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Shale Investment Dashboard in Ohio Q3 AND Q4 2019

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JOB SOHIO

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October 2020

**SHALE INVESTMENT
DASHBOARD IN OHIO
Q3 AND Q4 2019**

**Energy Policy
Center**

1717 Euclid Avenue Cleveland, Ohio 44115
<http://urban.csuohio.edu>

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Executive Summary

This report presents findings from an investigation into shale-related investment in Ohio. The investment estimates are cumulative from July through December of 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 second half of 2019 can be summarized as follows:

Total Estimated Upstream Utica Investment: July – December 2019

Lease Renewals and New Leases	\$344,000,000
Drilling	\$1,494,300,000
Roads	\$7,320,000
Lease Operating Expenses	\$262,185,000
Royalties	\$832,918,000
Total Estimated Upstream Investment	\$2,940,723,000

Total Estimated Midstream Investment: July – December 2019

Gathering Lines	\$18,381,000
Gathering System Compression and Dehydration	\$97,737,000
Total Estimated Midstream Investment	\$116,118,000

Total Estimated Downstream Investment: July – December 2019

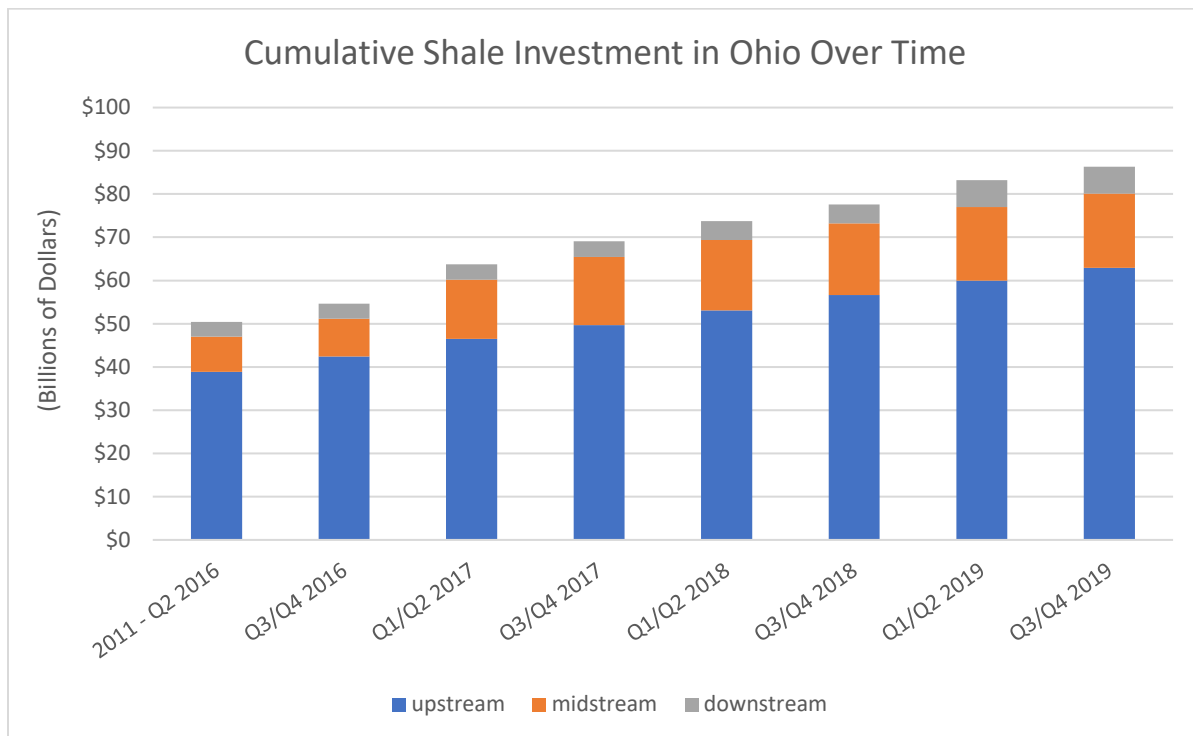
Hydrogen Generation from Natural Gas	\$2,500,000
CNG Stations	\$1,200,000
Total Estimated Downstream Investment	\$3,700,000

¹ The seven previous reports on shale investment in Ohio up to June 2019 can be found at:

http://engagedscholarship.csuohio.edu/urban_facpub/1464/
http://engagedscholarship.csuohio.edu/urban_facpub/1500/
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Total investment from July through December 2019 was approximately \$3.06 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 December of 2019 is estimated to be around \$86.4 billion. Of this, \$60.0 billion was in upstream, \$20.2 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 second half of 2019 compared to the first half of 2019, reflecting a reduction in the number of new wells drilled in the third and fourth quarters 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, 122 new wells were drilled during the third and fourth quarters of 2019, 25 fewer than the number drilled in the first half of the year. However, ODNR production data indicate that the total volume of gas-equivalent shale production in the second half of 2019 was 11.3% greater than production in the first half of the year. Belmont County again had the highest number of new wells, although there were 20 fewer than the 51 wells that were drilled in the first half of 2019. Noble County had the greatest increase in new wells from the first to second half of 2019, going from 1 to 12. Carroll and Columbiana Counties also saw increases in new wells from the last Shale report, going from 0 to 4 and 2 to 6, respectively. Except for Jefferson County, which saw no change in the number of

² Numbers may not add up precisely due to rounding.

new wells, all other counties saw a decrease in the number of new wells in the second half of 2019 compared to the previous 6-month period.

Ascent and Gulfport were once again the top producers for Q3 and Q4 of 2019, having produced 461 and 257.8 billion cubic feet equivalent (Bcfe), respectively. EAP Ohio LLC was third in production at 181.7 Bcfe, followed by Rice Drilling D LLC at 148.5 Bcfe, Eclipse Resources at 137.1 Bcfe, and Antero Resources at 82.4 Bcfe. These six companies made up around 89% of the total production for the second half of 2019.

The second half of 2019 in Ohio saw a reduction in midstream investment compared to the first half of 2019 as no major intrastate or interstate pipeline projects broke ground and the estimated completion date for new natural gas processing capacity was pushed further into 2020. The midstream spending that did occur in the latter half of 2019 was focused on gathering system pipeline (\$18.4 million) and gathering system compression and dehydration (\$97.7 million).

There was minimal downstream investment in the second half of 2019. Early-stage site preparation was done for the 1,875 MW Guernsey Power Station toward the end of 2019, but the project's ramp-up into construction did not begin until 2020.³ As a result, this investment will not appear until the next Shale Investment report. Construction activities on the 1,085 Harrison Power Station are also expected to commence in late 2020.⁴ CNG fueling stations and hydrogen production from natural gas (\$1.2 million and \$2.5 million, respectively) accounted for all downstream-related investments in the second half of 2019.

1. INTRODUCTION

This is the eighth 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 July 1 and December 31, 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

³ See Argan, Inc. *Annual Report*. (2020). http://arganinc.com/wp-content/uploads/2020/05/Argan-2020-Annual-Report_final.pdf

⁴ *Id.*

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 eighth 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 December 2019.⁵ 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.

2. SHALE INVESTMENT UPDATES

A. UPSTREAM DEVELOPMENT

1. Overview.

A total of 122 new wells were listed by the Ohio Department of Natural Resources as “drilled,” “drilling,” or “producing” during the period of July 1 to December 31, 2019.⁶ This represents a 17% decrease in new well development compared to the first half of 2019. The total number of producing wells in the Utica was 2,709 on December 31, 2019, a 21.9% increase from the end of June 2019. Total shale-related oil and gas production in billion cubic feet equivalent (Bcfe) for this period was 1,431 Bcfe, led by Belmont County with 487 Bcfe. Jefferson County was second with 299 Bcfe, followed by Monroe County with 290 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 third and fourth 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

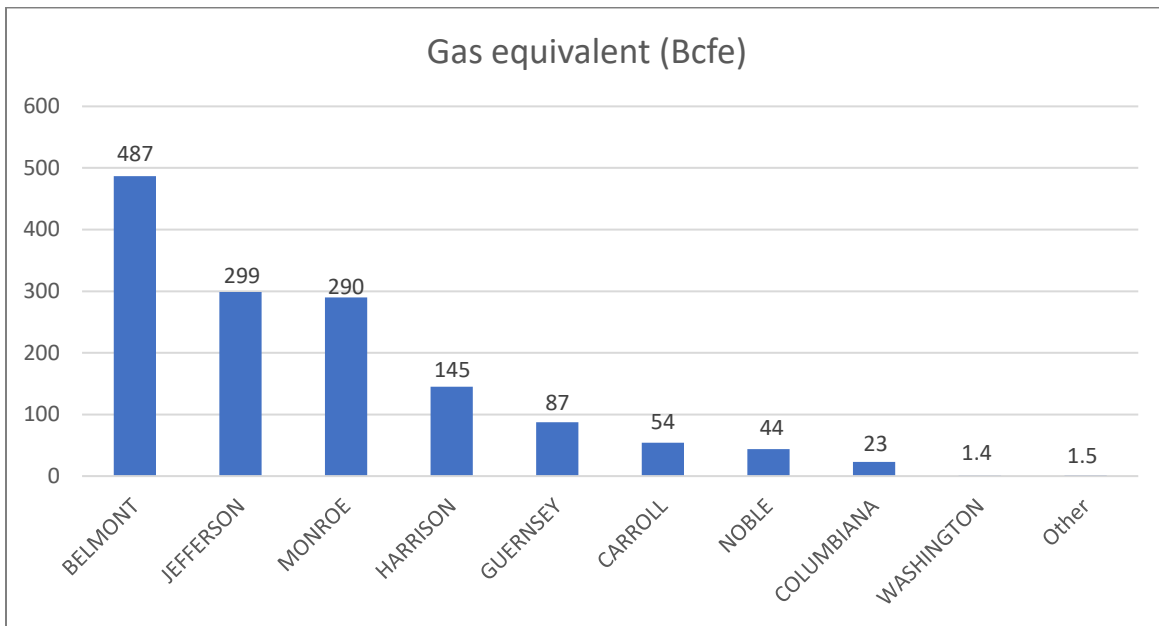
⁵ See fn 1, *supra*.

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 cryogenic and fractionation plants and not included in the ODNR production reports. For the purposes of this Study, oil and gas production is combined as gas equivalents (Mcf) 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 (Mcf) = Oil (bbl) x 5.659 Mcf/bbl + Gas (Mcf).

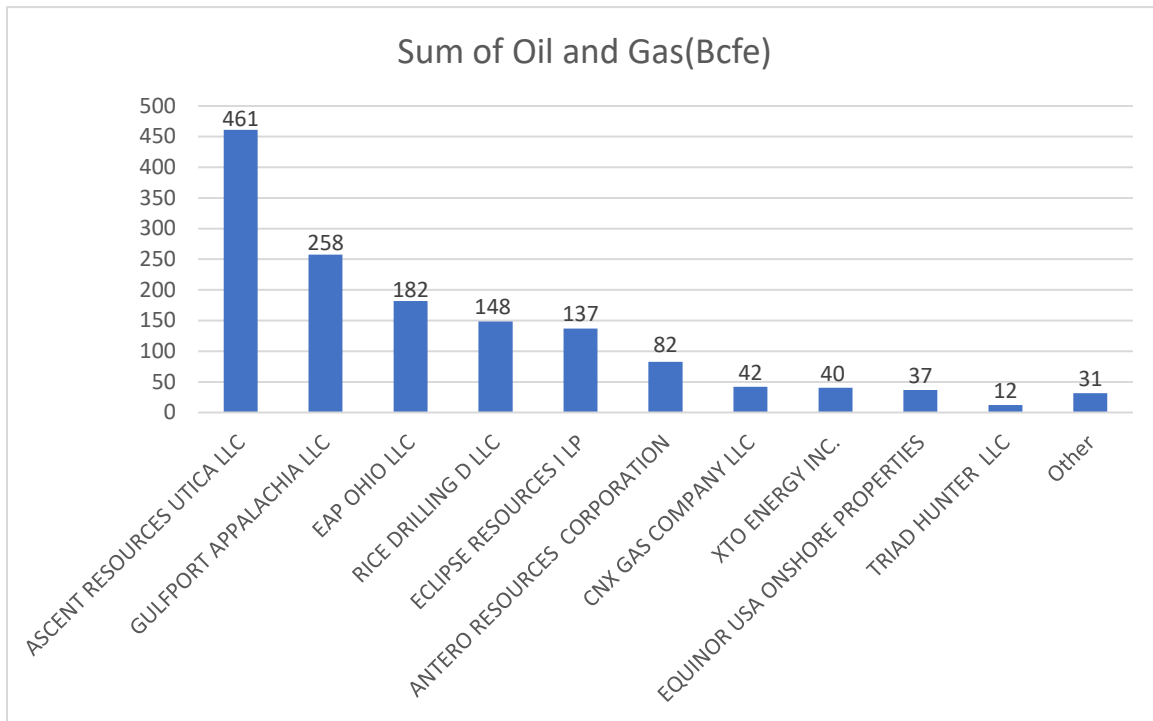
stretching from Columbiana in the north, to Monroe and Noble at the southern end of the play.. Total production in quarters 3 and 4 for 2019 is set forth by county and operator in Figures 2 and 3 below. Total cumulative production in billions of cubic feet equivalent (Bcfe) by county and by operator through December 2019 can be found in Appendix A as Figures 7 and 8.

Figure 2: Production by County for Q3 and Q4 of 2019



Data Source: ODNR (2020).

Figure 3: Production by Operator for Q3 and Q4 2019

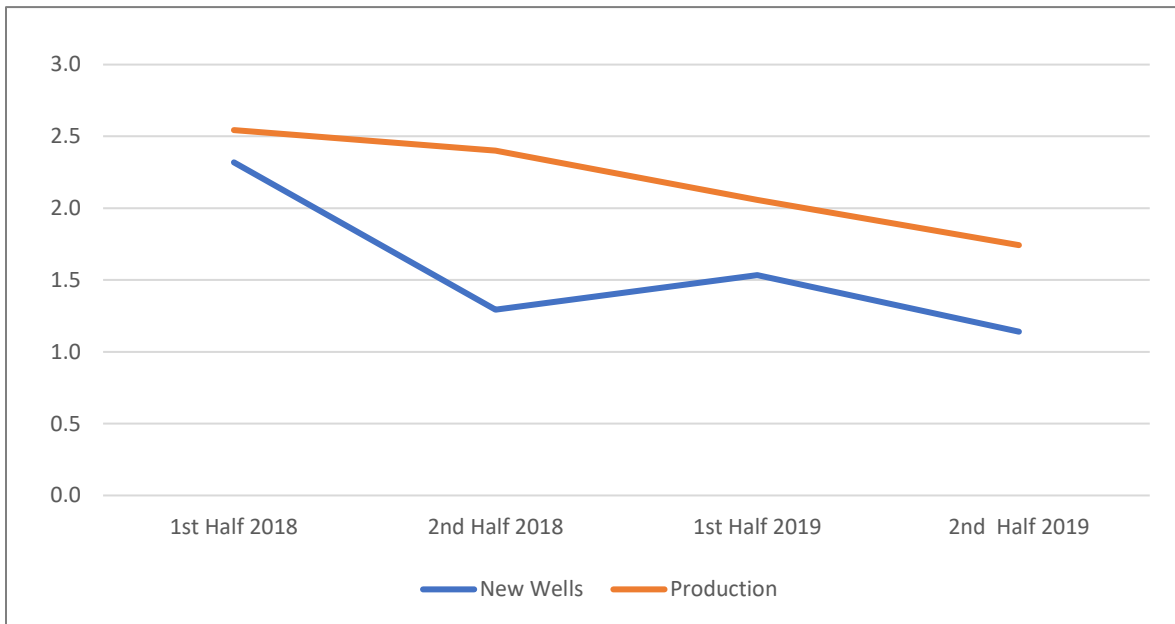


Data Source: ODNR (2020).

While we noted in previous reports how upstream activities were moving more from the north to the south of the Utica, this trend seems to be changing based on the relative increase in new drilling and production for counties such as Jefferson and Harrison in the second half of 2019. Figure 4 shows the ratios for southern-to-northern county new wells drilled and for production. Figure 4 compares the four most active southern (Belmont, Monroe, Guernsey, Noble) to the four most active northern (Jefferson, Harrison, Columbiana, Carroll) counties since the first half of 2018. Drilling data for these counties indicate that there is now almost one new shale well drilled in the north for every one drilled in the south, down from a ratio of more than two southern wells for every northern well in 2018.⁸ Likewise, relative production in the southern counties has declined from around two-and-a-half times that of northern counties to less than twice the gas-equivalent volume.⁹

⁸ See <https://ohiodnr.gov/wps/portal/gov/odnr/business-and-industry/energy-resources/oil-and-gas-wells/horizontal-wells>

⁹ See <https://ohiodnr.gov/wps/portal/gov/odnr/discover-and-learn/safety-conservation/about-odnr/oil-gas/oil-gas-resources/production>

Figure 4. Ratio of Southern-to-Northern County New Wells and Production Since 2018

Data source: ODNR (2020).

2. Production Analysis.

Production can be summarized using tables that show gas equivalent production measured in billions of cubic feet equivalent as a function of time. This summary, for both production in the third and fourth quarters of 2019 and also for cumulative production since 2011, is set forth in Table 1. Despite a slowed drilling rate, production has generally continued to increase from quarter to quarter since 2013. Table 2 sets forth production by county for the second half of 2019. Figure 5 sets forth the geographic distribution of production for the same period.

Table 1: Ohio's Shale Production by Reporting Period

Year	Quarter	Production Wells	Gas (Mcf)	Oil (bbl)	Gas Equivalents (Mcf)	Gas Production (% Change from Previous Quarter)
2019	4	2524	677,685,505	6,818,682	716,272,426	0.2
2019	3	2470	673,962,146	7,200,304	714,708,666	10
2019	2	2365	614,218,362	5,813,755	647,118,402	1.4
2019	1	2277	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	8,224,289,200	100,729,121	8,745,140,189	

Source: ODNR (2020).

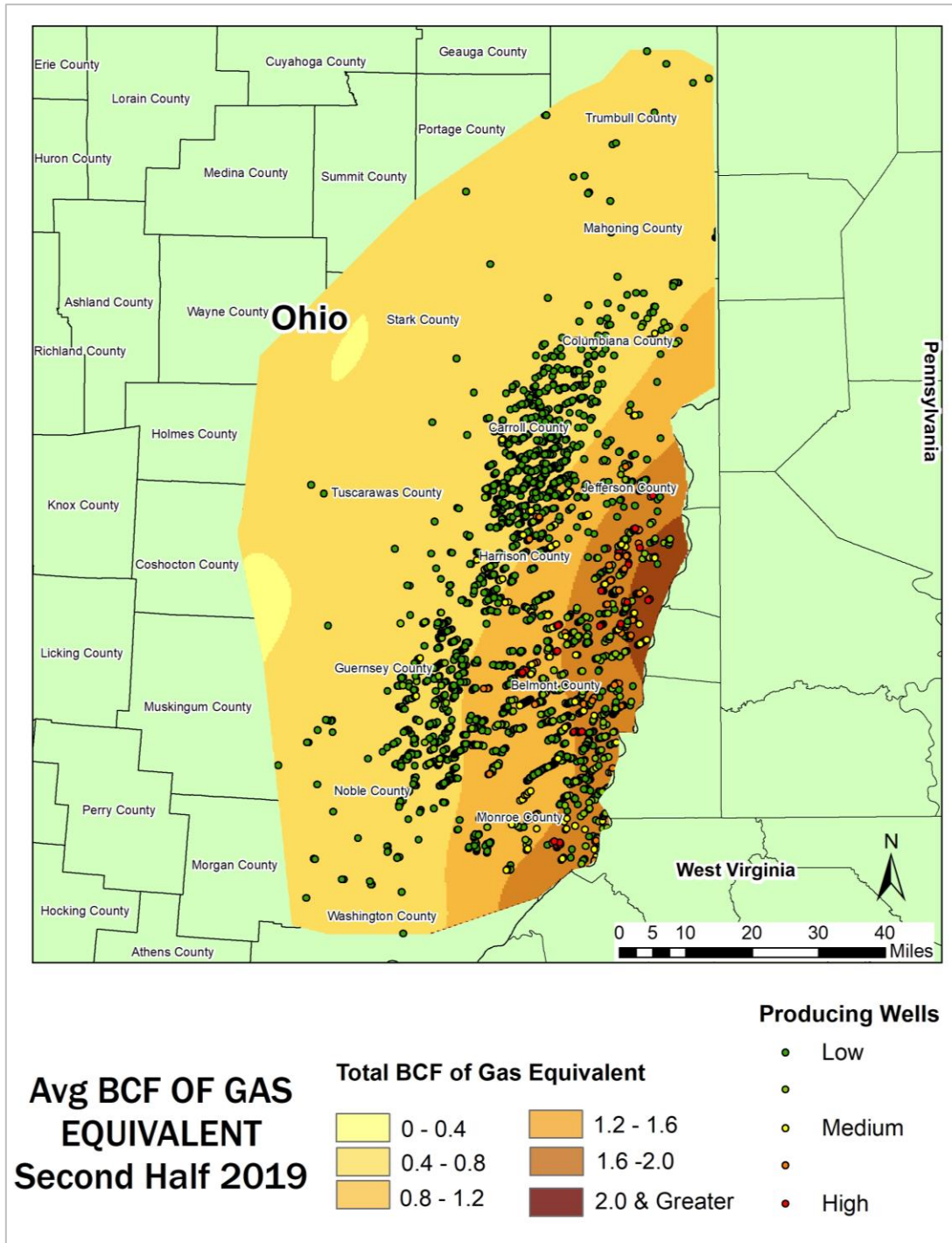
Table 2: Production by County for July - December 2019

County	Gas (Mcf)	Oil (bbl)	Gas Equivalents (Mcf)	Production Wells ¹⁰
BELMONT	482,905,123	705,984	486,900,286	532
CARROLL	47,382,474	1,190,850	54,121,494	474
COLUMBIANA	22,776,184	15,041	22,861,301	86
COSHOCTON	13,686	173	14,665	1
GUERNSEY	46,842,502	7,148,564	87,296,226	227
HARRISON	122,246,004	3,986,370	144,804,872	391
JEFFERSON	298,750,101	1	298,750,107	206
MAHONING	648,547	4,240	672,541	13
MONROE	285,925,242	675,928	289,750,319	364
MORGAN	86,987	3,755	108,237	2
MUSKINGUM	22,649	272	24,188	1
NOBLE	42,153,252	257,865	43,612,510	170
PORTAGE	33,870	170	34,832	3
STARK	42,000	978	47,535	2
TRUMBULL	212,410	1,746	222,291	7
TUSCARAWAS	233,343	14,077	313,005	7
WASHINGTON	1,354,331	12,884	1,427,242	11
WAYNE	18,946	88	19,444	1
Total	1,351,647,651	14,018,986	1,430,981,093	2,497

Source: ODNR (2020).

¹⁰ Represents the average number of production wells for the third and fourth quarters of 2019.

Figure 5: Distribution of Gas Equivalent Production for July – December 2019



Of the 2,709 total wells identified from the ODNR records for cumulative drilling activity as of December 2019, 158 were in the process of drilling, 128 wells had been drilled and were awaiting

markets, and 2,423 were in the production phase.¹¹ 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 December 2019

Well Status	No. of Wells
Drilled	128
Drilling	158
Producing	2,423
Total	2,709

Source: ODNR (2020).

Table 4: Well Status by County (December 2019)

County	Drilled	Drilling	Producing	Total
ASHLAND	1	0	0	1
BELMONT	22	47	525	594
CARROLL	2	1	472	475
COLUMBIANA	14	0	80	94
COSHOCTON	1	0	1	2
GUERNSEY	3	26	223	252
HARRISON	23	16	383	422
JEFFERSON	7	34	197	238
KNOX	1	0	0	1
MAHONING	0	0	13	13
MEDINA	1	0	0	1
MONROE	35	22	329	386
MORGAN	0	0	2	2
MUSKINGUM	0	0	1	1
NOBLE	2	10	168	180
PORTAGE	7	1	1	9
STARK	4	0	2	6
TRUMBULL	3	1	7	11
TUSCARAWAS	2	0	7	9
WASHINGTON	0	0	11	11
WAYNE	0		1	1
Total	128	158	2423	2709

¹¹ 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). This has been confirmed by recent drilling surveys that indicate an extra 1,700 of lateral length on average for wells drilled in southern counties.

This section covers upstream investments between July and December of 2019. Cumulative upstream investments to date in Ohio, including 2011 through the first half of 2019, are set forth in Table 17 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 31 new wells and an investment of around \$401.8 million between July and December of 2019. Jefferson and Harrison Counties were second and third, with 29 and 18 new wells, respectively, to go along with \$332.3 and \$206.3 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-Depth¹² 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.¹³

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 50 new wells and an estimated \$607.5 million invested, followed by EAP Ohio with 24 new wells and an estimated \$281.0 million. Rice Drilling drilled 10 new wells for an estimated investment of \$129.6 million.¹⁴ Gulfport and Antero Resources both drilled 8 wells for an estimated investment of 103.7 million each. See Table 6.

¹² 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>

¹³ 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.

¹⁴ 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, July-December 2019

County	No. of New Wells	Drilling (\$)	Roads (\$)	Total Amount (\$)
BELMONT	31	\$399,900,000	\$1,860,000	\$401,760,000
CARROLL	4	\$51,600,000	\$240,000	\$51,840,000
COLUMBIANA	6	\$68,400,000	\$360,000	\$68,760,000
GUERNSEY	13	\$167,700,000	\$780,000	\$168,480,000
HARRISON	18	\$205,200,000	\$1,080,000	\$206,280,000
JEFFERSON	29	\$330,600,000	\$1,740,000	\$332,340,000
MONROE	9	\$116,100,000	\$540,000	\$116,640,000
NOBLE	12	\$154,800,000	\$720,000	\$155,520,000
Total	122	\$1,494,300,000	\$7,320,000	\$1,501,620,000

Source: The Authors (2020)

Table 6: Estimated Upstream Shale Investment in Ohio by Company, July-December 2019

Operators	No. of Wells	Drilling (\$)	Roads (\$)	Total Amount (\$)
ANTERO RESOURCES CORPORATION	8	\$103,200,000	\$480,000	\$103,680,000
ASCENT RESOURCES UTICA LLC	50	\$604,500,000	\$3,000,000	\$607,500,000
CNX GAS COMPANY LLC	4	\$51,600,000	\$240,000	\$51,840,000
EAP OHIO LLC	24	\$279,600,000	\$1,440,000	\$281,040,000
ECLIPSE RESOURCES I LP	6	\$77,400,000	\$360,000	\$77,760,000
EQUINOR USA ONSHORE PROPERTIES INC.	1	\$12,900,000	\$60,000	\$12,960,000
GULFPORT APPALACHIA LLC	8	\$103,200,000	\$480,000	\$103,680,000
HILCORP ENERGY COMPANY	6	\$68,400,000	\$360,000	\$68,760,000
PIN OAK ENERGY PARTNERS LLC	2	\$25,800,000	\$120,000	\$25,920,000
RICE DRILLING D LLC	10	\$129,000,000	\$600,000	\$129,600,000
UTICA RESOURCE OPERATING LLC	3	\$38,700,000	\$180,000	\$38,880,000
Total	122	\$1,494,300,000	\$7,320,000	\$1,501,620,000

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, Belmont County and Carroll County lead the lease operating expense investment, with an estimated \$55.9 and \$49.8 million invested, respectively.

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.

Table 7: Estimated Lease Operating Expenses for July – December 2019 by County

County	No. of Production Wells¹⁶	Lease Operating Expenses for Period
BELMONT	532	\$55,860,000
CARROLL	474	\$49,770,000
COLUMBIANA	86	\$9,030,000
COSHOCTON	1	\$105,000
GUERNSEY	227	\$23,835,000
HARRISON	391	\$41,055,000
JEFFERSON	206	\$21,630,000
MAHONING	13	\$1,365,000
MONROE	364	\$38,220,000
MORGAN	2	\$210,000
MUSKINGUM	1	\$105,000
NOBLE	170	\$17,850,000
PORTAGE	3	\$315,000
STARK	2	\$210,000
TRUMBULL	7	\$735,000
TUSCARAWAS	7	\$735,000
WASHINGTON	11	\$1,155,000
WAYNE	1	\$105,000
Total	2,497	\$262,185,000

¹⁶ The number of wells producing was determined by taking the average of the number of wells with recorded production as identified by ODNR for the third and fourth quarters of 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 July – December 2019 by Operator

Operator	Producing	Lease Operating Expenses for Period
ANTERO RESOURCES CORP.	223	\$23,415,000
ARSENAL RESOURCES LLC	2	\$210,000
ARTEX ENERGY GROUP LLC	6	\$630,000
ASCENT RESOURCES UTICA LLC	515	\$54,075,000
ATLAS NOBLE LLC	12	\$1,260,000
CHESAPEAKE EXPLORATION LLC	8	\$840,000
CHEVRON APPALACHIA LLC	8	\$840,000
CNX GAS COMPANY LLC	42	\$4,410,000
EAP OHIO LLC	768	\$80,640,000
ECLIPSE RESOURCES I LP	167	\$17,535,000
EQUINOR USA ONSHORE	41	\$4,305,000
GEOPETRO LLC	4	\$420,000
GULFPORT APPALACHIA LLC	369	\$38,745,000
HILCORP ENERGY COMPANY	22	\$2,310,000
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	15	\$1,575,000
RICE DRILLING D LLC	126	\$13,230,000
TRIAD HUNTER LLC	21	\$2,205,000
UTICA RESOURCE OPERATING LLC	30	\$3,150,000
XTO ENERGY INC.	57	\$5,985,000
ALLIANCE PETROLEUM CORP.	12	\$1,260,000
GULFPORT ENERGY CORPORATION	3	\$315,000
ENERVEST OPERATING LLC	5	\$525,000
Total	2,497	\$262,185,000

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 July and December 2019 were around \$833 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 \$1.95/MMBtu during the second half of 2019, down from \$2.65 in the first half of the year.¹⁷

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.

Regional oil prices increased from \$50.34/bbl for the third quarter of 2019 to \$51.02/bbl for the fourth quarter, on average.

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

Year	Quarter	Oil Price ¹⁸ \$/bbl	Oil Royalty (20%) \$/bbl	Royalty (\$mm)
2019	4	51.02	10.20	\$69.58
2019	3	50.34	10.07	\$72.49
			Subtotal	\$142.07

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

Year	Quarter	Residue Gas Price \$/Mcf ¹⁹	Residue Gas Royalty (20%) \$/Mcf	Royalty (\$mm)
2019	4	2.17	0.434	\$ 258.53
2019	3	2.12	0.424	\$ 251.46
			Subtotal	\$ 510.00

**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	4	15.31	3.06	91.28
2019	3	15.1	3.02	89.56
			Subtotal	180.84

4. 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 six drilling companies in the region. These six companies have together drilled over 85% of the Utica wells to date, and it is assumed that they likewise control

¹⁸ <http://ergon.com/prices>

¹⁹ Based on conversion factor of 1.1 MMBtu/Mcf.

over 85% 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 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)
July - December 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 second 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
July – December 2019**

Company	Additions to Infrastructure	Total Amount (\$mm)
Blue Racer Midstream LLC	<ul style="list-style-type: none"> 0.67 miles of 8.6" pipeline 1.24 miles of 10.8" pipeline 	\$3.60
Cardinal Gas Services (Williams)	<ul style="list-style-type: none"> 0.07 miles of 6.6" pipeline 0.10 miles of 8.6" pipeline 4.42 miles of 16" pipeline 	\$13.59
MarkWest Energy Partners	<ul style="list-style-type: none"> 0.08 miles of 12" pipeline 	\$0.18
Summit Midstream Partners, LLC	<ul style="list-style-type: none"> 0.08 miles of 12" pipeline 	\$0.19
Utica Gas Services (Williams)	<ul style="list-style-type: none"> 0.51 miles of 8.6" pipeline 	\$0.83
	Total	\$18.38

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

Table 14: Additional Midstream Investment, July through December 2019

Company	Additions to Infrastructure	Estimated Investment (\$mm)
Blue Racer Midstream	<ul style="list-style-type: none"> 5,850 hp of compression in Carroll and Guernsey counties 495 MMscfd of dehydration in Belmont and Harrison counties 	29.93
Dominion East Ohio	<ul style="list-style-type: none"> 5,000 hp of compression in Switzerland Compressor Station, Monroe county 	18.06
E2 Ohio Compression	<ul style="list-style-type: none"> 40 hp of compression in Harrison county 	0.14
East Ohio Gas	<ul style="list-style-type: none"> 2,760 hp of compression at Augusta station, Carroll county 	9.97
Eclipse Resources	<ul style="list-style-type: none"> New well site in Monroe county 2,905 hp of compression 30 MMscfd of dehydration 	11.29
Strike Force East	<ul style="list-style-type: none"> 6,566 hp of compression 200 MMscfd of dehydration Empire, Lonestar, and Switz 27 Compressor Stations Hendershot Dehydration Facility, Belmont and Monroe counties 	27.82
URO	<ul style="list-style-type: none"> Natural gas-fired compressor engine to replace an electric compressor engine in Guernsey county 145 hp of compression 	0.52
	Total	97.74

Adding the amounts in the above tables yields a total midstream investment for the Second half of 2019 of \$ 116.1 million, less than half the \$460.7 million captured in the last Shale report for the first half of 2019.

MPLX put 80,000 barrels per day of C3+ fractionation capacity into service during the third quarter of 2020 at its Hopedale complex.²³ This investment, expected to be in excess of \$200 million, will be included in the next Shale report (first half of 2020).

After getting FERC approval in January 2020, portions of TC Energy's Buckeye Xpress natural gas pipeline had been completed as of June 2020.²⁴ Investment for this 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 will also be included in the next Shale report.²⁵

NGL storage, critical to balancing the supply and demand of petrochemical feedstocks, will continue to be tracked for midstream investment. Such projects include MPLX's Hopedale NGL Caverns and the Mountaineer NGL storage project in Monroe County, the latter of which is still expected to move forward following a fresh permitting and review process.²⁶

While not included as a midstream investment, one noteworthy acquisition during the study period was UGI Corporation's \$1.3 billion purchase of TC Energy's Utica midstream assets in July 2019.²⁷ This included the Columbia Midstream-operated Hickory Bend Gas Processing Plant in Mahoning County. It did not, however, include TC Energy's interstate pipelines operated as part of the Columbia Gas Transmission system.²⁸

Cumulative midstream investments through the end of 2019 are set forth in Table 18 in Appendix A.

²³ http://www.mplx.com/content/documents/mplx/investor_center/2020/MPLX_3Q20_Conf_Call_Slides.pdf
http://www.mplx.com/content/documents/mplx/investor_center/2020/MPLX_4Q19_Conf_Call_Slides_vFinal.pdf

²⁴ See <https://www.eia.gov/naturalgas/pipelines/EIA-NaturalGasPipelineProjects.xlsx>. See also <https://www.tcenergy.com/siteassets/pdfs/investors/reports-and-filings/annual-and-quarterly-reports/2020/tc-2020-q1-quarterly-report.pdf>

²⁵ 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/>.

²⁶ <https://www.naturalgasintel.com/mountaineer-ngl-storage-pulls-key-ohio-permits-but-project-still-moving-ahead/>

²⁷ <https://napipelines.com/tc-energy-sells-columbia-midstream-ugi/>

²⁸ *Id.*

D. DOWNSTREAM DEVELOPMENT

1. Combined Heat and Natural Gas Power Plants

Over the past seven 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. None of these plants entered the construction phase in earnest in the second half of 2019. While early site work on the 1,875 MW, \$1.6 billion Guernsey Power Station began toward the end of 2019, major construction did not commence until the first half of 2020.²⁹ This investment will therefore be included in the next Shale Investment report. The 1,085 MW Harrison Power Station had not started construction as of September 2020, although the project is moving forward with an engineering, procurement and construction services contract having been awarded in late 2019.³⁰

Continued low natural gas prices have led to an increase in 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.

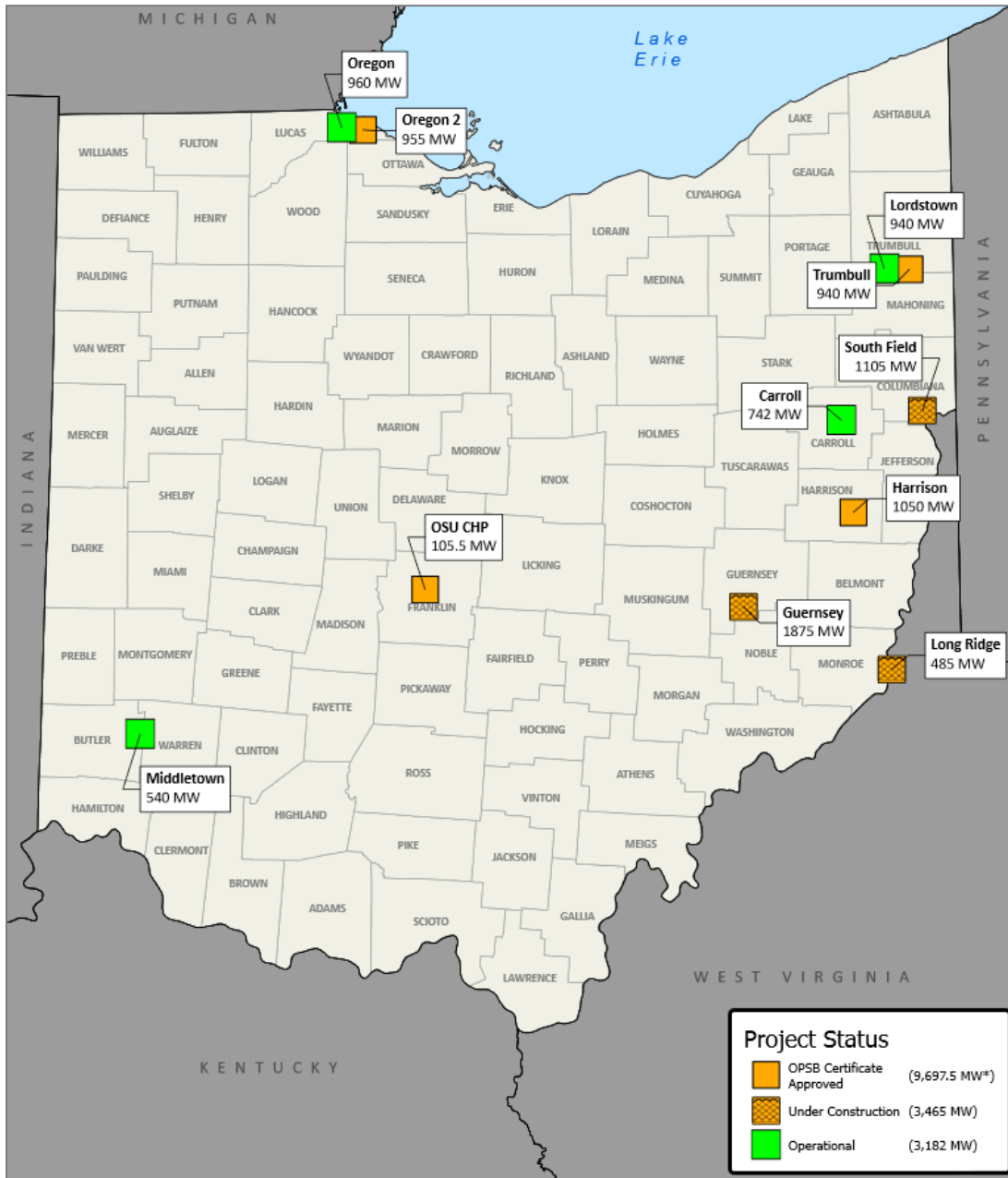
A \$278 million, 105.5 MW CHP plant at Ohio State University's main campus received construction approval from the Ohio Power Siting Board in September 2020 to go along with an Ohio EPA Air Pollution Permit-to-Install issued in October 2019.³¹ This investment will be included in a future Shale report. The 10 current and projected natural gas-powered facilities across 8 locations, along with the CHP project at Ohio State, including their current status, are set forth in Figure 6 below.

²⁹ http://arganinc.com/wp-content/uploads/2020/05/Argan-2020-Annual-Report_final.pdf

³⁰ See <https://opsb.ohio.gov/>. See also <https://www.dispatch.com/news/20200112/argan-subsidiary-scores-1085-mw-power-project-in-harrison-county>

³¹ See <https://buildingthefuture.osu.edu/news/2020/09/18/news-ohio-state-gains-approval-chp>. See also http://wwwapp.epa.ohio.gov/dapc/permits_issued/1911791.pdf

Figure 6. Existing and Projected Natural Gas Power Plants



Source: Ohio Power Siting Board (September 2020)

2. CNG Stations and Other Downstream Investment

Average construction costs for new compressed natural gas (CNG) stations are around \$1.2 million per station.³² One new private CNG refueling station opened at a UPS fleet garage in Middleburg Heights.³³ This could possibly represent the first of multiple CNG refueling stations for UPS in Ohio given the company's plans to purchase more than 6,000 natural gas-powered trucks by 2022 for its nationwide fleet of delivery vehicles.³⁴ As noted in the last Shale Investment report, we are also tracking a \$5 million CNG refueling station that the Greater Cleveland Regional Transit Authority plans to have installed at one of its bus depots.³⁵ As of June 2020, that station had been designed by Trillium but not yet constructed.³⁶

Also included as downstream investment for this report is an estimated \$2.5 million dollar hydrogen generation unit installed at an oleochemical manufacturing facility in Cincinnati.³⁷ The larger-capacity, onsite hydrogen generator installed there is aimed specifically at the chemical process industries and reforms natural gas to make hydrogen used in the hydrogenation of natural oils such as palm kernel and coconut oils.³⁸

No major petrochemical plant investments took place in the second half of 2019. A final investment decision on PTT Global's multi-billion dollar ethane cracker in Belmont County has been pushed back to 2021.³⁹ However, the company recently announced a long-term deal securing 15% of the ethane feedstock for the plant suggesting that progress continues on the project.⁴⁰

Petmin USA is preparing to begin construction on its pig iron manufacturing facility in Ashtabula after receiving its final Ohio EPA air permit in July 2020.⁴¹ The \$474 million plant, the first one in the U.S. dedicated to the production of high-grade nodular pig iron used in the metal casting industry, will use natural gas as a critical feedstock in reducing iron from its ore.⁴²

³² https://afdc.energy.gov/files/u/publication/cng_infrastructure_costs.pdf. See also https://afdc.energy.gov/files/u/publication/propane_costs.pdf

³³ See <https://afdc.energy.gov/>

³⁴ <https://pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=PressReleases&id=1570546455953-427>

³⁵ See http://www.riderta.com/sites/default/files/events/2019-08-20BoardMinutes_0.pdf.

³⁶ <https://www.trilliumcng.com/en/news/archive/2020/june/new-trillium-cng-refueling-station-to-power-cleveland-buses>

³⁷ The installed hydrogen generator has a daily generating capacity of 1,790 kilograms. According to the National Renewable Energy Laboratory (NREL), total capital investment for this scale of hydrogen production is \$1,416/kg in 2019 CPI-adjusted dollars. See <https://www.nrel.gov/docs/fy14osti/60528.pdf>

³⁸ See <https://www.chemengonline.com/scalable-onsite-hydrogen-generator-for-chemical-processing-applications/>. See also <https://www.emeryoleo.com/oleobasics>

³⁹ <https://www.kallanishenergy.com/2020/09/24/pttgca-range-resources-sign-deal-for-ethane-for-ohio-cracker/>

⁴⁰ *Id.*

⁴¹

⁴² The plant design includes Tenova's HYL Energiron ZR technology. For more on this process of directly reducing iron using natural gas, see

While not an investment for inclusion in this report or future ones, a recent downstream development worth noting is the \$2.9 billion acquisition of Husky Energy by Cenovus Energy in a September 2020 all-stock deal.⁴³ Among Husky's Ohio assets are the 40,000 bbl/day oil refinery in Lima and the 160,000 bbl/day oil refinery in Toledo jointly owned by BP. Heretofore, these facilities have been principally supplied by non-shale related production.

Cumulative downstream investments reported to date in Ohio, including 2011 through the first half of 2019, are set forth in Table 19 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

Total upstream shale investment in Ohio was down slightly in the second half of 2019 compared to the first half, due primarily to fewer wells being drilled, although quarterly production was at the highest it has been since the beginning of development in the Utica. Total gas equivalent production in the third and fourth quarters was 11.3% higher than total production in quarters 1 and 2. Higher growth rates for both new wells and production during the second half of 2019 in more northerly counties suggest that upstream activities may be becoming less concentrated in the southern part of the Utica. While upstream investment saw a slight decline of around 10% during the second half of 2019 compared to the first 6 months of 2019, the overall amount spent on this segment during the Study period was still a little over \$3 billion.

Gathering system buildout throughout the second half of 2019 represented all of the roughly \$116 million in midstream spending for this period. This amount should be significantly higher for the next Shale report given interstate pipeline expansion projects and additions to NGL processing capacity that took place in 2020.

Downstream investments were similarly down in the second half of 2019, especially given the absence of new natural gas-fired power generation during this period. Major construction on a \$1.6 billion natural gas power plant did however begin in 2020 and will be included in the next report. The \$4.2 billion in midstream and downstream mergers and acquisitions during the Study period suggest likely future growth for these segments, although it is still unclear how much COVID-19 will affect the timeline for this growth.

Shale related investment in Ohio for the second half of 2019, including upstream, midstream and downstream, was around \$3.06 billion. This brings total investment from 2011 through the end of 2019 to around \$86.4 billion.

https://www.tenova.com/fileadmin/user_upload/tenova_products/steel_making_direct_and_pre_reduction_technologies/energiron_book_2014.pdf

⁴³ See <https://www.reuters.com/article/husky-energy-ma-cenovus-energy-refining/canadian-energy-deal-creates-midwestern-refining-giant-amid-uncertain-demand-idINL1N2HH1WR>. See also <https://www.hydrocarbonengineering.com/refining/26102020/cenovus-energy-and-husky-energy-agree-merger/>

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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 7: Total Utica Production in Bcfe (Gas Equivalence) by County through December 2019

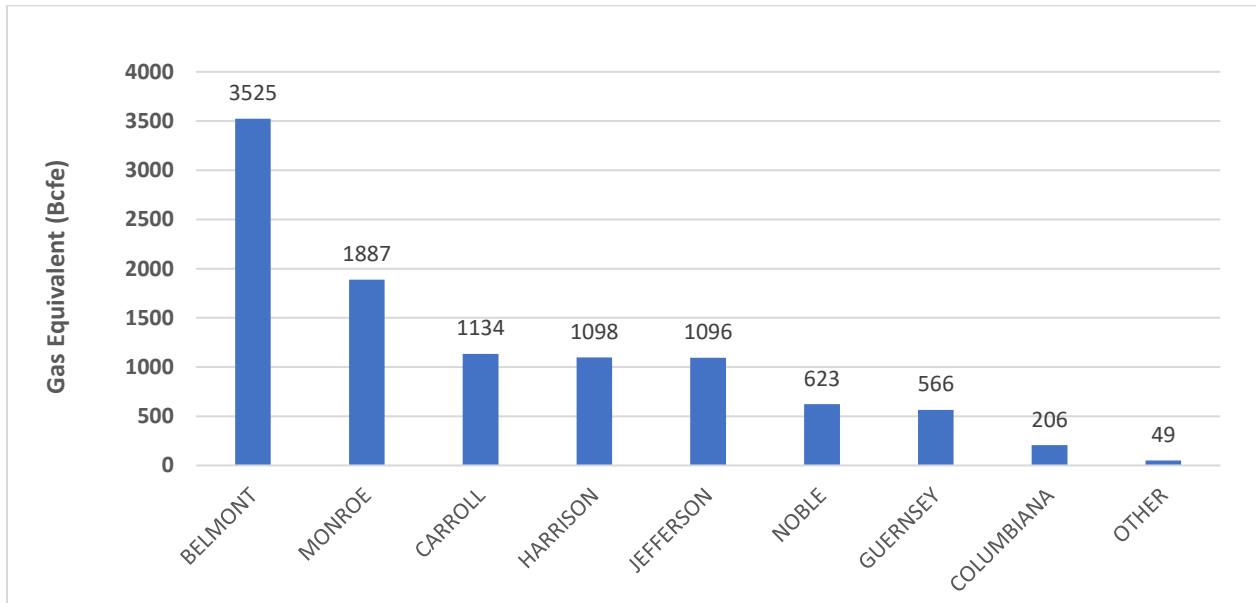


Figure 8: Total Utica Production in Bcfe by Operator through December 2019

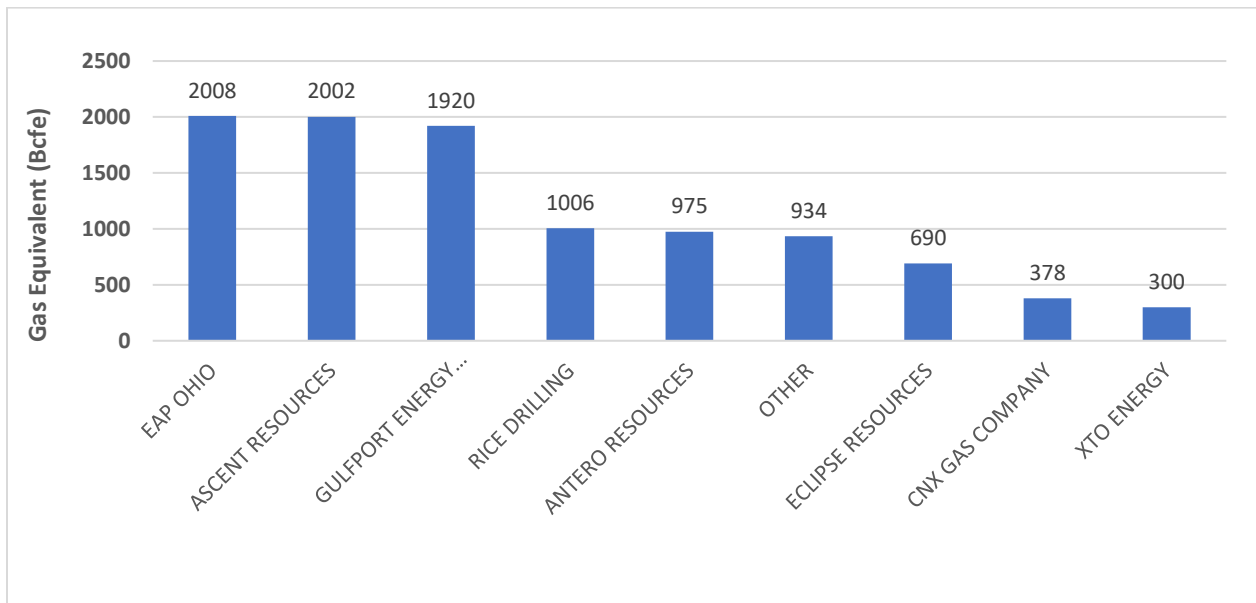
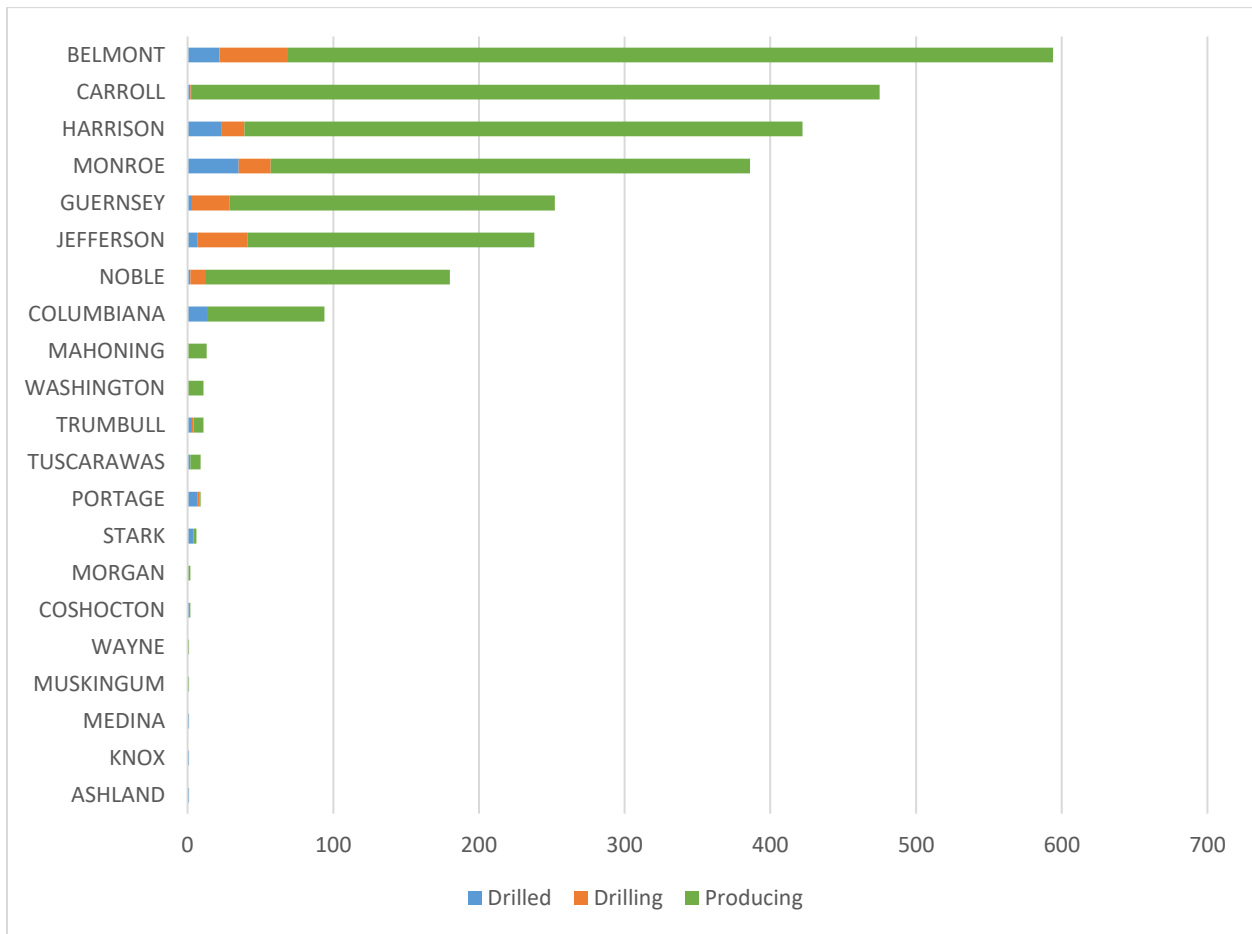
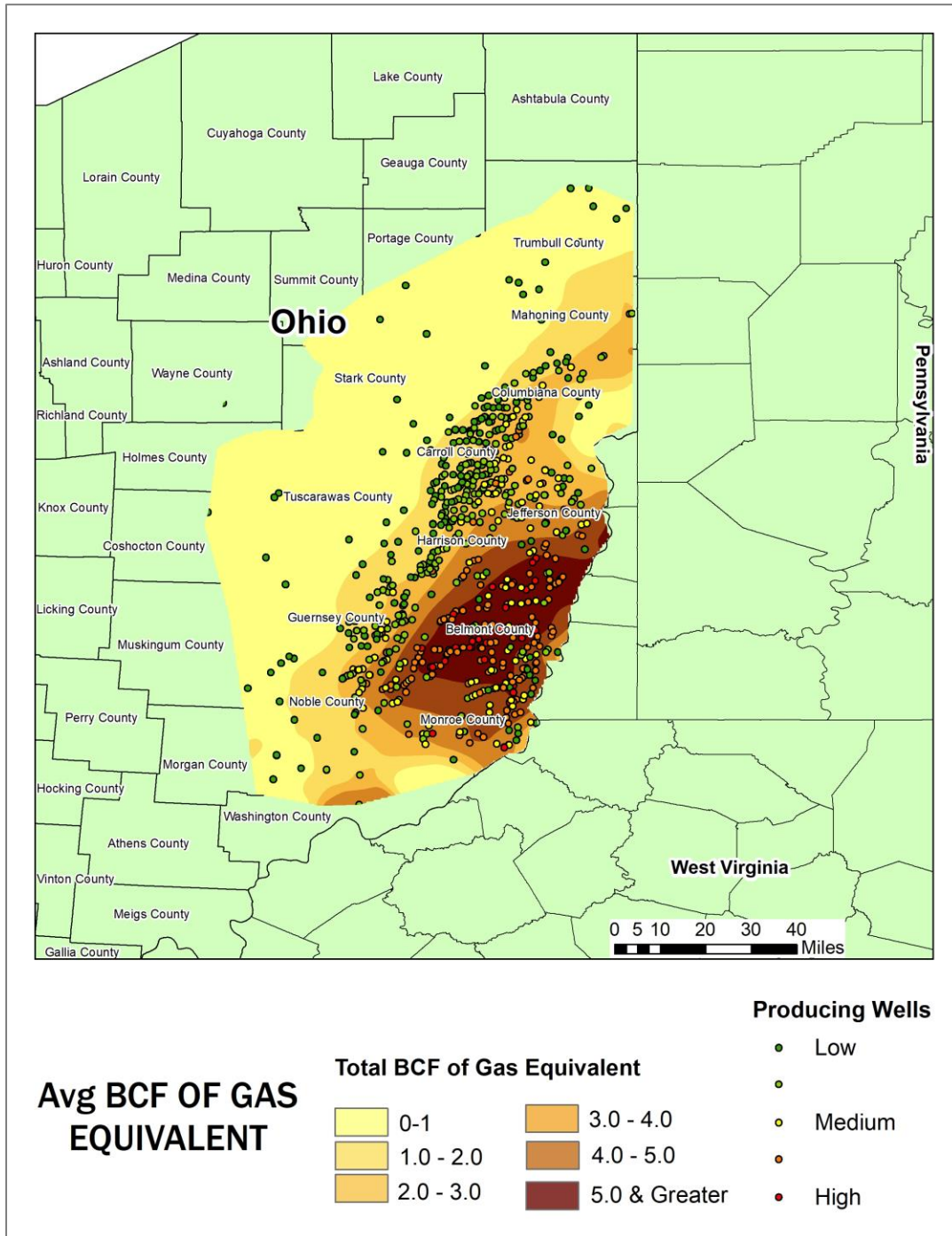


Figure 9: Cumulative Number of Wells by County



Source: Ohio Department of Natural Resources (December 2020)

Figure 10: Distribution of Gas Equivalent Production for 2011 through December 2019



Source: ODNR (2020)

Figure 11: Distribution of Utica Wells by Status as of December 2019

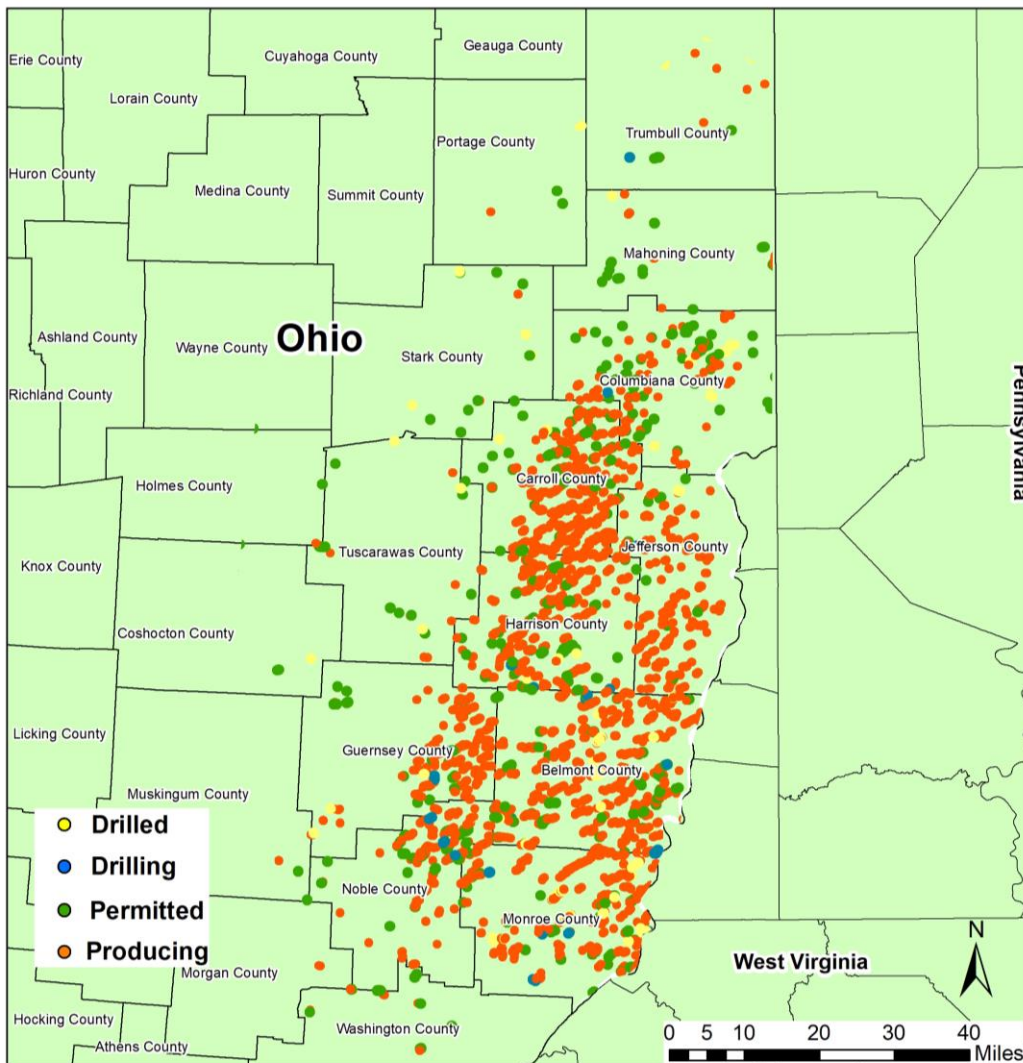


Table 15: Utica Upstream Companies Drilling in Ohio

Operator	Cumulative no. of Wells
ALLIANCE PETROLEUM CORPORATION	16
AMERICAN ENERGY UTICA LLC	1
ANTERO RESOURCES CORPORATION	234
ARSENAL RESOURCES LLC	6
ARTEX ENERGY GROUP LLC	7
ASCENT RESOURCES UTICA LLC	593
ATLAS NOBLE LLC	12
BP AMERICA PRODUCTION COMPANY	1
BRAMMER ENGINEERING INC	2
CHESAPEAKE EXPLORATION LLC	3
CHEVRON APPALACHIA LLC	8
CNX GAS COMPANY LLC	45
DEVON ENERGY PRODUCTION CO LP	3
EAP OHIO LLC	813
ECLIPSE RESOURCES I LP	166
EQT PRODUCTION COMPANY	2
EQUINOR USA ONSHORE PROPERTIES INC.	37
GEOPETRO LLC	5
GULFPORT APPALACHIA LLC	399
GULFPORT ENERGY CORPORATION	8
HILCORP ENERGY COMPANY	23
M & R INVESTMENTS OHIO LLC	1
NORTHWOOD ENERGY CORP	6
PENNENERGY RESOURCES LLC	40
PIN OAK ENERGY PARTNERS LLC	16
RICE DRILLING D LLC	144
STATOIL USA ONSHORE PROPERTIES INC	3
TRIAD HUNTER LLC	23
UTICA RESOURCE OPERATING LLC	33
XTO ENERGY INC.	59
Grand Total	2709

Note: Cumulative Number of Wells are calculated based upon the total numbers of Drilled, Drilling, and Producing. Source: ODNR (December 31, 2019).

**Table 16: Total Lease Operating Expenses through December 2019
(in millions of dollars)**

Year	Period	Production Wells	Lease Operating Expenses for Period (\$mm)
2019	Q3 and Q4	2497	262.2
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	1,678.4

Table 17: Cumulative Utica-Related Upstream Investments in Ohio through December 2019

Estimated Investments	Total Amount
Mineral Rights	\$24,924,541,000
Drilling	\$25,755,300,000
Roads	\$1,079,440,000
Lease Operating Expenses	\$1,648,671,000
Royalties	\$6,633,578,000
Total	\$60,041,530,000

Table 18: Cumulative Utica-Related Midstream Investments in Ohio through Dec. 2019

Estimated Investments	Total Amount
Midstream Gathering	\$7,154,341,000
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	\$9,672,357,000
Total	\$20,165,298,000

Table 19: Cumulative Utica-Related Downstream Investments in Ohio through Dec. 2019

Estimated Investments	Total Amount
Petrochemical Plants and Refineries	\$552,225,000
Other Industrial Plants	\$700,000,000
Natural Gas Refueling Stations	\$46,025,000
Natural Gas Power Plants	\$4,842,500,000
Combined Heat and Power (CHP) Plants	\$85,100,000
Total	\$6,225,850,000

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.⁴⁴
 - Equivalent true vertical depth (TVD) for wells in all counties.

⁴⁴ 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.

- Average drilling and completion costs of \$900 per lateral foot.⁴⁵
- Average lateral length of 12,660 ft. for northern counties and 14,360 ft. for southern counties.⁴⁶
- Roads: average investments - approximately \$60,000 per well based on 2013 data from Carroll County Engineer's Office.⁴⁷

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 July 1, 2019 from the number existent as of December 31, 2019. This information was downloaded from the ODNR Oil and Gas Well database.⁴⁸

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 lease operating expenses for 2019, divided by the number of wells operated, as reported in their financial statements.⁴⁹

For purposes of estimating the lease operating expenses for Q3 and Q4 2019, the Study Team assumed that all wells listed as "producing" by the Ohio Department of Natural Resources on July 1, 2019 were incurring this cost and continued to do so through December 31, 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:

⁴⁵ 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>

⁴⁶ Calculated using well completion reports obtained from the ODNR's *Ohio Oil & Gas Well Database*.

⁴⁷ See *fn 12, supra*.

⁴⁸ <http://oilandgas.ohiodnr.gov/well-information/oil-gas-well-database>

⁴⁹ 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>

- 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.⁵⁰
- The residue energy content was around 1.1 MMBtu/Mcf.⁵¹
- Residue gas in the Utica was selling at an average price of \$1.92 /MMBtu for Q3 and \$1.97 /MMBtu for Q4.⁵² 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.⁵³
- Natural gas liquids were selling for around 30% of the listed price for Marcellus-Utica light crude oil.⁵⁴
- Oil in the Utica region was selling for \$50.34 and \$51.02 per barrel, on average, during the third and the fourth quarter of 2019, respectively.⁵⁵
- 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.⁵⁶ 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

⁵⁰ Based on industry interviews, experts citing API 12.3, Manual of Petroleum Measurements and Standards

⁵¹ 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.

⁵² 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>

⁵³ Based on industry data.

⁵⁴ Based on industry interviews.

⁵⁵ 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>

⁵⁶ 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.

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 \$3,612 for the Midwest Region as obtained from the INGAA, as projected for 2019.⁵⁷

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/d⁵⁸
 - \$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

⁵⁷ *Id.*

⁵⁸ 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>).

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.⁵⁹

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).⁶⁰ 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

⁵⁹ 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.

⁶⁰ The INGAA Foundation, Inc. (2018). *North America Midstream Infrastructure through 2035*. <https://www.ingaa.org/File.aspx?id=34703>.

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

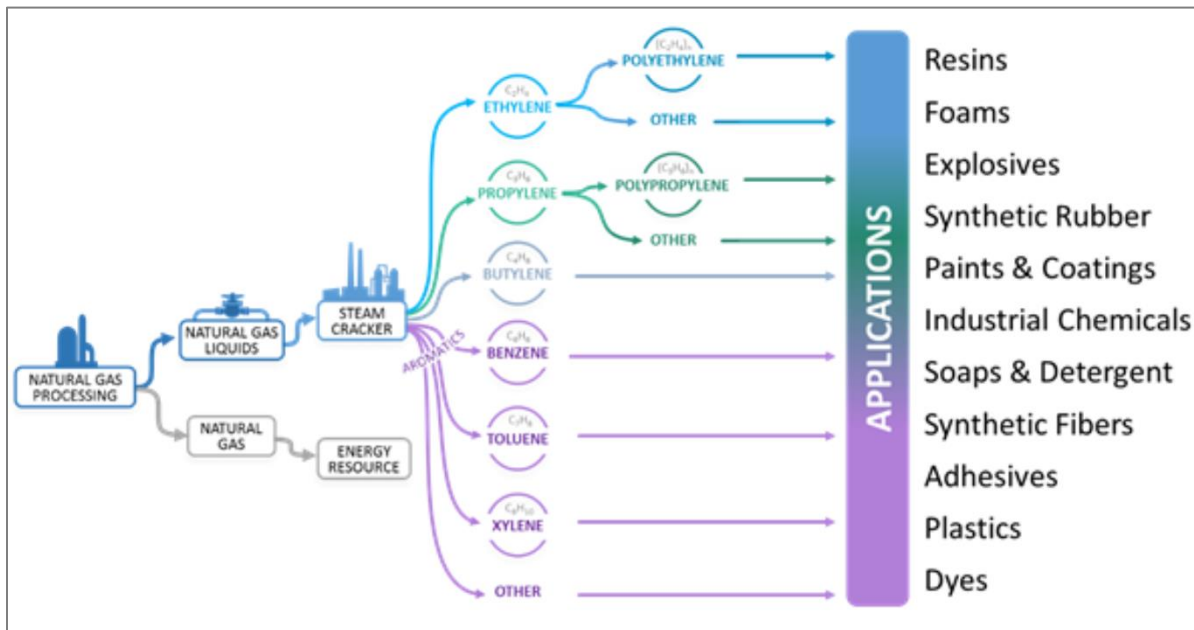
3255 – Paint, Coating, and Adhesive Manufacturing

3259 – Other Chemical Product and Preparation Manufacturing

3261 – Plastics Product Manufacturing

Downstream activities include the deployment of processes that turn hydrocarbons— natural gas (methane) and natural gas liquids (ethane, propane, butanes) —into higher-valued fuels and petrochemicals. Shale gas may be monetized into numerous resulting value-added products. Figure 12 shows the primary intermediates and products that can be manufactured from the main hydrocarbon components in shale gas as part of downstream production.⁶¹

Figure 12. Shale/Natural Gas Value Chain for Petrochemicals



⁶¹ See

https://www.energy.gov/sites/prod/files/2020/06/f76/Appalachian%20Energy%20and%20Petrochemical%20Report_063020_v3.pdf