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Shale Investment Dashboard in Ohio Q1 and Q2 2019

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Prepared for:
JOB SOHIO

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March 2020

**SHALE INVESTMENT
DASHBOARD IN OHIO
Q1 AND Q2 2019**

**Energy Policy
Center**

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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 January through June of 2019. Prior investments have been included in previous reports that 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 2019 can be summarized as follows:

Total Estimated Upstream Utica Investment: January – June 2019

Lease Renewals and New Leases	\$344,000,000
Drilling	\$1,810,300,000
Roads	\$8,820,000
Lease Operating Expenses	\$228,060,000
Royalties	\$908,150,000
Total Estimated Upstream Investment	\$3,299,330,000

Total Estimated Midstream Investment: January – June 2019

Gathering Lines	\$83,292,000
Interstate Pipelines	\$259,366,000
Gathering System Compression and Dehydration	\$118,032,000
Total Estimated Midstream Investment	\$460,690,000

Total Estimated Downstream Investment: January – June 2019

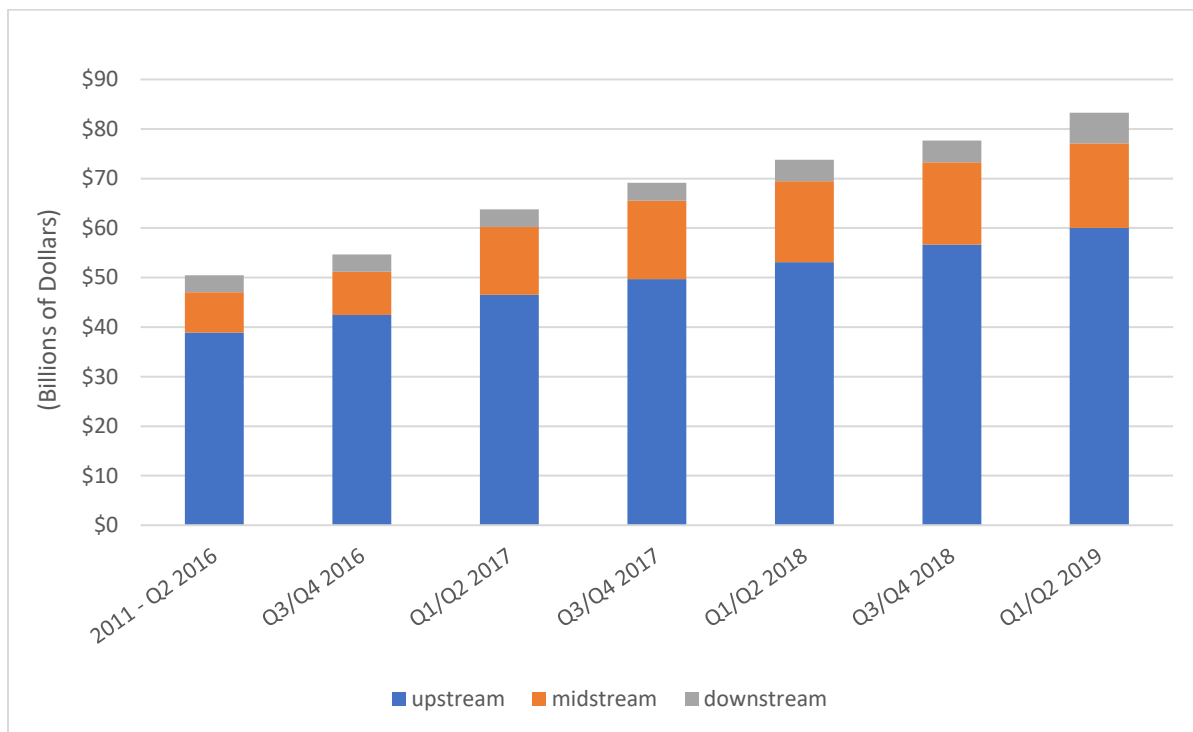
Natural Gas Power Plants	\$1,800,000,000
Petrochemical Plants	\$800,000
Total Estimated Downstream Investment	\$1,800,800,000

¹ The six previous reports on shale investment in Ohio up to December 2018 can be found at:

http://engagedscholarship.csuohio.edu/urban_facpub/1464/
http://engagedscholarship.csuohio.edu/urban_facpub/1500/
https://engagedscholarship.csuohio.edu/urban_facpub/1517/
https://engagedscholarship.csuohio.edu/urban_facpub/1576/
https://engagedscholarship.csuohio.edu/urban_facpub/1597/
https://engagedscholarship.csuohio.edu/urban_facpub/1628/

Total investment from January through June 2019 was approximately \$5.5 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 2019 is estimated to be around \$83.3 billion. Of this, \$57.1 billion was in upstream, \$20.0 billion in midstream, and \$6.2 billion in downstream industries.² Figure 1 shows the growth in cumulative shale-related investment for Ohio since the release of the first Dashboard.

Figure 1. Cumulative Shale Investment in Ohio Over Time



Overall upstream investments were slightly down in the first half of 2019 compared to the second half of 2018, even though drilling investments were up. This is largely explained by lower production volumes and commodity prices during the first half of 2019 compared to the previous 6-month period. As determined from Ohio Department of Natural Resources Division of Oil and Gas (ODNR) data for shale well drilling, 147 new wells were drilled during the first and second quarters of 2019, 30 more than that drilled in the second half of the previous year. Yet ODNR production data indicate that the volume of gas-equivalent shale production in the first half of 2019 was 3.6% lower than in the second half of 2018. While new well development continued to be concentrated more in the southern counties, due especially to drilling in Belmont County which had the highest number of new wells with 51, new well drilling picked up in northern

² Numbers may not add up precisely due to rounding.

counties such as Jefferson and Harrison as well which had the second and third highest number of new wells, with 29 and 27, respectively.

Ascent and Gulfport were once again the top producers for Q1 and Q2 of 2019, having produced 385.7 and 195.8 billion cubic feet equivalent (Bcfe), respectively. Rice Drilling was third in production at 170.3 Bcfe, followed by Encino Acquisition Partners at 162.2 Bcfe,³ Eclipse Resources at 100.8 Bcfe, and Antero Resources at 91.7 Bcfe. These six companies made up around 86.1% of the total production for the first half of 2019.

The first half of 2019 in Ohio saw a near doubling in midstream investment compared to the latter half of 2018, with spending focused on gathering system buildout (\$83.3 million), gathering system compression and dehydration (\$118.0 million), and interstate pipelines (\$259.4 million). The development of new processing facilities and underground storage for natural gas liquids is scheduled to begin in 2020 and will be included in future Shale Dashboards.

Two natural gas power plants broke ground in the first half of 2019, representing 1,667 megawatts of combined capacity and an investment of \$1.8 billion. Additional downstream investment during this period included nearly \$1 million in residential land purchases related to PTT Global's proposed petrochemical complex in Belmont County, where planning is ongoing, and a final investment decision is expected in mid-2020. Other large downstream projects being tracked for future Shale Dashboards include a 105.5 MW combined heat and power (CHP) facility on the campus of The Ohio State University.

1. INTRODUCTION

This is the seventh CSU 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 January 1 and June 30, 2019, 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

³ Includes production for wells that Encino was in the process of taking over from Chesapeake Energy during the first half of 2019.

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 seventh 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 2019.⁴ 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.

2. SHALE INVESTMENT UPDATES

A. UPSTREAM DEVELOPMENT

1. Overview.

A total of 147 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, 2019.⁵ This represents a 25.6% increase in new well development compared to the second half of 2018. The total number of producing wells in the Utica was 2,223 on June 30, 2019, a 4.9% increase from the end of December 2018. Total production in billion cubic feet equivalent (Bcfe) for this period was 1,285 Bcfe, led by Belmont County with 450 Bcfe. Monroe County was second with 279 Bcfe, followed by Jefferson County with 235 Bcfe.⁶

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 2019 provide the foundation for the upstream analyses presented in this Study.

The Utica is currently identified by the ODNR as producing in eighteen eastern Ohio counties with the vast majority (over ninety-eight 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

⁴ See fn 1, *supra*.

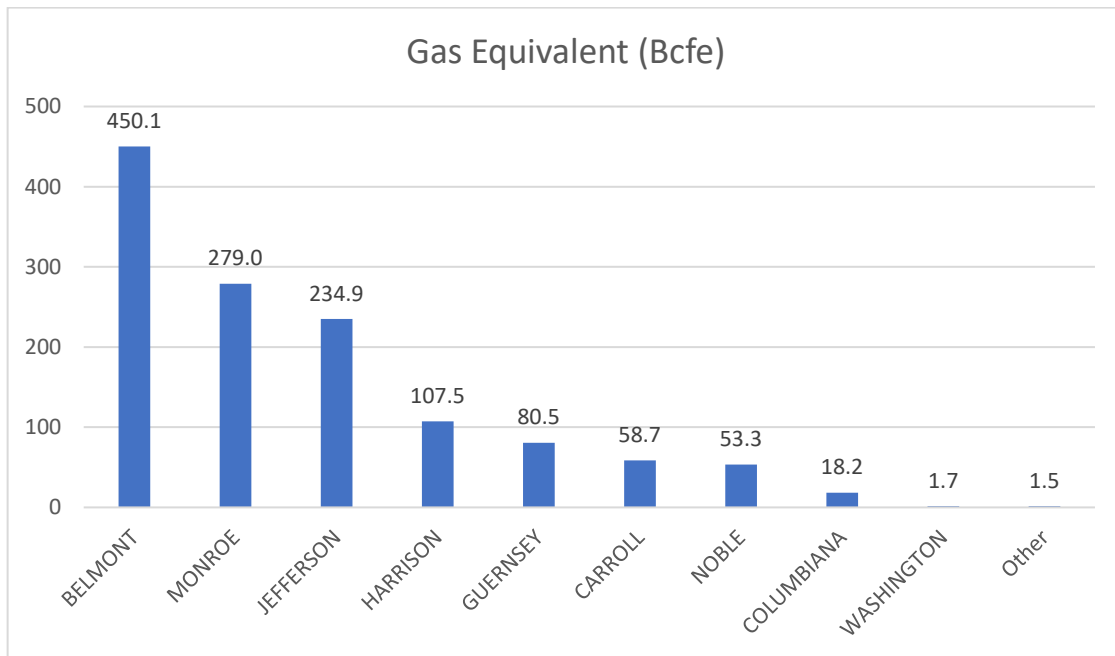
⁵ The number of new wells was determined using ODNR Cumulative Permitting Activity reports for the beginning and end of the 6-month period (see <http://oilandgas.ohiodnr.gov/shale>). Wells are assigned an American Petroleum Institute API number, which is included in the ODNR reports. Wells were considered 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 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).

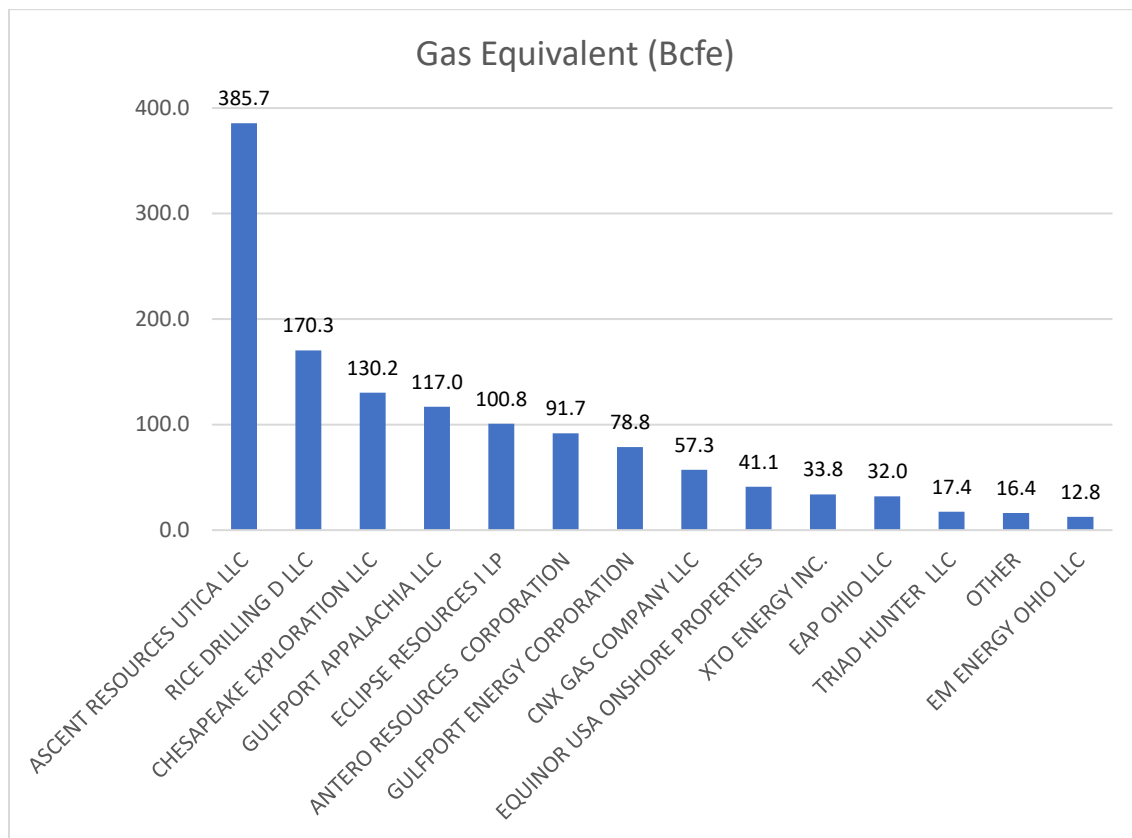
quarters of 2019. Total cumulative production in billions of cubic feet equivalent (Bcfe) by county and by operator through June 2019 can be found in Appendix A as Figures 6 and 7. New drilling and production have been moving steadily from the north (primarily Carroll County) to the south (primarily Belmont County) since 2014.

Total production in quarters 1 and 2 for 2019 is set forth by county and operator in Figures 2 and 3 below.

Figure 2: Production by County for Q1 and Q2 of 2019



Source: ODNR (2020).

Figure 3: Production by Operator for Q1 and Q2 2019⁷

Source: ODNR (2020).

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. Despite a slowed drilling rate, production has increased in all but two quarters since 2013. Table 2 sets forth production by county for the first half of 2019. Figure 4 sets forth the geographic distribution of production for the same period.

⁷ While EAP's deal to purchase Chesapeake's Ohio Utica assets was completed in 2018, the legal and operational transition of these assets to EAP did not commence until the first quarter of 2019 and was not complete as of the second quarter. See <https://www.shaledirectories.com/blog/encino-says-theyll-do-it-better-in-the-utica-than-chesapeake-did/>. See also ODNR Current Well Production, 2nd Quarter 2019.

Table 1: Shale Production by Reporting Period

Year	Quarter	Production Wells	Gas (Mcf)	Oil (bbl)	Gas Equivalents (Mcf)	Gas Equivalent Production (% Change from Previous Quarter)
2019	2	2317	614,218,362	5,813,755	647,118,402	1.4
2019	1	2228	609,452,391	5,073,536	638,163,531	-8.4
2018	4	2201	663,534,323	5,810,484	696,415,852	9.3
2018	3	2198	605,716,125	5,545,536	637,098,313	9.9
2018	2	2002	554,306,916	4,488,104	579,705,097	4.7
2018	1	1906	531,291,017	3,942,251	553,600,215	5.1
2017	4	1866	503,066,907	4,193,562	526,784,387	8.7
2017	3	1769	460,844,826	4,207,674	484,656,053	18.1
2017	2	1646	387,725,175	4,019,281	410,512,053	4.7
2017	1	1530	369,913,713	3,877,717	391,904,993	2.5
2016	4	1492	362,107,422	3,568,077	382,364,866	-0.2
2016	3	1442	360,681,356	3,954,095	383,057,580	5.9
2016	2	1382	334,257,982	4,839,792	361,646,365	0.3
2016	1	1328	329,537,838	5,485,854	360,582,286	7.0
2015	4	1248	301,486,508	6,248,451	336,846,492	39.1
2015	3	989	216,974,492	4,439,258	242,096,253	-4.5
2015	2	992	221,862,582	5,578,255	253,429,927	21.5
2015	1	907	183,585,256	4,432,195	208,667,049	12.8
2014	4	810	164,815,008	3,558,836	184,954,459	25.7
2014	3	688	130,282,395	2,984,534	147,171,872	45.0
2014	2	535	87,773,834	2,422,179	101,480,943	30.1
2014	1	415	67,095,693	1,928,076	78,006,674	53.5
2013	4	371	42,693,774	1,433,731	50,807,259	24.7
2013	3	269	33,255,706	1,323,812	40,747,160	126.2
2013	2	186	14,863,645	556,437	18,012,520	79.1
2013	1	117	8,237,177	321,439	10,056,202	-38.8
2012	ANNUAL	82	12,831,292	635,874	16,429,703	481.9
2011	ANNUAL	9	2,561,524	46,326	2,823,683	---
		Total	6,951,302,486	89,841,830	7,459,858,256	

Source: ODNR (2019).

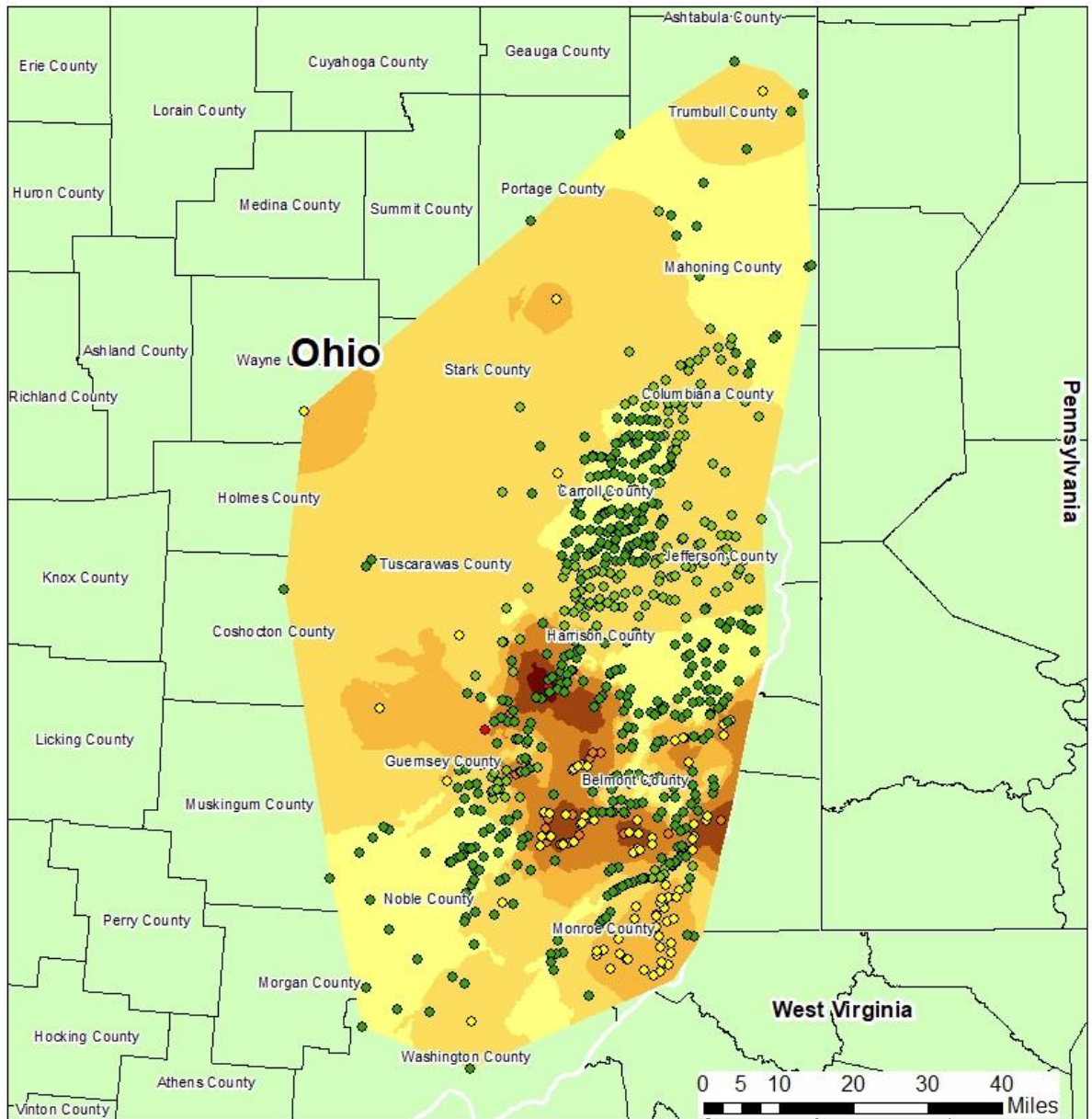
Table 2: Production by County for January - June 2019

County	Gas (Mcf)	Oil (bbl)	Gas Equivalents (Mcf)	Producing Wells ⁸
BELMONT	450,036,768	11,623	450,102,543	468
CARROLL	51,143,745	1,334,411	58,695,177	470
COLUMBIANA	18,040,533	19,367	18,150,131	73
COSHOCTON	16,734	166	17,673	1
GUERNSEY	44,236,202	6,407,614	80,496,890	209
HARRISON	93,331,434	2,494,966	107,450,447	355
JEFFERSON	234,855,674	10	234,855,731	164
MAHONING	672,438	4,781	699,494	12
MONROE	278,540,423	81,203	278,999,951	322
MORGAN	92,909	4,249	116,954	2
MUSKINGUM	18,013	543	21,086	1
NOBLE	50,569,077	490,082	53,342,451	168
PORTAGE	19,477	171	20,445	1
STARK	56,144	1,323	63,631	2
TRUMBULL	231,222	2,365	244,606	7
TUSCARAWAS	194,360	16,284	286,511	7
WASHINGTON	1,604,122	18,133	1,706,737	11
WAYNE	11,478	0	11,478	1
Total	1,223,670,753	10,887,291	1,285,281,933	2,273

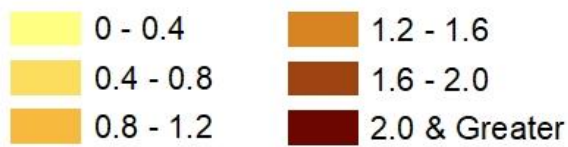
Source: ODNR (2019)

⁸ Represents the average number of production wells for the first and second quarters of 2019.

Figure 4: Distribution of Gas Equivalent Production for January – June 2019



Average BCF of Gas Equivalent Per Well for First Half of 2019



Producing Wells



Of the 2,636 total wells identified from the ODNR records for cumulative drilling activity as of June 2019, 173 were in the process of drilling, 240 wells had been drilled and were awaiting markets, and 2,223⁹ were in the production phase. See Table 3, Ohio Utica Well Status. Belmont County continued to lead in total wells. (see Table 4).

Table 3: Ohio Utica Well Status as of June 2019

Well Status	No. of Wells
Drilled	240
Drilling	173
Producing	2,223
Total	2,636

Source: Ohio Department of Natural Resources (2019)

Table 4: Well Status by County (June 2019)

County	Drilled	Drilling	Producing	Total
ASHLAND	1	0	0	1
BELMONT	64	48	456	568
CARROLL	7	1	468	476
COLUMBIANA	14	0	74	88
COSHOCTON	1	0	1	2
GUERNSEY	13	26	200	239
HARRISON	26	25	356	407
JEFFERSON	23	33	155	211
KNOX	1	0	0	1
MAHONING	1	0	13	14
MEDINA	1	0	0	1
MONROE	65	28	302	395
MORGAN	1	0	2	3
MUSKINGUM	0	0	1	1
NOBLE	4	10	166	180
PORTAGE	7	1	1	9
STARK	5	0	2	7
TRUMBULL	3	1	7	11
TUSCARAWAS	2	0	7	9
WASHINGTON	1	0	11	12
WAYNE	0	0	1	1
Total	240	173	2,223	2,636

Source: ODNR (2020)

⁹ The discrepancy between the number of “Producing” wells in Table 3 and “Production” wells in Table 2 is due to how wells are 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 activity yet have a record of 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 operating (post-production) expenses; new lease and lease renewal bonuses; and royalties on hydrocarbon production. The methodology used for each calculation is set forth in Appendix B. Average drilling costs were updated for this study, based upon reports from publicly traded operating companies. We continued to differentiate between northern counties (\$11.4 million per well) and southern counties (\$12.9 million per well) after reviewing recent drilling surveys that indicated an extra 1,700 of lateral length on average for wells drilled in southern counties.

This section covers upstream investments between January and June of 2019. Cumulative upstream investments to date in Ohio, including 2011-2018, are set forth in Table 19 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 was the leader in new upstream investment, with 51 new wells and an investment of around \$661.0 million between January and June of 2019. Jefferson and Harrison Counties were second and third, with 29 and 27 new wells, respectively, to go along with \$332.3 and \$310.4 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-Depth¹⁰ 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.¹¹

Ascent Utica Resources LLC, nearly half of whose new wells were in the lower cost, more northerly counties, was the leading operator investor during the six-month period, with 69 new wells and an estimated \$844.7 million invested, followed by Gulfport and EAP Ohio, both with 15 new wells and an estimated \$192.4 million and \$171.9 million invested, respectively.¹² Rice Drilling drilled 11 wells for an estimated investment of \$142.6 million, followed by Eclipse Resources who drilled 8 wells for an estimated investment of \$103.2 million. See Table 6.

¹⁰ 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>

¹¹ 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.

¹² The difference in the amount invested for the same number of wells is due to EAP Ohio having drilled a larger share of its wells in the less costly northern counties.

Table 5: Estimated Upstream Shale Investment by County, January-June 2019

County	No. of New Wells	Drilling (\$)	Roads (\$)	Total Amount (\$)
BELMONT	51	\$657,900,000	\$3,060,000	\$660,960,000
COLUMBIANA	2	\$22,800,000	\$120,000	\$22,920,000
GUERNSEY	19	\$245,100,000	\$1,140,000	\$246,240,000
HARRISON	27	\$308,800,000	\$1,620,000	\$310,420,000
JEFFERSON	29	\$330,600,000	\$1,740,000	\$332,340,000
MONROE	18	\$232,200,000	\$1,080,000	\$233,280,000
NOBLE	1	\$12,900,000	\$60,000	\$12,960,000
Total	147	\$1,810,300,000	\$8,820,000	\$1,819,120,000¹³

Source: The Authors (2020)

Table 6: Estimated Upstream Shale Investment in Ohio by Company, January-June 2019

Operators	No. of Wells	Drilling	Roads	Total Amount (\$)
ASCENT RESOURCES UTICA LLC	69	\$840,600,000	\$4,140,000	\$844,740,000
CHESAPEAKE EXPLORATION LLC	4	\$45,600,000	\$240,000	\$45,840,000
CNX GAS COMPANY LLC	2	\$25,800,000	\$120,000	\$25,920,000
EAP OHIO LLC	15	\$171,000,000	\$900,000	\$171,900,000
ECLIPSE RESOURCES I LP	8	\$103,200,000	\$480,000	\$103,680,000
EM ENERGY OHIO LLC	1	\$12,900,000	\$60,000	\$12,960,000
EQUINOR USA ONSHORE PROPERTIES INC.	6	\$77,400,000	\$360,000	\$77,760,000
GULFPORT APPALACHIA LLC	15	\$191,500,000	\$900,000	\$192,400,000
GULFPORT ENERGY CORPORATION	2	\$22,800,000	\$120,000	\$22,920,000
HILCORP ENERGY COMPANY	2	\$22,800,000	\$120,000	\$22,920,000
RICE DRILLING D LLC	11	\$141,900,000	\$660,000	\$142,560,000
TRIAD HUNTER LLC	5	\$64,500,000	\$300,000	\$64,800,000
UTICA RESOURCE OPERATING LLC	1	\$12,900,000	\$60,000	\$12,960,000
XTO ENERGY INC.	6	\$77,400,000	\$360,000	\$77,760,000
Total	147	\$1,810,300,000	\$8,820,000	\$1,819,120,000¹⁴

Source: The Authors (2020)

2. Lease Operating Expenses.

Post-production investments have been estimated on a half-year basis, assuming an average cost of around \$17,500/month/well. This estimate is based upon recent operator reports.¹⁵ These investments are set forth below. Consistent with total number of production wells, Carroll

¹³ Excludes royalties, bonuses for undeveloped acreage and lease operating expenses.

¹⁴ *Id.*

¹⁵ The per-month rule-of-thumb for lease operating expenses per producing well for this report is based on Ascent's and Gulfport's unit lease operating expenses for 2018 as reported in company financial statements.

County and Belmont County lead the lease operating expense investment, with an estimated \$49.1 and \$46.8 million invested, respectively.

Table 7: Estimated Lease Operating Expenses for January – June 2019 by County

County	No. of Production Wells ¹⁶	Lease Operating Expenses for Period
BELMONT	446	\$46,830,000
CARROLL	468	\$49,140,000
COLUMBIANA	73	\$7,665,000
COSHOCTON	1	\$105,000
GUERNSEY	193	\$20,265,000
HARRISON	352	\$36,960,000
JEFFERSON	141	\$14,805,000
MAHONING	13	\$1,365,000
MONROE	290	\$30,450,000
MORGAN	2	\$210,000
MUSKINGUM	1	\$105,000
NOBLE	164	\$17,220,000
PORTAGE	1	\$105,000
STARK	2	\$210,000
TRUMBULL	7	\$735,000
TUSCARAWAS	7	\$735,000
WASHINGTON	11	\$1,155,000
WAYNE	1	\$105,000
	Total	\$228,060,000

¹⁶ The number of wells producing was determined by taking the average of the number of such wells as identified by ODNR on January 1, 2019 and June 30, 2019. 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 2019 by Operator

Operator	No. of Production Wells	Lease Operating Expenses for Period
ANTERO RESOURCES CORPORATION	218	\$22,890,000
ARTEX OIL COMPANY	6	\$630,000
ASCENT RESOURCES UTICA LLC	399	\$41,895,000
ATLAS NOBLE LLC	12	\$1,260,000
CHESAPEAKE EXPLORATION LLC	352	\$36,960,000
CHEVRON APPALACHIA LLC	8	\$840,000
CNX GAS COMPANY LLC	38	\$3,990,000
EAP OHIO LLC	380	\$39,900,000
ECLIPSE RESOURCES I LP	129	\$13,545,000
EM ENERGY OHIO LLC	11	\$1,155,000
ENERVEST OPERATING LLC	5	\$525,000
EQUINOR USA ONSHORE PROPERTIES INC.	22	\$2,310,000
GEOPETRO LLC	2	\$210,000
GULFPORT APPALACHIA LLC	169	\$17,745,000
GULFPORT ENERGY CORPORATION	152	\$15,960,000
HILCORP ENERGY COMPANY	15	\$1,575,000
M & R INVESTMENTS OHIO LLC	1	\$105,000
NORTHWOOD ENERGY CORP	6	\$630,000
PENNENERGY RESOURCES LLC	40	\$4,200,000
PIN OAK ENERGY PARTNERS LLC	12	\$1,260,000
PROTEGE ENERGY III LLC	1	\$105,000
RICE DRILLING D LLC	108	\$11,340,000
TRIAD HUNTER LLC	13	\$1,365,000
UTICA RESOURCE OPERATING LLC	28	\$2,940,000
XTO ENERGY INC.	49	\$5,145,000
	Total	\$228,060,000

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 2019 were around \$908 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

\$2.65/MMBtu during the first half of 2019, down from \$3.19 in the second half of 2018.¹⁷ Regional oil prices increased from \$47.27/bbl for the first quarter of 2019 to \$53.85/bbl for the second quarter, on average.

**Table 9: Total Royalties from Oil
January – June 2019 (in millions of dollars)**

Year	Quarter	Oil Price ¹⁸ \$/bbl	Oil Royalty (20%) \$/bbl	Royalty (\$mm)
2019	2	\$53.85	\$10.77	\$62.61
2019	1	\$47.27	\$9.45	\$47.97
			Subtotal	\$110.58

**Table 10: Total Royalties from Residue Gas
January – June 2019 (in millions of dollars)**

Year	Quarter	Residue Gas Price ¹⁹ \$/Mcf	Residue Gas Royalty (20%) \$/Mcf	Royalty (\$mm)
2019	2	\$2.51	\$0.502	\$271.17
2019	1	\$3.32	\$0.664	\$356.01
			Subtotal	\$627.18

**Table 11: Total Royalties from Natural Gas Liquids
January – June 2019 (in millions of dollars)**

Year	Quarter	NGL Price \$/bbl	NGL Royalty (20%) \$/bbl	Royalty (\$mm)
2019	2	\$16.16	\$3.23	\$94.33
2019	1	\$14.18	\$2.84	\$76.06
			Subtotal	\$170.39

4. Lease Renewals and New Leases.

New leases and lease renewal investments have been estimated for the Utica region based upon the drilling activity of the top eight drilling companies in the region. These eight companies have together drilled over 80% of the Utica wells to date, and it is assumed that they likewise control 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 new leases and for five-year renewals, which may not accurately reflect actual lease bonus rates. Additional factors that may make the estimate inaccurate include the

¹⁷ Reflects average Columbia-Appalachia natural gas prices over the respective periods. See https://www.naturalgasintel.com/data/data_products/bidweek?region_id=appalachia&location_id=NEATCO.

¹⁸ <http://ergon.com/prices>

¹⁹ Based on conversion factor of 1.1 MMBtu/Mcf.10-K

following: (1) only net undeveloped lease acreage was used to avoid possible double counting (producing companies often collaborate on development), although bonuses would have been paid on the gross lease acreage; and (2) the assumption that new or renewed leases make up 20% of undeveloped acreage during the six month period may be too high or too low. The 20% assumption is based upon the notion that leases typically contain 5-year primary terms, and as a result around 20% of leases require bonus payments each year to maintain the acreage.

**Table 12: Total Est. Investments into Undeveloped Acreage (New & Renewed Leases)
January - June 2019 (in millions of dollars)**

Operator	Undeveloped Acreage	Estimated Bonus Investment (\$mm)
ANTERO RESOURCES CORPORATION	50,014	25.0
ASCENT RESOURCES UTICA HOLDINGS, LLC	241,524	120.8
EAP OHIO LLC	186,484 ²⁰	93.2
ECLIPSE RESOURCES I LP (Montage Resources)	59,133 ²¹	29.6
GULFPORT ENERGY CORPORATION	119,428	59.7
Rice Drilling D LLC (EQT)	332,454	16.2
Total	689,037	344.5

²⁰ Undeveloped acreage for EAP Ohio, a privately held company, was determined by revising the net Ohio Utica acres that Encino Energy Partners purchased from Chesapeake Energy in 2018 based upon the average ratio of net undeveloped-to-total acreage in Ohio for the other operators listed in Table 12, all publicly traded, as gleaned from their FY 2019 10-K reports. See <https://www.reuters.com/article/us-chesapeake-erngy-divestiture/chesapeake-energy-plans-to-sell-utica-shale-stake-for-2-billion-idUSKBN1KG2YS>.

²¹ The FY 2019 10-K for Eclipse's parent company, Montage Resources, had not been released as of this writing. However, quarterly 10-Qs for FY 2019 described 240,600 net acres in Ohio as of June 30, 2019. The same proportion of undeveloped-to-developed acres for FY 2018 was used to estimate the unknown number of undeveloped net acres for the first half of 2019, given the known number of total net acres for this period.

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 for storing and handling natural liquids 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 identified by the Study Team for the first half of 2019. 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 have occurred outside the six-month window for this study. However, because the investments cannot easily be separated and tracked while construction is ongoing, the investments are treated as though made entirely during the study period if construction on 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 – June 2019**

Company	Additions to Infrastructure	Total Amount (\$mm)
Blue Racer Midstream	<ul style="list-style-type: none"> 1.14 miles of 4.5" pipeline 1.20 miles of 8.6" pipeline 0.52 miles of 10.8" pipeline 5.21 miles of 16" pipeline 	19.74
Cardinal Gas Services (Williams)	<ul style="list-style-type: none"> 5.44 miles of 8.6" pipeline 2.80 miles of 12.8" pipeline 	15.61
Energy Transfer	<ul style="list-style-type: none"> 15.87 miles of 16" pipeline for Mariner East 2 Expansion²³ (ME2X) 	47.98
MarkWest (MPLX)	<ul style="list-style-type: none"> 0.66 miles of 12" pipeline 11.67 miles of 20" pipeline 	45.60
RH energytrans	<ul style="list-style-type: none"> 12 miles of 12" pipeline for Risberg Pipeline project²⁴ 	27.21
Falcon Pipeline (Shell Chemical)	<ul style="list-style-type: none"> 13 miles of 10" pipeline and 30.4 miles of 12" pipeline for the Falcon Ethane Pipeline project.²⁵ 	93.49
Utica Gas Services (Williams)	<ul style="list-style-type: none"> 0.97 miles of 12.8" pipeline 	2.34
Williams Ohio Valley Midstream	<ul style="list-style-type: none"> 40.0 miles of 12" pipeline for Harrison Hub Pipeline project connecting fractionation facilities in Harrison County, OH and Moundsville, WV.²⁶ 	90.69
	Total	342.66

Source for Pipeline Length and Diameter (unless otherwise footnoted): PUCO Gathering Construction Reports (2020)

²³ See following: <https://www.npms.phmsa.dot.gov>; https://www.eia.gov/petroleum/xls/EIA_LiqPipProject.xlsx; <https://articles2.marketrealist.com/2019/02/whats-ahead-for-energy-transfers-mariner-east-2-project/#>; <http://wwwapp.epa.ohio.gov/dsw/permits/Construction.pdf>; <https://www.alleghenyfront.org/mariner-east-2-pipeline-is-up-and-running-sunoco-says/>

²⁴ See <https://rhenergytrans.com/learn-more/>. See also <https://www.eia.gov/naturalgas/pipelines/EIA-NaturalGasPipelineProjects.xlsx>

²⁵ <http://web.epa.state.oh.us/dsw/401Applications/196337D/196337D%20DA%20Falcon%20Ethane%20Pipeline.pdf>

²⁶ See <http://edocpub.epa.ohio.gov/publicportal/ViewDocument.aspx?docid=934280>. Also, https://s24.q4cdn.com/611644275/files/doc_presentations/2019/2019_European_Investor_Meetings-_FINAL.pdf. See also https://s24.q4cdn.com/611644275/files/doc_presentations/2019/2019_European_Investor_Meetings-_FINAL.pdf

Table 14: Additional Midstream Investment, January through June 2019

Company	Additions to Infrastructure	Estimated Investment (\$mm)
Dominion	<ul style="list-style-type: none"> New Lyme Compressor Station, Ashtabula County 690 hp of compression 90 MMscfd of dehydration 	4.76
EQM	<ul style="list-style-type: none"> Big Kahuna Compressor Station, Belmont County 15,000 hp of compression 400 MMscfd of dehydration 	60.98
Equitrans Midstream	<ul style="list-style-type: none"> Cobra Compressor Station, Belmont County 7,500 hp of compression 	27.09
MarkWest (MPLX)	<ul style="list-style-type: none"> 1,380 MMscfd of dehydration in Jefferson and Belmont Counties Cameron, Friendship, Holmes, and Morelli Stations 	25.20
	Total	118.03

Source: Ohio EPA (2020)

Adding the amounts in the above tables yields a total midstream investment for the first half of 2019 of \$460.7 million, a near twofold increase compared to the amount identified for the second half of 2018.

Forthcoming midstream projects that will be tracked for future Shale reports include the Appalachia to Texas Express (ATEX) liquid pipeline expansion and TransCanada's Buckeye Xpress expansion.²⁷ The ATEX project, slated to be placed in-service by 2022, will increase the capacity of the 1,200-mile pipeline that transports ethane from the Marcellus/Utica Basin to liquid storage facilities in Texas by 30%, from 145,000 barrels per day to 190,000.²⁸ The \$709 million Buckeye Xpress expansion project to replace 60.8 miles of 20- and 24-inch-diameter pipeline with about 66.1 miles of new 36-inch-diameter pipeline in Ohio and West Virginia received FERC approval in January 2020 and is expected to be placed in-service for late 2020.²⁹

MPLX is still planning to move forward with adding 80,000 barrels per day of C3+ fractionation capacity at the Hopedale NGL fractionation complex.³⁰ The company, through its subsidiary MarkWest, began receiving final permits-to-install from the Ohio EPA for this fifth fractionation plant at the Jewett, Ohio complex in the second half of 2019 and expects project completion in the second quarter of 2020.³¹ According to the methodology we have used for estimating

²⁷ See https://www.eia.gov/petroleum/xls/EIA_LiqPipProject.xlsx. See also <https://www.eia.gov/naturalgas/pipelines/EIA-NaturalGasPipelineProjects.xlsx>

²⁸ <https://pgjonline.com/news/2019/10-oct/enterprise-to-expand-atex-pipeline-after-successful-open-season>

²⁹ See <https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/012420-ferc-approves-columbias-275-mmcf-buckeye-xpress-pipeline-expansion>. See also

<https://www.tcenergy.com/operations/natural-gas/buckeye-xpress-project/>.

³⁰

http://www.mplx.com/content/documents/mplx/investor_center/2020/MPLX_4Q19_Conf_Call_Slides_vFinal.pdf

³¹ *Id.* See also Ohio EPA Public Notices (https://ebiz.epa.ohio.gov/Notices/jsp/notice_search.jsp).

midstream investments, this would represent a \$224 million investment. However, the published costs for recent fractionation projects in other parts of the country suggest that our rule-of-thumb for estimating investments for these kinds of projects may be low.³² We will therefore revisit this portion of the midstream methodology in the next Shale report.

NGL storage plays a critical role in balancing seasonal supply and demand variations and reducing the operational risks for end users such as petrochemical plants that need a steady and reliable stream of feedstock.³³ There are currently two projects with a combined underground storage capacity for NGLs in the Utica of around 8 million barrels that are continuing to move forward, the investment for which will be included in future Shale reports. These include the Mountaineer NGL storage project in Monroe County, where construction is expected to begin during the first quarter of 2020, and MPLX's Hopedale NGL Caverns, which are projected to begin operations in 2021.³⁴

Cumulative midstream investments through the middle of 2019 are set forth in Table 20 in Appendix A.

³² See <https://www.ingaa.org/File.aspx?id=34658>. See also <https://www.marketwatch.com/press-release/oneok-announces-additional-ngl-fractionation-and-pipeline-capacity-and-natural-gas-processing-capacity-2018-09-25>.

³³ <https://www.energy.gov/sites/prod/files/2018/12/f58/Nov%202018%20DOE%20Ethane%20Hub%20Report.pdf>

³⁴ See <https://marcellusdrilling.com/2019/08/mountaineer-ngl-storage-says-construction-begins-in-oh-1q20/>. See also

http://www.mplx.com/content/documents/mplx/investor_center/2019/RBN_Energy_Export_Conference_5_21_19_Final.pdf

D. DOWNSTREAM DEVELOPMENT

1. Natural Gas Power Plants

The nation has continued to see growth in natural gas-fired electricity generation. Within the PJM regional transmission territory that includes Ohio, the U.S. Energy Information Administration (EIA) forecasts that natural gas will fuel 39% of electricity generation in the PJM region in 2020, up from a share of 31% in 2018.³⁵ Over the past six 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. Two of these plants entered the construction phase in the first half of 2019. Investments for these gas-fired generation facilities are set forth in Table 15.

Table 15. Natural Gas Power Plant Investments in Ohio, January - June 2019

Name	Owner	Location	County	Capacity (MW)	Investment (\$mm)
Long Ridge Energy Center	Fortress Transportation and Infrastructure Investors Ltd	Hannibal, OH	Monroe	485	500 ³⁶
South Field Energy	Advanced Power	Wellsville, OH	Columbiana	1,182	1,300 ³⁷
Total				1,667	1,800

As with pipeline investments, expenditures for natural gas-fired generation facilities 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 status as of August 2019, are set forth in Figure 5 below.

Construction on the \$1.6 billion Guernsey Power Station began in the second half of 2019. Investment for this 1,650 MW plant will be included in the next Shale report.³⁸ While construction had not started on the Trumbull Energy Center as of February 2020, installation of the fully permitted and financed generation facility near Lordstown will likely begin before the summer of 2020.³⁹ Also, a January 2020 engineering, procurement and construction contract entered into by the developer of the Harrison Energy Center could lead to groundbreaking on the 1,085 MW facility before the end of this year.⁴⁰ While the Study Team was unable to ascertain a

³⁵ See <https://www.eia.gov/todayinenergy/detail.php?id=41333>

³⁶ <https://wtov9.com/news/local/construction-begins-for-hannibal-gas-fired-power-plant>

³⁷ <https://www.southfieldenergy.com/news/south-field-energy-breaks-ground-for-1182-megawatt-energy-facility/>

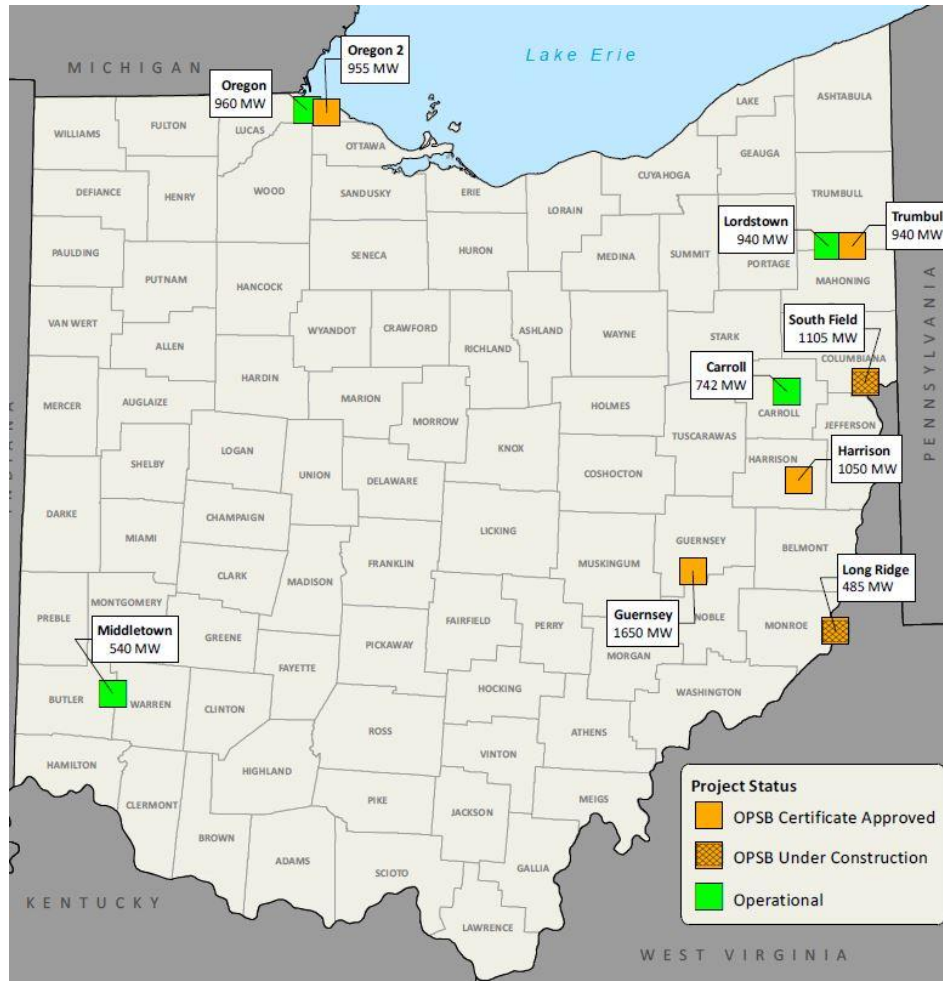
³⁸ <https://www.naturalgasintel.com/articles/119477-massive-natural-gas-fired-power-plant-moving-forward-in-ohio>

³⁹ See <https://www.wfmj.com/story/41664957/lordstown-village-schools-may-compromise-on-dollar225k-income-tax-revenue>

⁴⁰ <https://wtov9.com/news/local/contract-signed-groundbreaking-date-coming-for-harrison-power-plant>

timeline for the second power station in Oregon, OH, the developer’s renewal in January 2020 of its EPA air permit suggests that the project may be moving forward.⁴¹

Figure 5. Existing and Projected Natural Gas Power Plants



Source: Ohio Power Siting Board

Source (except for Ohio State): U.S. DOE Combined Heat and Power Installation Database⁴²

Note: Estimated investment is based on \$1,394 per kW for a 15 MW gas turbine CHP plant and \$1,760 per kW for a 7.5 MW gas turbine CHP plant.⁴³

2. Petrochemical Plants and Future Near-term Downstream Investment

While no major petrochemical plant investments took place in the first half of 2019, PTT Global did continue accumulating residential property near the proposed site of the multi-billion ethane

⁴¹ See <https://www.epa.gov/nsr/oregon-energy-center>

⁴² <https://doe.icfwebservices.com/chpdb/>

⁴³ Derived from Combined heat and Power Cost-benefit Analysis tool available through the Center for Energy, Economic & Environmental Policy at Rutgers. See <http://ceeep.rutgers.edu/wp-content/uploads/2015/07/CHP-Database-Technical-and-Financial-Parameters-v.4-06032015.xlsx>

cracker in Belmont County. The company went from purchases of \$125,000 in the second half of 2018 to \$800,000 during the first half of 2019.⁴⁴ Additional progress on the project during the first half of 2019 included PTT's awarding Bechtel the engineering, procurement and construction contract for the ethane cracker in Dilles Bottom.⁴⁵ A final investment decision for the petrochemical complex is expected in mid-2020.⁴⁶

As noted in the last Shale report, site preparation work for Petmin USA's \$474 million pig iron plant in Ashtabula was scheduled to commence in the second half of 2019. According to Petmin's CEO, \$50 million had been invested in the project as of October 2019, which will be included in the next Shale report.⁴⁷ Steelmaking based on Direct Reduction as will be employed at the Ashtabula plant fundamentally depends on natural gas to reduce iron ore to iron as part of the production process.⁴⁸

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 no CHP projects were undertaken during the first half of 2019, subsequent permitting progress on the proposed \$288 million CHP plant on the campus of Ohio State University indicates that a large CHP investment will likely be included in a future report.⁴⁹ This progress includes the issuing of an Air Pollution Permit-to-Install by the Ohio EPA in the second half of 2019, and the filing of an application with the Ohio Power Siting Board for a certificate of environmental compatibility and public need to construct a CHP facility at Ohio State, where the approval process is currently nearing the end of the staff investigation phase as of this writing.⁵⁰

No new compressed natural gas (CNG) stations were identified for the first half of 2019. However, the Greater Cleveland Regional Transit Authority authorized an expenditure of \$5 million in August 2019 for a CNG fueling system with public access at one of its bus depots.⁵¹ This investment will be included in the next Shale report.

⁴⁴ Belmont County Auditor (<http://oh-belmont-auditor.publicaccessnow.com/>). *See also*

<https://marcellusdrilling.com/2019/07/ptt-buying-homes-near-proposed-cracker-plant-in-belmont-county/>

⁴⁵ <https://www.icis.com/explore/resources/news/2019/06/20/10381121/bechtel-wins-epc-contract-for-ohio-petchem-project>

⁴⁶ <https://www.kallanishenergy.com/2020/02/28/fid-for-ohio-ethane-cracker-likely-in-mid-2020/>

⁴⁷ *See* https://www.starbeacon.com/news/local_news/jobs-and-environment-petmin-local-officials-outline-future-pig-iron/article_958cfff-bd21a-500f-aabf-591b6715a327.html

⁴⁸ *See* https://www.tenova.com/fileadmin/user_upload/HYL_News_-_December_2018.pdf. *See also:* 1)

<https://petminusa.com/>; 2) [http://www.millennium-steel.com/wp-content/uploads/2017/05/pp024-](http://www.millennium-steel.com/wp-content/uploads/2017/05/pp024-030_ms17.pdf)

<https://www.oilandgas360.com/jobs-and-environment-petmin-local-officials-outline-future-pig-iron-plants-impact/>

⁴⁹ <https://www.smartenergydecisions.com/news/2019/08/27/energy-efficient-chp-proposed-for-ohio-state>

⁵⁰ *See* http://wwwapp.epa.ohio.gov/dapc/permits_issued/1911791.pdf. *See also*

<https://www.opsb.ohio.gov/siting-case-breakdown/19-1641-el-bgn-ohio-state-university-combined-heat-and-power-facility-franklin-county/>

⁵¹ http://www.riderta.com/sites/default/files/events/2019-08-20BoardMinutes_0.pdf

Cumulative downstream investments reported to date in Ohio, including 2011-2018, are set forth in Table 21 in Appendix A. An outline of the key products and processes for this sector within the shale gas value chain is set forth in Appendix B.

3. CONCLUSION

Upstream shale investment in Ohio continued to be active, with 147 new wells being developed in the first half of 2019. Production growth declined in the first and second quarters of 2019, with the total amount of extracted gas equivalents for this period being 3.6% less than for the second half of 2018, coinciding with an overall downward trend in natural gas prices for the region over this period after a spike in late 2018.⁵² While upstream investment saw a slight decline of 6.8% during the first half of 2019 compared to the last 6 months of 2018, the overall amount spent on this segment during the Study period was still well over \$3 billion.

Midstream spending was driven largely by interstate pipeline construction for both natural gas and natural gas liquids that took place in early 2019. Representing around \$259 million in spending, these projects are part of an apparent uptick in pipeline construction. Subsequent pipeline projects are underway that will require an investment on par with what was spent in the first half of 2019, if not more. Significant gathering system buildout also continued during the first and second quarters of 2019, with an estimated \$201 million spent altogether on gathering lines, compression, and dehydration.

Two natural gas power plants broke ground in the first half of 2019, totaling \$1.8 billion in downstream investment. There was little other downstream spending. However, the PTT Global Petrochemical project continues to progress, and could ultimately represent an estimated \$5 billion shale-related investment.⁵³ At the time of this report, the world economy has been under placed into considerable turmoil due to the corona virus pandemic, and it is too early to know how this may affect interest in long term investments in ethane crackers and other petrochemical plants.

Total shale related investment in Ohio for the first half of 2019, including upstream, midstream and downstream, was around \$5.56 billion. Total investment from 2011 through mid-2019 is around \$83.3 billion.

⁵² See https://www.naturalgasintel.com/data/data_products/daily

⁵³ See <https://marcellusdrilling.com/2017/12/ptt-global-final-decision-re-belmont-cracker-plant-late-again/>

About the Study Team

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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 June 2019

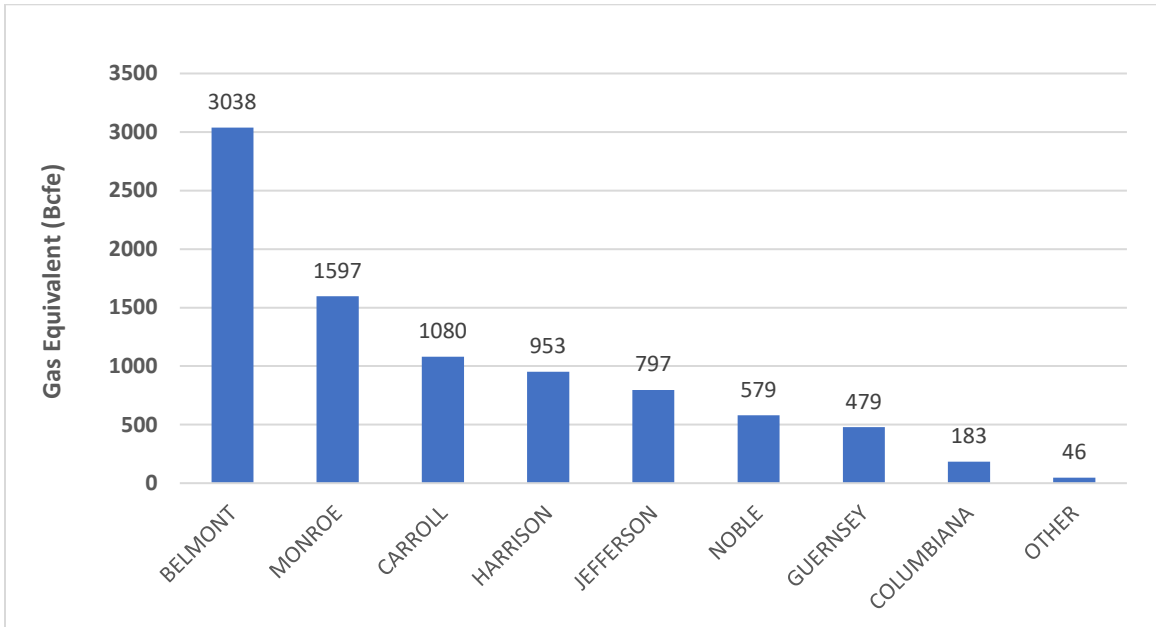


Figure 7: Total Utica Production in Bcfe by Operator through June 2019

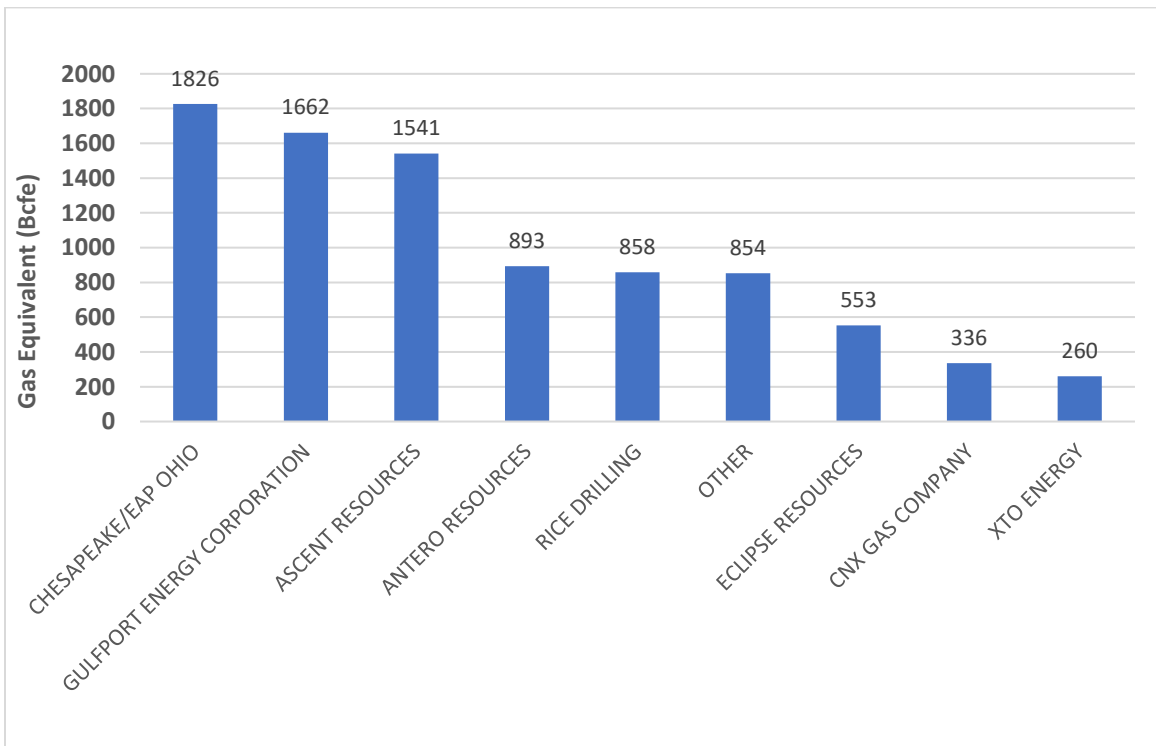


Figure 8: Cumulative Number of Wells by County

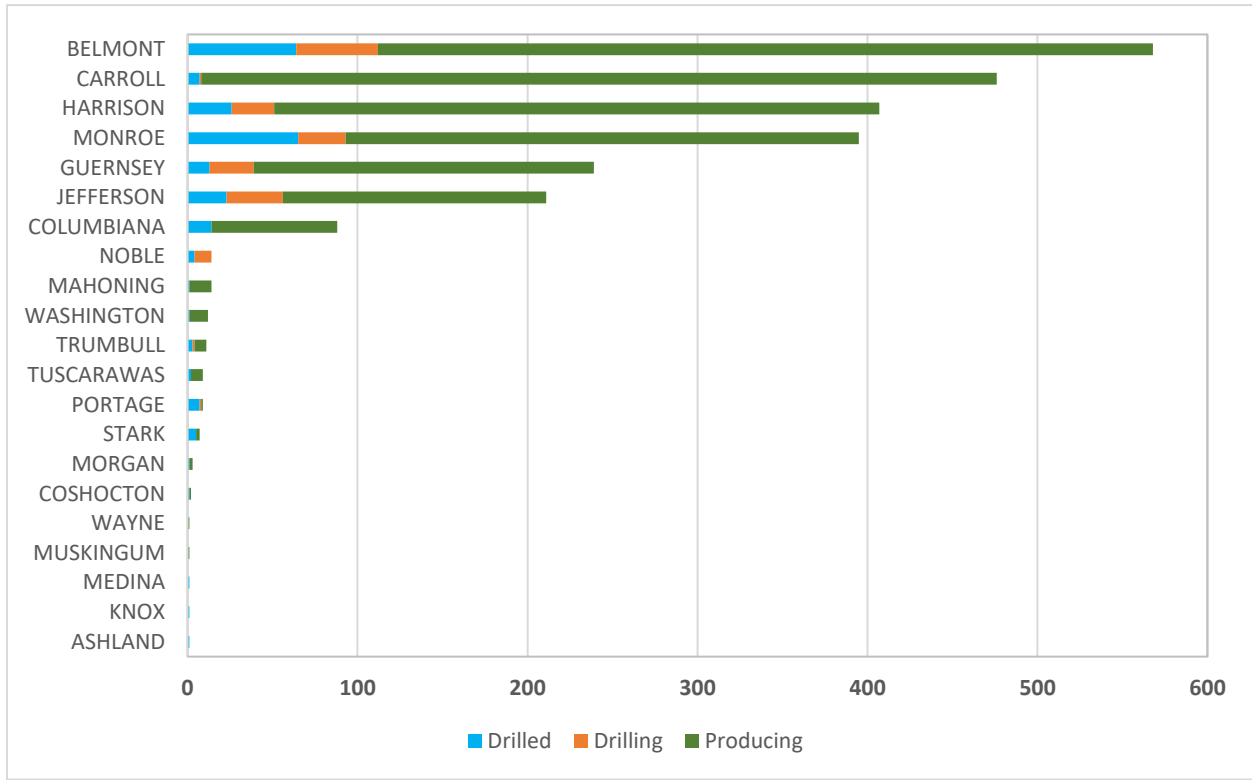
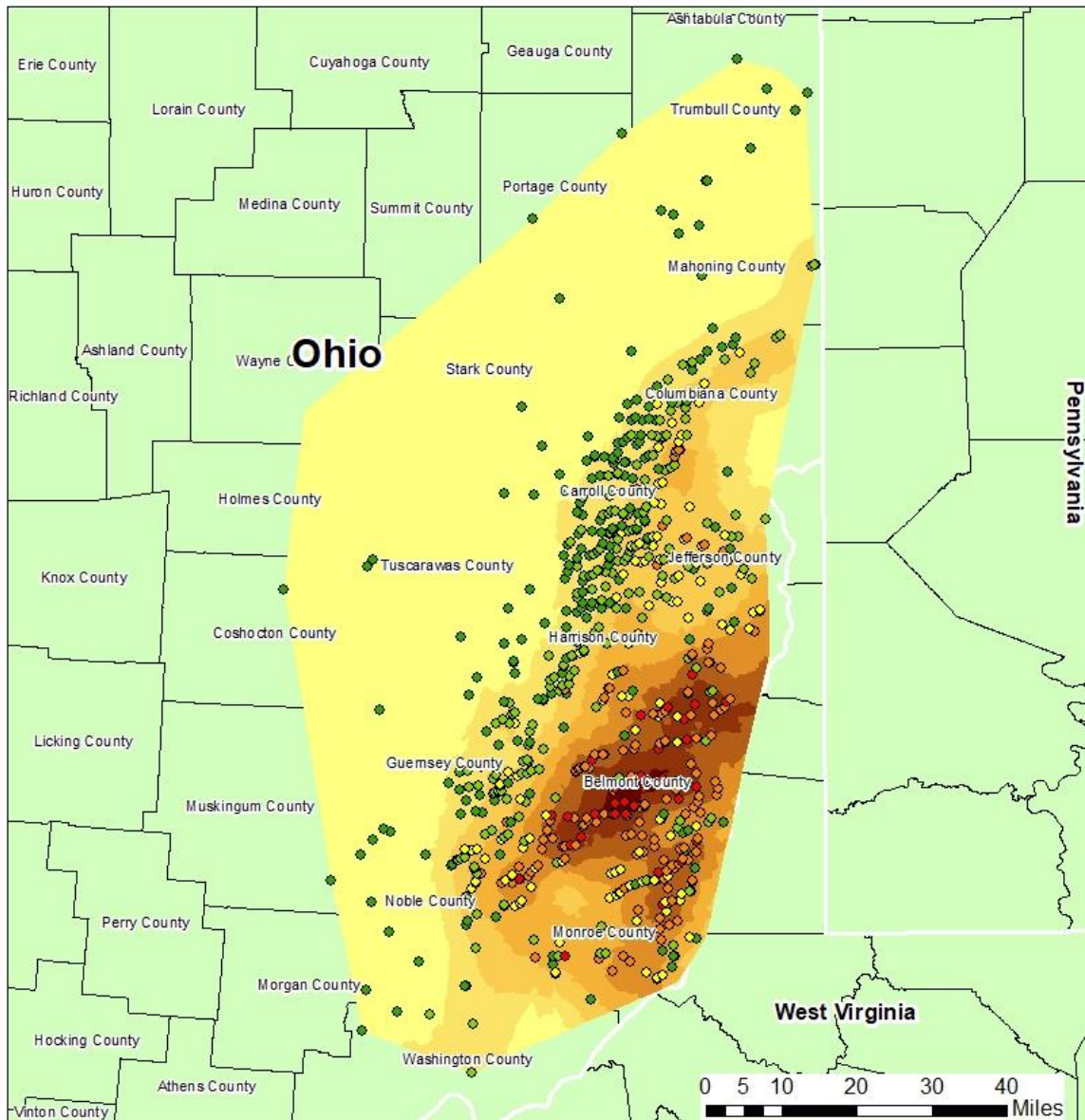


Figure 9: Distribution of Gas Equivalent Production for 2011 through June 2019



Avg. BCF of Gas Equivalent Per Well from 2011 - Mid 2019



Producing Wells

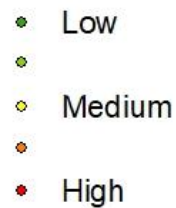
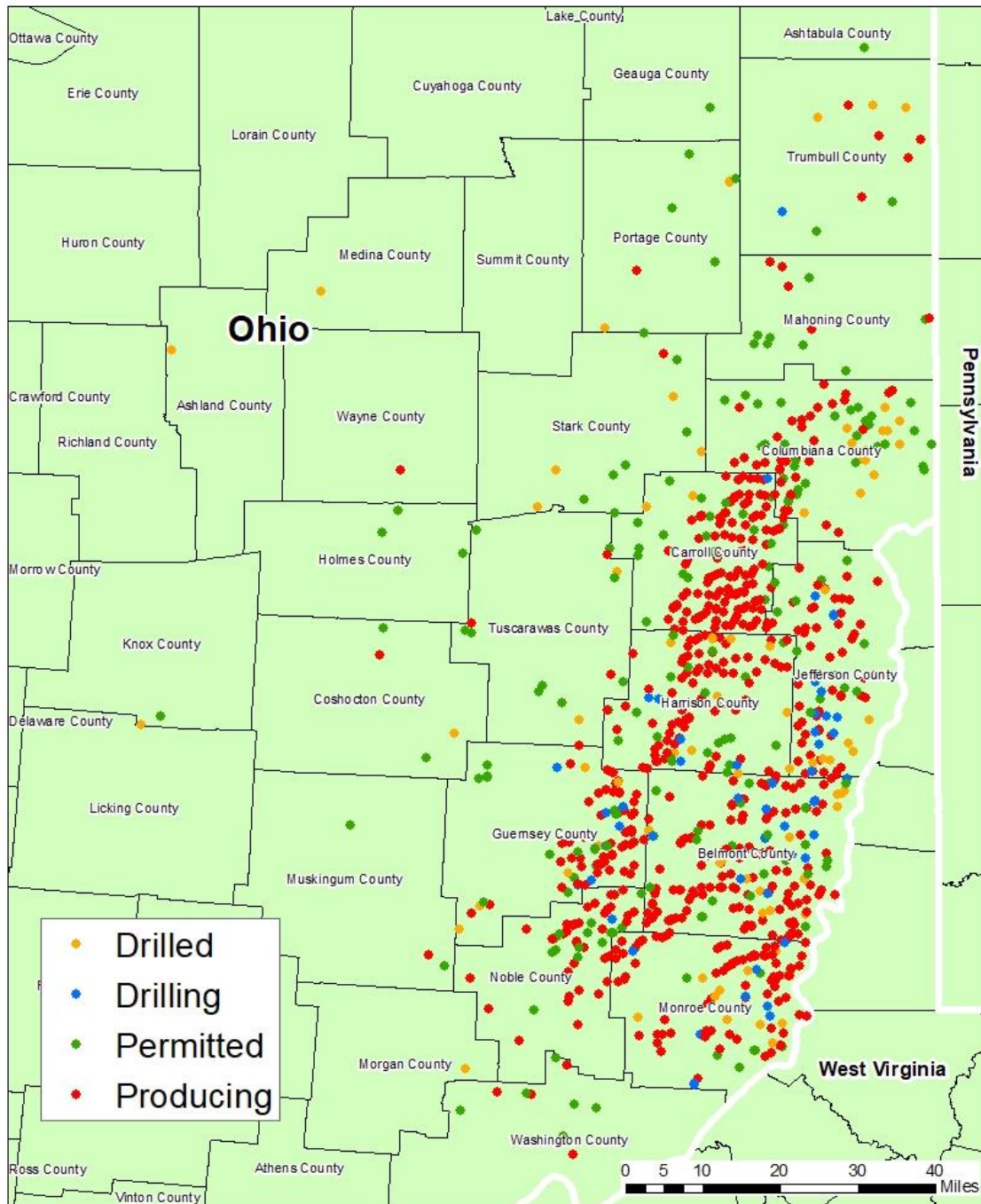


Figure 10: Distribution of Utica Wells by Status as of June 2019



Source: ODNR (2019)

Table 16: Utica Upstream Companies Drilling in Ohio

Company	Cumulative No. of Wells
AMERICAN ENERGY UTICA LLC	1
ANTERO RESOURCES CORPORATION	239
ARSENAL RESOURCES LLC	6
ARTEX ENERGY GROUP LLC	7
ASCENT RESOURCES UTICA LLC	547
ATLAS NOBLE LLC	12
BP AMERICA PRODUCTION COMPANY	1
BRAMMER ENGINEERING INC	2
CHESAPEAKE APPALACHIA LLC	1
CHESAPEAKE EXPLORATION LLC	32
CHEVRON APPALACHIA LLC	8
CNX GAS COMPANY LLC	41
DEVON ENERGY PRODUCTION CO LP	3
EAP OHIO LLC	762
ECLIPSE RESOURCES I LP	163
EM ENERGY OHIO LLC	17
ENERVEST OPERATING LLC	6
EQT PRODUCTION COMPANY	2
EQUINOR USA ONSHORE PROPERTIES INC.	36
GEOPETRO LLC	5
GULFPORT APPALACHIA LLC	387
GULFPORT ENERGY CORPORATION	12
HG ENERGY LLC	5
HILCORP ENERGY COMPANY	18
M & R INVESTMENTS OHIO LLC	1
NORTHWOOD ENERGY CORP	6
PDC ENERGY INC	1
PENNENERGY RESOURCES LLC	40
PIN OAK ENERGY PARTNERS LLC	13
PROTEGE ENERGY III LLC	1
R E GAS DEVELOPMENT LLC	1
RICE DRILLING D LLC	136
STATOIL USA ONSHORE PROPERTIES INC	4
TRIAD HUNTER LLC	25
UTICA RESOURCE OPERATING LLC	35
XTO ENERGY INC.	60
Total	2,636

Note: Cumulative Number of Wells are calculated based upon the total numbers of Drilled, Drilling, and Producing. Source: ODNR (June 29, 2019).

**Table 17: Total Lease Operating Expenses through June 2019
(in millions of dollars)**

Year	Period	Production Wells	Lease Operating Expenses for Period (\$mm)
2019	Q1 and Q2	2173	228.06
2018	Q3 and Q4	2200	231.0
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	1,416.2

Table 18: Cumulative Utica-Related Upstream Investments in Ohio through June 2019

Estimated Investments	Total Amount
Undeveloped Land	\$16,153,370,000
Developed Land	\$2,664,000,000
Lease Renewals	\$5,763,171,000
Drilling	\$24,261,000,000
Roads	\$1,072,120,000
Lease Operating Expenses	\$1,386,486,000
Royalties	\$5,800,660,000
Total	\$57,100,807,000

Table 19: Cumulative Utica-Related Midstream Investments in Ohio through June 2019

Estimated Investments	Total Amount
Midstream Gathering	\$7,038,223,000
Processing Plants	\$1,538,600,000
Fractionation Plants	\$1,414,000,000
NGL Storage	\$241,000,000
Rail Loading Terminals	\$145,000,000
Transmission Pipelines	\$9,612,386,000
Total	\$19,989,209,000

Table 20: Cumulative Utica-Related Downstream Investments in Ohio through June 2019

Estimated Investments	Total Amount
Petrochemical Plants and Refineries	\$552,225,000
Other Industrial Plants	\$700,000,000
Natural Gas Refueling Stations	\$44,825,000
Natural Gas Power Plants	\$4,840,000,000
Combined Heat and Power (CHP) Plants	\$85,100,000
Total	\$6,222,150,000

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 - \$11.4 mm/well; Southern Counties - \$12.9 mm/well.⁵⁴
 - Equivalent true vertical depth (TVD) for wells in all counties.
 - Average drilling and completion costs of \$900 per lateral foot.⁵⁵
 - Average lateral length of 12,660 ft. for northern counties and 14,360 ft. for southern counties.⁵⁶
- Roads: average investments - approximately \$60,000 per well based on 2013 data from Carroll County Engineer's Office.⁵⁷

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 January 1, 2019 from the number existent as of June 30, 2019. This information was downloaded from the ODNR Oil and Gas Well database.⁵⁸

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 \$17,500/month, throughout the life of the well. This average expense was developed by the study team based on analysis of Ascent's and Gulfport's

⁵⁴ Previous shale reports distinguished between drilling costs for northern counties (Carroll, Harrison, Jefferson, Columbiana, Trumbull, Mahoning and Tuscarawas) and southern counties (Noble, Guernsey, Belmont, Monroe and Washington) based on the assumption that the Utica is deeper in the south, requiring more expensive drilling in over-pressured formations. The Study Team conducted a review of drilling surveys associated with ODNR completion reports for new wells and found a difference in mean true vertical depth between northern and southern counties of less than 500 ft., which would likely not lead to significant cost differences. However, the same review of drilling surveys indicated that laterals for new wells in southern counties were 1,700 feet longer on average than for those in the north. This difference in average lateral length is the basis for the difference in drilling cost between northern and southern counties.

⁵⁵ Based on Ascent Resources' estimated drilling costs per lateral foot in the Utica according to the company's chairman and CEO. Ascent is active in both northern and southern counties. See <https://oklahoman.com/article/5626621/ascent-resources-reports-growth-in-utica-shale-field-during-2018>

⁵⁶ Calculated using well completion reports obtained from the ODNR's *Ohio Oil & Gas Well Database*.

⁵⁷ See fn 7, *supra*.

⁵⁸ <http://oilandgas.ohiodnr.gov/well-information/oil-gas-well-database>

lease operating expenses for 2019, divided by the number of wells operated, as reported in their financial statements.⁵⁹

For purposes of estimating the lease operating expenses for Q1 and Q2 2019, the Study Team assumed that all wells listed as “producing” by the Ohio Department of Natural Resources on January 1, 2019 were incurring this cost and continued to do so through June 30, 2019.

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 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.⁶⁰
- The residue energy content was around 1.1 MMBtu/Mcf.⁶¹
- Residue gas in the Utica was selling at an average price of \$3.01/MMBtu for Q1 and \$2.28/MMBtu for Q2.⁶² This price for the Columbia-Appalachia hub was used to estimate royalties.
- Around 44 barrels of liquids were recovered per million cubic feet of gas produced.⁶³
- Natural gas liquids were selling for around 30% of the listed price for Marcellus-Utica light crude oil.⁶⁴

⁵⁹ See

https://ascentresources.com/documents/18/2019_Consolidated_Financial_Statements__Ascent_Resources_Utica_Holdings_LLC.pdf. See also <https://ir.gulfportenergy.com/all-sec-filings/content/0001628280-20-002453/0001628280-20-002453.pdf>

⁶⁰ Based on industry interviews, experts citing API 12.3, Manual of Petroleum Measurements and Standards

⁶¹ 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.

⁶² https://www.naturalgasintel.com/data/data_products/bidweek?region_id=appalachia&location_id=NEATCO. Hub prices reflect the delivered price of natural gas and so do not require further deductions for transportation costs. See <https://www.eia.gov/todayinenergy/detail.php?id=18391>

⁶³ Based on industry data.

⁶⁴ Based on industry interviews.

- Oil in the Utica region was selling for \$47.27 and \$53.85 per barrel, on average, during the first and the second quarter of 2019, respectively.⁶⁵
- 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.⁶⁶ 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 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.

⁶⁵ See Marcellus/Utica prices for light crude at <http://ergon.com/prices>. More than 95% of Ohio oil production is light crude by API gravity. See <https://www.eia.gov/petroleum/production/xls/api-history.xlsx>

⁶⁶ 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.

Compressor station investments were calculated based on the horsepower rating listed in Ohio EPA air permit data and estimated construction costs per horsepower of \$3,612 for the Midwest Region as obtained from the INGAA, as projected for 2019.⁶⁷

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/d⁶⁸
 - \$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

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.⁶⁹

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

⁶⁷ *Id.*

⁶⁸ The Study Team will revisit the cost assumption for fractionation plants in the next report. INGAA's 2018 report on midstream infrastructure costs describes an average cost for NGL fractionation facilities of about \$6,300 per barrel per day of processed NGLs (see <https://www.ingaa.org/File.aspx?id=34658>). The published costs and throughput capacities of currently planned fractionation facilities in Texas suggests that an associated investment of about \$6,000 per barrel per day capacity is appropriate for these kinds of facilities (see <https://www.marketwatch.com/press-release/oneok-announces-additional-ngl-fractionation-and-pipeline-capacity-and-natural-gas-processing-capacity-2018-09-25>).

⁶⁹ that the data currently used supersedes 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.

(INGAA).⁷⁰ The estimated cost for natural gas pipelines for the Midwest Region as used in this analysis was \$188,943 per inch-mile, which included labor, raw materials, and permitting costs, as projected by the INGAA for 2019.

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
- 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

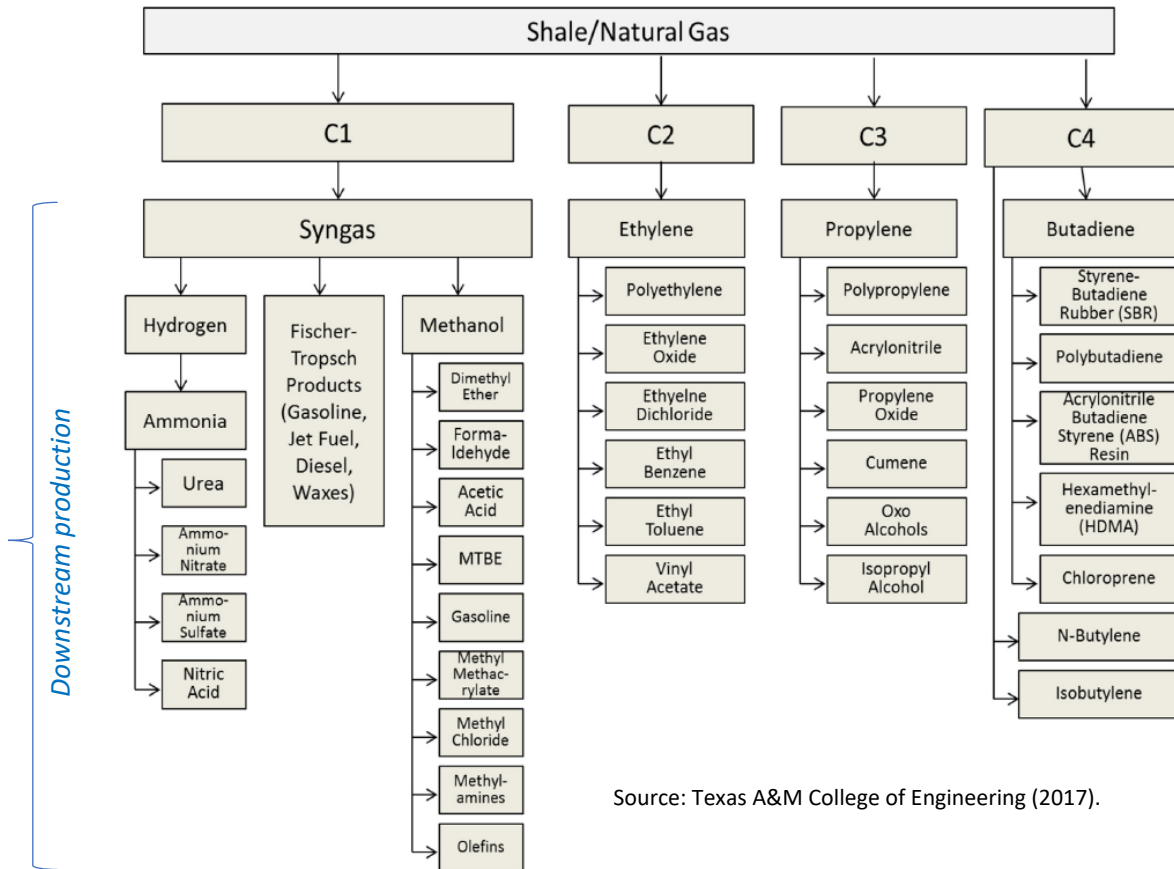
3261 – Plastics Product Manufacturing

Downstream activities include the deployment of processes that turn hydrocarbons—particularly the light hydrocarbons methane (C1), ethane (C2), propane (C3), and the butanes (C4)—into higher-valued fuels and petrochemicals. Shale gas may be monetized into numerous resulting value-added products. Figure 10 shows the primary intermediates and products that can be manufactured from the main hydrocarbon components in shale gas as part of downstream

⁷⁰ The INGAA Foundation, Inc. (2018). *North America Midstream Infrastructure through 2035*. <https://www.ingaa.org/File.aspx?id=34703>.

production.⁷¹ At or near the top of this hierarchy are what have been called the four main “building blocks” for petrochemicals: ethylene, propylene, butadiene, and methanol.⁷² The processes currently available for producing these critical downstream links in the shale gas value chain are listed in Table 21.⁷³ All of the products and processes shown in Figure 10 and Table 21 form the basis for additional search terms to identify downstream investment during the study period.

Figure 11. Shale/Natural Gas Value Chain for Petrochemicals



Source: Texas A&M College of Engineering (2017).

⁷¹ See Al-Douri, A., Sengupta, D., & El-Halwagi, M. M. (2017). Shale gas monetization—A review of downstream processing to chemicals and fuels. *Journal of Natural Gas Science and Engineering*, 45, 436-455.

⁷² Al-Douri, A. F. (2016). *A systems framework for shale gas monetization* (Doctoral dissertation). <https://oaktrust.library.tamu.edu/handle/1969.1/156938>

⁷³ See Elbashir, N. O., El-Halwagi, M. M., Economou, I. G., & Hall, K. R. (Eds.). (2018). *Natural Gas Processing from Midstream to Downstream*. Wiley.

Table 21. Downstream Production Processes for Petrochemical Building Blocks

Petrochemical Building Block	Production Processes for Converting Shale Gas
Ethylene	<ul style="list-style-type: none"> • steam cracking hydrocarbons (e.g. naphtha, ethane, propane, etc.) • oxidative coupling of methane (OCM) • methanol-to-olefins (MTO)
Propylene	<ul style="list-style-type: none"> • by-product of ethylene manufacture from steam cracking hydrocarbons • methanol-to-olefins (MTO) • propane dehydrogenation (PDH)
Butadiene	<ul style="list-style-type: none"> • by-product of ethylene manufacture from steam cracking hydrocarbons • dehydrogenation of n-butane (Houdry process) • oxidative dehydrogenation of n-butane (Oxo-D) • biomass-to-butadiene
Methanol	<p>Synthesis from syngas reformed via:</p> <ul style="list-style-type: none"> • partial oxidation (POX) • steam methane reforming (SMR) • auto-thermal reforming (ATR) • combined reforming (CR)