Kansas Coalbed Natural Gas
Coal bed methane (CBM) constituted 9.7% of Kansas annual gas production in 2014 (down from 10.5% of total Kansas gas production in 2013). 2014 CBM production for Kansas was 27.82 billion cubic feet (BCF) (Figure 1).

The peak of Kansas annual CBM production (49.14 BCF) was in 2008 (Figure 1). CBM annual production declined 2.2% from 2008 to 2009, 10.5% from 2009 to 2010, 5.8% from 2010 to 2011, 11.9% from 2011 to 2012, and 13.3% from 2012 to 2013. The number of wells reporting production during 2014 decreased by 44 wells from 2013 (Figure 1). CBM production in Kansas is principally in four counties in the southeastern part of the state (Figure 2).

Cumulatively, approximately 411 BCF of natural gas in eastern Kansas has been produced since 2001, which is the year southeastern Kansas gas production started rising dramatically (see Figure 1). The overwhelming majority of southeastern Kansas gas being produced is due to CBM. CBM production data for Kansas, and associated links, can be found on the Kansas Geological Survey (KGS) website: http://www.kgs.ku.edu/PRS/petroDB.html.
Figure 1 – Eastern Kansas Gas Production (overwhelmingly due to CBM) and the number of producing CBM wells reported annually (in blue), and total annual production divided by the total number of CBM wells (in green).
Figure 2 – Locations of sections (nominally 1 square mile) in eastern Kansas with record of CBM production (red) and sections with at least one well drilled for CBM, but with no production recorded (gray). Major gas pipelines are in orange (after Newell and Yoakum, 2010).
Most CBM in southeastern Kansas is from Middle and Upper Pennsylvanian high-volatile B and A rank bituminous coals. Almost all wells are vertical and have multiple completions.

To date (August 2014), 7849 wells have been reported spudded for CBM in eastern Kansas (Figure 3). The peak for drilling was in 2006, and drilling has languished since 2008. The drastic price decline for natural gas since the last half of 2008 and the economic slowdown in the USA continues to affect CBM and drilling at-large for natural gas in Kansas.

Twelve wells were drilled in 2014 in Kansas for CBM, and only 4 new CBM wells were reported for 2013. Operators drilling wells in 2014 are:

- LR Energy, Inc. (5 wells)
- Dart Cherokee Basin Operating Co., LLC (4 wells)
- Cherokee Wells, LLC (1 well)
- Magnum Exploration Kansas LLC (1 well)
- Running Foxes Petroleum, Inc. (1 well)

CBM production data has PostRock Energy, LLC recording the greatest CBM production for any operator in Kansas in 2014 at 14.2 BCF (compared to 15.6 BCF in 2013). Dart Cherokee Basin Operating Co. (4.6 BCF in 2014; 5.3 BCF in 2013) and Layne Energy Operating (2.9 BCF in 2014; 3.4 BCF in 2013) follow. In light of this decrease in gas production, and considering the better price commanded by oil in recent years, several operators changed their business model and reviewed data from their CBM wells with effort directed to find previously overlooked or ignored oil accumulations. The drop in oil price in the latter part of 2014 no doubt has put a damper on the drilling for oil in regions dominated by CBM.
The KGS continues to partner with industry to pursue additional CBM-related research. Ongoing research has focused on the gas content of coals and shales, the isotope chemistry and composition of produced gases, and production characteristics. The KGS has received grants from industry participants several times to core scientific test holes and recover coals and shales for desorption studies, utilizing the Survey wireline drilling rig and desorption laboratory. Other research partnerships are always welcomed.

**Kansas Coal**

Kansas coal production for 2013 totaled 24,994 short tons. Kansas coal production for 2014 totaled 69,671 short tons, based on coal tonnage information from the Surface Mining Section of the Kansas Dept. of Health and Environment. Coal production was from three small surface mines in southeastern Kansas. Of this total, 49,573 tons were produced from the Continental Coal Company Lucky Strike Mine in eastern Linn County (Figure 4), where the company resumed mining of Kansas coal after a number of years across the state line in Missouri. The Phoenix Coal Company finished their mining of Kansas coal at their Garland Mine with a 2014 production total of 16,793 tons in southeastern Bourbon County. The Mulberry Limestone Company produced 3,305 tons of coal from a multi-product mine in northeastern Crawford County. The last year Kansas produced at least one million tons of coal was 1987, and the last year the state produced at least 100 thousand tons of coal was 2010.

Kansas coal in recent years is used mainly as a blending fuel with western coal from Wyoming for local power generation in eastern Kansas and western Missouri. During
2012, Empire Electric Company’s Asbury power plant (Asbury, MO) blended 7.3% local coals with 86.8% Powder River Basin coal.

![Map of Kansas showing coal mines and power plants](image)

**Figure 4** – Coal mines in Kansas, and Asbury power plant, and location for the proposed Sunflower power plant in Holcomb, KS.

**Proposed Coal-Fired Power Plant in Kansas**

The proposed power plant has been the center of legal disputes for over 6 years. The $2.8 billion project involves construction of an 895-megawatt coal-fired plant to be operated by Hays, KS-based Sunflower Electric Power Corp. in southwestern Kansas, next to an existing coal-fired plant near the town of Holcomb (Figure 4). The plant will have the capacity to power approximately 500,000 homes, and Tri-State Transmission and Generation Association Inc. of Westminster, CO (an electricity wholesaler) would get 75% of the power for customers in Colorado.

In August 2012, the Kansas Supreme Court heard arguments regarding a brief filed by Earthjustice, which represented the Sierra Club of Kansas. The litigation was regarding a 2010 permit issued by the Kansas Department of Health and Environment (KDHE) for the proposed power plant. The Sierra Club attempted to block construction of the power plant, alleging that the permit issued by the KDHE did not comply with the Clean Air Act. Conversely, KDHE and Sunflower Electric maintained the permit met all state and federal requirements.

The court issued a decision in early October 2013 and overturned the project’s permit, stating that KDHE failed to apply Environmental Protection Agency regulations on pollution emissions that had become effective several months before the permit had been issued. The court thus sent the case back to the KDHE, telling the agency that
the permit must comply with one-hour emission limits for nitrogen dioxide and sulfur dioxide.

In a separate lawsuit, in late January, 2012, U.S. District Court Judge Emmett Sullivan in Washington, D.C. handed down a ruling that the Rural Utilities Service of the federal government, which was financially supporting the Sunflower project, failed to consider environmental impacts of the plant. The Rural Utilities Service was directed not to issue any approvals or consents related to the construction of the power plant until a new Environmental Impact Statement was completed.

Sunflower Electric maintained that the company would “continue to take the steps necessary to preserve and advance the project”, and as a result of their efforts to amend the 2010 permit, the KDHE in May 2014 approved the permit only days before the federal government was expected to announce new rules for utilities designed to curb greenhouse gas emissions. The Sierra Club, through Earthjustice, followed-on in June 2014 with a lawsuit filed with the state Court of Appeals alleging that the KDHE did not adequately impose limits on various pollutants that will be produced by the plant, including mercury, nitrogen dioxide, and sulfur dioxide. In addition, the lawsuit alleges that carbon dioxide emissions by the plant would not meet federal air-quality standards that the state is required to enforce. Litigation thus continues.

**Horizontal Wells and the Mississippian Limestone Play**

Although about 1000 horizontal wells have been drilled in Kansas over several decades, 2010 marked the beginning of a new era in drilling where staged massive hydraulic fracturing was extensively utilized in long-reach horizontal wells. Most horizontal wells since 2010 have been drilled to access poorly drained reservoir compartments and low-permeable oil zones in Mississippian carbonates in southern Kansas, particularly in the tier of counties immediately north of the Oklahoma state line. This new engineering and geological play is dubbed the Mississippian Lime(stone) Play, or MLP.

Some companies, including Chesapeake Energy, Shell Oil Gulf of Mexico, EnCana Oil and Gas (USA), and Apache Oil, gained acreage positions in Kansas, but then stated after initial drilling that that they would not pursue the play any more in the state. In February 2014, Tapstone Energy LLC (Oklahoma City, OK), a company founded by erstwhile SandRidge-Energy CEO Tom Ward, agreed to buy Shell’s Kansas assets and leases (~600,000 acres). SandRidge Energy (Oklahoma City, OK), Unit Petroleum (Tulsa, OK), and Woolsey Petroleum (Wichita, KS) are active in the play, as are several other independents from Oklahoma, Texas, Kansas, and Colorado. Reductions in the price of oil in late 2014, however, have scaled back drilling of all wells in Kansas, including horizontals wells targeting the Mississippian.

The number of intents-to-drill, which are posted on the website of the Kansas Corporation Commission (KCC), can aid in monitoring of the types of wells that are soon to be drilled in Kansas. As indicated by the intents-to-drill, the number of horizontal wells in the southern part of the state rapidly increased in 2011 and early 2012, and has remained relatively constant until the last four months of 2014 (Figure 5).
Permits dropped in the late months of 2014 in the southern tier of counties north of the Oklahoma state line. No permits for horizontal wells have been filed in the western counties (shown in blue in Fig. 5) in 2015. Horizontal wells in Trego County have mostly targeted Pawnee Limestone and Marmaton pay zones instead of Mississippian strata.
INTENTS-TO-DRILL for HORIZONTAL WELLS in SOUTHERN and WESTERN KANSAS
(half-month time increments - May 2011 through mid-April 2015)

NUMBER OF INTENTS-TO-DRILL FOR HORIZONTAL WELLS IN WESTERN KANSAS

NUMBER OF INTENTS-TO-DRILL IN A SIX-COUNTY TIER ALONG THE OKLAHOMA STATE LINE

(HORIZONTAL INTENTS IN RED, ALL INTENTS IN GRAY)

PERCENTAGE OF INTENTS THAT ARE HORIZONTAL WELLS

Figure 5 – Intents-to-drill for Kansas counties immediately north of the Oklahoma state line (in red), and western Kansas (in blue).
As of December 2014 (and since September 2010), 738 horizontal wells have been drilled in Kansas, not counting a few miscellaneous gas-storage, salt-water-disposal, CBM, Niobrara, and Hugoton-Field horizontal wells. 70 wells, the majority of which are recently drilled, have yet to report any production, but are still active. 527 of these wells have had some recorded oil or natural gas production (Figure 6). 17 of these producing wells have been officially plugged and abandoned. 69 wells have had no production reported and have been plugged or approved for plugging.

**Horizontal Wells in Kansas (post-2009)**

![Map of Kansas showing horizontal wells](image)

Figure 6 – Modern horizontal wells in Kansas. Most horizontal wells in the southern tier of counties in the state are targeting the Mississippian.

Examination of production in the first 113 MLP horizontal producing wells in Kansas by Newell and others (2014) indicates average monthly production one year after the peak month will be on the order of 25% of the peak month. Monthly production declines continually decrease the longer a well is produced. The initial rapid declines are collective expressed as a drastic decrease in production with wells drilled annually (Figure 7). If MLP wells cost about $3,000,000 to drill and complete, only one-fourth of the MLP horizontal wells are projected to recoup these costs with 2 years production.

The most prolific Kansas MLP horizontal well with respect to cumulative production is the SandRidge Bernice #1-17H well in sec. 17-T.35S.-R.07W. in Harper County just north of the Oklahoma state line. In 27 months (production reported through November 2013), this well produced 200,326 bbls of oil and 932,037 thousand cubic feet (mcf) of
natural gas (gross income ~$20.1 million). No production has been reported for this well since September 2013, and in October 2014 the KCC approved an application filed for its temporary abandonment. The second-most prolific MLP well (gross income ~$18.3 million) is the SandRidge Dean 3408 #1-27 well in sec. 27-T.34S.-R.08W, Harper County, with only 7 months production. Third is the SandRidge Lake #1-21H well in sec. 21-T.34S.-R.06W. in Harper County (~$18.1 million with 37 months production). Fourth is the SandRidge Lori #1-21H well in sec. 02-T.35S.-R.10W. in Barber County with a gross income ~$15.4 million in 34 months. The respective gross incomes are inferred from a simple multiplication of the monthly product price (published by the federal Energy Information Agency) times the respective monthly volumes of oil and gas (reported by the operator to the KCC).

Figure 7 – Production from modern horizontal wells in KS. 527 wells, 511 of which target the MLP, reported production as of December 2014.

In terms of monthly production in BOE (barrels of oil equivalence), in which natural gas is mathematically converted to barrels of oil with an approximate energy-equivalence of
6000 cubic feet equal to 1 barrel of oil, six wells stand apart with production greater than 1000 BOE/day (see Table 1). The nearest well after these six wells comes in at 883 BOE/day. The price discrepancy between natural gas and oil (where 6000 cubic feet of natural gas costs approximately \(\frac{1}{4}\) of its energy-equivalent one barrel of oil) affects the relative economic importance of these wells. Wells with greater liquids production fortuitously produced in months when oil prices are high (for example, the SandRidge Dean 3408 #1-27H well (Table 1) thus score high in a ranking based on monthly gross income.

**TABLE 1 – Most prolific monthly production for Mississippian horizontal wells**

<table>
<thead>
<tr>
<th>WELL and location</th>
<th>Mo. of prod.</th>
<th>Date</th>
<th>Monthly OIL (bbls/day)</th>
<th>Monthly GAS (mcf/day)</th>
<th>Monthly BOE (bbls/day) [6000 cf = 1 BOE]</th>
<th>Projected Income (monthly price (\times) monthly volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SandRidge Dean 3408 #1-27H 27-T34S-R08W, Harper Co.</td>
<td>4th</td>
<td>Sept 2014</td>
<td>1876</td>
<td>3341</td>
<td>2295</td>
<td>$5,164,204</td>
</tr>
<tr>
<td>SandRidge Lori #2-2H 02-T35S-R10W, Barber Co.</td>
<td>2nd</td>
<td>June 2012</td>
<td>238</td>
<td>7061</td>
<td>1415</td>
<td>$1,082,348</td>
</tr>
<tr>
<td>SandRidge Lori #1-2H 02-T35S-R10W, Barber Co.</td>
<td>2nd</td>
<td>April 2012</td>
<td>582</td>
<td>3576</td>
<td>1178</td>
<td>$1,895,746</td>
</tr>
<tr>
<td>SandRidge 3404 Peter #1-20H 20-T34S-R04W, Sumner Co.</td>
<td>3rd</td>
<td>Sept 2013</td>
<td>844</td>
<td>1753</td>
<td>1136</td>
<td>$2,714,390</td>
</tr>
<tr>
<td>SandRidge Bernice #1-17H 17-T35S-R07W, Harper Co.</td>
<td>5th</td>
<td>Dec 2011</td>
<td>849</td>
<td>1603</td>
<td>1116</td>
<td>$2,500,850</td>
</tr>
</tbody>
</table>

In December 2014 (the most recent publication of production data) 511 MLP horizontal wells (and 16 additional horizontal wells targeting other geological formations), constituted 13.7% of Kansas monthly oil and gas production (Figures 7, 8). This percentage has increased from 8.7% recorded in December 2013. The remaining 86% of oil and gas production in the state is from approximately 53,400 oil wells and 24,700 gas wells.

According to KCC and KGS data, in 2014 SandRidge produced 3,332,592 bbls of oil from 382 wells and 27,447,303 mcf of natural gas from 340 wells, making the company #1 in oil production with 6.7% of the total oil production in the state. In 2013 SandRidge was also #1 in oil production in Kansas, with production of 2,222,905 bbls, which translated to 5.6% of the total oil production in the state. In 2012, they were in 6th place with 995,091 bbls annual production, which was 2.5% of the total oil production in the state.

With respect to natural gas in 2014, SandRidge was in 2nd place with 9.6% of total gas production in Kansas. The #1 producer -- Linn Operating, Inc. -- and #3 ExxonMobil,
and #4 OXY USA, are all major producers in the giant Hugoton-Panhandle Field in western Kansas. In 2013 SandRidge was in 4th place with 20.27 BCF production (6.9% of total gas production in Kansas). In 2012 SandRidge was in 8th place, with 9.40 BCF production (2.5% of total gas production in Kansas).

New horizontal wells in Kansas in December 2014 produced 504,993 bbls of oil and 3,723,418 mcf of natural gas. Overall gas-oil ratio (GOR) for that month is 7.37 mcf/bbl. Cumulative production for the horizontal wells since September 2010 is 9,486,764 bbls and 73,215,861 mcf of natural gas. The cumulative GOR (7.72 mcf/bbl) indicates that 56% of the energy production from the new Kansas horizontal wells is attributed to natural gas. Most of this natural gas is associated with oil production. The cumulative production of the new horizontal wells since September 2010 represents ~$1,084 million in gross income.

Production reports acquired by the KCC and subsequently published on the KGS website are subject to a four-month time lag. As of December 2014, there have been 527 horizontal wells in Kansas that have produced oil or gas since September 2010. Operators for these 527 wells are:

<table>
<thead>
<tr>
<th>PRODUCING WELLS</th>
<th>COMPANY</th>
</tr>
</thead>
<tbody>
<tr>
<td>347</td>
<td>SandRidge Energy</td>
</tr>
<tr>
<td>41</td>
<td>Shell Gulf of Mexico/Tapstone Energy</td>
</tr>
<tr>
<td>37</td>
<td>Unit Petroleum</td>
</tr>
<tr>
<td>14</td>
<td>Source Energy Midcon</td>
</tr>
<tr>
<td>13</td>
<td>Woolsey Operating</td>
</tr>
<tr>
<td>13</td>
<td>Osage Resources</td>
</tr>
<tr>
<td>10</td>
<td>Tug Hill Operating</td>
</tr>
<tr>
<td>6</td>
<td>Chesapeake Operating</td>
</tr>
<tr>
<td>6</td>
<td>Samuel Gary Jr. &amp; Assoc.</td>
</tr>
<tr>
<td>5</td>
<td>Dorado E&amp;P Partners</td>
</tr>
<tr>
<td>5</td>
<td>McElvain Energy</td>
</tr>
<tr>
<td>30</td>
<td>(20 other companies, none with more than 4 wells)</td>
</tr>
</tbody>
</table>

Kansas oil production has generally increased since 2010 despite the additional production supplied by the new horizontal wells. Conversely, natural gas production in Kansas has generally decreased despite the additional production supplied by the new horizontal wells (Figure 8). This drop in natural gas production in Kansas is largely due to the relatively low price commanded by natural gas in recent years (ergo, fewer natural-gas wells and completions) and the depletion of the giant Hugoton-Panhandle Field. Natural gas and oil production in Kansas are virtually equivalent with regard to the energy content of each of these commodities (Figure 8), but the income produced by the natural gas is presently only a fraction (~1/4) of that of the oil. Production reductions are anticipated with the price drops for crude oil in late 2014.
Figure 8 – Kansas oil and gas production, with contribution from the 527 new horizontal wells. Scales are energy-equivalent.

Prolific MLP horizontal wells also produce prolific amounts of saltwater. This waste water is sent into the Arbuckle Group, which historically accepts large volumes of oil field brine and other industrial waste. Since 2013, however, eastern Harper County and western Sumner County have experienced several shallow earthquakes that are suspected to have been triggered by the prolific amount of production water sent to the Arbuckle (Figure 9). The seismicity is penecontemporaneous and geographically contiguous with a zone of recent earthquakes that continues south to Oklahoma City. Although cause-and-effect is disputed by oil producers, the Kansas Corporation Commission in March 2015 ordered limits on underground oil wastewater disposal in five “areas of seismic concern” in Harper and Sumner counties. After 100 days, disposal will be limited to 8000 bbls per well per day.
Figure 9 – Recent Kansas seismicity in eastern Harper and western Sumner counties (orange dots in southern Kansas) was the target of a March 2015 ruling by the Kansas Corporation Commission to locally limit the volume of oilfield brine injected into the Arbuckle Group. (Map courtesy of Shelby Peterie, Kansas Geological Survey).

References Cited