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## Shale Investment Dashboard in Ohio Q3 and Q4 2022

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October  
2023

**SHALE INVESTMENT  
DASHBOARD IN OHIO  
Q3 AND Q4 2022**

**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 July through December of 2022. Prior investments have been included in previous reports that are available from Cleveland State University.<sup>1</sup> Subsequent reports will estimate additional investment since the date of this report. Investment in Ohio into the Utica during the second half of 2022 can be summarized as follows:

### Total Estimated Upstream Utica Investment: July – December 2022

Lease Renewals and New Leases	\$71,628,000
Drilling	\$538,560,000
Roads	\$7,845,420
Lease Operating Expenses	\$150,205,856
Royalties	\$1,606,755,000
<b>Total Estimated Upstream Investment</b>	<b>\$2,374,994,276</b>

### Total Estimated Midstream Investment: July – December 2022

Gathering Lines	\$14,184,000
Gathering System Compression and Dehydration	\$26,751,000
<b>Total Estimated Midstream Investment</b>	<b>\$40,935,000</b>

### Total Estimated Downstream Investment: July – December 2022

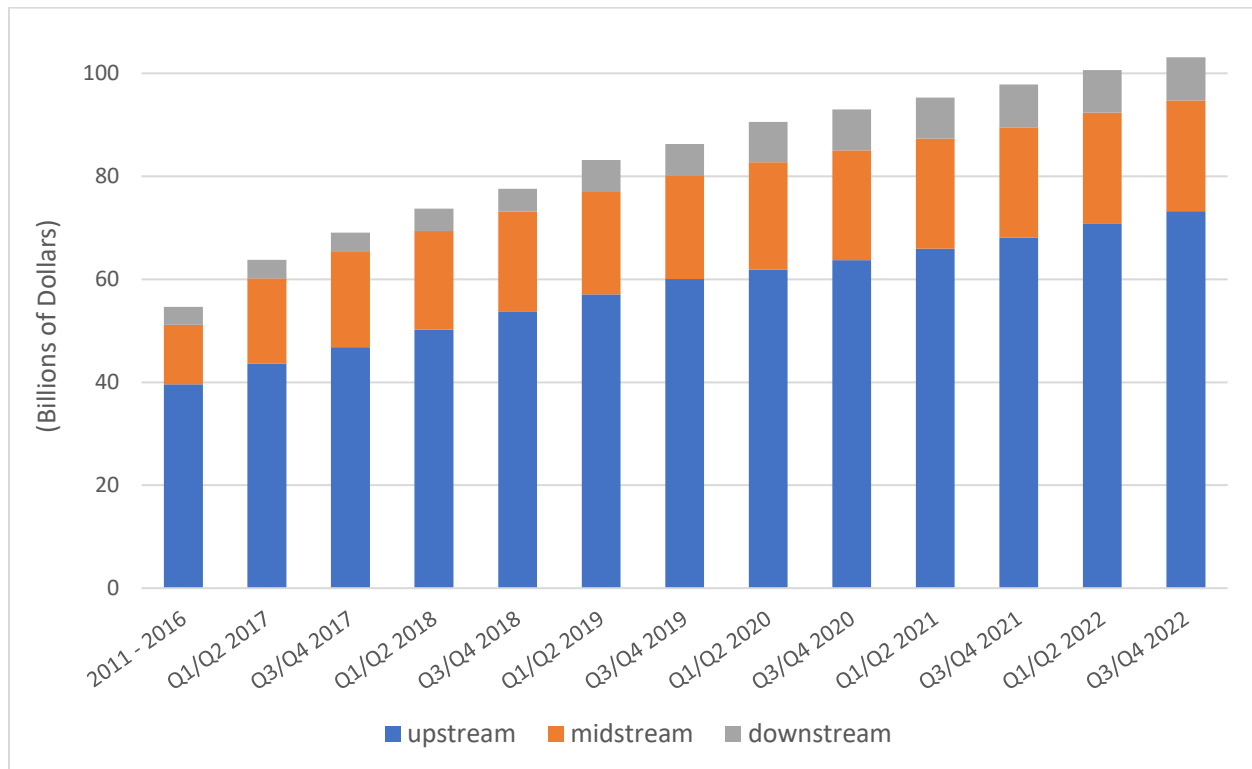
Petrochemical Plants	\$44,000,000
LPG Stations	\$1,800,000
<b>Total Estimated Downstream Investment</b>	<b>\$45,800,000</b>

Total investment from July through December 2022 was approximately \$2.5 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 December of 2022 is estimated to be around \$103.1 billion. Of this, \$73.2 billion has been in upstream, \$21.5 billion in midstream, and \$8.4 billion in downstream industries.<sup>2</sup> Figure 1 shows the growth in cumulative shale-related investment for Ohio since the release of the first Shale Dashboard.

<sup>1</sup> The thirteen previous reports on shale investment in Ohio up to June 2022 can be found at [https://engagedscholarship.csuohio.edu/urban\\_enpolc/](https://engagedscholarship.csuohio.edu/urban_enpolc/)

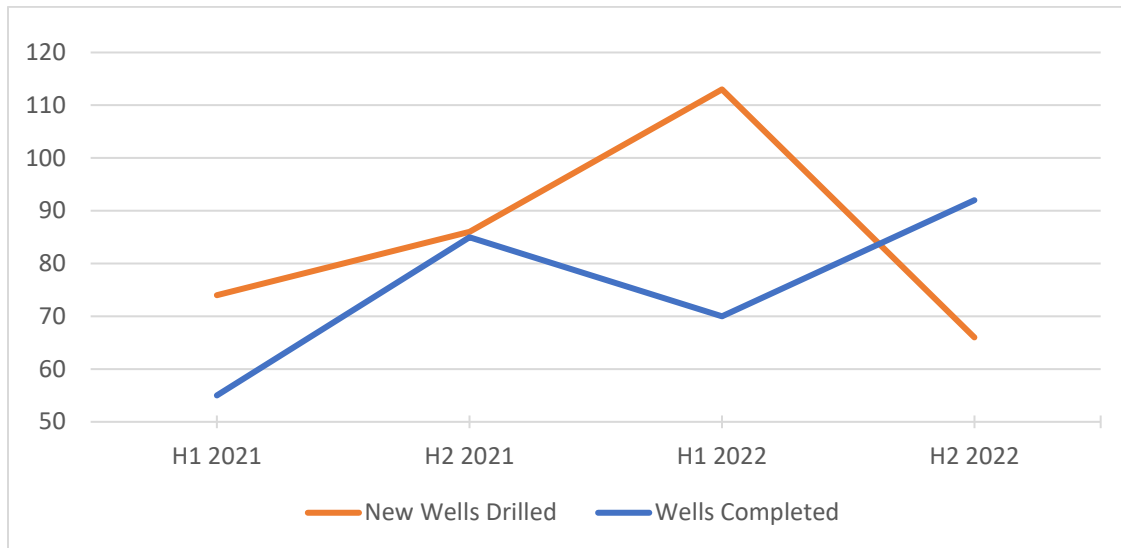
<sup>2</sup> Numbers may not add up precisely due to rounding.

Figure 1: Cumulative Shale Investment in Ohio Over Time



Overall upstream investments were down by about \$396 million in the second half of 2022 compared to the first half of the year, reflecting a decline in the number of new wells drilled that has accompanied falling natural gas prices while inflation has applied upward pressure on input costs. As outlined by EIA, this market uncertainty led operators across all U.S. shale basins to focus less on drilling new wells and more on completing existing wells.<sup>3</sup> Based on an analysis by the Study Team of ODNr drilling data, this trend has likewise been reflected in the Ohio Utica, where the second half of 2022 simultaneously saw the lowest number of new wells drilled but the highest number of wells completed for any 6-month period over the last two years. (See Figure 2.) The number of new wells has since rebounded, with 75 being drilled in the first half of 2023, which will be captured in the next shale report.

<sup>3</sup> See U.S. Energy Information Administration. (October 7, 2022). *Today in Energy: Number of Drilled but Uncompleted U.S. Wells Continues to Decline from Record in 2020*. <https://www.eia.gov/todayinenergy/detail.php?id=54179>. Drilling companies will often leave drilled wells uncompleted for a time, prioritizing available funds for new wells that will hold leases.

Figure 2: New vs. Completed Shale Wells in Ohio by 6-month Period<sup>4</sup>

Data Source: ODNR (2023).

As determined from Ohio Department of Natural Resources Division of Oil and Gas (ODNR) data for shale well drilling, 66 new wells were drilled during the third and fourth quarters of 2022. ODNR production data also indicated that the total volume of gas-equivalent shale production in the second half of 2022 was 1.2% greater than overall production in the first half of 2022. Most of this increase in production was due to renewed interest in the Utica oil window.<sup>5</sup> Improvements in operational efficiency over time have contributed to a steady decline in the oil price necessary for companies to earn required rates of return on capital.<sup>6</sup> At the same time, the price ratio of oil to natural gas (i.e., \$/bbl divided by \$/mmbtu for WTI-Cushing and Henry Hub spot prices) is currently near record highs. (See Figure 3.) The Study Team will continue to track this renewed attention toward oil in the Utica as it develops.

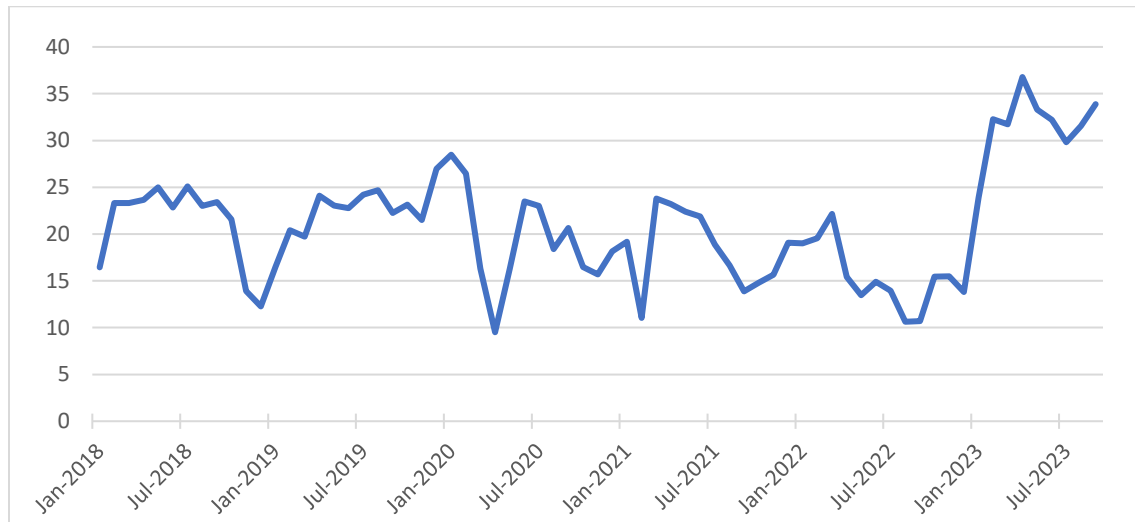
<sup>4</sup> The ODNR's database of drilling activity assigns a status to horizontal wells of *Permitted, Drilling, Drilled, or Producing*. For Figure 2, "New Wells Drilled" were defined as those wells with a status of *Drilled, Drilling, or Producing* at the end of the 6-month Study period that did not have any one of these status designations at the beginning of it. "Wells Completed," on the other hand, were defined as those wells with a status of either *Drilled* or *Drilling* at the beginning of the Study period, and a status designation of *Producing* at the end of it.

<sup>5</sup> Utica oil production was up 19.9% in the second half of 2022 compared to the first half of the year, while gas production was up 0.3% over this time frame.

<sup>6</sup> See EOG Resources' Q2 2023 earnings presentation.

[https://s24.q4cdn.com/589393778/files/doc\\_financials/2023/q2/EOG\\_0823.pdf](https://s24.q4cdn.com/589393778/files/doc_financials/2023/q2/EOG_0823.pdf)

Figure 3: Price Ratio of Crude Oil (WTI) to Natural Gas (Henry Hub)



Data Source: EIA (2023).

For the second half of 2022, Harrison County had the highest number of new wells with 21, followed by Monroe County with 10 new wells, Belmont County with 9, and Carroll and Columbiana Counties with 8 new wells each. Jefferson and Guernsey Counties had 7 and 3 new wells, respectively. No other new wells were drilled during the second half of 2022.

Ascent and EAP Ohio were the top producers for Q3 and Q4 of 2022, having produced 462 and 220 billion cubic feet equivalent (Bcfe), respectively. Gulfport was third in production at 143 Bcfe. SWN Production (Southwestern) and Rice Drilling produced 108 Bcfe and 64 Bcfe, respectively. Antero had the sixth highest production during the Study period at 51 Bcfe. These six companies represented a little over 91% of total production in Ohio for the second half of 2022, which was also their same share of production during the first half of the year.

The second half of 2022 saw midstream investment of \$40.9 million, a 10% increase in spending for this segment compared to the previous 6-month period. All midstream investment during the Study period was for gathering system buildout, with nearly \$27 million spent on compression and dehydration, and an additional \$14.2 million spent on gathering lines. Future midstream investment will include Ohio's share (\$19 million) of the Ohio Valley Connector Expansion project to increase takeaway capacity out of the region, which began construction in August 2023.<sup>7</sup> Additional midstream development will include DT Midstream's planned \$100 million trunkline and gathering system buildout in Ohio, with in-service expected by the middle of 2024.<sup>8</sup>

<sup>7</sup> See FERC Docket No. CP22-44. (September 2022). *Ohio Valley Connector Expansion Project: Draft Environmental Impact Statement*. <https://elibrary.ferc.gov/eLibrary/filedownload?fileid=b15f441d-a174-c0e5-8b1c-838ec4300000>. See also RBN Energy. (2023, August 11). *Appalachia Natural Gas Midstream Expansions Heat Up*. <https://rbnenergy.com/analyst-insights/appalachia-natural-gas-midstream-expansions-heat>

<sup>8</sup> See DT Midstream. (2023, August 22). *Citi One-on-One Midstream/Energy Infrastructure Conference* [investor presentation]. [https://s28.q4cdn.com/581450200/files/doc\\_presentations/2023/Aug/22/dtm-company-presentation-august-2023-vf.pdf](https://s28.q4cdn.com/581450200/files/doc_presentations/2023/Aug/22/dtm-company-presentation-august-2023-vf.pdf).



Downstream spending resumed during the second half of 2022 after a pause during the first and second quarters. Tessengerlo Kerley started construction on a \$44 million liquid fertilizer facility in Northwest Ohio during the Study period. Additionally, \$1.8 million in liquified petroleum gas (LPG) fueling stations opened during the second half of 2022, primarily around Northeast Ohio. The next major downstream investment to be captured in a future Shale report will be the \$1.2 billion natural gas power plant in Trumbull County, the construction phase for which will likely begin in Q4 2023.<sup>9</sup> Additionally, the next few years will see the announcement of projects stemming from the establishment of the Appalachian Regional Clean Hydrogen (ARCH2) hub, which will take advantage of the region’s abundant supply of natural gas for economical hydrogen production. Ohio’s share of the more than \$2 billion in public and private funding for ARCH2 project development—along with additional downstream investment within the state, including for the planned buildout of fueling infrastructure for CNG, LPG, LNG, and hydrogen-powered vehicles—will be tracked by the Study Team for future Dashboard reports.

## 1. INTRODUCTION

This is the fourteenth CSU study reporting investment resulting from oil and gas development in Ohio related to the Utica and Point Pleasant formations (hereinafter, the “Utica”).<sup>10</sup> This analysis looks at investments made in Ohio between July 1 and December 31, 2022, separately considering the upstream, midstream, and downstream portions of the industry. For the upstream part, the Study Team estimated spending primarily based upon the likely costs of drilling new and operating existing wells, together with royalties and lease bonuses.

For midstream estimates, the Study Team looked at new infrastructure built during the relevant time period downstream of production, from gathering to the point of hydrocarbon distribution. This included pipelines, processing, natural gas liquid storage, and intermodal transloading facilities.

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

This fourteenth 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

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<sup>9</sup> See Business Journal Daily. (2023, October 19). *Siting Board Opens Door for Trumbull Energy Center*. <https://businessjournaldaily.com/siting-board-opens-door-for-trumbull-energy-center/>

<sup>10</sup> This and other Investment Dashboard reports include drilling into the Marcellus and other shale units, but these comprise a very small portion of shale development in Ohio to date. This will be revisited as necessary in future iterations of the Investment Dashboard reports.

early 2011 through December 2022.<sup>11</sup> 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 66 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, 2022.<sup>12</sup> This represents a 41.6% decrease in new well development compared to the first half of 2022, and a 20.7% decrease in average new well development for all 6-month periods since the beginning of 2020. The total number of production wells in the Utica was 3,024 on December 31, 2022, a 4.8% increase from the end of June 2022. Total shale-related oil and gas production in billion cubic feet equivalent (Bcfe) for this period was 1,149 Bcfe, led by Belmont County with 279 Bcfe. Jefferson County was second with 270 Bcfe, followed by Harrison and Monroe Counties with 197 and 196 Bcfe, respectively.<sup>13</sup>

The Ohio Department of Natural Resources (ODNR), Division of Oil and Gas Resources Management, issues weekly reports on well status and quarterly reports on production. The ODNR production reports for the third and fourth quarters of 2022 provide the foundation for the upstream analyses presented in this Study.

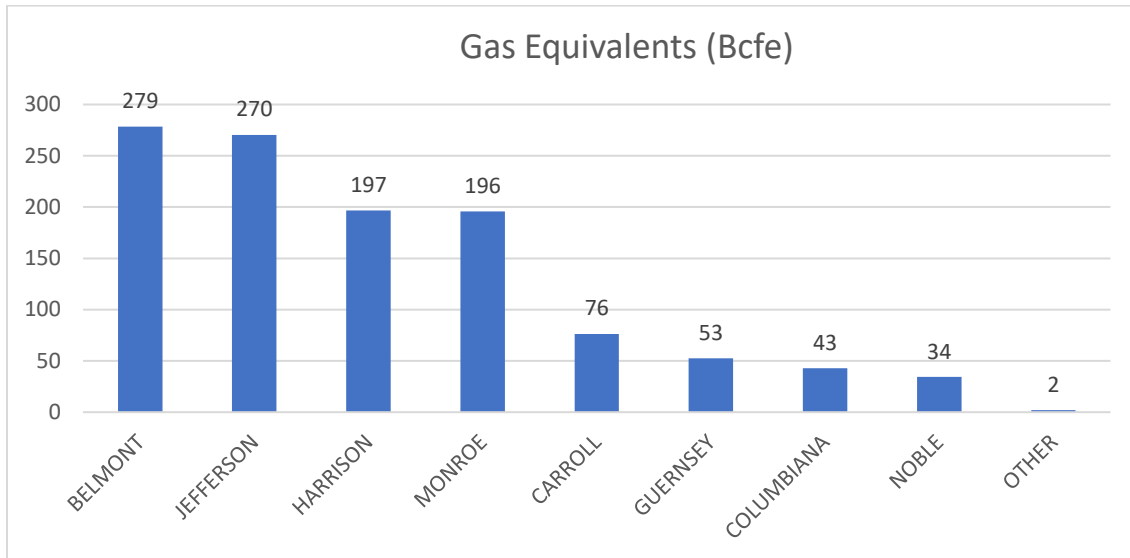
The Utica is currently identified by the ODNR as producing in eighteen eastern Ohio counties with the vast majority (over ninety-nine percent) of producing wells located in eight counties, stretching from Columbiana in the north, to Monroe and Noble at the southern end of the play. Total production in quarters 3 and 4 for 2022 is set forth by county and operator in Figures 4 and 5 below. Total cumulative production in billions of cubic feet equivalent (Bcfe) by county and by operator through December 2022 can be found in Appendix A as Figures 10 and 11.

<sup>11</sup> See *fn 1, supra*.

<sup>12</sup> The number of new wells was determined using ODNR’s report of cumulative permitting and drilling activity for the beginning and end of the 6-month period (see <https://ohiodnr.gov/business-and-industry/energy-resources/oil-and-gas-wells/horizontal-wells>). 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.

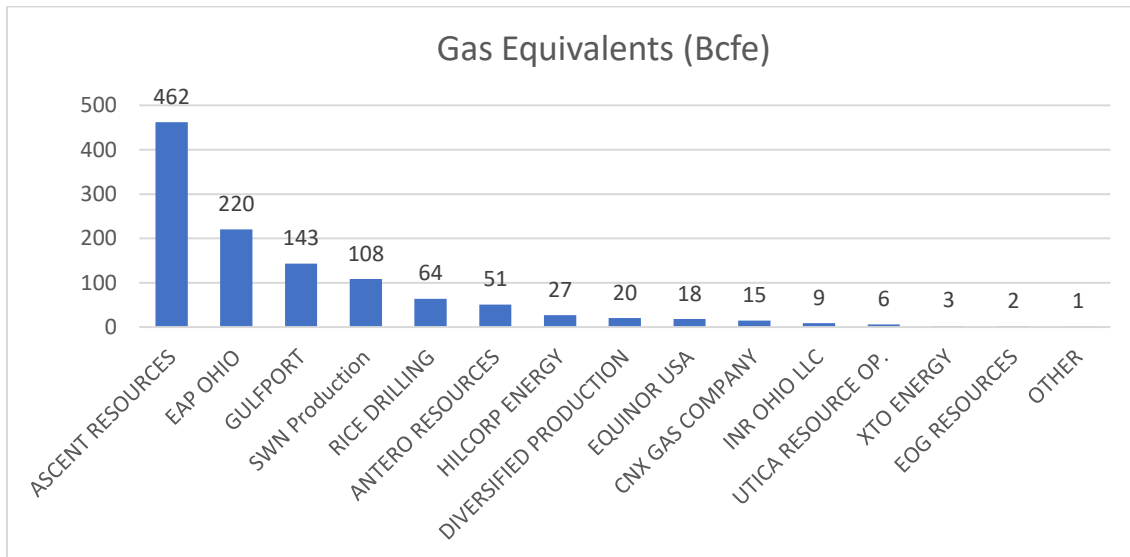
<sup>13</sup> Production is reported to the ODNR at the wellhead as gas measured in thousands of cubic feet (Mcf) and as oil measured in barrels (bbl). The Utica also produces significant volumes of natural gas liquids (NGLs) such as ethane, propane, butane and natural gasoline. These NGLs are separated 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 (Mcfe) based on the energy content of oil and gas, measured as British thermal units (Btu). Gas equivalents were calculated using the following formula: Gas Equivalents (Mcfe) = Oil (bbl) x 5.659 Mcf/bbl + Gas (Mcf).

**Figure 4: Production by County for Q3 and Q4 of 2022**



Data Source: ODNR (2023).

**Figure 5: Production by Operator for Q3 and Q4 of 2022**



Data Source: ODNR (2023).

## 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 2022, and also for cumulative production since 2011, is set forth in Table 1. Table 2 sets forth production by county for the second half of 2022. Figure 6 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)
2022	4	3,033	539,681,875	5,855,323	572,817,148	-0.6
2022	3	3,014	548,326,581	4,908,109	576,101,570	0.8
2022	2	2,921	543,019,311	5,018,523	571,419,133	1.3
2022	1	2,850	541,815,020	3,957,294	564,209,347	-5.8
2021	4	2,817	576,496,677	3,912,593	598,638,041	5.2
2021	3	2,764	547,540,443	3,781,319	568,938,927	-0.6
2021	2	2,805	549,211,398	4,154,041	572,332,375	-0.2
2021	1	2,752	548,129,151	4,543,462	573,417,606	-6.4
2020	4	2722	586,878,969	4,625,639	612,624,813	-1.3
2020	3	2688	588,630,465	5,713,477	620,431,107	3.6
2020	2	2643	569,396,136	5,182,481	598,723,796	-2.6
2020	1	2573	581,634,083	5,887,032	614,948,797	-14.1
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	ANNUAL	1248	923,908,838	20,698,159	1,041,039,721	--
2014	ANNUAL	810	449,966,930	10,893,625	511,613,948	--
2013	ANNUAL	371	99,050,302	3,635,419	119,623,141	--
2012	ANNUAL	82	12,831,292	635,874	16,429,703	--
2011	ANNUAL	9	2,561,524	46,326	2,823,683	--
<b>Total</b>			<b>15,159,372,543</b>	<b>161,523,968</b>	<b>16,071,805,223</b>	--

Source: ODNR (2023).

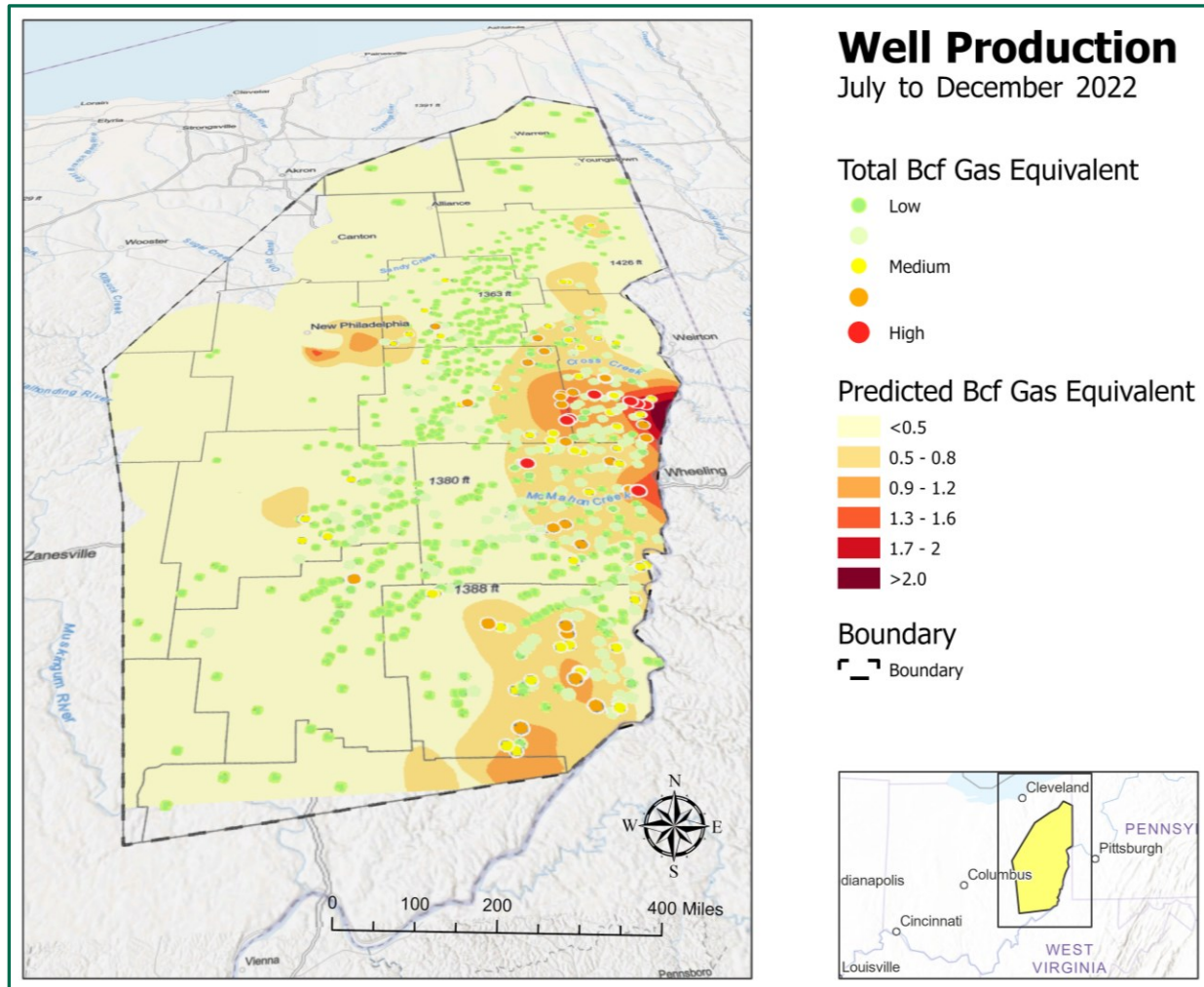
Table 2: Production by County for July – December 2022

County	Gas (Mcf)	Oil (bbl)	Gas Equivalents (Mcf)	Production Wells <sup>14</sup>
BELMONT	278,201,514	53,955	278,506,845	655
CARROLL	52,346,506	4,229,838	76,283,159	514
COLUMBIANA	42,858,545	9,337	42,911,383	119
COSHOCTON	10,250	0	10,250	1
GUERNSEY	32,545,956	3,550,962	52,640,850	265
HARRISON	182,928,123	2,403,736	196,530,865	488
JEFFERSON	270,264,716	0	270,264,716	334
MAHONING	434,783	2,056	446,418	12
MONROE	195,042,741	99,699	195,606,938	430
MORGAN	31,522	1,999	42,834	2
MUSKINGUM	211,947	3,333	230,808	2
NOBLE	32,096,260	395,499	34,334,389	179
PORTAGE	32,578	584	35,883	2
STARK	34,365	284	35,972	1
TRUMBULL	125,709	622	129,229	6
TUSCARAWAS	158,641	6,098	193,150	5
WASHINGTON	663,896	5,430	694,624	11
WAYNE	20,404	0	20,404	1
<b>Total</b>	<b>1,088,008,456</b>	<b>10,763,432</b>	<b>1,148,918,718</b>	<b>3,024</b>

Source: ODNR (2023).

<sup>14</sup> Represents the average number of production wells for the first and second quarters of 2022.

Figure 6: Distribution of Gas Equivalent Production for July – December 2022



Note: Predicted Bcf Gas Equivalent refers to the estimated average production for any random well located within one of the six color-coded spatial zones in the underlying contour plot.

Of the 3,184 total wells identified from the ODNR records for cumulative drilling activity as of December 2022, 117 were in the process of drilling, 77 wells had been drilled and were awaiting markets, and 2,990 were in the production phase.<sup>15</sup> (See Table 3, Ohio Utica Well Status.) Belmont County continued to lead in total wells. (See Table 4.)

<sup>15</sup> 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. Further, the Study Team has not sought to identify wells that may be listed as producing, but in fact are not.

**Table 3: Ohio Utica Well Status as of December 2022**

Well Status	No. of Wells
Drilled	77
Drilling	117
Producing	2,990
<b>Total</b>	<b>3,184</b>

Source: ODNR (2023)

**Table 4: Well Status by County (December 2022)**

County	Drilled	Drilling	Producing	Total
BELMONT	15	25	635	675
CARROLL	1	14	510	525
HARRISON	9	17	488	514
MONROE	17	12	412	441
JEFFERSON	1	18	344	363
GUERNSEY	2	19	260	281
NOBLE	1	0	180	181
COLUMBIANA	10	11	114	135
MAHONING	1	0	12	13
TRUMBULL	3	1	7	11
WASHINGTON	0	0	11	11
PORTAGE	7	0	2	9
TUSCARAWAS	2	0	7	9
STARK	4	0	2	6
COSHOCTON	1	0	1	2
MORGAN	0	0	2	2
MUSKINGUM	0	0	2	2
ASHLAND	1	0	0	1
KNOX	1	0	0	1
MEDINA	1	0	0	1
WAYNE	0	0	1	1
<b>Total</b>	<b>77</b>	<b>117</b>	<b>2,990</b>	<b>3,184</b>



## 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. Previous shale reports differentiated between northern and southern counties with respect to drilling costs based on the greater vertical depths and horizontal lengths of wells developed in southern counties, on average. However, a recent review of ODNR drilling surveys indicated that there is no longer a significant difference in average well depth and horizontal length between northern and southern counties. Based on an average lateral length of 13,600 ft. for the eight most active shale-producing counties in Ohio over the last two years, and average drilling and completion costs of \$600 per lateral foot for operators in the Utica during 2022, we assumed an average drilling cost of \$8.2 million per well for *all* horizontal wells.<sup>16</sup>

This section covers upstream investments between July and December 2022. Cumulative upstream investments to date in Ohio, including 2011 through the second half of 2022, 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. Harrison County was the leader in new upstream investment, with 21 new wells and an investment of around \$173.9 million between July and December 2022. Monroe and Belmont counties were second and third, with 10 and 9 new wells, and approximately \$82.8 million and \$74.5 million invested, respectively. (See Table 5.) Road-related investments for this version of the Shale Investment Dashboard reflect average road costs per well determined from three sources: The Ohio Oil and Gas Association's (OOGA) 2017 report *Ohio's Oil & Gas Industry Road Improvement Payments*; OOGA's 2022 *Community Impact/Sustainability Report*; and spending in 2021 on Road Use Maintenance Agreements (RUMAs) by companies in Monroe, Noble, and Carroll Counties as reported to the Study Team by the engineer's office for those counties.<sup>17</sup> Based on information from these sources, road costs related to drilling were assumed to be \$118,870 per well.

<sup>16</sup> See Upstream Methodology in Appendix B.

<sup>17</sup> OOGA's 2017 report indicated that oil and gas companies in Ohio had spent approximately \$300 million on roads from 2011 through 2017. OOGA's 2022 report indicated that cumulative spending by the industry on roads had reached approximately \$400 million by the end of 2021. This suggests that \$100 million was spent on roads from 2018 through 2021. The Study Team has tracked 846 new wells over that period for the bi-annual shale dashboards. This suggests an average expenditure per well on roads of around \$118,200. Independent of this estimate, the 2021 RUMA-based improvement totals as gathered by the engineer's office in Monroe, Noble, and Carroll counties and shared with the Study Team tallied about \$3.825 million. Based on the 32 new wells the Study Team tracked for those three counties last year, this comes out to \$119,500 per well. The two estimates were averaged and rounded to the nearest \$1,000 to yield the rule of thumb for spending on roads.



Ascent was the leading operator-investor during the six-month period, with 51 new wells and an estimated \$422.2 million. EAP Ohio recorded the second highest investment, with 32 new wells and an estimated \$264.9 million investment. Gulfport Appalachia and SWN Production invested \$91.1 million and \$82.8 million in 11 and 10 wells, respectively. (See Table 6.)

**Table 5: Estimated Upstream Shale Investment by County, July – December 2022**

County	No. of New Wells	Drilling (\$)	Roads (\$)	Total Amount (\$)
BELMONT	9	\$73,440,000	\$1,069,830	\$74,509,830
CARROLL	8	\$65,280,000	\$950,960	\$66,230,960
COLUMBIANA	8	\$65,280,000	\$950,960	\$66,230,960
GUERNSEY	3	\$24,480,000	\$356,610	\$24,836,610
HARRISON	21	\$171,360,000	\$2,496,270	\$173,856,270
JEFFERSON	7	\$57,120,000	\$832,090	\$57,952,090
MONROE	10	\$81,600,000	\$1,188,700	\$82,788,700
<b>Total</b>	<b>66</b>	<b>\$538,560,000</b>	<b>\$7,845,420</b>	<b>\$546,405,420</b>

Source: The Authors (2023)

**Table 6: Estimated Upstream Shale Investment in Ohio by Company, July – December 2022**

Operator	No. of New Wells	Drilling (\$)	Roads (\$)	Total Amount (\$)
ASCENT RESOURCES	29	\$236,640,000	\$3,447,230	\$240,087,230
EAP OHIO	17	\$138,720,000	\$2,020,790	\$140,740,790
HILCORP ENERGY	8	\$65,280,000	\$950,960	\$66,230,960
SWN Production	6	\$48,960,000	\$713,220	\$49,673,220
DIVERSIFIED PRODUCTION	4	\$32,640,000	\$475,480	\$33,115,480
EOG RESOURCES	1	\$8,160,000	\$118,870	\$8,278,870
GULFPORT APPALACHIA	1	\$8,160,000	\$118,870	\$8,278,870
<b>Total</b>	<b>66</b>	<b>\$538,560,000</b>	<b>\$7,845,420</b>	<b>\$546,405,420</b>

Source: The Authors (2023)

## 2. Lease Operating Expenses.

Post-production investments have been estimated on a half-year basis, assuming an average cost of \$0.131/Mcf-equivalent.<sup>18</sup> This estimate is based upon recent operator reports.<sup>19</sup> These investments are set forth below. Belmont County and Jefferson County led the lease operating expense investment, with an estimated \$36.4 million and \$35.3 million invested, respectively.

**Table 7: Estimated Lease Operating Expenses for July – December 2022 by County**

County	Gas Equivalents (Mcf)	Lease Operating Expense for Period
BELMONT	278,506,845	\$36,411,069
JEFFERSON	270,264,716	\$35,333,520
HARRISON	196,530,865	\$25,693,799
MONROE	195,606,938	\$25,573,008
CARROLL	76,283,159	\$9,973,009
GUERNSEY	52,640,850	\$6,882,092
COLUMBIANA	42,911,383	\$5,610,093
NOBLE	34,334,389	\$4,488,765
OTHER	1,839,573	\$240,500
<b>TOTAL</b>	<b>1,148,918,718</b>	<b>\$150,205,856</b>

**Table 8: Estimated Lease Operating Expenses for July – December 2022 by Operator**

Operator	Gas Equivalents (Mcf)	Lease Operating Expense for Period
ASCENT RESOURCES	461,949,629	\$60,393,776
EAP OHIO	219,947,971	\$28,755,275
GULFPORT APPALACHIA	143,058,571	\$18,703,007
SWN Production	108,091,808	\$14,131,568
RICE DRILLING	63,831,679	\$8,345,144
ANTERO RESOURCES	50,871,936	\$6,650,830
HILCORP ENERGY	27,174,582	\$3,552,716
DIVERSIFIED PRODUCTION	20,216,487	\$2,643,037
EQUINOR USA	17,940,186	\$2,345,441
CNX GAS COMPANY	14,911,851	\$1,949,526
INR OHIO	9,053,546	\$1,183,631
UTICA RESOURCE OPERATING	5,639,203	\$737,251
XTO ENERGY	2,688,784	\$351,523
EOG RESOURCES	2,052,631	\$268,354
OTHER	1,489,853	\$194,778
<b>TOTAL</b>	<b>1,148,918,718</b>	<b>\$150,205,856</b>

<sup>18</sup> Previous reports relied on a per-well rule-of-thumb to calculate lease operating expenses, which attributed an equal amount to both low- and high-producing wells. A production-based rule of thumb more accurately captures the expenses that companies are likely to incur while operating wells.

<sup>19</sup> The per-Mcfe rule-of-thumb for lease operating expenses is based on average production costs for Ascent's and Gulfport's Utica operations in the second half of 2022 as reported in quarterly financial statements for both companies. See Appendix B.

### 3. Royalties.

Royalty investments have been estimated on a per quarter basis, assuming the formulas set forth in Appendix B. Total estimated royalties spent on Ohio properties between July and December 2022 were \$1.6 billion, or about 1.3% higher than the amount dispersed in the first half of 2022. The breakdown by quarter for oil, residue gas (gas left after extracting liquids) and natural gas liquids is set forth in Tables 9, 10, and 11 below. The average price for natural gas was \$5.78/MMBtu during the second half of 2022, up from \$5.51 in the first half of 2022.<sup>20</sup> Regional oil prices decreased from an average of \$81.87/bbl during the third quarter of 2022 to \$72.53/bbl for the fourth quarter.<sup>21</sup> For comparison, regional oil prices averaged \$84.54 and \$98.71 per barrel in the first and second quarters of 2022, respectively.

**Table 9: Total Royalties from Oil, July – December 2022 (in millions)**

Year	Quarter	Oil Price \$/bbl	Oil Royalty (20%) \$/bbl	Royalty (\$mm)
2022	4	\$72.53	\$14.51	\$84.94
2022	3	\$81.87	\$16.37	\$80.37
			<b>Subtotal</b>	<b>\$165.31</b>

**Table 10: Total Royalties from Residue Gas, July – December 2022 (in millions)**

Year	Quarter	Residue Gas Price \$/Mcf	Residue Gas Royalty (20%) \$/Mcf	Royalty (\$mm)
2022	4	4.97	\$0.99	\$471.81
2022	3	7.75	\$1.55	\$747.78
			<b>Subtotal</b>	<b>\$1,219.59</b>

**Table 11: Total Royalties from Natural Gas Liquids, July – December 2022 (in millions)**

Year	Quarter	NGL Price \$/bbl	NGL Royalty (20%) \$/bbl	Royalty (\$mm)
2022	4	21.76	4.35	\$103.34
2022	3	24.56	4.91	\$118.52
			<b>Subtotal</b>	<b>\$221.86</b>

<sup>20</sup> Reflects average natural gas prices over the respective periods across the Columbia Gas, Eastern Gas South, and Texas Eastern M-2 trading hubs as derived from Intercontinental Exchange (ICE) trade data published in regular weekly market reports by Snyder Brothers Gas Marketing. See <https://www.snyderbrothersinc.com>.

<sup>21</sup> Reflects average prices reported by Ergon for Marcellus-Utica light crude (<https://ergon.com>). See Appendix B.

#### 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 six drilling companies in the region. These six companies have together drilled over 88% of the Utica wells to date, and it is assumed that they likewise control over 88% of the leases. The estimated investments into new leases and lease renewals are set forth below in Table 12.

There are several potential sources of error in these estimates. Because operators do not report lease bonus information, the Study Team was required to estimate investments into lease bonuses based upon some industry rules of thumb, together with information found in public leases. One important rule of thumb we deployed in estimating lease bonus investment is that “primary” lease terms average about 5 years. The primary term is that period of time during which the operator may conduct drilling operations but hold the lease without producing. Once a lease is drilled and production begins, the lease moves into its “secondary term,” and may be thereafter “held by production” (HBP) for the life of that production. Using this rule of thumb, we determined that each operator will, on average, every year replace about 20% of its undeveloped acreage that is not HBP.

However, it is possible to hold undeveloped acreage without producing it. This can be done through the process of unitization. An operator may, for instance, have a 750-acre unit that is designed to drain a reservoir by 3 wells draining 250 acres each. The operator may drill the first well and begin to pay royalties therefrom to all the unit leases, thereby moving all the unit leases into HBP status, even though only one third of the reservoir is actually producing. Under this scenario, 500 acres would be classified as “undeveloped acreage,” while 250 acres would be “developed acreage.”

Most operators report undeveloped acreage.<sup>22</sup> However, they generally do not distinguish what portions of their undeveloped acreage are HBP or under primary term. Some do, however, report what percentage of their overall acreage is HBP, and this number can be used to estimate the likely acreage of leases that required bonuses. Based on the most recent annual financial reports for Antero, Ascent, and Gulfport, the Study Team found that on average 14% of a Utica operator’s net Utica acreage was not classified as “Held-By-Production.” Accordingly, for purposes of this Study, and using the 5-year primary term assumption, we assumed that operators, on average, paid lease bonuses on 20% of such non-HBP acreage for the year (i.e. ~3% of the total net acreage), and 10% over the half-year Study period.

Another important assumption is the lease bonus rate. For this Study, we have assumed bonuses to average \$5000/acre lease for renewals and new leases. From 2013-2019, this was a pretty

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<sup>22</sup> *Undeveloped acreage* is defined by operators as that acreage on which wells have not been drilled or completed to a point that would permit the production of economic quantities of oil and natural gas regardless of whether the acreage contains proved reserves. Accordingly, undeveloped acreage can have a wide range of meaning, ranging from highly speculative to proven. Operators use a different, more rigorous classification system to account for proven or potential reserves.

conservative number in the Utica, and therefore likely to still be conservative for renewals of older leases. There is evidence that in 2020 new lease bonus rates were depressed due to sustained low natural gas prices. More recent publicly reported information on lease bonuses suggests, however, that \$5000/acre continues to be a reasonable estimate. In May 2022, for example, the Muskingum Watershed Conservancy District leased mineral rights for \$5,500/acre for a 5-year primary term on acreage in Harrison County.<sup>23</sup> A more recent bid to drill on state-owned land confirmed this per-acreage bonus estimate, although the primary term was shorter.<sup>24</sup>

One additional factor that may make the lease bonus estimate inaccurate is the use of only “net” non-HBP lease acreage data to avoid possible double counting of leases. Operating companies often collaborate on development with non-operators but report only their own portion of the lease. However, bonuses must be paid on the “gross” lease acreage. So long as the non-operators are among the top six operators (which is commonly the case), their own net acreage reports will capture all the acreage. But if they are not, the acreage will not be captured, and the bonuses estimated herein will be under reported.

<sup>23</sup> See Muskingum Watershed Conservancy District. (2022, May 20). *MWCD Negotiates Oil and Gas Lease with Encino Energy*. <https://www.mwcd.org/news/2022/05/20/mwcd-negotiates-oil-and-gas-lease-with-encino-energy>

<sup>24</sup> See Cleveland.com. (2023, April 10). *Texas Driller Offers Ohio ‘Potential’ of Nearly \$2 Billion to Frack Salt Fork State Park*. <https://www.cleveland.com/open/2023/04/texas-driller-offers-ohio-potential-of-nearly-2-billion-to-frack-salt-fork-state-park.html>

**Table 12: Total Estimated Investments into New Leases and Lease Renewals  
July – December 2022 (in millions)**

Operator	Acreage not held for production <sup>25</sup>	Estimated Bonus Investment (\$mm)
ANTERO RESOURCES <sup>26</sup>	17,302	\$8.7
ASCENT RESOURCES <sup>27</sup>	42,087	\$21.0
EAP OHIO <sup>28</sup>	21,802	\$10.9
GULFPORT ENERGY <sup>29</sup>	30,077	\$15.0
RICE DRILLING (EQT) <sup>30</sup>	17,129	\$8.6
SOUTHWESTERN ENERGY (SWN) <sup>31</sup>	14,861	\$7.4
<b>Total</b>	<b>143,257</b>	<b>\$71.6</b>

### C. ESTIMATED MIDSTREAM INVESTMENTS

Midstream investment includes natural gas processing and fractionation facilities, including rail and transloading facilities for storing and handling natural gas liquids. Midstream also includes transmission and gathering pipelines, storage facilities, compressor stations (including compressor engines), dehydration units, and generators installed as part of these stations.

Pipeline investments were estimated using mileage and size information from the Public Utilities Commission of Ohio, and cost information from the Interstate Natural Gas Association of America (INGAA). 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.

<sup>25</sup> Antero and Southwestern did not distinguish between Ohio, Pennsylvania, and West Virginia acreage for their Appalachia operations in their FY2022 10-K reports. EAP Ohio is privately held and does not release this sort of annual financial report. Gross developed acreage in Ohio for these companies was assumed to be equivalent to the total acreage for their horizontal drilling units in the state, data for which is available through the ODNR's Oil & Gas Well Viewer at <https://gis.ohiodnr.gov/mapviewer/?config=oilgaswells>. For operators who *do* file 10-K reports in which Appalachian acreage is differentiated by state (Ascent, Gulfport, and Rice Drilling), this estimate for gross developed acreage has been within  $\pm 10\%$  of the actual amount. Total net acreage for Antero, Southwestern Energy, and EAP Ohio were estimated based on the average ratio of total-net-acres-to-gross-developed-acres in Ohio for Ascent, Gulfport, and Rice Drilling.

<sup>26</sup> Fifteen percent of Antero's total net Ohio acreage was assumed to not be held by production as this was the percentage of the company's overall net Appalachian acreage not held by production in FY2022 based on its most recently filed 10-K.

<sup>27</sup> Twelve percent of Ascent's total net Ohio acreage was not held by production based on the company's FY2022 Consolidated Financial Statements.

<sup>28</sup> See *fn 24, supra*. Approximately 5% of EAP's acreage in Ohio is not held by production (see <https://www.encinoenergy.com/operations>).

<sup>29</sup> Sixteen percent of Gulfport's net Ohio acreage was not held by production based on the company's FY2022 10-K.

<sup>30</sup> Acreage not held by production was not identified in the FY2022 10-K for Rice Drilling or Southwestern Energy. This percentage was assumed to be 12%, which was the average for Antero, Ascent, EAP Ohio, and Gulfport.

<sup>31</sup> *Id.*

Additional investment information was collected from midstream company investor presentations, news reports, and other sources including Ohio EPA permits. Table 13 summarizes midstream investments identified by the Study Team for the second half of 2022. 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.

**Table 13: Midstream Gathering System Investment, July – December 2022**

Company	Additions to Infrastructure	Total Amount (\$mm)
Ascent Resources	• 65 MMscfd of dehydration in Belmont County	\$1.7
Blue Racer Midstream	• 1,950 hp of compression in Carroll County	\$9.0
Cardinal Gas Services (Williams)	• 1.54 miles of 8.63" pipeline • 3.13 miles of 12.75" pipeline • 200 MMscfd of dehydration in Carroll County	\$16.5
SWN Production (Southwest)	• 2,615 hp of compression in Monroe County	\$12.1
UGI Energy Services	• 0.59 miles of 8.63" pipeline	\$1.2
Utica Gas Services (Williams)	• 0.12 miles of 12.75" pipeline	\$0.4
<b>Total</b>		<b>\$40.9</b>

Source for Gathering Line Mileage and Diameter Data: PUCO Gathering Construction Reports (2023).

Midstream investments were up 10% during the second half of 2022 compared to the first half of the year, totaling nearly \$41 million. Midstream operators in the Utica continue to have considerable capacity available for gas processing (~60% available capacity), fractionation (~40% available capacity), and de-ethanization (~85% available capacity).<sup>32</sup> Near-term investments for this segment will focus more toward gathering system and pipeline development to increase the region's capacity to deliver gas to end markets. Such projects include DT Midstream's initial buildout of a new trunkline and gathering network in the Ohio Utica, with in-service expected during the first half of 2024, as well as the Ohio Valley Connector Expansion project to increase takeaway capacity out of the region, construction for which began in August 2023.<sup>33</sup> These and other midstream projects to be tracked for future shale reports are listed below in Table 14. Cumulative midstream investments through the end of December 2022 are set forth in Table 18 in Appendix A.

<sup>32</sup> See MPLX's Form 10-K for FY2022. <https://ir.mplx.com/CorporateProfile/sec-filings>.

<sup>33</sup> See DT Midstream. (2023, August 22). *Citi One-on-One Midstream/Energy Infrastructure Conference* [investor presentation]. [https://s28.q4cdn.com/581450200/files/doc\\_presentations/2023/Aug/22/dtm-company-presentation-august-2023-vf.pdf](https://s28.q4cdn.com/581450200/files/doc_presentations/2023/Aug/22/dtm-company-presentation-august-2023-vf.pdf). See also FERC Docket No. CP22-44. (2022, September 30). *Draft Environmental Impact Statement for Equitrans, LP's Ohio Valley Connector Expansion Project under CP22 44*. <https://elibrary.ferc.gov/eLibrary/filedownload?fileid=B15F441D-A174-C0E5-8B1C-838EC4300000>

**Table 14: Future Ohio Midstream Projects**

Project	Description	Est. Investment (\$mm)
DT Midstream Ohio Utica Development	Initial buildout of new trunkline and gathering network	\$100.0
Ohio Valley Connector Expansion	Takeaway capacity out of Appalachia (Ohio portion)	\$19.0
Additional gathering system buildout <sup>34</sup>	<ul style="list-style-type: none"> <li>• 2.5 miles of pipeline with 8" avg. diameter</li> <li>• 5,350 hp of compression</li> <li>• 97 MMscfd of dehydration</li> </ul>	\$29.9

## D. DOWNSTREAM DEVELOPMENT

### 1. Combined Heat and Natural Gas Power Plants

Over the past thirteen 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. Based on a recent review of EIA data for the six of these plants that were operational as of December 2022, the Study Team estimates that these facilities require around 42,400 mcf annually per MW of installed power generation capacity on average.<sup>35</sup> This translates to an estimated 40 Bcf of natural gas consumed annually for a 940 MW power plant.

No new construction starts occurred for plants under development during the second half of 2022. However, in December 2022 tree clearing and site preparation began for the \$1.2 billion, 940 MW Trumbull Energy Center, with foundation work taking place during the second half of 2023.<sup>36</sup> Investment for this natural gas-fired power plant will be included in a future shale report.

Meanwhile, construction has concluded on the \$1.6 billion, 1875MW Guernsey Power Station—investment for which was included in a previous report—with commercial operations having begun in June 2023.<sup>37</sup> Installation of Ohio State University’s 106 MW CHP system (investment

<sup>34</sup> Pipeline estimate reflects construction starts through the end of June 2023 as gathered from the PUCO’s Gathering Construction Reports. Compression estimate reflects projects receiving Final Issuance of Permit-to-Install and Operate from Ohio EPA as of June 30, 2023. See Appendix B for methodology used to calculate total dollar amount.

<sup>35</sup> See Energy Information Administration. (2023, March 27). *Form EIA-923 Detailed Data with Previous Form Data (EIA-906/920)*. <https://www.eia.gov/electricity/data/eia923>. Form EIA-923 data include monthly and annual fuel consumption and electricity generation at the power plant level. Based on EIA’s data for net generation and the PUCO’s data for nominal net capacity per facility, Ohio’s six operational natural gas-fired power plants developed since 2015 have an average capacity factor of nearly 77%.

<sup>36</sup> See Tribune Chronicle. (2023, April 27). *Work underway at \$1.2B Trumbull Energy Center as private ceremony takes place*. <https://www.tribtoday.com/news/local-news/2023/04/work-underway-at-1-2b-trumbull-energy-center-as-private-ceremony-takes-place>. See also [Notice\(s\) of Upcoming Concrete Pour Occurring at http://trumbullenergycenter.com/](http://trumbullenergycenter.com/)

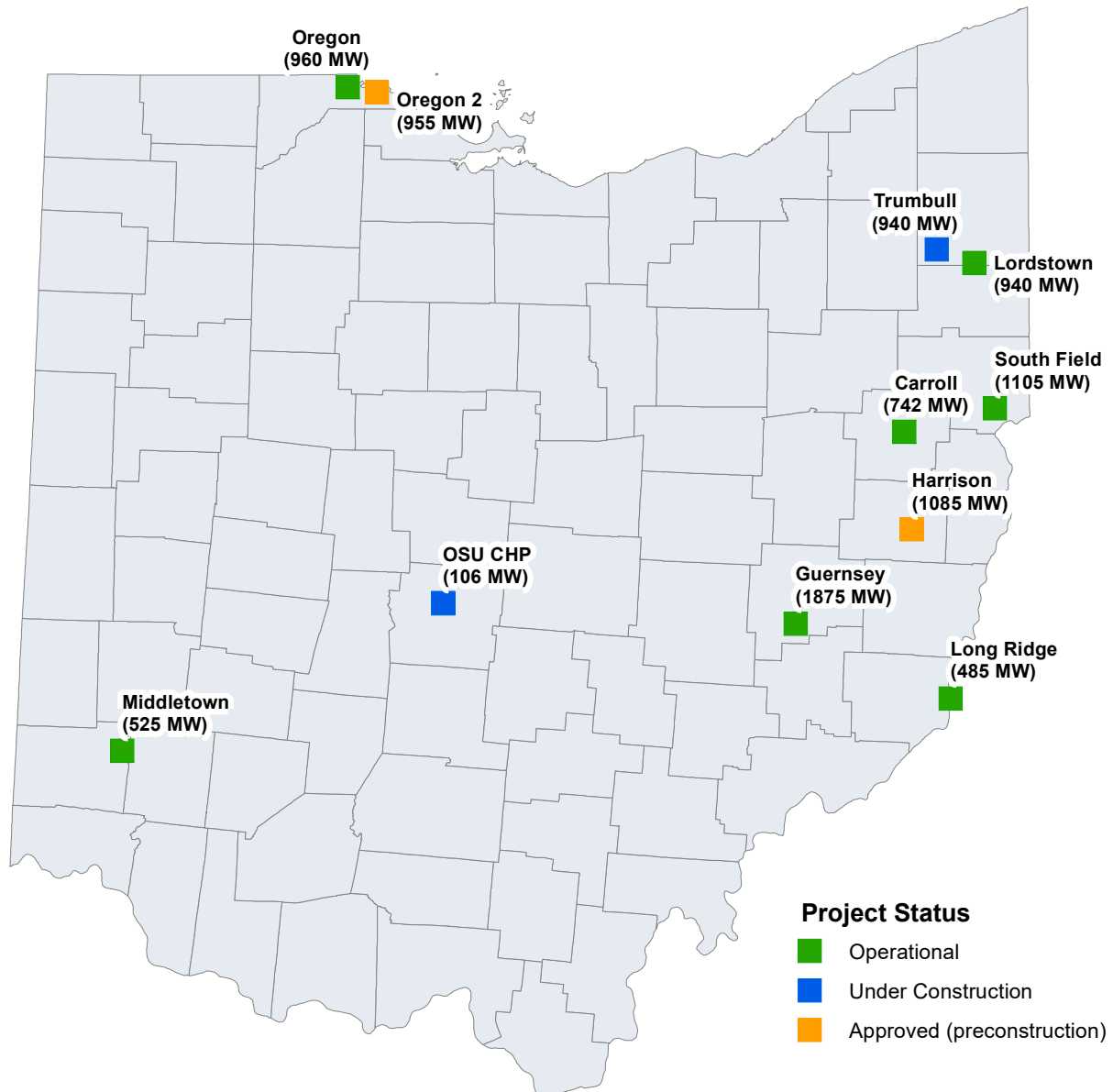
<sup>37</sup> General Electric. (2023, June 7). *GE-Powered Guernsey Power Station Delivers 1.8 GW of Electricity to Help Coal-to-Gas Transition in Ohio*. <https://www.ge.com/news/press-releases/ge-powered-guernsey-power-station-delivers-18-gw-of-electricity-to-help-coal-to-gas>



for which was also included in a previous Shale Dashboard) continued into the second half of 2023, although it was partially operational as of August 2023, providing chilled water and hot water to a handful of facilities on the university’s main campus.<sup>38</sup>

The 10 current and projected natural gas-powered facilities across 8 locations, along with the CHP project at Ohio State, are set forth in Figure 7 below.

**Figure 7: Existing and Projected Natural Gas Power Plants**



Source: Ohio Power Siting Board (2023)

<sup>38</sup> See Ohio State University Board of Trustees. (2023, August 17). Master Planning and Facilities Committee Meeting. [https://trustees.osu.edu/sites/default/files/documents/2023/08/0\\_public\\_materials\\_mpf\\_aug2023.pdf](https://trustees.osu.edu/sites/default/files/documents/2023/08/0_public_materials_mpf_aug2023.pdf)

## 2. Other Downstream Investment

### a. Petrochemical

Tessengerlo Kerley broke ground in August 2022 on a \$44 million facility in Defiance that will use natural gas as a feedstock to produce the company's range of liquid fertilizers.<sup>39</sup> Investment related to this project is included in this report. As previously reported, Nutrien plans to expand production capacity of Urea Ammonium Nitrate—a natural gas derivative—at its Lima complex as part of \$260 million in board-approved brownfield expansion projects across five nitrogen production sites in the United States and Canada.<sup>40</sup> This investment will continue to be tracked and included in a future shale report.

### b. Transportation

Six public liquefied petroleum gas (LPG) fueling stations opened across the state in the second half of 2022.<sup>41</sup> Most of these stations are located at U-Haul self-storage and vehicle rental locations as part of the company's efforts to convert medium and heavy-duty fleets from gasoline and diesel to LPG, also known as Autogas.<sup>42</sup> Costs for equipment purchases and site work for LPG refueling stations such as those installed during the Study period are around \$300,000 per station, for a total investment of \$1.8 million across six stations.<sup>43</sup> An additional five LPG stations became operational in the first half of 2023 and will be included in the next shale report.

### c. Hydrogen

The Battelle-led Appalachian Regional Clean Hydrogen Hub (ARCH2) consortium—composed of private, public, and non-profit sector participants from across parts of Ohio, West Virginia, Kentucky, and Pennsylvania—has been selected by the Department of Energy (DOE) to receive up to \$925 million to accelerate the commercial-scale deployment of clean hydrogen in the region.<sup>44</sup> The funding—stemming from 2021's Infrastructure Investment and Jobs Act—will catalyze at least the same amount in private investment under a 50 percent minimum cost matching requirement. The region's ample access to low-cost natural gas and CO<sub>2</sub> storage

<sup>39</sup> See Tessenderlo Kerley, Inc. (2022, August 31). *Tessengerlo Kerley, Inc. Celebrates Groundbreaking in Ohio for Fertilizer Facility*. <https://www.tkinet.com/en/defiance-ohio-groundbreaking>.

See also JobsOhio. (2022, January 31). *New Multi-Million Dollar Fertilizer Plant Coming to Northwest Ohio*. <https://www.jobsohio.com/news-press/new-multi-million-dollar-fertilizer-plant-coming-to-northwest-ohio>

<sup>40</sup> Nutrien. (January 2023). *Investor Presentation*. <https://nutrien-prod-asset.s3.us-east-2.amazonaws.com/s3fs-public/uploads/2023-01/Investor%20Presentation%202023-01%20FINAL.pdf>.

<sup>41</sup> Alternative Fuels Data Center. (2023). *Locate Stations [Station Data by State]*. [https://afdc.energy.gov/data\\_download](https://afdc.energy.gov/data_download).

<sup>42</sup> See U-Haul. (n.d.). *Propane AutoGas Trip Planner [What is Propane AutoGas Fleet?]*. <https://www.uhaul.com/Propane/AutoGas>. See also U-Haul. (n.d.). *Beginner's Guide to Autogas Vs. Gasoline*. <https://www.uhaul.com/Tips/Propane/Beginners-Guide-To-Autogas-Vs-Gasoline-18268/>

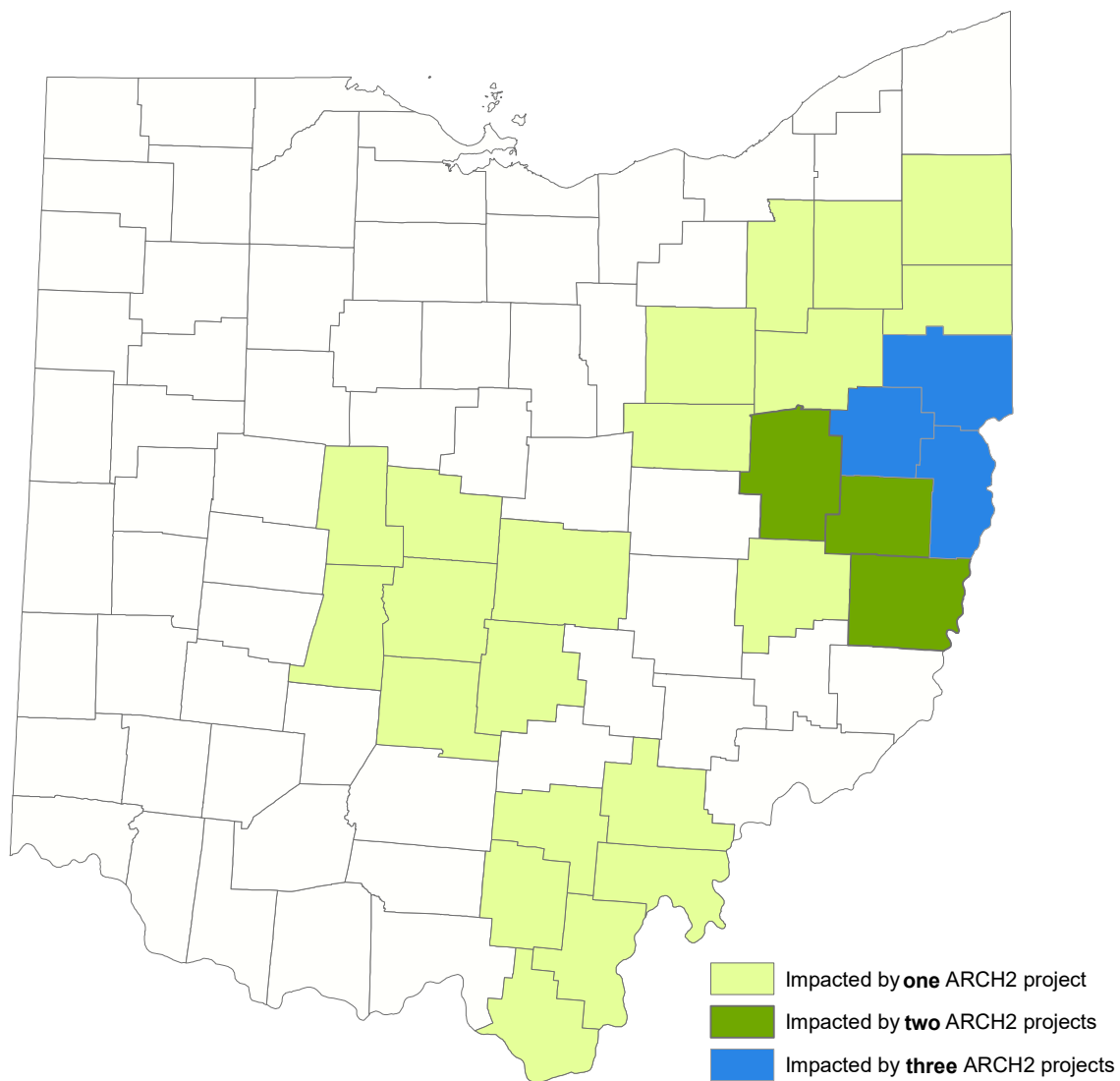
<sup>43</sup> See <https://www.uhaul.com/Propane/AutoGas/>

<sup>44</sup> See <https://www.whitehouse.gov/briefing-room/statements-releases/2023/10/13/biden-harris-administration-announces-regional-clean-hydrogen-hubs-to-drive-clean-manufacturing-and-jobs/>

capacity are expected to be key drivers in realizing low-cost *clean hydrogen*.<sup>45</sup> While final funding details are currently being negotiated with DOE, Battelle has released a preliminary high-level mapping of where ARCH2 projects that integrate clean hydrogen production and end-use will be located within Ohio.<sup>46</sup> (See Figure 8). Such projects that fall within the scope of upstream, midstream, or downstream activities will be tracked for inclusion in future shale reports.

Cumulative downstream investments reported to date in Ohio, including 2011 through the second half of 2022, 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.

**Figure 8: Ohio Counties Impacted by Planned ARCH2 Clean Hydrogen Projects**



<sup>45</sup> See <https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations>. The DOE’s clean hydrogen production standard (CHPS) targets 4 kg of CO<sub>2</sub>-equivalent or less per kilogram of generated hydrogen (see <https://www.hydrogen.energy.gov/library/policies-acts/clean-hydrogen-production-standard>).

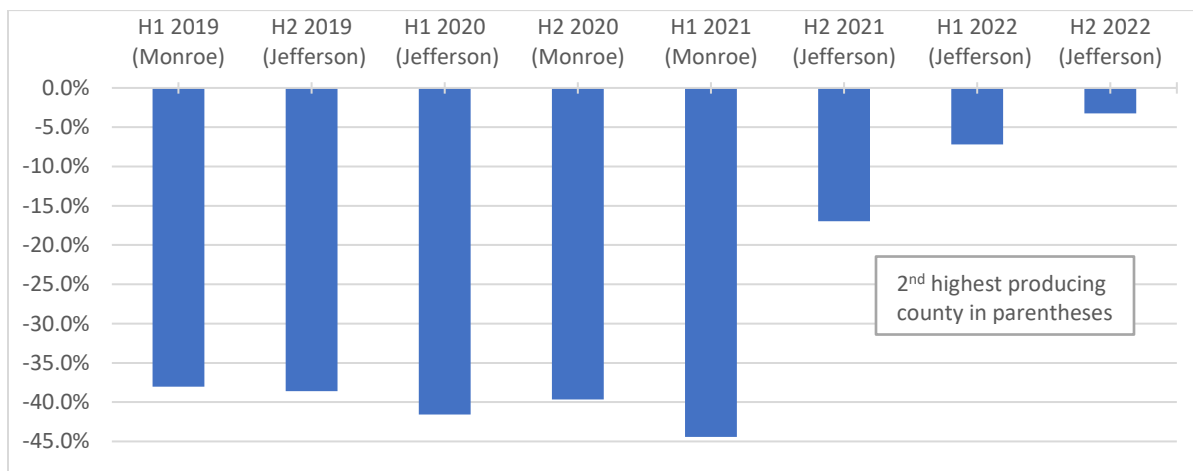
<sup>46</sup> See <https://www.arch2hub.com/about/why-arch2/>

### 3. CONCLUSION

Total upstream shale investment in Ohio was down somewhat (-14.3%) for the second half of 2022 compared to the first half of the year. This was due to a noticeable decline in the number of new wells drilled, as gas-equivalent production—along with the associated royalties—slightly increased (+1.1%) during this time frame. At the same time, the second half of 2022 saw a relatively high number of previously drilled wells being completed and put into production.<sup>47</sup> The number of new wells drilled subsequently rebounded (+13.6%) in the first half of 2023 compared to the latter half of 2022.

Southerly Belmont County again led all counties in production. However, more northerly Jefferson County trailed in production by the smallest margin of any county since the advent of these shale reports. (See Figure 9 for comparison of recent production history to Belmont County.) This increase in relative production has coincided with Jefferson County’s lead in new well development over the last few years.<sup>48</sup> Altogether, upstream shale investment totaled nearly \$2.4 billion for the second half of 2022.

**Figure 9: % Less Production for 2nd Highest Producing County Compared to Belmont County**



Data Source: ODNR (2023).

Midstream investments remained steady for the second half of 2022, increasing moderately (+10%) from spending during the first half of the year. Gathering system buildout continued during the Study period, with an estimated investment of \$14.2 million for pipelines, \$21.1 for compression, and \$5.6 million for dehydration. Construction on the \$161 million Ohio Valley Connector Expansion project to enhance takeaway capacity out of the region—\$19 million of which is expected to be spent in Ohio—commenced in Q3 2023. Additional midstream spending expected to start in the second half of 2023 includes DT Midstream’s \$100 million gathering system buildout to transport gas from Utica wells to interstate pipelines such as NEXUS.

<sup>47</sup> Investment for these completed wells was included in previous shale reports.

<sup>48</sup> From the beginning of 2020 through the end of 2022, the Study Team tracked 128 new wells in Jefferson County. Harrison County was second with 92 new wells during this time frame, followed by Belmont County with 83.

The second half of 2022 saw downstream investment resume after a pause during the first half of the year. Spending for this segment included \$44 million for construction on a plant in Defiance that will convert natural gas to fertilizer. Additionally, six LPG fueling stations representing a total investment of around \$1.8 million were placed into service during the Study period. Foundation work (i.e., concrete pouring) started in the second half of 2023 for the \$1.2 billion Trumbull Energy Center power plant. DOE's recent award of up to \$925 million to develop a clean hydrogen hub that leverages the region's abundant natural gas resources will spur additional matching private investment—up to \$6 billion in combination with upstream and midstream-related projects by some estimates—beyond 2023.<sup>49</sup>

Altogether, shale-related investment in Ohio for the second half of 2022, including upstream, midstream, and downstream, was around \$2.5 Billion. Cumulative total shale related investment since 2012 is around \$103.1 billion.

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<sup>49</sup> See West Virginia Press Association. (2023, October 13). *Manchin Announces West Virginia Selected as New Home of Appalachian Hydrogen Hub*. <https://wvpress.org/wvpa-sharing/manchin-announces-west-virginia-selected-as-new-home-of-appalachian-hydrogen-hub/>

## About the Study Team

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### **About the Energy Policy Center**

The Energy Policy Center is housed within the Maxine Goodman Levin School 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 10: Total Utica Production in Bcfe (Gas Equivalence) by County through December 2022

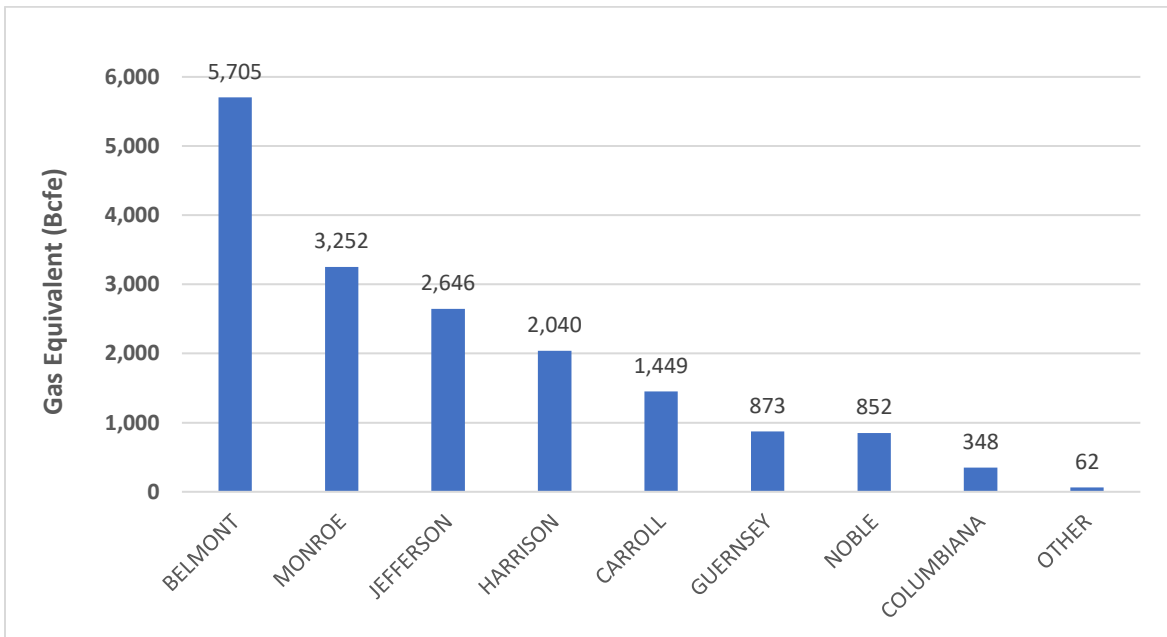
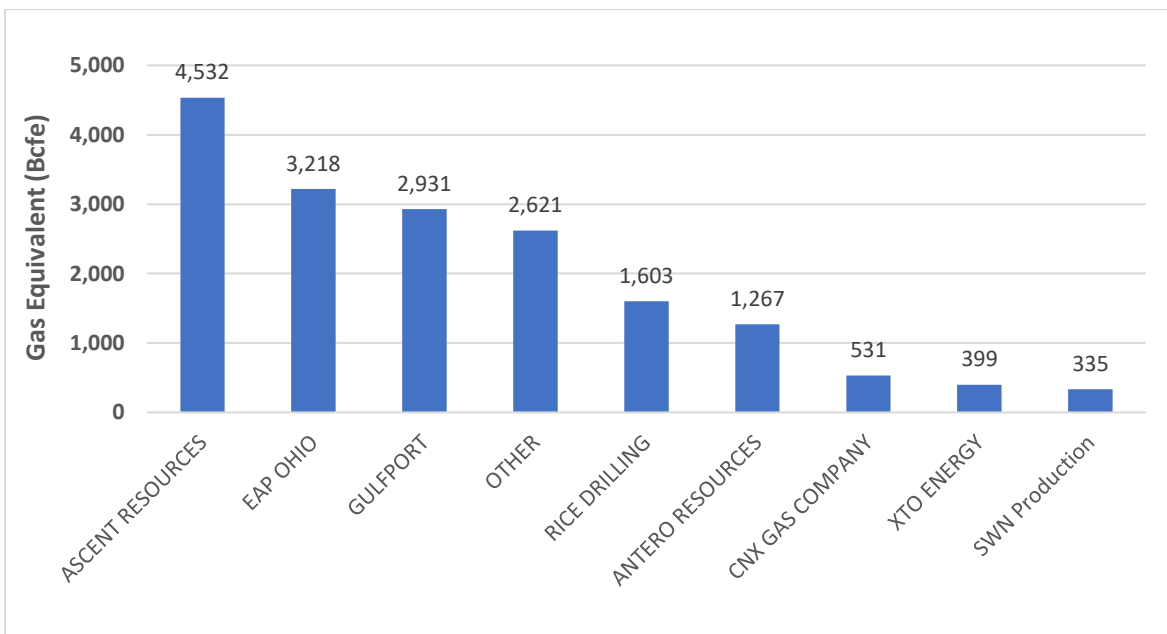
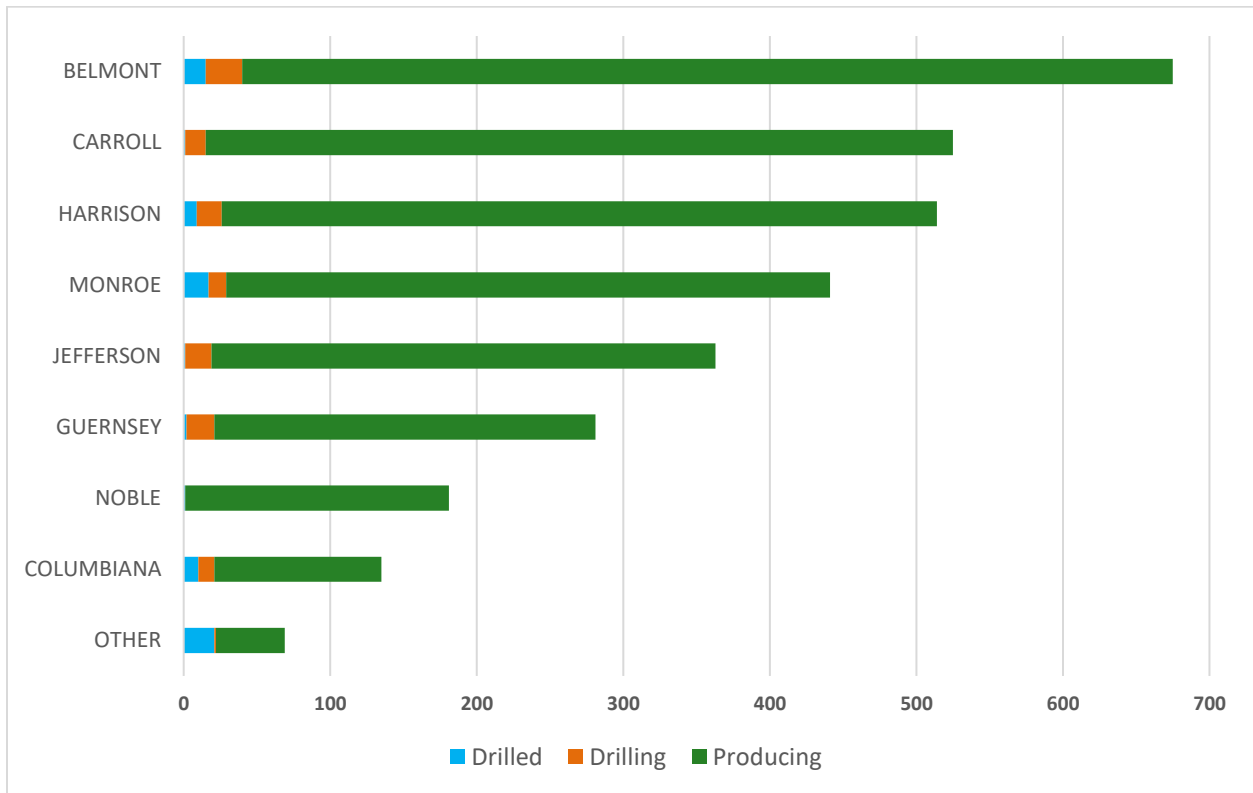


Figure 11: Total Utica Production in Bcfe by Operator through December 2022



**Figure 12: Cumulative Number of Wells by County through December 2022**



Source: Ohio Department of Natural Resources (December 2022)



Figure 13: Distribution of Gas Equivalent Production for 2011 through December 2022

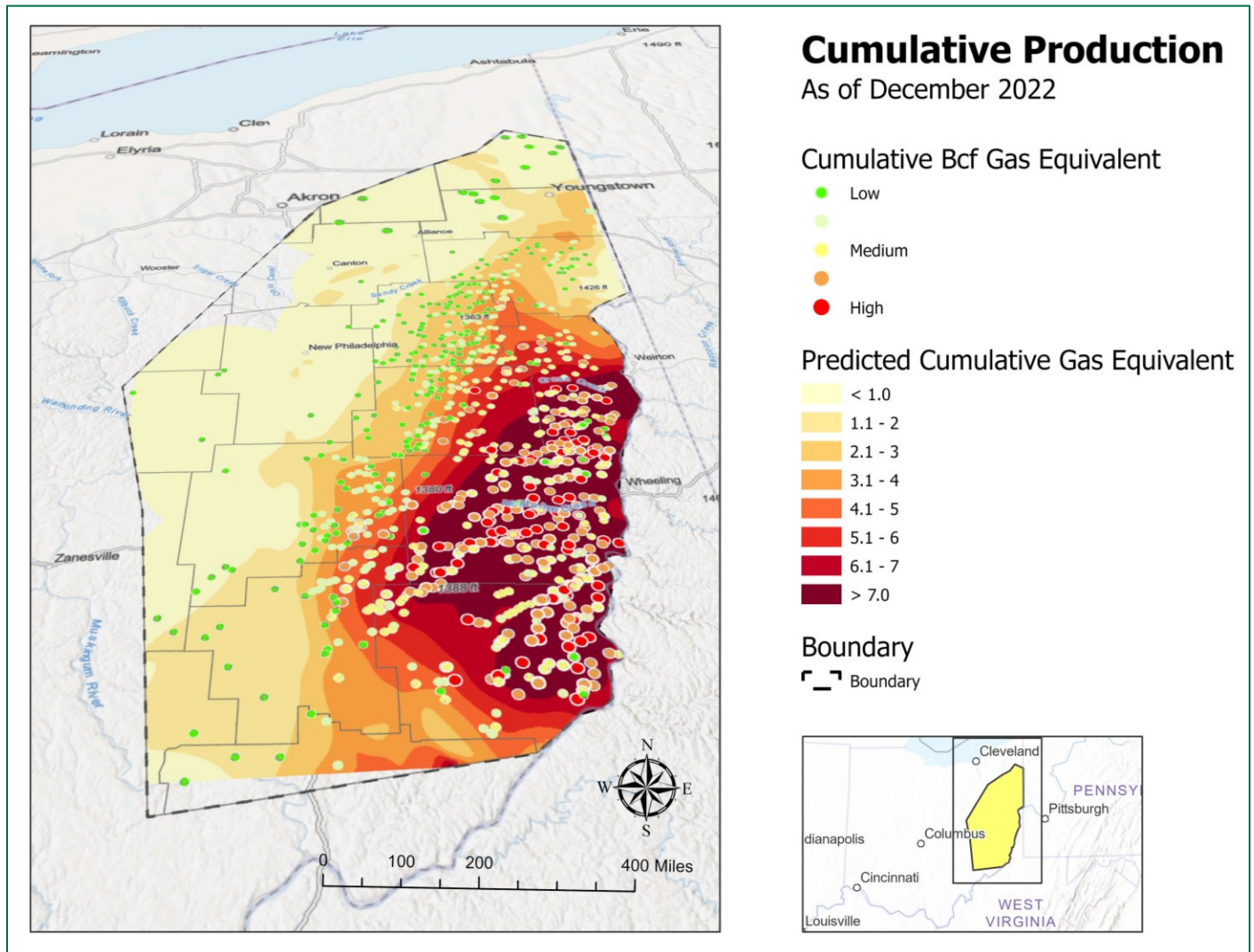
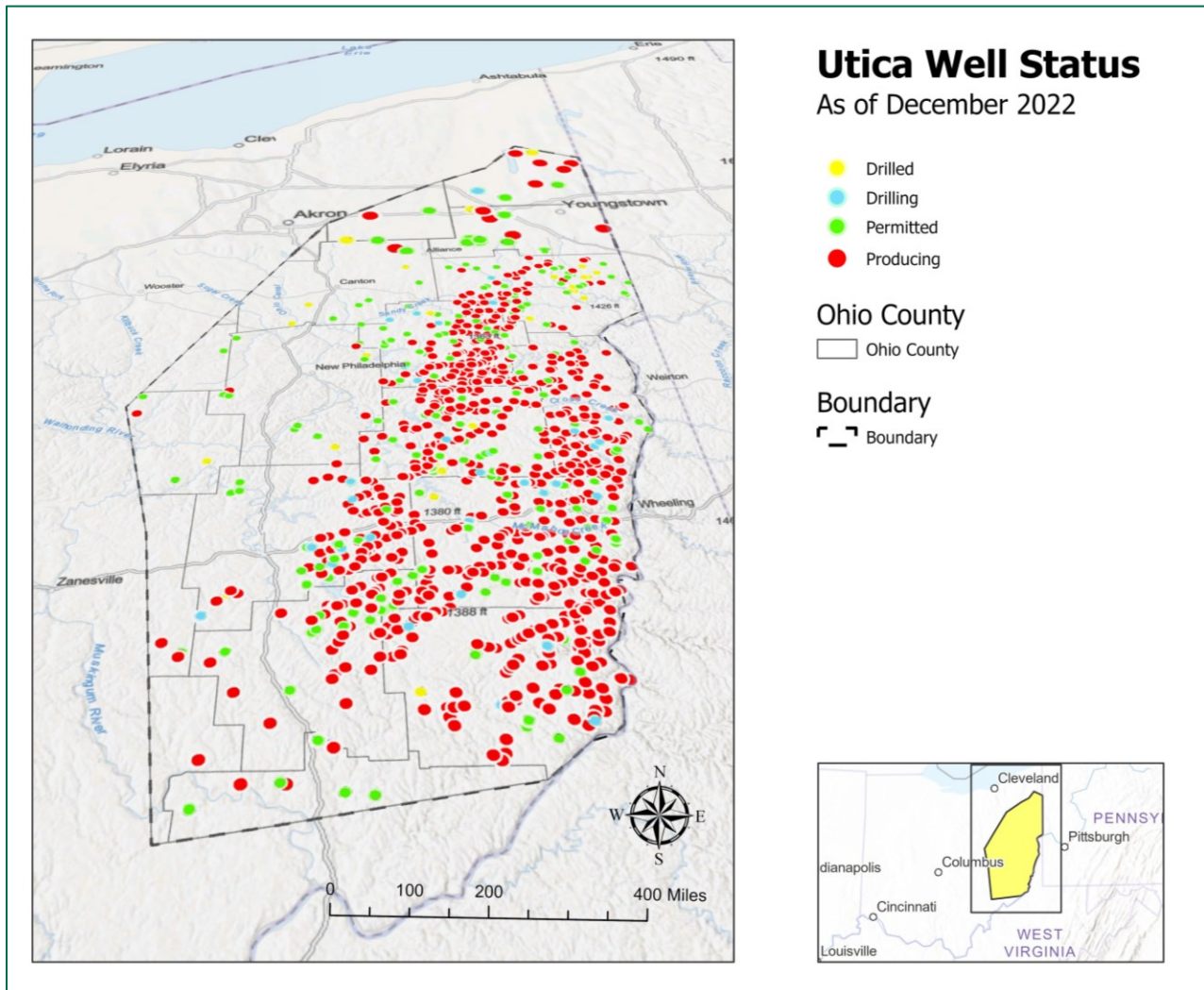


Figure 14: Distribution of Utica Wells by Status as of December 31, 2022



Source: ODNR (2023)

**Table 15: Utica Upstream Companies Drilling in Ohio as of December 31, 2022**

<b>Operator</b>	<b>Cumulative no. of Wells</b>
EAP OHIO LLC	943
ASCENT RESOURCES UTICA LLC	837
GULFPORT APPALACHIA LLC	438
ANTERO RESOURCES CORPORATION	242
SWN Production (Ohio) LLC	214
RICE DRILLING D LLC	149
HILCORP ENERGY COMPANY	55
CNX GAS COMPANY LLC	46
INR OHIO LLC	45
EQUINOR USA ONSHORE PROPERTIES INC.	42
UTICA RESOURCE OPERATING LLC	37
DIVERSIFIED PRODUCTION LLC	31
EOG RESOURCES INC.	25
PIN OAK ENERGY PARTNERS LLC	25
GEOPETRO LLC	17
GULFPORT ENERGY CORPORATION	12
NORTHWOOD ENERGY CORP	6
Holbrook LLC	4
CHESAPEAKE EXPLORATION LLC	3
DEVON ENERGY PRODUCTION CO LP	3
BRAMMER ENGINEERING INC	2
EQT PRODUCTION COMPANY	2
SUMMIT PETROLEUM INC	2
AMERICAN ENERGY UTICA LLC	1
ARTEX ENERGY GROUP LLC	1
BP AMERICA PRODUCTION COMPANY	1
ECLIPSE RESOURCES I LP	1
<b>Grand Total</b>	<b>3,184</b>

Note: Cumulative Number of Wells are calculated based upon the total number Drilled, Drilling, and Producing. Source: ODNR (December 31, 2022).

Table 16: Total Lease Operating Expenses through December 2022 (in millions)

Year	Period	Production Wells	Lease Operating Expenses for Period (\$mm)
2022	Q3 and Q4	3,024	150.2
2022	Q1 and Q2	2,886	178.6
2021	Q3 and Q4	2,791	151.8
2021	Q1 and Q2	2,806	205.7
2020	Q3 and Q4	2,705	206.1
2020	Q1 and Q2	2,610	266.2
2019	Q3 and Q4	2,497	262.2
2019	Q1 and Q2	2,273	228.0
2018	Q3 and Q4	2,200	231.0
2018	Q1 and Q2	1,874	191.2
2017	Q3 and Q4	1,818	121.8
2017	Q1 and Q2	1,588	141.3
2016	Q3 and Q4	1,467	101.2
2016	Q1 and Q2	1,355	97.6
2015	Annual	1,034	148.9
2014	Annual	612	88.1
2013	Annual	237	34.1
2012	Annual	82	3.0
2011	Annual	9	0.3
		<b>Total</b>	<b>2,807.3</b>

**Table 17: Cumulative Utica-Related Upstream Investments in Ohio through December 2022**

<b>Estimated Investments</b>	<b>Total Amount</b>
Mineral Rights	\$25,796,391,000
Drilling	\$30,513,000,000
Roads	\$1,123,960,730
Lease Operating Expenses	\$2,807,371,342
Royalties	\$12,992,443,000
<b>Total</b>	<b>\$73,233,166,072</b>

**Table 18: Cumulative Utica-Related Midstream Investments in Ohio through December 2022**

<b>Estimated Investments</b>	<b>Total Amount</b>
Midstream Gathering	\$7,848,214,000
Processing Plants	\$1,259,300,000
Fractionation Plants	\$1,697,360,000
NGL Storage	\$261,000,000
Rail Loading Terminals	\$150,270,000
Transmission Pipelines	\$10,304,128,000
<b>Total</b>	<b>\$21,520,272,000</b>

**Table 19: Cumulative Utica-Related Downstream Investments in Ohio through Dec. 2022**

<b>Estimated Investments</b>	<b>Total Amount</b>
Petrochemical Plants and Refineries	\$679,443,000
Other Industrial Plants	\$760,000,000
Natural Gas Refueling Stations	\$80,475,000
Natural Gas Power Plants	\$6,442,500,000
Combined Heat and Power (CHP) Plants	\$377,370,000
<b>Total</b>	<b>\$8,339,788,000</b>

## 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:
  - Drilling and completion costs of \$8.2 mm/well.<sup>50</sup>
  - Equivalent true vertical depth (TVD) for wells in all counties.
  - Average drilling and completion costs of \$600 per lateral foot.<sup>51</sup>
  - Average lateral length of 13,600 ft.<sup>52</sup>
- Roads: average investments - approximately \$119,000 per well based on recent OOGA reports and data for 2021 from engineer's office in Carroll, Noble, and Monroe counties.<sup>53</sup>

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, 2022, from the number existent as of December 31, 2022. This information was downloaded from the ODNR's weekly *Combined Utica/Point Pleasant Shale Permitting Report*.<sup>54</sup>

**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,

<sup>50</sup> 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 drilled since January 2020 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. Also, the same review of drilling surveys indicated that laterals for new wells in southern counties were not longer on average than for those in the north, contrary to prior analyses of lateral lengths by county. Indeed, laterals for wells in northern counties were found to be about 600 feet longer on average than those in the south, although this difference would likely not lead to significant cost differences.

<sup>51</sup> Based on Ascent Resources' and Antero Resources' recent estimated drilling costs per lateral foot in the Appalachian Basin. See PR Newswire. (2022, March 10). *Ascent Resources Utica Holdings, LLC Reports Fourth Quarter and Year-End 2021 Operating and Financial Results and Issues Initial 2022 Guidance*. <https://www.prnewswire.com/news-releases/ascent-resources-utica-holdings-llc-reports-fourth-quarter-and-year-end-2021-operating-and-financial-results-and-issues-initial-2022-guidance-301500382.html>. See also PR Newswire. (2021, February 17). *Antero Resources Reports Fourth Quarter Results, Announces 2021 Guidance, Proved Reserves and Drilling Partnership*. <https://www.prnewswire.com/news-releases/antero-resources-reports-fourth-quarter-results-announces-2021-guidance-proved-reserves-and-drilling-partnership-301230367.html>.

<sup>52</sup> Calculated using well completion reports obtained from the ODNR's *Ohio Oil & Gas Well Database*.

<sup>53</sup> See fn 17, *supra*.

<sup>54</sup> Ohio Department of Natural Resources. (2023). *Horizontal Wells*. <https://ohiodnr.gov/business-and-industry/energy-resources/oil-and-gas-wells/horizontal-wells>



processing and disposal of produced water, among other expenses. Lease operating expenses for Utica wells were estimated to be a production-based \$0.131/Mcf-equivalent. This average expense was developed by the Study Team based on analysis of Ascent’s and Gulfport’s lease operating expenses in the Utica for the second half of 2022 as reported in their quarterly financial statements.<sup>55</sup>

**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.<sup>56</sup>
- The residue energy content was around 1.1 MMBtu/Mcf.<sup>57</sup>
- Residue gas in the Utica was selling at an average price of \$7.04/MMBtu for Q3 and \$4.52/MMBtu for Q4.<sup>58</sup> These prices were used to estimate royalties.
- Around 44 barrels of liquids were recovered per million cubic feet of gas produced.<sup>59</sup>
- Natural gas liquids were selling for around 30% of the listed price for Marcellus-Utica light crude oil.<sup>60</sup>
- Oil in the Utica region was selling for \$81.87 and \$72.53 per barrel, on average, during the third and fourth quarters of 2022, respectively.<sup>61</sup>
- Royalty rates are 20% of gross production.

<sup>55</sup> See Ascent Resources’ financial reports at <https://ascentresources.com/financials>. See also Gulfport Energy’s financial reports at <https://www.gulfportenergy.com/investors/sec-filings/quarterly-reports>.

<sup>56</sup> Based on industry interviews, experts citing API 12.3, Manual of Petroleum Measurements and Standards.

<sup>57</sup> EIA estimates a conversion rate of 1.037 MMBtu/Mcf (see <https://www.eia.gov/tools/faqs/faq.php?id=45&t=8>). However, industry interviews suggest 1.1 is closer to the average conversion for the Utica Shale.

<sup>58</sup> Reflects average price across the Columbia Gas, Eastern Gas South, and Texas Eastern M-2 trading hubs as derived from ICE trade data published by Snyder Brothers Gas Marketing at <https://www.snyderbrothersinc.com>. 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>

<sup>59</sup> Based on industry data.

<sup>60</sup> Based on industry interviews.

<sup>61</sup> 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>

**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. In prior studies, based upon the assumption that most undeveloped acreage was in the primary term of the least, we assumed that approximately 20% of the undeveloped acreage identified will need to be renewed each year or is otherwise new.<sup>62</sup> Since this Study covered six months, we assumed that half of this 20% was renewed or new during the Study period. However, as units have developed in the Utica, we have changed this estimate going forward to assume that 25% of the operator's total acreage is in its primary term, and that 20% of this acreage must be renewed or replaced very year (10% for a six-month period). This estimate may be high insofar as companies are not renewing or replacing all their primary term acreage. However, it may also be low insofar as the studies have only identified net acreage for the top six to nine operators in Ohio and may not be capturing all of the non-operator net acreage. (Acreage status 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 Ohio and US 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 \$4,631 for the Midwest

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<sup>62</sup> 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.



Region as projected by the Interstate Natural Gas Association of America (INGAA) for 2022 after adjusting for inflation.<sup>63</sup>

The approximate capital cost for TEG dehydration units based on throughput was obtained from Carroll's *Natural Gas Hydrates: A Guide for Engineers* (2014, 3<sup>rd</sup> 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: \$3,542 per bbl/d<sup>64</sup>
- 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.

For this report, up-to-date cost projections for natural gas transmission and gathering line pipelines, per inch-mile, was obtained from the INGAA. The estimated cost for natural gas pipelines for the Midwest Region as used in this analysis was \$237,353 per inch-mile, which included labor, raw materials, and permitting costs, as projected by the INGAA for 2022 after adjusting for inflation.<sup>65</sup>

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

<sup>63</sup> See The INGAA Foundation, Inc. (2018). *North America Midstream Infrastructure through 2035*. <https://ingaa.org/wp-content/uploads/2018/06/34703.pdf>. INGAA's projections for midstream infrastructure costs are in 2016 dollars. These projections were converted to 2022 dollars using the Bureau of Labor Statistics' Producer Price Index for *Other Pipeline Transportation* (available at <https://fred.stlouisfed.org/series/PCU48694869>).

<sup>64</sup> The Study Team reviewed the published investment costs and throughput capacities of eight different fractionation facilities that have been developed since 2018, all of which are in Texas. The assumed unit cost for fractionation reflects the median investment per barrel of processing capacity per day for these eight facilities. See the following examples: Targa Resources Inc.'s Mont Belvieu fractionation facilities (<https://www.naturalgasintel.com/targa-building-two-new-fractionation-trains-at-mont-belvieu/>); Phillip 66's Sweeny fractionation facilities ([https://s22.q4cdn.com/128149789/files/doc\\_presentations/2019/11/Investor-Day-Slides-for-Website-11.06.2019-vF.pdf](https://s22.q4cdn.com/128149789/files/doc_presentations/2019/11/Investor-Day-Slides-for-Website-11.06.2019-vF.pdf)).

<sup>65</sup> See fn 62, *supra*.

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— 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 15 shows the primary intermediates and products that can be manufactured from the main hydrocarbon components in shale gas as part of downstream production.<sup>66</sup>

<sup>66</sup> See U.S. Department of Energy. (June 2020). *The Appalachian Energy and Petrochemical Renaissance: An Examination of Economic Progress and Opportunities*. [https://www.energy.gov/sites/prod/files/2020/06/f76/Appalachian%20Energy%20and%20Petrochemical%20Report\\_063020\\_v3.pdf](https://www.energy.gov/sites/prod/files/2020/06/f76/Appalachian%20Energy%20and%20Petrochemical%20Report_063020_v3.pdf)

Figure 15: Shale/Natural Gas Value Chain for Petrochemicals

