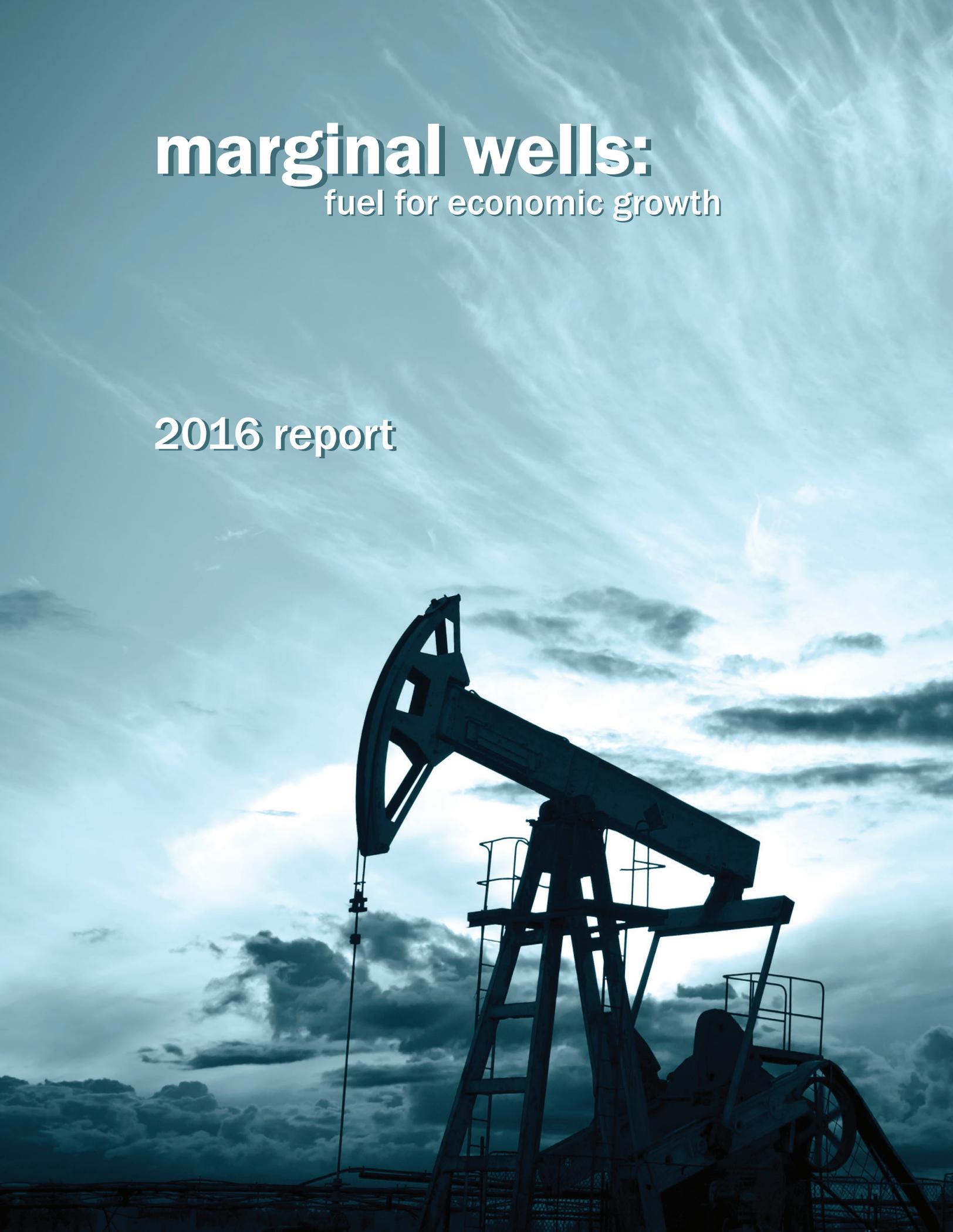


marginal wells: fuel for economic growth

2016 report



About the Interstate Oil and Gas Compact Commission

The Interstate Oil and Gas Compact Commission (IOGCC) is a multi-state quasi government agency that promotes the conservation and efficient recovery of our nation's oil and natural gas resources while protecting health, safety and the environment. The IOGCC consists of the governors of 38 states (30 members and eight associate states) that produce almost all of the onshore oil and natural gas in the United States. Chartered by Congress in 1935, the organization is the largest interstate compact in the nation. The IOGCC assists states in balancing interests through sound regulatory practices. These interests include: maximizing domestic oil and natural gas production, minimizing the waste of irreplaceable natural resources and protecting human and environmental health. The IOGCC also provides an effective forum for government, industry, environmentalists and others to share information and viewpoints, allowing members to take a proactive approach to emerging technologies and environmental issues. For more information, visit iogcc.ok.gov or call (405) 522-8380.

Acknowledgements

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Introduction

The Interstate Oil and Gas Compact Commission (IOGCC) champions the preservation of this country's low-volume, marginally economic wells. The IOGCC recognizes that it goes to the heart of conservation values to do all that is possible to productively recover the scarce oil and natural gas resources marginal wells produce.

The IOGCC defines a marginal well as a well that produces 10 barrels of oil or 60 Mcf of natural gas per day or less. Generally, these wells started their productive life producing much greater volumes using natural pressure. Over time, the pressure decreases and production drops. That is not to say that the reservoirs which feed the wells are necessarily depleted. It has been estimated that in many cases marginal wells may be accessing a reservoir that stills holds two-thirds of its potential value.

However, because these resources are not always easily or economically accessible, many of the marginal wells in the United States are at risk of being prematurely abandoned, leaving large quantities of oil or gas behind.

In addition to supplying much-needed energy, marginal wells are important to communities across the country, providing jobs and driving economic activity. Today, as the nation ponders the solution to its energy challenges, the commission continues to tell the story of how low-volume producing wells can collectively contribute to a sound energy and economic future.

Definitions used in this report

Marginal Well. A producing well that requires a higher price per Mcf or per barrel of oil to be worth producing, due to low production rates and/ or high production costs from its location (e.g. far offshore; in deep waters; onshore far from good roads for oil pickup and no pipeline) and/or its high co-production of substances that must be separated out and disposed of (e.g. saline water, non-burnable gasses mixed with the natural gas). A Marginal Well becomes unprofitable to produce whenever oil and/or gas prices drop below its crucial profit point. On land, this is often but not always a stripper well.

Stripper Well. An oil well whose maximum daily average oil production does not exceed 10 bbls oil per day during any consecutive 12 month period. Often used interchangeably with the term “Marginal Well”, although they are not the same.

Temporary Abandonment. “Cessation of work on a well pending determination of whether it should be completed as a producer or permanently abandoned.”
(Williams & Meyers)

Idle Well. (1) A well that is not producing or injecting, and has received state approval to remain idle or (2) a well that is not producing or injecting, has not received state approval to remain idle, and for which the operator is known or solvent.
(IOGCC)

Plugged and Abandoned. Wells that have had plugging operations during the calendar year. Does not include wells that have been plugged back up-hole in order to kick the well, etc. This category does not necessarily exclude those with site restoration remaining to be completed.

Abbreviations

Oil

bbls = barrels

Mbbls = one thousand barrels (1,000 barrels)

MMbbls = one million barrels (1,000,000 barrels)

BOPD = barrels of oil per day

BOEPD = barrels of oil equivalent per day

MMBOE = million barrels of oil equivalent (1,000,000 barrels of oil equivalent)

Natural Gas

Mcf = one thousand cubic feet (1,000 cubic feet)

Bcf = one billion cubic feet (1,000,000,000 cubic feet)

MCFD = one thousand cubic feet per day (1,000 cubic feet per day)

MMCF = one million cubic feet (1,000,000 cubic feet)

MMCFD = one million cubic feet per day (1,000,000 cubic feet per day)

Source: Langenkamp, Robert D., ed. The Illustrated Petroleum Reference Dictionary. 4th ed. PennWell Books: Tulsa, 1994.

State Patterns of U.S. Oil and Natural Gas Production

The United States has enjoyed a remarkable rebound in the domestic production of both oil and natural gas the past decade. Recent U.S. Energy Information Administration (EIA) estimates suggest that annual natural gas production increased 52 percent from the recent bottom in 2005 to the peak in 2015. Domestic natural gas production reached an all-time high of 28.75 billion Mcf in 2015 before pulling back in 2016 under pressure from softening natural gas prices (see Figure 1).

The recent rebound in U.S. oil output is comparatively larger. Producers added 1.6 billion barrels of new oil production from the recent bottom in 2008 to the peak in 2015, an 88 percent rise (see Figure 2). Oil production in 2015 was only 2.5% below the all-time peak output level reached in 1970 before pulling back in 2016 in response to low oil prices.

Policy Implications

The sizeable gains in oil and natural gas production the past decade have important national policy implications. The strong rebound in domestic oil production has reduced the reliance of the U.S. economy on imported oil by about one-third, and exports of U.S. petroleum products have increased four-fold since 2008.¹

Rising U.S. natural gas production has allowed the increased use of natural gas in electricity production as well as sharp increases in use by the U.S. industrial sector.² Natural gas exports are also expanding very rapidly and are only at an early stage of development.³

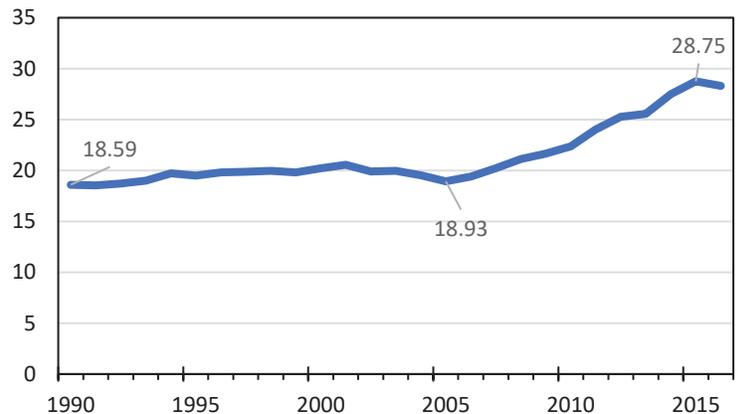
At the state level, the location where increasing oil and natural gas production is taking place remains of critical interest to policymakers and regional analysts. Large changes in oil and natural gas output at the state level often induce significant changes in regional economic activity, particularly in the key energy producing states and regions. Currently, thirty-four states produce either oil or natural gas while thirty-one produce both.

Largest Producing States

Figures 3 and 4, on the next couple of pages, detail the current ranks of the largest oil and natural gas producing

Figure 1. U.S. Natural Gas Production

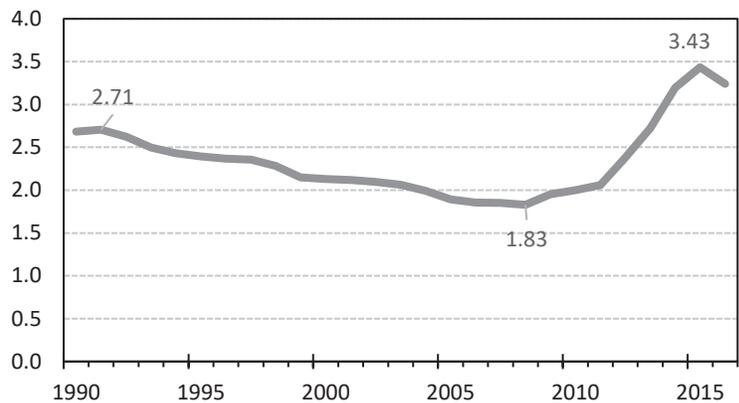
(billions of Mcf)



Source: U.S. EIA

Figure 2. U.S. Oil Production

(billions of barrels)



Source: U.S. EIA

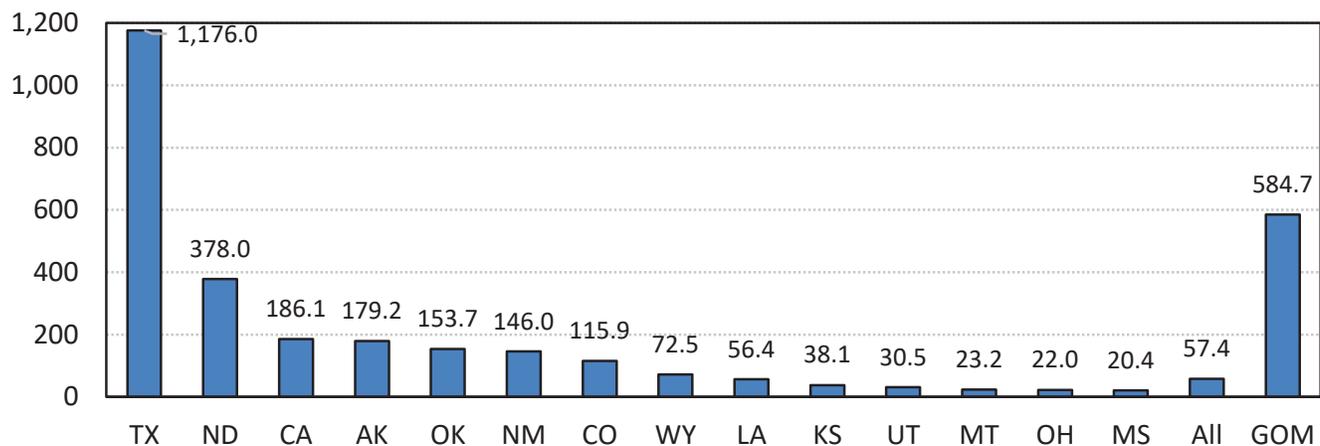
states and the degree to which each participated in the ongoing domestic energy resurgence. Both oil and natural gas production are shown in 2016 along with changes in production during the surge in the production of each fuel during the past decade.

Oil Production. In 2016, domestic oil production was reported in thirty-two states but remains largely concentrated in seven top-tier states (see Figure 3a). Texas remains the undisputed leader in oil output, producing 1.18 billion barrels in 2016, or more than one-third (36.3

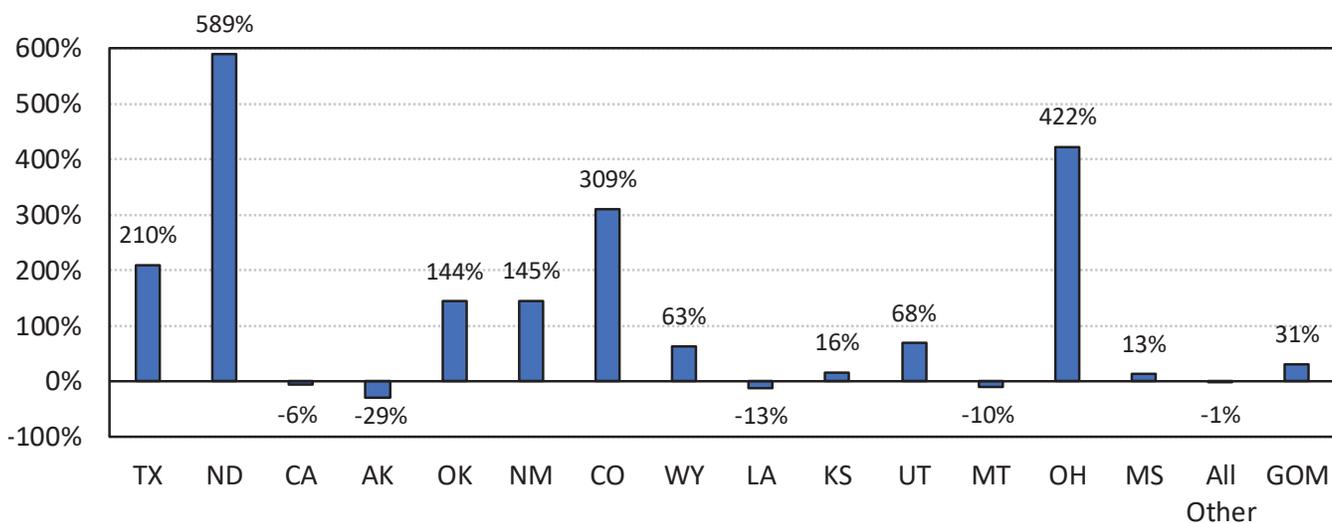
Figure 3. Production Trends in the Largest Oil Producing States

(millions of barrels, annual total)

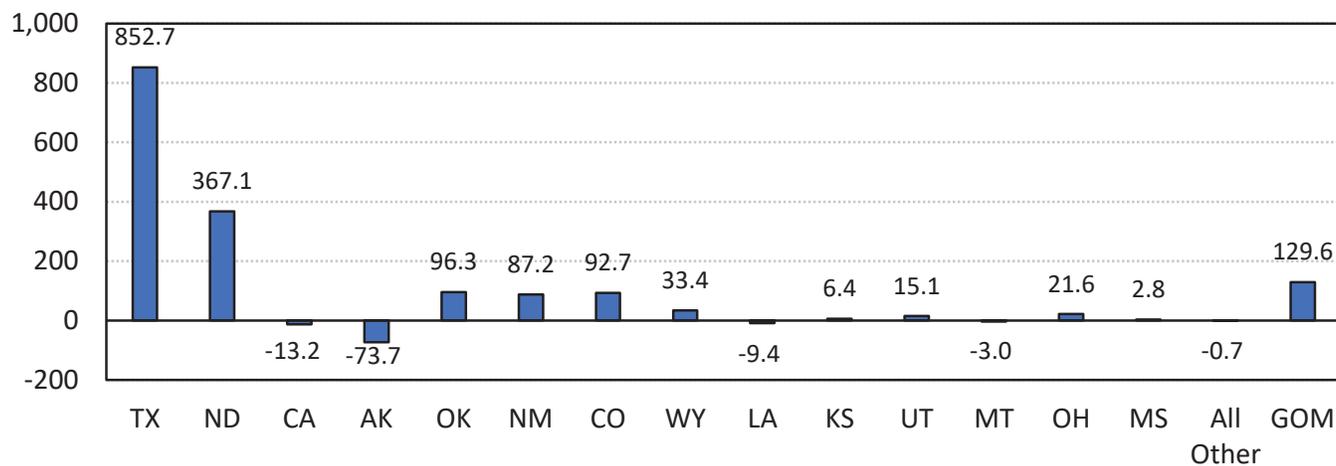
(a) Total Oil Production : 2016 (million barrels)



(b) Trough to Peak Percentage Change in Oil Production: 2008 - 2015



(c) Trough to Peak Change in Oil Production: 2008 - 2015 (million barrels)

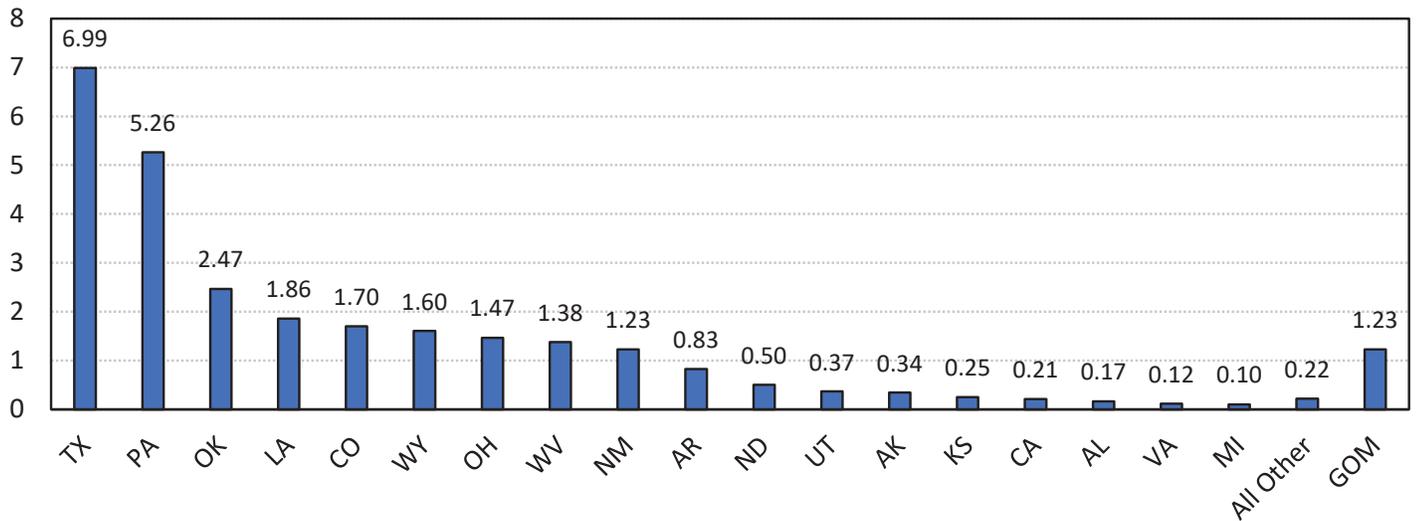


Source: U.S. EIA

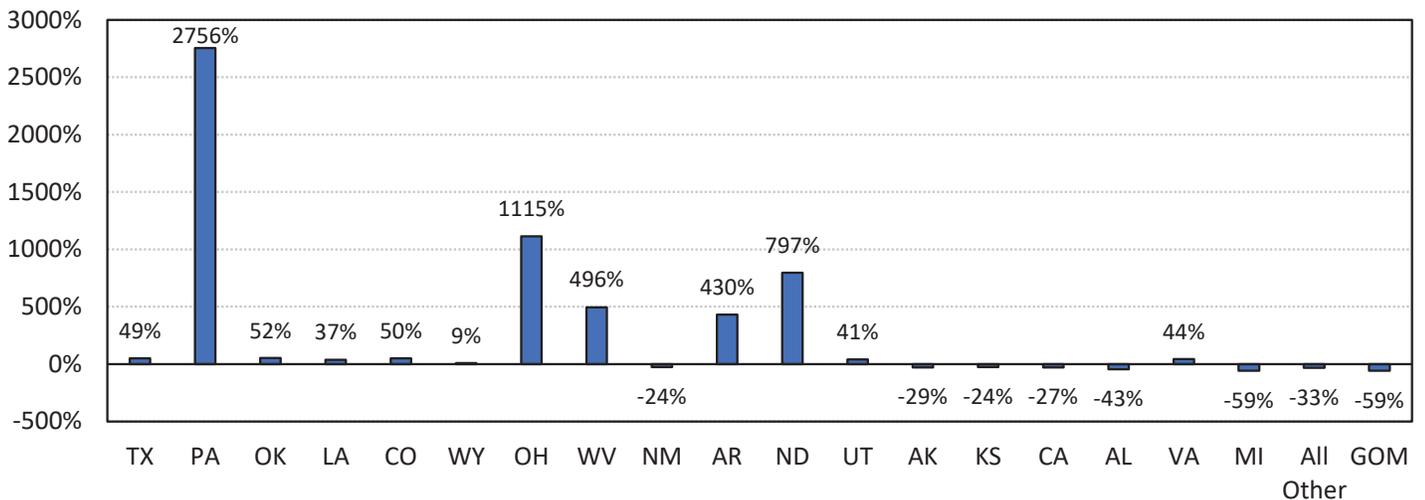
Notes: Includes the 14 states producing 20 million barrels of oil or more in 2016. GOM = Federal offshore production in the Gulf of Mexico.

Figure 4. Production Trends in the Largest Natural Gas Producing States

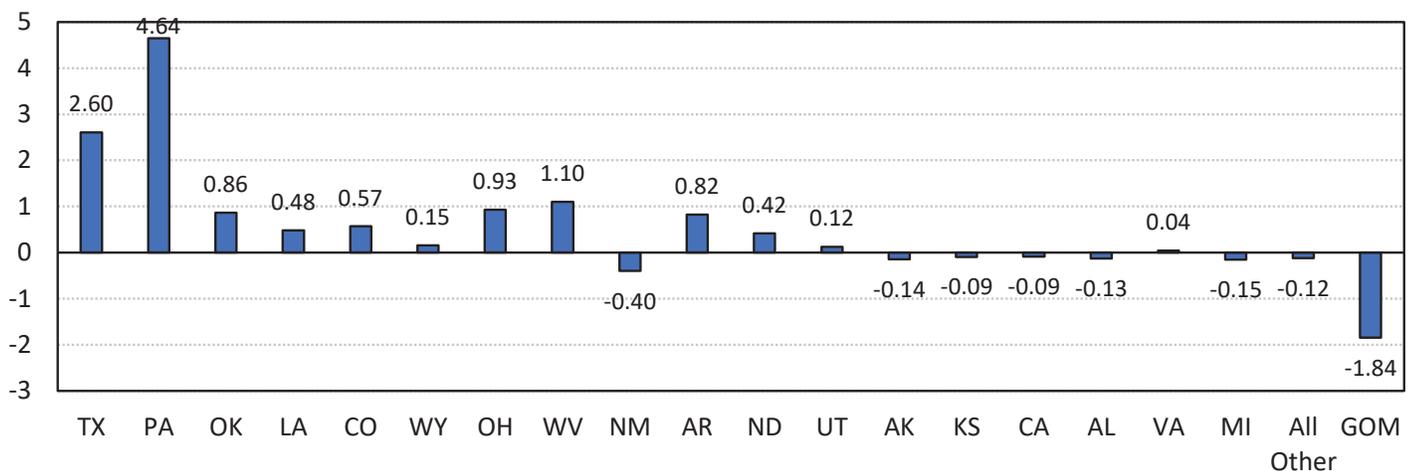
(a) Total Natural Gas Production : 2016 (billion Mcf)



(b) Trough to Peak Percentage Change in Natural Gas Production: 2005 - 2015



(c) Trough to Peak Change in Natural Gas Production: 2008 - 2015 (billion Mcf)



Source: U.S. EIA and RegionTrack

Notes: Includes the 18 states producing 100 million Mcf or more of natural gas in 2016. GOM = Federal offshore production in the Gulf of Mexico.

1.18 billion barrels in 2016, or more than one-third (36.3 percent) of total U.S. oil production. A second tier of six traditional energy-producing states – North Dakota, California, Alaska, Oklahoma, New Mexico, and Colorado – produced a combined 1.16 billion barrels of oil in 2016, capturing the same share of U.S. production as Texas. Among this second tier, North Dakota has assumed a strong second place ranking with 378 million barrels of oil production in 2016, or roughly one-third the output of Texas.

A third tier comprising seven smaller producing states – Wyoming, Louisiana, Kansas, Utah, Montana, Ohio, and Mississippi – reported a combined 263 million barrels in 2016, or 8.1 percent of total U.S. oil production. The remaining 18 states reporting oil production contributed a combined total of only 57.4 million barrels in 2016, less than 2 percent of national output. In addition to state-based production (both onshore and offshore), Federal offshore production in the Gulf of Mexico remains a key source of oil output with 585 million barrels produced in 2016, or 18 percent of total domestic oil production.

Natural Gas Production. Natural gas production occurred in 33 states in 2016 but was dominated by just two – traditional leader Texas (7.0 billion Mcf) and emerging leader Pennsylvania (5.3 billion Mcf) (see Figure 4a). These two states jointly produced 12.2 billion Mcf of natural gas, or 43 percent of total U.S. output in 2016. A second tier of seven traditional producing states – Oklahoma, Louisiana, Colorado, Wyoming, Ohio, West Virginia, and New Mexico – jointly produced an additional 11.7 billion Mcf of natural gas, or about 42 percent of total U.S. output. Each of these seven states produced more than 1 billion Mcf annually in 2016. The top nine states combined produced 85 percent of total U.S. natural gas output in 2016.

Nine additional smaller gas-producing states – Arkansas, North Dakota, Utah, Alaska, Kansas, California, Alabama, Virginia, and Michigan – comprise a third tier producing a combined total of 2.9 billion Mcf, or 10 percent of total domestic production. The remaining fifteen gas-producing states all produce less than 100 million Mcf each and combined to produce less than 220.1 million Mcf, or slightly less than 1 percent of total U.S. output in 2016. Federal offshore production in the Gulf of Mexico remains an important contributor with total production of 1.2 billion Mcf, or 4.3 percent of U.S. output in 2016.

Changes in State Production

A key question underlying the domestic production rebound the past decade is the degree to which each of

the oil- and natural gas-producing states participated in the production gains. Oil production gains were realized in the 2008 to 2015 period, while the surge in natural gas extended from 2005 to 2015.

Changes in Oil Production. For oil, twenty-one of the thirty-two producing states posted output gains during the recent surge in production between 2008 and 2015 (see Figure 3b). Six states produced unusually large percentage gains in oil production that contributed heavily to the 88 percent national gain in the period (see Figure 3a). North Dakota posted a nearly 600 percent increase, Ohio increased oil output by more than 400 percent, and Colorado posted a more than 300 percent gain in oil production. Other states that experienced a more than doubling of oil output between 2008 and 2015 include Texas (210 percent), New Mexico (145 percent), and Oklahoma (144 percent). While Utah and Wyoming posted strong gains of 68 percent and 63 percent, respectively, no other state posted a gain in oil production of more than 16 percent (Kansas) in the period.

However, when measured by the change in the number of barrels produced, Texas and North Dakota were the dominant contributors to the 1.6 billion barrels of net new oil production added in the U.S. between 2008 and 2015 (see Figure 3c). These two states jointly added 1.22 billion barrels in new output, or 76 percent of all new U.S. oil production added in the period. Texas alone accounted for 53 percent of the overall U.S. gain (852.7 million barrels) while North Dakota contributed 22 percent (367.1 million barrels).

Federal offshore production in the Gulf of Mexico was the third largest source of new oil with 129.6 million barrels added, or 8.1 percent of the total U.S. gain. Other states making a significant contribution to rising oil output include Oklahoma (96.3 million barrels), Colorado (92.7 million barrels), and New Mexico (87.2 million barrels). These three states contributed 17.2 percent of added oil output in the period. Wyoming (33.4 million barrels), Ohio (21.6 million barrels), and Utah (15.1 million barrels) are the only other states to add more than 10 million barrels to U.S. oil production between 2008 and 2015.

Only a handful of producing states experienced declining oil output in the 2008 to 2015 period. The most meaningful declines measured by the number of barrels produced occurred in Alaska and California. Alaska's annual production declined by 73.7 million barrels (30 percent decline) while California's output fell by 13.2 million barrels (6 percent decline). Other states with declines in annual oil production of more than 1 million barrels in the period include Louisiana (9.4 million), Montana (3.0

million), and Arkansas (1.6 million). Combined, the eleven states with declining output posted a loss of more than 101.0 million barrels in annual oil output between 2008 and 2015, with Alaska comprising roughly three-fourths of the loss.

Changes in Natural Gas Production. A group of five states posted the largest percentage gains in natural gas production in the surge period from 2005 to 2015 (see Figure 4b). Pennsylvania posted a remarkable 2,756 percent gain in production in the period, as the emergence of the Marcellus Shale quickly moved the state from a relatively small producer to the second largest among the states. Neighboring Ohio posted the second largest gain of 1,115 percent in the period, similarly vaulting the state from a very small producer to seventh largest. North Dakota posted the third largest increase in natural gas production at nearly 800 percent, exceeding its 600 percent gain in state oil output between 2008 and 2015. West Virginia and Arkansas also posted very large gains in natural gas output of 496 percent and 430 percent, respectively, between 2005 and 2015.

Six additional states produced important gains ranging from 37 percent to 52 percent. These include the traditional large producing states of Texas (49 percent), Oklahoma (52 percent), Louisiana (37 percent), and Colorado (50 percent) along with smaller producers Utah (41 percent), and Virginia (44 percent).

Significant percentage declines in natural gas production were also reported by six states between 2005 and 2015. New Mexico (-24 percent) is the only traditionally large producer to suffer a decline. Smaller producers with falling output in the period include Alaska (-29 percent), Kansas (-24 percent), California (-27 percent), Alabama (-43 percent), and Michigan (-59 percent). A large decline is similarly reported for offshore production in the Gulf of Mexico (-59 percent). Finally, all remaining producing states reported a combined decline of 33 percent from 2005 to 2015, though these states jointly produce less than 1 percent of total U.S. natural gas output. In total, 19 of 33 producing states reported declining production between 2005 and 2015.

However, when measured by the change in the total quantity of natural gas produced, gains in both Pennsylvania and Texas and losses in the Gulf of Mexico are the dominant sources of changing U.S. natural gas production (see Figure 4c). Of the 9.83 billion Mcf of net new natural gas production added in the U.S. between 2005 and 2015, Pennsylvania and Texas jointly added 7.25 billion Mcf, or 74 percent of net new U.S. natural gas production in the period. Pennsylvania alone accounted for 47 percent

of the overall U.S. gain (4.64 billion Mcf) while Texas contributed 27 percent (2.60 billion Mcf). Working to offset these gains, Federal offshore production in the Gulf of Mexico declined by 1.84 billion Mcf in the period.

Seven additional producing states contributed smaller but very meaningful net gains to U.S. natural gas output in the period including West Virginia (1.1 billion Mcf), Ohio (931.3 million Mcf), Oklahoma (860.3 million Mcf), Arkansas (819.7 million Mcf), Colorado (571.8 million Mcf), Louisiana (480.8 million Mcf), and North Dakota (418.9 million Mcf). In contrast, New Mexico is the only state that posted a meaningful decline in natural gas volume of 400.4 million Mcf. Five additional states – Arkansas, Kansas, California, Alabama, and Michigan – posted small losses of 150 million Mcf or less, with all ranked among the smaller producers.



Marginal Oil

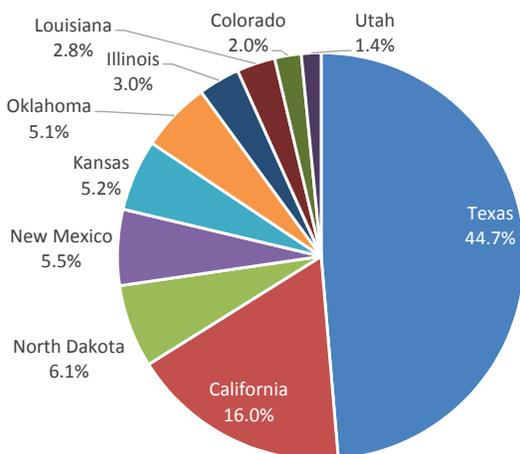
Table 3. National Marginal Oil Well Survey (2016)

State	Number of Marginal Oil Wells	Production from Marginal Wells (Bbls)	Average Daily Production per Well (Bbls)	Total Oil Production (Bbls)	Marginal Share of Total Production
Alabama	242	284,673	3.22	8,107,207	3.5%
Arizona	13	7,794	1.64	7,794	100.0%
Arkansas	4,072	2,738,067	1.84	5,470,299	50.1%
California	36,370	45,563,911	3.43	178,611,491	25.5%
Colorado	9,258	5,552,341	1.64	116,029,534	4.8%
Illinois	20,220	8,639,000	1.17	8,639,000	100.0%
Indiana	3,587	1,636,614	1.25	1,818,460	90.0%
Kansas	20,825	14,797,903	1.95	37,943,342	39.0%
Kentucky	25,875	2,205,238	0.23	2,594,398	85.0%
Louisiana	20,087	7,961,119	1.09	56,428,118	14.1%
Maryland	-	-	-	-	-
Michigan	2,341	3,162,524	3.70	6,445,857	49.1%
Mississippi	891	751,594	2.31	20,384,488	3.7%
Missouri	436	122,413	0.77	122,413	100.0%
Montana	2,738	1,884,086	1.89	23,186,799	8.1%
Nebraska	1,679	1,433,748	2.34	2,194,679	65.3%
Nevada	38	46,533	3.35	278,599	16.7%
New Mexico	16,678	15,747,393	2.59	144,875,588	10.9%
New York	3,528	220,901	0.17	220,901	100.0%
North Dakota	3,824	17,277,810	12.38	380,274,595	4.5%
Ohio	14,169	3,101,725	0.60	21,465,346	14.4%
Oklahoma	28,050	14,597,035	1.43	153,653,000	9.5%
Pennsylvania	21,136	1,256,283	0.16	6,306,000	19.9%
South Dakota	40	59,908	4.10	1,406,548	4.3%
Texas	150,929	127,242,392	2.31	1,147,663,408	11.1%
Utah	2,663	4,080,797	4.20	30,521,971	13.4%
Virginia	3	213	0.19	7,469	2.9%
West Virginia	2,985	690,217	0.63	10,415,347	6.6%
Wyoming	3,346	3,350,980	2.74	72,598,009	4.6%
Survey States	396,023	284,413,213	1.97	2,437,670,660	11.7%

State Rankings - Marginal Crude Oil (2016)

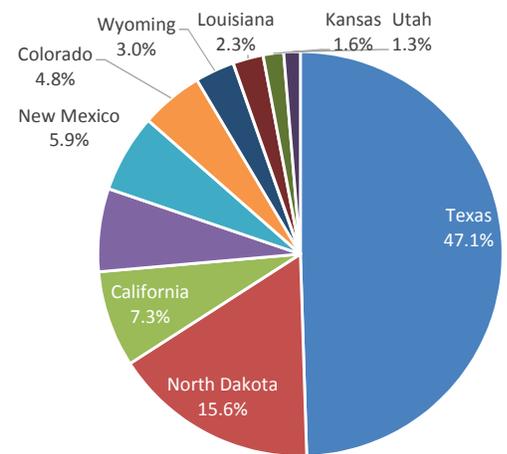
State	Number of Marginal Oil Wells	State	Production from Marginal Wells (Bbls)	State	Marginal Share of Total Production	State	Average Daily Production per Well (Bbls)
Texas	150,929	Texas	127,242,392	Arizona	100.0%	North Dakota	12.38
California	36,370	California	45,563,911	Illinois	100.0%	Utah	4.20
Oklahoma	28,050	North Dakota	17,277,810	Missouri	100.0%	South Dakota	4.10
Kentucky	25,875	New Mexico	15,747,393	New York	100.0%	Michigan	3.70
Pennsylvania	21,136	Kansas	14,797,903	Indiana	90.0%	California	3.43
Kansas	20,825	Oklahoma	14,597,035	Kentucky	85.0%	Nevada	3.35
Illinois	20,220	Illinois	8,639,000	Nebraska	65.3%	Alabama	3.22
Louisiana	20,087	Louisiana	7,961,119	Arkansas	50.1%	Wyoming	2.74
New Mexico	16,678	Colorado	5,552,341	Michigan	49.1%	New Mexico	2.59
Ohio	14,169	Utah	4,080,797	Kansas	39.0%	Nebraska	2.34
Colorado	9,258	Wyoming	3,350,980	California	25.5%	Mississippi	2.31
Arkansas	4,072	Michigan	3,162,524	Pennsylvania	19.9%	Texas	2.31
North Dakota	3,824	Ohio	3,101,725	Nevada	16.7%	Kansas	1.95
Indiana	3,587	Arkansas	2,738,067	Ohio	14.4%	Montana	1.89
New York	3,528	Kentucky	2,205,238	Louisiana	14.1%	Arkansas	1.84
Wyoming	3,346	Montana	1,884,086	Utah	13.4%	Colorado	1.64
West Virginia	2,985	Indiana	1,636,614	Texas	11.1%	Arizona	1.64
Montana	2,738	Nebraska	1,433,748	New Mexico	10.9%	Oklahoma	1.43
Utah	2,663	Pennsylvania	1,256,283	Oklahoma	9.5%	Indiana	1.25
Michigan	2,341	Mississippi	751,594	Montana	8.1%	Illinois	1.17
Nebraska	1,679	West Virginia	690,217	West Virginia	6.6%	Louisiana	1.09
Mississippi	891	Alabama	284,673	Colorado	4.8%	Missouri	0.77
Missouri	436	New York	220,901	Wyoming	4.6%	West Virginia	0.63
Alabama	242	Missouri	122,413	North Dakota	4.5%	Ohio	0.60
South Dakota	40	South Dakota	59,908	South Dakota	4.3%	Kentucky	0.23
Nevada	38	Nevada	46,533	Mississippi	3.7%	Virginia	0.19
Arizona	13	Arizona	7,794	Alabama	3.5%	New York	0.17
Virginia	3	Virginia	213	Virginia	2.9%	Pennsylvania	0.16
Maryland	0	Maryland	-	Maryland	-	Maryland	-
Survey States	396,023	Survey States	284,413,213	Survey States	11.7%	Survey States	1.97

Top 10 in Marginal Oil Production



Top 10 in Total Oil Production

State	Total Oil Production (Bbls)
Texas	1,147,663,408
North Dakota	380,274,595
California	178,611,491
Oklahoma	153,653,000
New Mexico	144,875,588
Colorado	116,029,534
Wyoming	72,598,009
Louisiana	56,428,118
Kansas	37,943,342
Utah	30,521,971



Comparative number of marginal oil wells and marginal oil well production 2012 - 2016

State	2012		2013		Number of Marginal Oil Wells
	Number of Marginal Oil Wells	Production from Marginal Wells (Bbls)	Number of Marginal Oil Wells	Production from Marginal Wells (Bbls)	
Alabama	275	425,567	284	440,183	288
Arizona	16	18,617	20	34,377	21
Arkansas	4,387	3,123,544	4,411	3,140,632	4,546
California	34,006	41,652,890	36,524	46,911,641	37,342
Colorado	10,405	10,039,715	10,685	8,289,694	10,626
Illinois	21,469	8,908,000	21,536	9,539,000	21,484
Indiana	4,323	2,115,032	4,351	2,158,967	4,360
Kansas	19,068	16,265,900	16,537	17,800,067	17,963
Kentucky	26,424	2,705,474	26,505	2,319,876	26,329
Louisiana	16,679	9,851,323	20,273	9,289,627	20,246
Maryland	-	-	-	-	-
Michigan	2,375	3,100,000	2,463	4,150,000	2,365
Mississippi	1,000	1,366,348	974	1,325,045	1,024
Missouri	412	175,369	463	198,871	458
Montana	2,788	2,192,351	2,839	2,122,406	2,834
Nebraska	1,553	1,545,886	1,617	1,544,109	1,678
Nevada	36	58,230	37	39,312	42
New Mexico	15,914	15,816,600	16,630	16,518,096	17,085
New York	3,386	347,780	3,694	366,262	4,028
North Dakota	2,587	11,215,102	3,080	17,334,985	3,093
Ohio	28,204	3,885,815	14,757	3,616,655	15,048
Oklahoma	29,167	16,103,475	28,895	15,798,476	28,623
Pennsylvania	20,498	1,982,529	20,150	1,747,552	24,833
South Dakota	28	45,090	38	56,506	34
Texas	142,726	114,190,108	148,363	118,172,917	151,691
Utah	2,352	3,485,740	2,437	3,533,456	2,559
Virginia	3	517	3	305	3
West Virginia	4,386	829,013	4,224	1,132,282	4,141
Wyoming	4,244	4,384,106	3,962	4,073,931	3,905
Survey States	398,711	275,830,121	395,752	291,655,231	406,649

2014		2015		2016	
Production from Marginal Wells (Bbls)	Number of Marginal Oil Wells	Production from Marginal Wells (Bbls)	Number of Marginal Oil Wells	Production from Marginal Wells (Bbls)	
444,348	283	403,595	242	284,673	
28,357	21	19,528	13	7,794	
3,235,615	4,658	3,315,331	4,072	2,738,067	
48,392,763	37,262	47,702,697	36,370	45,563,911	
8,339,626	9,992	5,829,735	9,258	5,552,341	
9,547,000	20,865	9,521,000	20,220	8,639,000	
2,255,918	4,320	1,996,902	3,587	1,636,614	
18,803,199	18,375	16,827,627	20,825	14,797,903	
3,270,565	26,192	2,289,229	25,875	2,205,238	
9,191,087	20,576	8,996,596	20,087	7,961,119	
-	-	-	-	-	
3,470,000	2,305	3,624,877	2,341	3,162,524	
1,337,570	992	1,170,601	891	751,594	
195,809	450	148,837	436	122,413	
2,173,566	2,880	2,047,732	2,738	1,884,086	
1,577,747	1,697	1,596,393	1,679	1,433,748	
62,580	43	69,285	38	46,533	
17,128,865	17,263	16,462,950	16,678	15,747,393	
355,505	3,629	284,316	3,528	220,901	
15,111,113	3,087	12,834,028	3,824	17,277,810	
3,519,097	14,778	3,304,838	14,169	3,101,725	
15,493,477	28,351	15,188,479	28,050	14,597,035	
2,050,989	21,284	1,423,504	21,136	1,256,283	
60,582	29	47,194	40	59,908	
125,217,363	152,376	126,659,423	150,929	127,242,392	
3,743,706	2,710	4,019,088	2,663	4,080,797	
1,321	3	958	3	213	
762,398	3,641	838,731	2,985	690,217	
3,995,200	3,141	3,291,306	3,346	3,350,980	
299,765,367	401,204	289,914,779	396,023	284,413,213	

Marginal Gas

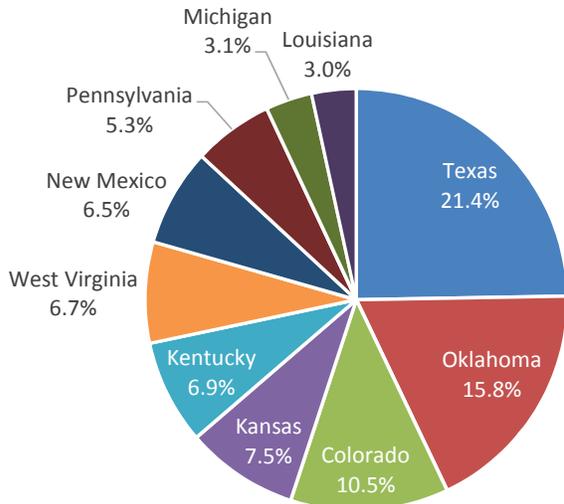
Table 4. National Marginal Gas Well Survey (2016)

State	Number of Marginal Gas Wells	Production from Marginal Wells (Mcf)	Average Daily Production per Well (Mcf)	Total Gas Production (Mcf)	Marginal Share of Total Production
Alabama	5,293	48,528,082	25.1	165,703,629	29.3%
Arizona	3	30,444	27.8	53,602	56.8%
Arkansas	3,312	30,673,961	25.4	829,447,402	3.7%
California	1,133	7,576,095	18.3	201,190,059	3.8%
Colorado	19,280	197,044,361	28.0	1,643,435,353	12.0%
Illinois	400	262,500	1.8	2,100,000	12.5%
Indiana	988	5,585,352	15.5	6,205,947	90.0%
Kansas	16,129	140,727,460	23.9	244,743,426	57.5%
Kentucky	19,300	130,323,250	18.5	173,764,333	75.0%
Louisiana	15,108	55,508,779	10.1	1,717,864,793	3.2%
Maryland	7	42,000	16.4	42,000	100.0%
Michigan	7,672	57,998,504	20.7	101,535,581	57.1%
Mississippi	1,424	1,275,677	2.5	47,553,881	2.7%
Missouri	-	-	-	-	-
Montana	5,338	25,050,840	12.9	52,308,293	47.9%
Nebraska	147	460,326	8.6	526,420	87.4%
Nevada	0	0	0.0	3,154	0.0%
New Mexico	14,341	121,678,670	23.2	1,276,117,173	9.5%
New York	6,673	8,008,961	3.3	13,445,545	59.6%
North Dakota	96	731,864	20.9	608,663,250	0.1%
Ohio	35,377	45,698,203	3.5	1,438,656,313	3.2%
Oklahoma	45,083	296,197,440	18.0	2,468,312,000	12.0%
Pennsylvania	67,731	99,609,644	4.0	5,216,827,756	1.9%
South Dakota	45	191,923	11.7	10,164,603	1.9%
Texas	56,412	402,462,615	19.5	8,140,325,026	4.9%
Utah	3,067	30,893,676	27.6	365,129,024	8.5%
Virginia	1,761	12,596,910	19.6	120,240,957	10.5%
West Virginia	51,243	126,030,034	6.7	1,347,619,374	9.4%
Wyoming	3,971	35,095,309	24.2	1,848,411,506	1.9%
Survey States	381,334	1,880,282,880	13.5	28,040,390,400	6.7%

State Rankings - Marginal Gas (2016)

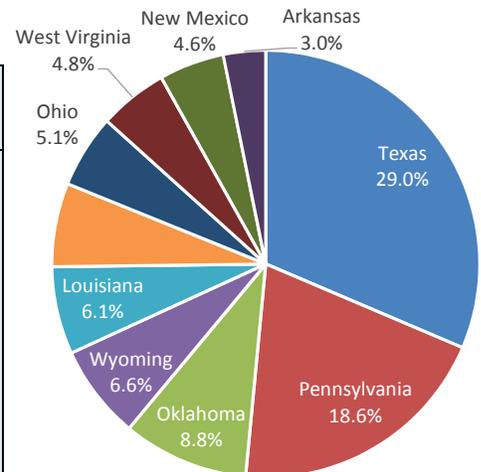
State	Number of Marginal Gas Wells	State	Production from Marginal Gas Wells (Mcf)	State	Marginal Share of Total Gas Production	State	Average Daily Production per Well (Mcf)
Pennsylvania	67,731	Texas	402,462,615	Maryland	100.0%	Colorado	28.0
Texas	56,412	Oklahoma	296,197,440	Indiana	90.0%	Arizona	27.8
West Virginia	51,243	Colorado	197,044,361	Nebraska	87.4%	Utah	27.6
Oklahoma	45,083	Kansas	140,727,460	Kentucky	75.0%	Arkansas	25.4
Ohio	35,377	Kentucky	130,323,250	New York	59.6%	Alabama	25.1
Kentucky	19,300	West Virginia	126,030,034	Kansas	57.5%	Wyoming	24.2
Colorado	19,280	New Mexico	121,678,670	Michigan	57.1%	Kansas	23.9
Kansas	16,129	Pennsylvania	99,609,644	Arizona	56.8%	New Mexico	23.2
Louisiana	15,108	Michigan	57,998,504	Montana	47.9%	North Dakota	20.9
New Mexico	14,341	Louisiana	55,508,779	Alabama	29.3%	Michigan	20.7
Michigan	7,672	Alabama	48,528,082	Illinois	12.5%	Virginia	19.6
New York	6,673	Ohio	45,698,203	Oklahoma	12.0%	Texas	19.5
Montana	5,338	Wyoming	35,095,309	Colorado	12.0%	Kentucky	18.5
Alabama	5,293	Utah	30,893,676	Virginia	10.5%	California	18.3
Wyoming	3,971	Arkansas	30,673,961	New Mexico	9.5%	Oklahoma	18.0
Arkansas	3,312	Montana	25,050,840	West Virginia	9.4%	Maryland	16.4
Utah	3,067	Virginia	12,596,910	Utah	8.5%	Indiana	15.5
Virginia	1,761	New York	8,008,961	Texas	4.9%	Montana	12.9
Mississippi	1,424	California	7,576,095	California	3.8%	South Dakota	11.7
California	1,133	Indiana	5,585,352	Arkansas	3.7%	Louisiana	10.1
Indiana	988	Mississippi	1,275,677	Louisiana	3.2%	Nebraska	8.6
Illinois	400	North Dakota	731,864	Ohio	3.2%	West Virginia	6.7
Nebraska	147	Nebraska	460,326	Mississippi	2.7%	Pennsylvania	4.0
North Dakota	96	Illinois	262,500	Pennsylvania	1.9%	Ohio	3.5
South Dakota	45	South Dakota	191,923	Wyoming	1.9%	New York	3.3
Maryland	7	Maryland	42,000	South Dakota	1.9%	Mississippi	2.5
Arizona	3	Arizona	30,444	North Dakota	0.1%	Illinois	1.8
Missouri	0	Missouri	-	Missouri	-	Missouri	-
Nevada	0	Nevada	-	Nevada	-	Nevada	-
Survey States	381,334	Survey States	1,880,282,880	Survey States	6.7%	Survey States	13.5

Top 10 in Marginal Gas Production



State	Total Gas Production (Mcf)
Texas	8,140,325,026
Pennsylvania	5,216,827,756
Oklahoma	2,468,312,000
Wyoming	1,848,411,506
Louisiana	1,717,864,793
Colorado	1,643,435,353
Ohio	1,438,656,313
West Virginia	1,347,619,374
New Mexico	1,276,117,173
Arkansas	829,447,402

Top 10 in Total Gas Production



Comparative number of marginal gas wells and marginal gas well production 2012 - 2016

State	2012		2013		Number of Marginal Gas Wells
	Number of Marginal Gas Wells	Production from Marginal Wells (Mcf)	Number of Marginal Gas Wells	Production from Marginal Wells (Mcf)	
Alabama	4,804	49,195,516	4,931	49,841,612	5,090
Arizona	2	17,471	3	23,737	3
Arkansas	3,681	26,447,304	3,578	28,164,306	3,785
California	741	5,999,884	770	6,984,346	774
Colorado	17,277	186,585,869	18,195	189,563,613	18,685
Illinois	1,054	265,073	549	360,875	367
Indiana	560	7,932,487	885	7,143,941	1,021
Kansas	17,598	170,458,990	17,437	168,154,160	17,250
Kentucky	18,355	179,419,019	19,335	223,651,597	19,418
Louisiana	15,118	59,808,791	8,647	54,374,585	14,114
Maryland	7	31,186	7	37,298	7
Michigan	7,967	80,200,240	7,985	75,804,752	8,049
Mississippi	1,567	1,158,549	1,537	1,175,746	1,505
Missouri	4	10,392	6	7,577	8
Montana	5,822	32,845,974	5,452	30,455,822	5,349
Nebraska	291	1,220,867	222	868,248	102
Nevada	-	-	-	-	-
New Mexico	13,867	117,374,597	13,876	118,227,596	14,193
New York	6,963	11,257,580	7,027	10,820,908	7,108
North Dakota	164	870,513	146	896,497	158
Ohio	32,360	61,941,296	36,242	55,294,531	36,772
Oklahoma	40,665	283,365,134	42,223	292,447,080	43,781
Pennsylvania	53,636	137,685,084	66,077	130,190,306	71,521
South Dakota	85	361,999	67	308,097	68
Texas	54,651	419,502,886	55,483	417,256,855	56,045
Utah	2,422	25,438,799	2,599	26,387,347	2,706
Virginia	1,582	12,411,043	1,652	12,680,229	1,689
West Virginia	51,678	166,595,970	54,794	157,783,446	54,763
Wyoming	4,955	38,878,967	4,549	36,166,110	4,403
Survey States	357,876	2,077,281,480	374,274	2,095,071,218	388,735

2014		2015		2016	
Production from Marginal Wells (Mcf)	Number of Marginal Gas Wells	Production from Marginal Wells (Mcf)	Number of Marginal Gas Wells	Production from Marginal Wells (Mcf)	
50,520,386	5,214	50,195,065	5,293	48,528,082	
27,597	3	53,728	3	30,444	
29,701,325	3,878	29,843,423	3,312	30,673,961	
7,301,350	819	7,288,955	1,133	7,576,095	
193,167,104	18,915	189,207,817	19,280	197,044,361	
241,125	396	260,000	400	262,500	
5,954,794	1,059	6,525,005	988	5,585,352	
164,216,400	16,932	165,656,920	16,129	140,727,460	
185,715,994	19,439	139,090,703	19,300	130,323,250	
56,826,213	15,449	56,865,395	15,108	55,508,779	
58,591	7	43,295	7	42,000	
72,158,442	7,886	71,072,012	7,672	57,998,504	
1,244,342	1,475	1,335,810	1,424	1,275,677	
7,571	6	1,975	0	0	
35,241,168	5,393	26,219,406	5,338	25,050,840	
337,222	141	375,328	147	460,326	
-	-	-	-	-	
124,007,910	14,292	122,454,849	14,341	121,678,670	
10,655,712	6,699	9,202,778	6,673	8,008,961	
989,699	155	797,909	96	731,864	
50,889,685	36,129	47,591,031	35,377	45,698,203	
301,529,027	45,340	310,610,973	45,083	296,197,440	
124,220,419	65,755	102,196,082	67,731	99,609,644	
247,953	66	225,240	45	191,923	
418,245,862	56,561	406,325,755	56,412	402,462,615	
28,408,439	2,905	30,135,108	3,067	30,893,676	
12,586,543	1,731	14,480,577	1,761	12,596,910	
153,958,229	52,684	136,611,541	51,243	126,030,034	
35,009,180	2,180	20,468,449	3,971	35,095,309	
2,063,468,282	381,508	1,945,135,129	381,334	1,880,282,880	



Measuring the Contribution of Marginal Wells

Marginal oil and gas production in the U.S. has faced two major market challenges in recent years. First, the surge in domestic oil and natural gas drilling and exploration the past decade has worked to reduce the focus on marginal oil and natural gas within the overall U.S. energy production framework. Second, the sharp pullback in oil and natural gas prices since 2015 is currently working to reduce the economic viability of many marginal wells.

Despite these pressures, marginal wells continue to provide a significant share of domestic oil and natural gas output. Over the past decade, marginal wells have produced oil and natural gas valued at nearly \$30 billion annually, or approximately ten percent of the total value of oil and natural gas produced domestically.

Marginal wells continue to contribute to overall U.S. energy production in other ways. Extending the life of mature U.S. oil and natural gas fields continues to play an important transitional role in exploration and development by keeping them active and available for further exploration. Marginal production requires the ongoing use of existing surface roads for servicing access and the maintenance of local pipelines for distribution. The wide, national footprint of marginal well activity has also helped ease the path for new unconventional drilling and exploration activity in most existing fields across the country. For these reasons, marginal oil and natural gas wells production and its related infrastructure will continue to make a key economic contribution to U.S. energy production.

Marginal Well Survey

To quantify the ongoing economic contribution of marginal wells in the U.S., the IOGCC periodically surveys its member states⁴ to acquire data related to production from marginal oil and natural gas wells. The survey results have served as the basis for a long-standing series of reports documenting marginal well activity and the economic contribution of marginal oil and natural gas production in the U.S.⁵

The current report is based on data collected in the latest IOGCC marginal well survey covering production activity in calendar year 2016. The current survey also captures

revised data for previous survey periods.

The survey questionnaire is extensive and collects a range of information on the behavior of marginal oil and natural gas operators across the responding states. The primary data items used in this report include the number of producing marginal and total wells, type of wells, amounts of marginal and total production, and the number of plugged and abandoned wells.

Twenty-nine states are included in the current marginal wells report as producers of either marginal oil or natural gas, or both. Twenty-eight states produced marginal oil during the survey period, while twenty-seven reported the production of natural gas. Twenty-eight states submitted extensive responses to the current IOGCC survey, while data for the remaining state (Oklahoma) is estimated from alternative sources.

While the IOGCC survey covers 29 states, the Energy Information Administration (EIA) reports that 32 states currently produce oil and 33 produce natural gas.⁶ A few states that produce very small amounts of marginal oil or natural gas production in the survey period are not included in the report. Even after excluding these very small producers, the 29 states included in the report are believed to represent substantially all the marginal oil and natural gas produced within the U.S.

While each state receives the same survey questionnaire, the methodology used by the states in defining a marginal well and its associated production can differ. Similarly, the reporting entity within a state and the methods used by a state to derive estimates may also vary over time. Because of the inherent variability in reporting, every effort is made to place all reported data on comparable terms to facilitate valid state-to-state and year-to-year comparisons where possible. Where a state's reporting is incomplete, estimates are obtained from reliable alternative sources or formed using statistical-based methods. Most non-survey estimates are derived from data published by the EIA or state oil and gas reporting agencies. Appendix A provides a detailed description of the survey responses, alternative data sources, and any estimates used in the report.

Table 1. National Marginal Oil Well Survey from 1992 - 2016

Year	Number of Marginal Oil Wells	Production from Marginal Oil Wells (Bbls)	Price of Oil (\$/Bbl)	Value of Marginal Oil Production	Average Daily Production per Well (Bbls)
1992	453,277	368,132,000	15.99	5,886,430,680	2.23
1993	452,248	355,961,000	14.25	5,072,444,250	2.16
1994	442,500	339,930,000	13.19	4,483,676,700	2.10
1995	433,048	332,288,089	14.62	4,858,051,861	2.10
1996	428,842	323,468,274	18.46	5,971,224,338	2.06
1997	420,674	323,487,914	17.23	5,573,696,758	2.11
1998	406,380	316,870,286	10.87	3,444,380,009	2.14
1999	410,680	315,514,283	15.56	4,909,402,243	2.10
2000	411,629	325,947,181	26.72	8,709,308,676	2.16
2001	403,459	316,099,192	21.84	6,903,606,353	2.15
2002	402,072	323,776,606	22.51	7,288,211,401	2.21
2003	393,463	313,748,001	27.56	8,646,894,908	2.18
2004	397,362	310,922,122	36.77	11,432,606,426	2.14
2005	401,072	321,761,570	50.28	16,178,171,740	2.20
2006	422,381	324,496,483	59.69	19,369,195,070	2.10
2007	396,537	291,067,592	66.52	19,361,816,220	2.01
2008	378,950	265,751,608	94.04	24,991,281,204	1.92
2009	390,033	262,416,602	56.35	14,787,175,500	1.84
2010	390,842	267,488,671	74.97	20,052,388,648	1.88
2011	397,721	274,697,863	93.71	25,741,435,384	1.89
2012	398,711	275,830,121	92.80	25,597,410,421	1.90
2013	395,752	291,655,231	95.57	27,874,764,146	2.02
2014	406,649	299,765,367	87.33	26,178,153,079	2.02
2015	401,204	289,914,779	44.44	12,884,851,361	1.98
2016	396,023	284,413,213	38.73	11,016,504,280	1.97

Value of Annual Marginal Production per Well (\$)	Oil Wells Plugged/ Abandoned	Total Oil Production (Bbls)	Value of Total Oil Production (\$)	Marginal Share of Total Production
12,986	16,211	2,624,632,000	41,967,865,680	14.0%
11,216	16,914	2,499,033,000	35,611,220,250	14.2%
10,133	17,896	2,431,476,000	32,071,168,440	14.0%
11,218	16,389	2,394,268,000	35,004,198,160	13.9%
13,924	16,674	2,366,017,000	43,676,673,820	13.7%
13,249	15,172	2,354,831,000	40,573,738,130	13.7%
8,476	13,912	2,281,919,000	24,804,459,530	13.9%
11,954	11,227	2,146,732,000	33,403,149,920	14.7%
21,158	10,718	2,130,707,000	56,932,491,040	15.3%
17,111	12,234	2,117,511,000	46,246,440,240	14.9%
18,127	13,635	2,096,588,000	47,194,195,880	15.4%
21,976	14,300	2,061,995,000	56,828,582,200	15.2%
28,771	11,977	1,991,394,000	73,223,557,380	15.6%
40,337	11,058	1,892,095,000	95,134,536,600	17.0%
45,857	11,738	1,856,606,000	110,820,812,140	17.5%
48,827	11,296	1,853,243,000	123,277,724,360	15.7%
65,949	10,328	1,830,416,000	172,132,320,640	14.5%
37,913	10,070	1,954,241,000	110,121,480,350	13.4%
51,306	10,483	1,998,554,000	149,822,351,029	13.4%
64,722	10,698	2,060,744,000	193,108,559,345	13.3%
64,200	12,857	2,374,136,000	220,323,050,363	11.6%
70,435	11,653	2,725,665,000	260,503,707,478	10.7%
64,375	11,389	3,198,694,000	279,338,143,874	9.4%
32,115	13,279	3,434,023,000	152,620,284,158	8.4%
27,818	13,235	3,239,114,000	125,464,330,265	8.8%

Table 2. National Marginal Gas Well Survey from 1992 - 2016

Year	Number of Marginal Gas Wells	Production from Marginal Gas Wells (Mcf)	Price of Natural Gas (\$/Mcf)	Value of Marginal Gas Production	Value of Annual Marginal Production per Well (\$)
1992	130,432	670,451,027	1.74	1,166,584,788	8,944
1993	142,100	759,897,057	2.04	1,550,189,997	10,909
1994	159,369	940,421,000	1.85	1,739,778,850	10,917
1995	159,669	925,563,034	1.55	1,434,622,703	8,985
1996	168,702	986,676,219	2.17	2,141,087,395	12,692
1997	189,756	1,042,153,002	2.32	2,417,794,965	12,742
1998	199,745	1,104,683,975	1.96	2,165,180,591	10,840
1999	207,766	1,138,979,506	2.19	2,494,365,118	12,006
2000	223,222	1,258,726,664	3.68	4,632,114,124	20,751
2001	234,507	1,353,516,378	4.00	5,414,065,512	23,087
2002	245,961	1,418,273,779	2.95	4,183,907,648	17,010
2003	260,563	1,478,105,524	4.88	7,213,154,957	27,683
2004	271,856	1,539,960,495	5.46	8,408,184,303	30,929
2005	288,898	1,760,063,552	7.33	12,901,265,836	44,657
2006	304,000	1,716,319,702	6.39	10,967,282,896	36,077
2007	322,160	1,763,592,746	6.25	11,022,454,663	34,214
2008	326,340	1,831,809,216	7.97	14,599,519,453	44,737
2009	331,579	2,152,036,402	3.67	7,897,973,596	23,819
2010	353,483	2,171,035,452	4.47	9,710,490,967	27,471
2011	360,993	2,089,652,663	3.94	8,232,410,818	22,805
2012	357,876	2,077,281,480	2.66	5,522,470,336	15,431
2013	374,274	2,095,071,218	3.73	7,815,414,649	20,882
2014	388,735	2,063,468,282	4.37	9,021,494,481	23,207
2015	381,508	1,945,135,129	2.62	5,104,495,649	13,380
2016	381,334	1,880,282,880	2.53	4,748,728,722	12,453

Average Daily Production per Well (Mcf)	Gas Wells Plugged/ Abandoned	Total Gas Production (Bbls)	Value of Total Gas Production (\$)	Marginal Share of Total Production
14.1	3,161	18,711,808,000	32,558,545,920	3.6%
14.7	3,162	18,981,915,000	38,723,106,600	4.0%
16.2	3,163	19,709,525,000	36,462,621,250	4.8%
15.9	3,189	19,506,474,000	30,235,034,700	4.7%
16.0	4,671	19,812,241,000	42,992,562,970	5.0%
15.0	4,661	19,866,093,000	46,089,335,760	5.2%
15.2	4,203	19,961,348,000	39,124,242,080	5.5%
15.3	3,546	19,804,848,000	43,372,617,120	5.8%
15.4	3,534	20,197,511,000	74,326,840,480	6.2%
15.8	3,600	20,570,295,000	82,281,180,000	6.6%
15.8	3,870	19,884,780,000	58,660,101,000	7.1%
15.5	3,883	19,974,360,000	97,474,876,800	7.4%
15.5	4,129	19,517,491,000	106,565,500,860	7.9%
16.7	4,517	18,927,095,000	138,735,606,350	9.3%
15.5	4,463	19,409,674,000	124,027,816,860	8.8%
15.0	5,155	20,196,346,000	126,227,162,500	8.7%
15.4	5,075	21,112,053,000	168,263,062,410	8.7%
17.8	5,381	21,647,936,000	79,447,925,120	9.9%
16.8	6,333	22,381,873,000	100,108,441,531	9.7%
15.9	6,803	24,036,352,000	94,693,787,019	8.7%
15.9	9,123	25,283,278,000	67,215,807,815	8.2%
15.3	7,545	25,562,232,000	95,356,874,151	8.2%
14.5	8,249	27,497,754,000	120,220,329,109	7.5%
14.0	7,329	28,752,935,000	75,454,516,984	6.8%
13.5	6,269	28,294,939,000	71,459,986,648	6.6%

U.S. Marginal Well Count and Production Trends

Year-to-year changes in the number and production of marginal oil and gas wells are traced to a range of factors including trends in oil and gas exploration, the aging of producing wells, tax treatment of marginal production, crude oil and natural gas prices, and other factors. Despite constant changes in these factors, marginal wells remain in widespread operation across the country and continue to reliably produce a meaningful share of total domestic oil and natural gas output.

Continued Growth in the Number of Marginal Wells

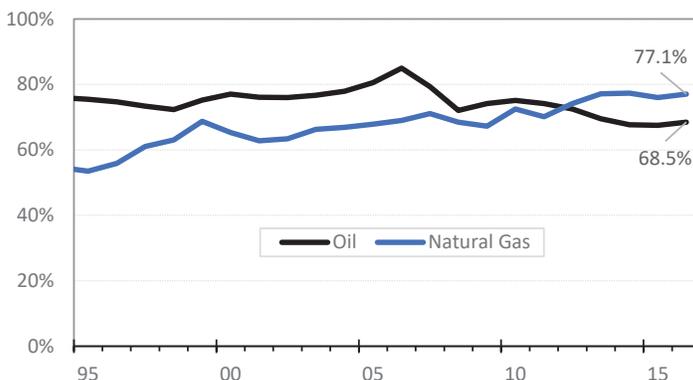
Tables 1 and 2 provide a summary of annual U.S. marginal oil and natural gas production, respectively, derived from IOGCC marginal well surveys administered for calendar years 1992 to 2016. An estimated 777,000 marginally-producing wells (396,000 oil wells and 381,000 natural gas wells) contributed to U.S. oil and natural gas production in 2016 (see Figure 5). In total, the number of marginal wells declined in both 2015 and 2016, falling by a cumulative 18,000 wells, or 2.3 percent.

Losses are slightly larger for oil than for natural gas. On the oil side, the number of marginal wells similarly dropped in both 2015 and 2016. The cumulative decline has now reached 10,600 marginal oil wells under pressure from both increased exploration and an extended pullback in oil prices. The recent decline has also reversed some of the sharp runup in the number of marginal oil wells in the 2008 to 2014 period when nearly 28,000 new marginal oil wells were added.

The number of marginal natural gas wells similarly declined for a second consecutive year in 2016. After rising steadily and more than doubling in the two decades up to 2014, the number of marginal gas wells has dropped by 7,400 since reaching an all-time high in 2014, a nearly 2 percent decline.

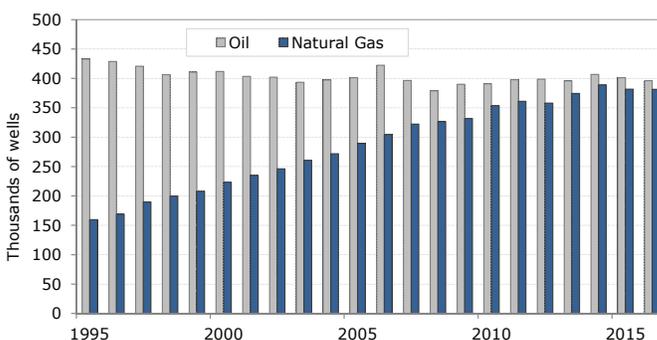
The only other period the past two decades where the total number of marginal wells declined was in 2007 and 2008, as 21,000 marginal wells were lost, with the losses exclusively on the oil side of the market in the period. Despite weakness in 2015 and 2016, the total number of marginal wells is still believed to be in a long-run uptrend.

Figure 5. Number of Marginal Oil and Natural Gas Wells



Source: IOGCC Marginal Well Survey and RegionTrack

Figure 6. Marginal Share of Total Oil and Natural Gas Wells



Source: U.S. EIA, World Oil and RegionTrack

The share of all operating wells in the U.S. that are marginal producers remains quite high (see Figure 6). In fact, most wells currently producing in the U.S. are marginal based on their rate of production. The nation's 396,000 marginal oil wells comprise an estimated 68.5 percent of all operating oil wells in the U.S. in 2016. The 381,000 reported marginal gas

wells comprise an even larger share, 77.1 percent, of all operating natural gas wells. Overall, nearly three-fourths (72.4 percent) of all operating wells in the U.S. in 2016 are marginal producers.

Marginal Production Trends

Marginal oil and natural gas production declined in both 2015 and 2016 along with the number of marginal wells (see Figure 7).

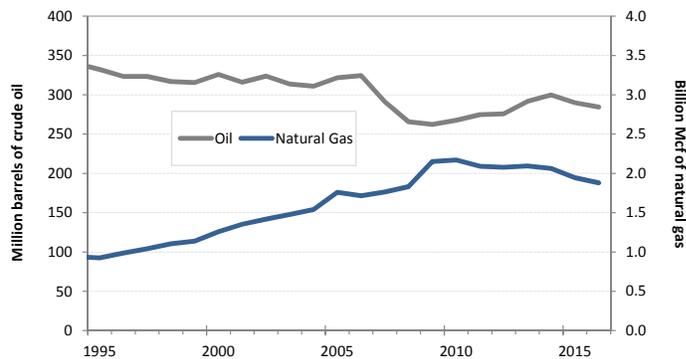
Marginal oil production posted a second consecutive year of decline in 2016, falling to 284.4 million barrels. Marginal oil production has now declined by 15.4 million barrels since reaching approximately 300 million barrels in 2014. Marginal oil production remains in a slight long-run downtrend, though it remains approximately 8.5 percent above the recent low of 262.4 million barrels reached in 2009.

The reversal of the long-run increase in marginal natural gas production that has been underway since 2010 remains in place (see Figure 7). Marginal natural gas production fell for a third consecutive year in 2016 to 1.88 billion Mcf, a 10.3 percent decline in the period. Marginal natural gas output is now 13.4 percent below the recent peak reached in 2010.

Both declining marginal production volumes and relatively low oil and natural gas prices weighed on the value of total marginal production in 2016.⁷ The combined market value of marginal oil and natural gas fell to only \$15.8 billion in 2016, the lowest total market valuation since 2002. This marks the third consecutive year in which marginal production has remained relatively weak as oil and natural gas prices remained well below recent historical highs.

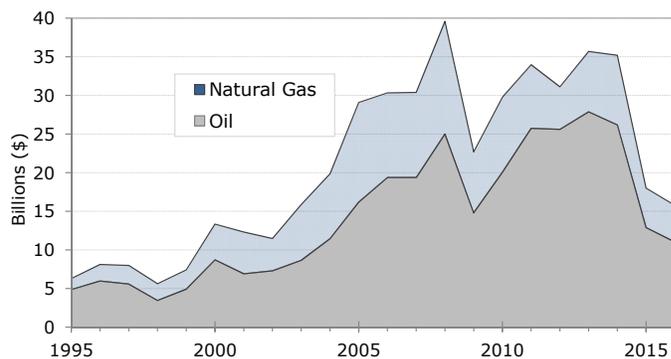
The extended collapse in crude oil prices played the largest role in reducing the value of marginal output between the 2014 and 2016 survey periods (see Figure 9). Marginal oil typically provides at least two-thirds of the total market value of marginal production and can more readily sway the overall valuation. In 2016, the 284.4 million barrels of marginal oil produced were valued at only \$11.0 billion based on an average price of \$38.73 per barrel. This reflects a 60 percent decline in the market value of relative to the recent peak value of \$27.9 billion reached in 2013.

Figure 7. Marginal Oil and Natural Gas Production



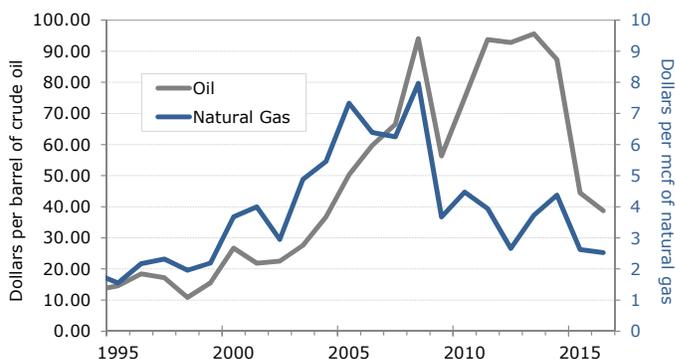
Source: IOGCC Marginal Well Survey, U.S. EIA, and RegionTrack

Figure 8. Market Value of Marginal Production



Source: IOGCC Marginal Well Survey, U.S. EIA, and RegionTrack

Figure 9. Oil and Natural Gas Prices



Source: U.S. EIA and RegionTrack

Notes: Prices are annual averages. Oil price is West Texas Intermediate. Natural gas price is Henry Hub spot.

The value of marginal natural gas production declined slightly in 2016 to \$4.75 billion. This represents the lowest valuation for marginal natural gas production since 2002 and is less than one-third the \$14.6 billion produced in 2008 at the recent peak in natural gas prices. The recent decline in natural gas prices is the key factor in the falling valuation, decreasing from an average of \$4.37 per Mcf in 2014 and to only \$2.53 per Mcf in 2016. Combined with the steep decline posted in 2015, the value of marginal

natural gas output in 2016 is 47 percent below the recent peak of \$9.0 billion reached in 2014 under much higher natural gas prices.

Marginal Production Remains a Substantial Share of U.S. Oil and Gas Output

The ongoing boom in domestic oil and natural gas exploration and production continues to weigh on the share of total U.S. production derived from marginal wells. Despite the reduction in share, marginal wells remain a critical contributor to total domestic production.

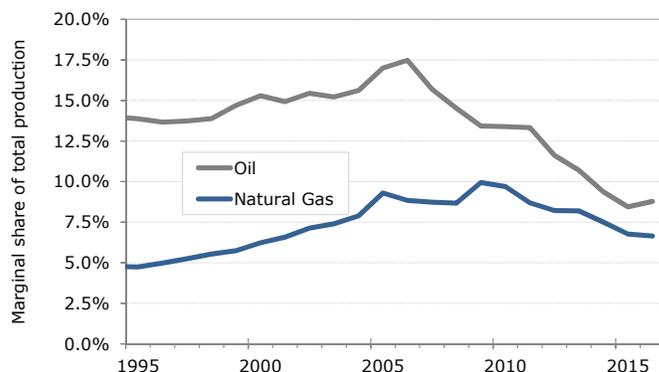
Figure 10 illustrates the share of total U.S. oil and natural gas production derived from marginal wells the past two decades. The share of marginal oil has been in a steady decline since a long-run peak was reached in 2005, while the share of marginal natural gas has declined since a more recent peak was reached in 2009.

Although the quantity of oil produced from marginal wells dropped slightly in 2016, the share of total U.S. oil production from marginal wells managed to increase slightly to 8.8 percent as non-marginal production pulled back more sharply due to the drilling slowdown in 2015 and 2016. For comparison, marginal oil production in 2016 declined only 1.9 percent versus a 5.7 percent pullback in total U.S. oil production. Viewed longer-term, the share of U.S. oil production coming from marginal wells is now only slightly more than half the 17.9 percent share posted at the recent peak in 2006.

Despite the falling share of marginal oil production, the 284.4 million barrels of marginal oil produced in the U.S. in 2016 still exceeded the total oil production of every producing state except Texas (1.18 billion barrels) and North Dakota (378.0 million barrels). Production in third-ranked California fell to only 186.1 million barrels of oil in 2016.

The marginal share of total U.S. natural gas production increased steadily much of the past two decades before peaking at an all-time high of 9.9 percent in 2009 (see Figure 10). The marginal share of U.S. natural gas production has since retreated steadily to 6.6 percent in 2016, the lowest share reported since 2001.

Figure 10. Marginal Share of Total U.S. Production



Source: IOGCC Marginal Well Survey, U.S. EIA, and RegionTrack

The current U.S. marginal natural gas volume of 1.88 billion Mcf exceeds the total production of all but the top three natural gas-producing states – Texas (6.99 billion Mcf), Pennsylvania (5.26 billion Mcf), and Oklahoma (2.47 billion Mcf). U.S. marginal gas output continues to slightly exceed the total output of top-tier gas producing states such as Louisiana (1.86 billion Mcf), Colorado (1.70 billion Mcf), and Wyoming (1.60 billion Mcf).

Measured across both oil and natural gas, the estimated \$15.8 billion in market value of marginal oil and natural gas produced in 2016 represents 8.0 percent of the value of all oil and natural gas produced domestically in the U.S. This is up slightly from the 7.9 percent share posted in 2015 but remains almost five percentage points below the 12.9 percent all-time peak share of total production established in 2006.

Marginal Well Productivity

Tables 1, page 19, and 2, page 21, also contain a summary of the productivity characteristics of marginal oil and natural gas wells, respectively, for the 1992 to 2016 survey periods. A typical marginal oil well in the U.S. produced about 718 barrels of oil annually, or 1.97 barrels per day, in 2016. This is down slightly from the long-run average production rate of 2.06 barrels per day in the 1992 to 2016 period, or 753 barrels per year.

The market value of oil produced per marginal oil well fell in 2016 for a third consecutive year under pressure from low oil prices and a slight decline in average daily production. The value of production from an average marginal oil well decreased to only

\$27,818 annually at an average oil price of \$38.73 per barrel. This is 60 percent below the all-time peak annual revenue of \$70,435 derived from a typical marginal oil well in 2013.

The production from the average marginal natural gas well in the U.S. declined to 13.5 Mcf of natural gas per day, or 4,931 Mcf annually, in 2016. This is the lowest daily output reported since 1992 and is 2.0 Mcf per day below the 15.5 Mcf per day average since 1992. Average daily marginal gas output also continues to fall steadily from the all-time high of 17.8 Mcf set in 2009, a decline of 24 percent in the period.

The value of production from the average marginal natural gas well in 2016 reflects both a pullback in marginal natural gas production and continued weak natural gas prices. The average marginal gas well produced annual revenue of only \$12,453 in 2016 at a relatively low average price of \$2.53 per Mcf of natural gas. This value has declined 72 percent from the \$44,737 in marginal gas value produced per well at the recent natural gas price peak in 2008.

State - Level Trends in Marginal Production

Tables 3, page 9, and 4, page 13, provide state-level well counts and production data from the IOGCC survey of marginal oil and natural gas producers for 2016. Marginal oil production is reported by 28 states while marginal natural gas is reported by 27 states in the period.

Marginal Oil Production

Marginal oil is produced from wells that operate on the lower edge of profitability. Generally speaking, low-volume “stripper” wells – defined by the IOGCC as those wells producing 10 barrels of oil per day or less – fall into this category.

The ranks of the top 10 marginal oil-producing states in 2016 is little changed from prior years although their relative positions continue to shuffle. The top marginal oil states include the traditional oil patch states of Texas, Oklahoma, Kansas, and Louisiana as well as a diverse group of other producing states including New Mexico, California, North Dakota, Colorado, and Illinois. Utah replaced Ohio as the tenth ranked state following a sharp downturn in Ohio marginal oil output. Jointly, the 308,904 marginal oil wells located in the top ten states produced 261.5 million barrels of oil, or 92 percent of total U.S. marginal oil production, in 2016.

Texas and California alone produced 61 percent of the 284.4 million barrels of total marginal oil output in 2016. A second tier of four states – North Dakota, New Mexico, Kansas, and Oklahoma – produced between 14 million and 18 million barrels of marginal oil each in 2016 and jointly produced a total of 62.4 million barrels (22 percent of total marginal oil). An additional 13 states produced more than 1 million barrels of oil from marginal wells in 2016.

The number of marginal oil wells declined by 5,180 in the 2016 survey, with 22 states reporting a decline for the year. Eight states posted a decline of 500 or more marginal oil wells, including Texas (-1,447),

California (-892), Colorado (-734), Indiana (-733), West Virginia (-656), Illinois (-645), Ohio (-609), and New Mexico (-585).

Six states reported a flat or rising number of marginal oil wells in the latest survey period, with the largest increase of 2,450 wells reported in Kansas. Other states that added a significant number of new marginal oil wells include North Dakota (+737 wells) and Wyoming (+205 wells).

Texas remains home to the largest number of marginal oil wells (150,929) and now accounts for 38 percent of the total. Other states with more than 10,000 producing marginal oil wells include California (36,370), Oklahoma (28,050), Kentucky (25,875), Pennsylvania (21,136), Kansas (20,825), Illinois (20,220), Louisiana (20,087), New Mexico (16,678), and Ohio (14,169).

The total amount of marginal oil produced in the U.S. decreased 1.9 percent (-5.50 million barrels) in the 2016 survey. Declines of more than 500,000 barrels of oil occurred in California (-2.14 million barrels), Kansas (-2.02 million barrels), Louisiana (-1.04 million barrels), Illinois (-882,000 barrels), New Mexico (-715,600 barrels), Oklahoma (-591,400 barrels), and Arkansas (-577,300 barrels). The only significant gains in marginal oil production occurred in North Dakota and Texas with gains of 4.4 million barrels and 583,000 barrels, respectively, in the period.

The average daily production rate for marginal oil wells has remained at or slightly below 2 barrels per day for several years but continues to vary widely across the states. Average daily oil production exceeding 3 barrels per day is found in only 7 states - North Dakota (12.38 Bbls), Utah (4.20 Bbls), South Dakota (4.10 Bbls), Michigan (3.70 Bbls), California (3.43 Bbls), Nevada (3.35 Bbls), and Alabama (3.22 Bbls). Seven states report average daily volume from marginal wells of less than 1 barrel per day, including

Pennsylvania (0.16 Bbls), New York (0.17 Bbls), Virginia (0.19 Bbls), Kentucky (0.23 Bbls), Ohio (0.60 Bbls), West Virginia (0.63 Bbls), and Missouri (0.77 Bbls).

While the average share of total U.S. oil production from marginal wells is 8.8 percent (see Table 1, page 9), the contribution of marginal oil to total state oil production remains highly variable across the survey states. Four states – Arizona, Illinois, Missouri, and New York – report producing all their oil from marginal wells. Two additional states, Indiana and Kentucky, produce more than 85 percent of total state oil output from marginal wells. Four additional states – Nebraska, Arkansas, Michigan, and Kansas – generate between one-third and two-thirds of state oil production from marginal wells. Most of the major marginal oil-producing states generate a relatively small share of total state oil output from marginal wells. Eight of the ten largest marginal oil-producing states – Louisiana (14.1 percent), Texas (11.1 percent), New Mexico (10.9 percent), Utah (13.4 percent), Oklahoma (9.5 percent), Colorado (4.8 percent), Wyoming (4.6 percent), and North Dakota (4.5 percent) – continue to derive less than 15 percent of total state oil production from marginal wells.

Marginal Natural Gas Production

Marginal natural gas wells are defined by the IOGCC as those wells producing 60 Mcf of natural gas per day or less.

A top tier of eight states – Texas, Oklahoma, Colorado, Kansas, Kentucky, West Virginia, New Mexico, and Pennsylvania – remains the core source of U.S. marginal natural gas production. Each of these states produced 100 million Mcf or more of natural gas from marginal wells in 2016. Jointly they accounted for 1.51 billion Mcf, or 81 percent of total U.S. marginal production. Two of the top 8 states, Texas and Oklahoma, are the clear leaders and combined to produce 37 percent (698.7 million Mcf) of total U.S. marginal natural gas output in 2016, the same share they produced in the prior two surveys. The remaining 6 top-tier states reported combined production of 815.4 million Mcf, or 44 percent of total U.S. marginal natural gas output.

Eight states comprising a second tier of marginal natural gas producers includes Michigan, Louisiana,

Alabama, Ohio, Wyoming, Utah, Arkansas, and Montana. Each of these states produced between 25 million and 60 million Mcf of marginal natural gas in 2016 and jointly accounted for 329.4 million Mcf of production. The 16 states in the top two tiers produced 98 percent of all marginal natural gas output. Overall, 20 of the 27 states reporting marginal gas production in the survey produced more than 5 million Mcf of natural gas from marginal wells in 2016. The number of marginal gas wells operating in the U.S. decreased slightly by 174 in the 2016 survey period. Reflective of the falling number of marginal natural gas wells at the national level, 16 of 27 states that produced marginal natural gas in 2016 posted a decrease in the number of active marginal natural gas wells in 2016. States reporting a decline of more than 200 marginal gas wells in the period include West Virginia (-1,441 wells), Kansas (-803 wells), Ohio (-752 wells), Arkansas (-566 wells), Louisiana (-341 wells), Oklahoma (-257 wells), and Michigan (-214 wells). Among the states adding marginal gas wells in 2016, Pennsylvania and Wyoming posted the most significant increases of 1,976 and 1,791 marginal gas wells, respectively.

By total number of marginal gas wells, Pennsylvania, Texas, West Virginia, Oklahoma, and Ohio are the largest, with each having more than 35,000 wells. These five states jointly accounted for two-thirds (255,800) of all marginal natural gas wells in the U.S. in 2016. A second tier of five states with each reporting more than 10,000 marginal natural gas wells includes Kentucky, Colorado, Kansas, Louisiana, and New Mexico.

States in the survey posted an aggregate 3.3 percent decline (-64.9 million Mcf) in total marginal natural gas output in 2016. This follows a 5.7 percent decline in 2015 and a 1.5 percent decline in 2014. Twenty-one of the 27 states producing marginal natural gas reported a decline in 2016. Eight of the 21 declining states reported a decline of 10 percent or more. Of the states reporting a double-digit decline, only two – Kansas and Michigan – are among the top ten marginal natural gas producing states.

The daily production rate for all marginal natural gas wells declined further in 2016 to only 13.5 Mcf. This marks the seventh consecutive year of declining average well output and a nearly 25 percent total

decline from the 17.8 Mcf per day rate posted at the recent peak in 2009. Daily production rates continue to vary greatly across the producing states, with average rates above 25 Mcf in Colorado (28.0 Mcf), Arizona (27.8 Mcf), Utah (27.6 Mcf), Arkansas (25.4 Mcf), and Alabama (25.1 Mcf). States with especially low volume marginal gas wells (less than 10 mcf per day) include Illinois (1.8 Mcf), Mississippi (2.5 Mcf), New York (3.3 Mcf), Ohio (3.5 Mcf), Pennsylvania (4.0 Mcf), West Virginia (6.7 Mcf), and Nebraska (8.6 Mcf).

Like oil, marginal natural gas production as a share total state natural gas output remains highly variable across the survey states. While Maryland is the only state reporting all their natural gas production from marginal wells in 2016, three additional states currently produce three-fourths or more from marginal wells – Indiana, Nebraska, and Kentucky. Four additional states – New York, Kansas, Michigan, and Arizona – produce between 50 percent and 75 percent of total state natural gas output from marginal wells. In contrast, the nine states that now produce more than 1 billion Mcf annually in total natural gas averaged only 5.5 percent of total state natural gas output from marginal wells in 2016. This is slightly below the overall average of 6.7 percent across all survey states and reflects in part the attractive environment for the exploration and development of new natural gas wells in these states.

Total Marginal Production

Table 5 provides a ranking of total marginal oil and natural gas output for the survey states by both volume (in barrel-of-oil-equivalent, or BOE, terms) and value of production.⁸ Combined, the 29 survey states produced the equivalent of 597.8 million barrels of oil equivalent valued at \$15.8 billion in 2016. Marginal production represents 7.5 percent of the total volume of U.S. oil and gas production in the survey states, but 9.5 percent of the total value of output. The higher share of marginal production based on value is traced to two factors. First, is the current high market value of crude oil relative to natural gas on a Btu-equivalent basis. Second, is the nearly even split between oil and natural gas output on a Btu basis for marginal production, versus natural gas production that is nearly 50 percent higher than oil on a Btu basis for total U.S. production. Similarly, at the state level, those states with high oil production

relative to natural gas generally benefit in the value rankings in Table 5.

Texas remains the top-ranked marginal producer based on both the value (\$6.1 billion) and volume of production (194.3 million Bbls). Based on value, California ranks second with \$1.75 billion in marginal oil and natural gas production, just ahead of Oklahoma with \$1.36 billion. California and Oklahoma swap rankings based on volume, with Oklahoma second due to its high output of natural gas relative to oil in 2016. New Mexico, Kansas, and Colorado are the next three highest ranked marginal producers, with differing ranks for the three states when viewed by either value or volume. All three states produced between \$650 million and \$1 billion in value of output in 2016. However, Colorado's marginal output is more tilted toward natural gas and ranks higher based on volume, while Kansas and New Mexico have a greater share of oil production and rank higher on value.

North Dakota ranks seventh based on the value of marginal output (\$632 million) but falls to tenth based on volume due to its very low output of marginal natural gas. Louisiana ranks eight based on value, but falls to eleventh based on Btu-equivalent volume of output. Conversely, Pennsylvania ranks ninth based on volume of production, due primarily to its significant natural gas production, but only twelfth based on the value of output. Two other states in the top ten based on volume, West Virginia and Kentucky, fall in the value rankings due to their high natural gas share of production.

In total, nineteen states produced total marginal oil and natural gas valued at \$100 million or more in 2016. States experiencing more recent growth in their oil and gas sector including North Dakota, Pennsylvania, Arkansas and Ohio have moved up the rankings in recent surveys. Traditional producing states with more limited development in recent years such as Utah, Wyoming, and Montana have moved down the rankings.

Table 5. State Rankings - Value of Marginal Production (2016)

State	BOE Marginal Oil and Natural Gas Production (Bbls)	State	Value of Marginal Oil and Gas Production (\$)	State	Value of Total Oil and Gas Production (\$)	State	Marginal Share of Total Value of Production
Texas	194,319,495	Texas	6,070,998,664	Texas	66,681,539,392	Maryland	100.0%
Oklahoma	63,963,275	Oklahoma	1,750,359,827	North Dakota	15,225,927,930	Missouri	100.0%
California	46,826,594	Colorado	1,361,466,945	Pennsylvania	13,389,186,946	Illinois	98.6%
Colorado	38,393,068	New Mexico	981,106,278	Oklahoma	12,610,314,135	Indiana	90.0%
Kansas	38,252,480	Kansas	895,239,987	New Mexico	9,495,006,178	Arizona	87.3%
New Mexico	36,027,171	Kentucky	648,850,341	Colorado	8,047,828,929	Kentucky	76.9%
Kentucky	23,925,780	West Virginia	632,426,603	California	7,331,227,216	New York	67.4%
West Virginia	21,695,223	Pennsylvania	459,118,970	Wyoming	7,082,921,694	Nebraska	65.7%
Pennsylvania	17,857,890	Louisiana	415,780,792	Louisiana	6,405,511,629	Michigan	52.6%
North Dakota	17,399,787	Michigan	339,068,337	Ohio	4,541,876,951	Kansas	44.3%
Louisiana	17,212,582	Alabama	336,286,650	West Virginia	3,720,022,267	California	23.9%
Michigan	12,828,941	Ohio	299,383,198	Kansas	2,019,250,751	Alabama	18.2%
Ohio	10,718,092	Wyoming	259,855,469	Utah	1,995,650,041	Nevada	16.7%
Utah	9,229,743	Utah	233,903,151	Arkansas	1,995,156,214	Montana	12.7%
Wyoming	9,200,198	Arkansas	224,170,666	Montana	927,913,915	Utah	11.2%
Illinois	8,682,750	Montana	205,455,039	Mississippi	910,207,812	Oklahoma	10.8%
Alabama	8,372,687	Virginia	168,139,229	Alabama	728,079,665	Virginia	10.5%
Arkansas	7,850,394	New York	132,713,276	Kentucky	540,554,896	New Mexico	10.3%
Montana	6,059,226	California	117,988,239	Michigan	494,084,228	West Virginia	9.1%
Indiana	2,567,506	Indiana	76,754,319	Illinois	340,917,150	Texas	9.1%
Virginia	2,099,698	Mississippi	52,960,907	Virginia	303,293,197	Arkansas	8.4%
New York	1,555,728	North Dakota	32,439,713	Indiana	85,282,577	Colorado	8.1%
Nebraska	1,510,469	Nebraska	31,752,369	Nebraska	80,669,796	Louisiana	7.2%
Mississippi	964,207	Illinois	29,406,738	South Dakota	76,799,081	Ohio	5.1%
Missouri	122,413	South Dakota	4,687,194	New York	43,626,803	North Dakota	4.2%
South Dakota	91,895	Maryland	2,663,698	Nevada	10,667,556	Mississippi	3.6%
Nevada	46,533	Arizona	1,781,749	Missouri	4,687,194	South Dakota	3.5%
Arizona	12,868	Missouri	368,815	Arizona	422,353	Wyoming	2.9%
Maryland	7,000	Nevada	105,840	Maryland	105,840	Pennsylvania	2.2%
Survey States	597,793,693	Survey States	15,765,233,002	Survey States	165,088,732,335	Survey States	9.5%

Economic Spillover Effects from Marginal Production

While marginal oil and natural gas production remains a relatively small segment of the overall U.S. energy complex, it nonetheless remains a sizeable business sector. In 2016, marginal wells produced oil and natural gas valued at \$15.8 billion.

This business activity is driven largely by thousands of small well operators who focus on the less visible production side of the industry rather than drilling and exploration. Keeping a marginal well in active production extends the life of a large and long-lived stream of payments to a range of recipients. An operating marginal well provides a multi-year stream of revenue for marginal well operators, earnings to employees, income to servicing firms, payments to royalty owners, and tax revenue to federal, state, and local governments.

Spillover Effects from Marginal Production

The combined activity of marginal well operators exerts a range of substantial direct economic effects upon the state in which they operate. These direct effects are captured in the prior sections of the report. This direct activity, in turn, induces spillover economic activity in other areas of the broader economy of each producing state.

This indirect, or spillover, activity occurs as producers purchase goods and services from firms in other sectors of the economy. Marginal wells must be monitored, maintained, and serviced on a continual basis by local servicing firms. The daily production of marginal oil and natural gas requires ongoing expenditures for electricity and other fuels, truck transportation, and storage. Well work-overs and stimulation are frequently used to extend the life of existing wells. Manufactured goods are needed to support a well's operation until final shut-in. Marginal well activity also feeds downstream relationships with pipelines and refineries. And like all oil and gas activity, marginal production requires the ongoing

use of significant legal, financial, and other business services. In short, nearly every major industry sector in every producing state benefits from some level of direct or indirect purchases from the operation of marginal wells.

To assess the direct and indirect economic contribution of marginal oil and natural gas production, a hypothetical case is evaluated where all marginal oil and natural gas production is eliminated.⁹ Estimates of the size of the spillover effects to the broader economy are formed for each survey state. The economic impacts are estimated at the individual state level to capture differing degrees of economic linkages between the oil and natural gas sector and other industry sectors within each survey state. The state-level estimates are then aggregated to assess the total expected effect nationwide.

Measuring Economic Impact

Estimates of the economic spillover effects from marginal oil and gas production are formed for each state using RIMS II input-output multipliers from the U.S. Bureau of Economic Analysis (BEA).¹⁰ RIMS II multipliers provide model-based estimates of the impact that a local final demand shock has on total gross output, value added, earnings, and employment within a region.¹¹

In other words, multipliers provide a convenient method for estimating the effects that a change in *output*, *employment*, or *earnings* within an industry sector may have on broader state economic activity. The use of RIMS II multipliers also maintains consistency with the approach used in marginal well reports in prior years.

The demand shock evaluated is a change in marginal oil and natural gas output. Estimates of the spillover effects are formed using Type-2 state-level multipliers derived for NAICS industry sector 211000 (Oil and

Gas Extraction).¹² For the marginal oil and natural gas sector, output multipliers provide an estimate of the total change in output in the broader state economy per dollar of output (or revenue) added or lost in the form of changing marginal oil and natural gas production. *Employment* multipliers provide an estimate of the total number of jobs generated in the broader state economy as marginal production changes. Similarly, *earnings* multipliers provide an estimate of the total amount of additional earnings received by households in the broader state economy as marginal production changes.

It is important to note that the RIMS multipliers represent estimates of gross economic effects and do not account for any public or private costs associated with oil and gas production.¹³ And while the estimated spillover effects are calculated for each of the 29 states in the survey and then aggregated, they represent only an approximation of the total national impact.

Many of the traditional energy-producing states such as California, Colorado, Kansas, Louisiana, Oklahoma, Texas, and Wyoming have a large and highly diverse industry mix that has developed over time to support oil and natural gas activity. The smaller producing states generally have smaller support sectors located within the state and must import significant quantities of both goods and services from outside the state to support oil and natural gas activity. The larger and more developed these linkages to other industries within a given state, the greater the resulting multiplier tends to be on average.

Economic Contribution of Marginal Oil

Table 6a provides an assessment of the overall economic contribution of marginal oil production in 2016. Again, the estimates are based upon a hypothetical elimination of all marginal oil production in each of the 28 marginal oil-producing states.¹⁴

Table 6a. Economic Impact of Hypothetical Elimination of Marginal Oil Production

Well Type	Direct Impact			Multipliers			Total Impact		
	Lost Output (\$)	Earnings Loss (\$)	Employment Loss	Output	Earnings	Employment	Lost Output (\$)	Earnings Loss (\$)	Employment Loss
Texas	5,006,988,125	1,295,808,527	14,057	1.73	2.14	3.80	8,648,069,890	2,774,196,475	53,421
California	1,729,606,062	410,954,400	4,385	1.51	1.82	2.45	2,612,051,074	749,950,685	10,749
North Dakota	630,812,843	146,159,336	1,869	1.46	1.68	2.22	921,617,564	244,831,503	4,148
New Mexico	616,982,858	137,525,479	1,895	1.45	1.72	2.33	892,527,402	236,392,546	4,411
Oklahoma	576,728,853	145,451,017	1,611	1.57	1.91	2.88	908,232,597	277,156,912	4,636
Kansas	560,396,587	128,442,898	2,398	1.50	1.75	2.01	838,857,650	225,211,777	4,820
Illinois	335,625,150	75,985,534	1,699	1.50	1.82	1.95	502,632,225	138,210,088	3,312
Louisiana	327,042,769	80,485,225	926	1.56	1.90	3.40	509,925,085	152,777,055	3,152
Colorado	209,934,027	53,827,084	583	1.64	2.05	3.79	344,900,613	110,313,227	2,212
Utah	150,663,025	37,424,695	483	1.57	1.92	2.31	236,992,939	71,990,144	1,116
Michigan	136,209,909	30,865,165	706	1.41	1.70	1.94	192,369,254	52,609,674	1,369
Wyoming	120,568,260	27,730,700	290	1.41	1.61	2.09	169,663,656	44,729,619	606
Ohio	114,887,894	25,803,821	535	1.48	1.80	2.08	170,034,083	46,503,646	1,111
Arkansas	101,883,473	23,147,925	426	1.44	1.75	2.00	147,078,982	40,467,203	850
Kentucky	88,099,270	19,108,732	446	1.40	1.65	1.92	123,673,755	31,531,318	855
Montana	66,696,644	14,319,770	208	1.45	1.76	2.48	96,510,044	25,197,067	516
Indiana	63,778,848	13,291,512	175	1.40	1.67	1.90	89,009,760	22,168,913	332
Nebraska	51,930,353	11,336,396	262	1.34	1.58	2.28	69,513,970	17,865,026	598
Pennsylvania	48,366,896	11,148,569	120	1.56	1.94	2.96	75,520,071	21,677,278	356
Mississippi	29,447,453	6,684,572	87	1.45	1.71	2.45	42,737,088	11,453,345	214
West Virginia	21,472,651	4,842,083	112	1.47	1.69	1.95	31,500,379	8,196,678	219
Alabama	10,968,451	2,473,386	58	1.40	1.64	1.95	15,339,378	4,060,557	113
New York	8,458,299	1,756,789	21	1.34	1.55	2.11	11,362,879	2,721,793	44
Missouri	4,687,194	1,004,934	23	1.41	1.66	2.46	6,605,662	1,670,000	57
South Dakota	2,180,052	454,977	11	1.30	1.51	2.16	2,833,196	687,925	23
Nevada	1,781,749	394,301	9	1.36	1.61	2.38	2,414,804	636,638	22
Arizona	298,432	63,745	1	1.38	1.67	1.97	413,269	106,735	3
Virginia	8,156	1,665	0	1.37	1.63	2.33	11,175	2,719	0
Maryland	-	-	-	-	-	-	-	-	-
Survey States	11,016,504,280	2,706,493,237	33,397	1.60	1.96	2.97	17,662,398,444	5,313,316,546	99,265

The value of lost marginal oil output totaling \$11.0 billion in 2016 is used to estimate both the employment required to produce the output and the earnings that would be lost if marginal oil production were eliminated. Using ratios of output to employment and output to earnings derived from RIMS multipliers for each state, the shuttering of marginal oil production (NACIS sector 211000) would produce an estimated decline in direct employment of 33,397 workers and a reduction in direct household earnings of \$2.71 billion across the states reporting marginal oil production in 2016.

More than 60 percent of the direct economic loss is concentrated in the two largest marginal oil producing states, Texas and California. The direct impact in these two states totals \$6.74 billion in lost output, 18,441 lost jobs, and \$2.7 billion in lost earnings. Four additional states – North Dakota, New Mexico, Oklahoma, and Kansas – all suffer direct reductions in output in the oil and gas sector of more than \$500 million. Eight additional states – Illinois, Louisiana, Colorado, Utah, Michigan, Wyoming, Ohio, and Arkansas – suffer an estimated loss in direct output in the oil and gas sector of at least \$100 million with the elimination of marginal oil production.

RIMS II multipliers provide an estimate of the spillover effects to the broader economy of the survey states due to the elimination of marginal oil production. In addition to the overall direct loss of \$11.0 billion in oil and gas output, the weighted average of the output multipliers in Table 6a suggest that each dollar of reduced marginal oil output reduces the total output of goods and services across the marginally producing states by an additional 60 cents (1.60-1.0) through spillover effects. Based on the overall employment multiplier, each direct job lost through the elimination of marginal oil production will reduce total employment in these states by an additional 1.97 jobs (2.97-1.00). Similarly, based on the earnings multiplier, cutting marginal oil production by one dollar reduces total earnings in the marginal producing states by an additional \$0.96 (1.96-1.0).

Accounting for both direct and spillover effects, lost output from a hypothetical shuttering of marginal oil production would total an estimated \$17.7 billion in 2016. This consists of a loss of \$11.0 billion in direct oil production and \$6.7 billion in lost production in

other areas of the economy through spillover effects. Total employment losses reach an estimated 99,265 full- and part-time jobs, consisting of a direct loss of 33,397 energy sector jobs and an additional loss of 65,868 jobs through spillover effects. The total earnings decline to households is estimated at \$5.3 billion, with nearly half (\$2.6 billion) resulting from spillover earnings losses in other sectors of the survey states.

Including spillover losses, the overall impact of shuttering marginal oil production is heavily concentrated in 8 states with output losses exceeding \$500 million each. The total output loss is greatest in Texas (\$8.6 billion) and California (\$2.6 billion). The estimated share of total jobs lost in the scenario originating from these two states alone is 65 percent (64,169 jobs). Four additional states – North Dakota, New Mexico Oklahoma, and Kansas – are expected to suffer a total output loss of more than \$800 million from eliminating marginal oil production. Three more states – Illinois, Louisiana, and Colorado – suffer a total decline in the output of goods and services of \$300 million or more. The top nine states measured by lost output are expected to suffer combined total job losses ranging between 2,212 (Colorado) and 53,421 (Texas) workers, as well as earnings declines ranging from \$110 million (Colorado) to \$2.77 billion (Texas). Jointly, the top nine marginal oil producing states would account for more than 92 percent of total lost output, 92 percent of total lost earnings, and 92 percent of total lost employment if marginal oil production were eliminated.

Economic Contribution of Marginal Gas

Table 6b provides estimates of the expected impact of eliminating marginal natural gas output totaling \$4.75 billion in 2016. Using RIMS multipliers for each state in the survey, the shuttering of marginal natural gas production produces an estimated decline in direct oil and gas employment of 16,293 workers, approximately half the estimated number of direct jobs lost under the scenario of ending marginal oil production. Direct earnings lost total an estimated \$1.14 billion across the 27 states reporting marginal natural gas production in 2016.

Twelve states would suffer a loss in direct output of natural gas of more than \$100 million. Texas suffers

the greatest loss at \$1.0 billion, or 22 percent of the total reduction in marginal gas across all states. Oklahoma (\$784.7 million) suffers the second largest output loss, and when combined with Texas accounts for approximately 39 percent (\$1.85 billion) of the total direct loss to the marginal oil and gas sector. Texas would experience an earnings loss of \$275 million versus \$198 million in Oklahoma, along with a direct employment loss of 2,987 jobs in Texas versus 2,193 jobs in Oklahoma.

Six additional key marginal gas producing states – Colorado, New Mexico, Kansas, Kentucky, West Virginia, and Pennsylvania – would suffer direct reductions in oil and gas industry output of at least \$250 million if marginal gas production ceased. Four more states – Louisiana, Michigan, Alabama, and Ohio – would suffer estimated direct reductions in output in the oil and gas sector of more than \$100 million.

RIMS II multipliers provide an estimate of the spillover economic loss in each of the survey states due to the elimination of marginal natural gas production. Using weighted average results across all 27 states, the output multipliers in Table 6b suggest that each dollar reduction in marginal gas output reduces total economic activity in the survey states through spillover effects by an additional 56 cents (1.56-1.0). Each direct job lost in marginal natural gas production will reduce total employment by an additional 1.67 jobs (2.67-1.00). Similarly, reducing household earnings from marginal oil production by one dollar will reduce total household earnings in the survey states by an additional \$0.90 (1.90-1.0).

Including multiplier effects, lost output from a hypothetical shuttering of marginal natural gas production totals an estimated \$7.4 billion in 2016. This is less than half the size of the loss expected from shuttering marginal oil production. The \$7.4 billion total loss comprises a \$4.75 billion loss in

Table 6b. Economic Impact of Hypothetical Elimination of Marginal Natural Gas Production

Well Type	Direct Impact			Multipliers			Total Impact		
	Lost Output (\$)	Earnings Loss (\$)	Employment Loss	Output	Earnings	Employment	Lost Output (\$)	Earnings Loss (\$)	Employment Loss
Texas	1,064,010,538	275,365,927	2,987	1.73	2.14	3.80	1,837,759,002	589,530,914	11,352
Oklahoma	784,738,093	197,910,947	2,193	1.57	1.91	2.88	1,235,805,548	377,119,309	6,309
Colorado	438,916,314	112,538,143	1,220	1.64	2.05	3.79	721,095,613	230,635,670	4,625
New Mexico	364,123,420	81,163,110	1,118	1.45	1.72	2.33	526,740,939	139,511,270	2,603
Kansas	334,843,400	76,746,107	1,433	1.50	1.75	2.01	501,227,086	134,566,625	2,880
Kentucky	327,681,522	71,074,122	1,658	1.40	1.65	1.92	459,999,320	117,279,409	3,179
West Virginia	317,595,686	71,617,827	1,660	1.47	1.69	1.95	465,912,871	121,234,658	3,235
Pennsylvania	251,016,303	57,859,258	624.4	1.56	1.94	2.96	391,936,855	112,501,541	1,848.8
Louisiana	132,076,201	32,503,953	374	1.56	1.90	3.40	205,933,213	61,699,004	1,273
Michigan	123,645,561	28,018,084	641	1.41	1.70	1.94	174,624,625	47,756,824	1,242
Alabama	121,744,826	27,453,458	641	1.40	1.64	1.95	170,260,139	45,070,342	1,250
Ohio	119,015,257	26,730,827	554	1.48	1.80	2.08	176,142,581	48,174,296	1,151
Wyoming	84,886,779	19,523,959	204	1.41	1.61	2.09	119,452,675	31,492,146	427
Utah	73,507,640	18,259,298	235	1.57	1.92	2.31	115,627,518	35,123,585	545
Arkansas	66,255,756	15,053,308	277	1.44	1.75	2.00	95,646,809	26,316,193	553
Montana	51,291,595	11,012,305	160	1.45	1.76	2.48	74,218,938	19,377,253	397
Virginia	31,744,213	6,482,168	148.5	1.37	1.63	2.33	43,495,921	10,584,733	346.3
New York	20,948,439	4,350,991	52	1.34	1.55	2.11	28,142,132	6,740,990	109
California	20,753,765	4,931,095	53	1.51	1.82	2.45	31,342,336	8,998,755	129
Indiana	12,975,472	2,704,088	36	1.40	1.67	1.90	18,108,568	4,510,149	68
Mississippi	2,992,260	679,243	9	1.45	1.71	2.45	4,342,667	1,163,815	22
North Dakota	1,613,760	373,908	5	1.46	1.68	2.22	2,357,704	626,334	11
Nebraska	1,030,555	224,970	5	1.34	1.58	2.28	1,379,501	354,530	12
Illinois	661,500	149,764	3	1.50	1.82	1.95	990,662	272,405	7
South Dakota	483,646	100,937	2	1.30	1.51	2.16	628,546	152,617	5
Maryland	105,840	20,734	0	1.32	1.56	2.14	139,963	32,436	1
Arizona	70,383	15,034	0.4	1.38	1.67	1.97	97,466	25,173	0.7
Missouri	-	-	-	-	-	-	-	-	-
Nevada	-	-	-	-	-	-	-	-	-
Survey States	4,748,728,722	1,142,863,566	16,293	1.56	1.90	2.67	7,403,409,198	2,170,850,974	43,579

direct natural gas output plus \$2.65 billion in lost output in other industry sectors through spillover effects. Total employment losses reach an estimated 43,579 full- and part-time jobs, consisting of a direct loss of 16,293 energy sector jobs and an additional loss of 27,286 jobs in other sectors through spillover effects. Total household earnings decline by an estimated \$2.2 billion, with \$1.1 billion of the loss attributed to spillover wage losses in other industry sectors.

Total lost output remains greatest in Texas (\$1.84 billion) and Oklahoma (\$1.24 billion), the two largest marginal natural gas-producing states. These two states account for 42 percent of total lost economic output and 41 percent of total jobs lost. Five states – Colorado, New Mexico, Kansas, Kentucky, and West Virginia – are expected to suffer a loss in total output of goods and services of more than \$400 million.

Seven more states – Pennsylvania, Louisiana, Michigan, Alabama, Ohio, Wyoming, and Utah – are expected to suffer a loss in total output of more than \$100 million. Across the 14 states with an expected total output loss of \$100 million or more, the projected loss in total employment averages approximately 3,000 jobs and annual earnings of \$149 million as marginal natural gas production ends.

Total impact of eliminating marginal oil and natural gas production

In total, the elimination of \$15.8 billion in production of both marginal oil and marginal natural gas in 2016 would trigger an estimated direct loss within the oil and gas sector of 49,690 jobs and \$3.85 billion in direct earnings within the survey states. Including spillover effects, total output of goods and services would fall by an estimated \$25.1 billion, 142,844 jobs would be lost, and household earnings would decline by an estimated \$7.5 billion.

Overall, Texas, California, and Oklahoma suffer the greatest losses in total output from eliminating all marginal oil and natural gas production. These three states suffer estimated declines in output of \$10.5 billion, \$2.6 billion, and \$2.1 billion, respectively. Total earnings (and total employment) lost in these three states is estimated at \$3.4 billion (64,773 jobs) in Texas, \$759 million (10,878 jobs) in California, and \$654 million (10,945 jobs) in Oklahoma.

Three additional states – New Mexico, Kansas, and Colorado – suffer estimated losses in total output of goods and services exceeding \$1.0 billion.

Fourteen states suffer estimated total output declines of between \$100 million and \$1 billion. These states include North Dakota, Louisiana, Kentucky, West Virginia, Illinois, Pennsylvania, Michigan, Ohio, Utah, Wyoming, Arkansas, Alabama, Montana, and Indiana.

Four states – Nebraska, Mississippi, Virginia, and New York – have estimated lost output of between \$25 million and \$75 million from shuttering all marginal production.

Finally, the five smallest marginally-producing states – Missouri, South Dakota, Nevada, Arizona, and Maryland – experience less than \$10 million in lost direct and spillover output of goods and services.

Across all 29 survey states, each million dollars of lost marginal production would reduce total economic output by an additional \$589,940 on average. Per million dollars of lost marginal production, total employment falls by 5.9 jobs and household earnings decline by \$230,560. The overall multiplier effect tends to be the highest in many of the traditional key energy producing states including Texas, Oklahoma, Colorado, Louisiana, Pennsylvania, Utah, and California.

Economic Losses from Plugged and Abandoned Wells

Marginal wells represent lost future economic activity as they are plugged and abandoned. Once a marginal well is removed from production, a stream of economic benefits is forfeited going forward, potentially for many years into the future. While the decision to shut-in any individual well may be a minor economic event, when viewed cumulatively across the U.S. and over time they can have a large and significant impact on national and state-level oil and natural gas production.

Reversal in the number of plugged and abandoned wells

Tables 7a and 7b on the following pages provide historical estimates of the number of oil and natural gas wells plugged and abandoned annually in the U.S., including estimates of the volume and market value of foregone production.

Results from the current IOGCC survey indicate that the total number of plugged and abandoned wells declined for a second consecutive year in 2016. The total number of plugged and abandoned oil wells fell to 19,504 in 2016, down 1,100 wells (5.4 percent) from 2015.

However, the longer-term results for oil and natural gas have diverged (see Figure 11). Oil wells remained near the highest levels reported since 2003 while plugged and abandoned natural gas wells are now almost one-third below the recent peak reached in 2012.

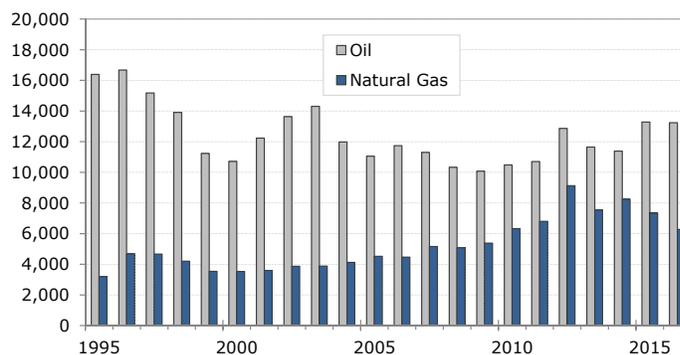
The number of oil wells plugged annually has fluctuated in a range between 10,000 and 15,000 much of the past two decades. Following the upturn in oil prices in 2008, the number of plugged oil wells surged from a little more than 10,000 in 2009 to nearly 13,000 by 2012. After easing in 2013 and 2014, the number of reported oil wells plugged and abandoned surged to 13,279 in 2015. Only 13,235 plugged and abandoned oil wells were reported in 2016.

The number of natural gas wells plugged and abandoned reached a bottom at only 3,534 wells in 2000 before entering a steady uptrend, eventually peaking at more than 9,100 wells in the 2012 survey. This rise coincides closely with rising natural gas prices beginning in 2001 and the resulting increase in domestic natural gas exploration. The number of plugged and abandoned natural gas wells eased to 7,329 wells in 2015 and fell further to only 6,269 in 2016. Plugged and abandoned natural gas wells are now down by approximately 2,000 (24 percent) since 2014 but remain well above historical plugging totals.

By estimated production, more than 13,200 oil wells producing 9.5 million barrels of oil, and nearly 6,300 natural gas wells producing 30.9 million Mcf of natural gas, annually, were plugged and abandoned in the U.S. in 2016. The estimated market value of lost annual production from these wells totaled \$441.8 million – \$363.9 million for oil and \$77.9 million for natural gas.

Over the past decade a cumulative total of more than 115,000 oil wells and 67,200 natural gas wells have been plugged and abandoned with a total annual market value of lost production estimated at \$7.6 billion measured in the year production ceased.

Figure 11. Plugged and Abandoned Wells



Source: IOGCC Marginal Well Survey and RegionTrack

The Economic Impact of Plugged and Abandoned Wells

The direct and spillover economic impacts of the output lost from marginal wells plugged and abandoned in 2016 is estimated in Table 8. The impacts are based on the amount of earnings and employment that would have been required to produce an additional year's output at prevailing market prices for oil and natural gas.

In total, the \$441.8 million in lost direct oil and gas output from 19,504 wells plugged and abandoned across the U.S. in 2016 would have supported an estimated 1,371 full- and part-time jobs with annual earnings of \$108.2 million.

Spillover economic effects realized in other sectors of the economy are formed using the average effective multiplier for both oil and natural gas across the 29 marginally-producing states. With spillover

effects included, total lost output from plugged and abandoned wells in 2016 produced an estimated total decline in output of goods and services in the survey states of \$703 million. This in turn reduces total employment in the survey states by 3,940 full- and part-time jobs and total earnings by an estimated \$210 million annually.

Again, the impact estimates are highly conservative in that they reflect only one year of reduced future production from wells plugged and abandoned in 2016. Nonetheless, the reduced output from plugged and abandoned wells could persist for many years going forward. This is true as well for each annual cohort of wells plugged and abandoned prior to 2016. Hence, the annual estimates in Table 8 provide a lower bound of the estimate of the potential lifetime value of production from plugged and abandoned wells.

Table 7a. National Plugged and Abandoned Oil Wells

Year	Number of Marginal Oil Wells	Production from Marginal Oil Wells (Bbls)	Value of Marginal Oil Production	Average Daily Production per Well (Bbls)	Oil Wells Plugged/ Abandoned	Lost Oil Production (Bbls)	Price of Oil (\$/Bbl)	Lost Value of Oil Production (\$)
1992	453,277	368,132,000	5,886,430,680	2.23	16,211	13,165,874	15.99	210,522,325
1993	452,248	355,961,000	5,072,444,250	2.16	16,914	13,312,882	14.25	189,708,572
1994	442,500	339,930,000	4,483,676,700	2.10	17,896	13,747,768	13.19	181,333,058
1995	433,048	332,288,089	4,858,051,861	2.10	16,389	12,562,169	14.62	183,658,903
1996	428,842	323,468,274	5,971,224,338	2.06	16,674	12,537,181	18.46	231,436,354
1997	420,674	323,487,914	5,573,696,758	2.11	15,172	11,684,716	17.23	201,327,653
1998	406,380	316,870,286	3,444,380,009	2.14	13,912	10,866,663	10.87	118,120,629
1999	410,680	315,514,283	4,909,402,243	2.10	11,227	8,605,496	15.56	133,901,510
2000	411,629	325,947,181	8,709,308,676	2.16	10,718	8,450,071	26.72	225,785,902
2001	403,459	316,099,192	6,903,606,353	2.15	12,234	9,600,632	21.84	209,677,792
2002	402,072	323,776,606	7,288,211,401	2.21	13,635	10,998,673	22.51	247,580,124
2003	393,463	313,748,001	8,646,894,908	2.18	14,300	11,378,510	27.56	313,591,736
2004	397,362	310,922,122	11,432,606,426	2.14	11,977	9,355,235	36.77	343,991,980
2005	401,072	321,761,570	16,178,171,740	2.20	11,058	8,871,323	50.28	446,050,143
2006	422,381	324,496,483	19,369,195,070	2.10	11,738	9,017,782	59.69	538,271,399
2007	396,537	291,067,592	19,361,816,220	2.01	11,296	8,291,533	66.52	551,552,758
2008	378,950	265,751,608	24,991,281,204	1.92	10,328	7,242,856	94.04	681,118,179
2009	390,033	262,416,602	14,787,175,500	1.84	10,070	6,775,164	56.35	381,780,500
2010	390,842	267,488,671	20,052,388,648	1.88	10,483	7,174,474	74.97	536,004,938
2011	397,721	274,697,863	25,741,435,384	1.89	10,698	7,388,541	93.71	707,305,038
2012	398,711	275,830,121	25,597,410,421	1.90	12,857	8,894,523	92.80	840,710,271
2013	395,752	291,655,231	27,874,764,146	2.02	11,653	8,587,839	95.57	824,346,692
2014	406,649	299,765,367	26,178,153,079	2.02	11,389	8,395,514	87.33	733,683,986
2015	401,204	289,914,779	12,884,851,361	1.98	13,279	9,595,572	44.44	425,947,463
2016	396,023	284,413,213	11,016,504,280	1.97	13,235	9,505,020	38.73	363,947,205

Table 7b. National Plugged and Abandoned Natural Gas Wells

Year	Number of Marginal Gas Wells	Production from Marginal Gas Wells (Mcf)	Value of Marginal Gas Production	Average Daily Production per Well (Mcf)	Gas Wells Plugged/ Abandoned	Lost Gas Production (Mcf)	Price of Gas (\$/Mcf)	Value of Lost Gas Production (\$)
1992	130,432	670,451,027	1,166,584,788	14.1	3,161	16,248,280	1.74	28,272,008
1993	142,100	759,897,057	1,550,189,997	14.7	3,162	16,909,180	2.04	34,494,727
1994	159,369	940,421,000	1,739,778,850	16.2	3,163	18,664,556	1.85	34,529,429
1995	159,669	925,563,034	1,434,622,703	15.9	3,189	18,507,362	1.55	28,686,410
1996	168,702	986,676,219	2,141,087,395	16.0	4,671	27,278,640	2.17	59,194,649
1997	189,756	1,042,153,002	2,417,794,965	15.0	4,661	25,518,975	2.32	59,204,022
1998	199,745	1,104,683,975	2,165,180,591	15.2	4,203	23,318,244	1.96	45,703,758
1999	207,766	1,138,979,506	2,494,365,118	15.3	3,546	19,802,637	2.19	43,367,775
2000	223,222	1,258,726,664	4,632,114,124	15.4	3,534	19,864,614	3.68	73,101,780
2001	234,507	1,353,516,378	5,414,065,512	15.8	3,600	20,761,200	4.00	83,044,800
2002	245,961	1,418,273,779	4,183,907,648	15.8	3,870	22,318,290	2.95	65,838,956
2003	260,563	1,478,105,524	7,213,154,957	15.5	3,883	21,968,073	4.88	107,204,194
2004	271,856	1,539,960,495	8,408,184,303	15.5	4,129	23,359,818	5.46	127,544,604
2005	288,898	1,760,063,552	12,901,265,836	16.7	4,517	27,519,080	7.33	201,714,854
2006	304,000	1,716,319,702	10,967,282,896	15.5	4,463	25,197,154	6.39	161,009,814
2007	322,160	1,763,592,746	11,022,454,663	15.0	5,155	28,219,893	6.25	176,374,329
2008	326,340	1,831,809,216	14,599,519,453	15.4	5,075	28,486,994	7.97	227,041,344
2009	331,579	2,152,036,402	7,897,973,596	17.8	5,381	34,924,175	3.67	128,171,724
2010	353,483	2,171,035,452	9,710,490,967	16.8	6,333	38,896,260	4.47	174,255,244
2011	360,993	2,089,652,663	8,232,410,818	15.9	6,803	39,377,113	3.94	155,539,595
2012	357,876	2,077,281,480	5,522,470,336	15.9	9,123	52,954,226	2.66	140,858,242
2013	374,274	2,095,071,218	7,815,414,649	15.3	7,545	42,234,612	3.73	157,535,102
2014	388,735	2,063,468,282	9,021,494,481	14.5	8,249	43,787,075	4.37	191,349,517
2015	381,508	1,945,135,129	5,104,495,649	14.0	7,329	37,367,210	2.62	97,902,091
2016	381,334	1,880,282,880	4,748,728,722	13.5	6,269	30,911,225	2.53	77,896,288

Table 8. Economic Impact of Plugged and Abandoned Wells in 2016

Well Type	Direct Impact			Multipliers			Total Impact		
	Lost Output (\$)	Earnings Loss (\$)	Employment Loss	Output	Earnings	Employment	Lost Output (\$)	Earnings Loss (\$)	Employment Loss
Crude Oil	363,947,205	89,413,177	1,103	1.59	1.94	2.87	578,654,984	173,842,860	3,172
Natural Gas	77,896,288	18,747,087	267	1.59	1.94	2.87	123,850,587	36,449,294	768
Total	441,843,493	108,160,264	1,371	1.59	1.94	2.87	702,505,571	210,292,154	3,940

Conclusion

The reemergence of domestic oil and gas production in the U.S. the past decade has been remarkable. Estimates suggest that U.S. natural gas production increased 52 percent during its recent surge from 2005 to 2015, while oil production increased 88 percent between 2008 and 2015. Nineteen of the 33 natural gas producing states posted increased production in the surge period, while 21 of the 32 oil producing states posted output gains. These production gains have fueled reduced imports and increased exports of petroleum products along with growing domestic use of natural gas and a burgeoning natural gas export industry.

Despite the resurgence in domestic oil and natural gas production and sharply lower prices for oil and natural gas in recent years, the critical role played by marginal wells in U.S. energy production remains intact. Currently, an estimated 777,000 marginally-producing wells – more than 396,000 oil wells and nearly 381,000 natural gas wells – serve a strategic role within the U.S. energy production framework.

Most operating wells in the U.S. in 2016 are marginal producers, including 68.5 percent of all oil wells and 77.1 percent of all natural gas wells. Overall, 72.4 percent of all operating wells in the U.S. in 2016 have marginal production levels.

The 284.4 million barrels of marginal oil produced in the U.S. in 2016 represent 8.8 percent of total domestic oil production of 3.24 billion barrels. This share increased slightly from 8.4 percent in 2015 due to a sharper relative pullback in overall U.S. oil production in 2016. For perspective, the volume of marginal oil produced in 2016 exceeds the total oil production of every producing state except Texas and North Dakota. Marginal oil production exceeds the total oil output of California, Alaska, and Oklahoma, the third-, fourth-, and fifth-largest oil-producing states.

Marginal natural gas production in the U.S. totaled a reported 1.88 billion Mcf in 2016, down 3.3 percent from 2015. Current production represents 6.6 percent of the 28.3 billion Mcf of natural gas produced domestically in 2016. Marginal natural gas output exceeds the total natural gas output of all but the top three producing states – Texas, Pennsylvania, and Oklahoma – and exceeds the total natural gas output of other top-tier natural gas producing states such as Wyoming, Louisiana, Colorado, Ohio, West Virginia, and New Mexico.

The estimated value of marginal oil and natural gas produced in 2016 declined slightly to \$15.8 billion. This is nearly 50 percent below recent years and reflects current low prices for both oil and natural gas. The value of the 284.4 million barrels of marginal oil produced totaled \$11.0 billion based on an average price of \$38.29 per barrel. The 1.88 billion Mcf of marginal natural gas produced in 2016 is valued at \$4.75 billion based on an average natural gas price of \$2.52 per Mcf.

Marginal oil and natural gas production in the U.S. continues to exert tremendous spillover economic activity across the energy-producing regions. The hypothetical elimination of \$15.8 billion in marginal oil and natural gas production in 2016 would trigger an estimated direct loss of 49,690 jobs and \$3.85 billion in earnings within the oil and natural gas industry. Including spillover effects to other industries, total output of goods and services across the survey states would fall by an estimated \$25.1 billion, 142,844 jobs would be lost, and household earnings would decline by an estimated \$7.5 billion.

Texas, California, and Oklahoma would suffer the greatest estimated loss in total output of goods and services from the hypothetical elimination of marginal oil and natural gas production. These three states suffer estimated declines in output of \$10.5 billion, \$2.6 billion, and \$2.1 billion, respectively.

Total earnings (and total employment) lost in the three hardest-hit states reaches \$3.4 billion (64,773 jobs) in Texas, \$759 million (10,878 jobs) in California, and \$654 million (10,945 jobs) in Oklahoma. Three additional states - New Mexico, Kansas, and Colorado - suffer estimated losses in total economic output ranging from \$1.1 billion to \$1.4 billion including spillover effects.

Fourteen states suffer estimated total output declines of between \$100 million and \$1 billion. These states include North Dakota, Louisiana, Kentucky, West Virginia, Illinois, Pennsylvania, Michigan, Ohio, Utah, Wyoming, Arkansas, Alabama, Montana, and Indiana. Four states - Nebraska, Mississippi, Virginia, and New York - have estimated lost output of between \$25 million and \$75 million from shuttering all marginal production. The five smallest marginally-producing states - Missouri, South Dakota, Nevada, Arizona, and Maryland - experience less than \$10 million in lost direct and spillover output of goods and services.

The large number of wells plugged and abandoned each year presents an ongoing economic cost to U.S. energy production.

Over the past decade, a cumulative total of more than 182,500 wells - 115,000 oil wells and 67,000 natural gas wells - have been plugged and abandoned. The lost production from these wells the past decade has an estimated market value of \$7.6 billion annually (measured in the year production ceased). The estimated market value of the lost production from these wells in 2016 totaled \$442 million - \$364 million for oil and \$78 million for natural gas.

Including estimated spillover effects, the reduction in output from wells plugged and abandoned in 2016 creates a total decline in U.S. output of \$703 million. This in turn reduces total employment by an estimated 3,940 full- and part-time jobs and total household earnings by an estimated \$210 million annually across the survey states.

Appendix A. Marginal Well Survey

Data Notes

Marginal well production data for calendar year 2016 were collected by IOGCC staff in a recent survey of state oil and gas reporting entities. Data in the report for years prior to 2016 are either from prior marginal well annual reports or represent revised estimates provided by the states in the latest survey.

Twenty-eight of the twenty-nine states report the production of marginal oil; twenty-seven report the production of marginal natural gas. Nevada reports only oil and Maryland only natural gas. Missouri has traditionally reported small quantities of natural gas production but reported none in 2016.

A few states not included in the survey have very small amounts of marginal oil and natural gas production. These states include Alaska, Florida, Georgia, South Carolina, and Tennessee. Omitting the small amounts of production from these states does not materially affect the results presented in the report.

Marginal Oil Production Data:

Oil production data is as reported from the IOGCC annual marginal well survey for the following 24 states: Alabama, Arizona, Arkansas, California, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Montana, Nebraska, Nevada, New Mexico, New York, North Dakota, Ohio, South Dakota, Texas, Utah, Virginia, West Virginia, and Wyoming.

For the remaining states:

Colorado: The state of Colorado reports stripper production only for oil wells producing 15 barrels or less of oil per day. For consistency with IOGCC's definition of a marginal well, well-level oil production data for 2015 released by the Colorado Oil and Gas Conservation Commission is adjusted to match the 10 barrels per day or less production bracket used in the report. The number of oil wells was adjusted in the same

manner using the ratio of wells by well size from the same dataset.

Illinois: Total oil production for 2016 is from EIA. Consistent with past surveys, all oil production is assumed marginal. The number of marginal wells for 2016 is estimated using the output per marginal well from 2009.

Missouri: Total oil production for 2016 is from EIA. Consistent with past surveys, all oil production is assumed marginal. The number of marginal wells for 2016 is estimated using the output per marginal well from 2012, the last year average output was reported.

North Dakota: Average oil production per marginal well as reported for North Dakota exceeds 10 barrels per day. This is a preliminary estimate that reflects a change in reporting by the state and that is subject to revision in future releases.

Oklahoma: Total oil production for 2016 is from EIA. Marginal oil production for 2013-2016 is estimated using a linear model based on total oil production, total oil production per well, and historical marginal production. The number of marginal wells for 2016 is estimated using the output per marginal well derived from a time series model using the 2009 Distribution and Production of Oil and Gas Wells by State series provided by EIA.

Pennsylvania: Total oil production for 2016 is from EIA.

Marginal Natural Gas Production Data:

Natural gas production data is as reported from the IOGCC annual survey for the following 25 states: Alabama, Arizona, Arkansas, California, Indiana, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, New York, North Dakota, Ohio, Pennsylvania, South Dakota, Texas, Utah, Virginia, West Virginia, and Wyoming.

For the remaining states:

Colorado: The state of Colorado reports stripper production only for natural gas wells producing 90 Mcf or less of gas per day. To match IOGCC's definition of a marginal well, well-level natural gas production data for 2015 released by the Colorado Oil and Gas Conservation Commission is adjusted to match the 60 Mcf or less per day production bracket used in the report. The number of natural gas wells was adjusted in the same manner using the ratio of wells by well size from the same dataset.

Illinois: Total gas production for 2016 is from EIA. Marginal gas production for 2016 is estimated using the ratio of marginal production to total production from 2015. The number of marginal gas wells for 2016 is estimated using the output per marginal well from the 2009 Distribution and Production of Oil and Gas Wells by State series provided by EIA.

Maryland: Consistent with past surveys, marginal gas production is assumed equal to total gas production in 2016 period. The small number of marginal gas wells in 2016 is assumed unchanged from 2015.

Oklahoma: Total natural gas production for 2016 is from EIA. Marginal gas production for 2016 is estimated using a linear model based on total gas production, total gas production per well, and historical marginal gas production. The number of marginal gas wells for 2016 is estimated using the output per marginal well derived from a time series model using the 2009 Distribution and Production of Oil and Gas Wells by State series provided by EIA.

Endnotes

¹ Import data are available online at: https://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mdbl_m.htm. Data on exports of petroleum products are available online at: https://www.eia.gov/dnav/pet/pet_move_exp_dc_NUS-Z00_mdblpd_m.htm.

² Data on natural gas use by sector are available online at: https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm.

³ Data on natural gas exports are available online at: https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm.

⁴ The survey respondent is generally a state official within the agency that is responsible for oil and gas industry reporting.

⁵ Recent Marginal Wells reports published by the IOGCC are available online at: <http://iogcc.ok.gov>

⁶ Crude oil production estimates are available online at: https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mdbl_m.htm. Natural gas production estimates by state are available online at: https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGM_mmcfa.htm.

⁷ The market value of marginal production is estimated using state-level prices for oil and natural gas as reported by the U. S. Energy Information Agency (EIA). Oil prices reflect the first purchase price of crude oil field production, while natural gas prices are reported as the wellhead price through 2010 and the ratio of the 2010 wellhead price to the current year spot price for Henry Hub natural gas for 2011-2016. The market value of total U.S. production is estimated using the U.S. crude oil first purchase price for oil and the wellhead price for natural gas.

⁸ Total BOE marginal production is calculated by adding barrels of marginal oil produced to the volume of natural gas in Mcf divided by six.

⁹ Economic impact estimates are most reliable when applied to scenarios involving a small, incremental change in economic activity. The hypothetical case used in the report does not attempt to evaluate any resulting structural changes to the regional economy of each of the states.

¹⁰ The multipliers are based on the 2015 regional update of the input-output model underlying the RIMS II estimates.

¹¹ Caution must always be used when using input-output multipliers to assess the total economic activity 'supported' by an existing industry or firm. Input-output multipliers are intended to predict the change in economic activity that results from an incremental change in the current state of a regional economy. More specifically, the estimates provided for marginal oil and natural gas production reflect predictions from the RIMS II input-output model of the incremental impact that would result if industry revenue in the marginally producing states contracted incrementally. The actual realized impact is determined by the unique adjustment process that would take place in each state as marginal production changes.

¹² The estimated spillover effects include both indirect and induced effects. The indirect effect is the statewide inter-industry economic activity resulting from purchases by the state's marginal producers, while the induced effect reflects the economic activity resulting from new household spending out of employee earnings received as part of the direct and indirect effects. For convenience, the spillover impacts are typically summarized using economic impact multipliers. The multipliers quantify the amount of spillover activity resulting from each dollar of activity in the state oil and natural gas sector. The indirect and induced effects are derived using Type II multipliers calculated as $(\text{direct} + \text{indirect} + \text{induced})/\text{direct}$. More generally, RIMS II output multipliers provide an estimate of the amount of output generated statewide per dollar of new output generated in the oil and natural gas industry. Employment multipliers provide an estimate of the number of full- and part-time jobs generated statewide per new job added in the oil and gas industry. Earnings multipliers provide an estimate

of the amount of new labor income received by households statewide per new dollar of labor income added in the oil and natural gas industry.

¹³ A well-known limitation of input-output models is that they do not account for subsequent general equilibrium-type effects such as changes in the relative prices of goods and services or changes in wage rates at the industry level.

¹⁴ The resulting net effect is an empirical modeling question that cannot be answered with certainty. The estimates are best viewed as providing an upper bound on the spillover effects.

¹⁵ The State of Colorado reports only the total number of wells plugged and abandoned and has not differentiated between oil and natural gas wells since 2009. Based on historical reports prior to 2009, there is an approximately even split between the two well types. Estimates of the number of plugged and abandoned wells by type for Colorado for 2010-2016 are based on an equal split between oil and gas wells.



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