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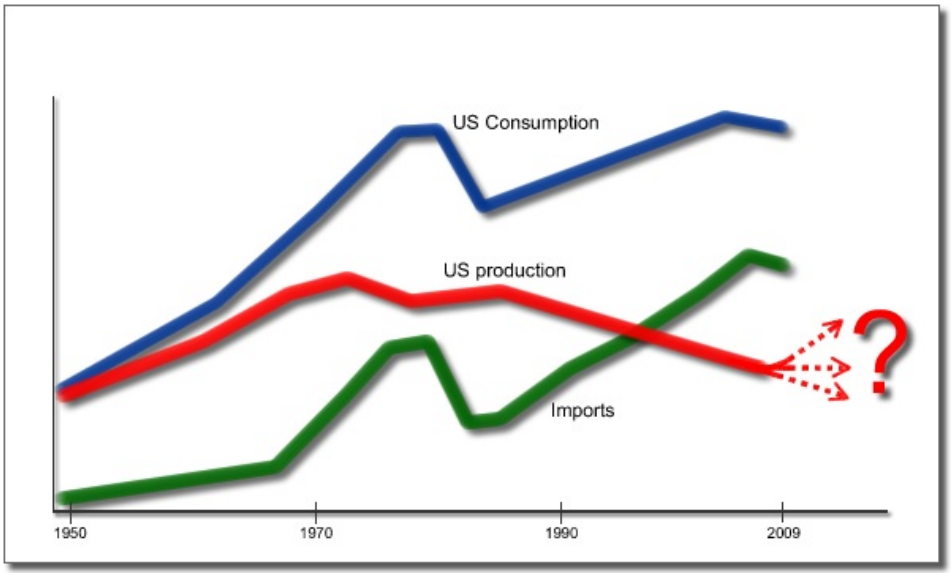
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Bakken Shale - Has it Moved the Oil Needle?

Posted by Gail the Actuary on November 2, 2009 - 8:00am
Topic: Supply/Production
Tags: bakken, bakken shale, williston basin [list all tags]

This is a post by Piccolo, a petroleum engineer working in the petroleum industry.

In April 2008, we published an initial assessment of the Bakken Shale and compared it to the USGS estimates of the resource: "The Bakken – How much will it help?" That piece covered production up to October 2007; the current article extends that analysis 18 months to March 2009. With this installment I would like to look at phases of development as they relate to geographical movement of the play, and discuss whether the Bakken is making an impact on total US production. In other words, has the Bakken moved the needle on US production?



Total production of the Bakken

The Bakken formation is one of many producing formations of the Williston basin in the northern US and southern Canada. For this analysis we are concentrating on the US production only (Figure 1). Production has been divided into three segments according to when and where the wells were drilled; the detail of those segments is discussed below. The black curve in Figure 1 represents the entire US Bakken production, and the three others show constituent incremental production streams that make up the total. Figure 2 provides the same information as Figure 1, but is a more detailed look at the period of 2001 to present.

The Bakken began production in 1961 with a few vertical wells. Production remained flat until around 1989 when horizontal well technology became more widely adopted in the industry. Horizontal well completions during the 1980s and 1990s were primarily of two types; open hole

or cased and cemented completions. In open hole completions, no cemented casing was placed across the producing formation and the formation was allowed to produce naturally, or with minimal stimulation such as a small volume of acid. In many cases, a perforated liner (a piece of casing with holes in it) was run across the producing formation to keep the wellbore open and allow future access if needed. The other common completion option was to run casing, cement it in place, and then perforate it. This was a more expensive option than an open hole completion, but would allow for more targeted stimulation either by pumping acid or by pumping sand to create a hydraulic fracture (a "frac").

In the 1990s hydraulic fracturing technology in horizontal wells continuously improved, but mass application of very large multi-stage frac jobs took off only in the late 1990s with the advent of shale plays such as the Barnett Shale in Texas. This technology was applied to the Bakken in 2000/2001 and production increased tremendously, with an incremental increase of about 60,000 barrels per day (the red curve). This production increase mainly occurred from wells drilled in Montana, as we shall see below. Beginning in about 2005, the development focus began shifting to the North Dakota side, setting the stage for an even larger production increase (the green curve in Figures 1 and 2).

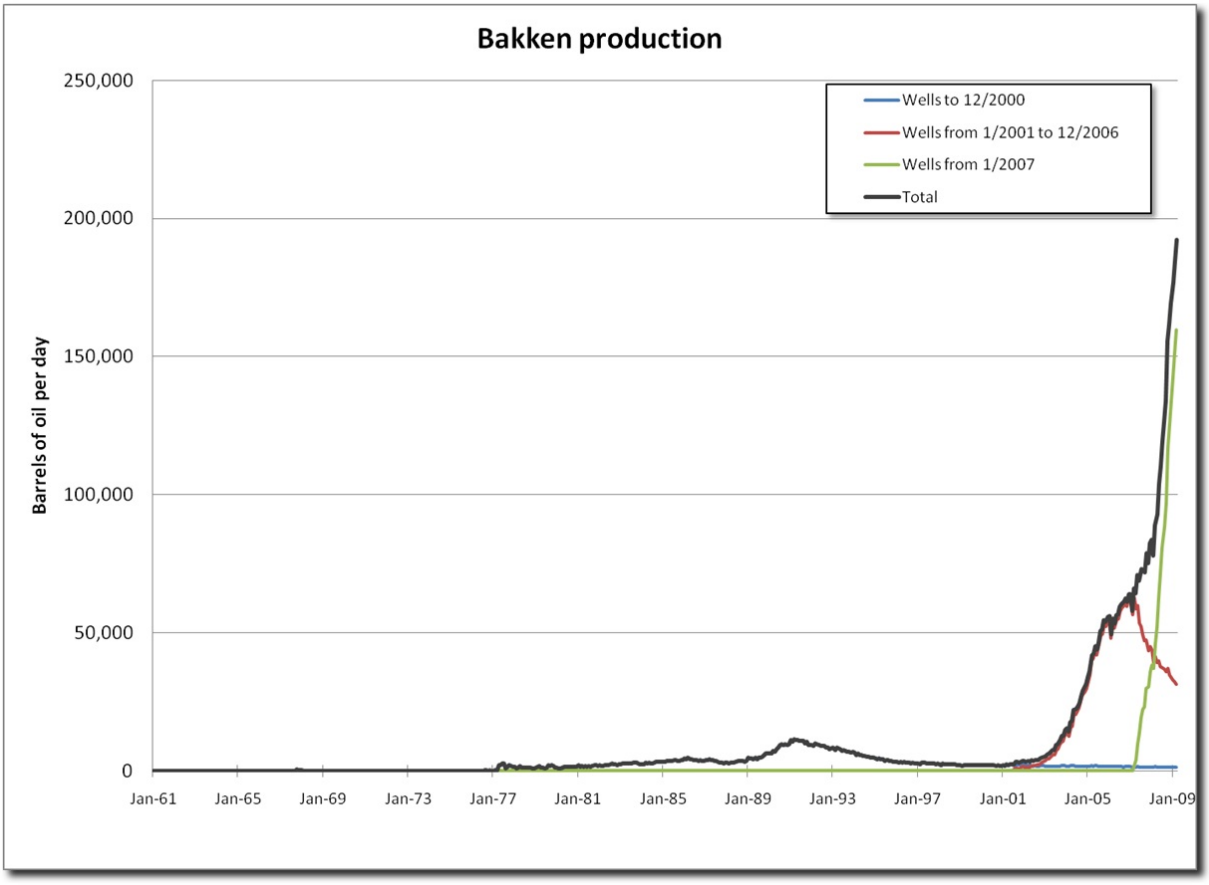


Figure 1 – Production from various phases of development

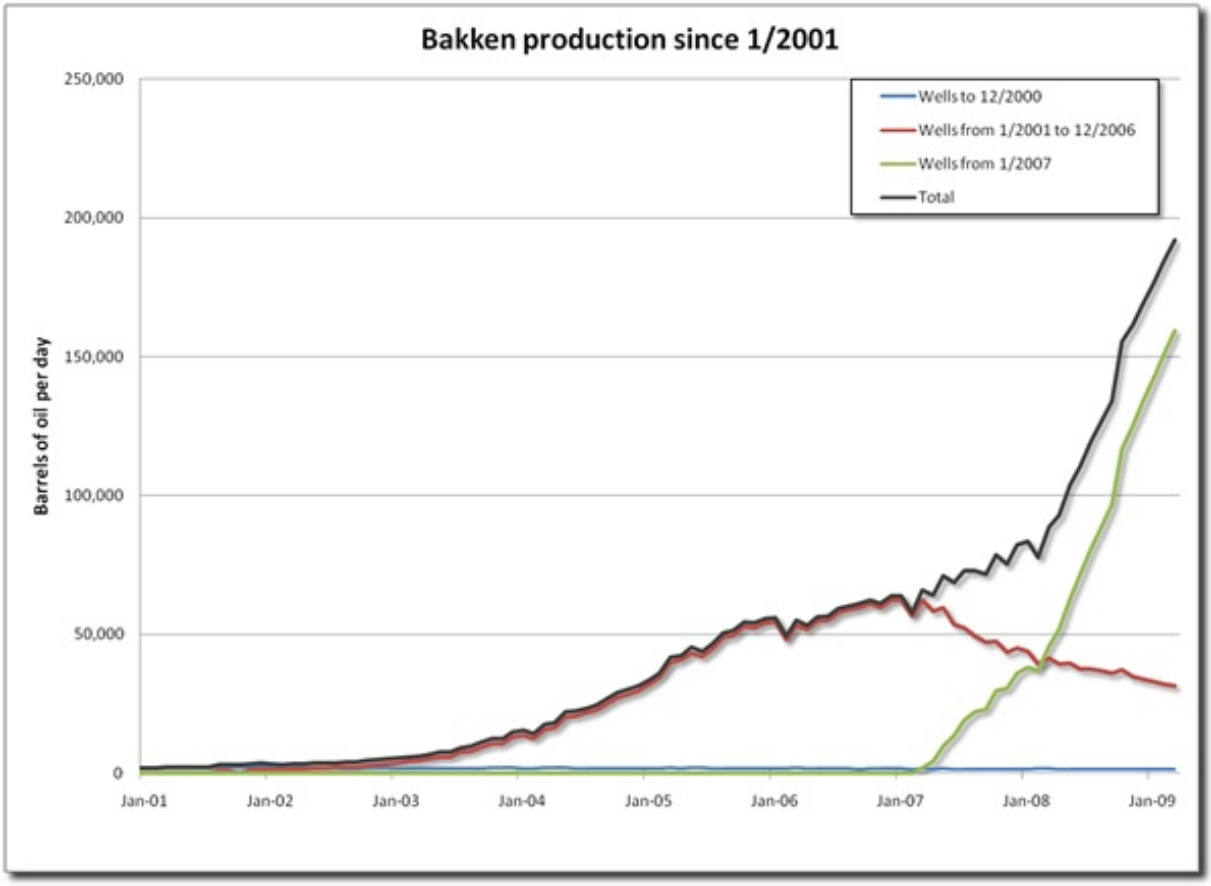


Figure 2 – Detail Production from various phases of development

Development up to 2001

The majority of wells up to 2001 mainly occurred in western North Dakota (Figure 3) in the Bicentennial and Elkhorn Ranch areas. Most of these wells were vertical, but beginning in the late 1980s horizontal wells became more common (more on this topic later in the piece). The production associated with the nearly 200 producing wells is shown in Figures 4 and 5. The wells produced about 10 million barrels up to 1988 and thereafter a significant production increase was created by new horizontal wells. The new wells pushed production up to nearly 14,000 barrels per day, the peak occurring in 1991, after which a steep decline ensued. The production decline was about 45% per year up to 1997, after which the decline rate lessened to about 7% per year. This behavior is typical of fractured reservoirs – an initial steep decline followed by a long tail with a less serious decline. We can estimate from Figure 5 that these wells together may ultimately produce around 50 million barrels. It's likely that with workovers, recompletions, re-frac'ing of wells, and other techniques, that ultimate recovery will exceed 50 million barrels.

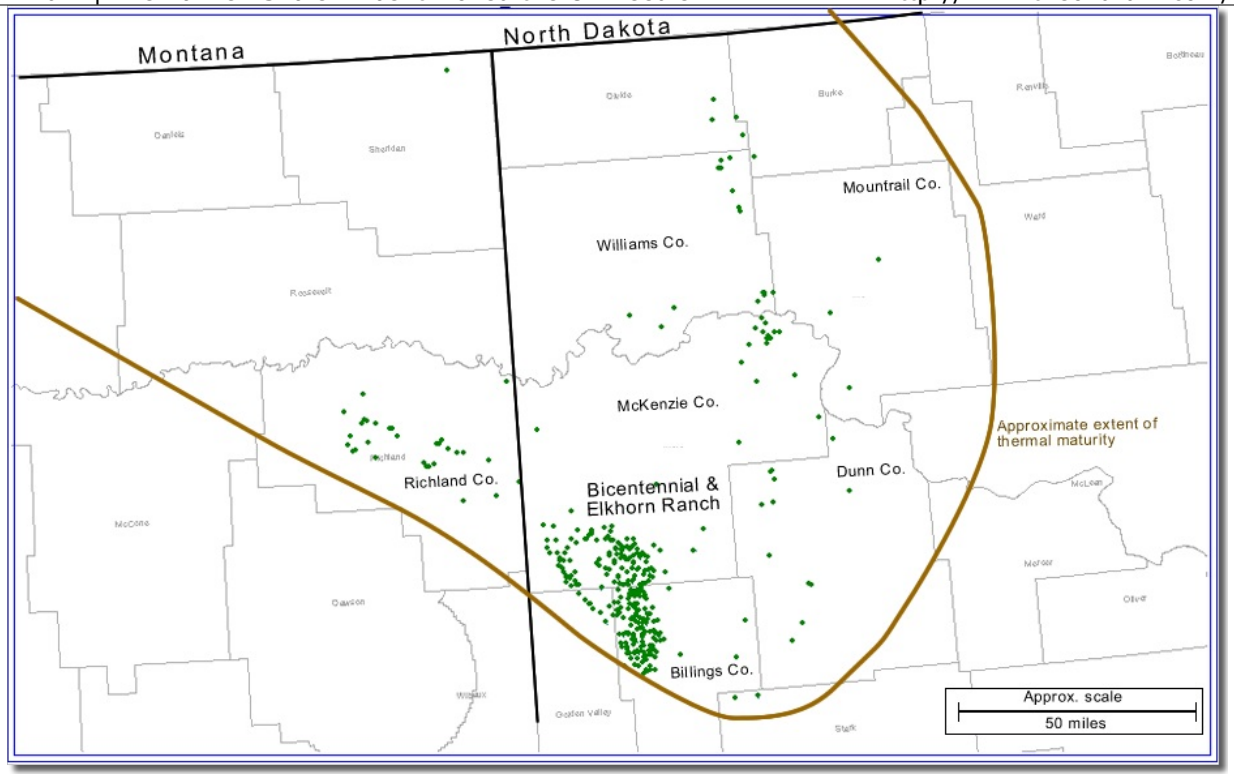


Figure 3 – Bakken development up to 2001

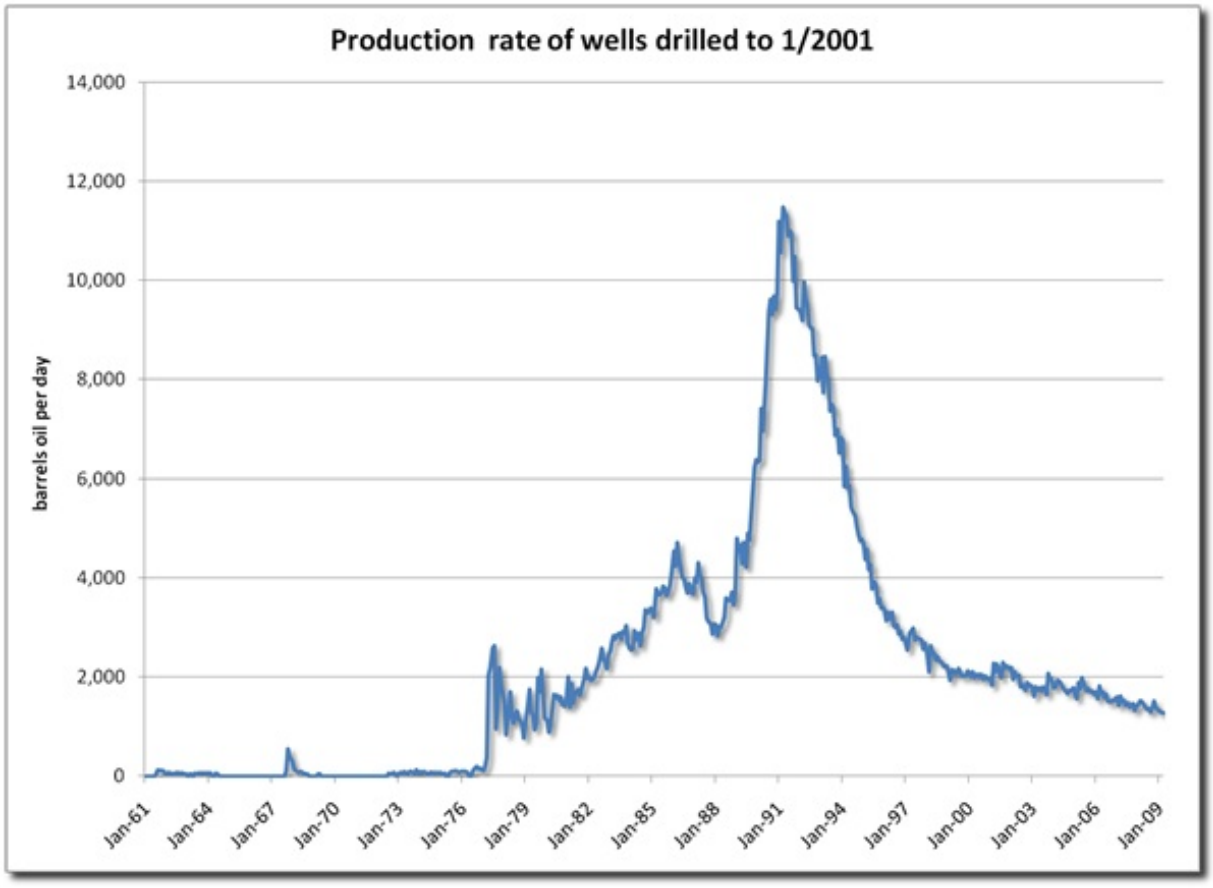


Figure 4 – Bakken production up to 2001

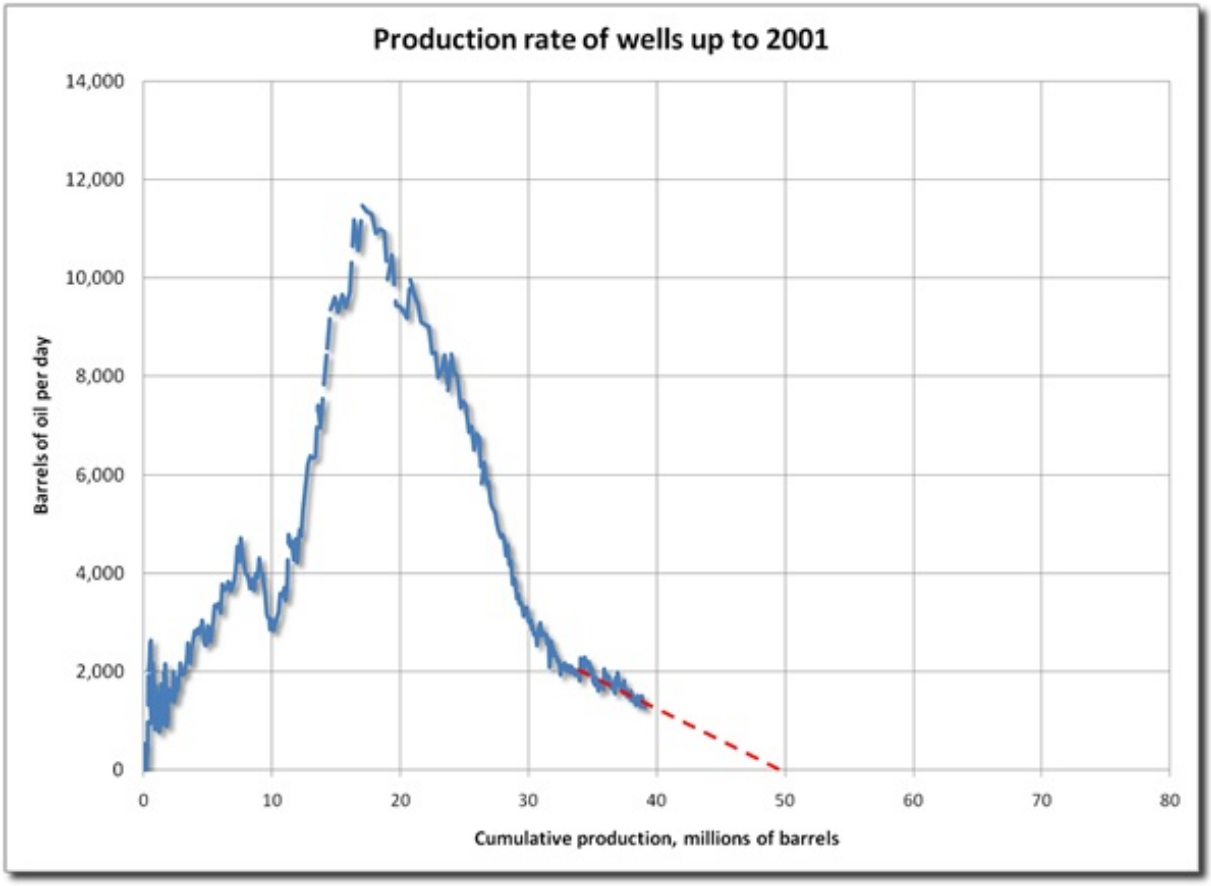


Figure 5 – Bakken cumulative production for wells up to 2001

Development 2001 through 2006

In 2000-2001, hydraulic fracturing of horizontal wells greatly improved production rates in Elm Coulee field in Richland County, Montana (Figure 6). The well count in the Elm Coulee area went from a few dozen wells prior to 2001, to around 600 wells by December 2006. Looking at only the Bakken wells drilled from 1/2001 to 12/2006, the corresponding production increase was tremendous (at least relative to past success), adding an incremental 65,000 barrels per day at the peak, which occurred in 2007 (Figure 7). Current production decline is in the neighborhood of 25% per year. On the current trend, the wells might produce at least 130 million barrels (Figure 8). With the likely flattening of the decline curve, the recovery could be up to 200 million barrels, possibly more.

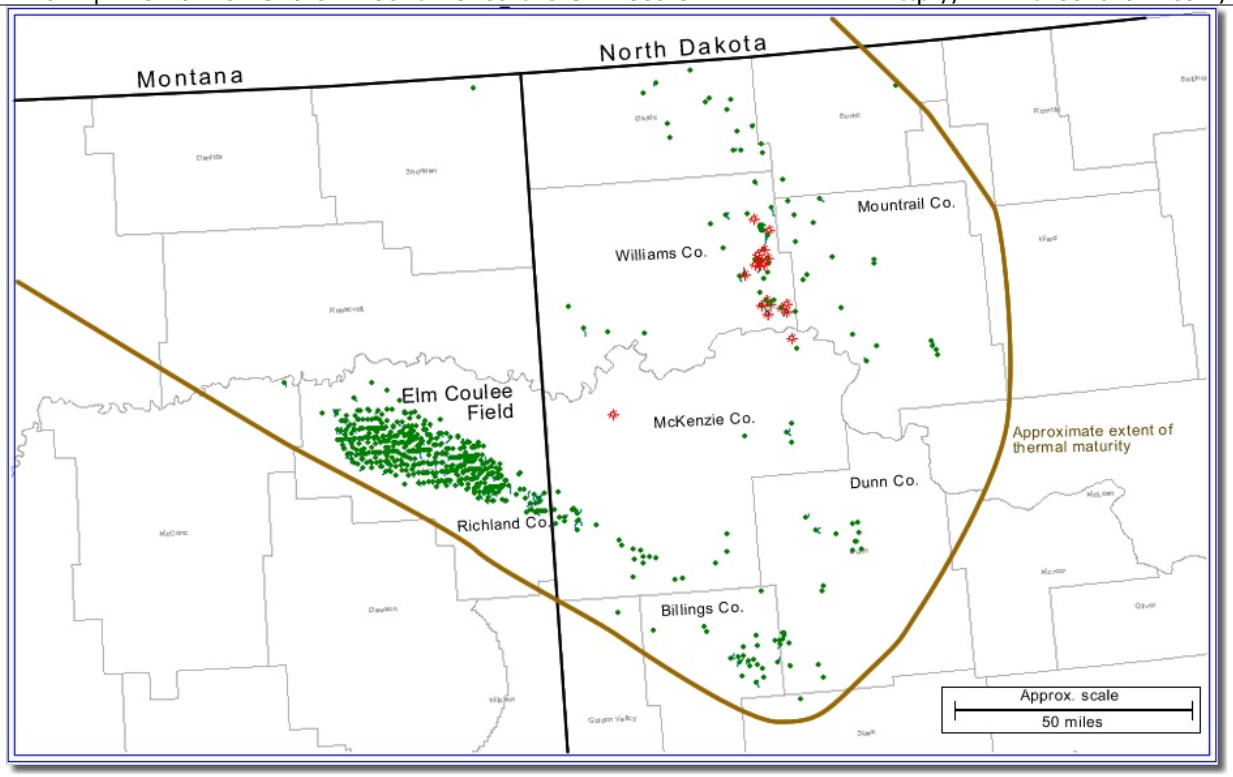


Figure 6 – Bakken Development 2001 through 2006

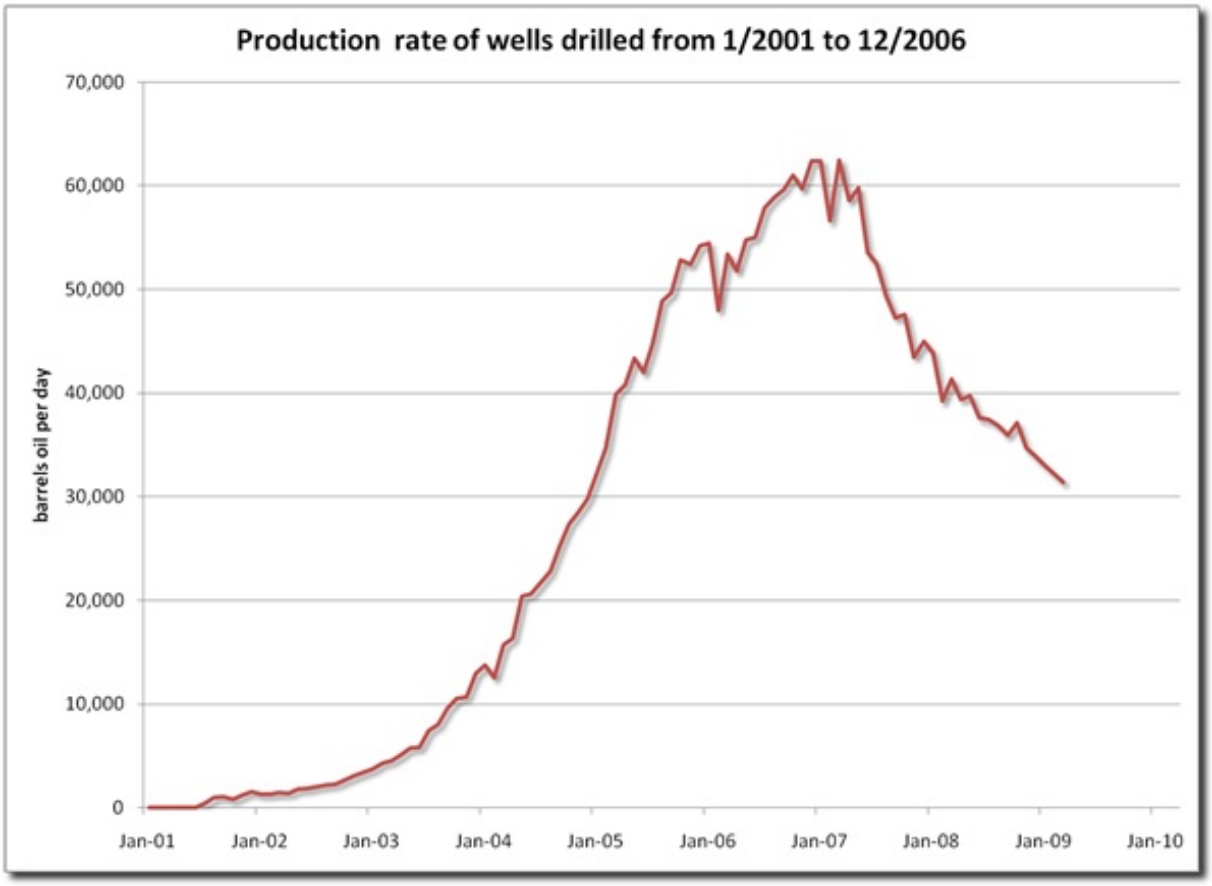


Figure 7 – Bakken production for wells drilled -1/2001 to 12/2006

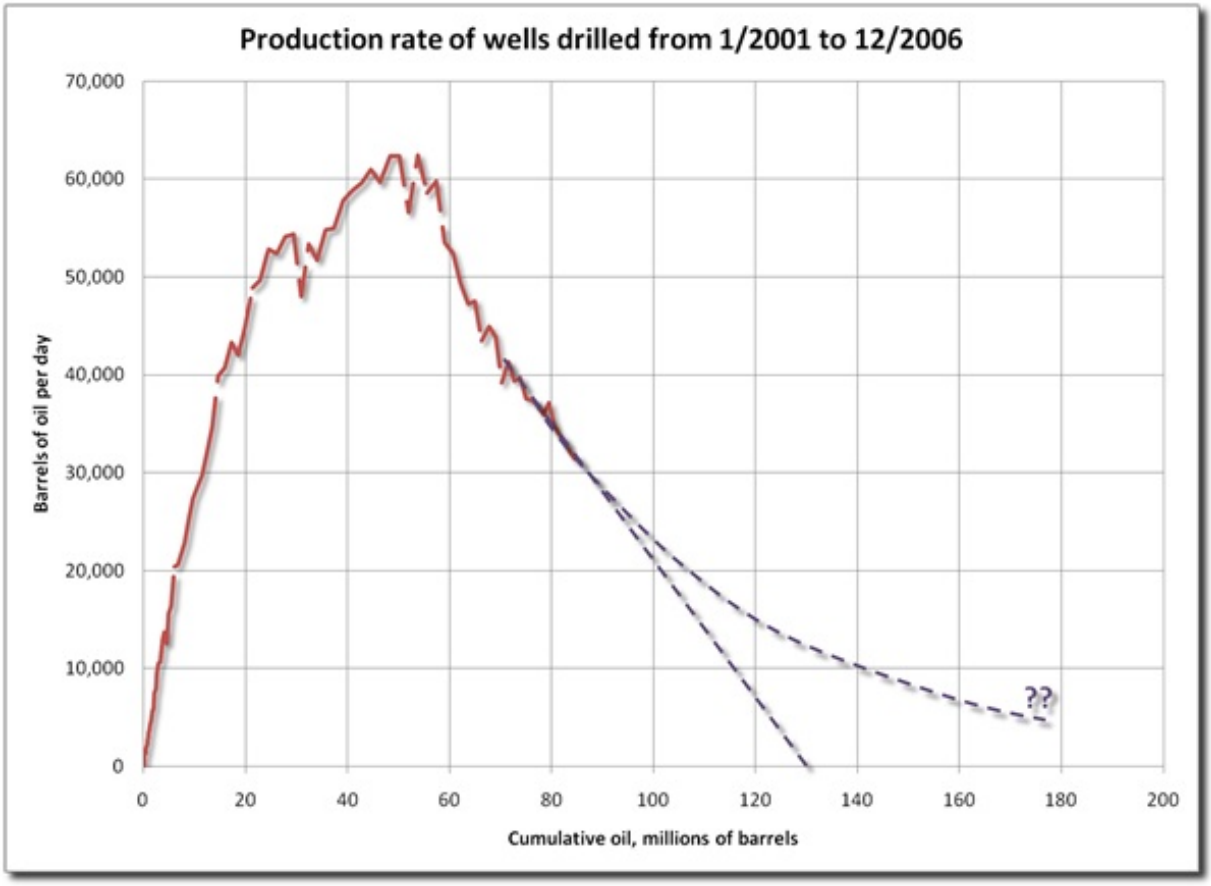


Figure 8 – Bakken cumulative production for wells drilled -1/2001 to 12/2006

Development 1/2007 to 3/2009

Since 2007, development has continued in Montana's Elm Coulee field, but the bulk of the activity has moved to North Dakota (Figure 9). The production rate from wells drilled since 1/2007 (Figure 10) shows a rapid increase in incremental rate to 160,000 barrels per day and rising. (This includes wells drilled up to December 2008; production rate data for January to March 2009 was incomplete so estimates for those months were based on the previous trend.) The cumulative production (Figure 11) shows that about 50 million barrels were produced up to 3/2009. Comparing this phase of development to the previous phase (Figure 12), current phase is far exceeding production of the previous phase. It is too early to predict what reserves may be recovered from this tranche of wells, but overall it is reasonable to think that they should be double or triple the reserves expected from the 2001 to 2006 group of wells.

On an individual well basis, ultimate recovery from the better recent North Dakota wells is reportedly in the range of 500,000 to 800,000 barrels, compared to 100,000 to 400,000 barrels per well in Elm Coulee. The reasons for these astoundingly good wells are the topic of another discussion, but improved frac technology and more frac stages are likely to be big contributors. In addition, the productive reservoir section on the North Dakota side is thicker and more widely distributed, typical of an unconventional resource play. If the predictions prove to be accurate and are repeatable over a wide area, this would likely be the most prolific onshore play in the US, at least in the last 20 or 30 years.

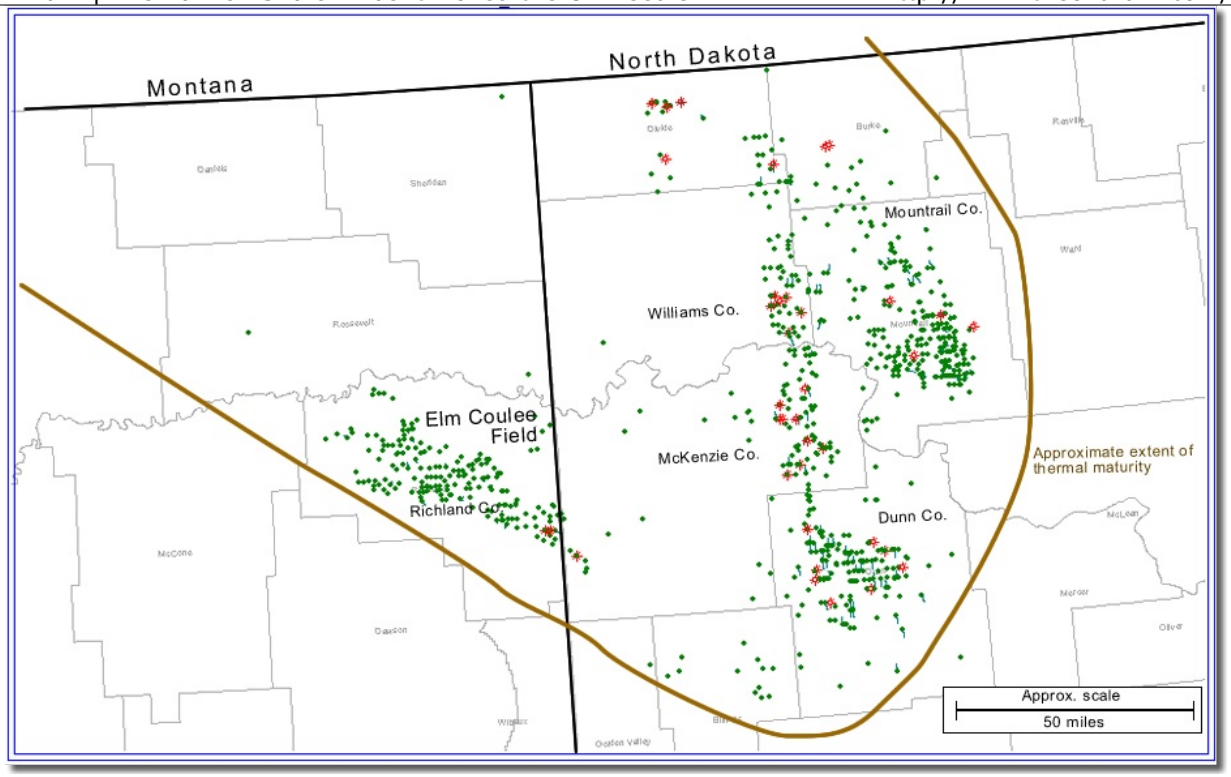


Figure 9 – Bakken development starting in 1/2007

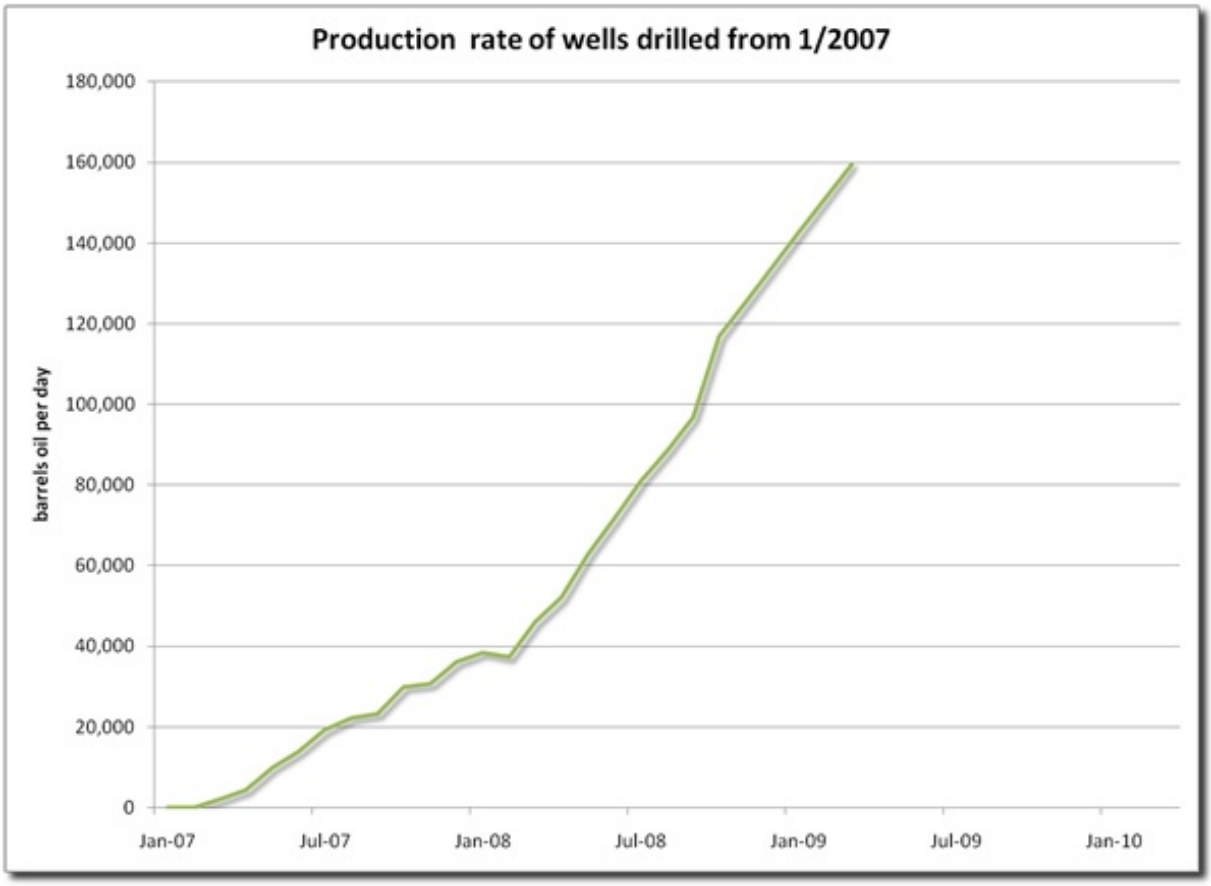


Figure 10 – Bakken production for wells drilled starting 1/2007

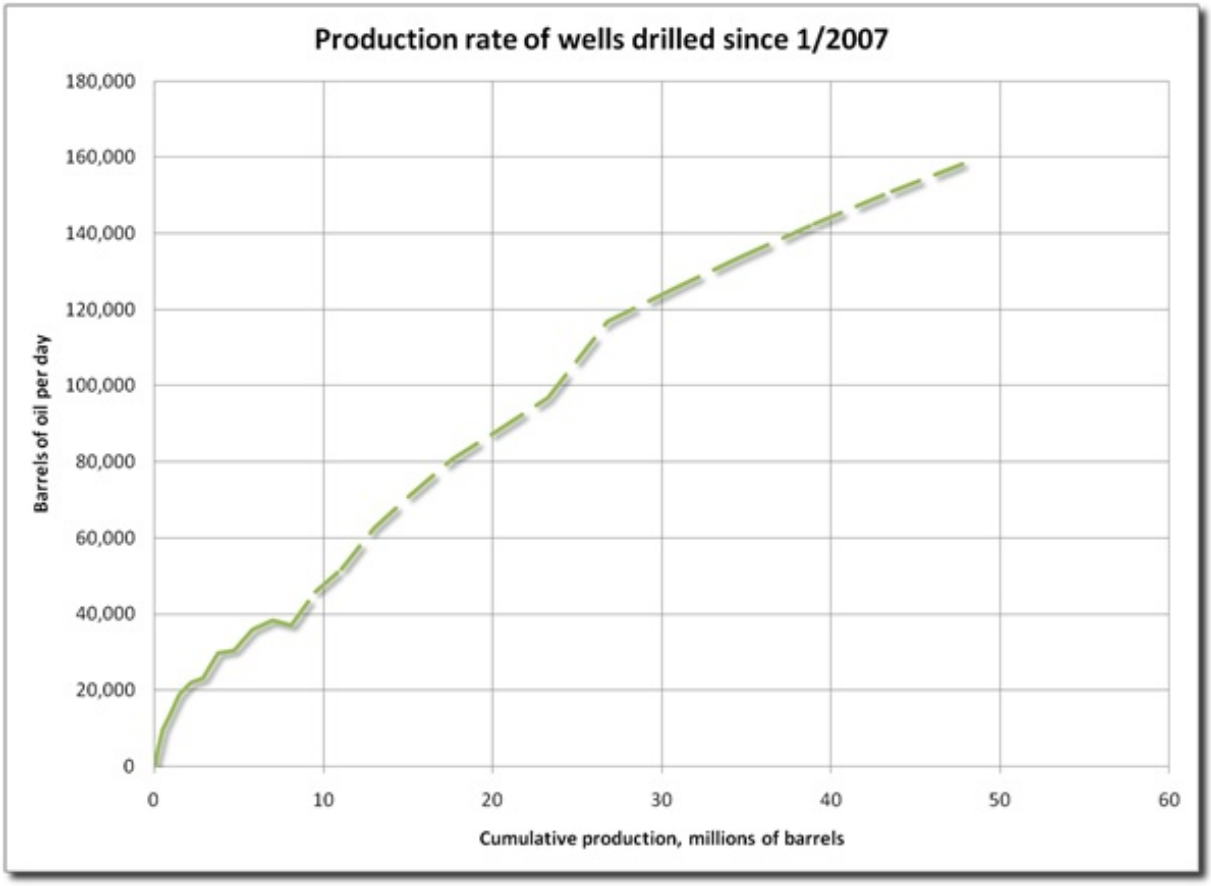


Figure 11 – Cumulative production for wells drilled starting 1/2007

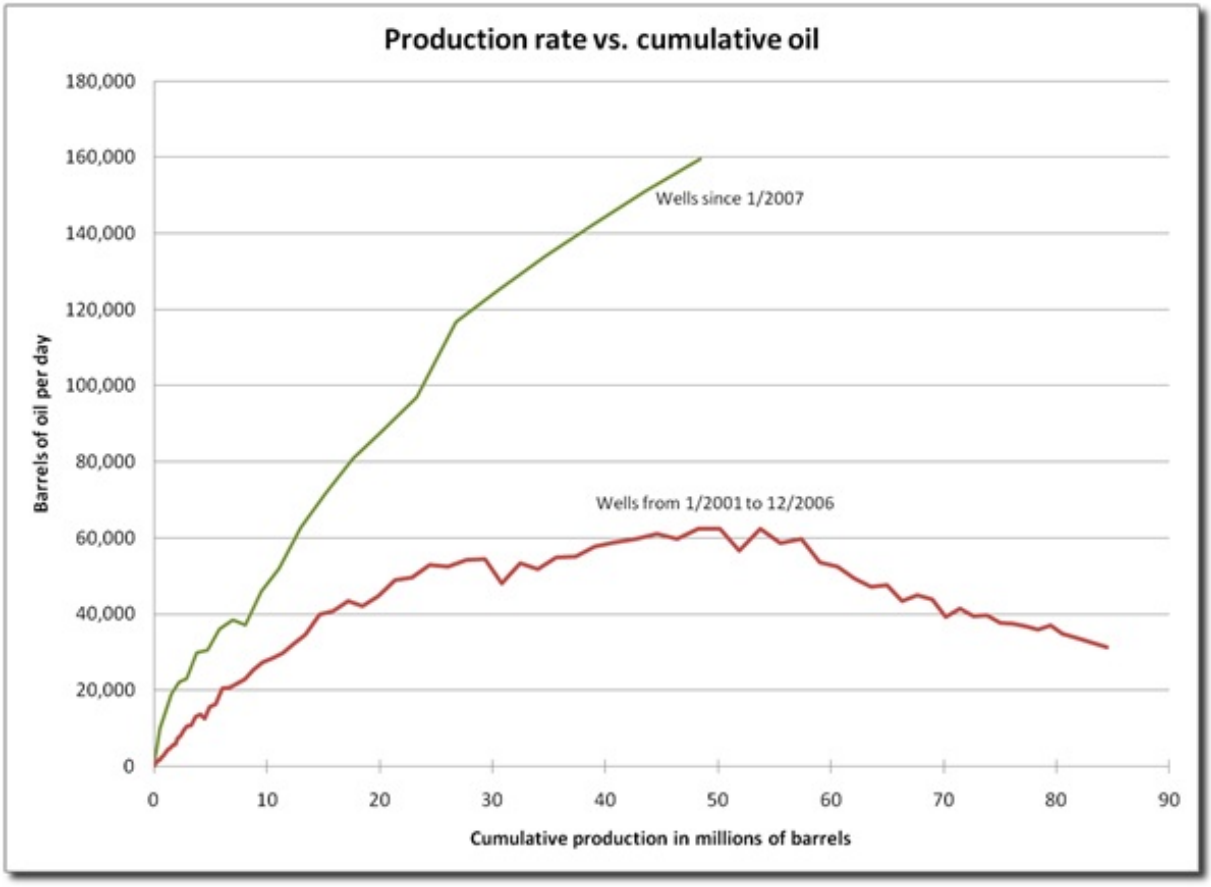


Figure 12 – Comparison of cumulative production for wells drilled from 2001 to 2006 and wells drilled starting in 2007

A statistical look at well numbers

Figure 13 clearly shows the dramatic shift from vertical to horizontal wells that occurred in the 1990s. (The horizontal well count Figure 13 is actually number of laterals and not strictly the number of horizontal wells; that is, many wells are drilled where two or more subsurface laterals are connected to a wellhead. Usually these are called multilaterals. For purposes of this discussion, I've used the terms horizontal well and horizontal lateral interchangeably.) The Bakken formation is now developed almost exclusively with horizontal (or multilateral) well technology, and vertical wells are rarely drilled.

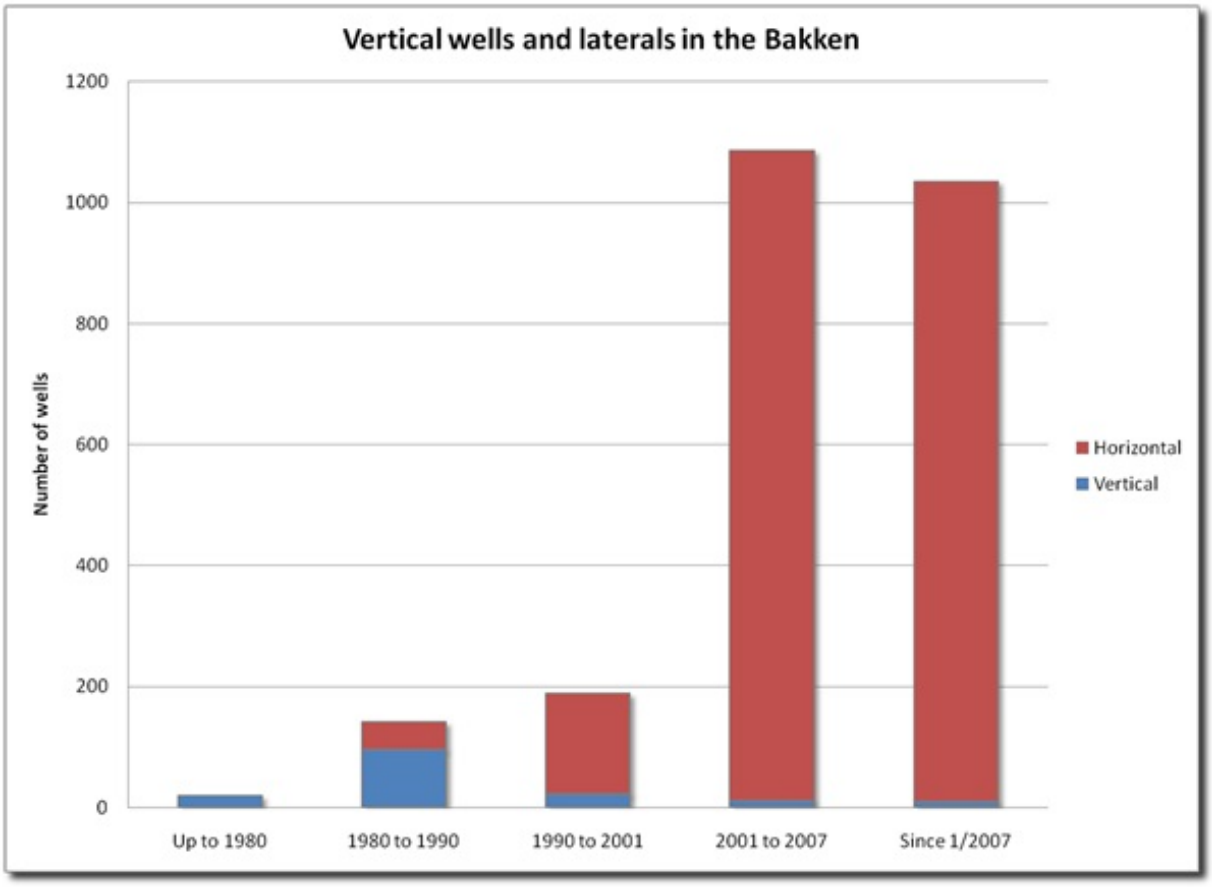


Figure 13 – The shift from vertical wells to horizontal laterals

The other big shift, mentioned above, is the geographical focus of development. This can be seen in Figure 14, which shows early focus in North Dakota (the 1990s), later focus in Montana, and then a shift back to North Dakota starting in 2005.

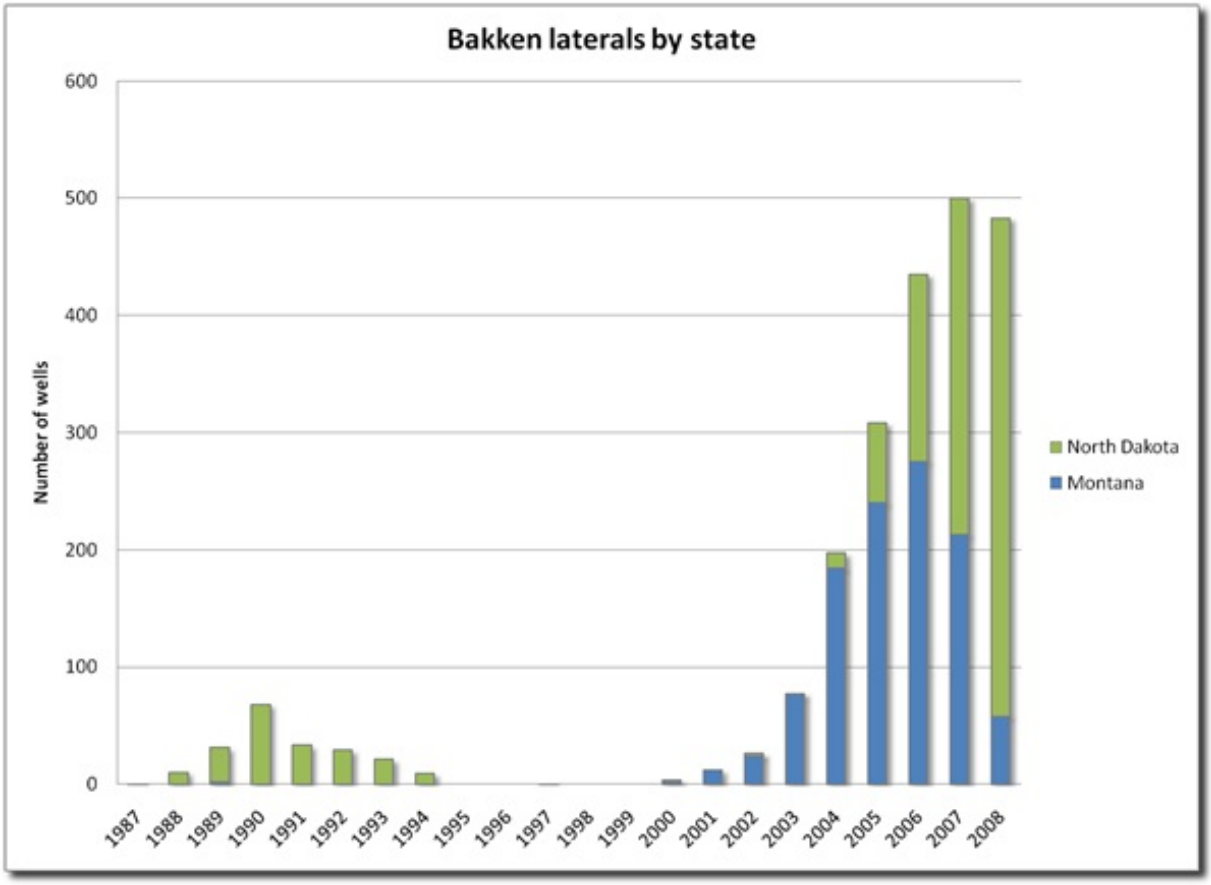


Figure 14 – Horizontal wells by state

Comparison to the 2008 USGS estimate

The 2008 USGS study (Figure 15) estimates 3,600 million barrels of "undiscovered oil resources" in the "Bakken-Lodgepole Total Production System." For a more detailed discussion of oil resources, and technically and economically recoverable reserves the reader is referred to my original post. In that post I took a stab at what was meant by the USGS term of "undiscovered oil resources" by defining it this way: "the volume of hydrocarbons that theoretically could be produced if enough wells were drilled to drain the entire known area of Bakken oil accumulation."

	Oil, MMBO			
	P95	P50	P5	Mean
Elm Coulee AU	374	410	450	410
Central Basin AU	394	482	589	485
Nesson AU	818	908	1007	909
Eastern Expulsion AU	864	971	1091	973
Northwest Expulson A	613	851	1182	868
Total				3645
Middle Bakken	1	4	8	4
Total				3649

Figure 15 – Undiscovered resources from the USGS study

It is interesting to compare the phases of development outlined above, to the USGS map of Assessment Units (AU's) in Figure 16. The majority of production from wells drilled up to 2007 came from the Elm Coulee- Billings Nose AU. Ultimate recovery from those wells based on current information is in the range of 200 to 250 million barrels of oil (MMBO). That compares to a USGS mean ultimate recovery of 410 MMBO. Since 2007, development has been mainly in the Nesson-Little Knife Structural AU and the Easter Expulsion Threshold AU. The post 1/2007 wells have recovered 50 MMBO and production is rising rapidly. But production must increase for some time and many more wells are needed to approach the 1882 MMBO estimated technical reserves of the USGS study.

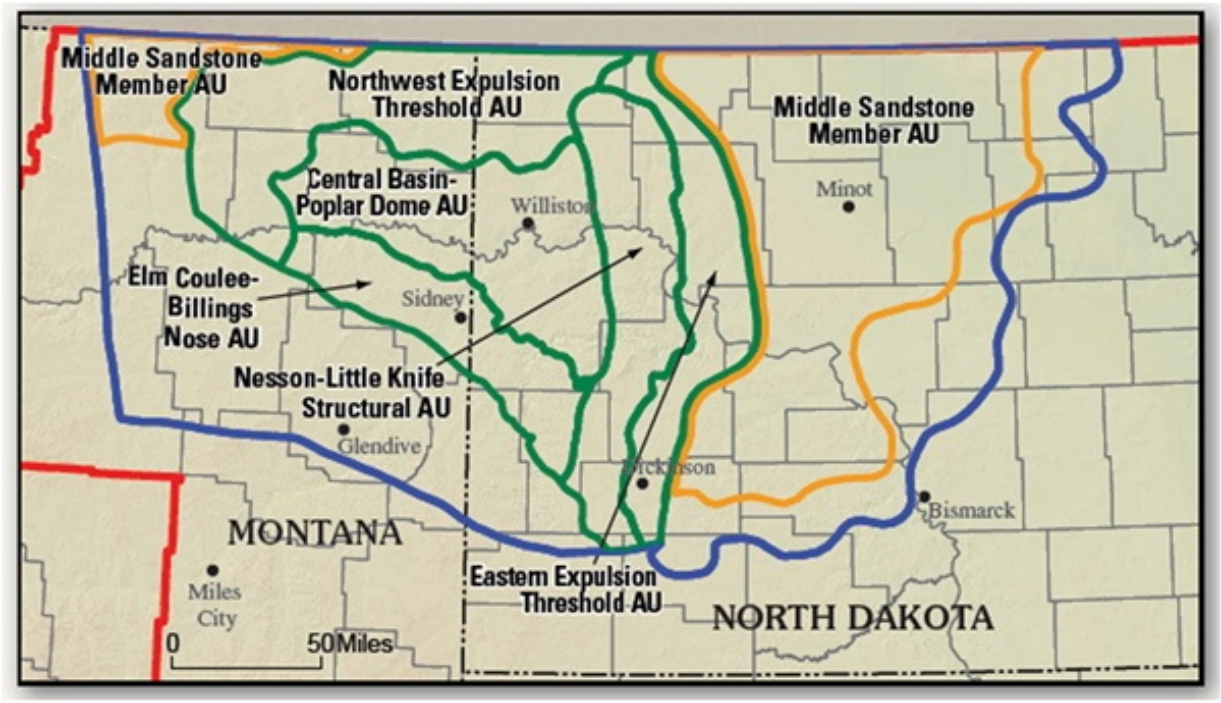


Figure 16 – Undiscovered resources from the USGS study

Bakken production – a drop in the bucket or a big boost to US production?

So, let's put the Bakken production in perspective. From the point of view of combining technology with geology to increase oil production, the Bakken is a shining example. It's no mean feat to increase production as rapidly as is indicated in Figure 1, and it's a credit to the oil industry, the free market system, and the serendipity of geology; land owners, oil producers, service companies, and mother nature (geology) have all contributed to make this a top class oil development.

But what about from the perspective of US production and consumption (Figure 15)? The EIA estimates that US oil consumption in 2008 was equivalent to 17.8 million barrels per day, declining from a high of 19.4 million barrels per day in 2005. US production continued its long slow decline to a level of 6.7 million barrels per day (including natural gas liquids). Bakken production in 2008 averaged about 118,000 barrels, or about 1.8% of US domestic production, and about 0.7% of US consumption. The Bakken displaced about 1.1% of the US net 2008 imports of 11.1 million barrels per day.

Domestic production with and without Bakken production is shown below; graphically the change

in US production due to the Bakken is barely perceptible. (The dashed black line in figure 15 is US production without the Bakken; the red line is total US production. The divergence between the two lines is imperceptible except during at the very end of 2008.) To answer the question originally posed, the Bakken, even with its high and rapidly increasing production rate, has barely moved the needle on US production.

The longer term take away from the Bakken experience may be that indeed there are additional oil resources in the US that can be developed with technology, but the resource must be enormous and be pursued over a long period of time to have any impact. It is not clear at this time whether there are other onshore oil plays that will match the Bakken. It can be argued, though, that there is a good analogy in the development of US gas shales: development of the Barnet, Woodford, Devonian, Haynesville, and other gas shales the last 10 years has been extensive enough to "move the needle" on US gas production. But the argument is diminished somewhat, when one considers the difference in properties between gas and oil; the viscosity of oil is approximately 100 times more than gas, making it extremely challenging to recover oil from tight shales on the same scale as we have seen in gas development. Nevetheless, the industry is doing what it can, with active oil shale developments: Tuscaloosa Marine Shale, the oil leg of the Barnett shale, and the Eagleford shale, to mention a few. It's too early to tell whether these will be as prolific as the Bakken.

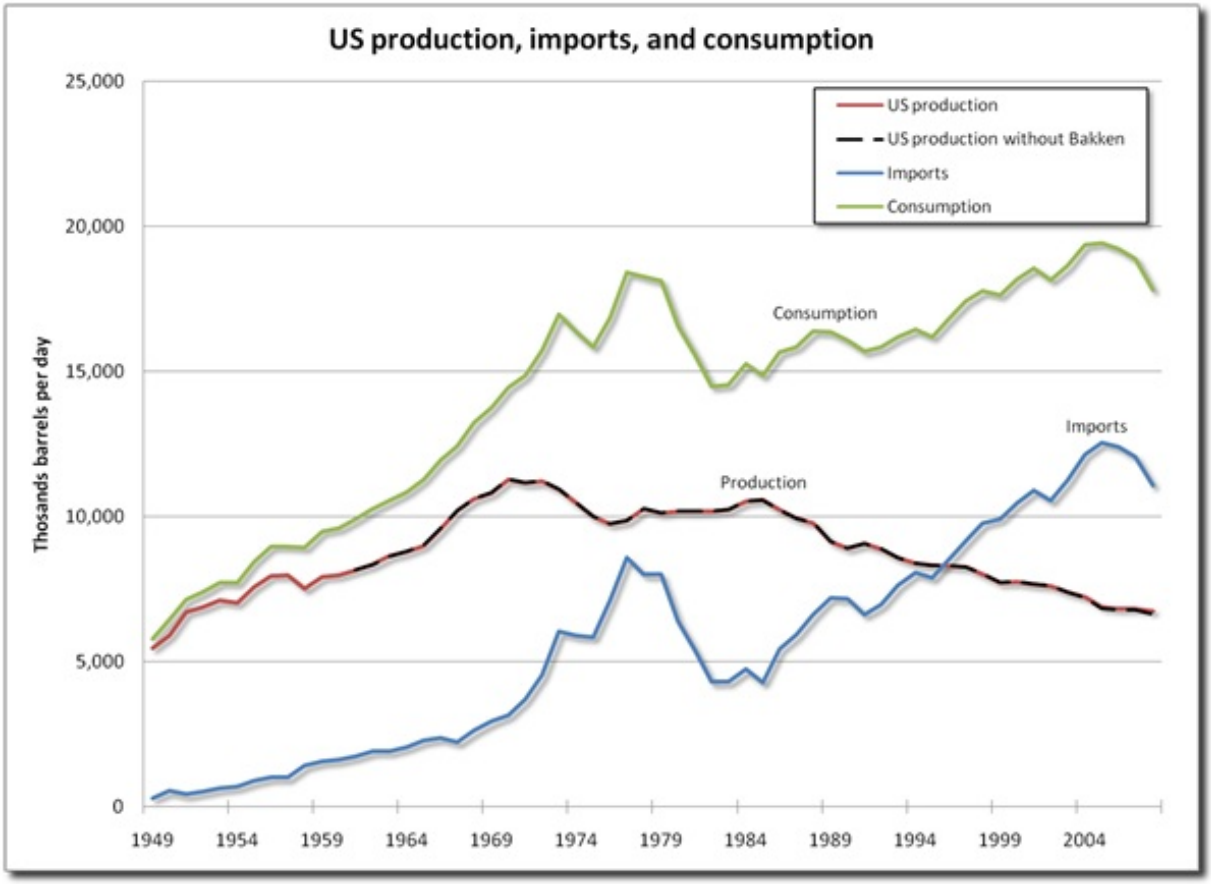


Figure 17 – US production, imports, and consumption

Conclusions

1. The focus of Bakken Shale development has shifted from the Elm Coulee field in Montana to several counties in North Dakota.

2. Total Bakken production was approaching 200,000 barrels per day and rapidly increasing as of March 2009. Cumulative production was about 160 million barrels.

3. The current phase of development has greater reserve potential than the previous two phases combined.

4. The 2008 Bakken production rate of 118,000 barrels per day constituted 1.8% of US domestic production and 0.7% of total US petroleum usage.

5. It's too early to say whether other shales as prolific as the Bakken can be developed in the US.