

COLORADO'S OIL PRODUCTION FLIPS BETWEEN FIELDS

BY TRACY HUME • FOR ENERGY PIPELINE

IN 2013, Colorado broke a 56-year-old record for crude oil production. Data collected by the Colorado Oil and Gas Conservation Commission showed a record-breaking 64.9 million barrels were produced in Colorado in 2013. The previous record was set in 1956, when Colorado produced 61.9 million barrels.

Monthly production figures for 2014 appear to be running ahead of 2013's figures. However, COGCC won't have final, verified 2014 crude oil production figures for several months. Will 2014 be another record-breaking year for Colorado? Although it is still too early to tell, looking at the factors behind the production records set in 1956 and 2013 record may give clues as to what the future holds for Colorado crude oil production.

BEHIND THE NUMBERS

The story of Colorado's record-breaking oil production is about more than just total annual barrels produced. The "where," "why" and "how" behind the numbers tell the interesting part of the story.

COGCC has been tracking statistics related to oil and gas production in Colorado since the commission was established in the early 1950s. Thom Kerr worked for COGCC for 23 years. Now retired from COGCC, he works as an independent consultant for the industry, but he still knows his way around the data. He used annual oil production data to put together a graph that neatly tells the story of the 1956 and 2013 production records.

"The big story in 1956 was in the Denver-Julesburg basin," said Kerr. "They were finding channel sands in the D and J sand formations in the Denver basin. A lot of fields were discovered in Morgan, Logan and Washington counties, and some of those fields were amazing."

Indeed, in 1956, Washington County produced 6.8 million barrels; Logan County produced almost 8 million barrels; and Morgan County produced 12 million barrels. Those three counties accounted for about 43 percent of Colorado's total oil production in 1956.

But the county that made the single biggest contribution to Colorado's production record in 1956 was Rio Blanco County. Rio Blanco County is located in western Colorado, near the Utah border. The giant Rangely Oil Field is located in the county. The Rangely Field is one of the oldest and largest oil fields in the Rocky Mountain region.



Rio Blanco County's contribution to Colorado's 1956 production record was 30.2 million barrels, which was equal to almost 49 percent of Colorado's total production that year.

By way of comparison, Weld County contributed a paltry 1.5 million barrels to Colorado's total production in 1956. According to COGCC data, it wasn't until much later, in 2000, that Weld County bested Rio Blanco County with respect to percentage of Colorado's total oil production. In 1999, Rio Blanco was still ahead, producing 6.65 million barrels, which represented 33.78 percent of Colorado's total annual production; that same year, Weld County was right behind Rio Blanco County, producing 6.48 million barrels, which represented 32.89 percent of Colorado's total production.

In 2000, Weld County finally bested Rio Blanco County. Weld County produced 7.08 million barrels (35.37 percent of Colorado's total). Rio Blanco County produced 6.52 million barrels (32.56 percent). Over the last 14 years, Weld County has continued to significantly outproduce Rio Blanco County. In 2013, the last year for which final figures are available, Weld County produced 52.6 million barrels (81 percent of Colorado's total production) to Rio Blanco's 2.9 million barrels (6.1 percent of Colorado's total production).

What made Rio Blanco County the largest contributor to Colorado's oil production in 1956? And why did Weld County usurp that role in 2000?

The answer to those questions lies largely in the attributes of three variables that significantly impact oil production. Those three variables are the location and nature of the resource; the market for that resource; and the technology used to access the resource.

THE COUNTY THAT MADE THE SINGLE BIGGEST CONTRIBUTION TO COLORADO'S PRODUCTION RECORD IN 1956 WAS RIO BLANCO COUNTY

COLORADO OIL PRODUCTION: Rio Blanco County and Weld County Change Places					
YEAR	COLORADO TOTAL	RIO BLANCO COUNTY TOTAL	RIO BLANCO COUNTY PERCENT OF TOTAL	WELD COUNTY TOTAL	WELD COUNTY PERCENT OF TOTAL
1956	61,895,970	30,182,000	48.76%	1,477,285	2.39%
1999	19,701,671	6,654,444	33.78%	6,480,159	32.89%
2000	20,021,426	6,518,049	32.56%	7,081,950	35.37%
2013	64,906,698	4,645,576	7.16%	52,606,725	81.05%

Over the past 15 years, the use of horizontal drilling and hydraulic fracturing in the Wattenberg Field has allowed Weld County to overtake Rio Blanco County as a major contributor to Colorado's annual oil production.

LOCATION, LOCATION, LOCATION

The real estate agents' mantra, "location, location, location," can apply equally well to oil production. But beyond simple location, oil production is specifically about geological structure.

Bob Weimer began working full-time in the oil and gas industry in 1949, after earning a bachelor's and a master's degree in geology from the University of Wyoming. He earned his doctorate in geology from Stanford in 1953, and served as a professor of geology at the Colorado School of Mines for many years.

"As a petroleum geologist, Colorado is an interesting area to study," Weimer said. "It is an unusual area because you can observe a lot of the rocks that contain oil along the flanks of the mountains. You can use direct observations of the different rock formations and map the structure.

"Rangely has a large dome-type uplift called an anticline," explained Weimer. "That was a known structure, identified in the early mapping done by geologists. There were also some seeps of gas, and maybe some oil as well, along the White River, which gave the petroleum geologists reason to believe there would be oil and gas accumulation at depth."

An anticline is like an upside-down bowl, under the earth's surface. Impermeable rock in the dome structure traps an accumulation of oil and gas. The anticline structure at Rangely created a conventional target for the industry: oil in a known structure, accessible by vertical wells and conventional pumping equipment.

Rangely Field's conventional anticline structure contrasts significantly with the Wattenberg Field's low-permeability (tight) formation.

"It's a different horizon," explained Steve Sonnenberg, professor and Charles Boettcher Distinguished Chair in Petroleum Geology at the Colorado School of Mines. "The current drilling activity in the Wattenberg is largely chasing the Niobrara and the Codell sandstone. Those two reservoirs have much lower reservoir quality. Porosity - the pore spaces in the rock - and permeability - the connected porosity that enables fluids to flow through the rock - are much lower in the Wattenberg and the Niobrara and the Codell sandstone than it ever was in Rangely.

"Rangely was a pretty high quality reservoir to begin with," said Sonnenberg. "The Niobrara and the Codell sandstone are located in the bottom of the sedimentary basin, fairly deep. They require hydraulic fracture stimulation because without it, quite honestly, they would be uneconomic wells."

SHOW ME THE MONEY

Another factor that clearly impacts production in any given year is the price of oil.

"In general, production is related to the number of wells being drilled," said Sonnenberg, "and when the price of oil drops, it impacts whether somebody is going to drill wells or not. If the price of oil goes down, depending on what a particular company's economics are, they may decide not to drill any more wells. It is one of those things that is always operator-specific."

Lack of a market contributed to the Rangely Oil Field's slow start. Shallow wells were drilled into the Mancos Shale formation in Rangely in the very early 1900s; it wasn't until the early 1930s that Chevron drilled deeper and hit a vast reservoir of oil in the Weber (pronounced WEE-burr) Sandstone.

"There was not a lot of market for the oil they found in 1902, and for the oil they produced in the 1920s and '30s," Weimer said. "The oil price you would get in the marketplace from the refinery was less than one dollar per barrel at that time."

Only after WWII ended in 1945 did the price of oil begin a consistently upward trend, jumping to \$2.60 per barrel by 1948. Production rose accordingly. "By the end of '45, 182 wells had been drilled at Rangely," Weimer said, "and in '46, there were 54 rigs operating in Rangely."

According to U.S. Energy Information Administration data, oil was priced at \$2.79 per barrel in 1956, Colorado's record-breaking production year.

"Still, if they drilled a well in 1956, they would have to find the money to drill," said Weimer. "And then get a contract and leases and so on. And it would cost them \$3 a foot, if it were a dry hole. If it is a dry hole, you just pull out of the hole and plug it. And so if it were a 5,000 foot dry hole, it would cost you \$15,000.

"But if you found the sand that had oil in it, mainly oil or gas and oil, you would still have to spend money to complete the well - you would have to run more casing to total depth; seal off the near surface water bearing sands; put tubing down the hole, inside the casing; and then install the pumping equipment and so on," said Weimer. "It was a big decision to make, whether or not if you drilled the well you could produce it at an economic rate. That was a critical factor, because you had to invest so much money."

For people interested in a personal look at the history of that time, Weimer recommends the book, "A Look Back: The D-J Play, 1950-1965" which was published in 1998 by R.E. Chancellor and A. A. McGregor. "It is an interesting collection of personal reminiscences," Weimer said. "They do a good job of describing what these people



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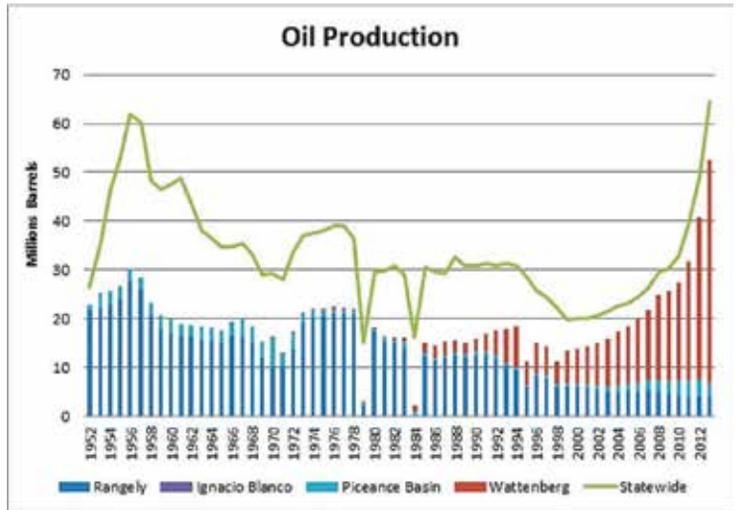
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Between 1952 and 2013, the Wattenberg Field overtook the Rangely Field as a major contributor to Colorado's total annual oil production.

went through, what the risks were that they took, what it meant to be successful, and what it meant to go broke.”

The market played a significant role in Colorado's 2013 production record as well. EIA data indicates the price of oil in 2013 was \$95.99 per barrel, which, at that time, was the highest price per barrel ever recorded.

This past year has been an extremely volatile year for oil prices, with the West Texas Intermediate crude oil benchmark exceeding \$100 per barrel in July, and then dropping to below \$70 per barrel in December 2014. The price drop came so late in the year, it may not have a significant impact on Colorado's final 2014 production numbers, but could make a difference in 2015.

THE ROLE OF TECHNOLOGY

The third factor critical to oil production records is the technology used to access the oil.

When the first deep well - the Raven A-I - was drilled in the Rangely Field, it took nearly two years to break through the Weber sandstone.

“The thick, thousand foot Weber sandstone reservoir was a very difficult reservoir to drill with the tools available at that time,” said Weimer. “They developed a new innovation of drilling the wells through this interval to depths of 5,000 to 6,000 feet, by drilling and coring with diamond bits. The diamond, being a very hard substance, was able to drill that economically. Whereas the other type rotary bits were not very effective.”

In addition to the bits, other oilfield technologies, such as pumping equipment, evolved as well.

Ken Bailey, an amateur photographer who attended high school in Rangely during the late 1960s and early 1970s, watched with fascination as the oil field technology in Rangely evolved over time. In his photographs, he documented the evolution of the pumping equipment as it changed from conventional pumping equipment, like the Lufkin 64 used at the Raven A-I Discovery site, to replacement equipment designed for secondary (water flooding) and tertiary (carbon dioxide flooding) recovery phases in the field.

“Back when Rangely still had hundreds of these walking beam pumpers, the great majority of them were running on internal combustion engines, so they made a chugging or a rumbling sound,” Bailey remembered. “The town was at one end of the field, and at night when the air was clear, the hundreds of pumps in the field made a kind of distant rumbling sound that actually was rather soothing.”

“The Rangely Field today is vastly different from the era of my photographs,” Bailey said. “Today most of the wells are pumped by

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"In fact, the latest uptick in production is all related to technological changes."

DR. STEVE SONNENBERG, professor, Colorado School of Mines

electric pumps underground and there is no sound at all. A person driving through Rangely Field today would be lucky to see any pumps. There is not much on the surface but tanks and buildings."

Just as the development of diamond bits and more efficient pumps has enabled the Rangely Field to be produced more effectively, the development of horizontal drilling and hydraulic fracturing has enabled the Wattenberg Field to be produced more efficiently and economically.

"The technology always advances through time," said Sonnenberg. "There were deep wells drilled in the 1950s, but when we got into the '60s, '70s and '80s, the drilling technology dramatically improved and enabled wells to be much deeper. The bits improved, the rigs improved, everything improved through time."

"Technology plays a huge role in production," Sonnenberg said. "In fact, the latest uptick in production is all related to technological changes. And the largest part of that is horizontal drilling and multi-stage hydraulic fracturing."

THE OUTLOOK GOING FORWARD

The Rangely field has been steadily producing oil for nearly 70 years, when primary production, secondary production and tertiary production are taken into account.

Thom Kerr notes that between 1952, when the COGCC started keeping statistics, and the first part of 2014, the Rangely Oil Field has produced a cumulative total of 783.6 million barrels of oil.

The Wattenberg, which started producing oil in 1970, has produced a cumulative total of 296.1 million barrels of oil. That is equivalent to 38 percent of Rangely's total production. Considering the fact that Rangely had at least a 20-year headstart, "Wattenberg's production is phenomenal," said Kerr.

Is it possible that the Wattenberg Field will see the same long life that the Rangely Field has had?

According to Kerr, that answer is yet to be determined.

"Rangely and Wattenberg are completely different plays," Kerr said. "All reservoirs function on porosity and permeability. In the conventional reservoir, like Rangely, you have much greater porosity and permeability. So in the initial phase of production, you may recover 20-25 percent of the oil in place. And then you start secondary recovery, typically water floods. And then you go to the next phase, tertiary recovery, which is an even more enhanced process, using CO₂ or heat or some other methodology.

"What you are trying to do is to get your recovery factor up. Ultimately, the recovery in Rangely, of the total oil in place, may be 50 percent, or 60 percent if they are really lucky," Kerr said. "But the Wattenberg is not a conventional reservoir, so the porosity and permeability are not in place there for a well to produce on traditional methods, such as reservoir pressure and pumping. It requires additional technology. It requires artificial stimulation, which is hydraulic fracturing."

And as for the potential total recovery from an unconventional reservoir, Kerr said, "that is what they are still trying to figure out and learn." ♦

Keith Beamer

970-397-3779 • 207 1st St. Kersey, CO
kbeamer@kboilttoolsllc.com

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Oil Tools, LLC