined from the assessment.

This analysis finds that EIA projections of production through 2050 at the play-level are highly to extremely optimistic, and are therefore very unlikely to be realized. EIA play forecasts count on recovering all proven reserves plus a high percentage of unproven resources—in some cases over 100%—by 2050. (Proven reserves have been demonstrated by drilling to be technically and economically recoverable. Unproven resources are thought to be technically recoverable but have not been demonstrated to be economically viable; as such they are much less certain than proven reserves.) Furthermore, most of these play-level projections assume that production will exit

¹ Drillinginfo, <https://info.drillinginfo.com/>

2050 at high levels compared to current rates, implying that there are vast additional resources to be recovered beyond 2050.

Key findings:

- Well productivity
 - o Better technology—including longer horizontal laterals, a tripling of water and proppant injection since 2012, and more fracking stages—has resulted in increased average well productivity in most plays.
 - o A significant portion of the increased average well productivity is a result of “high-grading” sweet spots: focusing drilling on the highest quality reservoir rocks (which form a relatively small portion of most plays).
 - o Average well productivity in some counties and plays has declined in 2017, indicating technology there has reached the point of diminishing returns. This is a result of drilling outside of sweet spots and/or drilling wells too close together, resulting in “frac hits” and well interference which compromises individual well production.
- Tight oil plays
 - o The Permian Basin plays are the main driver for tight oil production growth. In Permian plays such as the Wolfcamp and Spraberry production is increasing rapidly, although Bone Spring production has flat-lined recently. EIA estimates for production through 2050 for these plays are rated as highly to extremely optimistic.
 - o Production in older tight oil plays like the Bakken and Eagle Ford, which were among the first tight oil plays developed, is down substantially from peak. EIA projections for these and other tight oil plays, including the Niobrara and Austin Chalk, are rated as highly to extremely optimistic.
- Shale gas plays
 - o The Appalachian plays are the main driver for shale gas production growth - the Marcellus and Utica now account for 48% of U.S. shale gas production. EIA forecasts for the Marcellus and Utica, which project these will provide 52% of cumulative production of U.S. shale gas through 2050, are rated as extremely optimistic.
 - o Production in older shale gas plays—including the Barnett, Haynesville, and Fayetteville, which were among the first to be developed—is now down more than 40% from peak. EIA projections for these plays—along with the Woodford, which is down 25% from peak—are rated as highly to extremely optimistic.
- All plays
 - o The EIA AEO2017 reference case projects that 1.29 million wells will be drilled to recover oil and gas from both conventional and unconventional reservoirs in the period 2015–2050. At \$6 million per well, this amounts to \$7.7 trillion. Shale plays reviewed herein, which account for 88% of the EIA’s estimated shale oil and gas production through 2050, would require 1.04 million wells using EIA assumptions—at an estimated cost of \$5.7 trillion. Recovering the remaining 12% of shale resources would require an additional .68 million wells at a cost of \$4.1 trillion. Given the EIA’s overestimates of future shale production and recoverable resources, it is unlikely that all of these wells will be drilled.

There is no doubt that the U.S. can produce substantial amounts of shale gas and tight oil over the short- and medium-term. Unrealistic long-term forecasts, however, are a disservice to planning a viable long-term energy strategy. The very high to extremely optimistic EIA AEO2017 projections impart an unjustified level of comfort for

long-term energy sustainability. As sweet spots are exhausted, the reality is likely to be much higher costs and higher drilling rates to maintain production and/or stem declines.

The “shale revolution” has provided a reprieve from what just 13 years ago was thought to be a terminal decline in oil and gas production in the U.S. It has sparked calls for “American energy dominance”²—despite the fact that the U.S. is projected to be a net oil importer through 2050, even given EIA forecasts. This reprieve is temporary, and the U.S. would be well advised to plan for much-reduced shale oil and gas production in the long term based on this analysis of play fundamentals.

² Time, June 29, 2017, *President Trump Says He Wants 'Energy Dominance.' What Does He Mean?* <http://time.com/4839884/energy-dominance-energy-independence-donald-trump/>

1. Introduction

As recently as 2005, U.S. oil and gas production were thought to be in terminal decline. The advent of high-volume hydraulic fracturing (fracking) in combination with horizontal drilling changed all that, as it allowed access to oil and gas resources in impermeable source rocks that were previously inaccessible. This technology was first developed and applied by George Mitchell³ to gas in the Barnett shale of east Texas in the late 1990s, and quickly spread to other regions. It was later applied to tight oil, beginning with the Bakken shale of North Dakota, and has resulting in the doubling of U.S. oil production.

Shale has raised expectations for U.S. oil and gas production and has underpinned calls for U.S. “energy dominance” by the Trump Administration,⁴ after decades of being a net importer of oil and gas. International exports of gas via LNG and of crude oil have begun over the past three years. The optimism has been bolstered by the U.S. Department of Energy’s Energy Information Administration (EIA), which has issued optimistic forecasts projecting U.S. oil and gas abundance due to shale through 2050 at least.

But how reliable are these forecasts? They have recently been questioned by oil magnate Harold Hamm as overly optimistic,⁵ and MIT has released a study of the Bakken play suggesting the same thing.⁶ I have also pointed this out in reports over the past several years.⁷ The answer to this question is very important, as the prospect of cheap, abundant oil and gas for the foreseeable future discourages investment in alternative energy and the adoption of policies to reduce consumption which would enhance long-term sustainability. Incorrect assumptions about future oil and gas availability also increases vulnerability to price shocks and supply disruptions.

Shale plays share several common characteristics:

1. Although each play may cover several hundred to thousands of square miles, well productivity and ultimate recovery (EUR) per well are highly variable. Core areas or “sweet spots,” where well productivity and EUR are high, generally comprise only 10–20% of total play area. Industry has focused on sweet spots with the downturn in oil and gas prices, but for full development higher prices and higher drilling rates will be required as sweet spots are exhausted.
2. Production decline for a typical shale well averages 70–90% over the first three years, with much of the decline in the first year. This means payback of well drilling costs must be achieved in the first few years, and that new wells must continually be drilled to maintain production.
3. Field declines, made up of older wells declining at lower rates and new wells declining at higher rates, typically average 20–40% per year, meaning that this much production must be replaced each year by new drilling to keep production flat.
4. Technology has made a big difference in well productivity over the past few years. This has been achieved through higher levels of water and proppant injection, and longer horizontal laterals. Average water use per foot of horizontal lateral has tripled since 2012, to nearly 50 barrels (2100 gallons per foot), and proppant use has also tripled, to nearly 2000 pounds per foot.⁸ This means a well with a 10,000 foot lateral (typical in the Bakken but normally somewhat less elsewhere) will use 21 million gallons of water and 20 million pounds of proppant. Some wells use even more, such as a well in the Haynesville of

³ The Economist, August 3, 2013, *The Father of Fracking*, <https://www.economist.com/news/business/21582482-few-businesspeople-have-done-much-change-world-george-mitchell-father>

⁴ Time, June 30, 2017, *President Trump Says He Wants 'Energy Dominance.' What Does He Mean?*, <http://time.com/4839884/energy-dominance-energy-independence-donald-trump/>

⁵ Bloomberg, November 17, 2017, *Shale King Hamm Wants to Give Oil Forecasters a Reality Check*, <https://www.bloomberg.com/news/articles/2017-11-16/shale-king-hamm-wants-to-give-oil-forecasters-a-reality-check>

⁶ J.B. Montgomery and F.M. O'Sullivan, *Spatial variability of tight oil well productivity and the impact of technology*, Applied Energy, 2017, <http://dx.doi.org/10.1016/j.apenergy.2017.03.038>

⁷ J.D. Hughes, *Drilling Deeper: A Reality Check on U.S. Government Forecasts for a Lasting Tight Oil & Shale Gas Boom* (Santa Rosa, CA: Post Carbon Institute, 2014); <http://shalebubble.org>.

⁸ C. Cross, November 14, 2017, *Completion Trends: Proppant and Fluid Concentrations on the Upswing Across All Basins*, <https://info.drillinginfo.com/completion-trends-proppant-and-fluid-concentrations-on-the-upswing-across-all-basins/>

Louisiana which used 50 million pounds of proppant in a horizontal lateral of nearly 10,000 feet, or 5,000 pounds per foot.⁹ An excellent review of water use in the Permian Basin reports that water use there can go as high as 124 barrels per foot (5208 gallons per foot).¹⁰ More aggressive technology, coupled with longer horizontal laterals, allows each well to drain more reservoir area, but reduces the number of drilling locations and therefore does not necessarily increase the total recovery from a play—it just allows the resource to be recovered more quickly at lower cost from fewer wells. Well locations in sweet spots are limited and placing wells too close together has resulted in well interference and lower per well recoveries, as documented by Rystad Energy in the Eagle Ford¹¹, and others in shale plays more generally.¹²

5. Although well quality as measured by initial productivity has risen due to more aggressive technology and the high-grading of sweet spots in most plays, it has plateaued in the top counties of some plays and is declining in others. This is a result of geological limits and the exhaustion of drilling locations which will ultimately be experienced in all plays.

EIA forecasts of oil production published in its *Annual Energy Outlook* (AEO) are viewed by industry and government as the best available assessment of what to expect in the longer term, with the EIA's reference case typically viewed as the most likely scenario for future production. This report assesses the viability of the EIA's *Annual Energy Outlook 2017* (AEO2017) reference case projections at the play level, using well production data from the Drillinginfo¹³ database (which is also a key input to EIA data collection). Plays are reviewed in terms of overall production, county-level production, well productivity trends, and well- and field-decline rates. EIA assumptions, including play area, drilling density and wells needed, are then assessed in the context of this data analysis to determine the credibility of EIA play-level production forecasts.

On average, EIA projections are highly to extremely optimistic when reviewed at the play level. These play-level forecasts are then aggregated by the EIA and presented in its AEO as an overall rosy outlook. As noted above, rosy forecasts discourage investment in alternative energy and the adoption of policies to reduce consumption—which would enhance long-term sustainability—and increases vulnerability to price shocks and supply disruptions.

⁹ World Oil, October 21, 2016, *Chesapeake declares 'propagedd' with record frac job*, <http://www.worldoil.com/news/2016/10/21/chesapeake-declares-propagedd-with-record-frac-job>

¹⁰ B. R. Scanlon et al., 2017, *Water Issues Related to Transitioning from Conventional to Unconventional Oil Production in the Permian Basin*, *Environ. Sci. Technol.*, 2017, 51 (18), pp 10903-10912

¹¹ Rystad Energy, December, 2017, *Empirical evidence for collapsing production rates in Eagle Ford*, <https://communications.rystadenergy.com/acton/rif/12327/s-04e3-1712/-/l-0044:4dab/q-005a/showPreparedMessage?sid=TV2:x1Eq3cVo4>

¹² T. Jacobs, November, 2017, *Frac Hits Reveal Well Spacing May be too Tight, Completion Volumes too large*, *Journal of Petroleum Technology*, http://www.slb.com/~media/Files/stimulation/industry_articles/201711-jpt-frac-hits-tight-spacing-large-completion-volumes.pdf

¹³ Drillinginfo, <https://info.drillinginfo.com/>

2. Tight Oil Plays

Figure 1 illustrates tight oil production from the seven major plays assessed in AEO2017, as well as “other” plays¹⁴, as of November 2017. Production from tight oil plays is at an all-time high, although the two largest plays—the Eagle Ford and the Bakken, which constituted 44% of tight oil production in November 2017—are down 30% and 8% from peak, respectively (the last two months are estimates; Drillinginfo data show the Bakken down 16% as of September 2017). Including “other” plays, 51% of tight oil production was down 19% from a March 2015 peak. The Permian Basin, which produced 39% of U.S. tight oil in November 2017, has been responsible for most of the growth in U.S. tight oil production. The Permian Basin has been producing oil and gas for nearly a century, but industry has proven adept at accessing unconventional resources in the basin.

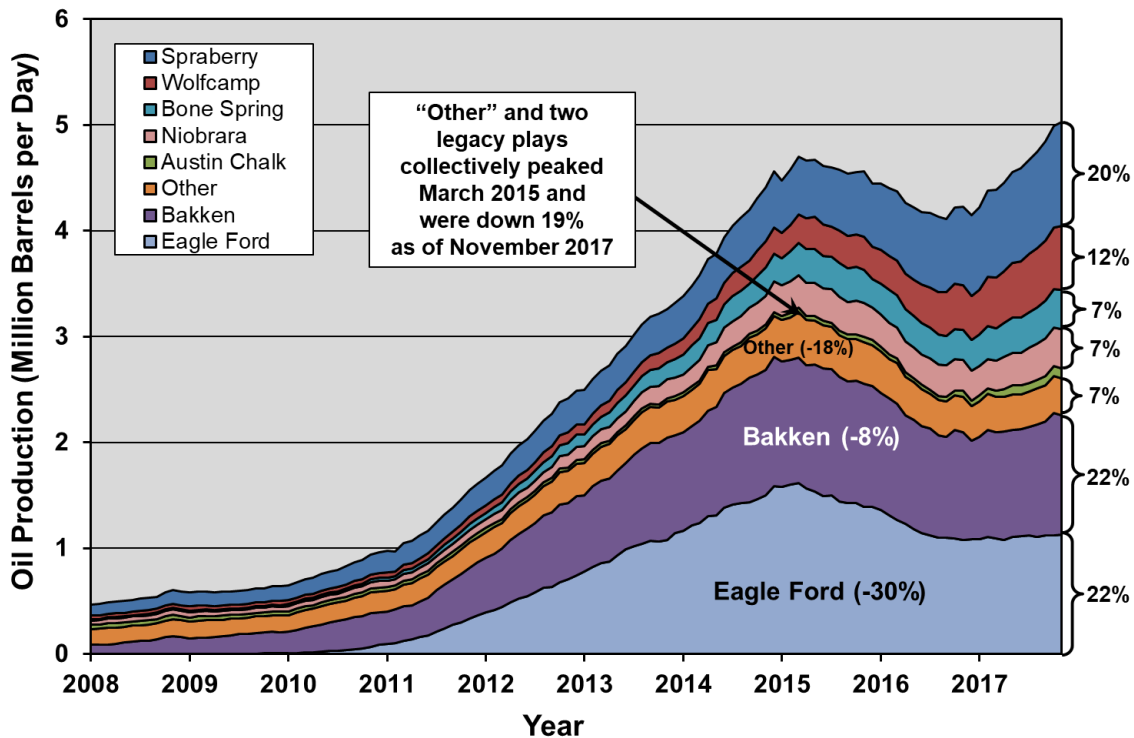


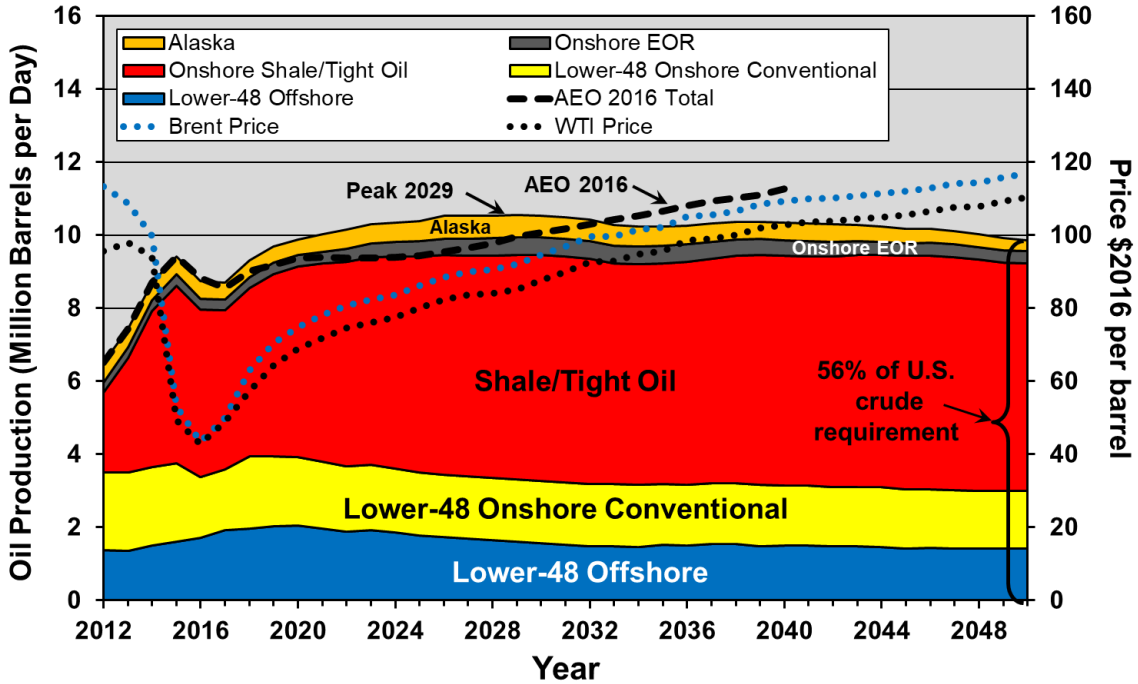
Figure 1. U.S. tight oil production by play, 2008 through November 2017¹⁵

Note the last two months are estimated. The Spraberry, Wolfcamp, and Bone Spring lie within the Permian Basin.

¹⁴ “Other” plays include the Monterey, Granite Wash, Yeso, Glorieta, Delaware, and liquids from mainly gas plays including the Woodford, Haynesville, Marcellus and Utica.

¹⁵ EIA, December, 2017, *How Much Tight Oil is Produced in the U.S.?*, <https://www.eia.gov/energyexplained/data/U.S.%20tight%20oil%20production.xlsx>

Figure 2 illustrates the AEO2017 reference case for U.S. oil production by source with price projections. Tight oil constitutes by far the largest source of supply overall, and is forecast to make up 63% of 2050 production. Production from other major sources, such as onshore and offshore conventional oil, is projected to decline, while overall U.S. production is projected to grow to an all-time high of 10.5 million barrels per day (mbd) in 2029. Prices are projected to remain below \$100/barrel until 2031, and 2050 production is projected to meet 56% of projected crude oil demand—meaning that despite the aggressive production growth forecast for tight oil, the U.S. will remain a large net importer of oil.

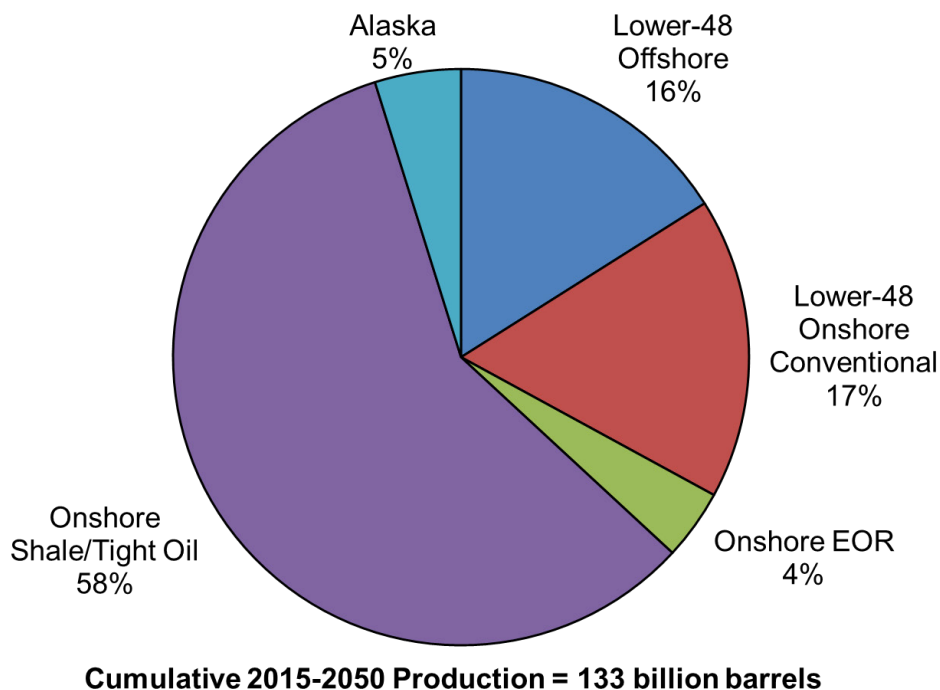


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(data from EIA Annual Energy Outlook 2017)

Figure 2. EIA AEO2017 reference case forecast of oil production by source, 2012–2050. Also shown is projected price (West Texas Intermediate and Brent in 2016 dollars per barrel).

The importance of tight oil in the EIA's reference forecast is illustrated in Figure 3. Tight oil is projected to provide 58% of total crude oil production of 133 billion barrels over the 2015–2050 period. That is more than triple proven U.S. crude oil reserves of 35.2 billion barrels at year-end 2015¹⁶, and half of U.S. proven reserves plus unproven resources.¹⁷ The tight oil portion is forecast to recover 6.7 times proven U.S. tight oil reserves and 76% of proven reserves plus unproven technically recoverable resources. This is an extremely aggressive forecast and is based on some tenuous assumptions, as will be shown in the following play-by-play review of major tight oil plays.



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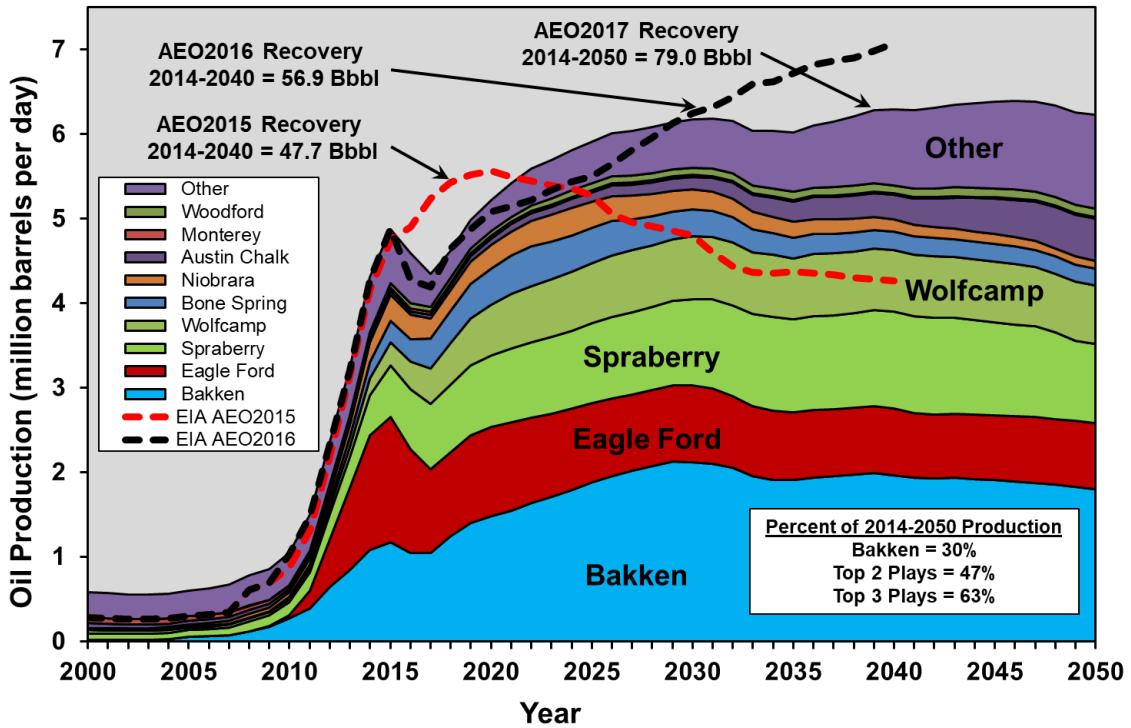
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(data from EIA Annual Energy Outlook 2017)

Figure 3. EIA AE02017 reference case forecast of cumulative oil production by source, 2015–2050.

¹⁶ EIA, Table 1. U.S. proved reserves, and reserves changes, 2014-15, <https://www.eia.gov/naturalgas/crudeoilreserves/>.

¹⁷ EIA, Assumptions to the Annual Energy Outlook 2017, <https://www.eia.gov/outlooks/aeo/assumptions/>

The EIA's reference case AEO2017 forecast by play is illustrated in Figure 4. Tight oil is not expected to peak until 2046, and to produce 79 billion barrels of oil by 2050, when production is projected to be considerably higher than today. The Bakken is forecast to produce 30% of 2014–2050 tight oil production and the Bakken, Eagle Ford, and the Permian Basin's Spraberry play to collectively produce 63%.

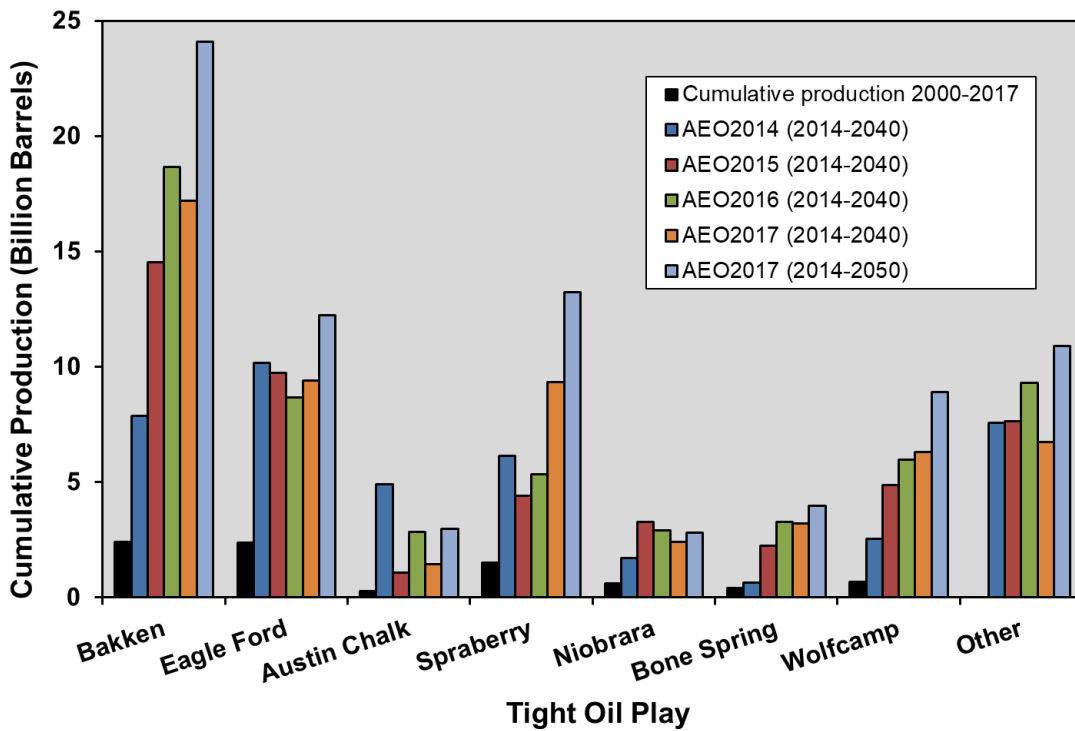


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(data from EIA AEO2015, AEO2016 and AEO2017)

Figure 4. U.S. tight oil production by play in EIA AEO2017 projection compared to AEO2015 and AEO2016.

The changes in EIA AEO production projections by play from 2014 to 2017 are illustrated in Figure 5. In general, these forecasts have become more optimistic from year to year, with the most aggressive increases occurring in the Bakken and Eagle Ford, as well as the Permian Basin plays including the Bone Spring, Wolfcamp, and Spraberry.



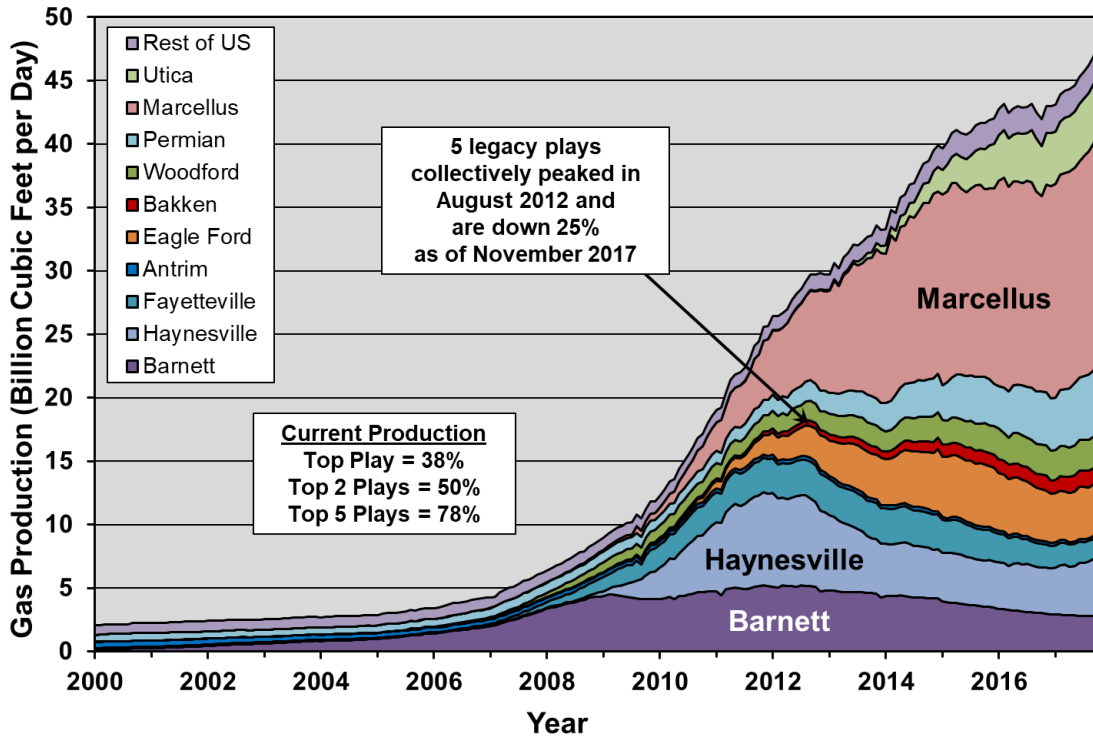
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(data from EIA August 2017 (cumulative production) and AEO2014, AEO2015, AEO2016 and AEO2017)

Figure 5. Cumulative oil production projections by play for 2015–2040 and 2015–2050 in the AEO2017 reference case compared to AEO2014, AEO2015, and AEO2016.

3. Shale Gas Plays

Figure 73 illustrates shale gas production from major plays assessed in AEO2017, as well as “other” plays, as of November 2017. Production of shale gas is at an all-time high, although production from five legacy plays—including the Barnett, where shale gas was first successfully produced, and the Haynesville, which was once the largest shale gas play in the U.S.—peaked in August 2012 and has since fallen by 25%. The Marcellus and Utica plays of Pennsylvania, Ohio, and West Virginia, along with associated gas from the Permian Basin, have dominated production growth in recent years, and currently provide 60% of shale gas production.



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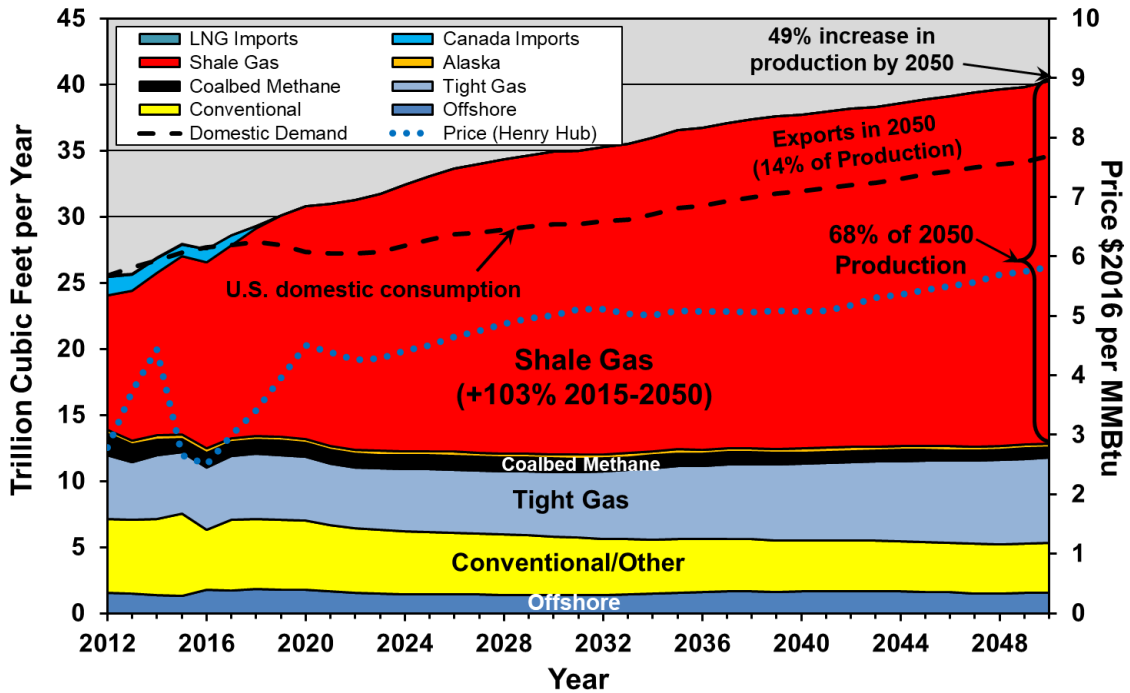
(data from EIA Natural Gas Weekly Update, January, 2018)

Figure 73. U.S. shale gas production by play, 2008 through November 2017

Note the last two months are estimated.⁵⁶

⁵⁶ EIA, January 2018, *Natural Gas Weekly Update*, <https://www.eia.gov/naturalgas/weekly/>

Figure 74 illustrates the AEO2017 reference case for U.S. gas production by source with price projections. Shale gas production is expected to double and constitutes by far the largest source of supply overall, making up 68% of 2050 production. Production from other major sources, such as onshore and offshore conventional gas, with the exception of tight gas (the recovery of which is improved by fracking technology), is projected to decline. Overall U.S. production is projected to grow by 49% to an all-time high of 40.3 trillion cubic feet per year (tcf/year), or 110.3 billion cubic feet per day (bcf/day), in 2050. Exports via LNG to international markets and by pipeline to Canada and Mexico are projected to account for 14% of production in 2050. Prices are projected to remain below \$6/MMBtu until 2032.



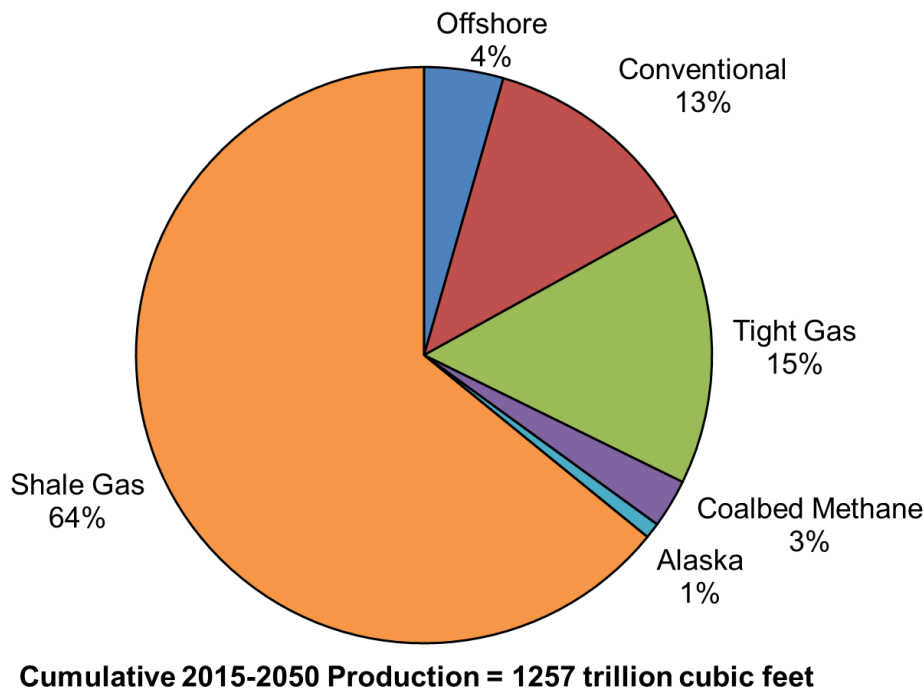
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(data from EIA Annual Energy Outlook 2017)

Figure 74. EIA AEO2017 reference case forecast of gas production by source, 2012–2050.

Also shown is projected price (Henry Hub in 2016 dollars per barrel).

The importance of shale gas in the EIA's reference forecast is illustrated in Figure 75. Shale gas is projected to provide 64% of total natural gas production of 1,257 trillion cubic feet (tcf) over the 2015–2050 period. Production through 2050 is projected to be nearly quadruple proven U.S. natural reserves of 323 tcf at year-end 2015⁵⁷, and half of U.S. proven reserves plus unproven resources.⁵⁸ The shale gas portion is forecast to recover 4.6 times proven U.S. shale gas reserves and 81% of proven reserves plus unproven resources.⁵⁹ This is an extremely aggressive forecast and is based on some tenuous assumptions, as will be shown in the following play-by-play review of major shale gas plays.



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(data from EIA Annual Energy Outlook 2017)

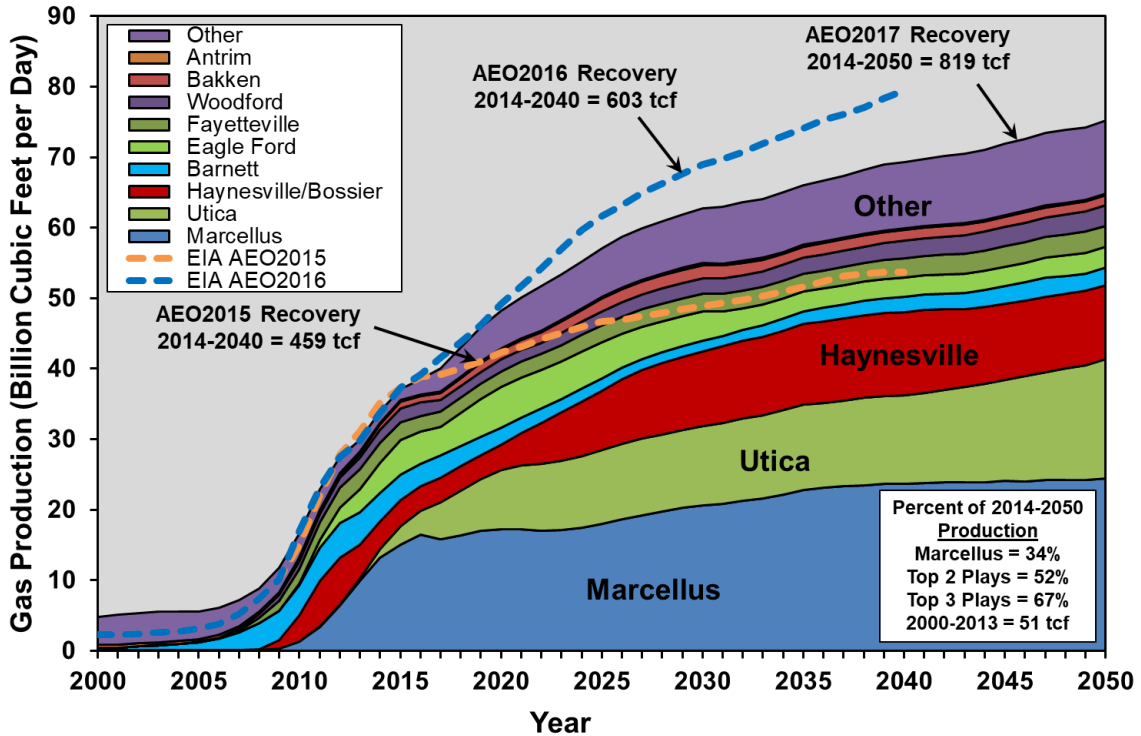
Figure 75. EIA AE02017 reference case forecast of cumulative natural gas production by source, 2015–2050.

⁵⁷ EIA, Table 1. U.S. proved reserves, and reserves changes, 2014-15, <https://www.eia.gov/naturalgas/crudeoilreserves/>.

⁵⁸ EIA, Assumptions to the Annual Energy Outlook 2017, <https://www.eia.gov/outlooks/aeo/assumptions/>, unproven resources were 1,986 tcf as of January 1, 2015.

⁵⁹ EIA, shale gas proven reserves were 175.6 tcf at year-end 2015, <https://www.eia.gov/naturalgas/crudeoilreserves/>, and unproven resources were 825.2 tcf as of January 1, 2015, <https://www.eia.gov/outlooks/aeo/assumptions/>

The EIA's reference case AEO2017 shale gas production forecast by play is illustrated in Figure 76. Production is projected to grow continuously, exiting 2050 at levels of nearly double current shale gas production, suggesting vast additional resources are available for recovery after 2050. The majority of production is forecast to be confined to relatively few plays, however, with two-thirds of the total 2014–2050 recovery of 819 tcf coming from three plays: the Marcellus, Utica, and Haynesville. The Marcellus alone is expected to account for 34% of production.

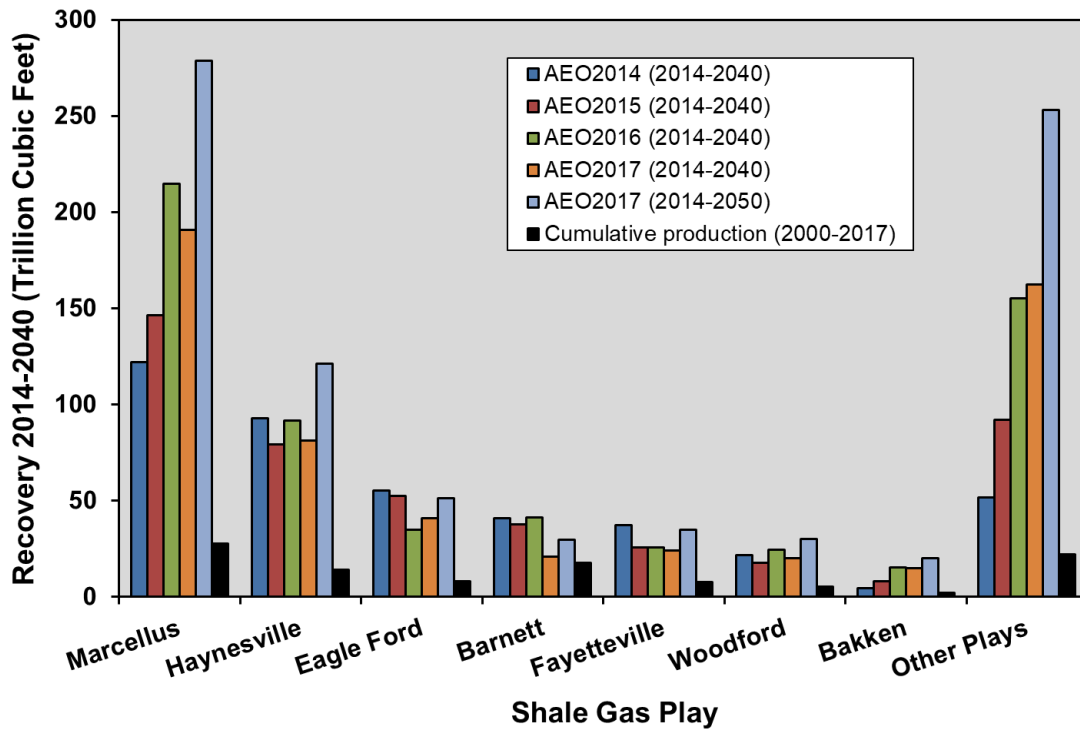


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(data from EIA AEO2015, AEO2016 and AEO2017)

Figure 76. U.S. shale gas production by play in the EIA AEO2017 reference case projection compared to AEO2015 and AEO2016.

The changes in EIA AEO reference case production projections over the past four years are illustrated in Figure 77 compared to cumulative production to date.



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(Historic production from EIA; EIA AEO2014, AEO2015, AEO2016 and AEO2017)

Figure 77. Cumulative shale gas production projections by play for 2015–2050 in the AEO2017 reference case compared to AEO2014, AEO2015, and AEO2016.

5. Summary and Implications

Shale gas and tight oil from low permeability reservoirs have provided a new lease on life for U.S. oil and gas production. Tight oil has allowed U.S. oil production to double from its 2005 lows, and shale gas has similarly allowed a major increase in U.S. gas production. However, the nature of these reservoirs is that they decline quickly, such that production from individual wells falls 70-90% in the first three years, and field declines without new drilling typically range 20-40% per year. Continual investment in new drilling is therefore required to avoid steep production declines. Older fields like the Barnett, where drilling has nearly ceased, are in terminal decline. Shale plays also exhibit variable reservoir quality, with “sweet spots” or “core areas” containing the highest quality reservoir rock typically comprising 20% or less of overall play area. In the post-2014 era of low oil prices drilling has focused on sweet spots which provide the most economically viable wells.

This review of well-level production data for major US shale plays reveals that EIA projections of production through 2050 at the play-level are highly to extremely optimistic, and are therefore highly unlikely to be realized. EIA play forecasts count on recovering all proven reserves and a high percentage of unproven resources—in some cases over 100%—by 2050. Furthermore, most of these play-level projections assume that production will exit 2050 at high levels compared to current rates, implying that there are vast additional resources to be recovered beyond 2050.

The analysis considered drillable play area, well- and field-decline rates, change in average well productivity over time, well density, and recent production history. It contrasted these play fundamentals with the EIA AEO2017 reference case projections for each play. Key findings include:

- Well productivity
 - o Better technology—including longer horizontal laterals, a tripling of water and proppant injection since 2012, and more fracking stages—has resulted in increased average well productivity in most plays.
 - o A significant portion of the increased average well productivity is a result of “high-grading” sweet spots: focusing drilling on the highest quality reservoir rocks (which form a relatively small portion of most plays).
 - o Average well productivity in some counties and plays has declined in 2017, indicating technology there has reached the point of diminishing returns. This is a result of drilling outside of sweet spots and/or drilling wells too close together, resulting in “frac hits” and well interference.
- Tight oil plays
 - o The Permian Basin plays are the main driver for tight oil production growth. In Permian plays such as the Wolfcamp and Spraberry production is increasing rapidly, although Bone Spring production has flat-lined recently. EIA estimates for production through 2050 for these plays are rated as highly to extremely optimistic.
 - o Production in older tight oil plays like the Bakken and Eagle Ford, which were among the first tight oil plays developed, is down substantially from peak. EIA projections for these and other tight oil plays, including the Niobrara and Austin Chalk, are rated as highly to extremely optimistic.
- Shale gas plays
 - o The Appalachian plays are the main driver for shale gas production growth - the Marcellus and Utica now account for 48% of U.S. shale gas production. EIA forecasts for the Marcellus and Utica, which project these will provide 52% of cumulative production of U.S. shale gas through 2050, are rated as extremely optimistic.

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- All plays
 - The EIA AEO2017 reference case projects that 1.29 million wells will be drilled to recover oil and gas from both conventional and unconventional reservoirs in the period 2015–2050. At \$6 million per well, this amounts to \$7.7 trillion. Shale plays reviewed herein, which account for 88% of the EIA’s estimated shale oil and gas production through 2050, would require 1.04 million wells using EIA assumptions—an estimated cost of \$5.7 trillion. Recovering the remaining 12% of shale resources would require an additional .68 million wells at a cost of \$4.1 trillion. Given the EIA’s overestimates of future shale production and recoverable resources, it is unlikely that all of these wells will be drilled.

There is no doubt that the U.S. can produce substantial amounts of shale gas and tight oil over the short- and medium-term. Unrealistic long-term forecasts, however, are a disservice to planning a viable long-term energy strategy. The high to extremely optimistic EIA AEO2017 projections impart an unjustified level of comfort for long-term energy sustainability. As sweet spots are exhausted, the reality is likely to be much higher costs and higher drilling rates to maintain production and/or stem declines.

The “shale revolution” has provided a reprieve from what just 13 years ago was thought to be a terminal decline in oil and gas production in the U.S. It has sparked calls for “American energy dominance”¹⁰⁷ – despite the fact that the U.S. is projected to be a net oil importer through 2050, even given EIA forecasts. This reprieve is temporary, and the U.S. would be well advised to plan for much reduced shale oil and gas production in the long term based on this analysis of play fundamentals.

¹⁰⁷ Time, June 29, 2017, *President Trump Says He Wants 'Energy Dominance.' What Does He Mean?* <http://time.com/4839884/energy-dominance-energy-independence-donald-trump/>