



WHITE PAPER

# Oklahoma: A Major Player for Future Hydrocarbon Production

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## Bottom Line

1. Despite sharp drilling activity declines over the past year in most areas of the country, Oklahoma oil and gas production has been increasing, driven by the Anadarko Basin.
2. Although much of the state's liquids (crude and condensate) production growth since 2005 has been from the Mississippian Lime play, activity there has dropped sharply and is being replaced by other increasing Anadarko Basin production.
3. Most of the recent high estimated ultimate recovery (EUR) Oklahoma wells have been completed in wet gas windows of shale plays in the Anadarko Basin, primarily in the Cana and South Central Oklahoma Oil Province (SCOOP) plays.
4. Improved completion practices and a focus on sweet spots have resulted in large increases in EUR per well. Well economics in several areas of the Anadarko are competitive with the best U.S. tight oil plays.
5. However, only a small part of the overall Oklahoma tight oil resource is economic at less than \$50 per barrel oil prices, suggesting a potential for substantially increased activity when oil prices increase.

## Introduction

While U.S. tight oil production growth has been dominated by Bakken, Permian Basin, and Eagle Ford, and shale natural gas production growth has been dominated by the Marcellus and Utica plays, Oklahoma—location of numerous other active plays—has experienced large oil and gas production increases as well. Since 2005, liquids production in the state has doubled and gas production has increased by 50 percent, driven by large tight oil and shale gas plays.

Recent development of unconventional oil and gas in the state has only begun to prove up the assessed resource base, which is estimated to be 17 billion barrels and 278 Tcf of recoverable oil and gas, respectively. While activity in dry gas areas of the state has declined, liquids activity elsewhere has thrived, driven primarily by the Woodford Shale and Mississippian plays in the Anadarko Basin.

## Unconventional Drilling and Production

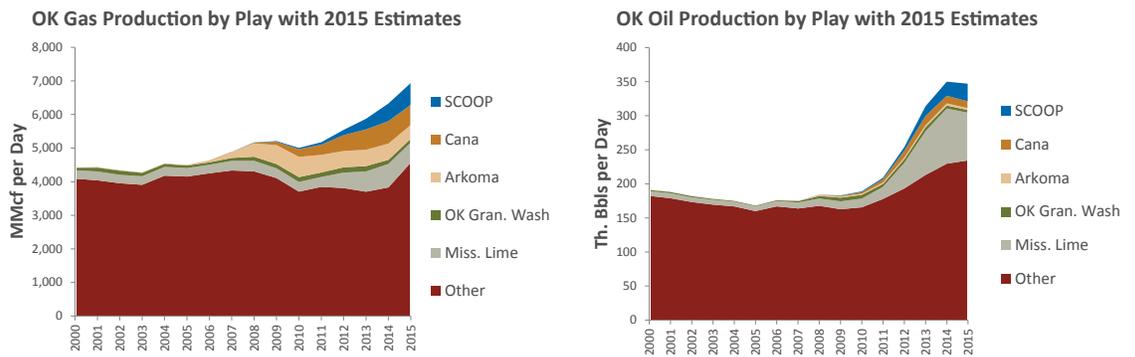
Operators have achieved success with both shale gas and tight oil in Oklahoma. On the gas side, the Arkoma Basin Woodford dry gas play in southeast Oklahoma was the first large-scale horizontal play in the state. While Arkoma Woodford drilling activity has slowed to just a few rigs due to lack of liquids, it is still the largest shale gas producing play in the state. Another early play was at Cana Woodford in the Anadarko Basin. It continues to be successful and is the location of approximately 18 rigs that primarily target wet gas and liquids (crude and condensate).



The other three significant plays discussed here are the Woodford SCOOP play (21 rigs), the Granite Wash play (12 Oklahoma rigs plus the Texas portion), and the Mississippian Lime (20 rigs) tight oil play.<sup>1</sup> The Anadarko STACK<sup>2</sup> play with multiple objectives (that is, several potential producing formations) is also increasing in activity.

The charts in Exhibit 1 show the impact of these plays on state production. The data source is an ICF analysis of commercial oil and gas data with state-level totals from the U.S. Energy Information Administration (EIA), current state agency data, and estimated totals for 2015. On the gas production side, the Cana, SCOOP, and Mississippian Lime plays are most significant, while liquids growth is dominated by SCOOP and the Mississippian Lime. The oil increase in the “other” category represents a mix of additional formations, primarily located in the Anadarko Basin.

**Exhibit 1. Trends in Oklahoma Oil and Gas Production**



Source: ICF estimates developed from Drilling Info’s HPDI database and state total production data from EIA through June, 2015.

### Abundant Untapped Resources

ICF’s estimates of the undeveloped unconventional resource base indicate that development of these plays has only begun to scratch the surface of what is potentially available. The table in Exhibit 2 shows that the five plays contain an ICF-assessed technically recoverable resource base of 17 billion barrels of liquids and 278 Tcf of gas. This liquids volume equates to about 14 percent of Lower-48 assessed recoverable tight oil. The gas resources for the SCOOP and Mississippian Lime tight oil plays alone account for more than 30 percent of the Lower-48 tight oil play gas resource base. Exhibit 2 also shows the amount of resource that has been drilled to date (EUR in existing wells). For gas, only 8 Tcf out of 278 Tcf (3 percent) represents EUR from existing producing wells. For liquids, about 320 million barrels (2 percent) of the technically recoverable potential has been established in producing wells.

The ICF play assessment above employs a method utilizing commercial well-level oil and gas production data.<sup>3</sup> The concept leverages our extensive analysis of well-level EURs using monthly data to create a section-by-section resource assessment that reflects actual well recoveries.<sup>4</sup> Technically recoverable resources are the oil and gas volumes that could be recovered at remaining undrilled risked-adjusted well spots in the play using current drilling practices but not limited by the selling price for that oil and gas.

<sup>1</sup> Baker Hughes website with ICF estimates [www.bakerhughes.com](http://www.bakerhughes.com)

<sup>2</sup>“STACK” is an abbreviation for Sooner Trend (oil field), Anadarko (basin), Canadian and Kingfisher (counties).

<sup>3</sup> The data source is Drilling Info’s HPDI commercial oil and gas well database through early 2015.

<sup>4</sup> A section is a one-square-mile area as defined here by geographic information systems (GIS) methods.



### Exhibit 2. ICF Resources and EUR Established by Producing Wells

Play	Tight Oil	Shale Gas	Tight Sands	Assessed Resources		Drilled EUR (OK) *		% of Resource Drilled	
				Liquids B - Bbl	Gas Tcf	Liquids B - Bbl	Gas Tcf	Liquids	Gas
Woodford SCOOP	X	X		3.4	92.2	0.1	1.5	1.5%	1.6%
Woodford Cana		X		2.6	62.6	0.0	2.4	1.5%	3.8%
Granite Wash			X	1.9	44.8	0.0	0.4	1.1%	0.9%
Mississippi Lime	X			8.1	43.1	0.2	1.5	2.5%	3.5%
Arkoma Woodford		X		0.5	35.2	0.0	2.5	2.2%	7.1%
<b>Total</b>				<b>16.6</b>	<b>277.9</b>	<b>0.3</b>	<b>8.3</b>	<b>1.9%</b>	<b>3.0%</b>

Source: ICF analysis of commercial well data and ICF resource assessments.

The assessment incorporates the average EUR per well, as evaluated by ICF, to estimate the averages for sections with existing wells. It also assigns an estimated ultimate recovery to undrilled sections that are sufficiently close to wells in the play. In addition, the method uses GIS to take into account the number of remaining undrilled well spots to determine the inventory of remaining wells given an assumed well spacing.

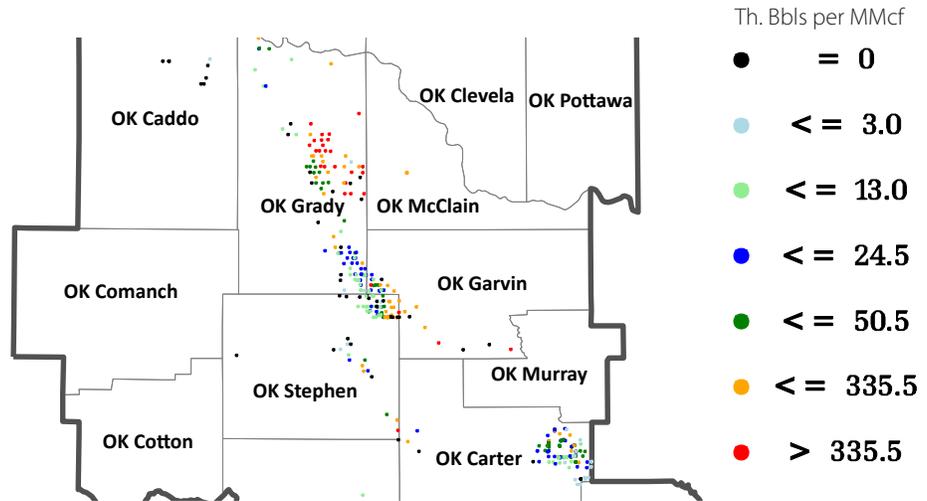
#### Woodford SCOOP Play Surge

The SCOOP in the Woodford Shale, located in the eastern Anadarko Basin in western Oklahoma, has seen the completion of numerous high-volume horizontal wet gas and oil wells. Production exceeds 700 MMcf of natural gas and 25,000 barrels of crude/condensate per day. Operators include Continental Resources, Marathon, and Newfield. Continental has the largest acreage position and the most production and has recently focused on a wet gas area near the center of the play. SCOOP has oil, condensate, and dry gas windows, as is the case with the Eagle Ford. Most of the highest EUR wells (boe basis adding together natural gas and crude/condensate) have been in the condensate window.

Using commercial well-level data, ICF evaluated liquids-to-gas ratios, EUR per well, and initial production rates. Exhibit 3 is a map showing the liquids-to-gas ratio categories for individual wells in the SCOOP play. The highest liquids-to-gas ratios on the map (shown as red well spots) represent more than 335 barrels of liquids or more per MMcf of gas, which are oil wells. The map shows that most of the wells to date are in the wet gas window, and there is one main area (Grady County) of horizontal oil well development, shown with red well spots.



**Exhibit 3. ICF Map of SCOOP Liquid to Gas Ratios - Western OK**



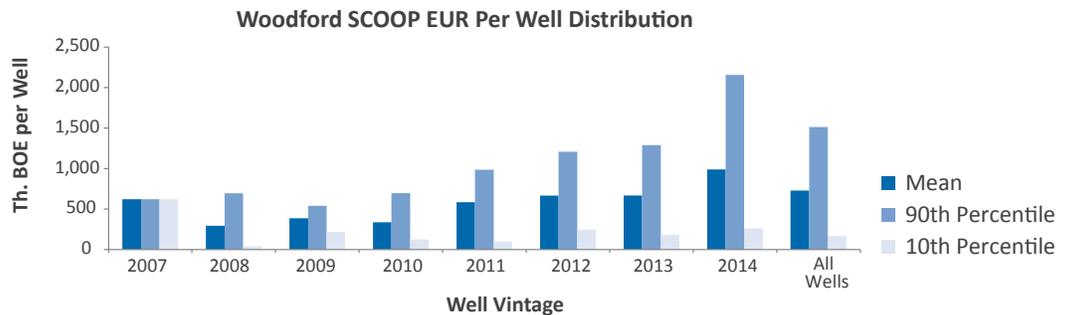
Source: ICF analysis of monthly commercial well data through 2014.

### Recovery per Well Trends and Impacts

In many of the best U.S. unconventional oil and gas plays, ultimate recoveries have continued to increase with each new vintage (completion year) of wells in recent years. An example is shown in Exhibit 4, which shows SCOOP well recoveries by vintage. As seen, mean well recoveries have increased from the 500,000 boe range to 750,000 or more since 2011. Generally, a tight oil recovery of 500,000 boe or more is considered very good. Of interest also is the large increase in the “90th percentile” of SCOOP ultimate recoveries, which has increased to 1.3 mmboe or more. This increased EUR per well is due to a combination of focusing on the best areas of the play and improved completion practices.

While SCOOP remains active, Mississippian Lime drilling activity has plunged since 2014, exhibiting one of the steepest declines of all tight oil plays since the 2014 oil price decline. Analysis of Mississippian Lime well recovery indicates EURs in the 300,000 boe range. Although well depths are relatively shallow, it is apparent that sub-\$50 oil does not support economic development of the play, with the exception of a few areas.

**Exhibit 4. Trends in SCOOP Recovery per Well**



Source: ICF analysis of monthly commercial well data through 2014.



## Modeling of Drilling Economics

In addition to evaluating ultimate recovery, ICF estimates the resource cost distribution of each play. The “resource cost” is the wellhead price, typically on a dollar-per-MMBtu or dollar-per-barrel basis, that is needed to meet a specified rate of return. Factors influencing wellhead production economics include EUR; vertical depth; lateral length; number of stimulation stages; drilling costs; completion costs; production decline parameters; mix of gas, oil, and NGL production; rate of return requirement; taxes and royalties; and the future oil, natural gas, and NGL prices.

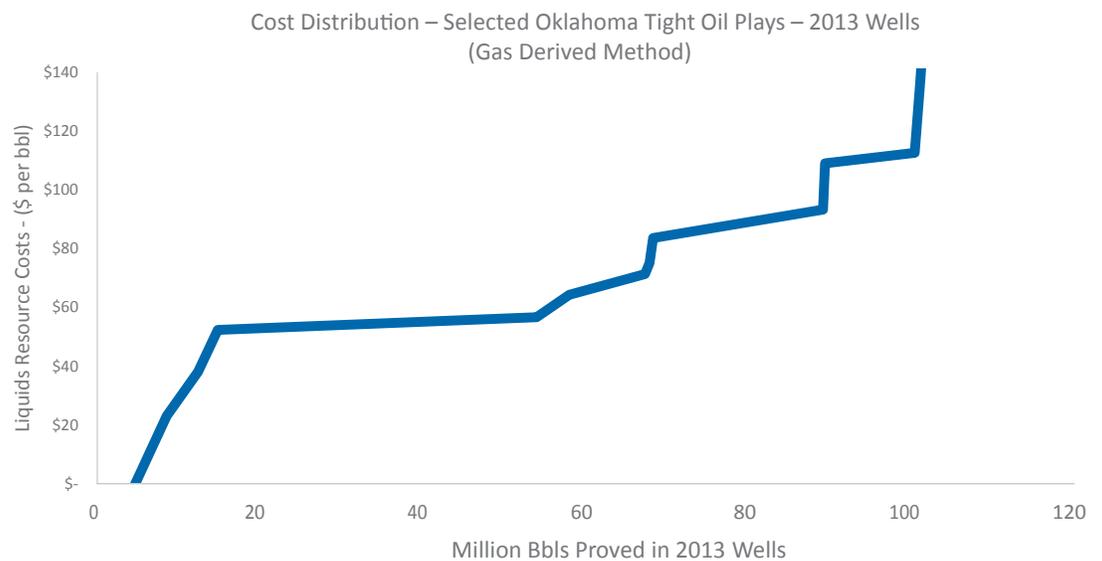
For each ICF play, resource economics are used to develop a cost-of-supply curve, indicating how much of the play is economic at a particular wellhead price.

Exhibit 5 shows the results of the resource cost analysis for combined historic drilling in the Granite Wash, Cana, SCOOP, and Mississippian Lime plays. The curve shows the reserve additions associated with 2013 wells. The year 2013 was selected because these wells have a significant amount of historical monthly production information from which reliable EUR estimates can be made. The chart shows that approximately 100 million barrels were proved in 2013, and about 50 million barrels are characterized with resource costs of below \$60 per barrel. Only about 10 percent of the resource was economic at \$50 per barrel.

## Midstream

A great deal of SCOOP and STACK oil and gas midstream activity has recently occurred or is planned over the next year. Major midstream players in the Anadarko include Oneok, Enable Midstream, Southern Star, Tall Oak, Enbridge, and Kinder Morgan. Enable Midstream Partners is a leading midstream provider in the Anadarko, and it expects SCOOP production to double in 10 years. Southern Star and NextEra recently announced the planned 1.2 bcf/d Sooner Trails Pipeline from the Cana area southeastward to Bennington, Oklahoma, near the border with Texas.

**Exhibit 5. Cost Curve for Oklahoma Tight Oil 2013 Reserve Additions**



Source: Commercial well data, ICF reserve analysis, and ICF discounted cash flow model.



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### Production Outlook

The state of Oklahoma has contributed to the run up in U.S. oil and gas production and is well positioned both geographically and geologically to play a large role in future production and oil and gas exports. The Anadarko Basin of western Oklahoma is particularly well positioned due to its liquids content and the presence of high-rate wells. Continued robust activity in the Cana and SCOOP plays, despite low product prices, is an indication of the quality of the sweet spots and economics of those plays. Increased gas-directed drilling in the Arkoma and Granite Wash will likely require sustained prices of \$4 to \$5 per MMcf. From a resource perspective, tremendous volumes are available within both wet and dry areas and reasonable drilling depths. These resources could support substantial future drilling and production activity in the future, given adequate oil and gas pricing.

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