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Shale Investment Dashboard in Ohio Q1 and Q2 2018

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LIST OF TABLES

LIST OF FIGURES

Executive Summary

This report presents findings from an investigation into shale-related investment in Ohio. The investment estimates are cumulative from January through June of 2018. 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 first half of 2018 can be summarized as follows:

Total Estimated Upstream Utica Investment: January-June 2018

Lease Renewals and New Leases	**$793,428,000**
Drilling	**$1,586,000,000**
Roads	**$9,420,000**
Lease Operating Expenses	**$191,148,000**
Royalties	**$787,390,000**
Total Estimated Upstream Investment	**$3,367,386,000**

Total Estimated Midstream Investment: January-June 2018

Gathering Lines	**$5,790,000**
Gathering System Compression and Dehydration	**$229,600,000**
Fractionation Plants	**$168,000,000**
NGL Storage	**$1,000,000**
Transmission Lines (including compression and interconnect)	**$98,120,000**
Rail Transloading Facilities	**$3,000,000**
Total Estimated Midstream Investment	**$505,510,000**

Total Estimated Downstream Investment: January-June 2018

Manufacturing/Industrial Plants with Natural Gas as a Critical Feedstock	**$700,000,000**
Petrochemical Plants (Including Refineries)	**$17,500,000**
Natural Gas Refueling Stations	**$1,000,000**
Total Estimated Downstream Investment	**$718,500,000**

[1] The four previous reports on shale investment in Ohio up to December 31, 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/
https://engagedscholarship.csuohio.edu/urban_facpub/1576/

Total investment from January through June 2018 was approximately $4.6 billion, including upstream, midstream and downstream. 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 June of 2018 is estimated to be around $74.0 billion. Of this, $50.3 billion was in upstream, $19.3 billion in midstream, and $4.4 billion was in downstream industries.[2]

Upstream investment slowed but continued to be significant in the first half of 2018, 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. By June of 2018, the ODNR had listed 157 new wells as "drilled, drilling or producing," compared to 206 in the second half of 2017. The majority of new wells were listed in southern counties, continuing the trend noted in previous reports, with Belmont, Monroe and Jefferson counties having the highest number of new wells at 57, 44 and 27 new wells, respectively.

Ascent Resources and Gulfport Energy were once again the top producers for Q1 and Q2 of 2018, having produced 252.3 and 198.1 billion cubic feet equivalent (Bcfe), respectively. Chesapeake Exploration was third in production at 149.6 Bcfe, followed by Rice Drilling at 134.1, Antero Resources at 99.9, and CNX at 78.5 Bcfe, respectively.[3] These six companies made up around 81% of the total production for the first half of 2018.

The first half of 2018 in Ohio saw continued investment in midstream infrastructure, although reported as less than the previous half-year because all of the Nexus pipeline investment was attributed to the second half of 2017, with limited new investment in transmission lines attributed to the first half of 2018. Midstream construction starts of $505.5 million during the study period included $398 million for processing plants (compression, dehydration and fractionation), and $98 million in additional transmission line investment. As noted in previous reports, the method of reporting used, since data on construction timelines is limited, is to attribute the entire value of the investment to the half-year during which the investment began. The Nexus transmission pipeline construction continued in 2018, even though its cost was attributed to an earlier report.

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

[2] As noted in the last report (2017 Q3 and Q4), previously reported near lease gathering line expenditures were shifted from upstream to midstream investment where they are included in the Gathering Lines line item.
[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

an ethane cracker in Belmont County in 2018, including the acquisition of additional land. Two additional investments noted included a Cleveland Cliffs hot briquetted iron plant (HBI) which broke ground in Toledo in April of 2018 ($700 million), and a new public compressed natural gas fueling station in Columbus ($1 million). Research work continues to expand the methodology for tracking similar downstream investment which is dependent on nearby natural gas availability for its success.

1. INTRODUCTION

This is the fifth CSU study reporting investment resulting from oil and gas development in Ohio related to the Utica and Point Pleasant formations (hereinafter, the "Utica").[4] This analysis looks at investment made in Ohio between January 1 and June 30, 2018, 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 existing 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. This included pipelines, processing, natural gas liquid storage, and intermodal transloading facilities.

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 dependent on, or 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 fifth Study 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 2018.[5] The methodology for determining the investments is set forth in Appendix B, and has been updated since the last report. Subsequent reports will include incremental spending on a six-month basis.

[4] In 2018 Cabot Oil and Gas Company acquired leases and drilled multiple wells in and around Ashland County for purposes of testing the Knox shale formation. These investments were made principally in the second half of 2018 and will be discussed in the next report. *See:* https://marcellusdrilling.com/2018/12/cabot-making-offers-to-oh-landowners-new-well-in-richland-co/

[5] *See fn 1, supra*.

2. SHALE INVESTMENT UPDATES

A. UPSTREAM DEVELOPMENT

1. Overview

A total of 157 new wells were listed by the Ohio Department of Natural Resources as "drilled," "drilling," or "producing" during the period of January 1 to June 30, 2018.[6] This represents a 24% reduction in new well development compared to the second half of 2018. The total number of producing wells in the Utica was 1957 on June 30, 2018, a 10% increase from the end of 2017. Total production in billion cubic feet equivalent (Bcfe) for this period was 1133 Bcfe, led by Belmont County with 458 Bcfe. Monroe County was second with 252 Bcfe, followed by Jefferson County with 152 Bcfe.[7]

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 first and second quarters of 2018 provide the foundation for the analyses presented in this Study.

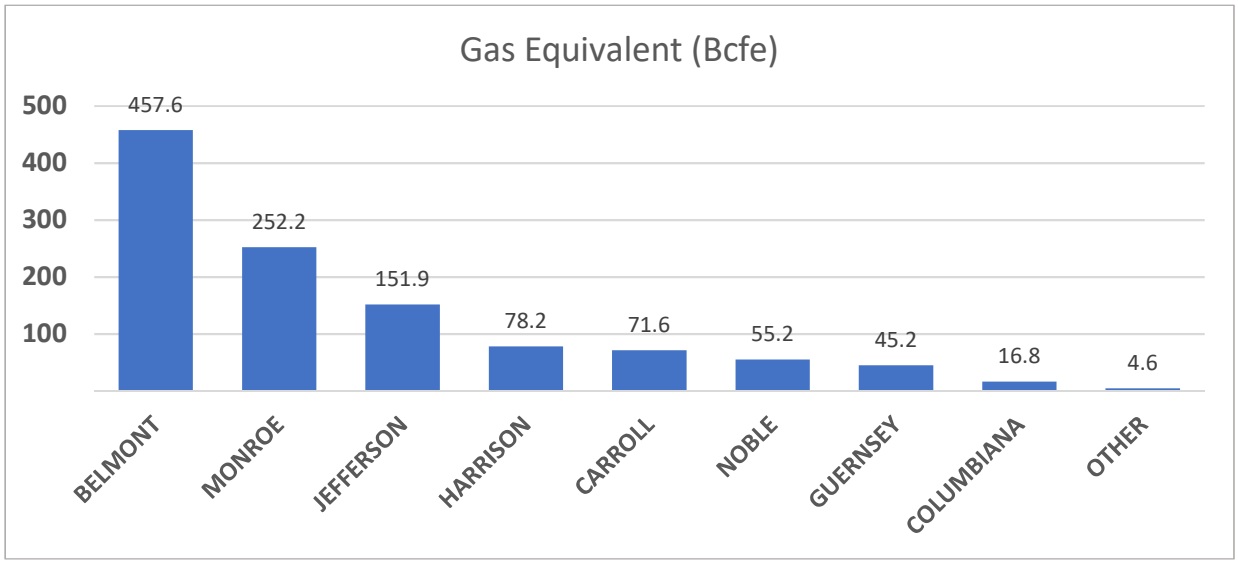
The Utica is currently identified by the ODNR as producing in twenty-one eastern Ohio counties with the vast majority (ninety-seven percent) of producing wells located in eight counties stretching from Columbiana in the north, to Monroe and Noble at the southern end of the play. Table 1 provides a summary of cumulative production and production for the first and second quarters of 2018. Total cumulative production in Billions of cubic feet equivalent (Bcfe) by county and by operator through June 2018 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 1 and 2 production for 2018 are set forth by county and operator in Figures 1 and 2 below.

[6] 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.

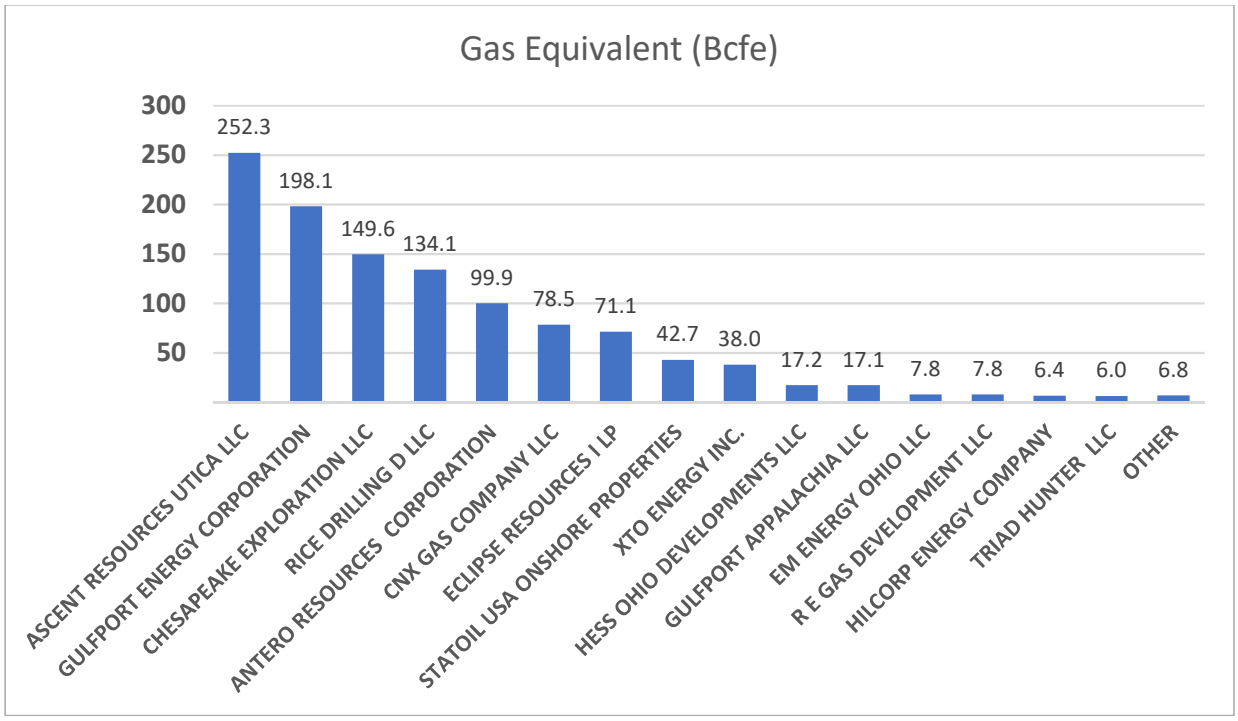
[7] Production is reported to the ODNR at the wellhead as gas measured in thousands of cubic feet (Mcf) and as oil measured in barrels (bbl). The Utica also produces significant volumes of natural gas liquids (NGLs) such as ethane, propane, butane and natural gasoline. These NGLs are separated from the natural gas stream at midstream cryogenand 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 1: Production by County for Q1 and Q2 of 2018



Source: ODNR (2018).

Figure 2: Production by Operator for Q1 and Q2 of 2018



Source: ODNR (2018).

2. Production Analysis

Production can be summarized 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 first half of 2018. Figure 3 sets forth the geographic distribution of production for the same period.

Table 1: Shale Production by Reporting Period

Year	Quarter	Production Wells	Gas (Mcfe)	Oil (bbl)	Gas Equivalents (Mcfe)	Gas Production (% Change from Previous Quarter)
2018	2	2002	554,306,916	4,488,104	579,705,097	4.3
2018	1	1906	531,291,017	3,942,251	553,600,215	5.6
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**	

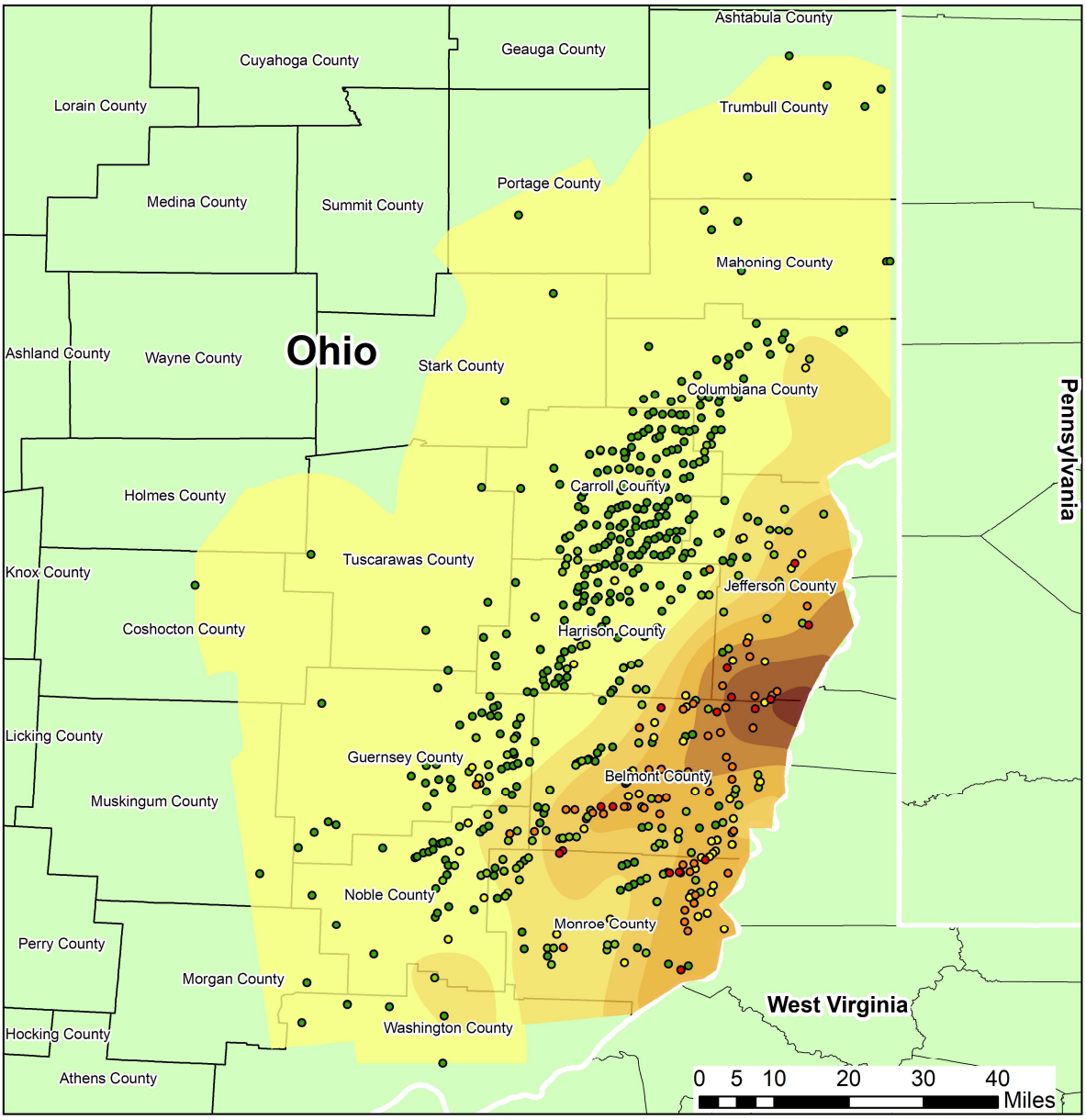
Source: ODNR (2018).

Table 2: Production by County for January-June 2018

County	Gas (Mcfe)	Oil (bbl)	Gas Equivalents (Mcfe)	Production Wells
BELMONT	457,479,894	24,016	457,615,801	386
CARROLL	61,057,966	1,870,776	71,644,687	467
COLUMBIANA	16,644,718	23,410	16,777,195	69
COSHOCTON	16,715	178	17,722	1
GUERNSEY	27,396,240	3,144,219	45,189,375	174
HARRISON	64,319,997	2,457,909	78,229,304	328
JEFFERSON	151,890,095	15	151,890,180	114
MAHONING	869,795	8,385	917,246	12
MONROE	251,215,280	168,613	252,169,461	267
MORGAN	98,310	5,336	128,506	2
MUSKINGUM	22,031	548	25,132	1
NOBLE	51,496,964	646,564	55,155,870	155
PORTAGE	16,751	163	17,673	1
STARK	69,125	1,517	77,710	2
TRUMBULL	191,772	1,535	200,459	6
TUSCARAWAS	191,422	14,937	275,950	6
WASHINGTON	2,620,858	62,234	2,973,040	11
Total	**1,085,597,933**	**8,430,355**	**1,133,305,312**	**2,002**

Source: ODNR (2018)

Figure 3: Distribution of Gas Equivalent Production for January-June 2018



2018 Q1 & Q2 Production

Total BCF of Gas Equivalent

- 0 - 0.4
- 0.41 - 0.8
- 0.81 - 1.2
- 1.21 - 1.6
- 1.61 - 2
- 2.01 - 2.4
- 2.41 - 2.8

Producing Wells

- Low
- Medium
- High

Of the 2,382 total wells identified from the ODNR records as of June 2018, 132 were in the process of drilling, 293 wells had been drilled and were awaiting markets, and 1,957 were in the production phase.[8] *See* Table 3, Ohio Utica Well Status. Carroll County has been surpassed as leader in total wells by Belmont County. (*see* Table 4)

Table 3: Ohio Utica Well Status as of June 2018

Well Status	No. of Wells
Drilled	293
Drilling	132
Producing	1,957
Total	**2,382**

Source: Ohio Department of Natural Resources (2018)

Table 4: Well Status by County (June 2018)

County	Drilled	Drilling	Producing	Total
ASHLAND	1	0	0	1
BELMONT	77	33	391	501
CARROLL	17	1	458	476
COLUMBIANA	15	0	69	84
COSHOCTON	1	0	1	2
GUERNSEY	26	16	158	200
HARRISON	21	6	333	360
JEFFERSON	33	25	98	156
KNOX	1	0	0	1
MAHONING	1	0	13	14
MEDINA	1	0	0	1
MONROE	67	39	250	356
MORGAN	1	0	2	3
MUSKINGUM	0	0	1	1
NOBLE	11	10	156	177
PORTAGE	7	1	1	9
STARK	5	0	2	7
TRUMBULL	3	1	7	11
TUSCARAWAS	3	0	6	9
WASHINGTON	1	0	11	12
WAYNE	1	0	0	1
Total	**293**	**132**	**1,957**	**2,382**

Source: ODNR (2018)

[8] The difference in the number of "producing" and "production" wells is due to a discrepancy in the number of such wells reported in the ODNR's *Shale Well Drilling & Permitting* and *Well Production* spreadsheets. For a particular point in time, a given well may be classified as non-producing in the spreadsheet for cumulative permitting activity yet have a record of shale production in the well production spreadsheet.

B. Upstream Investment Estimates

Upstream investments have been broken down into four areas: investments into drilling, including road construction associated with well development; lease operation (post production) expenses; lease renewal bonuses; and royalties on well production. The methodology used for each calculation is set forth in Appendix B. This section covers upstream investments between January and June of 2018. Cumulative upstream investments to date in Ohio, including 2012-2018, 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 57 new wells and an investment of around $630.4 million between January and June of 2018. Monroe and Jefferson Counties are second and third, with 44 and 27 new wells, respectively, and with $486.6 and $217.6 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 describing Road Use Maintenance Agreements (RUMAs) that companies have entered into with local governments for infrastructure improvements since Utica production began in 2011.[9] 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.[10]

Ascent Utica Resources LLC, two-thirds 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 41 new wells and an estimated $378.5 million invested, followed by Gulfport Energy with 27 new wells and an estimated $298.6 million invested. Chesapeake Exploration,[11] which was entirely active in northern counties, and Eclipse,[12] drilled 19 and 16 wells, with an estimated $153.1 and $177.0 million invested, respectively. Rice Drilling drilled 11 wells, with an estimated investment of $121.7 million.[13] *See* Table 6.

[9] *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

[10] The previously used method for determining road investments was a rule-of-thumb estimate based on an analysis by this study team of lease operating expenses for Gulfport Energy, as obtained from company financial reports.

[11] As noted earlier in this report, Chesapeake sold its Utica holdings to Encino as of 12/31/2018.

[12] Eclipse merged with Blue Mountain Resources to become Montage Resources as of 12/31/2017. https://s2.q4cdn.com/175866200/files/doc_presentations/2019/Strategic-Combination-Final.pdf

[13] Rice Drilling is now operating under the name EQT as of mid-2018 https://www.sec.gov/Archives/edgar/data/33213/000003321319000006/eqt1231201810k.htm

Table 5: Estimated Upstream Shale Investment by County, January-June 2018

County	No. of New Wells	Drilling ($)	Roads ($)	Total Amount ($)
CARROLL	7	$56,000,000	$420,000	$56,420,000
COLUMBIANA	1	$8,000,000	$60,000	$8,060,000
JEFFERSON	27	$216,000,000	$1,620,000	$217,620,000
HARRISON	12	$96,000,000	$720,000	$96,720,000
BELMONT	57	$627,000,000	$3,420,000	$630,420,000
GUERNSEY	4	$44,000,000	$240,000	$44,240,000
MONROE	44	$484,000,000	$2,640,000	$486,640,000
NOBLE	4	$44,000,000	$240,000	$44,240,000
WASHINGTON	1	$11,000,000	$60,000	$11,060,000
Total	**157**	**$1,586,000,000**	**$9,420,000**	**$1,595,420,000**[14]

Source: The Authors (2018)

Table 6: Estimated Upstream Shale Investment in Ohio by Company, January-June 2018

Operators	No. of Wells	Drilling	Roads	Total Amount ($)
ANTERO RESOURCES CORPORATION	9	$99,000,000	$540,000	$99,540,000
ASCENT RESOURCES UTICA LLC	41	$376,000,000	$2,460,000	$378,460,000
CHESAPEAKE EXPLORATION LLC	19	$152,000,000	$1,140,000	$153,140,000
CNX GAS COMPANY LLC	6	$66,000,000	$360,000	$66,360,000
ECLIPSE RESOURCES I LP	16	$176,000,000	$960,000	$176,960,000
EM ENERGY OHIO LLC	1	$11,000,000	$60,000	$11,060,000
EQUINOR USA ONSHORE PROPERTIES INC.	3	$33,000,000	$180,000	$33,180,000
GULFPORT APPALACHIA LLC	9	$99,000,000	$540,000	$99,540,000
GULFPORT ENERGY CORPORATION	27	$297,000,000	$1,620,000	$298,620,000
R E GAS DEVELOPMENT LLC	3	$24,000,000	$180,000	$24,180,000
RICE DRILLING D LLC	11	$121,000,000	$660,000	$121,660,000
STATOIL USA ONSHORE PROPERTIES INC	4	$44,000,000	$240,000	$44,240,000
TRIAD HUNTER LLC	4	$44,000,000	$240,000	$44,240,000
UTICA RESOURCE OPERATING LLC	1	$11,000,000	$60,000	$11,060,000
XTO ENERGY INC.	3	$33,000,000	$180,000	$33,180,000
Total	**157**	**$1,586,000,000**	**$9,420,000**	**$1,595,420,000**[15]

Source: The Authors (2018)

[14] Excludes royalties, bonuses for undeveloped acreage and lease operating expenses
[15] *Id.*

2. Lease Operating Expenses

Post production investments have been estimated on a half-year basis, assuming an average cost of around $17,000/month/well. This is an increase from the previous estimate of around $12,000/month/well, and is based upon recent operator reports.[16] These investments are set forth below. In line with total number of production wells, Carroll County and Belmont County lead the lease operating expense investment, with an estimated $46.5 and $37.2 million invested, respectively.

Table 7: Estimated Lease Operating Expenses for January-June 2018 by County

County	No. of Production Wells[17]	Lease Operating Expenses for Period
BELMONT	365	$37,230,000
CARROLL	456	$46,512,000
COLUMBIANA	67	$6,834,000
COSHOCTON	1	$102,000
GUERNSEY	155	$15,810,000
HARRISON	326	$33,252,000
JEFFERSON	87	$8,874,000
MAHONING	13	$1,326,000
MONROE	223	$22,746,000
MORGAN	2	$204,000
MUSKINGUM	1	$102,000
NOBLE	150	$15,300,000
PORTAGE	3	$306,000
STARK	2	$204,000
TRUMBULL	7	$714,000
TUSCARAWAS	6	$612,000
WASHINGTON	10	$1,020,000
	Total	**$191,148,000**

[16] The per-month rule-of-thumb for lease operating expenses per producing well was updated for this report by analyzing Gulfport's lease operating expenses for 2017 as reported in company financial statements.

[17] The number of wells producing was determined by taking the average of the number of such wells as identified by ODNR on December 31, 2017 and June 30, 2018. 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 January-June 2018 by Operator

Operator	No. of Production Wells	Lease Operating Expenses for Period
ANTERO RESOURCES CORPORATION	191	$19,482,000
ARTEX OIL COMPANY	7	$714,000
ASCENT RESOURCES UTICA LLC	200	$20,400,000
ATLAS NOBLE LLC	12	$1,224,000
CHESAPEAKE APPALACHIA LLC	4	$408,000
CHESAPEAKE EXPLORATION LLC	694	$70,788,000
CHEVRON APPALACHIA LLC	8	$816,000
CNX GAS COMPANY LLC	56	$5,712,000
ECLIPSE RESOURCES I LP	104	$10,608,000
EM ENERGY OHIO LLC	8	$816,000
ENERVEST OPERATING LLC	5	$510,000
EQUINOR USA ONSHORE PROPERTIES INC.	9	$918,000
GEOPETRO LLC	1	$102,000
GULFPORT APPALACHIA LLC	9	$918,000
GULFPORT ENERGY CORPORATION	283	$28,866,000
HESS OHIO DEVELOPMENTS LLC	59	$6,018,000
HILCORP ENERGY COMPANY	14	$1,428,000
M & R INVESTMENTS OHIO LLC	1	$102,000
NORTHWOOD ENERGY CORP	5	$510,000
PIN OAK ENERGY PARTNERS LLC	12	$1,224,000
PROTEGE ENERGY III LLC	1	$102,000
R E GAS DEVELOPMENT LLC	32	$3,264,000
RICE DRILLING D LLC	77	$7,854,000
TRIAD HUNTER LLC	3	$306,000
UTICA RESOURCE OPERATING LLC	14	$1,428,000
XTO ENERGY INC.	42	$4,284,000
EQT PRODUCTION COMPANY	1	$102,000
MOUNTAINEER KEYSTONE LLC	2	$204,000
NGO DEVELOPMENT CORP.	1	$102,000
PDC ENERGY INC	14	$1,428,000
STATOIL USA ONSHORE PROP INC	5	$510,000
	Total	**$191,148,000**

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 January and June 2018 were around $787.4 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 $2.35/MMBtu during the first half of 2018, up from $2.22 in 2017.[18] Regional oil prices increased from $61.93/bbl for the first quarter of 2018 to $66.83/bbl for the second quarter, on average.

Table 9: Total Royalties from Oil
January- June 2018 (in millions of dollars)

Year	Quarter	Oil Price[19] $/bbl	Oil Royalty (20%) $/bbl	Royalty ($mm)
2018	2	66.83	13.37	$59.99
2018	1	61.93	12.39	$48.83
			Subtotal	**$108.82**

Table 10: Total Royalties from Residue Gas
January- June 2018 (in millions of dollars)

Year	Quarter	Residue Gas Price[20] $/Mcf	Residue Gas Royalty (20%) $/Mcf	Royalty ($mm)
2018	2	2.59	0.517	$252.19
2018	1	2.59	0.52	$241.72
			Subtotal	**$493.90**

Table 11: Total Royalties from Natural Gas Liquids
January-June 2018 (in millions of dollars)

Year	Quarter	NGL Price $/bbl	NGL Royalty (20%) $/bbl	Royalty ($mm)
2018	2	20.05	4.01	$97.80
2018	1	18.58	3.72	$86.87
			Subtotal	**$184.67**

4. Lease Renewals and New Leases.

New leases and lease renewal investments have been estimated for the Utica region based upon the public reporting of undeveloped acreage from the top nine drilling companies in the region. These nine companies have together drilled over 90% of the Utica wells to date, and it is assumed that they likewise control over 90% of the leases. The estimated investments into undeveloped acreage is set forth below in Table 12.

[18] $2.35/bbl is equivalent to $2.59/mcf per EIA reports; see https://www.eia.gov/tools/faqs/faq.php?id=62&t=7
[19] http://ergon.com/prices
[20] https://www.ferc.gov/market-oversight/mkt-gas/northeast/ngas-ne-yr-pr.pdf?csrt=14746738715782415708

There are several potential sources of error in this estimate. All estimates assume $5000/acre lease bonus for new leases and for five-year renewals, which may not accurately reflect lease bonus rates. Additional factors that may make the estimate inaccurate include the following: (1) only net undeveloped 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; and (2) the assumption that new or renewed leases make up 10% of undeveloped acreage during the six month period may be too high or too low.

Table 12: Total Est. Investments into Undeveloped Acreage (New & Renewed Leases) January-June 2018 (in millions of dollars)

Operator	Undeveloped Acreage	Estimated Bonus Investment ($mm)
ANTERO RESOURCES CORPORATION[21]	86,151	43.08
ASCENT RESOURCES UTICA HOLDINGS, LLC	228,786	114.39
CHESAPEAKE ENERGY CORPORATION	686,000	343.00
CNX RESOURCES CORPORATION	259,519	129.76
ECLIPSE RESOURCES I LP	136,850	68.43
GULFPORT ENERGY CORPORATION	136,839	68.42
HESS CORPORATION	26,000	13.00
XTO ENERGY INC	26,000	13.00
EQT Corporation	711	0.36
Total	**1,586,856**	**793.43**

[21] REX Energy, one of the top ten drillers in the Utica in the first half of 2018, sold its Utica assets to Antero in January of 2017, and filed for bankruptcy in June of 2018. It is assumed that REX Energy's undeveloped acreage is included in Antero's financial reporting information for 2018. *See* https://www.sec.gov/Archives/edgar/data/1397516/000156459018020532/rexx-10q_20180630.htm

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. Rail and transloading facilities related to pipelines are also included.

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 first half of 2018. Table 13 sets forth gathering and transmission line investments while Table 14 sets forth all other midstream investments, including that for compression.[22]

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.

[22] For project mileage and compressor station deployment within Ohio, *see* https://www.ferc.gov/CalendarFiles. For compressor station horsepower ratings, *see* http://epawwwextp01.epa.ohio.gov:8080/ords/epaxp/f?p=999:10:0:

Table 13: Midstream Transmission and Gathering Line Investment January through June 2018

Company	Additions to Infrastructure	Total Amount ($mm)
Texas Eastern	• TEAL Phase II: Salineville compressor station, 18800 HP Salineville communications tower Colerain compressor station, 9400 HP	98.12
Cardinal Gas Services (Williams)	• 1.57 miles of 6" pipeline	1.92
Eureka Midstream	• 1.35 miles of 8" and 12" pipeline	2.64
Utica Gas Services - Apex Landfill Pipeline	• 1.33 miles of 4" pipeline	1.10
Utica Gas Services - Hanchin Well Connect Project	• 0.08 miles of 8" pipeline	0.13
	Total	**$103.9**

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

Table 14: Additional Midstream Investment, January through June 2018

Company	Additions to Infrastructure	Total Amount ($mm)
Antero Midstream	• Madison Compressor Station and Dehydration, Monroe County	101.0[23]
Blue Racer Midstream	• Harrison County Field Station no. 1	6.26[24]
Blue Racer Midstream	• Carroll County Field Station #1, Compressor and Dehydration	8.46[25]
Blue Racer Midstream	• Harrison County Field Station #2	8.46[26]
Bue Racer Midstream	• Athens Dehydration Facility, Harrison County • 1 compressor	6.26
Clean Energy Future	• Generator, Trumbull County	6.54
E2 Ohio	• Dehydration facility, Guernsey County	.9
Eureka Midstream	• Cain Ridge Compressor Station, Monroe County • 9 compressors and 2 dehydrators	60.76
Goliath	• Compressor Station, Monroe County • 3 compressors • 1 dehydration unit	27.84
Washington Energy Facility	• Compression ignition generator, Washington County	3.12
Markwest	• Hopedale IV fractionation, Harrison County[27]	168.00
Mountaineer NGL	• Storage facility in Monroe County[28] • Acquired additional 200 acres	1.00
S&S Heavy Haul	• Two transloading facilities in Steubenville, OH	3.00[29]
	Total	**401.6**

Adding the amounts in the above tables yields a total midstream investment for the first half of 2018 of $505.5 million.

[23] https://www.esvllc.com/news/mountaineer-ngl-included-u-s-department-energy-natural-gas-liquids-primer/
[24] https://www.federalregister.gov/documents/2017/09/07/2017-18996/columbia-gas-transmission-llc-notice-of-request-under-blanket-authorization
[25] 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
[26] 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
[27]https://marcellusdrilling.com/2018/02/markwest-building-new-fractionation-plant-in-harrison-county-oh/
[28] 200 acres added is estimated at $5000/acre, as per upstream land investments. https://www.esvllc.com/news/mountaineer-ngl-included-u-s-department-energy-natural-gas-liquids-primer/
[29] https://shalesupport.com/shale-support-expands-transload-capabilities-marcellus-shale/
Note that S&S Heavy Haul filed for bankruptcy in mid-2018 and its equipment was liquidated. https://shalesupport.com/shale-support-expands-transload-capabilities-marcellus-shale/
Liquid transloading facilities have been noted at construction costs between $1.5 and $3.0 million; a conservative $1.5 million per facility is assumed here. http://www.wsdot.wa.gov/NR/rdonlyres/3042FBC3-1119-4FA7-9B5D-5B48DD142CCD/0/GSTF_Final_v25mb.pdf

As anticipated in the previous report, development in gas processing in Ohio has picked up in 2018. MarkWest, for instance, 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.[30] More natural gas processing facilities are anticipated for the next report.

Transmission pipeline additions for the first half of 2018 were limited to Texas Eastern's TEAL project, Phase II, which included compressor capacity as noted in the tables above. While Nexus pipeline construction continues, its investment was included in the previous report in entirety due to limited information on construction scheduling. In addition, Shell Energy's Falcon Pipeline, connecting Scio and Cadiz fractionation plants in Ohio to the planned Pennsylvania Chemicals Project Ethane Cracker in Monaca, PA, is anticipated to begin construction in early 2019. With approximately 43 miles of 10" and 12" pipeline in Ohio, this represents a potential investment of about $90 million.[31] Construction of RH Energy's Risberg Pipeline, which will include 12 miles in Ohio, was slated to begin in early 2019. This will represent a major new investment.[32]

Cumulative midstream investments through mid-2018 are set forth in Table 19 in Appendix A.

[30] *See* note 27, *supra*. *See also* http://www.kallanishenergy.com/2018/04/05/markwest-adding-8-processing-plants-6-fractionators-in-appalachia/
[31] See https://www.shell.us/business-customers/shell-pipeline/falcon/facts-about-falcon-pipeline.html and http://edocpub.epa.ohio.gov/publicportal/ViewDocument.aspx?docid=791044
[32] https://rhenergytrans.com/

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 four 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.

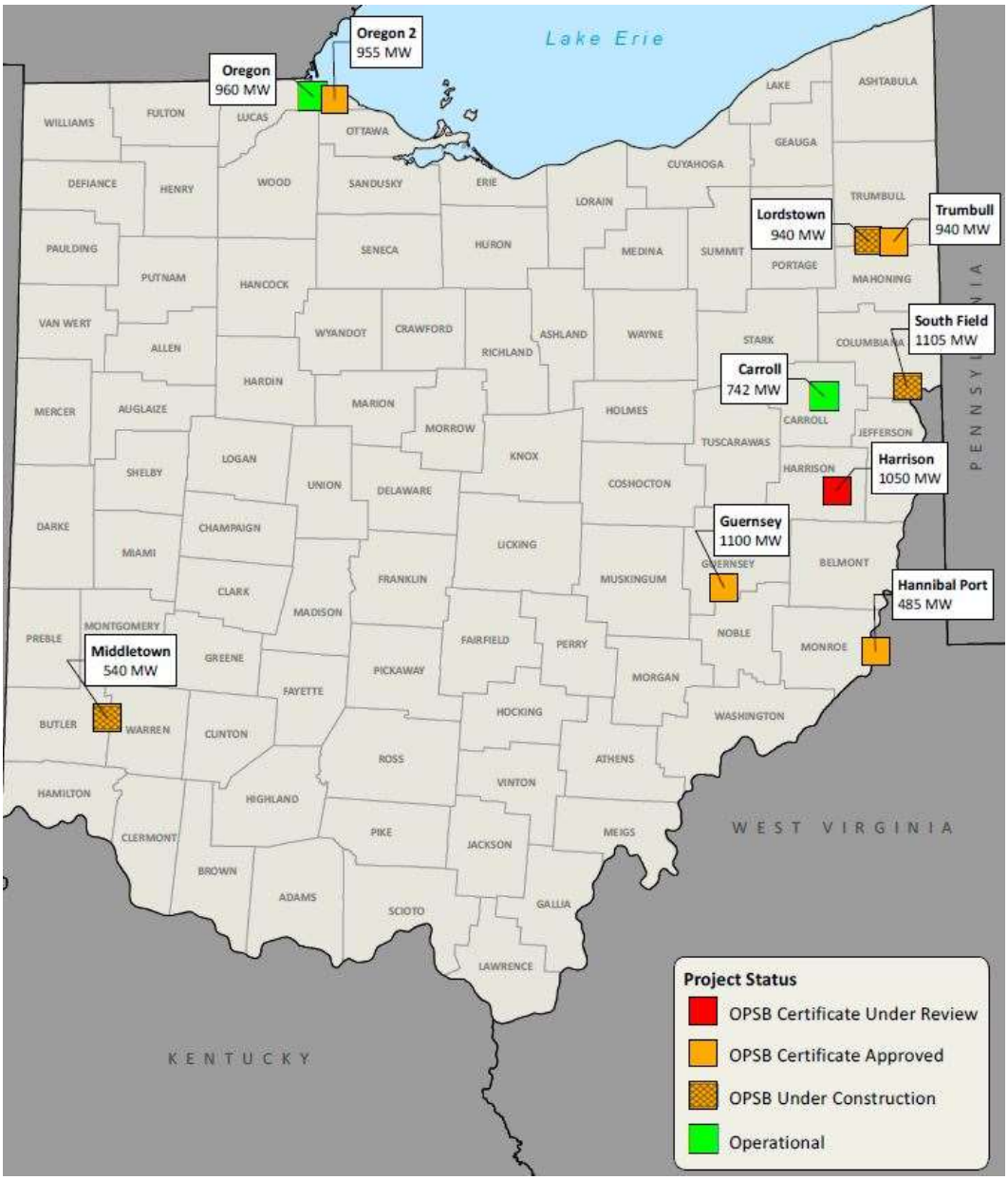
As with pipeline investments, expenditures are considered for purposes of this report as one-time investments by the builder during the six-month Study window, since it is difficult to separate the investments into half-year segments. However, major projects such as pipelines and gas plants usually take 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 first half of 2018. The South Field Energy facility was expected to begin construction later in 2018, with a possible anticipated investment of about $1.3 billion, which would be included in a future report.[33] The Hannibal power plant in Monroe County (estimated $500-$600 million) is slated to begin construction in the first half of 2019.[34] As also noted in the last report, Table 15 includes four additional natural gas plants, including the Hannibal Plant, that have received OPSB approval where construction, if it does commence, may begin as early as 2019.

[33] *See* https://businessjournaldaily.com/lordstown-energy-center-model-future-power-plants/ https://www.power-eng.com/articles/2018/08/firm-closes-funding-for-1-3b-gtcc-south-field-energy-plant.html https://www.power-technology.com/news/bechtel-build-1-182gw-south-field-energy-facility-ohio-us/

[34] http://www.newsandsentinel.com/news/business/2018/11/timeline-for-new-monroe-county-power-plant-extended/

Figure 4: Existing & Projected Natural Gas Power Plant



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[35]
Guernsey Power Station	OPSB Certificate Approved	1,500[36]
Hannibal Port Power Project	OPSB Certificate Approved	500[37]
Trumbull Energy Center	OPSB Certificate Approved	900[38]

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 the first half of 2018, 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.[39]

The U.S. Department of Energy report on CHP construction reports no new CHP in Ohio in 2017 or the first half of 2018. Likewise, no independent media reports were found that established any CHP facilities were built during the first half of 2018.[40]

3. Refineries, Petrochemical Plants and Other Downstream Investment

Construction of a new compressed natural gas (CNG) station costs around $1,000,000, depending upon its size and application.[41] One new Compressed Natural Gas (CNG) refueling station opened in Columbus in March 2018.[42] Three more CNG stations opened in the second half of 2018 and will be included in the next Shale report.

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

[35] *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
[36] *See* https://www.daily-jeff.com/news/20180606/power-plant-on-target-for-fall-groundbreaking
[37] *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/
[38] *Id.*
[39] *See* https://www.epa.ohio.gov/dapc/newpermits/issued
[40] *See* https://doe.icfwebservices.com/chpdb/state/OH
[41] This amount excludes land cost. *See* "CNG Station Construction and Economics," NGV America (2014). http://www.ngvamerica.org/stations/cng-station-construction-and-economics/.
[42] https://afdc.energy.gov/data_download

purposes of potentially developing an ethane cracker plant in Belmont County.[43] PTT made an additional land purchase in the first half of 2018, acquiring another 300 acres, representing an estimated $17.5 million investment.[44] As noted in the previous report, in addition to land purchases, by 2017 PTT had spent around $150 million on preliminary front-end engineering and design work in preparation for the proposed plant.[45] 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 this study period.

Another downstream industry that has been identified as a direct result of shale development is hydrogen, which is reformed from natural gas. No new hydrogen refueling stations have been built in 2018. However, Cliff Natural Resources has built a Hot Briquetted Iron (HBI) plant in Toledo that used the hydrogen-based Midrex process. This project represents a $700 million investment.[46]

Similarly, construction of a $500 million pig iron plant in Ashtabula is expected to begin in the summer of 2019.[47] A key enabler of the project is the recently FERC-approved Risberg Pipeline that will deliver natural gas to the region from western Pennsylvania.[48] The plant, operated by Petmin USA Inc., will not merely consume natural gas for fuel but will also utilize Tenova's HYL Energiron ZR process to permit the direct use of natural gas as a reducing agent.[49]

These new investments into industrial hydrogen and natural gas reduction processes have placed into a category of "manufacturing/industrial plants with natural gas as a critical feedstock," and we are tracking these separately from petrochemical and large natural gas generation facilities. Cumulative downstream investments reported to date in Ohio, including 2012-2018, are set forth in Table 20 in Appendix A.

Further research is underway to develop a methodology for identifying additional downstream industry investment that could be directly attributed to shale development.

[43] "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

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

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

[46] *See* https://www.crainscleveland.com/article/20180402/news/156871/cleveland-cliffs-break-ground-week-700-million-toledo-plant

[47] https://www.news5cleveland.com/new-pig-iron-plant-set-to-bring-hundreds-of-jobs-to-ashtabula-county

[48] *See* https://rhenergytrans.com/risberg-pipeline-is-a-game-changer-for-the-county-says-gp-executive-director/

[49] *See* https://petminusa.com/. *See also* http://www.millennium-steel.com/wp-content/uploads/2017/05/pp024-030_ms17.pdf

3. CONCLUSION

Despite depressed hydrocarbon prices, upstream shale investment in Ohio continued to be active, with 157 new wells in the first half of 2018, and a total of approximately $3.37 billion in upstream investment. Upstream investment activity has continued to move to the southern counties, especially in Belmont and Monroe Counties. Carroll County, which was surpassed as the leader in overall total number of Utica wells drilled or producing, had 7 new wells drilled during the Study period, while 57 wells were drilled in Belmont County, and 44 in Monroe County. Production from the higher-pressured wells in the southern counties continue to increase, with drilling investment in the next few years likely continuing to be focused in and around Belmont and Monroe Counties.

Midstream investment continued its momentum from 2017 into the first half of 2018. While 2017 showed substantial investment in transmission and gathering pipelines with no new processing investment, early 2018 is proving to be the opposite. New midstream investment has included $505.5 million primarily in compression, dehydration and fractionation capacity, with smaller amounts in gathering lines, NGL storage investment for additional land acquisition, and transmission line enhancement. The Nexus transmission line was wholly reported in the dashboard study for the second half of 2017, although construction continues. Construction of RH Energy's Risberg Pipeline, which will include 12 miles in Ohio, was slated to begin in late 2018.[50] Construction of Shell's new Falcon Ethane Pipeline, with 43 miles in Ohio, is anticipated for early 2019.

As anticipated in the previous report, downstream development began to pick up during the first half of 2018, with more investment anticipated in late 2018 and early 2019. Downstream investment tracked during the first half of 2018 is estimated at $718.5 million, including a natural gas refueling station in Columbus, acquisition of land for a planned ethane cracker in Belmont County, and an innovative hot briquetted iron plant in Toledo.

Total shale related investment in Ohio for the first half of 2018, including upstream, midstream and downstream, was around $4.59 Billion. Cumulative total shale related investment since 2012 is around $74 billion.

[50] https://rhenergytrans.com/

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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 5: Total Utica Production in Bcfe (Gas Equivalence) by County through June 2018

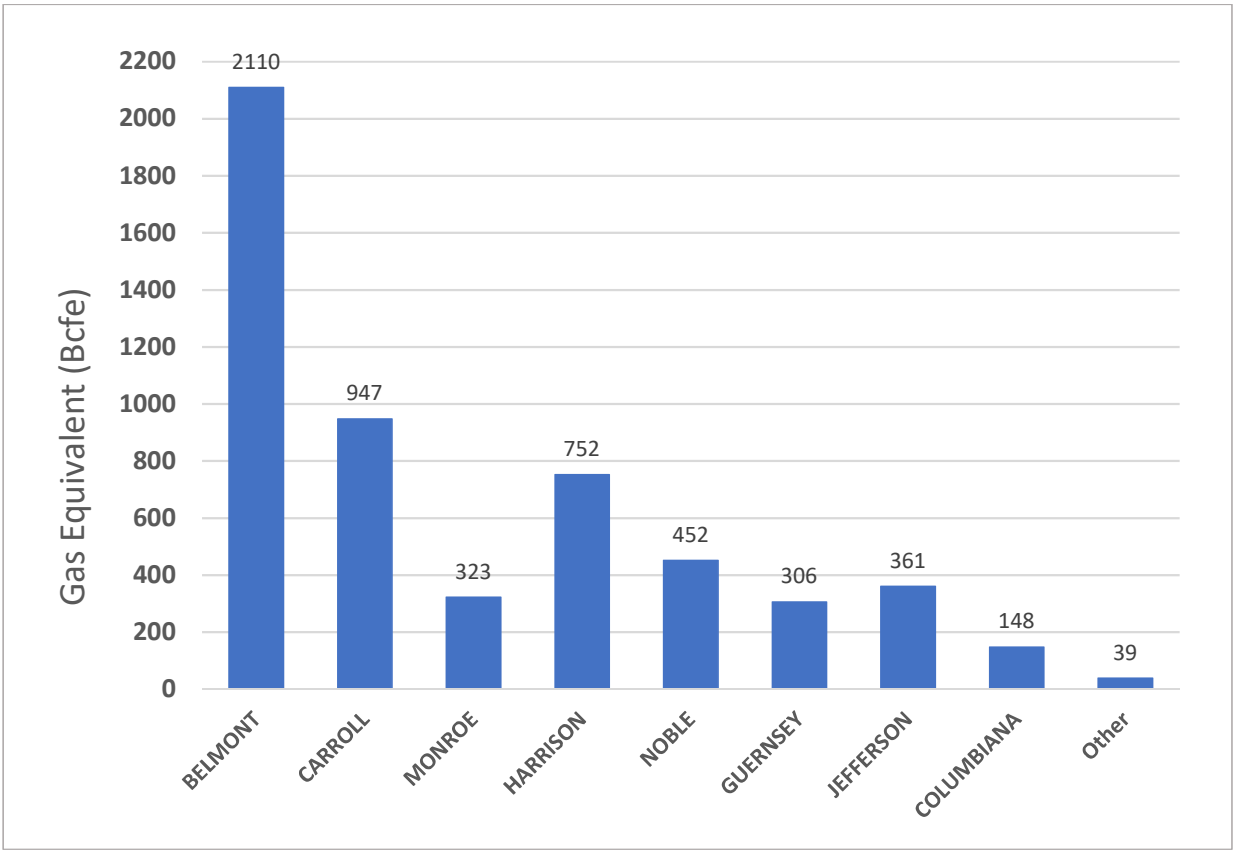


Figure 6: Total Utica Production in Bcfe by Operator through June 2018

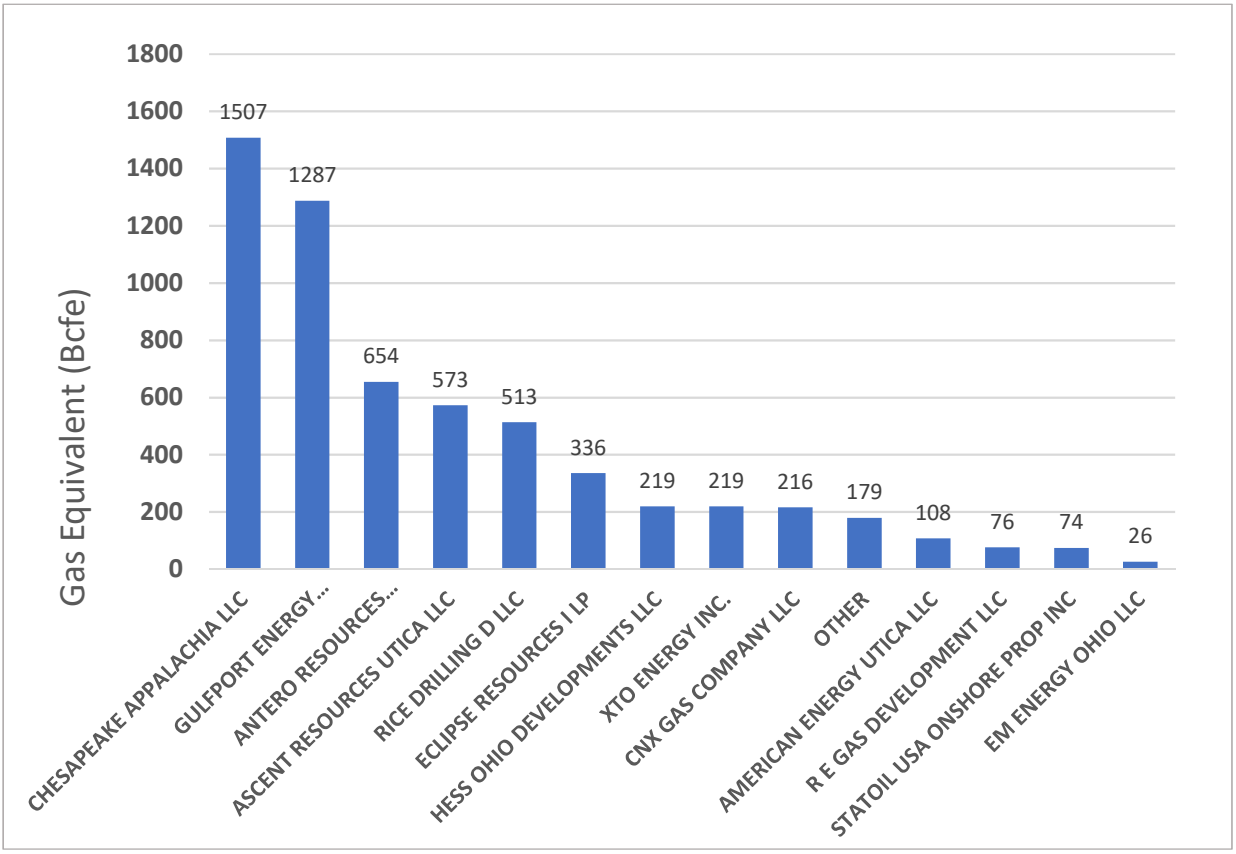
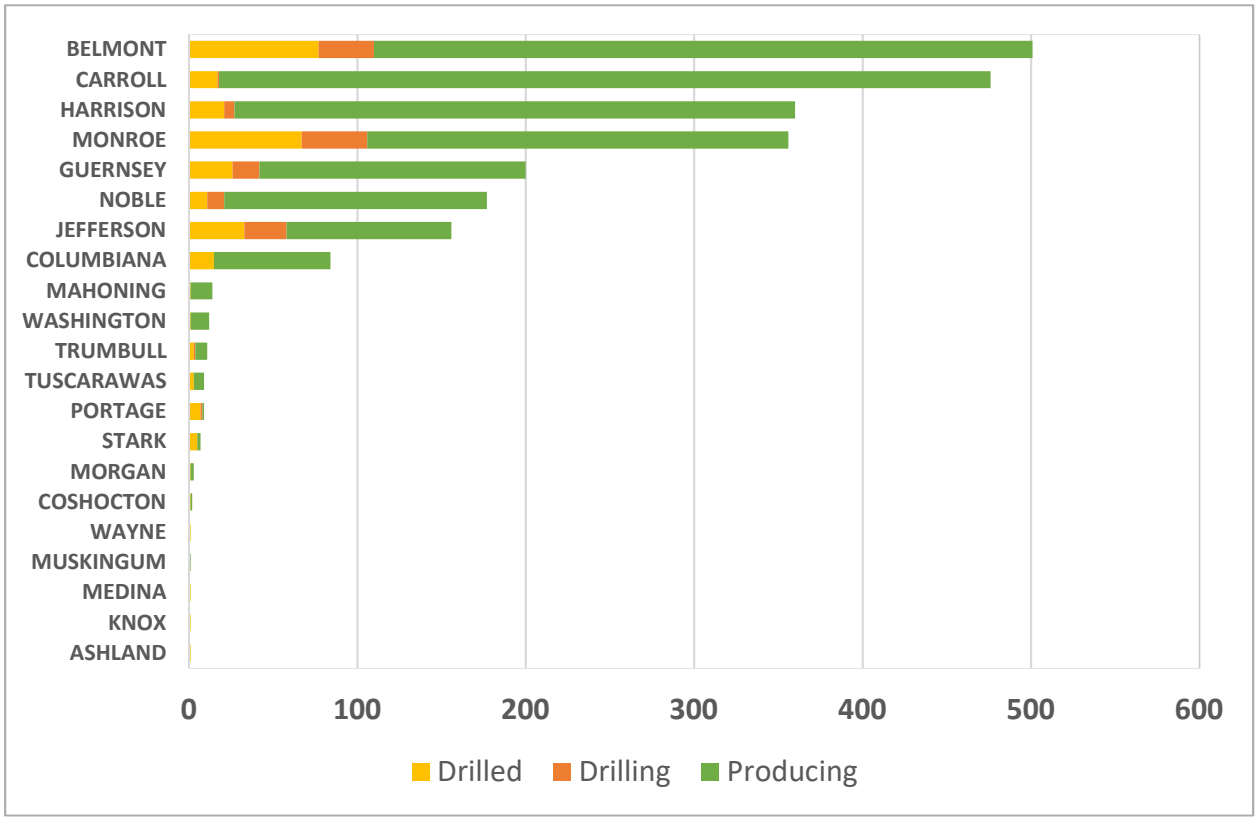


Figure 7: Cumulative Number of Wells by County



Source: Ohio Department of Natural Resources (June 2018)

Figure 8: Distribution of Gas Equivalent Production for 2011 through June 2018

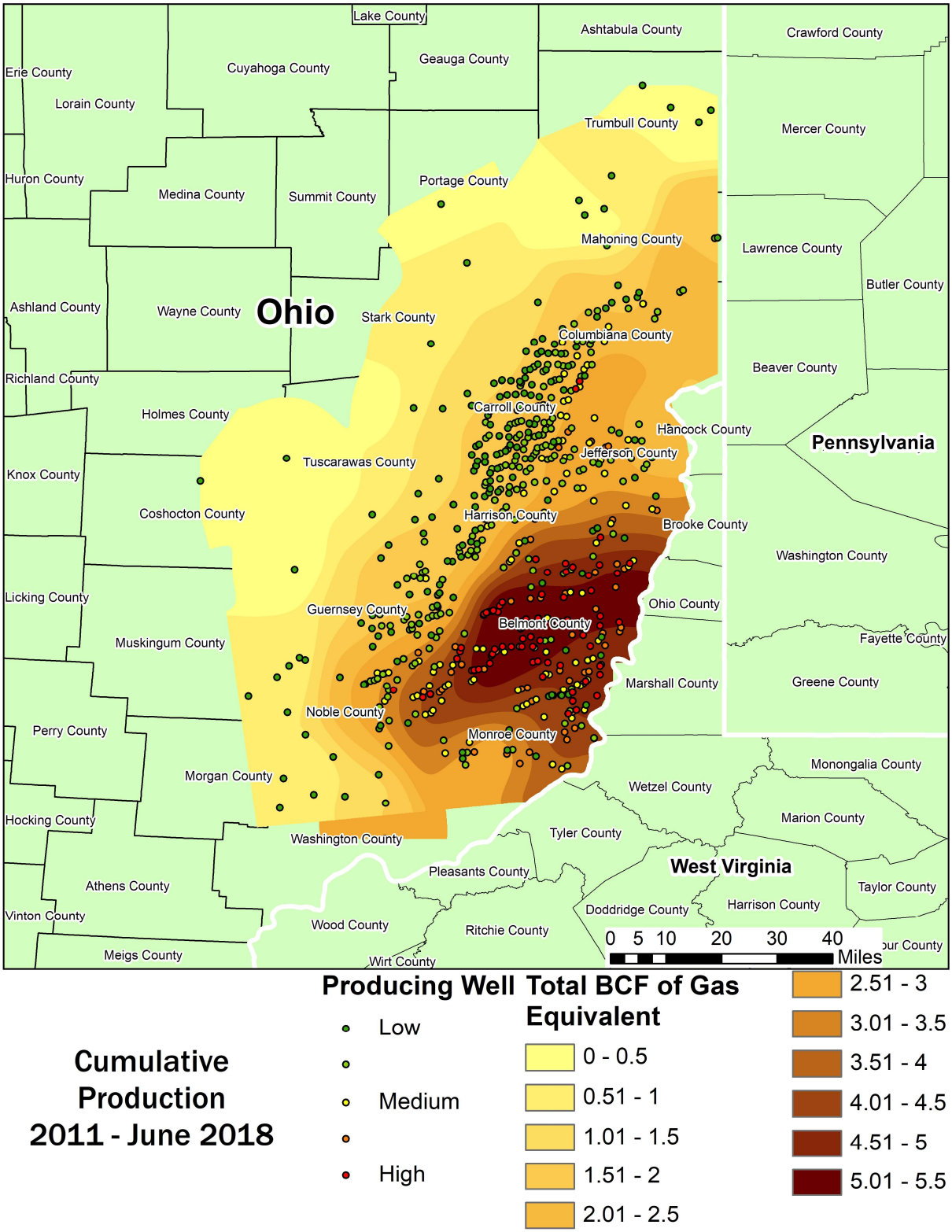


Figure 9: Distribution of Utica Wells by Status as of June 2018

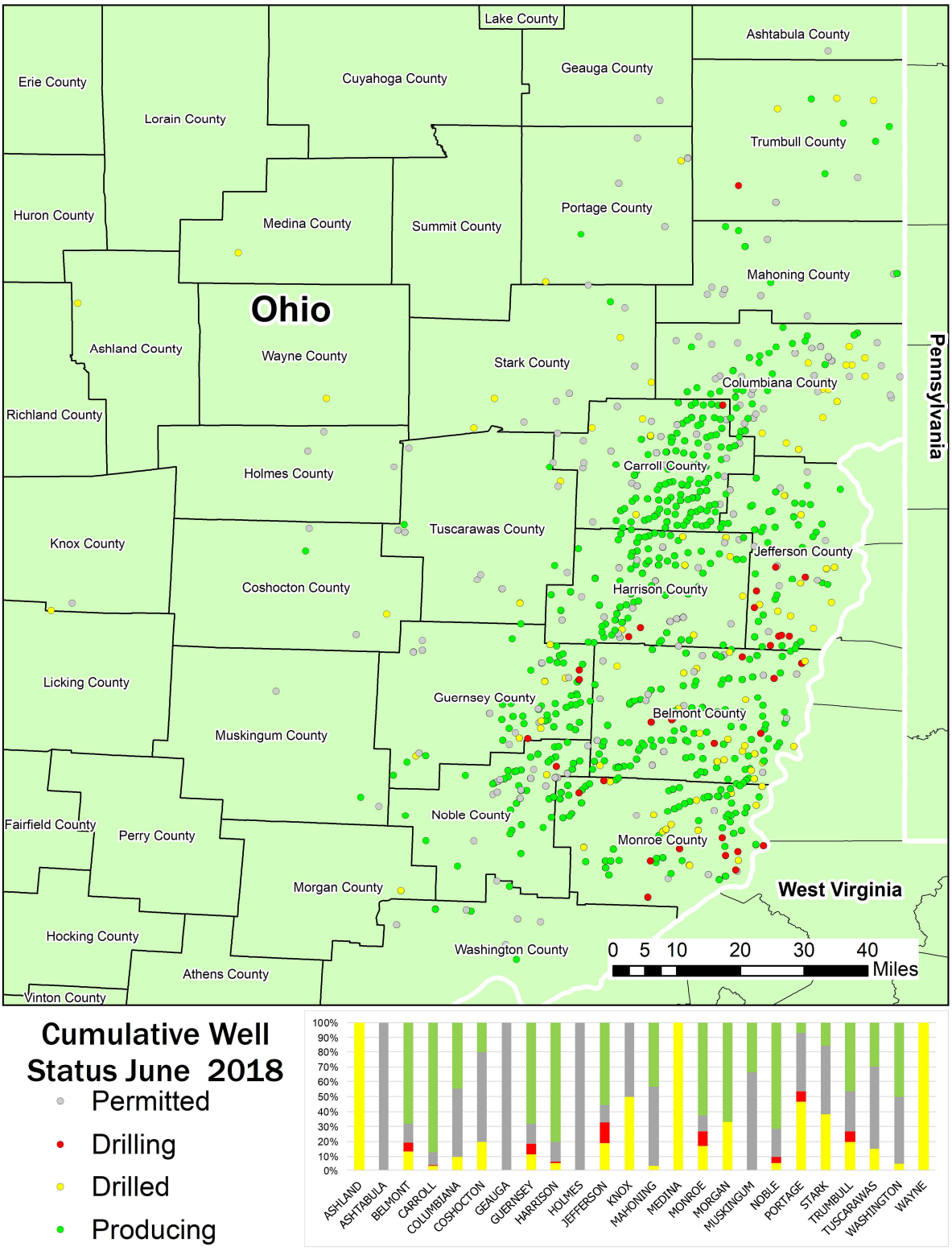


Table 16: Utica Upstream Companies Drilling in Ohio

Company	Cumulative No. of Wells
CHESAPEAKE EXPLORATION LLC	757
GULFPORT ENERGY CORPORATION	364
ASCENT RESOURCES UTICA LLC	325
ANTERO RESOURCES CORPORATION	237
ECLIPSE RESOURCES I LP	134
RICE DRILLING D LLC	123
CNX GAS COMPANY LLC	72
HESS OHIO DEVELOPMENTS LLC	65
XTO ENERGY INC.	48
R E GAS DEVELOPMENT LLC	41
UTICA RESOURCE OPERATING LLC	33
EQUINOR USA ONSHORE PROPERTIES INC.	27
GULFPORT APPALACHIA LLC	19
HILCORP ENERGY COMPANY	16
TRIAD HUNTER LLC	15
EM ENERGY OHIO LLC	14
PIN OAK ENERGY PARTNERS LLC	13
ATLAS NOBLE LLC	12
CHEVRON APPALACHIA LLC	8
ARTEX OIL COMPANY	7
ARSENAL RESOURCES LLC	6
ENERVEST OPERATING LLC	6
NORTHWOOD ENERGY CORP	6
CHESAPEAKE APPALACHIA LLC	5
GEOPETRO LLC	5
HG ENERGY LLC	5
STATOIL USA ONSHORE PROPERTIES INC	5
AMERICAN ENERGY UTICA LLC	3
DEVON ENERGY PRODUCTION CO LP	3
BRAMMER ENGINEERING INC	2
EQT PRODUCTION COMPANY	2
BP AMERICA PRODUCTION COMPANY	1
M & R INVESTMENTS OHIO LLC	1
PDC ENERGY INC	1
PROTEGE ENERGY III LLC	1
Total	**2,382**

Note: Cumulative Number of Wells are calculated based upon the total numbers of Drilled, Drilling, and Producing. Source: ODNR (June 30, 2018).

Table 17: Total Lease Operating Expenses through June 2018 (in millions of dollars)

Year	Period	Production Wells	Lease Operating Expenses for Period ($mm)
2018	Q1 and Q2	1874	191.15
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
		Total	**957.2**

Table 18: Cumulative Utica-Related Upstream Investments in Ohio through June 2018

Estimated Investments	Total Amount
Undeveloped Land	$16,153,370,000
Developed Land	$2,664,000,000
Lease Renewals	$4,677,791,000
Drilling	$20,994,000,000
Roads	$1,056,280,000
Lease Operating Expenses	$927,426,000
Royalties	$3,787,530,000
Total	**$50,260,397,000**

Table 19: Cumulative Utica-Related Midstream Investments in Ohio through June 2018

Estimated Investments	Total Amount
Midstream Gathering	$6,636,079,000
Processing Plants	$1,538,600,000
Fractionation Plants	$1,414,000,000
NGL Storage	$235,000,000
Rail Loading Terminals	$120,000,000
Transmission Pipelines	$9,353,020,000
Total	**$19,296,699,000**

Table 20: Cumulative Utica-Related Downstream Investments in Ohio through June 2018

Estimated Investments	Total Amount
Petrochemical Plants and Refineries	$551,300,000
Manufacturing/Industrial Plants with Natural Gas as a Critical Feedstock	$700,000,000
Natural Gas Refueling Stations	$41,000,000
Natural Gas Power Plants	$3,040,000,000
Combined Heat and Power (CHP) Plants	$41,000,000
Total	**$4,373,300,000**

APPENDIX B. METHODOLOGY

1. Upstream Methodology.

Investment into the upstream for this fourth report has been broken down into four categories.

a. Wells and Related Roads. The first category is investment into wells and includes one-time investments into drilling and road construction related to well development. They were estimated as:

- Drilling: Northern Counties - $8 mm/well; Southern Counties - $1 mm/well.[51]
- Roads: average investments - approximately $60,000 per well based on 2013 data from Carroll County Engineer's Office.[52]

The number of new wells developed in the study period, used as a basis for these calculations, were accounted for by subtracting the number of wells in the drilled, drilling and producing categories as of December 31, 2017 from the number existent as of June 30, 2018. This information was downloaded from the ODNR Oil and Gas Well database.[53]

b. Lease Operating Expense. 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 to be around $17,000/month, throughout the life of the well. This average expense was developed by the study team based on analysis of Gulfport's lease operating expenses for 2017, divided by the number of wells operated, as reported in their financial statements.[54]

For purposes of estimating the lease operating expenses for Q1 and Q2 2018, the Study Team assumed that all wells listed as "producing" by the Ohio Department of Natural Resources on January 1, 2018 were incurring this cost and continued to do so through June 30, 2018. Lease operating expenses for wells that began production after January 1, 2018 were averaged at three months since they did not produce for all six months.[55]

c. Oil and Gas Production Royalties. 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

[51] 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.

[52] *See fn 7, supra.*

[53] http://oilandgas.ohiodnr.gov/well-information/oil-gas-well-database

[54] https://www.sec.gov/Archives/edgar/data/874499/000162828018002041/gpor-12312017x10k.htm

[55] *See fn 5, supra.*

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 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. This represents the average situation.
- The average production shrinkage after processing was 12%, thereby making the residue gas volume 88% of the total natural gas production.[56]
- The residue energy content was around 1.1 MMBtu/Mcf.[57]
- Residue gas in the Utica area was selling at an average annual price of $2.35/MMBtu for both quarters.[58] 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 for residue gas revenues.[59]
- Around 44 barrels of liquids were recovered per million cubic feet of gas produced.[60]
- Natural gas liquids were selling for around 30% of the listed price for Marcellus-Utica medium crude oil.[61]
- Condensate and oil in the Utica region were selling for $61.93 and $68.83 per barrel during the first and the second quarter of 2018, respectively.[62]
- Royalty rates are 20% of gross production.

d. New and Renewal Lease Bonuses. Finally, a fourth form of upstream investment was estimated: new and renewal lease bonuses. For this purpose, we assumed that the average new lease or 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 will need to be renewed each year, or is otherwise new.[63] Since this Study covered six months, we assumed that half of this 20% was renewed or new 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

[56] Based on industry interviews, experts citing API 12.3, Manual of Petroleum Measurements and Standards
[57] 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.
[58] https://www.ferc.gov/market-oversight/mkt-gas/northeast/ngas-ne-yr-pr.pdf?csrt=14746738715782415708
[59] Based on industry data.
[60] Based on industry data.
[61] Based on industry interviews.
[62] http://ergon.com/prices
[63] This estimate was confirmed through industry interviews. New operator undeveloped acreage reports are likely to be made available over time that may suggest these estimates could be either too high or too low.

as the studies have only identified undeveloped acreage for the top six to nine operators in Ohio. Undeveloped acreage is typically reported in company 10-K and other financial statements.

2. Midstream Methodology.

Midstream investments include pipeline construction (intrastate, gathering lines and inter-state), processing plants (compression, dehydration, fractionation, and others), natural gas liquid storage facilities, and railroad terminals and transloading facilities. 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.

a. Processing plants. Processing plant information was obtained by searching a wide range of resources including EPA permit databases, news agencies, and company web sites and presentations. For purposes of estimating the investments for midstream processing plants, rules of thumb were developed based upon facility throughput capacities. These rules of thumb were applied to the processing plants that have been built in Ohio, using the throughput capacity estimates cited in permit documents, or 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.

Compressor station investments were calculated based on the horsepower rating listed in Ohio EPA air permit data and estimated construction costs per horsepower of $3,479 for the Midwest Region as obtained from the INGAA, as projected for 2018.[64]

The approximate capital cost for TEG dehydration units 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.

The following assumptions were used to estimate midstream-related investments:

- 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

[64] *Id.*

- Rail Loading Terminals: $40 MM for 1 Bcf/d throughput

b. Pipelines. 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 obtained from the Public Utilities Commission of Ohio.[65]

For this report, up-to-date cost projections for natural gas transmission and gathering line pipelines, per inch-mile, was obtained from the Interstate Natural Gas Association of America (INGAA).[66] The estimated cost for natural gas pipelines for the Midwest Region as used in this analysis was $183,457 per inch-mile, which included labor, raw materials, and permitting costs, as projected by the INGAA for 2018.

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.

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 permits and public notices to identify projects and support investment estimates. Search terms included identified company names, and key words associated with specific facility types and industries.

As of this report, downstream investment is categorized into eight categories:

- Natural Gas Power Plants
- Combined Heat and Power Plants
- Ethane Cracker Plants
- Methanol Plants
- Refineries
- Natural Gas refueling stations
- Petrochemical Plants

[65] The data currently used supercedes data used in previous reports for study periods through June 30, 2017. Newer 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. 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.

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

- Other industrial plants with natural gas inputs

NAICS codes used to generate keywords for searches included the following:
3251 – Basic Chemical Manufacturing
3252 – Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing
3253 – Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
3255 – Paint, Coating, and Adhesive Manufacturing
3259 – Other Chemical Product and Preparation Manufacturing
3261 – Plastics Product Manufacturing

In addition, certain newer processing methods in the iron/steel industry are closely tied to the presence of proximate natural gas resources, including the production of pig iron and hot briquetted iron. Work is underway to identify additional industries that represent oil and gas-related investments that should be included in future reports.