BAKKEN REALITY CHECK

THE NATION’S NUMBER TWO TIGHT OIL PLAY
AFTER A YEAR OF LOW OIL PRICES

J. DAVID HUGHES
post carbon institute
FALL 2015
Bakken Reality Check

The Nation’s Number Two Tight Oil Play After A Year Of Low Oil Prices

J. David Hughes
Fall 2015
About the Author

David Hughes is an earth scientist who has studied the energy resources of Canada for four decades, including 32 years with the Geological Survey of Canada as a scientist and research manager. He developed the National Coal Inventory to determine the availability and environmental constraints associated with Canada’s coal resources. As Team Leader for Unconventional Gas on the Canadian Gas Potential Committee, he coordinated the publication of a comprehensive assessment of Canada’s unconventional natural gas potential.

Over the past decade, Hughes has researched, published and lectured widely on global energy and sustainability issues in North America and internationally. His work with Post Carbon Institute includes: a series of papers (2011) on the challenges of natural gas being a "bridge fuel" from coal to renewables; *Drill, Baby, Drill* (2013), which took a far-ranging look at the prospects for various unconventional fuels in the United States; *Drilling California* (2013), which critically examined the U.S. Energy Information Administration’s (EIA) estimates of technically recoverable tight oil in the Monterey Shale, which the EIA claimed constituted two-thirds of U.S. tight oil (the EIA subsequently wrote down its resource estimate for the Monterey by 96%); *Drilling Deeper* (2014), which challenged the U.S. Department of Energy’s expectation of long-term domestic oil and natural gas abundance with an in-depth assessment of all drilling and production data from the major shale plays through mid-2014; and *Shale Gas Reality Check* (2015) and *Tight Oil Reality Check* (2015), updates to *Drilling Deeper*. Separately from Post Carbon, Hughes authored *BC LNG: A Reality Check* in 2014 and *A Clear View of BC LNG* in 2015, which examined the issues surrounding a proposed massive scale-up of shale gas production in British Columbia for LNG export.

Hughes is president of Global Sustainability Research, a consultancy dedicated to research on energy and sustainability issues. He is also a board member of Physicians, Scientists & Engineers for Healthy Energy (PSE Healthy Energy) and is a Fellow of Post Carbon Institute. Hughes contributed to *Carbon Shift*, an anthology edited by Thomas Homer-Dixon on the twin issues of peak energy and climate change, and his work has been featured in *Nature, Canadian Business, Bloomberg, USA Today*, as well as other popular press, radio, and television.

About Post Carbon Institute

Post Carbon Institute’s mission is to lead the transition to a more resilient, equitable, and sustainable world by providing individuals and communities with the resources needed to understand and respond to the interrelated environmental, energy, economic, and equity crises of the 21st century.

---

*Bakken Reality Check: The Nation’s Number Two Tight Oil Play After A Year Of Low Oil Prices*

By J. David Hughes

In association with Post Carbon Institute

Copyright © 2015 by J. David Hughes. All rights reserved. Published October 2015.

For reprint requests and other inquiries, contact:
Post Carbon Institute, 613 Fourth St., Suite 208, Santa Rosa, California, 95404

Cover image (cc-by-nd) National Parks Conservation Association.
CONTENTS

1 Bakken Production Overview ......................................................................................................................... 1
2 Dominance of Sweet Spots ............................................................................................................................ 7
3 Technology Improvement Meets Geology ................................................................................................... 10
4 Future Outlook .............................................................................................................................................. 12
5 Summary and Implications .......................................................................................................................... 14
6 Appendix: Well Addition Rate Versus Production Change and Total Production by County ............... 15

FIGURES

Figure 1. Oil production in the Bakken Play from 2003 through June 2015. ...................................................... 1
Figure 2. Cumulative oil and gas production in the Bakken Play by county through July 2015. ....................... 2
Figure 3. Bakken Play oil production by county from 2006 through June 2015. .............................................. 3
Figure 4. Oil production in individual counties from 2006 through June, 2015. .............................................. 4
Figure 5. Bakken Play oil production change per month versus new producing wells added per month from 2006 through June 2015. .............................................................................. 5
Figure 6. Average production of Bakken wells by county from 2010 through June 2015. ............................... 6
Figure 7. Distribution and initial oil production (highest month) of wells in the Bakken Play of North Dakota and Montana as of June 2014. ...................................................................................... 7
Figure 8. Type well decline curves by county for the Bakken Play using data to year-end 2014. ....................... 8
Figure 9. Estimated ultimate oil recovery (EUR) by county in the Bakken Play. .............................................. 9
Figure 10. Average production rate of Bakken wells by county over the first six-months of production ........ 10
Figure 11. Historical production from the Bakken Play using Drillinginfo and EIA Drilling Productivity Report (DPR) data. .................................................................................................................. 12
Figure 12. Dunn County oil production change per month versus new producing wells added per month from 2006 through June, 2015. ............................................................................... 15
Figure 13. McKenzie County oil production change per month versus new producing wells added per month from 2006 through June, 2015. .............................................................................. 16
Figure 14. Mountrail County oil production change per month versus new producing wells added per month from 2006 through June, 2015. ............................................................................... 16
Figure 15. Williams County oil production change per month versus new producing wells added per month from 2006 through June, 2015. ............................................................................... 17
Figure 16. Other 11 counties oil production change per month versus new producing wells added per month from 2006 through June, 2015. ............................................................................... 17
1 Bakken Production Overview

Oil production in the Bakken Play of North Dakota and Montana, the birthplace of tight (shale) oil and the number two tight oil play in the U.S., is now falling after more than a year of low oil prices—but it has proven more resilient than many observers expected. This paper reviews the latest developments in the Bakken Play and provides an update of the assessment in my Drilling Deeper report,1 which was published in October 2014 just as the turmoil in the oil markets began.

Figure 1 illustrates Bakken production through June 2015. Production peaked in December 2014, at 1.21 million barrels per day (mbd) and has fallen 68,000 barrels per day, or 5.5%, since then. As of June there were 10,886 producing wells in the play, compared to 10,025 in December 2014 (production data in this paper are from Drillinginfo).

![Figure 1. Oil production in the Bakken Play from 2003 through June 2015. Also shown is the cumulative number of producing wells.](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAEwAAAAHCAIAAAAD6gaAAAAAXN0b3joMTU4CQAAAAAElFTkSuQmCC)

---

More than 80% of the Bakken’s cumulative production has come from four counties in North Dakota: Mountrail, McKenzie, Dunn, and Williams (Figure 2). Half of the balance came from the Elm Coulee Field in Richland County of Montana, where Bakken production first got underway in the early 2000s, and the remainder has come from ten other counties in North Dakota and Montana.

Figure 2. Cumulative oil and gas production in the Bakken Play by county through July 2015.

Natural gas production is expressed in “barrels of oil equivalent” at a conversion rate of 6,000 cubic feet of gas to one barrel of oil.
The trend in the concentration of production within top counties has continued. As of June 2015, 35% of production came from one county, McKenzie, and 89% of production came from the top four counties (Figure 3).

![Figure 3. Bakken Play oil production by county from 2006 through June 2015.](image)
Figure 4 illustrates, however, that the bulk of the production decline has come from the top two counties, McKenzie and Mountrail, with lesser declines in Dunn and other counties and flat production in Williams County. This is counterintuitive as conventional wisdom suggests that companies are focusing drilling efforts on their best acreage, which is in the top counties, and withdrawing from marginal parts of the play in order to maximize economics in a low oil price environment.

The drop in rig count, from 198 in October 2014 to 68 today (September 2015), should by now, in theory, have resulted in a precipitous collapse in the rate of addition of new producing wells. This has been muted, however, owing to the completion of wells drilled earlier (termed DUCs: drilled but uncompleted wells), and to greater efficiencies allowing more wells to be drilled by a single rig per unit of time (although such improvements are likely to have been marginal over the past 10 months compared to earlier gains).
Figure 5 illustrates the correlation between drilling rate and production. In order to maintain production at the peak rate of 1.2 mbd, 157 new producing wells need to be added each month to overcome the static production decline of the play, which in 2014 was 40% per year. The rate of well additions fell below this threshold in January and production began to fall, although the rate of producing well additions remained much higher than implied by the drastic drop in rig count given that many of the wells being added in recent months were drilled during the period of high rig counts. The drop in rig count will manifest itself in steeper production declines in future months as DUC wells are worked out of the system.

Figure 5 indicates that to maintain a peak production rate of 1.2 mbd, 157 wells must be drilled each month (1,884 wells each year). At a cost of $8 million per well, this necessitates investment of $15 billion per year, not including operating, leasing and other ancillary costs. Stories of negative cash flows within shale producers have been rampant in the media, even at much higher oil prices. Many shale producers, depending on the quality of their land holdings, cannot break even at oil prices of $50-$60 per barrel, hence the prospect of attracting the level of investment needed to maintain Bakken production is slim indeed unless oil prices rise substantially. Operators have been able to continue to complete and/or drill new wells in the Bakken thanks in large measure to debt, but those days may be nearing an end.

---


Figure 6 illustrates the average production per well by county. Average production is dropping in all counties, which is to be expected as new wells comprise a smaller and smaller proportion of the total complement of producing wells. A decline in the rate of addition of new producing wells will accelerate this trend.

Figure 6. Average production of Bakken wells by county from 2010 through June 2015.
Dominance of Sweet Spots

Sweet spots—core areas of high well productivity—produce most of the oil, as indicated by the fact that 89% of Bakken oil in June 2015 was produced from four of 15 counties. Figure 7 illustrates the distribution of producing wells in the Bakken categorized by well quality, as defined by initial oil production. As can be seen, the actual area of highest quality wells constitutes a small proportion of the total play area and, even within the top four counties, the area of highest quality wells is only a portion of the total county area.

Figure 7. Distribution and initial oil production (highest month) of wells in the Bakken Play of North Dakota and Montana as of June 2014.
Figure 8 illustrates average type well decline curves by county and Figure 9 illustrates average oil EUR (estimated ultimate recovery). The average well declines 86% in its first three years and 60% of a well’s ultimate recovery, assuming a 30-year life, is produced in the first four years. Given the difference in production between the sweet spots and the rest of the play, it is easy to see why drilling has been focused on the best parts of the top counties. In the longer term, however, drilling will have to move into lower quality parts of the play as sweet spots become saturated with wells. Higher prices will be required to justify this.

Figure 8. Type well decline curves by county for the Bakken Play using data to year-end 2014.
Figure 9. Estimated ultimate oil recovery (EUR) by county in the Bakken Play.
This average reflects the concentration of recent wells in the best parts of these counties.
3 Technology Improvement Meets Geology

A major theme in investor presentations is that wells are getting ever more productive through the use of longer horizontal laterals, more fracking stages, and larger volumes of water, chemicals and proppants in the fracking process. This has certainly been true over the 2011 to 2014 period although in 2015 it appears to have met with the law of diminishing returns and the fact that there are only so many locations to drill in sweet spots.

Figure 10 illustrates the average production rate over the first six months for new Bakken wells by county from 2010 through 2015. Average productivity for the Bakken increased by 23% from 2012 to 2014 but slowed to just 1% growth in 2015; it declined in the past year in McKenzie County, which produces 35% of Bakken oil. Productivity has also declined since 2013 in Mountrail and Williams counties, and was flat in Dunn County in 2015. The only increase in productivity in the past year has been in the “other 11” counties where a very limited number of new wells have been drilled in the highest quality part of this area (see well addition rate in Figure 16 in the Appendix). These trends confirm an earlier analysis which showed that initial well productivity has declining significantly in Mountrail County in recent months and declined slightly in the Bakken Play overall.4

![Figure 10. Average production rate of Bakken wells by county over the first six-months of production.](image)

---

The failure of technology to boost average well productivity in top counties in recent months is due to:

- Well saturation in sweet spots causing interference between wells.
- Exhaustion of the best drilling locations in sweet spots, necessitating drilling in lower-quality parts of the top counties.

A further consideration is that although these improved technologies have allowed an individual well to drain more of the reservoir at higher production rates, and hence have allowed the recoverable oil to be produced with fewer wells, they will not necessarily increase the ultimate oil recovery of the play. Wells with interference will allow the oil to be produced faster, but ultimately will represent higher capital cost inputs than necessary to recover the resource.

The Bakken Play still has enough drilling locations available to triple the number of producing wells that have been drilled to date, but these locations are increasingly in poorer quality rock. Thus the drilling rate will have to be increased substantially, as well productivity decreases, in order to stem the steep intrinsic field decline rate. These wells will also require progressively higher oil prices to be economic.
4 Future Outlook

Figure 11 illustrates historical production and the number of producing wells over time, as well as forecasts of future production from the Energy Administration’s (EIA) Annual Energy Outlook 2015 (AEO2015)5, and my “Most Likely” forecast from Drilling Deeper. Also shown is the number of new wells required through 2021 in order to meet the production forecast from Drilling Deeper, and the EIA’s historical data and short-term forecast from its Drilling Productivity Report for September 2015.6

![Figure 11. Historical production from the Bakken Play using Drillinginfo and EIA Drilling Productivity Report (DPR) data.](image)

Also shown are the “Most Likely” production forecast and number of wells required from Drilling Deeper, and the production forecast from the EIA AEO2015 reference case. DPR data refers to the “Bakken Region” which includes non-Bakken production.

Some observations:

- Drilling rates have dropped below those assumed in the Drilling Deeper forecast, hence production is currently slightly lower than projected.

- The number of DUC wells (estimated to be 914 in North Dakota as of July 20157) is sufficient to maintain production on the plateau forecast in Drilling Deeper out to mid-2016, assuming the rig count remains stable at current levels. Whether this happens or not depends in large part on oil price and financing, as the North Dakota Industrial Commission has recently relaxed regulations which required the completion of wells within one year of permitting. This effectively makes DUC

---

wells an oil storage strategy for companies with deep enough pockets to forgo the cash flow from putting these wells on production until prices go higher.

- The EIA AEO2015 reference case forecasts continued growth in Bakken production to a plateau at 1.7 mbd in 2020, which is 42% above the December 2014 peak. It would require 2,700 wells per year to maintain production of 1.7 mbd, and even higher drilling rates during the ramp up to that level—assuming well quality stayed constant, which is unlikely given that sweet spot locations are becoming saturated. Such drilling rates would exceed the highest levels ever achieved, which occurred in early 2014 when oil prices were $100/barrel, yet the EIA is suggesting oil prices will remain below $75/barrel through 2021.

- The “most likely” forecast from Drilling Deeper still looks on track. The EIA forecast to 2021 is highly unlikely, and in the longer term it is based on unrealistic estimates of technically recoverable resources. Ramping up drilling rates to the level required by the EIA forecast would require much higher oil prices and would exhaust available drilling locations before the middle of the next decade.

---

5 Summary and Implications

Bakken production is falling, which is a result of the decline in the rate of well completions to levels insufficient to offset the static 40% yearly decline rate of the play (1,884 well completions per year are required to maintain production at the peak level of 1.2 mbd).

Although rig counts have dropped by 65% since October 2014, the rate of well completions has fallen only 35% from the peak levels of mid-2014. This is due to the delayed completion of wells drilled when rig counts were much higher. There was an inventory of some 914 drilled but uncompleted (DUC) wells in North Dakota in July 2015. Bakken production will be supported by the completion of these DUC wells over the coming months, even if rig count does not recover.

Well productivity gains have essentially stopped after a significant ramp-up in the 2012 to 2014 period. The only recent well productivity gains were outside the top four counties, where drilling has moved to the best quality areas from more marginal regions. Average well productivity in the Bakken will decline as sweet spots become saturated with wells and drilling moves into lesser quality parts of the play.

The observation that new well quality is declining in top counties, despite every incentive to maximize individual well production, is key. Pundits such as Morningstar, while bearish on the short term, are convinced that rig counts and production will rise dramatically at prices of $60-$70 per barrel. They miss the point that the best quality parts of the play are being exploited now, and that lower quality geology going forward will dictate lower well productivities, with worse economics, which will require higher prices to justify. Thus even to maintain the peak rate of 1.2 mbd, the drilling rate would have to increase from the 1,884 wells per year currently required. To substantially increase production above the December peak would require a return to rig count levels of triple current rates or higher, which would accelerate the consumption of the finite number of remaining drilling locations. As noted in Drilling Deeper, high drilling rates serve to recover the resource sooner, but do not result in a significantly higher ultimate recovery.

If sub-fifty-dollar oil continues, Bakken production will likely continue its decline until it reaches a level where static field decline can be offset by completion rates, which are a combination of new drilling and the inventory of DUC wells. Once these DUCs are worked off, completion rates will fall and production decline will steepen until a balance between static field decline and the drilling rate is reached. Barring a substantial recovery in oil price, the “Most Likely” Bakken production forecast in Drilling Deeper may prove to be optimistic—this would push some projected oil production further into the future.

The EIA AEO2015 projection that Bakken production will continue to grow by 2020 to a plateau 42% higher than the December 2014 peak would require more than triple the current rate of drilling activity, and much higher prices to justify it. It would also require vastly more high quality drilling locations than are actually available, given that it forecasts the recovery of more than twice as much oil by 2040 as the U.S. Geological Survey (USGS) has estimated to be technically recoverable in its recent assessment. Hence the EIA forecast has a very low probability of occurring.

---

6 Appendix: Well Addition Rate Versus Production Change and Total Production by County

The following charts provide county-level detail on rates of well completions and production change for the top four counties as well as the group of other counties that make up the Bakken Play. Also noted are the number of new wells that need to be added each month to offset the static field decline in each county.

Figure 12. Dunn County oil production change per month versus new producing wells added per month from 2006 through June, 2015.

A three-month trailing moving average has been fitted to the data.
Figure 13. McKenzie County oil production change per month versus new producing wells added per month from 2006 through June, 2015. A three-month trailing moving average has been fitted to the data.

Figure 14. Mountrail County oil production change per month versus new producing wells added per month from 2006 through June, 2015. A three-month trailing moving average has been fitted to the data.
Figure 15. Williams County oil production change per month versus new producing wells added per month from 2006 through June, 2015.
A three-month trailing moving average has been fitted to the data.

Figure 16. Other 11 counties oil production change per month versus new producing wells added per month from 2006 through June, 2015.
A three-month trailing moving average has been fitted to the data.