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Shale Investment Dashboard in Ohio Q3 and Q4 2017

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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 2017. 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 2017 can be summarized as follows:

Total Estimated Upstream Utica Investment: July-December 2017

Lease Renewals	**$653,563,000**
Drilling	**$1,856,000,000**
Roads	**$12,360,000**
Lease Operating Expenses	**$121,608,000**
Royalties	**$519,139,500**
Total Estimated Upstream Investment	**$3,162,670,400**

Total Estimated Midstream Investment: July-December 2017

Gathering Lines	**$40,989,400**
Gathering System Compression and Dehydration	**$111,400,000**
Fractionation Plants	**$0**
NGL Storage	**$20,000,000**
Transmission Lines (including compression and interconnect)	**$1,912,300,000**
Total Estimated Midstream Investment	**$2,084,689,400**

Total investment from July through December 2017 was approximately $5.3 billion, including upstream and midstream. There was no significant Ohio investment in downstream oil and gas industries in the second half of 2017. Indirect downstream investment, such as development of new manufacturing as a result of lower energy costs, was not investigated as part of this Study. Together with previous investment to date, cumulative oil and gas investment in Ohio through the end of 2017 is estimated to be around $69.4 billion. Of this, $46.9 billion[2] was in upstream, $18.8 billion in midstream, and $3.7 billion was in downstream industries.

[1] The three previous reports on shale investment in Ohio up to June 30, 2017 can be found at:
http://engagedscholarship.csuohio.edu/urban_facpub/1500/
http://engagedscholarship.csuohio.edu/urban_facpub/1464/
https://engagedscholarship.csuohio.edu/urban_facpub/1517/

[2] Data obtained from the PUCO for gathering line construction during preparation of this dashboard iteration allowed the Study Team to calculate the inch-mile of such midstream infrastructure directly rather than as a function of well development utilizing a rule-of-thumb. As such, previously reported near lease gathering line expenditures were shifted from upstream to midstream investment where they are included in the Gathering Lines line item.

Upstream investment continued to be significant in the second half of 2017, continuing in the southern part of the Utica Shale formation. The industry investment strategy for Ohio is apparent from the Ohio Department of Natural Resources Division of Oil and Gas (ODNR) listing of new wells during this time. In the first several years of development, the principal Utica drilling activity had been in Carroll County. By the second half of 2017, however, the ODNR had listed 206 new wells as "drilled, drilling or producing," only ten of which were drilled in Carroll County. On the other hand, 70 and 35 new wells were listed for Belmont and Monroe Counties, respectively. This trend continues from the first half of 2017.

Gulfport Energy and Ascent Resources were the top producers for Q3 and Q4 of 2017, having produced 208 and 206 billion cubic feet equivalent (Bcfe), respectively. Chesapeake Exploration[3] was third in production at 168 Bcfe, followed by Rice Drilling at 116, Antero Resources at 73, and Eclipse Resources at 68 Bcfe, respectively. These six companies made up around 83% of the total production for the second half of 2017.

The second half of 2017 in Ohio saw continued investment in midstream infrastructure, especially for pipelines and related infrastructure. Midstream construction starts of nearly $2.1 billion during the study period included $1.8 billion for the Nexus pipeline and its related infrastructure. Although the investments are listed herein as occurring in 2017, some of these projects continued into 2018.

In downstream developments, progress was made on the permitting of several proposed natural gas-fired electric generation facilities, but none began construction in the second half of 2017. The South Field Energy plant in Columbiana County saw construction commence in 2018. Several more plants are projected to begin in 2019 or later. Likewise, no significant investments were found in combined heat and power plants in the second half of 2017, although at least two projects have been permitted for 2018. Further progress has been made in the siting of an ethane cracker in Belmont County in 2018, including the acquisition of additional land, but no significant investments were identified for the second half of 2017.

[3] Chesapeake sold its Ohio assets to Encino Acquisition Partners in July 2018 for $2 billion. *See* https://www.wsj.com/articles/chesapeake-selling-ohio-assets-for-2-billion-1532646875

1. INTRODUCTION

This is the fourth Study 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, 2017, 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 fourth Study also includes as Appendix A the cumulative investment made in Ohio resulting from shale development, based upon all previous reports that tracked total investment from early 2011 through June 2017.[4] The methodology for determining the investments is set forth in Appendix B. Subsequent reports will include incremental spending on a six-month basis.

2. SHALE INVESTMENT UPDATES

A. UPSTREAM DEVELOPMENT

1. Overview.

A total of 206 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, 2017.[5] This represents a 27% increase in new well development compared to the first half of 2017. The total number of producing wells in the Utica was 1787 on June 30, 2017. Total production in billion cubic feet equivalent (Bcfe) for this period was 1081 Bcfe, led by Belmont County with 442 Bcfe. Monroe County was second with 178 Bcfe, followed by Jefferson County with 171 Bcfe.[6]

[4] *See fn 1, supra*.

[5] The number of new wells was determined using ODNR Cumulative Permitting Activity reports for the beginning and end of the 6-month period (*see* http://oilandgas.ohiodnr.gov/shale). Wells are assigned an American Petroleum Institute API number, which is included in the ODNR reports. Wells were considered new if they had a status of drilled, drilling, or producing at the end of the 6-month period but did not have any one of these status designations at the beginning of it.

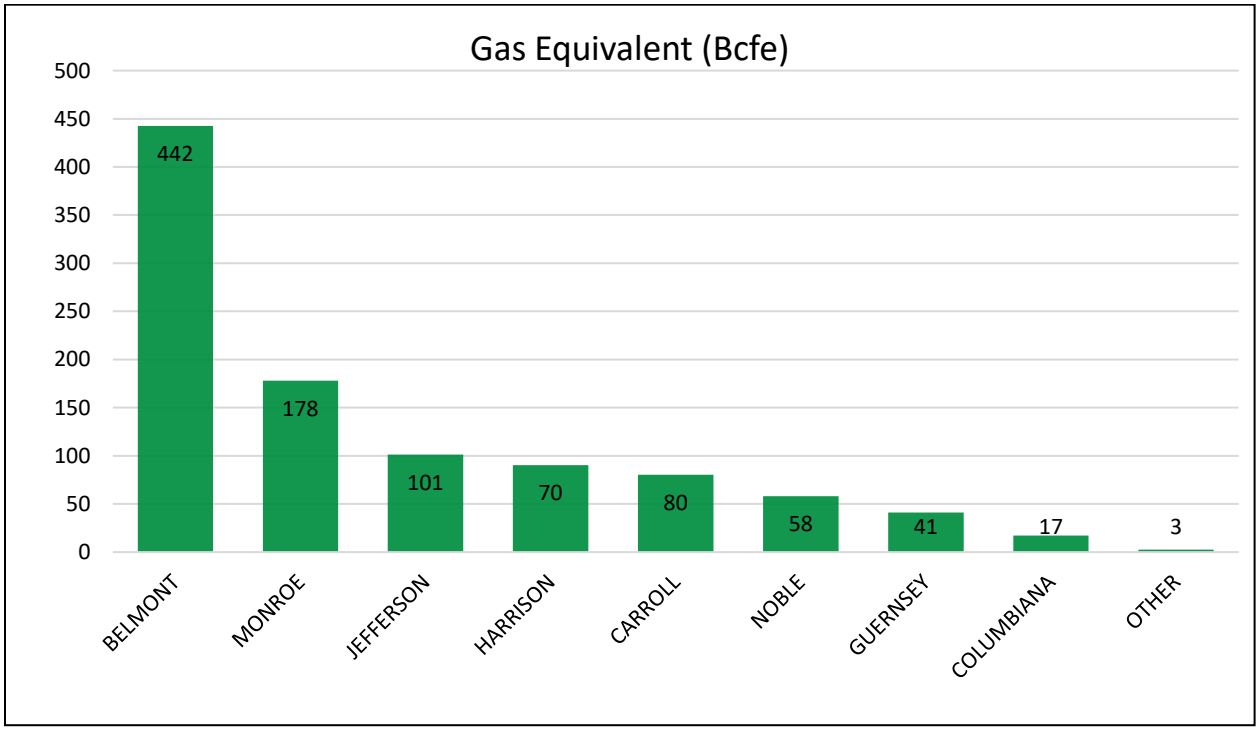
[6] Production is reported to the ODNR at the wellhead as gas measured in thousands of cubic feet (Mcf) and as oil measured in barrels (bbl). The Utica also produces significant volumes of natural gas liquids (NGLs) such as ethane, propane, butane and natural gasoline. These NGLs are separated from the natural gas stream at midstream cryogenic

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 2017 provide the foundation for the analyses presented in this Study.

The Utica is currently identified by the ODNR as producing in twenty-one eastern Ohio counties with the vast majority (ninety-nine percent) of producing wells located in eight counties stretching from Columbiana in the north, to Monroe and Noble at the southern end of the play. Table 1 provides a summary of cumulative production and production for the third and fourth quarters of 2017. Total cumulative production in Billions of cubic feet equivalent (Bcfe) by county and by operator through December 2017 can be found in Appendix A as Figures 6 and 7. New drilling and production have been moving steadily from the north (primarily Carroll County) to the south (primarily Belmont County) since 2014.

Total quarters 3 and 4 production for 2017 are set forth by county and operator in Figures 1 and 2 below.

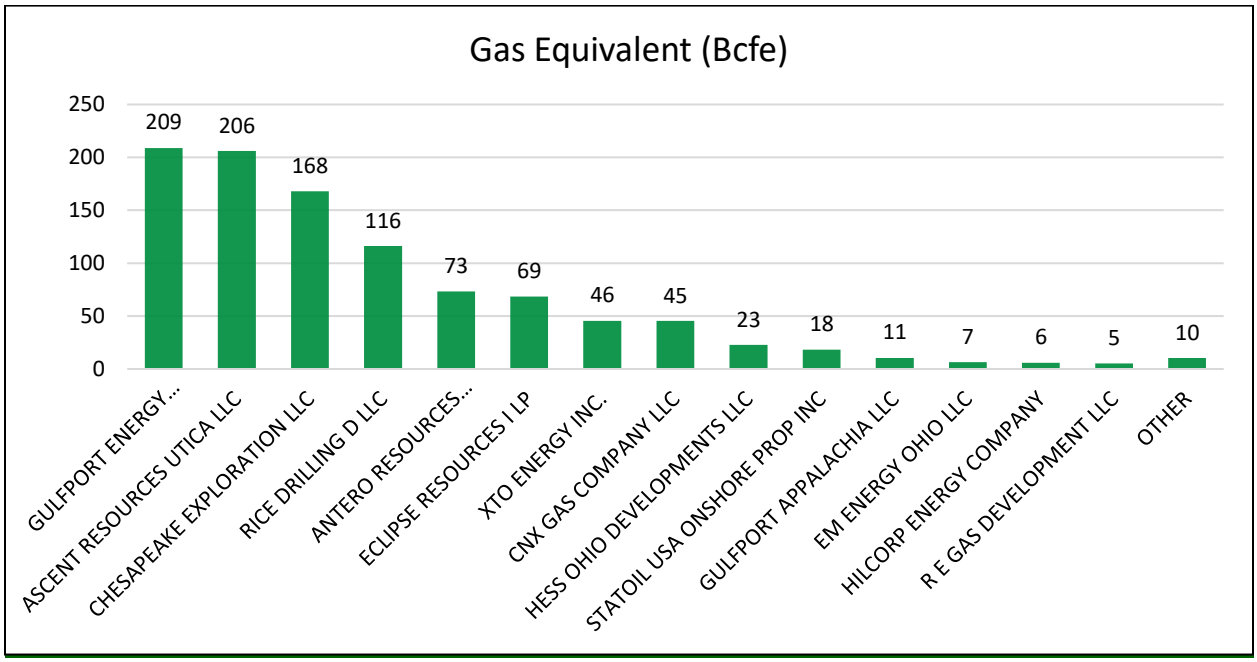
Figure 1: Production by County for Q3 and Q4 of 2017



Source: ODNR (2018).

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)

Figure 2: Production by Operator for Q3 and Q4 of 2017



Source: ODNR (2018).

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 as a function of time. This summary is set forth in Table 1. Table 2 sets forth production by county for the second half of 2017. Figure 3 sets forth the geographic distribution of production for the same period.

Table 1: Production by Reporting Period

Year	Quarter	Production Wells	Gas (Mcfe)	Oil (bbl)	Gas Equivalents (Mcfe)	Gas Production (% Change from Previous Quarter)
2017	4	1866	503,066,907	4,193,562	526,784,387	9.2
2017	3	1769	460,844,826	4,207,674	484,656,053	18.9
2017	2	1646	387,725,175	4,019,281	410,512,053	4.8
2017	1	1530	369,913,713	3,877,717	391,904,993	2.2
2016	4	1492	362,107,422	3,568,077	382,364,866	0.4
2016	3	1442	360,681,356	3,954,095	383,057,580	7.9
2016	2	1382	334,257,982	4,839,792	361,646,365	1.4
2016	1	1328	329,537,838	5,485,854	360,582,286	9.3
2015	4	1248	301,486,508	6,248,451	336,846,492	39.0
2015	3	989	216,974,492	4,439,258	242,096,253	-2.2
2015	2	992	221,862,582	5,578,255	253,429,927	20.8
2015	1	907	183,585,256	4,432,195	208,667,049	11.4
2014	4	810	164,815,008	3,558,836	184,954,459	26.5
2014	3	688	130,282,395	2,984,534	147,171,872	48.4
2014	2	535	87,773,834	2,422,179	101,480,943	30.8
2014	1	415	67,095,693	1,928,076	78,006,674	57.2
2013	4	371	42,693,774	1,433,731	50,807,259	28.4
2013	3	269	33,255,706	1,323,812	40,747,160	123.7
2013	2	186	14,863,645	556,437	18,012,520	80.4
2013	1	117	8,237,177	321,439	10,056,202	-35.8
2012	ANNUAL	82	12,831,292	635,874	16,429,703	400.9
2011	ANNUAL	9	2,561,524	46,326	2,823,683	
		Total	**4,596,454,105**	**70,055,455**	**4,993,038,779**	

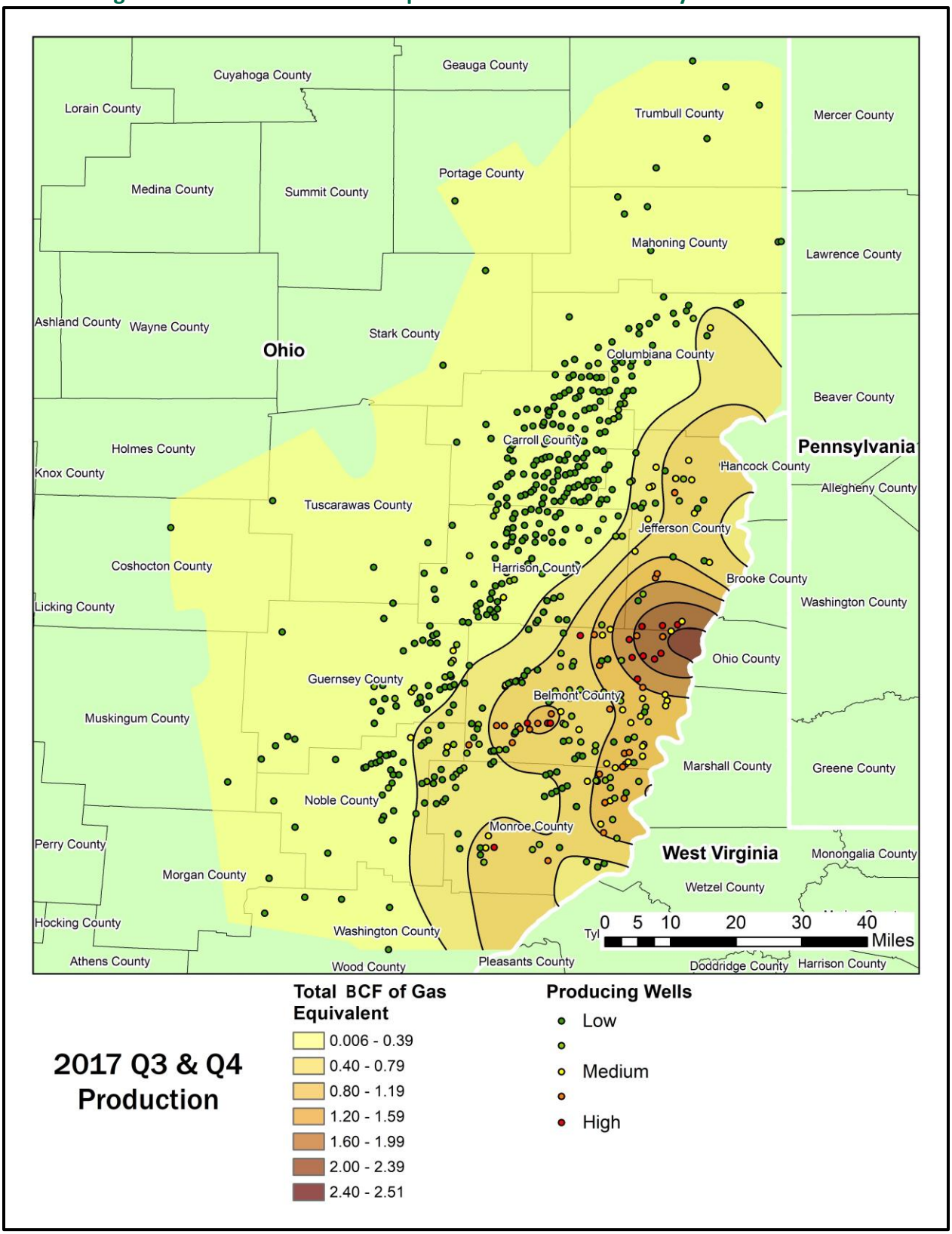
Source: ODNR (2018).

Table 2: Production by County for July-December 2017

County	Gas (Mcfe)	Oil (bbl)	Gas Equivalent (Mcfe)	Production Wells
BELMONT	442,252,196	31,682	442,431,484	360
MONROE	177,750,917	45,308	178,007,315	234
JEFFERSON	101,270,094	101	101,270,666	93
HARRISON	73,546,346	2,987,246	90,451,171	317
CARROLL	68,525,726	2,084,809	80,323,660	460
NOBLE	54,612,562	584,782	57,921,843	145
GUERNSEY	26,516,372	2,590,340	41,175,106	149
COLUMBIANA	16,982,973	25,691	17,128,358	67
MAHONING	968,539	5,279	998,413	13
WASHINGTON	832,894	13,266	907,966	8
TUSCARAWUS	196,018	19,674	307,353	6
TRUMBULL	225,219	1,805	235,433	6
MORGAN	105,528	6,056	139,799	2
STARK	62,752	1,752	72,667	2
MUSKINGUM	24,381	555	27,522	1
PORTAGE	25,909	176	26,905	2
COSHOCTON	13,307	260	14,778	1
Total	**963,911,733**	**8,398,782**	**1,011,440,440**	**1866**

Source: ODNR (2018)

Figure 3: Distribution of Gas Equivalent Production for July-December 2017



Of the 2,236 total wells identified from the ODNR records as of December 2017, 204 were in the process of drilling, 245 wells had been drilled and were awaiting markets, and 1,787 were in the production phase. *See* Table 3, Ohio Utica Well Status. Carroll County continues to lead in total wells (*see* Table 4), even though it has been surpassed in total production.

Table 3: Ohio Utica Well Status as of December 2017

Well Status	
Drilled	245
Drilling	204
Producing	1,787
Total	**2,236**

Source: Ohio Department of Natural Resources (January 2018)

Table 4: Well Status by County (December 2017)

County	Drilled	Drilling	Producing	Total
CARROLL	15	2	453	470
BELMONT	45	60	339	444
HARRISON	20	14	318	352
MONROE	62	57	196	315
GUERNSEY	17	29	152	198
NOBLE	18	12	143	173
JEFFERSON	27	27	75	129
COLUMBIANA	18	0	65	83
MAHONING	1	0	13	14
WASHINGTON	3	0	9	12
TRUMBULL	3	1	7	11
PORTAGE	3	1	5	9
TUSCARAWAS	2	1	6	9
STARK	5	0	2	7
MORGAN	1	0	2	3
COSHOCTON	1	0	1	2
ASHLAND	1	0	0	1
KNOX	1	0	0	1
MEDINA	1	0	0	1
MUSKINGUM	0	0	1	1
WAYNE	1	0	0	1
Total	**245**	**204**	**1787**	**2236**

Source: ODNR (2018)

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 methodology used for each calculation is set forth in Appendix B. This section covers upstream investments between July and December of 2017. Cumulative upstream investments to date in Ohio, including 2012-2017, are set forth in Table 18 of Appendix A.

1. Investments into Drilling.

The following tables set forth estimated investments for the study period made into drilling shale wells in Ohio. Belmont County remains the leader in recent upstream investment, with 70 new wells and an investment of around $704.2 million between July and December of 2017. Monroe and Jefferson Counties are second and third, with 35 and 32 new wells, respectively, and with $352.1 and $251.6 million invested. *See* Table 5. Road-related investments for this version of the Shale Investment Dashboard reflect the average road costs per well determined from a 2017 report by Energy-In-Depth [7] describing Road Use Maintenance Agreements (RUMAs) that companies have entered into with local governments for infrastructure improvements since Utica production began in 2011. The data for that report were obtained directly from the engineer's office for the top eight oil and natural gas producing counties in Ohio.[8]

Ascent Utica Resources LLC, half of whose new wells were in more northerly counties where production is less expensive, was the leading operator investor during the six-month period, with 65 wells and an estimated $551.9 mm invested, followed by Gulfport Energy with 38 wells and an estimated $382.3 million invested. Rice Drilling and Chesapeake Exploration, the latter of which was entirely active in northern counties, drilled 21 and 24 wells, with an estimated $211.3 and $169.4 million invested, respectively. Eclipse Resources drilled 15 wells, with an estimated investment of $147.9 million. *See* Table 6.

[7] *See* "Ohio's Oil & Gas Industry Road Improvement Payments." Prepared by The Ohio Oil & Gas Association and Energy in Depth. https://www.energyindepth.org/wp-content/uploads/2017/11/2017-Utica-Shale-Local-Support-Series-Ohios-Oil-and-Gas-Industry-Road-Payments.pdf

[8] The previously used method for determining road investments was a rule-of-thumb estimate based on industry interviews.

Table 5: Estimated Upstream Shale Investment by County, July-December 2017 (Excludes royalties, bonuses for undeveloped acreage and lease operating expenses)

County	No of Wells	Drilling	Roads	Total Amount ($ mm)
BELMONT	70	$700.00	$4.20	$704.20
MONROE	35	$350.00	$2.10	$352.1
GUERNSEY	26	$260.00	$1.56	$261.56
JEFFERSON	32	$224.00	$1.92	$225.92
HARRISON	22	$154.00	$1.32	$155.32
CARROLL	10	$70.00	$0.60	$70.60
NOBLE	7	$70.00	$0.42	$70.42
COLUMBIANA	4	$28.00	$0.24	$28.24
Total	**206**	**$1,856.00**	**$12.36**	**$1,868.36**

Source: The Authors (2018)

Table 6: Estimated Upstream Shale Investment in Ohio by Company, July-December 2017 (Excludes royalties, bonuses for undeveloped acreage and lease operating expenses)

Operators	No. of Wells	Drilling	Roads	Total Amount ($ mm)
ASCENT RESOURCES UTICA LLC	65	$548.00	$3.90	$551.90
GULFPORT ENERGY CORP.	38	$380.00	$2.28	$382.28
RICE DRILLING D LLC	21	$210.00	$1.26	$211.26
CHESAPEAKE EXPLORATION LLC	24	$168.00	$1.44	$169.44
ECLIPSE RESOURCES I LP	15	$147.00	$0.90	$147.90
STATOIL USA ONSHORE PROP INC	8	$80.00	$0.48	$80.48
R E GAS DEVELOPMENT LLC	7	$49.00	$0.42	$49.42
ANTERO RESOURCES CORP.	5	$50.00	$0.30	$50.30
CNX GAS COMPANY LLC	5	$50.00	$0.30	$50.30
EM ENERGY OHIO LLC	4	$40.00	$0.24	$40.24
GULFPORT APPALACHIA LLC	4	$40.00	$0.24	$40.24
EQT PRODUCTION COMPANY	3	$30.00	$0.18	$30.18
PDC ENERGY INC	2	$20.00	$0.12	$20.12
TRIAD HUNTER LLC	2	$20.00	$0.12	$20.12
HILCORP ENERGY COMPANY	2	$14.00	$0.12	$14.12
XTO ENERGY INC.	1	$10.00	$0.06	$10.06
Total	**206**	**$1,856.00**	**$12.36**	**$1868.36**

Source: The Authors (2018).

2. Lease Operating Expenses.

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

Table 7: Estimated Lease Operating Expenses for July-December 2017 by County

County	No. of Production Wells[9]	Lease Operating Expenses for Period ($mm)
CARROLL	446	$32.11
HARRISON	308	$22.18
BELMONT	305	$21.96
MONROE	173	$12.46
GUERNSEY	146	$10.51
NOBLE	139	$10.01
COLUMBIANA	64	$4.61
JEFFERSON	63	$4.54
MAHONING	13	$0.94
WASHINGTON	9	$0.65
TRUMBULL	7	$0.50
TUSCARAWAS	6	$0.43
PORTAGE	4	$0.29
MORGAN	2	$0.14
STARK	2	$0.14
COSHOCTON	1	$0.07
MUSKINGUM	1	$0.07
	Total	**$121.61**

[9] The number of wells producing was determined by taking the average of the number of such wells as identified by ODNR on July 1, 2017 and December 30, 2017. It is assumed that this number of average production wells incurred lease operating expenses for all six months.

Table 8: Estimated Lease Operating Expenses for July-December 2017 by Operator

Operator	No. of Production Wells	Lease Operating Expenses for Period ($mm)
CHESAPEAKE EXPLORATION LLC	660	$47.52
GULFPORT ENERGY CORPORATION	247	$17.78
ANTERO RESOURCES CORPORATION	176	$12.67
ASCENT RESOURCES UTICA LLC	165	$11.88
ECLIPSE RESOURCES I LP	87	$6.26
HESS OHIO DEVELOPMENTS LLC	59	$4.25
RICE DRILLING D LLC	59	$4.25
CNX GAS COMPANY LLC	45	$3.24
XTO ENERGY INC.	41	$2.95
R E GAS DEVELOPMENT LLC	30	$2.16
PDC ENERGY INC	28	$2.02
HILCORP ENERGY COMPANY	13	$0.94
ATLAS NOBLE LLC	12	$0.86
CHEVRON APPALACHIA LLC	8	$0.58
STATOIL USA ONSHORE PROP INC	8	$0.58
ARTEX OIL COMPANY	7	$0.50
PIN OAK ENERGY PARTNERS LLC	6	$0.43
EM ENERGY OHIO LLC	5	$0.36
ENERVEST OPERATING LLC	5	$0.36
CHESAPEAKE APPALACHIA LLC	4	$0.29
EQT PRODUCTION COMPANY	4	$0.29
TRIAD HUNTER LLC	4	$0.29
HALCON OPERATING COMPANY INC	4	$0.29
MOUNTAINEER KEYSTONE LLC	3	$0.22
GULFPORT APPALACHIA LLC	3	$0.22
CARRIZO (UTICA) LLC	2	$0.14
NORTHWOOD ENERGY CORP	2	$0.14
NGO DEVELOPMENT CORP.	1	$0.07
PROTEGE ENERGY III LLC	1	$0.07
GULFPORT BUCKEYE LLC	1	$0.07
GEOPETRO LLC	1	$0.07
	Total	**$121.75**

3. Royalties.

Royalty investments have been estimated on a per quarter basis, assuming the formula set forth in Appendix B. Total estimated royalties spent on Ohio properties between July and December 2017 were around $632.28 million. The breakdown by quarter for oil, residue gas and natural gas liquids is set forth in Tables 9, 10, and 11 below. The average price for natural gas was $2.22/MMBtu during all of 2017. Regional oil prices were known to have increased from $47.17/bbl for the third quarter of 2017 to $54.49/bbl for the fourth quarter, on average.

Table 9: Total Royalties from Oil
July-December 2017 (in millions of dollars)

Year	Quarter	Oil Price[10] $/bbl	Oil Royalty (20%) $/bbl	Royalty ($mm)
2017	4	54.49	10.90	45.67
2017	3	47.17	9.43	39.70
			Subtotal	**85.37**

Table 10: Total Royalties from Residue Gas
January-December 2017 (in millions of dollars)

Year	Quarter	Residue Gas Price[11] $/Mcf	Residue Gas Royalty (20%) $/Mcf	Royalty ($mm)
2017	4	2.44	0.36	158.66
2017	3	2.44	0.36	145.35
			Subtotal	**304.01**

Table 11: Total Royalties from Natural Gas Liquids
January-December 2017 (in millions of dollars)

Year	Quarter	NGL Price $/bbl	NGL Royalty (20%) $/bbl	Royalty ($mm)
2017	4	16.35	3.27	73.40
2017	3	14.15	2.83	59.23
			Subtotal	**129.76**

4. Lease Renewals.

Lease renewal investments have been estimated for the Utica region based upon the drilling activity of the top six drilling companies in the region. 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 12.

There are several potential sources of error in this estimate. All estimates assume $5000/acre lease bonus for five-year renewals, which may not accurately reflect lease renewal option rates. Factors that suggest the estimate may be too low include the following: (1) 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; (2) only acreage from the top six drillers was used, and (3) bonuses paid on new leases were not include. On the other

[10] http://ergon.com/prices
[11] https://www.ferc.gov/market-oversight/mkt-gas/northeast/ngas-ne-yr-pr.pdf?csrt=14746738715782415708

hand, continuing low prices through 2017 may have caused producers to renew leases at a lower rate than estimated.

Table 12: Total Estimated Investments into Undeveloped Acreage (Lease Renewals) July-December 2017 (in millions of dollars)

Operator	Undeveloped Acreage	Estimated Bonus Investment ($mm)
CHESAPEAKE APPALACHIA LLC	686,000[12]	343.00
GULFPORT ENERGY CORPORATION	157,943	78.97
ASCENT RESOURCES UTICA LLC	156,287	78.14
ANTERO RESOURCES CORPORATION	105,542	52.77
ECLIPSE RESOURCES I LP	64,954	32.48
RICE DRILLING D LLC	49,258	24.63
PDC ENERGY INC	41,100	20.55
HESS OHIO DEVELOPMENTS LLC37	37,000	18.50
CNX GAS COMPANY LLC	8,449	4.22
R E GAS DEVELOPMENT LLC	593	0.30
Total	**1,307,126**	**653.56**

C. Estimated Midstream Investments

Midstream investment includes transmission and gathering pipelines, additional investments in storage facilities, and investments in compressor stations, which included compressor engines, dehydration units, and generators installed as part of these stations.

Pipeline investments were estimated using mileage and size information from the Public Utilities Commission of Ohio, and cost information from the INGAA Foundation. Similarly, compressor station investments were based on estimated cost per unit of power output for the region as obtained from the INGAA. A full description of the methodology can be found in Appendix B.

Additional investment information was collected from midstream company investor presentations, news reports, and other sources including Ohio EPA permits. The following two tables summarize midstream investments discovered by the Study Team for the second half of 2017. Table 13 sets forth gathering and transmission line investments while Table 14 sets forth all other midstream investments, including that for compression.

Some costs related to these projects may not all have been incurred during the six-month window for this study. However, because the investments cannot easily be separated and tracked while construction is ongoing, they are treated as though made entirely during the study period if the project was begun then.

[12] The previous report for Q1 and Q2 2017 incorrectly reported Chesapeake's undeveloped acreage as 2,514,000, which included other holdings outside of the Utica. The total Utica acreage should have been reported as 1,335,680 net-acres. This report reflects the correct acreage for the second half of 2017: 686,000. Chesapeake's drop in Utica acreage from the previous year's report was actually 48% and was likely attributable to development or to the decision to decline to renew some leases.

Table 13: Midstream Transmission and Gathering Line Investment July through December 2017

Company	Additions to Infrastructure	Total Amount ($mm)
Spectra Energy/DTE Energy	• NEXUS Gas Transmission • Approximately 210.7 miles of 36-inch pipeline and four interstate pipeline compressor stations with 130,000 combined horsepower in Ohio[13]	1,785.1
Texas Eastern	• TEAL Phase I • 4.4 miles of 36-inch-diameter pipeline and 1/3 mile of 30-inch-diameter pipeline in Ohio[14]	30.0
Antero Midstream Partners	• 0.36 miles of 16-inch gathering line	1.0
Blue Racer	• 0.12 miles of 20-inch gathering lines	0.4
Cardinal Gas Svcs (Williams)	• 1.53 miles of 6-inch gathering lines	1.8
Eclipse Resources	• 8.80 miles of 8-, 10-, and 12-inch gathering lines	14.9
Energy Transfer	• 0.88 miles of 24-inch gathering lines	3.8
Eureka	• 2.08 miles of 8-, 12-, and 24-inch gathering lines	5.4
Rice Olympus	• 0.13 miles of 8-inch gathering lines	0.2
Strike Force	• 0.40 miles of 8-inch gathering lines	0.6
Utica Gas Scvs (Williams)	• 6.3 miles of 8- and 12-inch gathering lines	12.9
	Total	**1,856.1**

Source for Gathering Lines: PUCO Gathering Construction Reports (2018)

Table 14: Additional Midstream Investment, July through December 2017

Company	Additions to Infrastructure	Total Amount ($mm)
Mountaineer NGL	• Monroe County Natural Gas Liquids Underground Storage Facility	20.0[15]
Columbia Gas Transmission	• Crawford Compressor Station with Dehydration • 24 mmscf/d of glycol dehydration	20.0[16]
Knox Energy	• Homer and Otto Compressor Stations	3.4[17]
Strike Force	• Rifle and Tygerr Compressor Stations with Dehydration • 810 mmscf/d of combined glycol dehydration	111.4[18]
Tennessee Gas Pipeline (Kinder Morgan)	• Compressor Station #216.5 in Mahoning County	70.4
Energy Transfer	• Panhandle Backhaul Project • Upgrades to allow for bi-directional flow of natural gas within the Panhandle system as well as to establish the Panhandle-Rover Interconnect near Defiance, Ohio.	3.4[19]
	Total	**228.6**

[13] For project mileage and compressor station deployment within Ohio, *see* https://www.ferc.gov/CalendarFiles/20170825170323-CP16-22-000.pdf

[14] *Id.*

[15] https://www.esvllc.com/news/mountaineer-ngl-included-u-s-department-energy-natural-gas-liquids-primer/

[16] https://www.federalregister.gov/documents/2017/09/07/2017-18996/columbia-gas-transmission-llc-notice-of-request-under-blanket-authorization

[17] For horsepower rating, *see* http://wwwapp.epa.ohio.gov/dapc/permits_issued/1604400.pdf; *see also* http://wwwapp.epa.ohio.gov/dapc/permits_issued/1604404.pdf

[18] For horsepower rating, *see* http://wwwapp.epa.ohio.gov/dapc/permits_issued/1611534.pdf; *see also* http://wwwapp.epa.ohio.gov/dapc/permits_issued/1626217.pdf

[19] https://www.ferc.gov/industries/gas/enviro/eis/2016/02-19-16-eis/DEIS.pdf?csrt=6638644805575557193

Adding the amounts in the above tables yields a total midstream investment for the second half of 2017 of $2.08 billion.

There were no significant investments in gas processing identified for the second half of 2017. However, development in this area has picked up in 2018 and may be included in the next dashboard report, depending upon when it started. For instance, MarkWest has announced plans to add three fractionators in the Appalachian basin during 2018, including 60,000 bbl/d of C3+ processing at its Hopedale facility in Jewett, Ohio.[20] Using the estimation methodology applied in previous reports, this could mean an investment of more than $170 million into Ohio processing infrastructure in 2018.[21]

The general location of transmission pipeline additions for the second half of 2017 is presented below in Figure 4. Cumulative midstream investments to date in Ohio, including 2012-2017, are set forth in Table 19 in Appendix A.

[20] https://marcellusdrilling.com/2018/02/markwest-building-new-fractionation-plant-in-harrison-county-oh/ https://marcellusdrilling.com/2018/04/markwest-building-6-new-processing-plants-3-fractionators-in-2018/
[21] https://engagedscholarship.csuohio.edu/urban_facpub/1517/

Figure 4: Pipeline Additions During the 3rd and 4th Quarters of 2017

D. Downstream Development

1. Natural Gas Power Plants.

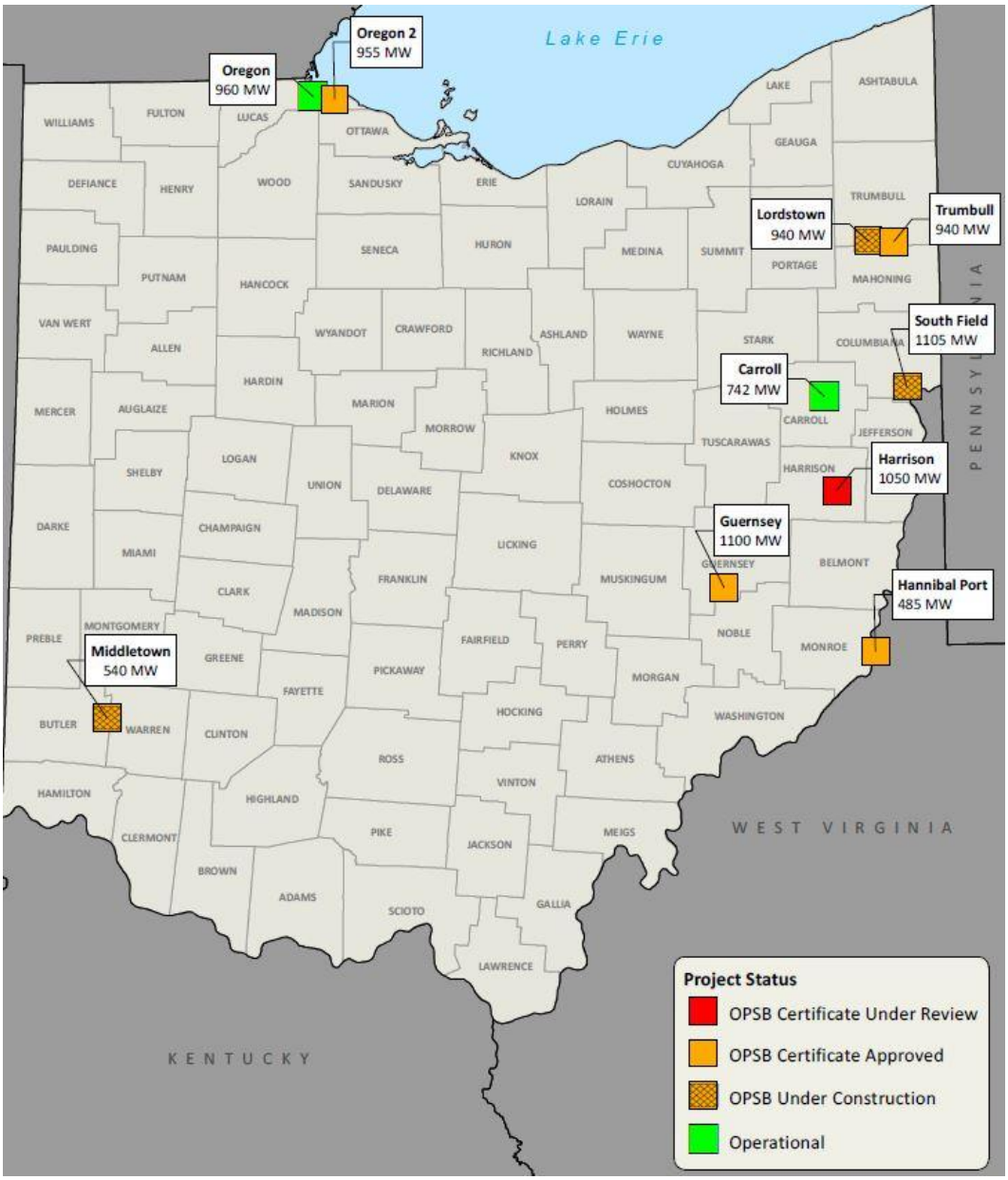
The nation has seen a number of new natural gas power plants coming online near shale plays, assisted by growing networks of pipelines which enable distribution of natural gas. Over the past three reports we have noted 10 new natural gas-powered power plants in Ohio that were in the planning, construction, or newly operational stages since 2015.

As with pipeline investments, expenditures are considered for purposes of this report as one-time investments by the builder during the six-month Study window, since it is difficult to separate the investments into half-year segments. However, major projects such as pipelines and gas plants usually take a year or more to develop. The 10 current and projected natural gas power facilities across 8 locations, including their current status, are set forth in Figure 5 below.

No investment in new natural gas generation plants was identified during the second half of 2017. The South Field Energy facility is expected to begin construction during 2018, with a possible anticipated investment of about $1.3 billion, which would be included in a future report.[22] Table 15 includes four additional natural gas plants that have received OPSB approval where construction, if it does commence, may begin as early as 2019.

[22] *See* https://businessjournaldaily.com/lordstown-energy-center-model-future-power-plants/

Figure 5: Existing & Projected Natural Gas Power Plant Investment in Ohio



Source: Ohio Power Siting Board (March 2018)

Table 15: Potential Future Natural Gas Power Plant Investment in Ohio

Project	Status	Estimated Likely Investment ($mm)
Oregon Energy Center	OPSB Certificate Approved	900[23]
Guernsey Power Station	OPSB Certificate Approved	1,500[24]
Hannibal Port Power Project	OPSB Certificate Approved	500[25]
Trumbull Energy Center	OPSB Certificate Approved	900[26]

2. Combined Heat and Power Plants

Continued low natural gas prices have also led to an increase in the regional development of combined heat and power (CHP) plants. CHP plants are usually designed for heat or steam generation, with electricity as a secondary product, thereby improving overall system efficiency. While there appears to have been no new CHP construction in Ohio in 2017, neighboring states saw the installation of large plants during this time. For example, the City of Holland in Michigan installed a 145 MW plant, while Lancaster General Hospital in Lancaster, Pennsylvania installed a 6.6 MW plant. Further, CHP installations are scheduled in Ohio in the coming years. These include Cleveland Thermal's Hamilton plant in Cleveland and Cooper Tire's manufacturing facility in Findlay, both of which have been issued final permits-to-install by the Ohio EPA.[27]

The U.S. Department of Energy report on CHP construction reports no new CHP in Ohio in 2017. That report may be updated at the end of 2018 to include 2017 CHP construction, and if so, it will be reported in the next study as a 2018 investment. Likewise, no independent media reports were found that established any CHP facilities were built during 2017.[28]

3. Refineries, Chemicals and Other Downstream Investment.

Two new Compressed Natural Gas (CNG) refueling stations (in Canton and Sharonville) were constructed in the first half of 2017 and were reported in the previous study. We have not found reports of new CNG stations for the second half of 2017. However, two new CNG stations came online in 2018 and will be included in future reports.[29]

In the last study, we reported that while no new refineries were developed in the first half of 2017, PTT Global did make a significant land acquisition in the second quarter of last year for

[23] *See* https://marcellusdrilling.com/2017/12/ohio-approves-2nd-oregon-utica-fired-elec-plant-near-toledo/. *See also* http://cleanenergyfuturellc.com/wp-content/uploads/2016/12/CEF-Oregon-Energy-Center.pdf
[24] *See* https://www.daily-jeff.com/news/20180606/power-plant-on-target-for-fall-groundbreaking
[25] *See* http://www.mariettatimes.com/news/2017/04/power-plant-to-be-built-at-ormet-location/. *See also* http://www.mariettatimes.com/news/2018/01/plans-ahead-for-former-ormet-site/
[26] *Id.*
[27] *See* https://www.epa.ohio.gov/dapc/newpermits/issued
[28] *See* https://doe.icfwebservices.com/chpdb/state/OH
[29] *See* U.S. DOE Alternative Fuels Data Center. https://www.afdc.energy.gov/data_download. *See also* https://www.afdc.energy.gov/fuels/natural_gas_locations.html#/analyze?fuel=CNG

purposes of potentially developing an ethane cracker plant in Belmont County.[30] It appears that PTT made no additional land purchases in the second half of 2017, although it did acquire another 300 acres in early 2018 (which will be captured in our next report).[31] In addition to land purchases, by 2017 PTT has spent around $150 million on preliminary front-end engineering and design work in preparation for the proposed plant.[32] This amount, invested over the last several years, is not easily attributable to any six-month period and so is included in the cumulative downstream totals found in Appendix A but not in the investments for the latter half of 2017.

Further research is being undertaken to develop a methodology for identifying additional downstream industry investment that could be directly attributed to the shale industry development. Examples may include Cliff Natural Resource's Iron Processing facility in Toledo,[33] or possibly Mitsui Chemicals' polypropylene and Milastomer thermoplastic olefin elastomer production expansion at the Ohio-based plant of its U.S. subsidiary.[34] Shale gas in general has reduced production costs for companies that make resins and plastics.[35] This may serve to attract additional downstream operations in Ohio.

Cumulative downstream investments reported to date in Ohio, including 2012-2017, are set forth in Table 20 in Appendix A.

3. CONCLUSION

Despite depressed hydrocarbon prices, upstream shale investment in Ohio continued to be active, with 206 new wells in the second half of 2017, and a total of approximately $3.16 billion in upstream investment. Upstream investment activity has continued to move to the southern counties, especially in Belmont and Monroe Counties. Carroll County, which still leads in overall

[30] "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

[31] The sale was for $17.5 million. *See* https://marcellusdrilling.com/2018/05/ptt-buys-another-300-acres-for-belmont-county-oh-cracker/

[32] *See* http://www.weirtondailytimes.com/news/local-news/2018/03/potential-belmont-county-cracker-investment-could-hit-10-billion/

[33] Cliffs Natural Resources broke ground on a $700 million iron processing in Toledo in the first half of 2018. As indicated by the company's CEO, "affordable gas availability" was one of the primary attractions to the chosen site. The plant will utilize the MIDREX® Process whereby hydrogen reformed from natural gas plays a central role in the direct reduction of iron ore to iron. *See* https://www.crainscleveland.com/article/20170615/news/170619858/cliffs-natural-resources-picks-toledo-700-million-iron-processing. The natural gas variant of this process, as opposed to others such as the use of Syngas derived from coal, is the most widely-used technology for the production of all forms of such direct reduced iron (DRI) products. *See* https://www.midrex.com/assets/user/media/MIDREX_NG.pdf. *See also*, https://www.midrex.com/process-technologies/the-midrex-process/sources-of-reducing-gas.

[34] https://www.chemengonline.com/mitsui-chemicals-to-build-production-plant-for-thermplastic-olefin-elastomers-in-ohio/?printmode=1
https://www.chemengonline.com/mitsui-to-construct-u-s-production-plant-for-glass-fiber-reinforced-polypropylene/

[35] https://www.ptonline.com/articles/the-boom-in-natural-gas-what-will-it-mean-for-plastics-processors

total number of Utica wells drilled, had ten new wells drilled during the Study period, while 70 wells were drilled in Belmont County. Production from the higher-pressured wells in the southern counties continue to increase, with drilling investment in the next few years continuing to be focused in and around Belmont County.

Midstream investment continued its momentum from early 2017 into the second half of the year. New midstream investment has included $2.1 billion primarily in gathering and transmission system buildout and pipeline construction, although there were no new additions to processing capacity in the second half of 2017.

There was no significant downstream development during the second half of 2017, notwithstanding the ongoing depressed natural gas prices. However, this is likely to change in 2018, with one natural gas plant slated for construction in late 2018, and more possible in 2019. New investment was also made in early 2018 to acquire additional land for a planned ethane cracker in Belmont County. Total shale related investment in Ohio for the second half of 2017, including upstream, midstream and downstream, was around $5.3 Billion.

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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/.

4. APPENDICES

APPENDIX A. CUMULATIVE OHIO SHALE INVESTMENT

Figure 6: Total Utica Production in Bcfe (Gas Equivalence) by County through December 2017.

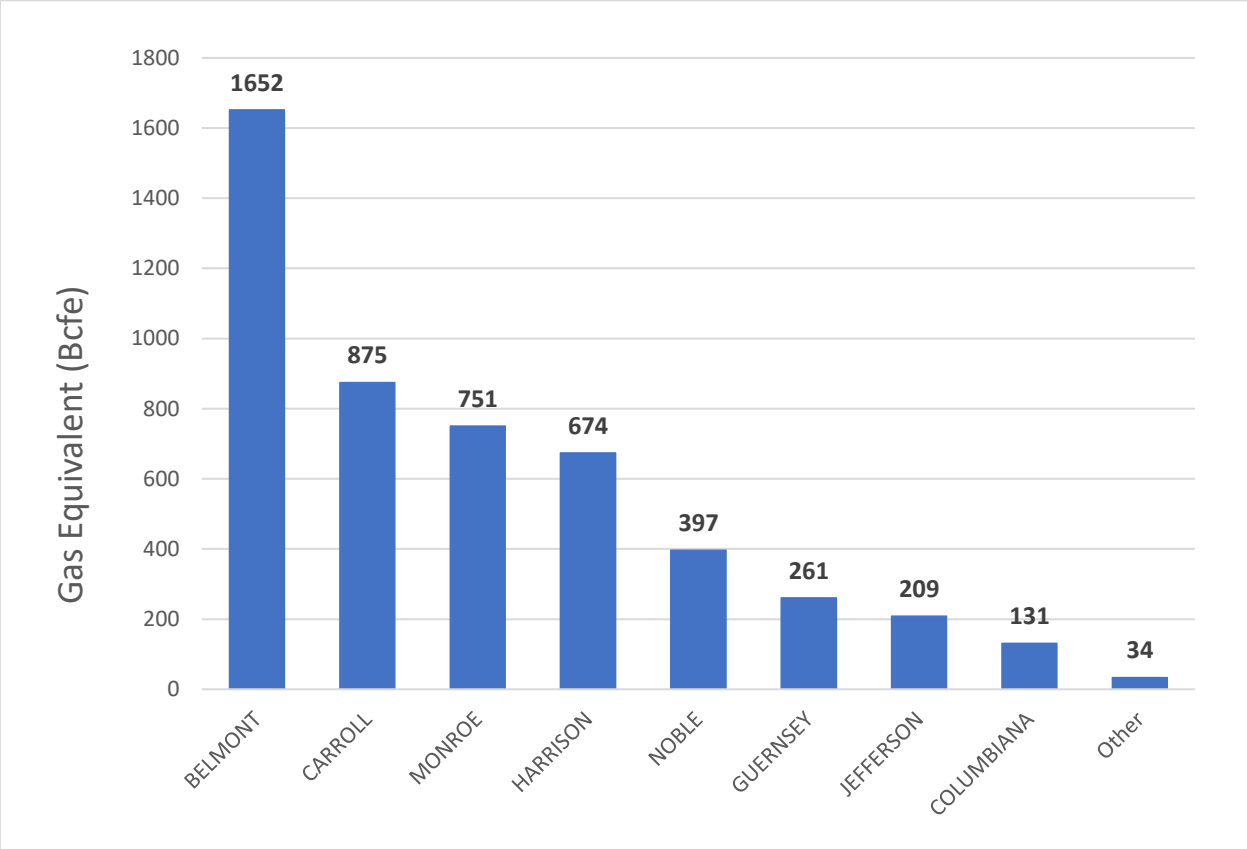


Figure 7: Total Utica Production in Bcfe by Operator through December 2017.

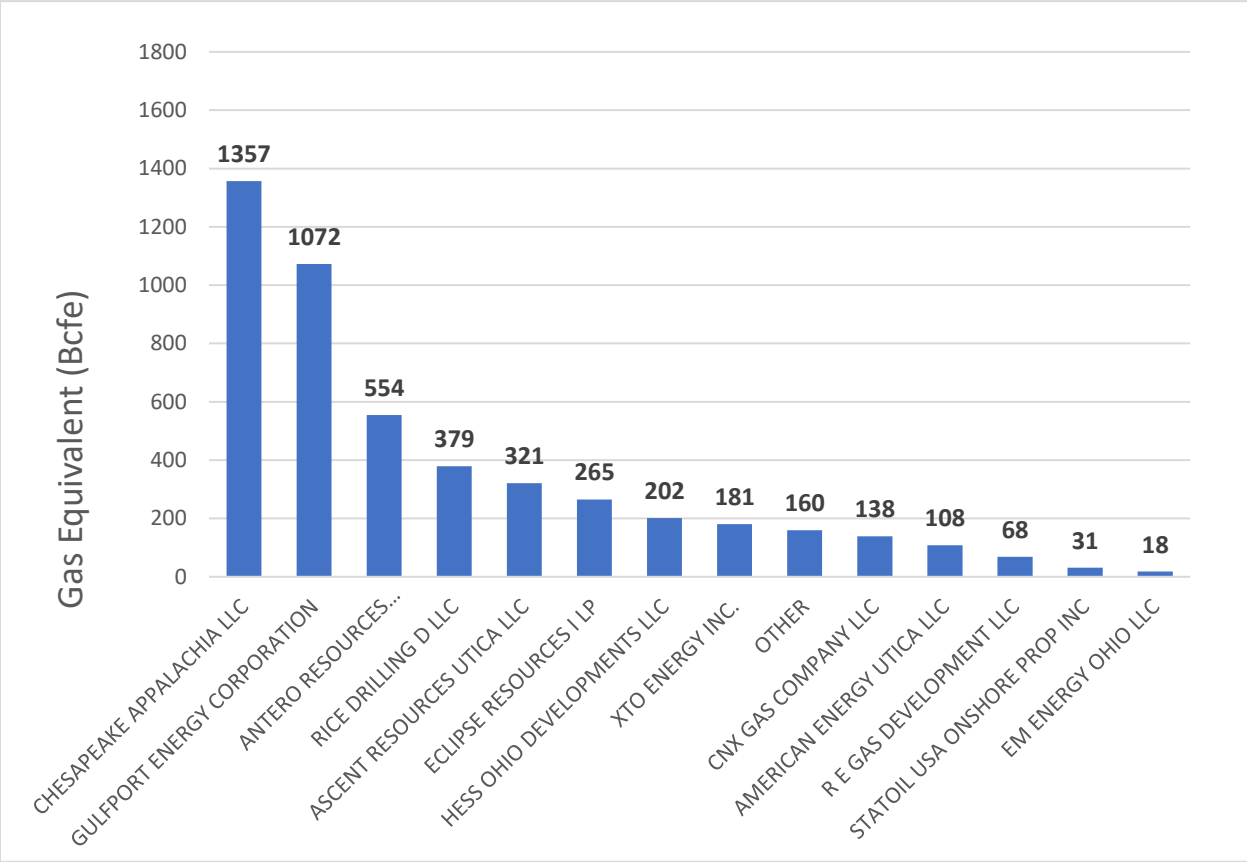
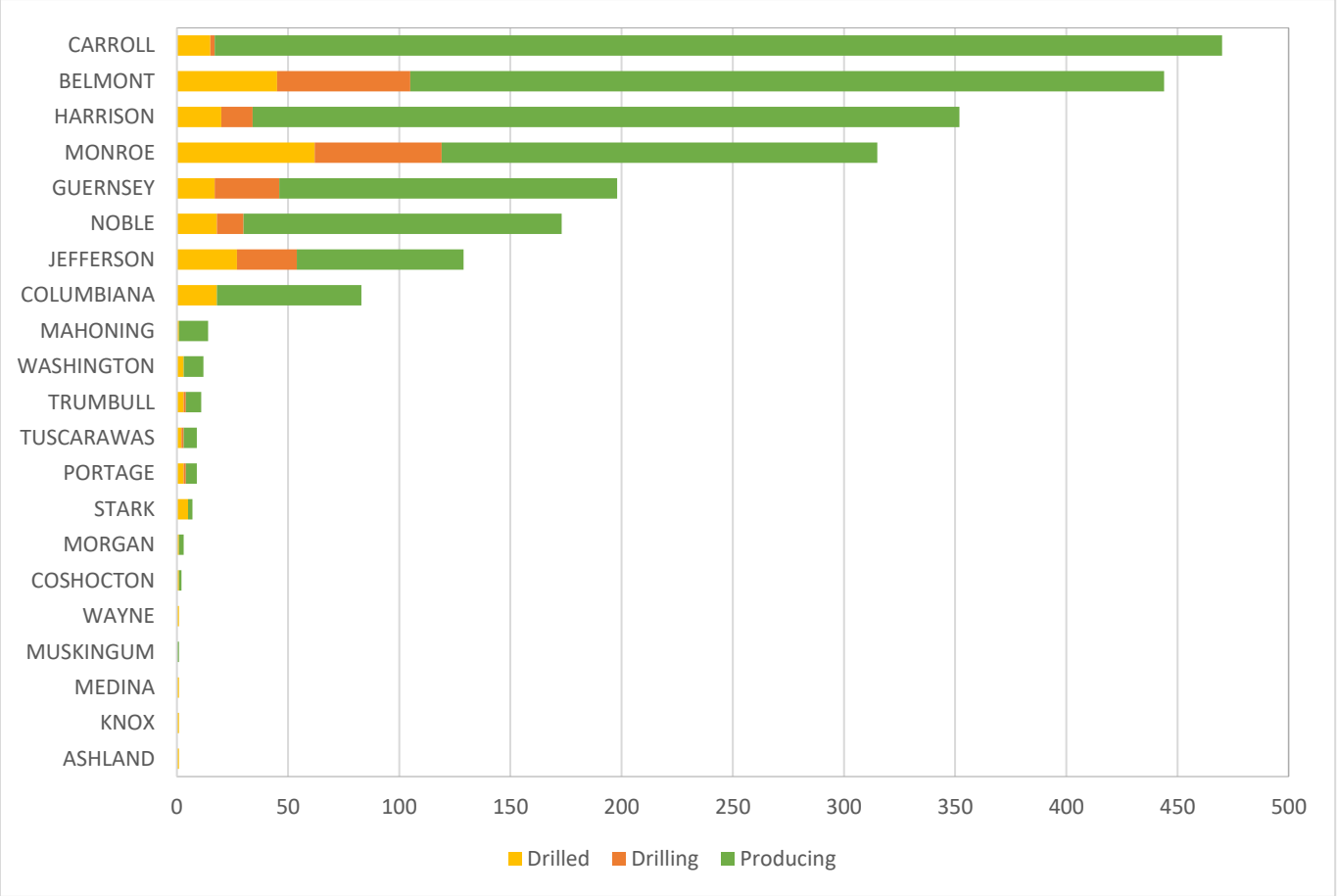


Figure 8: Cumulative Number of Wells by County



Source: Ohio Department of Natural Resource (December 2017)

Figure 9: Distribution of Gas Equivalent Production for 2011 through December 2017

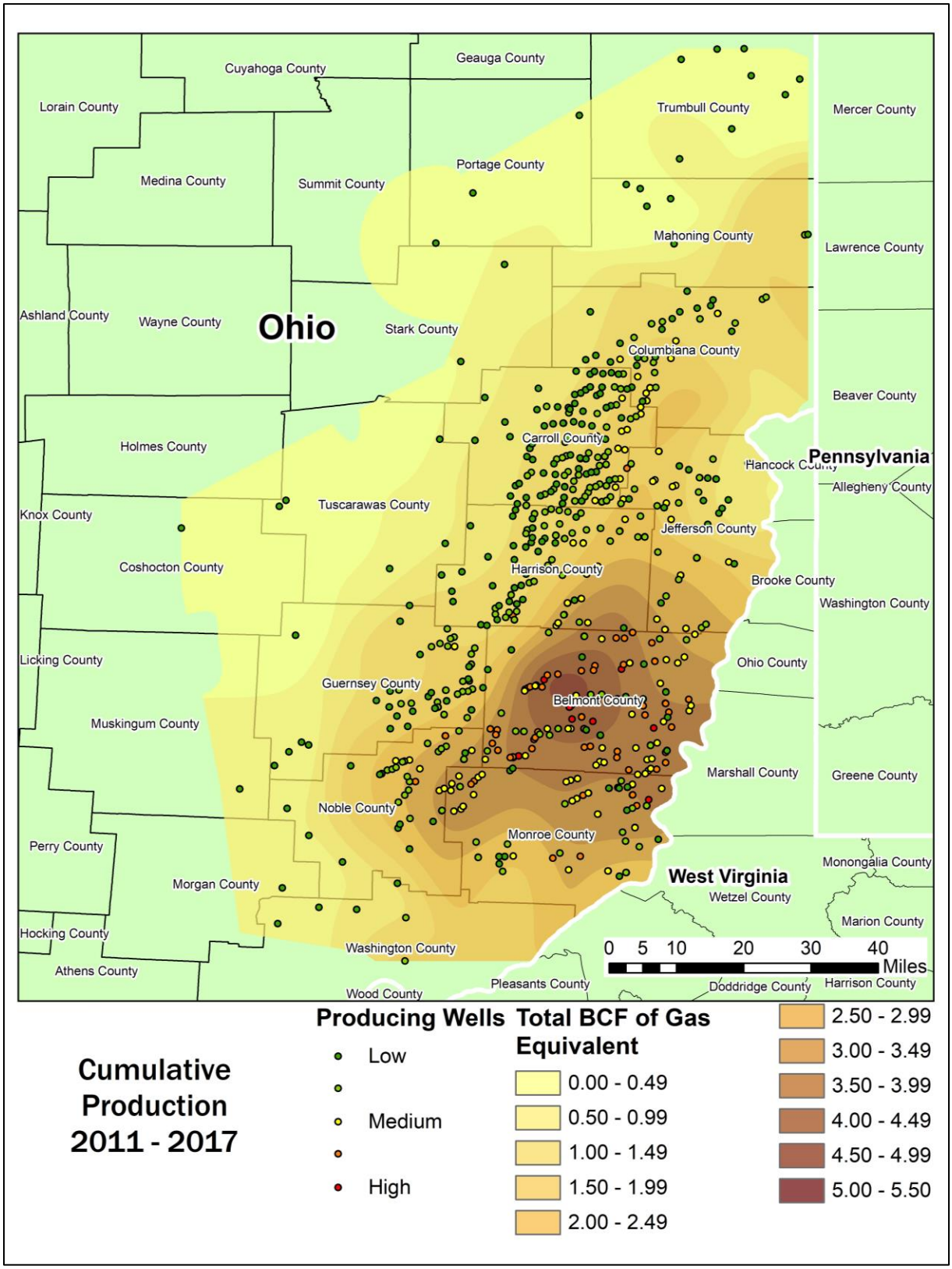


Figure 10: Distribution of Utica Wells by Status as of December 2017

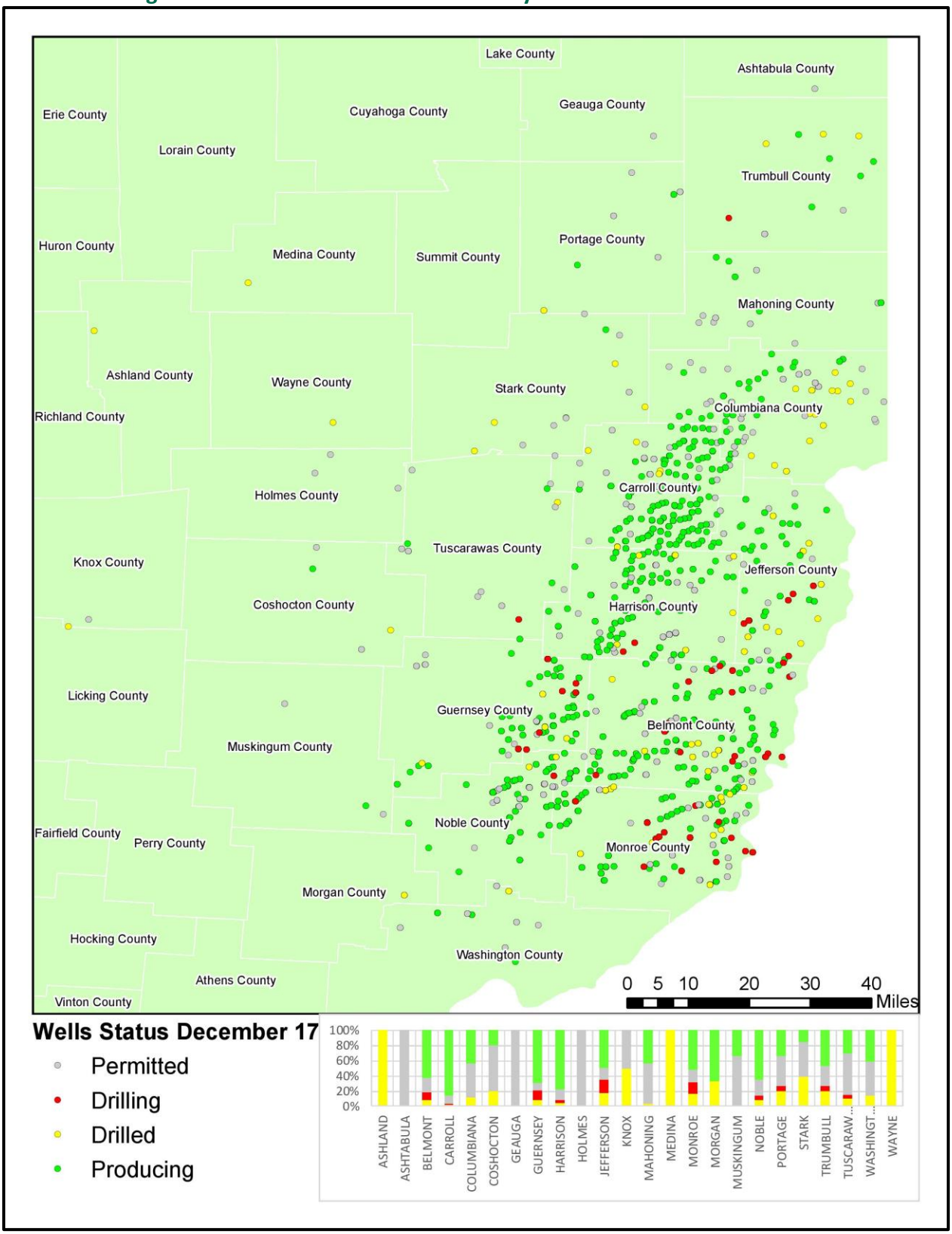


Table 16: Utica Upstream Companies Drilling in Ohio

Well Operators	Cumulative Number of Wells
CHESAPEAKE EXPLORATION LLC	739
GULFPORT ENERGY CORPORATION	337
ASCENT RESOURCES UTICA LLC	288
ANTERO RESOURCES CORPORATION	228
ECLIPSE RESOURCES I LP	119
RICE DRILLING D LLC	112
CNX GAS COMPANY LLC	66
HESS OHIO DEVELOPMENTS LLC	65
XTO ENERGY INC.	45
R E GAS DEVELOPMENT LLC	38
PDC ENERGY INC	34
STATOIL USA ONSHORE PROP INC	27
HILCORP ENERGY COMPANY	16
EM ENERGY OHIO LLC	13
PIN OAK ENERGY PARTNERS LLC	13
ATLAS NOBLE LLC	12
TRIAD HUNTER LLC	11
GULFPORT APPALACHIA LLC	10
CHEVRON APPALACHIA LLC	8
ARTEX OIL COMPANY	7
ENERVEST OPERATING LLC	6
MOUNTAINEER KEYSTONE LLC	6
NORTHWOOD ENERGY CORP	6
CHESAPEAKE APPALACHIA LLC	5
GEOPETRO LLC	5
HG ENERGY LLC	5
EQT PRODUCTION COMPANY	4
AMERICAN ENERGY UTICA LLC	3
DEVON ENERGY PRODUCTION CO LP	3
BRAMMER ENGINEERING INC	2
BP AMERICA PRODUCTION COMPANY	1
NGO DEVELOPMENT CORP.	1
PROTEGE ENERGY III LLC	1
Total Number of Wells in 21 Counties	**2236**

Note: Cumulative Number of Wells are calculated based upon the total numbers of Drilled, Drilling, and Producing. Source: ODNR (December 30, 2017).

Table 17: Total Lease Operating Expenses through December 2017 (in millions of dollars)

Year	Period	Production Wells	Lease Operating Expenses for Period ($mm)
2017	Q3 and Q4	1818	121.8
2017	Q1 and Q2	1588	141.3
2016	Q3 and Q4	1467	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	766

Table 18: Cumulative Utica-Related Upstream Investments in Ohio through December 2017

Estimated Investments	Total Amount
Undeveloped Land	$16,153,370,000
Developed Land	$2,664,000,000
Lease Renewals	$3,884,363,000
Drilling	$19,408,000,000
Roads	$1,046,860,000
Lease Operating Expenses	$736,278,000
Royalties	$3,000,139,500
Total	$46,893,010,500

Table 19: Cumulative Utica-Related Midstream Investments in Ohio through December 2017

Estimated Investments	Total Amount
Midstream Gathering	$6,630,289,400 [36]
Processing Plants	$1,309,000,000
Fractionation Plants	$1,246,000,000
Storage Tankage	$234,000,000
Rail Loading Terminals	$117,000,000
Transmission Pipelines	$9,254,900,000
Total	$18,791,189,400

[36] Cumulative Near Lease Gathering Line investments from prior reports are included in the cumulative Midstream Gathering line item.

Table 20: Cumulative Utica-Related Downstream Investments in Ohio through December 2017

Estimated Investments	Total Amount
Petrochemical Plants (including refineries)	$533,800,000
Natural Gas Power Plants	$3,040,000,000
Combined Heat and Power (CHP) Plants	$41,000,000
CNG Stations	$40,000,000
Total	$3,654,800,000

APPENDIX B. METHODOLOGY

1. Upstream Methodology.

Investment into the upstream for this fourth report has been broken down into four categories. The first category is investment into wells and includes one-time investments into drilling and roads. They were estimated as:

- Drilling: Northern Counties - $7 mm/well; Southern Counties - $10 mm/well.[37]
- Roads: average investments - approximately $60,000 per well based on 2013 data from Carroll County Engineer's Office.[38]

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 $12,000/month, throughout the life of the well. For purposes of estimating the lease operating expenses for Q3 and Q4 2017, the Study Team assumed that all wells listed as "producing" by the Ohio Department of Natural Resources on July 1, 2017 were incurring this cost and continued to do so through December 31, 2017. Lease operating expenses for wells that began production after July 1, 2017 were averaged at three months since they did not produce for all six months.[39]

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

[37] 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.

[38] *See fn 7, supra.*

[39] *See fn 5, supra.*

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 hydrocarbons were sold. 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.
- 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.[40]
- Residue gas in the Utica area was selling at an average annual price of $2.22/MMBtu[41]. This price for the Columbia-Appalachia hub was used to estimate royalties.
- 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 listed price for Marcellus-Utica medium crude oil.
- Condensate and oil in the Utica region were selling for $47.17 and $54.49 per barrel during the third and the fourth quarter of 2017, respectively.[42]
- 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.[43] 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.

2. 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,

[40] 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.
[41] https://www.ferc.gov/market-oversight/mkt-gas/northeast/ngas-ne-yr-pr.pdf?csrt=14746738715782415708
[42] http://ergon.com/prices
[43] This estimate was confirmed through industry interviews. New operator undeveloped acreage reports are likely to be made available after the new year that may suggest these estimates could be either too high or too low.

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 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 applying "inch-mile" cost estimates to known pipeline diameter and length for both inter- and intrastate projects. Interstate pipeline diameters and mileage can be determined from Federal Energy Regulatory Commission data; these estimates were confirmed from investor presentations, when available. Intrastate mileage and diameter were determined using data for gathering system construction that was newly obtained from the Public Utilities Commission of Ohio. This data suggests that the previously used assumption of 4 miles of gathering line per well pad was about twice as high as what midstream companies actually deploy in the field on average. Additionally, oil and gas companies can accommodate more than three times the 3-wells-per-pad that the Study Team assumed in prior studies.[44] Earlier iterations of this dashboard assumed companies would drill three wells per pad on average, move on to other locations, and then come back later to infill. As the Utica play becomes more mature, we can expect that there will be a greater number of wells per pad, and therefore fewer gathering pipeline miles per well. Future dashboards will use the PUCO numbers.

For this report, up-to-date cost for natural gas transmission and gathering line pipelines, per inch-mile, was obtained from the Interstate Natural Gas Association of America (INGAA).[45] The estimated cost for natural gas pipelines for the Midwest Region as used in this analysis was $177,970 per inch-mile, which included labor, raw materials, and permitting 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.

Compressor station investments were calculated based on the horsepower rating listed in Ohio EPA air permit data and estimated construction costs per horsepower of $3,347 for the Midwest Region as obtained from the INGAA.[46] The approximate capital cost for TEG dehydration units

[44] *See* http://www.post-gazette.com/business/powersource/2018/01/15/these-days-oil-and-gas-companies-are-super-sizing-their-well-pads/stories/201801140023

[45] The INGAA Foundation, Inc. (2018). *North America Midstream Infrastructure through* 2035. https://www.ingaa.org/File.aspx?id=34703.

[46] *Id.*

based on throughput was obtained from Carroll's *Natural Gas Hydrates: A Guide for Engineers* (2014, 3rd ed.). Facilities receiving a final permit-to-install or permit-to-install-and operate were assumed to be constructed during the same 6-month period in which the permit was issued by the Ohio EPA.

Finally, no assumptions were made for fractionation or processing plants for this report insofar as no new fractionation or processing capacity was added during the Study period. The following assumptions were used for previous reports and may be applied in future reports to estimate midstream-related investments, unless direct information, such as may be found in corporate 10K reports, is developed:

- 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

3. 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 and Ohio EPA public notices to support investment estimates.