

7-2017

Shale Investment Dashboard in Ohio Q3 and Q4 2016

Andrew R. Thomas

Cleveland State University, A.R.THOMAS99@csuohio.edu

Jeffrey C. Dick

Mark Henning

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Prepared for:
JOBSONIO

Prepared by:
Andrew R. Thomas
Jeffrey C. Dick
Mark Henning

July 2017

**SHALE INVESTMENT
DASHBOARD IN OHIO
Q3 AND Q4 2016**

**Energy Policy
Center**

2121 Euclid Avenue Cleveland, Ohio 44115
<http://urban.csuohio.edu>

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Executive Summary

This report presents findings from an investigation into shale-related investment in Ohio. The investment estimates are cumulative from July through December of 2016. Prior investments have previously been reported and are available from Cleveland State University.¹ Subsequent reports will estimate additional investment since the date of this report.

Investment in Ohio into the Utica during the second half of 2016 can be summarized as follows:

Total Estimated Upstream Utica Investment: July-December 2016

Lease Renewals	\$1,615,400,000
Drilling	\$1,220,000,000
Roads	\$ 65,500,000
Near Lease Gathering Lines	\$ 196,500,000
Lease Operating Expenses	\$101,230,000
Royalties	\$362,840,000
Total Estimated Upstream Investment	\$3,561,470,000

¹ The previous report on shale investment in Ohio up to July 1, 2016 can be found at:
http://engagedscholarship.csuohio.edu/cgi/viewcontent.cgi?article=2468&context=urban_facpub

Total Estimated Midstream Investment: July-December 2016

Gathering Lines	\$202,850,000
Processing Plants	\$ 89,300,000
Transmission Lines	\$ 250,000,000
Total Estimated Midstream Investment	\$ 542,150,000

Total Estimated Downstream Investment: July-December 2016

Petrochemical Plants	\$0
Natural Gas Power Plants	\$0
CHP Plants	\$36,450,000
Natural Gas Refueling Stations	\$0
Total Estimated Downstream Investment	\$36,450,000

Total investment from July through December 2016 is approximately \$4.14 billion, including upstream, midstream and downstream. This does not include indirect development, such as development into new manufacturing as a result of lower energy costs. Together with previous investment to date, cumulative investment in Ohio through 2016 was estimated to be around \$54.9 billion. Of this, \$42.8 billion was in upstream, \$8.7 billion in midstream, and \$3.4 billion was in downstream industries.

The industry investment strategy for Ohio is readily apparent from the Ohio Department of Natural Resources Division of Oil and Gas (ODNR) listing of new wells during the second half of 2016. In the first several years of development, the principal Utica drilling activity had been in Carroll County. By the second half of 2016, however, the ODNR had listed 131 new wells as “drilled, drilling or producing” during this period. Of this number, only five were drilled in Carroll County. On the other hand, 45 and 33 new wells were listed for Belmont and Monroe counties, respectively.

Chesapeake Exploration remained the top producer for Q3 and Q4 of 2016, having produced 173 billion cubic feet equivalent (Bcfe). However Gulfport Energy was close behind, having produced 166 Bcfe, followed by Antero Resources, Ascent Resources and Rice Drilling at 97, 70, and 68 Bcfe, respectively. These five companies made up around 76% of the total production from the second half of 2016.

1. INTRODUCTION

A. BACKGROUND.

This is the second of four studies reporting investment resulting from oil and gas development in Ohio related to the Utica and Point Pleasant formations (hereinafter, the “Utica”). This analysis looks at investment made in Ohio between July 1 and December 31, 2016, separately considering the upstream, midstream and downstream portions of the industry. For the upstream part, the study team estimated spending primarily based upon the likely costs of drilling new and operating old wells, together with royalties and lease bonuses. For midstream estimates, the study team looked at new infrastructure built during the relevant time period downstream of production, from gathering to the point of hydrocarbon distribution.

For the downstream analysis, the study team considered those industries that directly consume large amounts of oil, natural gas or natural gas liquids. Since hydrocarbon consumption may or may not be related to shale development, the examination of downstream investment has been limited to those projects that have been deemed by the study team to be directly the result of the large amount of oil and gas being developed in the region as a result of the Marcellus and Utica shale formations.

This second study also includes as an appendix the cumulative investment made in Ohio a result of shale development, based upon a previous report that tracked total investment through June 2016.² Subsequent reports will include incremental spending on a quarterly basis.

2. METHODOLOGY

A. UPSTREAM METHODOLOGY.

Investment into the upstream for this second report has been broken down into four categories. The first category is investment into wells, and includes one-time investments into drilling, roads and close-to-the-lease gathering lines.³ Drilling costs were estimated as:

² *Id.*

³ Operating companies do not make available their “authorities for expenditure,” the common accounting device used to estimate well costs. Further, while many operators provide average well costs in their public investment documents, they do not usually break it down into specific areas of investment. As a result, the study team used industry interviews to estimate investment into various portions of the well, and then compared this to the overall well costs set forth in the investment presentations. The estimates did not differentiate between those portions of the investments that go directly into the Ohio economy, and those that go elsewhere.

- Drilling: Northern Counties - \$7 mm/well; Southern Counties - \$10 mm/well.⁴
- Roads: average investments - \$500,000 per well. Based upon:
 - \$1 mm/mile road improvement, with one mile per pad.
 - \$250,000/bridge, \$200,000/culvert, with one each per pad.
 - 3 wells per pad.⁵
- Near-Lease Gathering: \$1.5 mm/well. Based upon:
 - 4 miles of 8-inch gathering lines per pad.
 - \$140,000/inch-mile.
 - 3 wells per pad.

The second estimated upstream cost identified by operators is the “lease operating expense.” This includes post-production costs such as the storage, processing and disposal of produced water, among other expenses. Lease operating expenses for Utica wells were estimated (based upon industry interviews) to be around \$1200/month, throughout the life of the well. For purposes of estimating the lease operating expenses for Q3 and Q4 2016, the study team assumed that all wells listed as “producing” by the Ohio Department of Natural Resources on July 1, 2016 were incurring this cost, and continued to do so through December 31, 2016. Lease operating expenses for wells that began production after July 1, 2016 were averaged since they did not produce for all six months.⁶

A third area of upstream investment, royalty calculation, is more complicated. The estimate is based upon the total production over the six month period and the likely price received for sales of the hydrocarbon during that same period. However, because much of the natural gas has been processed, Ohio Department of Natural Resources production records cannot be readily converted to royalty payments. Accordingly, a number of assumptions are required to estimate the royalties paid. These include estimating the local market conditions at the time hydrocarbon were sold, together with adjustments required to account for transportation costs. Royalties were estimated on a per quarter basis for Utica production based upon the hydrocarbon content for a typical Utica well.

To estimate the royalties, the following assumptions were made based upon industry interviews, industry investor presentations, and Energy Information Agency reports:

- Production for each well was similar to that found in the wet gas region, and not the dry gas or condensate regions.

⁴ The difference in costs between counties are a result of the Utica being deeper in the southern counties than in the north, requiring more expensive drilling in over-pressured formations. The northern counties are: Carroll, Harrison, Jefferson, Columbiana, Trumbull, Mahoning and Tuscarawas. The southern counties are: Noble, Guernsey, Belmont, Monroe and Washington.

⁵ Pads are built for 6-8 wells, however early drilling is averaging around 3 wells per pad. This may change in the next several years as units are drilled out. Many operators are still putting resources into drilling and holding new units, thereby reducing the average number of wells per pad.

⁶ See fn 11, *infra*.

- The average production shrinkage after processing was 12%, thereby making the residue gas volume 88% of the total natural gas production.
- The residue energy content was around 1.1 MMBtu/Mcf.⁷ Energy Information Agency prices were used to estimate royalties, which prices are based upon MMBtu at the Henry Hub market, and were adjusted accordingly.
- Residue gas in the Utica area was selling at prices around \$0.65/Mcf below the Henry Hub market (local price differential).
- Transportation costs of around \$0.65/Mcf were deducted from the royalty price.
- Around 44 barrels of liquids were recovered per million cubic feet of gas produced.
- Natural gas liquids were selling for around 30% of the EIA listed price for West Texas Intermediate crude oil.
- Condensate and oil in the Utica region were selling for around \$10 below the EIA listed price for West Texas Intermediate crude (local price differential).
- Royalty rates are 20% of gross production.

Finally, a fourth form of upstream investment was estimated: lease renewal bonuses. For this purpose, we assumed that the average renewal bonus paid was \$5000/acre, and that the typical lease has a five-year primary term. Accordingly, we have assumed that approximately 20% of the undeveloped acreage identified in the first study will need to be renewed each year.⁸ Since this study covered six months, we assumed that half of this 20% was renewed during the study period. However, this estimate is based upon total undeveloped acreage, and not allocated on a per well basis. This estimate may be high insofar as companies are not renewing all their acreage, and some acreage will be developed and not need renewal. However, it is also likely to be low insofar as the prior study only identified undeveloped acreage for the top six operators in Ohio, and insofar as new leases were not included.

B. MIDSTREAM METHODOLOGY.

Midstream expenditures were estimated based upon a combination of midstream company investor reports, media reports, and industry “rules of thumb” obtained from industry interviews, government reports, and industry trade journals. Estimated investments were then compared against investor presentations and other information gleaned from public sources to confirm their accuracy. Interviews were also used to confirm ranges of expenditures.

For purposes of estimating the investments for midstream processing plants, rules of thumb were developed based upon throughput capacities for facilities. These rules of thumb were applied to the processing plants that have been built in Ohio, using the throughput capacity estimates made available from public literature. Likewise, rules of thumb based upon throughput capacity were used to estimate investments downstream of the processing plants, such as storage facilities and

⁷ The EIA estimates that the average conversion should be 1.037 MMBtu/Mcf (see: www.eia.gov/tools/faqs/faq.php?id=45). However, industry interviews suggest 1.1 is closer to the average conversion for the Utica Shale.

⁸ This estimate was confirmed through industry interviews.

loading terminals. Dehydration processing plants were estimated using average cost per Mcf capacity for similarly designed and recently built plants in the Appalachian region.

Pipeline investments were estimated by using “inch-mile” cost estimates, and knowing the pipeline diameter and length. Interstate pipeline diameters and mileage can be determined from Federal Energy Regulatory Commission data; intrastate mileage and diameter were estimated based upon investor reports. These estimates were confirmed from investor presentations, when available. Table 1 provides an estimated cost for natural gas transmission pipelines published by the Oil and Gas Journal.

Table 1: Per Mile Cost Estimates for Natural Gas Pipelines.

Size (in.)	Right of Way	Material	Labor	Misc.	Total
12	\$ 68,779.00	\$ 188,942.00	\$ 737,056.00	\$ 438,626.00	\$ 1,433,403.00
16	\$ 267,288.00	\$ 415,979.00	\$ 1,937,269.00	\$ 1,473,663.00	\$ 4,094,199.00
20	\$ 199,333.00	\$ 329,680.00	\$ 2,728,127.00	\$ 1,740,590.00	\$ 4,997,730.00
24	\$ 134,000.00	\$ 337,650.00	\$ 2,021,810.00	\$ 836,247.00	\$ 3,329,707.00
30	\$ 736,129.00	\$ 920,316.00	\$ 4,919,086.00	\$ 3,406,645.00	\$ 9,982,176.00
36	\$ 504,104.00	\$ 895,253.00	\$ 3,301,095.00	\$ 2,763,844.00	\$ 7,464,296.00

Source: Oil and Gas Journal (2016).

For purposes of this Study, we have differentiated between gathering lines on or near the lease (around 4 miles per pad) and gathering lines that pick up the production at some central location and deliver it to a processing plant (trunk lines) or to an interstate pipeline. The former tend to be smaller diameter pipelines (typically 8 inches), with lower pressures; the latter tend to be larger diameter pipelines (12 inches and greater), with higher pressures. The investment costs for the lower pressure lease lines are included in the upstream “post production” costs, while the high-pressure trunk lines are included in the midstream “gathering” costs. No investments into distribution lines were included in the Study, since it is assumed that these have not grown as a direct result of shale development.

For pipelines carrying liquids, the investment assumption is that expenditures will be comparable to those seen for gas pipelines. These were also corroborated by industry investor reports. Finally, no assumptions were made for fractionation plants, insofar as no new fractionation capacity was added during the study period.

The following estimated costs were assumed for midstream infrastructure:

- Gathering (Trunk) Lines.⁹
 - 12 inch pipelines
 - \$1.4 MM/mile

⁹ Because only one company reported new processing facilities during the study period, the study team used actual reported gathering line mileage to estimate the gathering line investment rather than relying on average mileage per unit of throughput. However, we did include the compressor investment estimate based upon the rules of thumb. See Table 14.

- 170 miles per 1 Bcf/d throughput
 - 20 inch pipelines
 - \$2.4 MM/mile
 - 30 miles per 1 Bcf/d throughput
 - Compressors
 - 3 compressor stations per 1 BCFD throughput
 - \$10 mm/station
- Processing Plants.
 - \$400,000 per MMcf/d throughput
 - \$80 MM per 200 MMcf/d plant (typical skid size)
- Fractionation Plants.
 - \$2800 per bbl/d
 - \$100 mm per 36000 bbl/d unit (typical size of plant)
- Storage Tankage: \$80 MM for 1 Bcf/d throughput
- Rail Loading Terminals: \$40 MM for 1 Bcf/d throughput

C. DOWNSTREAM METHODOLOGY.

For estimating downstream expenditures, the study team relied upon publicly available reports gathered from news media, trade association publications, company websites and investor presentations. The study team also used interviews from time to time to support investment estimates.

3. SHALE INVESTMENT UPDATES

A. UPSTREAM DEVELOPMENT

1. Background

A total of 131 new wells were listed by the Ohio Department of Natural Resources as “drilled,” “drilling,” or “producing” during the period of July 1 to December 31, 2016. The total number of producing wells in the Utica was at 1472 by January 1, 2017. Total production in billion cubic feet equivalent (Bcfe) for this period was 751 Bcfe, led by Belmont County with 272 Bcfe. Monroe County was second with 127 Bcfe, followed by Harrison County with 107 Bcfe.¹⁰

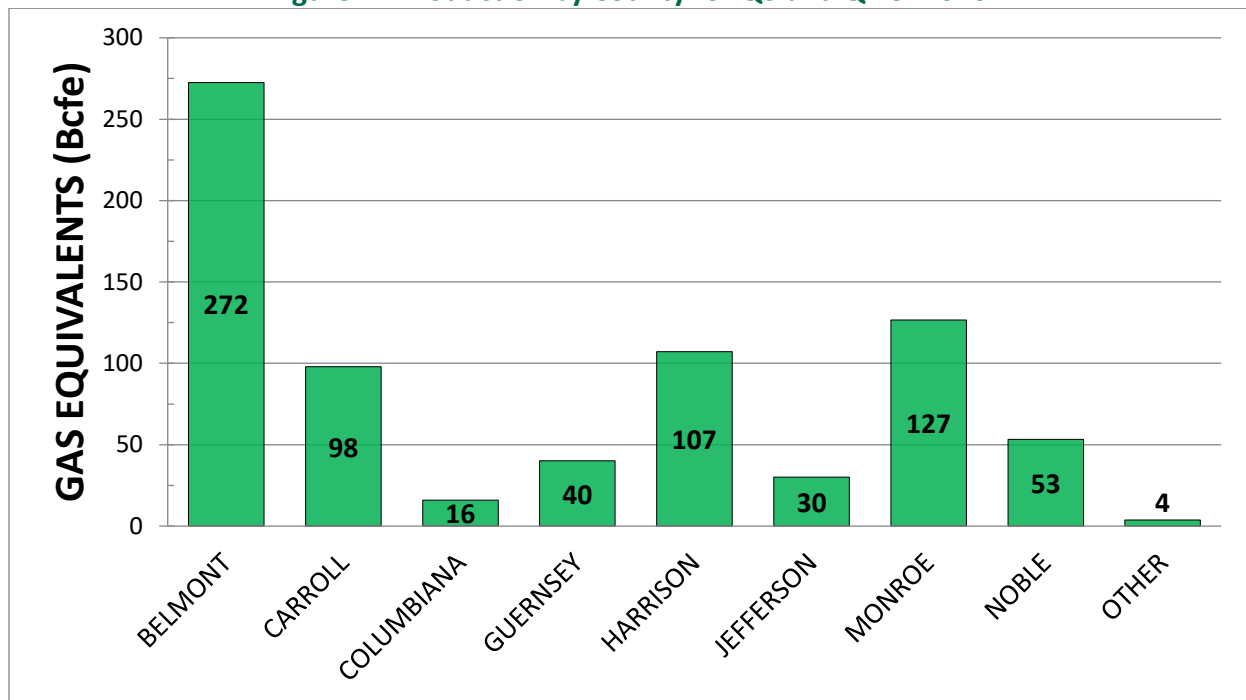
¹⁰ Production is reported to the ODNR at the wellhead as gas measured in thousands of cubic feet (Mcf) and as oil measured in barrels (bbl). The Utica also produces significant volumes of natural gas liquids (NGLs) such as ethane, propane, butane and natural gasoline. These NGLs are separated from the natural gas stream at midstream cryogenic and fractionation plants and not included in the ODNR production reports. For the purpose of this study, oil and gas production is combined as gas equivalents (Mcfe) based on the energy content of oil and gas, measured as British thermal units (Btu). Gas equivalents were calculated using the following formula: Gas Equivalents (Mcfe) = Oil (bbl) x 5.659 Mcf/bbl + Gas (Mcf)

The Ohio Department of Natural Resources (Division of Oil and Gas Resources Management) (ODNR) issues weekly reports on well status and quarterly reports on production. The ODNR production reports for the third and fourth quarters of 2016 provide the foundation for the analyses presented in this Study.

The Utica is currently identified by the ODNR as producing in nineteen eastern Ohio counties with the vast majority (ninety-nine percent) of producing wells located in twelve counties stretching from Trumbull County in the north to Washington County at the southern end of the play. Table 2 provides a summary of cumulative production and production for the third and fourth quarters of 2016. Total cumulative production in Bcfe by county and by operator through December 2016 can be found in the appendix as Figures 5 and 6. New drilling and production have been moving steadily from Carroll County to Belmont County since 2014. For comparison of historical drilling between these two counties, see Figure 10 in the appendix, Trend in Drilling and Production (Carroll and Belmont Counties).

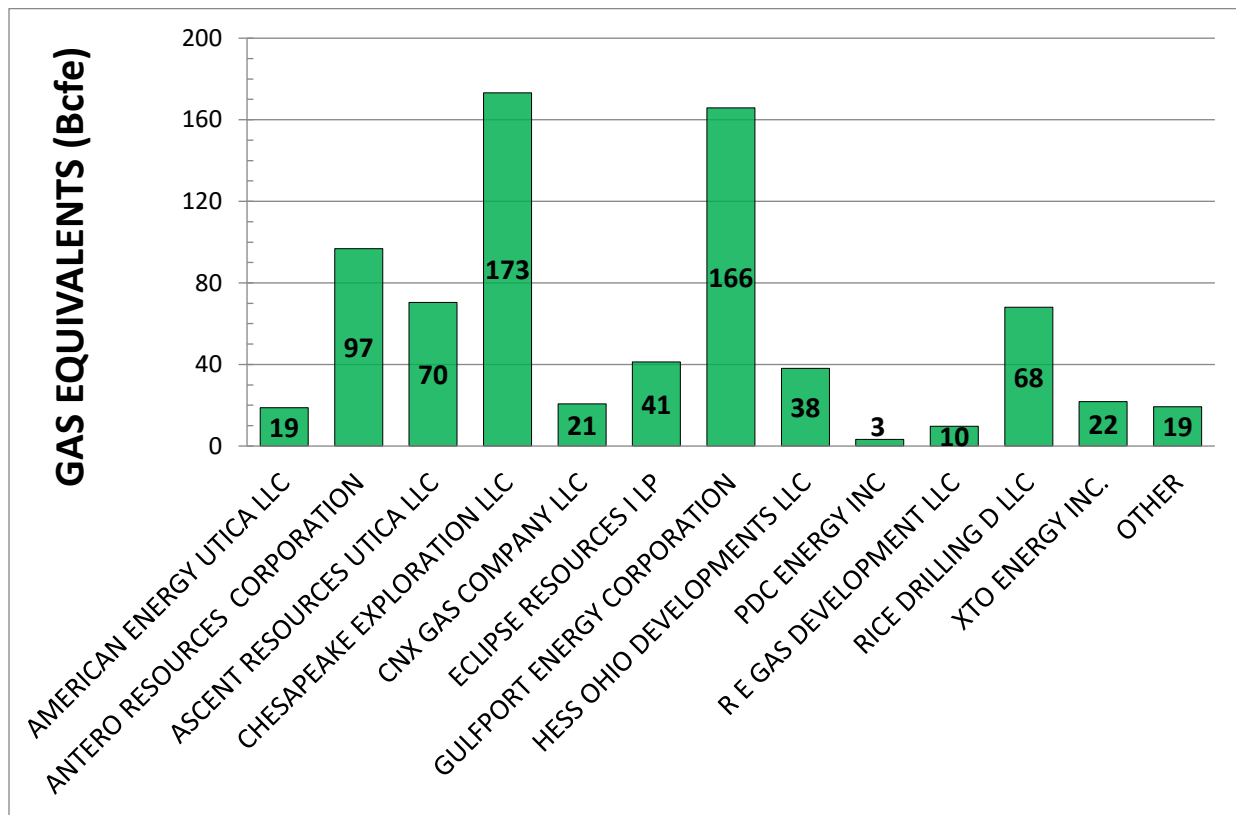
Total quarters 3 and 4 production for 2016 are set forth by county and operator in Figures 1 and 2 below.

Figure 1: Production by County for Q3 and Q4 of 2016.



Source: J. Dick (2017).

Figure 2: Production by Operator for Q3 and Q4 of 2016.



Source: J. Dick (2017).

2. Production Analysis

A meaningful way to summarize production is through the use of tables that show gas equivalent production measured in billions of cubic feet equivalent (Bcfe) as a function of time. This summary is set forth in Table 2. Table 3 sets forth production by county for the second half of 2016. Figure 3 sets forth the geographic distribution of production for the same period.

Table 2: Production by Reporting Period

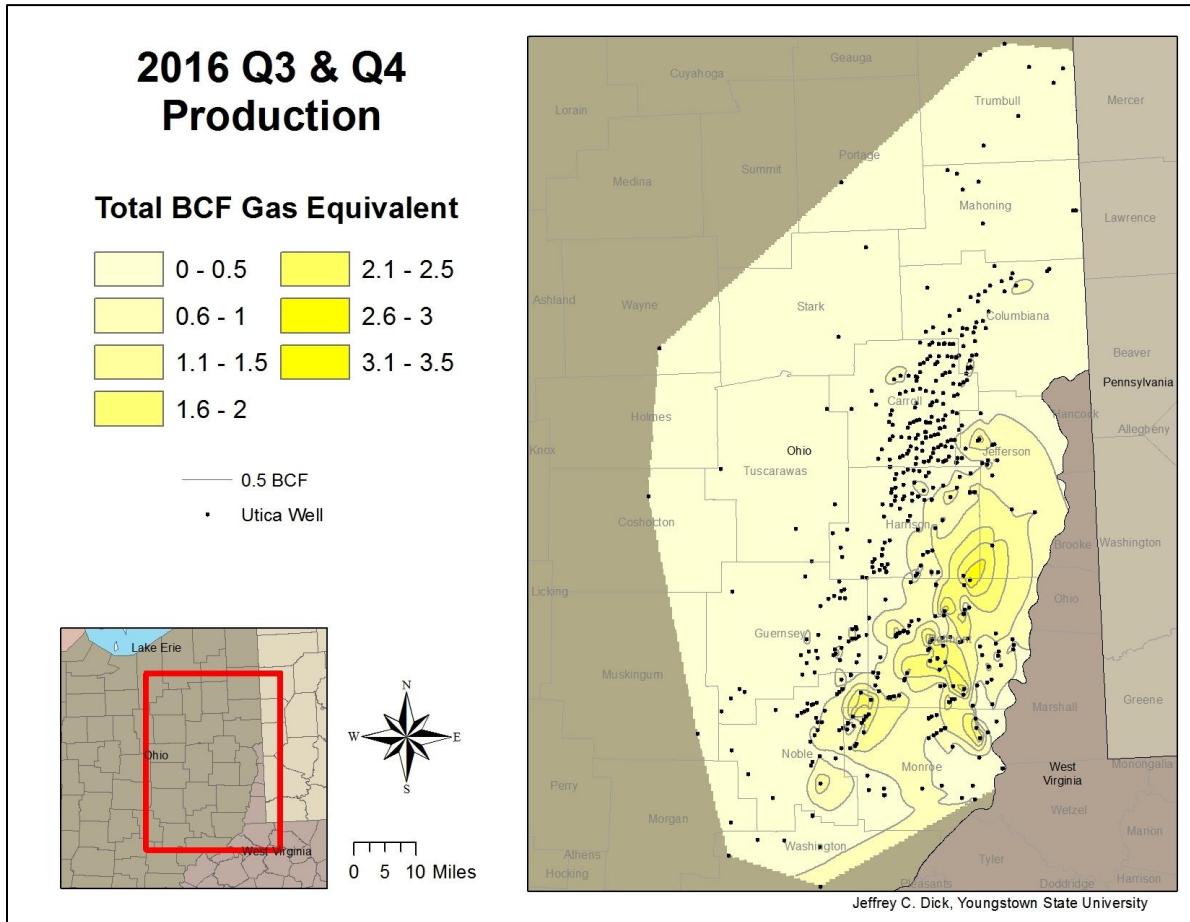
Year	Quarter	Production Wells	Gas Equivalents (Mcfe)	Oil (bbl)	Gas (Mcfe)	Gas Prod. (% Change)
2016	4	1472	364,362,772	3,568,788	344,167,001	-4.6
2016	3	1442	383,057,580	3,954,095	360,681,356	7.9
2016	2	1382	361,646,365	4,839,792	334,257,982	1.4
2016	1	1328	360,582,286	5,485,854	329,537,838	9.3
2015	4	1248	336,846,492	6,248,451	301,486,508	39.0
2015	3	989	242,096,253	4,439,258	216,974,492	-2.2
2015	2	992	253,429,927	5,578,255	221,862,582	20.8
2015	1	907	208,667,049	4,432,195	183,585,256	11.4
2014	4	810	184,954,459	3,558,836	164,815,008	26.5
2014	3	688	147,171,872	2,984,534	130,282,395	48.4
2014	2	535	101,480,943	2,422,179	87,773,834	30.8
2014	1	415	78,006,674	1,928,076	67,095,693	57.2
2013	4	371	50,807,259	1,433,731	42,693,774	28.4
2013	3	269	40,747,160	1,323,812	33,255,706	123.7
2013	2	186	18,012,520	556,437	14,863,645	80.4
2013	1	117	10,056,202	321,439	8,237,177	-35.8
2012	ANNUAL	82	16,429,703	635,874	12,831,292	400.9
2011	ANNUAL	9	2,823,683	46,326	2,561,524	
		Totals	3,161,179,200	53,757,932	2,856,963,063	

Source: J. Dick (2017).

Table 3: Production by County for July-December 2016

County	Gas Equivalents (Mcfe)	Oil (bbl)	Gas (Mcfe)	Production Wells
BELMONT	272,498,933	65,474	272,128,416	266
CARROLL	97,930,140	1,822,893	87,614,389	438
COLUMBIANA	15,830,190	38,267	15,613,637	66
COSHOCTON	22,622	479	19,911	1
GUERNSEY	40,152,913	2,249,967	27,420,350	128
HARRISON	107,098,629	2,570,824	92,550,336	290
JEFFERSON	30,061,965	330	30,060,098	35
MAHONING	1,373,284	7,170	1,332,709	14
MONROE	126,680,715	103,302	126,096,129	163
MORGAN	182,784	8,944	132,170	2
MUSKINGUM	32,670	1,079	26,564	1
NOBLE	53,380,326	602,765	49,969,279	130
OTHER	3,786,539	69,061	3,395,723	57
PORTAGE	1,725	0	1,725	5
STARK	76,874	2,261	64,079	2
TRUMBULL	175,179	2,366	161,790	10
TUSCARAWUS	396,192	27,487	240,643	7
WASHINGTON	1,525,209	19,275	1,416,132	12
Totals	751,206,891	7,591,944	708,244,080	1,630

Source: J. Dick (2017).

Figure 3: Distribution of Gas Equivalent Production for July-December 2016

Of the 1,882 total wells identified from the ODNR records, 135 were in the process of drilling in December of 2016, 275 wells had been drilled and apparently were awaiting markets, and 1,472 wells were in the production phase. See Table 4, Ohio Utica Well Status. Carroll County continues to lead in total wells. See Table 5.

Table 4: Ohio Utica Well Status – January 1, 2017

Well Status	
Drilled	275
Drilling	135
Producing	1,472

Source: Ohio Department of Natural Resources (January, 2017)

Table 5: Well Status by County (January 2017)

County	Drilled	Drilling	Producing	Total
CARROLL	28	5	430	463
HARRISON	41	9	278	328
BELMONT	40	38	240	318
MONROE	56	38	138	232
GUERNSEY	26	12	127	165
NOBLE	19	19	119	157
COLUMBIANA	17	1	60	78
JEFFERSON	27	10	33	70
MAHONING	1	0	13	14
WASHINGTON	1	0	11	12
TRUMBULL	3	1	7	11
PORTAGE	5	1	3	9
TUSCARAWAS	1	1	7	9
STARK	5	0	2	7
OTHER 7 COUNTIES	5	0	4	9
Total	275	135	1472	1882

Source: ODNR (2017)

B. UPSTREAM INVESTMENT ESTIMATES

Upstream investments have been broken down into four areas: investments into drilling, lease operation (post production) expenses, bonuses and royalties. The formula used for each calculation is set forth in section 2A above. This section covers upstream investments between July and December of 2016. Cumulative upstream investment to date in Ohio, including 2012-June 2016, is set forth in Table 18 of the appendix.

1. Investments into Drilling.

The following tables set forth estimated investments to date made into drilling shale wells in Ohio. Belmont County is the leader in recent upstream investment, with 45 new wells and an investment of around \$540 million between July and December 2016. Monroe and Jefferson Counties are second and third, with 33 and 23 new wells, respectively, and with \$396 and \$207 million invested. See Table 6.

Rice Drilling was the leading operator investor during the six-month period, with 22 wells and an estimated \$264 mm invested, followed by Gulfport with 21 wells and an estimated \$252 million invested. Ascent Resources and Chesapeake Exploration each drilled 18 wells, with \$201 and \$162 million (reflecting Chesapeake's continued investment into the northern counties) invested, respectively. Antero drilled 15 wells, with an estimated investment of \$180 million. See Table 7.

Table 6: Estimated Upstream Shale Investment by County, July-December 2016
(Excludes royalties, bonuses for undeveloped acreage and lease operating expenses)

County	No. of wells	Drilling	Roads	Near Lease Gathering	Total Amount (\$mm)
BELMONT	45	\$450.00	\$22.50	\$67.50	\$540.00
CARROLL	5	\$35.00	\$2.50	\$7.50	\$45.00
COLUMBIANA	2	\$14.00	\$1.00	\$3.00	\$18.00
GUERNSEY	9	\$90.00	\$4.50	\$13.50	\$108.00
JEFFERSON	23	\$161.00	\$11.50	\$34.50	\$207.00
MONROE	33	\$330.00	\$16.50	\$49.50	\$396.00
NOBLE	14	\$140.00	\$7.00	\$21.00	\$168.00
Total	131	\$1,220.00	\$65.50	\$196.50	\$1,482.00

Source: The Authors (2017)

**Table 7: Estimated Upstream Shale Investment in Ohio by Company, July-December 2016
(Excludes royalties, bonuses for undeveloped acreage and lease operating expenses)**

Well Operators	No. of Wells	Drilling	Roads	Near Lease Gathering	Total (\$mm)
ANTERO RESOURCES CORPORATION	15	\$150.00	\$7.50	\$22.50	\$180.00
ASCENT RESOURCES UTICA LLC	18	\$165.00	\$9.00	\$27.00	\$201.00
CARRIZO (UTICA) LLC	3	\$30.00	\$1.50	\$4.50	\$36.00
CHESAPEAKE APPALACHIA LLC	1	\$7.00	\$0.50	\$1.50	\$9.00
CHESAPEAKE EXPLORATION LLC	18	\$126.00	\$9.00	\$27.00	\$162.00
CNX GAS COMPANY LLC	8	\$80.00	\$4.00	\$12.00	\$96.00
ECLIPSE RESOURCES I LP	6	\$60.00	\$3.00	\$9.00	\$72.00
EM ENERGY OHIO LLC	1	\$10.00	\$0.50	\$1.50	\$12.00
GULFPORT BUCKEYE LLC	1	\$7.00	\$0.50	\$1.50	\$9.00
GULFPORT ENERGY CORPORATION	21	\$210.00	\$10.50	\$31.50	\$252.00
HILCORP ENERGY COMPANY	1	\$7.00	\$0.50	\$1.50	\$9.00
PDC ENERGY INC	1	\$10.00	\$0.50	\$1.50	\$12.00
R E GAS DEVELOPMENT LLC	4	\$28.00	\$2.00	\$6.00	\$36.00
RICE DRILLING D LLC	22	\$220.00	\$11.00	\$33.00	\$264.00
STATOIL USA ONSHORE PROP INC	7	\$70.00	\$3.50	\$10.50	\$84.00
XTO ENERGY INC.	4	\$40.00	\$2.00	\$6.00	\$48.00
Total	131	\$1,220.00	\$65.50	\$196.50	\$1,482.00

Source: The Authors (2017).

2. Lease Operating Expenses

Post production investments have been estimated on a per quarter basis, assuming an average cost of around \$12,000/month. These investments are set forth below.

Table 8: Estimated Lease Operating Expenses for July-December 2016 by County

County	No. of Production Wells ¹¹	Lease Operating Expenses for Period (\$mm)
BELMONT	203	14.62
CARROLL	428	30.82
COLUMBIANA	60	4.32
COSHOCTON	1	0.07
GUERNSEY	118	8.50
HARRISON	273	19.66
JEFFERSON	27	1.94
MAHONING	13	0.94
MONROE	134	9.65
MORGAN	2	0.14
MUSKINGUM	1	0.07
NOBLE	117	8.42
PORTAGE	3	0.22
STARK	2	0.14
TRUMBULL	7	0.50
TUSCARAWAS	7	0.50
WASHINGTON	10	0.72
Totals		101.23

¹¹ The number of wells producing was determined by taking the average of the number of such wells as identified by ODNR on July 2, 2016 and January 7, 2017. It is assumed that this number of average production wells incurred lease operating expenses for all six months.

Table 9: Estimated Lease Operating Expenses for July-December 2016 by Operator

Operator	No. of Production Wells ¹²	Lease Operating Expenses for Period (\$mm)
ANTERO RESOURCES CORPORATION	140	10.08
ARTEX OIL COMPANY	6	0.43
ASCENT RESOURCES UTICA LLC	93	6.70
ATLAS NOBLE LLC	12	0.86
CARRIZO (UTICA) LLC	5	0.36
CHESAPEAKE APPALACHIA LLC	3	0.22
CHESAPEAKE EXPLORATION LLC	613	44.14
CHEVRON APPALACHIA LLC	8	0.58
CNX GAS COMPANY LLC	40	2.88
ECLIPSE RESOURCES I LP	58	4.18
EM ENERGY OHIO LLC	2	0.14
ENERVEST OPERATING LLC	5	0.36
EQT PRODUCTION COMPANY	6	0.43
GULFPORT ENERGY CORPORATION	198	14.26
HALCON OPERATING COMPANY INC	8	0.58
HESS OHIO DEVELOPMENTS LLC	59	4.25
HILCORP ENERGY COMPANY	10	0.72
MOUNTAINEER KEYSTONE LLC	2	0.14
NGO DEVELOPMENT CORP.	1	0.07
PDC ENERGY INC	26	1.87
PROTEGE ENERGY III LLC	1	0.07
R E GAS DEVELOPMENT LLC	38	2.74
RICE DRILLING D LLC	37	2.66
STATOIL USA ONSHORE PROP INC	1	0.07
TRIAD HUNTER LLC	8	0.58
XTO ENERGY INC.	27	1.94
Totals		101.2

3. Royalties.

Royalty investments have been estimated on a per quarter basis, assuming the formula set forth in Section 2A above. Total estimated royalties spent on Ohio properties between July and December 2016 were around \$362.8 million. The breakdown by quarter for oil, residue gas and natural gas liquids is set forth in Tables 10 , 11, and 12 below.

**Table 10: Total Royalties from Oil in Millions of Dollars
July-December 2016**

Year	Quarter	Oil Price \$/bbl	Oil Royalty (20%) \$/bbl	Royalty (\$mm)
2016	4	39.13	7.83	27.94
2016	3	34.85	6.97	27.56
			Subtotal	55.49

**Table 11: Total Royalties from Residue Gas in Millions of Dollars
July-December 2016**

Year	Quarter	Residue Gas Price \$/Mcf	Residue Gas Royalty (20%) \$/Mcf	Royalty (\$mm)
2016	4	2.04	0.41	124.17
2016	3	1.87	0.37	117.44
			Subtotal	219.98

¹² See *id.*

**Table 12: Total Royalties from Natural Gas Liquids in Millions of Dollars
July-December 2016**

Year	Quarter	NGL Price \$/bbl	NGL Royalty (20%) \$/bbl	Royalty (\$mm)
2016	4	14.74	2.95	44.67
2016	3	13.46	2.69	42.69
			Subtotal	87.36

4. Lease Renewals.

Lease renewal investments have been estimated for the Utica region based upon the drilling activity of top five drilling companies in the region, plus Ascent Resources, which company has acquired a significant leasehold in the Utica. These six companies have together drilled over 80% of the Utica wells to date, and it is assumed that they likewise have over 80% of the leases. The estimated investments into undeveloped acreage is set forth below in Table 13.

All estimates assume \$5000/acre lease bonus. Only net lease acreage was used to avoid possible double counting (producing companies often collaborate on drilling), although bonuses would have been paid on the gross lease acreage. This may result in underestimating the total investment. Likewise, using only acreage from the top five drillers, plus Ascent, may also introduce some error. In addition, this estimate does not include bonuses paid on any new leases, which also may make the estimate low. Continued low prices through 2016, though, may have also induced operators to not renew some leases, which may cause the estimate to be high. Likewise, some leases were developed, meaning no renewal would be required.

**Table 13: Total Estimated Investments into Undeveloped Acreage in Millions of Dollars
July-December 2016**

Operator	Undeveloped Acreage	Estimated Bonus Investment (\$mm)
Gulfport ¹³	171,919	86
Chesapeake ¹⁴	2,514,000	1,257
Antero ¹⁵	126,798	63.4
Rice ¹⁶	52,049	26
Ascent ¹⁷	300,000	150
Eclipse ¹⁸	65,908	33
Total		1,615.4

¹³ <http://ir.gulfportenergy.com/all-sec-filings/content/0001628280-17-001359/0001628280-17-001359.pdf>

¹⁴ http://www.chk.com/Documents/investors/20150908_Latest_IR_Presentation.pdf, and
<http://www.chk.com/investors/sec-filings>

¹⁵ <https://www.fool.com/investing/2016/08/17/the-5-companies-dominating-the-utica-shale-play.aspx>

¹⁶ http://investors.riceenergy.com/phoenix.zhtml?c=252759&p=IROL-sec&secCat01Enhanced.1_rs=21&secCat01Enhanced.1_rc=10

¹⁷ <http://ascentresources.com/operations.html>

¹⁸ http://ir.eclipseresources.com/sites/eclipseresources.investorhq.businesswire.com/files/report/additional/ECR_AR_260150.pdf

C. Estimated Midstream Investments.

Midstream investment has been determined in part based upon additions to processing capacity set forth by the various midstream companies operating in Ohio in their investor presentations and reports. Additional midstream investment was determined by estimating gathering and transmission line costs, including compression. Table 14 sets forth both processing and pipeline investment in Ohio for Q3 and Q4 2016.

Table 14: Midstream Infrastructure Investment. July-December 2016 (in millions of dollars).

Company	Additions to Infrastructure	Total Amount (\$mm)
Blueracer (Caiman)	<ul style="list-style-type: none"> 25 miles of wet gas gathering lines¹⁹ 200 MMcf/d of processing plant capacity²⁰ 	\$188.4
Eureka Midstream	<ul style="list-style-type: none"> Cain Ridge metering and dehydration facility. 	\$9.3 ²¹
Gulfport	<ul style="list-style-type: none"> 11 miles of 12-inch gathering lines for dry gas through its midstream subsidiaries 	\$15.8 ²²
Summit Midstream	<ul style="list-style-type: none"> Continued expansion of both dry and wet gathering systems as well as further development of condensate stabilization facility 	\$78.7 ²³
Marathon Pipe Line	<ul style="list-style-type: none"> Cornerstone Pipeline: 42 miles of 16-inch pipe and 8 miles of 8-inch pipe to carry condensate from the MarkWest Cadiz facility to the Marathon Canton refinery 	\$250 ²⁴
Total		\$542.2

Source: The Authors (2017).

Momentum Midstream describes its Utica East Ohio C2+ fractionation capacity as 160,500 Bpd²⁵, suggesting an increase from the previously reported 135,000 Bpd since our last report. However, we could not confirm any additions to Momentum's M4 processing infrastructure. Additionally, Williams Partners, which also owns an equity share in Utica East Ohio, described the Harrison

¹⁹ The pipe diameter was assumed to be no less than 16 inches upon reviewing press releases pertaining to the company's gathering system. See <http://www.blueracermidstream.com/news>. Pipeline mileage was determined based on investor presentations.

²⁰ Blue Racer's non-pipeline investments—including compressors and processing plants—were estimated by applying the formulas from the midstream methodology section to the throughput as included in the company's investor presentations.

²¹ This estimate is based on known costs for similar glycol dehydration plants in New York and Pennsylvania with comparable throughput.

²² See form 10-K for fiscal year 2016.

²³ *Id.*

²⁴ This is part of a \$500 million overall investment by Marathon in its pipeline network that will continue into 2017 with construction of the 49-mile Harpster to Lima pipeline. See <http://marcellusdrilling.com/2017/02/marathon-begins-to-build-new-49-mile-utica-pipeline-in-ohio/>

²⁵ See <http://www.momentummidstream.com/what-we-do/current-projects/m4-assets>

location in its 2017 10-K filing as a 135 Mbbls/d fractionation facility. We therefore did not include any new investment related to the Harrison Hub fractionation facility.

We identified one significant new investment into liquids transmission pipelines for July through December of 2016. That investment was made by Marathon Pipeline and was estimated to be around \$250 million for condensate pipeline facilities near its Canton refinery.

There will be large expenditures on interstate pipelines during 2017, some of which have already begun as of the date of this report. These will be included in subsequent reports. Some of these interstate pipeline projects and their estimated investment include:

- KinderMorgan's \$540 million Utopia East pipeline. Construction on the 215 miles of 12-inch pipe began in the first quarter of 2017 and is expected to be complete by Q1 2018.
- The \$2.1 billion Nexus project, with 255 miles of 36-inch pipeline running through Ohio, was awaiting FERC approval as of June 2017. The FERC commission was without a quorum as of the time of this report.
- Energy Transfer's \$4.2 billion Rover pipeline, with nearly 400 miles of primarily 42-inch pipe in Ohio, began construction in the first quarter of 2017 and is expected to be in service by November 2017.
- Columbia's \$1.5 billion Leach Xpress²⁶ project, with approximately 150 miles of 36-inch pipe in Ohio, began construction in February 2017 with Q4 2017 completion anticipated.

Cumulative midstream investment to date in Ohio, including 2012-June 2016, is set forth in Table 19 in the appendix.

D. DOWNSTREAM DEVELOPMENT

1. Natural Gas Power Plants.

Ten new natural gas power plants were either under construction or in the planning stages across the state by the end of 2016. Four of these plants (in Oregon, Lordstown, Washington Township, and Middletown) were included as investments in the last study. The Oregon plant is now operational while the other three are still under construction.

Notwithstanding plans for the six other new power facilities, no new apparent construction had begun on the proposed plants during the six-month period covered by this study. Construction on an 1,100 MW, \$1.1 billion in Yellow Creek Township was slated to begin in January, 2017.²⁷ In

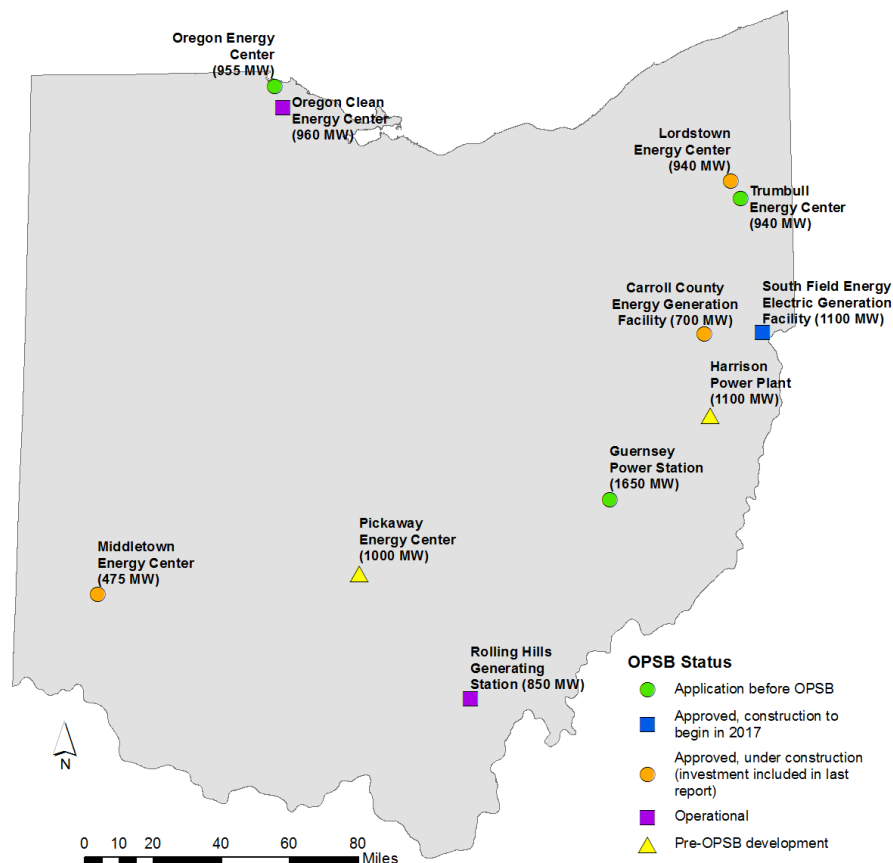
²⁶ Leach Xpress was mistakenly described as being under construction in our last report. FERC gave approval for the pipeline in January 2017 and construction began the following month. See: <http://marketwired.sys-con.com/node/3990263>.

²⁷ "Updated: \$1.1B Power Plant to be Built in Wellsville," *Business Journal Daily* (October 8, 2015). Retrieved from <http://businessjournaldaily.com/breaking-1-1b-power-plant-to-be-built-in-wellsville>. See also: "South Field Energy Wins Air Permit for 1,150 MW, Gas-fired Project in Ohio" *Electric Light & Power* (September 27, 2016). Retrieved

addition to these 10 plants, the Rolling Hills Generating Facility plans to convert its 850 MW peaking plant to a 1,414-megawatt combined-cycle natural gas-fueled generating station. However, conversion of this facility in Wilkesville had not yet begun by June of 2017 and will apparently depend on a demonstrated need for new baseload generation in Ohio.²⁸

The 11 current and projected natural gas power facilities across 9 locations, including their status, are set forth in Figure 4 below.

Figure 4: Existing & Projected Power Plant Investment in Ohio through 2016



Source: Ohio Power Siting Board (2017)

Continued low natural gas prices have also led to increased development of combined heat and power (CHP) plants.²⁹ Table 15 shows the estimated investment in Ohio for CHP plants during

from <http://www.elp.com/articles/2016/09/south-field-energy-wins-air-permit-for-1-150-mw-gas-fired-project-in-ohio.html>.

²⁸See <http://www.rollinghillspower.com/>

²⁹ CHP plants are usually designed for heat or steam generation, with electricity as a byproduct. Traditionally companies in Ohio have used coal-fired boilers to generate heat. However, the new BoilerMACT laws have encouraged many companies to switch to natural gas-fired boilers. Low natural gas prices have also accelerated this

2016. Because the U.S. Department of Energy report does not give specific dates for construction, and because the last report only included CHP investment through the end of 2015, we have included all new natural gas CHP reported by the Department of Energy and previously not listed in its 2015 report. Continued investment into CHP in Ohio is likely to continue not only due to the low cost of natural gas but also due to the energy efficiency portfolio which has re-emerged in Ohio following the sunset of Ohio Senate Bill 310, which had frozen Ohio's portfolio standards through December 31, 2016.

Table 15: Natural Gas Fired Combined Heat and Power Plants in Ohio, 2016.³⁰

City	Facility Name	Application	Year	Capacity (KW)	Fuel Class	Estimated Investment (thousands of dollars)
Cleveland	Office Building	Office Building	2016	200	Natural Gas	\$450
Belpre	Kraton Polymers	Chemicals	2015	8,000	Natural Gas	\$18,000
Marietta	Solvay Specialty Polymers	Chemicals	2015	8,000	Natural Gas	\$18,000

Note: Estimated investment is estimated based on a formula: \$2250/kW x kW capacity = Estimated Investment.

Source: U.S. DOE Combined Heat and Power Installation Database. Retrieved on July 5, 2017 from <https://doe.icfwebservices.com/chpdb/state/OH>. Data current as of December 31, 2016.

2. Natural Gas Transportation, Refineries, and Other Downstream Investment.

No new CNG refueling stations were reported during the second half of 2016. However, two new stations (in Canton and Sharonville) are in the process of construction in 2017 and will be included in future reports. Likewise, no new investments in refineries or other downstream investments were identified for the second half of 2016. However, in 2017 PTT Global made a land acquisition for purposes of developing a cracker plant in Belmont County.³¹ This investment will also be included in a future report.

Cumulative downstream investment to date in Ohio, including 2012-June 2016, is set forth in Table 20 in the appendix.

4. CONCLUSION

Despite depressed hydrocarbon prices, upstream shale investment in Ohio continued to be active, with some 131 new wells in the second half of 2016, totaling approximately \$3.56 billion

transition. Nevertheless, because it is difficult to say that shale development has directly led to this change, boilers are not included in this investment study. Combined heat and power plants, on the other hand, are more clearly a direct result of shale development.

³⁰ The two natural gas CHP plants that became operational in 2015 were not contained in the DOE's list of Combined Heat and Power Installations until an update occurring after our last report was published and so are included here.

³¹ "Ohio Ethane Cracker Plant Closer to Reality on Former FirstEnergy Property," *Cleveland.com* (July 13, 2017). Retrieved from http://www.cleveland.com/metro/index.ssf/2017/07/ohio_ethane_cracker_plant_clos.html

in total investment. Upstream investment activity has moved to the southern counties, especially in Belmont and Monroe Counties. Carroll County, which still leads in overall total number of Utica wells drilled, had only five new wells drilled during the study period, while forty-five wells were drilled in Belmont County. Production rates from the high pressured wells in the southern counties suggest that we can expect drilling investment in the next few years to continue to be focused in and around Belmont County.

Midstream investment has also continued in the Utica during the second half of 2016. New midstream investment has included \$542 million primarily in gathering system buildout and pipeline construction, though there have also been some additions to processing capacity. Additional new midstream investment is moving away from new processing and fractionation facilities toward new pipeline development, including major new interstate pipelines scheduled to begin or already begun in 2017.

Downstream development during the second half of 2016 slowed some, although interest in ethane crackers and petrochemical refineries continue to be high, as abundant natural gas and natural gas liquids are expected to provide an inexpensive feedstock. Likewise, new investment into natural gas fueled electricity generation slowed in the second half of 2016, even as industry plans call for an expected 11,000 MW capacity in the next several years. It is possible, however, that low wholesale electricity prices slowed investment into electricity generation in the second half of 2016 and will continue to do so, despite low natural gas prices. However, low natural gas prices appear to have driven new thermal generation in the form of combined heat and power plants, which in turn has been increasing power generation. Since the economics of CHP are not as dependent upon wholesale power prices, CHP development is likely to continue, especially while Ohio's energy efficiency portfolio standards remain unfrozen.

About the Study Team

Andrew R. Thomas, J.D.

Andrew Thomas directs the Energy Policy Center in the Maxine Goodman Levin College of Urban Affairs of Cleveland State University, where he conducts research on oil and gas, electricity and transportation policy. He teaches oil and gas contracting courses internationally, and is an Ohio oil and gas commissioner.

a.r.thomas99@csuohio.edu, 216-687-9304.

Jeffrey C. Dick, Ph.D.

Dr. Jeffrey D. Dick is Professor of Geology, Chair of the Department of Geological and Environmental Sciences and Director of the Natural Gas and Water Resources Institute at Youngstown State University, Youngstown, Ohio. His expertise in petroleum exploration, production and environmental issues spans more than thirty-five years from both professional and academic perspectives.

Mark Henning

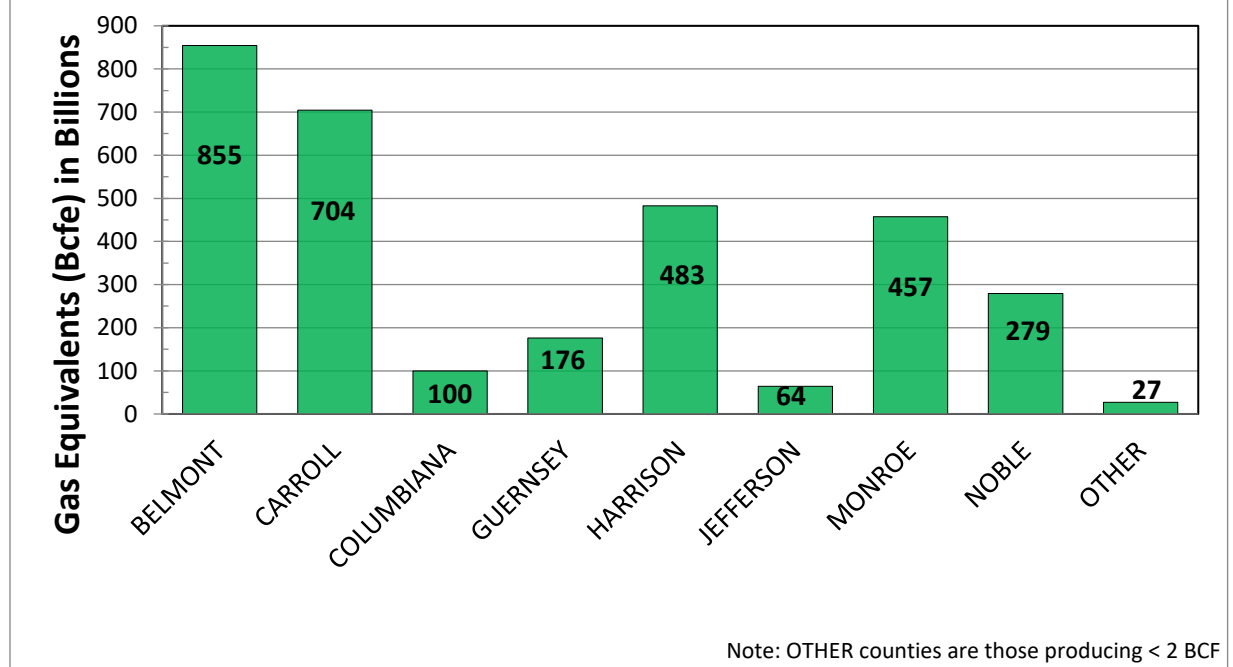
Mark Henning is a graduate student in the Master of Public Administration and M.S. in Mathematics with Specialization in Applied Statistics programs at Cleveland State University. m.d.henning@vikes.csuohio.edu

About the Energy Policy Center

The Energy Policy Center is housed within the Maxine Goodman Levin College of Urban Affairs at Cleveland State University. The mission of the EPC is to help overcome social and institutional barriers to the implementation of solutions to energy challenges by providing an objective channel for the free exchange of ideas, the dissemination of knowledge, and the support of energy related research in the areas of public policy, economics, law, business and social science. For more information, go to <http://urban.csuohio.edu/epc/>.

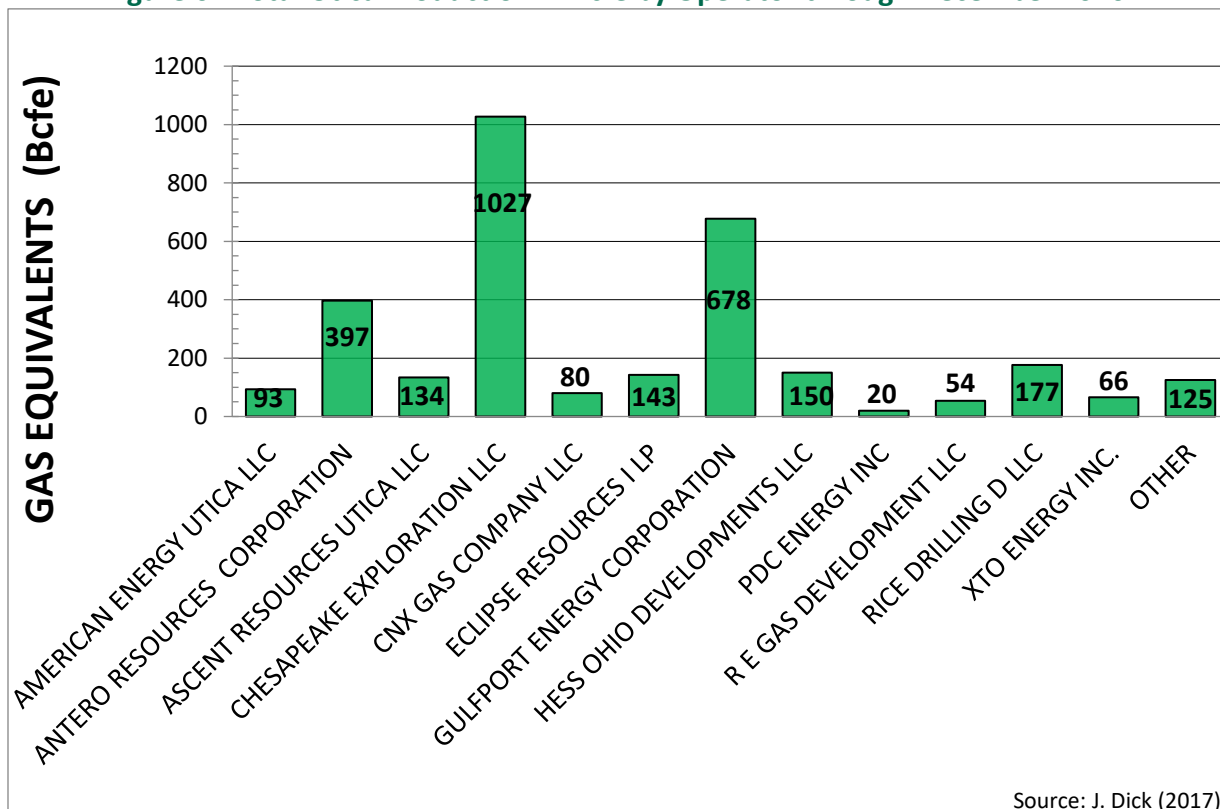
Appendix

Figure 5: Total Utica Production in Bcfe (Gas Equivalence) by County through December 2016.



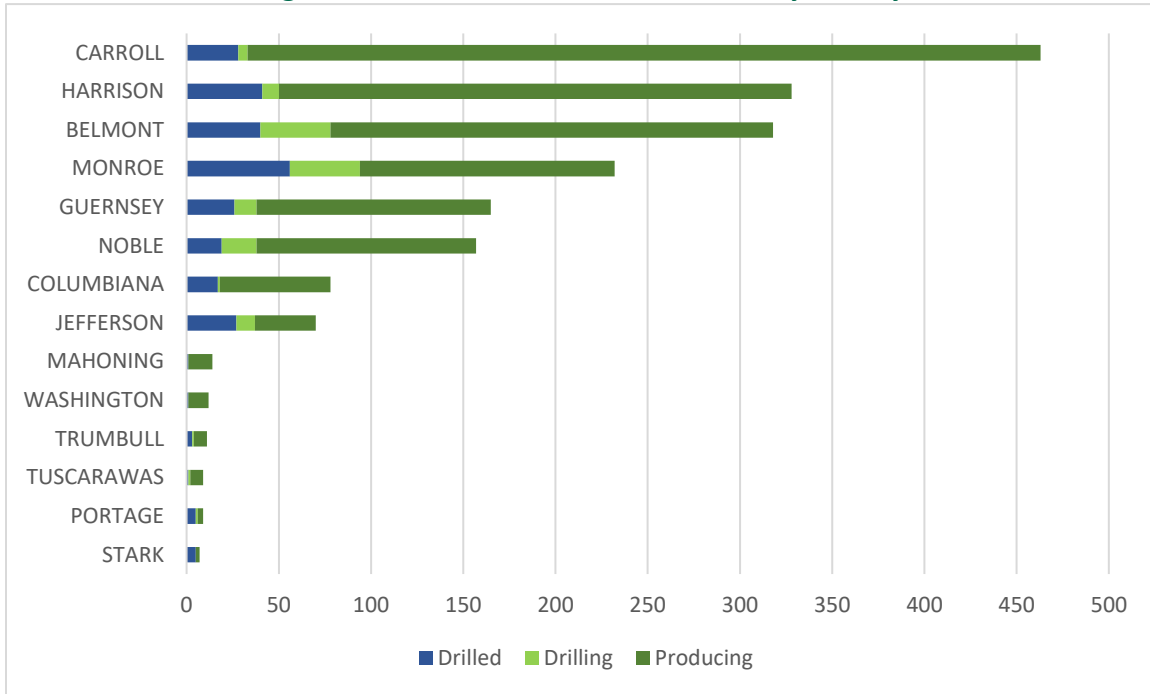
Source: J. Dick (2017).

Figure 6: Total Utica Production in Bcfe by Operator through December 2016.



Source: J. Dick (2017)

Figure 7: Cumulative Number of Wells by County



Source: Ohio Department of Natural Resource (January, 2017)

Figure 8: Distribution of Gas Equivalent Production for 2011 through 2016

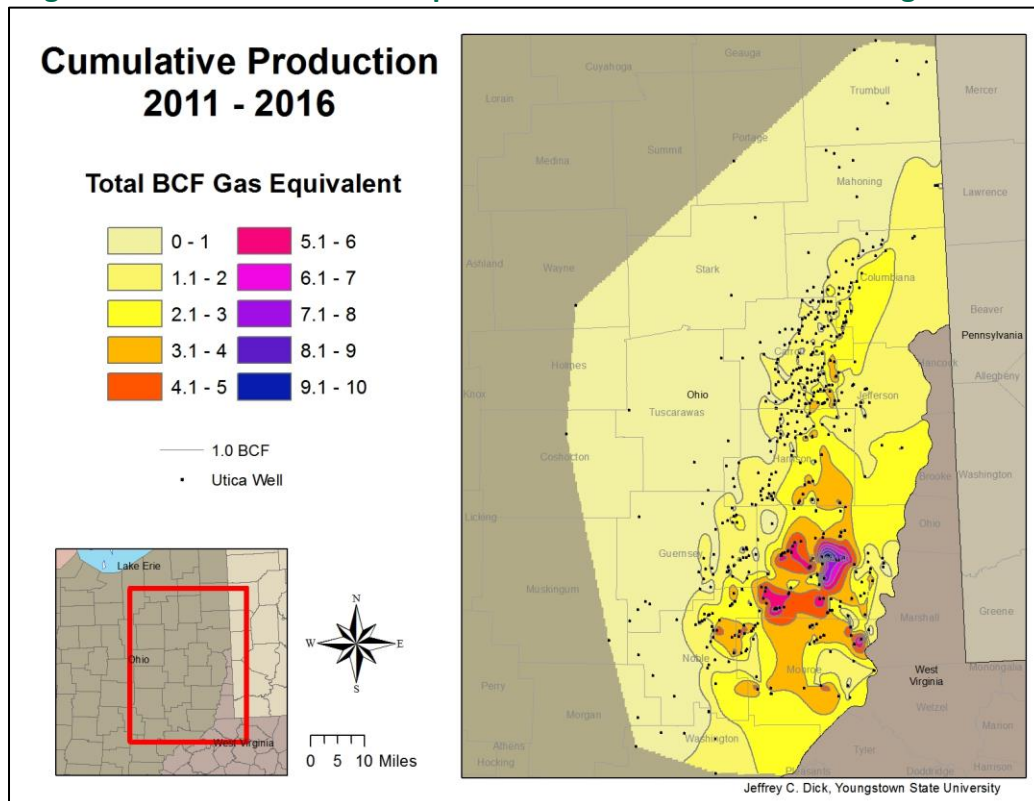


Figure 9: Distribution of Utica Wells by Status as of December 2016

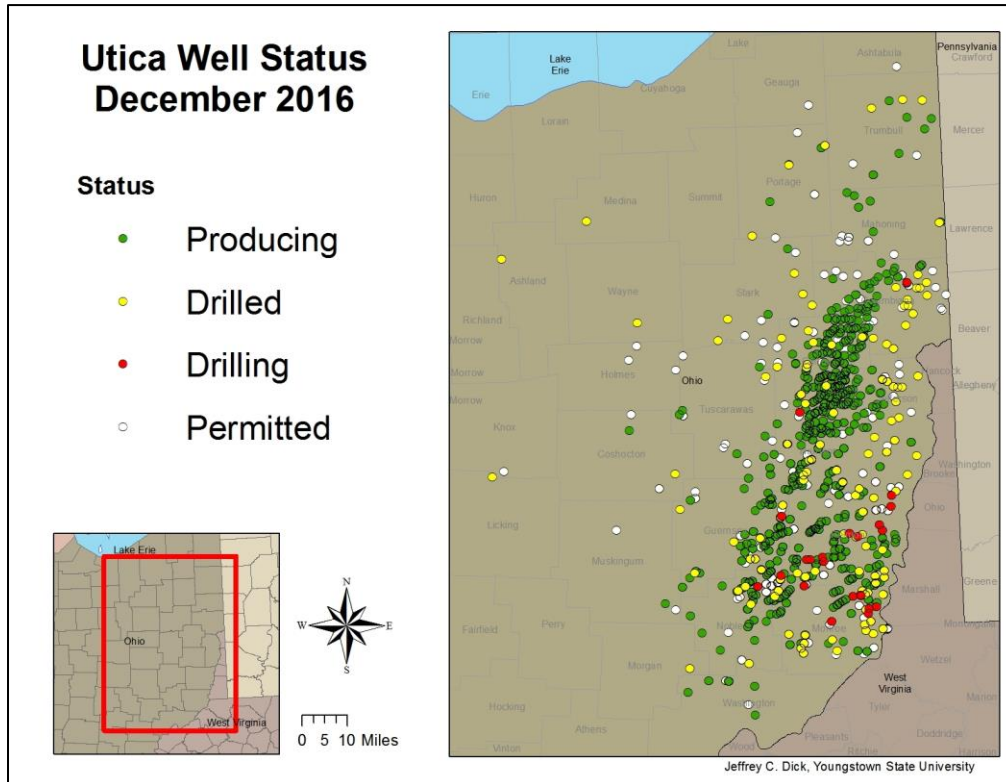


Table 16: Utica Upstream Companies Drilling in Ohio

Well Operators	Cumulative Number of Wells	Well Operators	Cumulative Number of Wells
CHESAPEAKE EXPLORATION LLC	708	CHEVRON APPALACHIA LLC	8
GULFPORT ENERGY CORPORATION	266	EQT PRODUCTION COMPANY	8
ANTERO RESOURCES CORPORATION	185	DEVON ENERGY PRODUCTION CO	6
ASCENT RESOURCES UTICA LLC	173	ARTEX OIL COMPANY	6
ECLIPSE RESOURCES I LP	94	CHESAPEAKE APPALACHIA LLC	6
RICE DRILLING D LLC	72	EM ENERGY OHIO LLC	6
HESS OHIO DEVELOPMENTS LLC	66	ENERVEST OPERATING LLC	6
CNX GAS COMPANY LLC	56	MOUNTAINEER KEYSTONE LLC	6
R E GAS DEVELOPMENT LLC	45	HG ENERGY LLC	5
XTO ENERGY INC.	42	AMERICAN ENERGY UTICA LLC	3
PDC ENERGY INC	32	BRAMMER ENGINEERING INC	2
STATOIL USA ONSHORE PROP INC	16	GEOPETRO LLC	2
CARRIZO (UTICA) LLC	13	BP AMERICA PRODUCTION COMPANY	1
TRIAD HUNTER LLC	13	GULFPORT BUCKEYE LLC	1
ATLAS NOBLE LLC	12	NGO DEVELOPMENT CORP.	1
HILCORP ENERGY COMPANY	12	PROTEGE ENERGY III LLC	1
HALCON OPERATING COMPANY INC	9		
Total Number of Wells in 14 Counties:			1,882

Note: Cumulative Number of Wells are calculated based upon the total numbers of Drilled, Drilling, and Producing
Source: Ohio Department of Natural Resources (January 7, 2017).

Table 17: Total Lease Operating Expenses through December 2016

Year	Period	Production Wells	Lease Operating Expenses for Period (\$mm)
2016	Q3 and Q4	1406	101.2
2016	Q1 and Q2	1355	97.6
2015	Annual	1034	148.9
2014	Annual	612	88.1
2013	Annual	237	34.1
2012	Annual	82	30
2011	Annual	9	3
		Totals	502.9

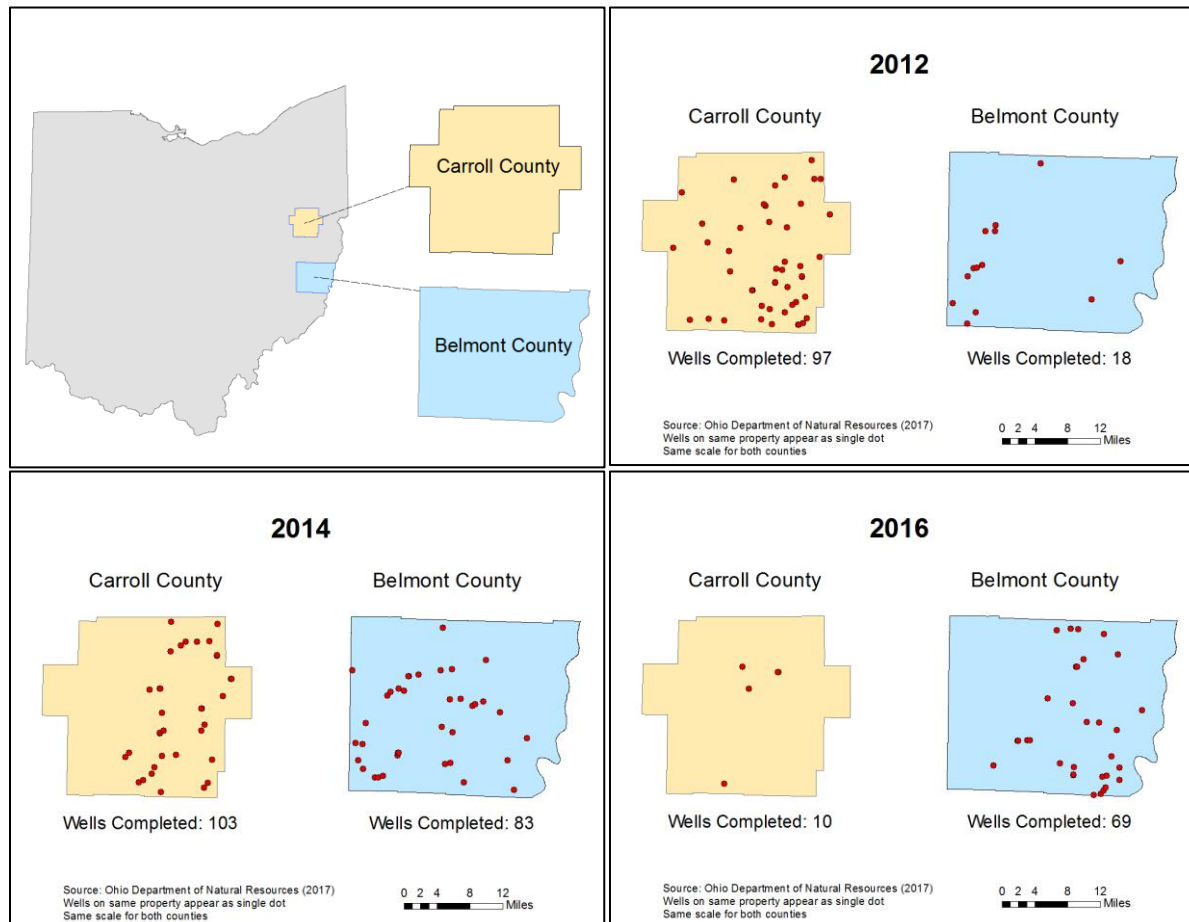
Figure 10: Trend in Drilling and Production (Carroll and Belmont Counties)

Table 18: Cumulative Utica-Related Upstream Investments in Ohio through 2016
(in millions of dollars)

Estimated Investments	Total Amount (\$mm)
Undeveloped Land	\$16,153,370,000
Developed Land	\$2,664,000,000
Lease Renewals	\$1,615,400,000
Drilling	\$16,031,000,000
Roads	\$953,500,000
Near Lease Gathering Lines	\$2,860,500,000
Lease Operating Expenses	\$473,330,000
Royalties	\$2,044,840,000
Total	\$42,795,940,000

Table 19: Cumulative Utica-Related Midstream Investments in Ohio through 2016
(in millions of dollars)

Estimated Investments	Total Amount (\$mm)
Midstream Gathering	\$3,363
Processing Plants	\$1,250
Fractionation Plants	\$1,078
Storage Tankage	\$234
Rail Loading Terminals	\$117
Transmission Pipelines	\$2,616
Total	\$8,658

Table 20: Cumulative Utica-Related Downstream Investments in Ohio through 2016
(in millions of dollars)

Estimated Investments	Total Amount (\$mm)
Petrochemical Plants (including refineries)	\$315
Natural Gas Power Plants	\$3,040
Combined Heat and Power (CHP) Plants	\$41
CNG Stations	\$38
Total	\$3,434