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Shale Investment Dashboard in Ohio Q1 and Q2 2017

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Executive Summary

This report presents findings from an investigation into shale-related investment in Ohio. The investment estimates are cumulative from January through June of 2017. Prior investments have previously been reported and are available from Cleveland State University.[1] Subsequent reports will estimate additional investment since the date of this report.

Investment in Ohio into the Utica during the first half of 2017 can be summarized as follows:

Total Estimated Upstream Utica Investment: January-June 2017

Lease Renewals	**$1,615,400,000**
Drilling	**$1,521,000,000**
Roads	**$81,000,000**
Near Lease Gathering Lines	**$243,000,000**
Lease Operating Expenses	**$141,340,000**
Royalties	**$436,160,000**
Total Estimated Upstream Investment	**$4,037,900,000**

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

Total Estimated Midstream Investment: January-June, 2017

Gathering Lines	**$9,000,000**
Gathering System Compression and Dehydration	**$59,000,000**
Fractionation Plants	**$168,000,000**
Transmission Lines	**$4,709,000,000**
Total Estimated Midstream Investment	**$4,945,000,000**

Total Estimated Downstream Investment: January-June, 2017

Ethane Cracker Plants	**$13,800,000**
Methanol Plants	**$55,000,000**
Natural Gas Refueling Stations	**$2,000,000**
Natural Gas Power Plants	**$0**
CHP Plants	**$0**
Total Estimated Downstream Investment	**$70,800,000**

Total investment from January through June 2017 is approximately $9.05 billion, including upstream, midstream and downstream. This does not include indirect development, such as development into new manufacturing as a result of lower energy costs. Together with previous investment to date, cumulative investment in Ohio through the first half of 2017 is estimated to be around $63.9 billion. Of this, $46.8 billion was in upstream, $13.6 billion in midstream, and $3.5 billion was in downstream industries.

The major shale story for the first half of 2017 in Ohio has been the investment into midstream infrastructure, especially for pipelines. Construction began during this period of time into natural gas, natural gas liquid and oil pipeline transmission systems which lead to an investment of over $4.7 billion. Of course many of these projects continued past June of 2017, and are ongoing.

However upstream investment continued to be significant in the first half of 2017, especially in the southern part of the Utica Shale formation. The industry investment strategy for Ohio is readily apparent from the Ohio Department of Natural Resources Division of Oil and Gas (ODNR) listing of new wells during this time. In the first several years of development, the principal Utica drilling activity had been in Carroll County. By the first half of 2017, however, the ODNR had listed 162 new wells as “drilled, drilling or producing” during this period. Of this number, none were drilled in Carroll County. On the other hand, 58 and 49 new wells were listed for Belmont and Monroe counties, respectively.

Gulfport Energy was the top producer for Q1 and Q2 of 2017, having produced 174 billion cubic feet equivalent (Bcfe). Chesapeake Appalachia was second in production at 143 Bcfe, followed by Ascent Resources, Rice Drilling and Antero Resources at 115, 86, and 83 Bcfe, respectively. These five companies made up around 79% of the total production from the first half of 2017.

Downstream investment slowed as no new construction began on any natural gas-fired electric generation facilities, possibly as a result of low wholesale power prices. However, progress was made on the siting and permitting of several of the proposed generation facilities. Likewise, progress was also made in the siting of an ethane cracker in Belmont County, including the acquisition of land therefore. Finally, construction began on an ethanol plant in the Toledo area, which included an investment of around $55 million.

1. INTRODUCTION

This is the third Study reporting investment resulting from oil and gas development in Ohio related to the Utica and Point Pleasant formations (hereinafter, the "Utica"). This analysis looks at investment made in Ohio between January 1 and June 30, 2017, separately considering the upstream, midstream and downstream portions of the industry. For the upstream part, the Study Team estimated spending primarily based upon the likely costs of drilling new and operating old wells, together with royalties and lease bonuses. For midstream estimates, the Study Team looked at new infrastructure built during the relevant time period downstream of production, from gathering to the point of hydrocarbon distribution.

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

This third Study also includes as Appendix A the cumulative investment made in Ohio resulting from shale development, based upon a previous report that tracked total investment through December 2016.[2] The methodology for determining the investments is set forth in Appendix B. Subsequent reports will include incremental spending on a quarterly basis.

2. SHALE INVESTMENT UPDATES

A. UPSTREAM DEVELOPMENT

1. Background

A total of 162 new wells were listed by the Ohio Department of Natural Resources as "drilled," "drilling," or "producing" during the period of January 1 to June 30, 2017. The total number of producing wells in the Utica was at 1646 by June 30, 2017. Total production in billion cubic feet equivalent (Bcfe) for this period was 758 Bcfe, led by Belmont County with 336 Bcfe. Monroe County was second with 125 Bcfe, followed by Harrison County with 81 Bcfe.[3]

[2] *Id.*

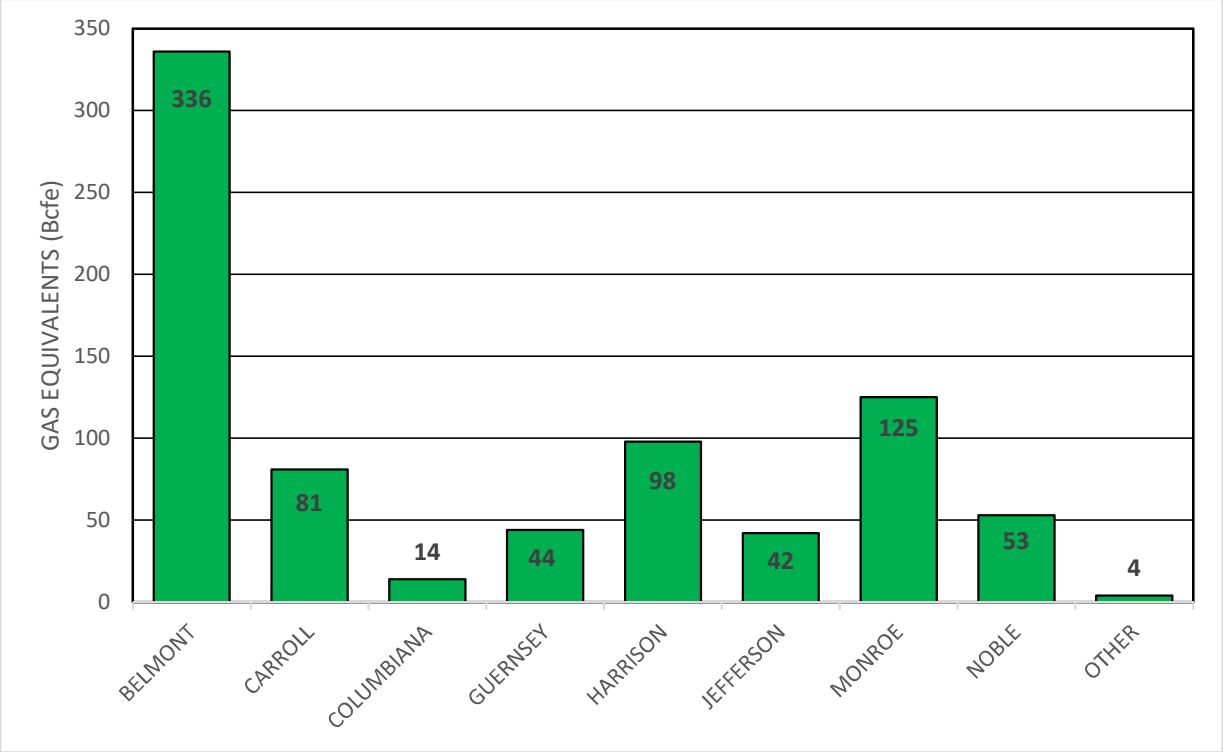
[3] Production is reported to the ODNR at the wellhead as gas measured in thousands of cubic feet (Mcf) and as oil measured in barrels (bbl). The Utica also produces significant volumes of natural gas liquids (NGLs) such as ethane, propane, butane and natural gasoline. These NGLs are separated from the natural gas stream at midstream cryogenic and fractionation plants and not included in the ODNR production reports. For the purpose of this Study, oil and gas production is combined as gas equivalents (Mcfe) based on the energy content of oil and gas, measured as British thermal units (Btu). Gas equivalents were calculated using the following formula: Gas Equivalents (Mcfe) = Oil (bbl) x 5.659 Mcf/bbl + Gas (Mcf)

The Ohio Department of Natural Resources (Division of Oil and Gas Resources Management) (ODNR) issues weekly reports on well status and quarterly reports on production. The ODNR production reports for the first and second quarters of 2017 provide the foundation for the analyses presented in this Study.

The Utica is currently identified by the ODNR as producing in nineteen eastern Ohio counties with the vast majority (ninety-nine percent) of producing wells located in twelve counties stretching from Trumbull County in the north to Washington County at the southern end of the play. Table 1 provides a summary of cumulative production and production for the first and second quarters of 2017. Total cumulative production in Bcfe by county and by operator through June 2017 can be found in Appendix A as Figures 7 and 8. New drilling and production have been moving steadily from the north (primarily Carroll County) to the south (primarily Belmont County) since 2014.

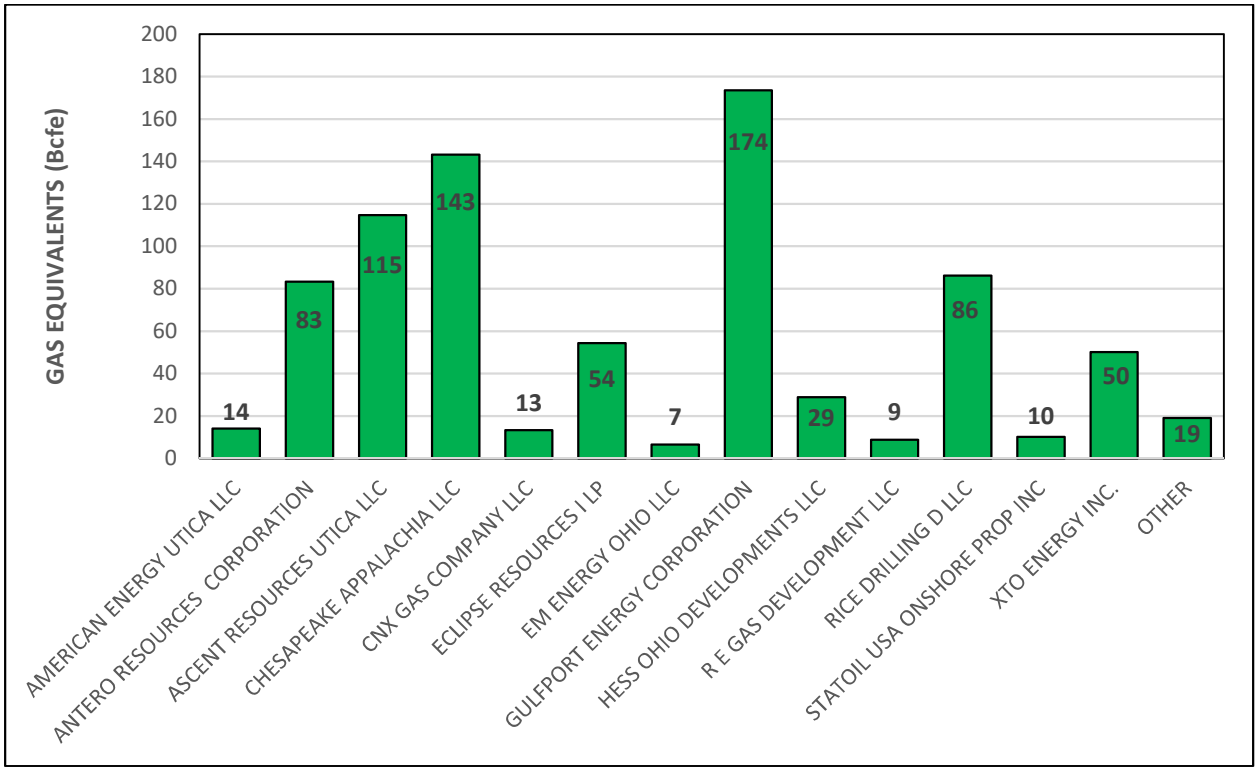
Total quarters 1 and 2 production for 2017 are set forth by county and operator in Figures 1 and 2 below.

Figure 1: Production by County for Q1 and Q2 of 2017



Source: ODNRDOG (2017), J.C. Dick (2017).

Figure 2: Production by Operator for Q1 and Q2 of 2017



Source: ODNRDOG (2017), J.C. Dick (2017).

2. Production Analysis.

A meaningful way to summarize production is through the use of tables that show gas equivalent production measured in billions of cubic feet equivalent (Bcfe) as a function of time. This summary is set forth in Table 1. Table 2 sets forth production by county for the first half of 2017. Figure 3 sets forth the geographic distribution of production for the same period.

Table 1: Production by Reporting Period

Year	Quarter	Production Wells	Gas (Mcfe)	Oil (bbl)	Gas Equivalents (Mcfe)	Gas Prod. (% Change from Previous Quarter)
2017	2	1646	387,725,175	4,019,281	410,512,053	4.8
2017	1	1530	369,913,713	3,877,717	391,904,993	2.2
2016	4	1492	362,107,422	3,568,077	382,364,866	0.4
2016	3	1442	360,681,356	3,954,095	383,057,580	7.9
2016	2	1382	334,257,982	4,839,792	361,646,365	1.4
2016	1	1328	329,537,838	5,485,854	360,582,286	9.3
2015	4	1248	301,486,508	6,248,451	336,846,492	39.0
2015	3	989	216,974,492	4,439,258	242,096,253	-2.2
2015	2	992	221,862,582	5,578,255	253,429,927	20.8
2015	1	907	183,585,256	4,432,195	208,667,049	11.4
2014	4	810	164,815,008	3,558,836	184,954,459	26.5
2014	3	688	130,282,395	2,984,534	147,171,872	48.4
2014	2	535	87,773,834	2,422,179	101,480,943	30.8
2014	1	415	67,095,693	1,928,076	78,006,674	57.2
2013	4	371	42,693,774	1,433,731	50,807,259	28.4
2013	3	269	33,255,706	1,323,812	40,747,160	123.7
2013	2	186	14,863,645	556,437	18,012,520	80.4
2013	1	117	8,237,177	321,439	10,056,202	-35.8
2012	ANNUAL	82	12,831,292	635,874	16,429,703	400.9
2011	ANNUAL	9	2,561,524	46,326	2,823,683	
		Totals	**3,632,542,372**	**61,654,219**	**3,981,598,339**	

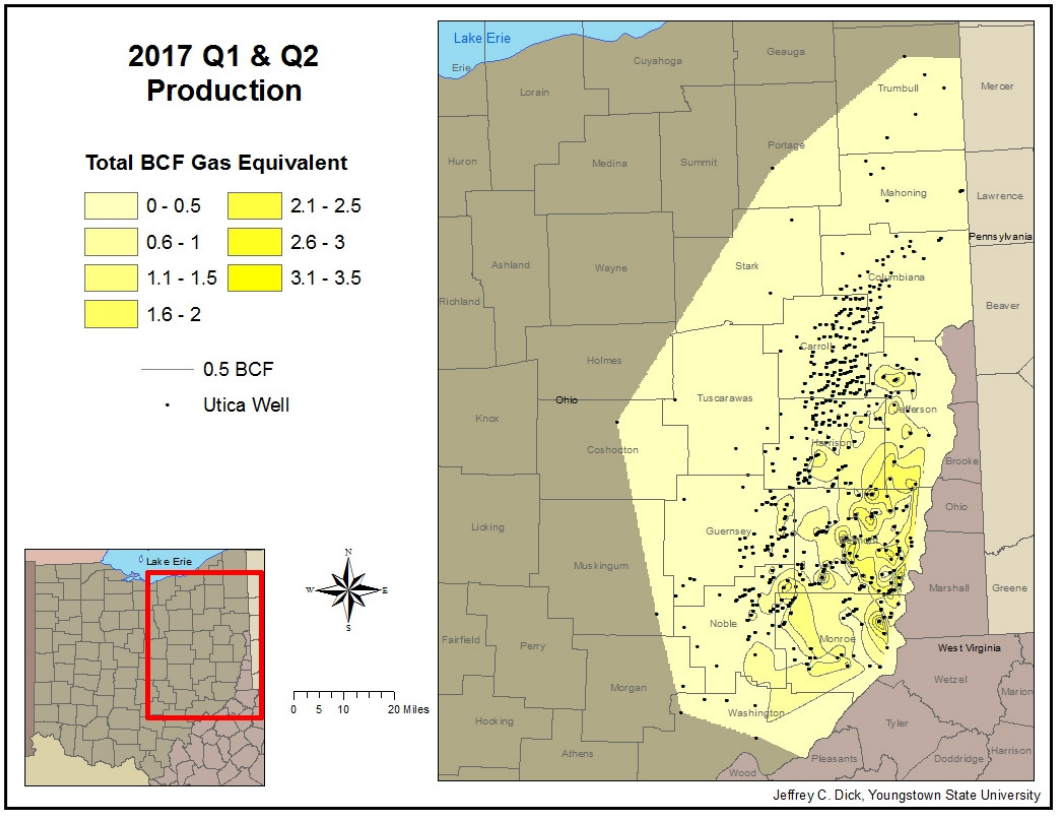
Source: ODNRDOG (2017) and J.C. Dick (2017).

Table 2: Production by County for January-June 2017

County	Gas (Mcfe)	Oil (bbl)	Gas Equivalents (Mcfe)	Production Wells
BELMONT	336,074,208	35,071	336,272,675	305
CARROLL	72,660,037	1,514,724	81,231,860	443
COLUMBIANA	13,728,398	32,788	13,913,945	70
COSHOCTON	18,860	254	20,297	1
GUERNSEY	29,036,547	2,598,079	43,739,076	144
HARRISON	80,945,420	2,996,016	97,899,875	311
JEFFERSON	41,996,225	154	41,997,096	61
MAHONING	1,133,030	5,509	1,164,205	14
MONROE	125,291,365	8,638	125,340,247	178
MORGAN	108,318	7,115	148,582	2
MUSKINGUM	23,808	663	27,560	1
NOBLE	55,056,385	659,825	58,790,335	139
PORTAGE	6,175	187	7,233	5
STARK	657,119	34,111	850,151	2
TRUMBULL	261,569	2,333	152,753	10
TUSCARAWUS	157,823	15,609	246,154	7
WASHINGTON	1,160,351	18,056	1,262,530	11
Totals	**758,315,638**	**7,929,132**	**803,064,576**	**1,704**

Source: ODNRDOG (2017), J.C. Dick (2017)

Figure 3: Distribution of Gas Equivalent Production for January-June 2017



Of the 2,039 total wells identified from the ODNR records, 179 were in the process of drilling in July of 2017, 273 wells had been drilled and apparently were awaiting markets, and 1,587 wells were in the production phase. *See* Table 3, Ohio Utica Well Status. Carroll County continues to lead in total wells (*see* Table 4), even though it has been surpassed in total production.

Table 3: Ohio Utica Well Status – July 1, 2017

Well Status	
Drilled	273
Drilling	179
Producing	1,587

Source: Ohio Department of Natural Resources (July, 2017)

Table 4: Well Status by County (July 2017)

County	Drilled	Drilling	Producing	Total
CARROLL	20	5	438	463
HARRISON	24	8	298	330
BELMONT	52	52	271	375
MONROE	74	58	149	281
GUERNSEY	18	19	139	176
NOBLE	19	13	134	166
COLUMBIANA	16	0	63	79
JEFFERSON	25	21	51	97
MAHONING	1	0	13	14
WASHINGTON	3	0	9	12
TRUMBULL	3	1	7	11
PORTAGE	5	1	3	9
TUSCARAWAS	2	1	6	9
STARK	5	0	2	7
OTHER 7 COUNTIES	6	0	4	10
Totals	**273**	**179**	**1587**	**2039**

Source: ODNR (2017)

B. Upstream Investment Estimates

Upstream investments have been broken down into four areas: investments into drilling, lease operation (post production) expenses, bonuses and royalties. The methodology used for each calculation is set forth in Appendix B. This section covers upstream investments between January and June of 2017. Cumulative upstream investments to date in Ohio, including 2012-2016, are set forth in Table 17 of Appendix A.

1. Investments into Drilling

The following tables set forth estimated investments to date made into drilling shale wells in Ohio. Belmont County is the leader in recent upstream investment, with 58 new wells and an investment of around $696 million between January and June of 2017. Monroe and Jefferson Counties are second and third, with 49 and 27 new wells, respectively, and with $588 and $243 million invested. *See* Table 5.

Gulfport Energy was the leading operator investor during the six-month period, with 33 wells and an estimated $396 mm invested, followed by Ascent Resources with 37 wells and an estimated $387 million invested (reflecting Ascent's continued investment into the less expensive northern counties). Antero Resources and Rice Drilling drilled 21 and 20 wells, with $252 and $240 million invested, respectively. Chesapeake Exploration drilled 12 wells, with an estimated investment of $108 million. *See* Table 6.

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

County	No. of wells	Drilling	Roads	Near Lease Gathering	Total Amount ($mm)
BELMONT	58	$580.0	$29.0	$87.0	$696.0
HARRISON	4	$28.0	$2.0	$6.0	$36.0
COLUMBIANA	2	$14.0	$1.0	$3.0	$18.0
GUERNSEY	13	$130.0	$6.5	$19.5	$156.0
JEFFERSON	27	$189.0	$13.5	$40.5	$243.0
MONROE	49	$490.0	$24.5	$73.5	$588.0
NOBLE	9	$90.0	$4.5	$13.5	$108.0
Totals	**162**	**$1,521.00**	**$81.0**	**$243.0**	**$1,845.0**

Source: The Authors (2017)

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

Well Operators	No. of Wells	Drilling	Roads	Near Lease Gathering	Total ($mm)
ANTERO RESOURCES CORPORATION	21	$210.0	$10.5	$31.5	$252.00
ARTEX OIL COMPANY	1	$10.0	$0.5	$1.5	$12.00
ASCENT RESOURCES UTICA LLC	37	$313.0	$18.5	$55.5	$387.00
CHESAPEAKE EXPLORATION LLC	12	$84.0	$6.0	$18.0	$108.00
CNX GAS COMPANY LLC	11	$110.0	$5.5	$16.5	$132.00
ECLIPSE RESOURCES I LP	11	$110.0	$5.5	$16.5	$132.00
EM ENERGY OHIO LLC	4	$40.0	$2.0	$6.0	$48.00
GULFPORT BUCKEYE LLC	5	$50.0	$2.5	$7.5	$60.00
GULFPORT ENERGY CORPORATION	33	$330.0	$16.5	$49.5	$396.00
HILCORP ENERGY COMPANY	2	$14.0	$1.0	$3.0	$18.00
RICE DRILLING D LLC	20	$200.0	$10.0	$30.0	$240.00
STATOIL USA ONSHORE PROP INC	3	$30.0	$1.5	$4.5	$36.00
XTO ENERGY INC.	2	$20.0	$1.0	$3.0	$24.00
Totals	**162**	**$1,521.00**	**$81.0**	**$243.0**	**$1,845.00**

Source: The Authors (2017).

2. Lease Operating Expenses

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

Table 7: Estimated Lease Operating Expenses for January-June 2017 by County

County	No. of Production Wells[4]	Lease Operating Expenses for Period ($mm)
ASHLAND	1	0.07
BELMONT	347	24.98
CARROLL	463	33.34
COLUMBIANA	79	5.69
COSHOCTON	2	0.14
GUERNSEY	171	12.31
HARRISON	329	23.69
JEFFERSON	84	6.05
KNOX	1	0.07
MAHONING	14	1.01
MEDINA	1	0.07
MONROE	257	18.50
MORGAN	3	0.22
MUSKINGUM	1	0.07
NOBLE	162	11.66
PORTAGE	9	0.65
STARK	7	0.50
TRUMBULL	11	0.79
TUSCARAWAS	9	0.65
WASHINGTON	12	0.86
	Total	**141.32**

[4] The number of wells producing was determined by taking the average of the number of such wells as identified by ODNR on January 7, 2017 and July 1, 2017. It is assumed that this number of average production wells incurred lease operating expenses for all six months.

Table 8: Estimated Lease Operating Expenses for January-June 2017 by Operator

Operator	No. of Production Wells[5]	Lease Operating Expenses for Period ($mm)
AMERICAN ENERGY UTICA LLC	3	0.22
ANTERO RESOURCES CORPORATION	204	14.69
ARTEX OIL COMPANY	7	0.50
ASCENT RESOURCES UTICA LLC	191	13.75
ATLAS NOBLE LLC	12	0.86
BP AMERICA PRODUCTION COMPANY	1	0.07
BRAMMER ENGINEERING INC	2	0.14
CARRIZO (UTICA) LLC	13	0.94
CHESAPEAKE APPALACHIA LLC	6	0.43
CHESAPEAKE EXPLORATION LLC	714	51.41
CHEVRON APPALACHIA LLC	8	0.58
CNX GAS COMPANY LLC	62	4.46
DEVON ENERGY PRODUCTION CO	5	0.36
ECLIPSE RESOURCES I LP	97	6.98
EM ENERGY OHIO LLC	8	0.58
ENERVEST OPERATING LLC	6	0.43
EQT PRODUCTION COMPANY	8	0.58
GEOPETRO LLC	3	0.22
GULFPORT BUCKEYE LLC	4	0.29
GULFPORT ENERGY CORPORATION	283	20.38
HALCON OPERATING COMPANY INC	9	0.65
HESS OHIO DEVELOPMENTS LLC	66	4.75
HG ENERGY LLC	5	0.36
HILCORP ENERGY COMPANY	13	0.94
MOUNTAINEER KEYSTONE LLC	6	0.43
NGO DEVELOPMENT CORP.	1	0.07
PDC ENERGY INC	32	2.30
PROTEGE ENERGY III LLC	1	0.07
R E GAS DEVELOPMENT LLC	38	2.74
RICE DRILLING D LLC	82	5.90
STATOIL USA ONSHORE PROP INC	18	1.30
TRIAD HUNTER LLC	13	0.94
XTO ENERGY INC.	43	3.10
	Total	**141.41**

3. Royalties

Royalty investments have been estimated on a per quarter basis, assuming the formula set forth in Appendix B. Total estimated royalties spent on Ohio properties between January and June 2017 were around $436.2 million. The breakdown by quarter for oil, residue gas and natural gas liquids is set forth in Tables 9, 10, and 11 below. Average price for natural gas changed from $2.96/MMBtu to $3.05/MMBtu between the fall of 2016 and the spring of 2017. Oil prices changed from $46.98/bbl to $49.85/bbl during the same period.

Table 9: Total Royalties from Oil
January-June 2017 (in millions of dollars)

Year	Quarter	Oil Price $/bbl	Oil Royalty (20%) $/bbl	Royalty ($mm)
2017	2	38.10	7.62	30.63
2017	1	41.62	8.32	32.26
			Subtotal	**62.89**

[5] *See id.*

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

Year	Quarter	Residue Gas Price $/Mcf	Residue Gas Royalty (20%) $/Mcf	Royalty ($mm)
2017	2	2.08	0.42	143.30
2017	1	2.02	0.40	130.21
			Subtotal	**273.51**

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

Year	Quarter	NGL Price $/bbl	NGL Royalty (20%) $/bbl	Royalty ($mm)
2017	2	14.43	2.89	49.30
2017	1	15.49	3.10	50.46
			Subtotal	**99.76**

4. Lease Renewals

Lease renewal investments have been estimated for the Utica region based upon the drilling activity of top five drilling companies in the region, plus Ascent Resources, which company has acquired a significant leasehold in the Utica. These six companies have together drilled over 80% of the Utica wells to date, and it is assumed that they likewise have over 80% of the leases. The estimated investments into undeveloped acreage is set forth below in Table 12.

All estimates assume $5000/acre lease bonus. Only net lease acreage was used to avoid possible double counting (producing companies often collaborate on drilling), although bonuses would have been paid on the gross lease acreage. This may result in underestimating the total investment. Likewise, using only acreage from the top five drillers, plus Ascent, may also introduce some error. In addition, this estimate does not include bonuses paid on any new leases, which also may make the estimate low. Continued low prices through 2016, though, may have also induced operators to not renew some leases, which may cause the estimate to be high. Likewise, some leases were developed, meaning no renewal would be required. These numbers are the same as those estimated from the second half of 2016 because operating companies had, at the time of this Study, reported no new undeveloped acreage in their 2018 10Ks.

Table 12: Total Estimated Investments into Undeveloped Acreage January-June 2017 (in millions of dollars)

Operator	Undeveloped Acreage	Estimated Bonus Investment ($mm)
Gulfport[6]	171,919	86
Chesapeake[7]	2,514,000	1,257
Antero[8]	126,798	63.4
Rice[9]	52,049	26
Ascent[10]	300,000	150
Eclipse[11]	65,908	33
	Total	**1,615.4**

C. Estimated Midstream Investments

Midstream investment has been determined in part based upon additions to processing capacity set forth by the various midstream companies operating in Ohio in their investor presentations and reports. Additional midstream investment was determined by estimating gathering and transmission line costs, including compression. Table 13 sets forth processing and Table 14 sets forth pipeline investment in Ohio for Q1 and Q2 2017.

Table 13: Midstream Processing Investment, January-June 2017 (in millions of dollars)

Company	Additions to Infrastructure	Total Amount ($mm)
Marathon Petroleum (MarkWest)	• Hopedale III C3+ Fractionation • 60,000 bbl/d of added capacity	168[12]
Rice Energy	• Titan and Cobra Compressor Stations with Dehydration • 710 mmscf/d of combined glycol dehydration	24[13]
Summit Midstream (Ohio Gathering)	• Larew Compressor Station with Dehydration • 525 mmscf/d of glycol dehydration	13[14]
Williams	• Salem and Stock Compressor Stations with Dehydration • 300 mmscf/d of combined glycol dehydration	22[15]
	Total	$227

[6] http://ir.gulfportenergy.com/all-sec-filings/content/0001628280-17-001359/0001628280-17-001359.pdf
[7] http://www.chk.com/Documents/investors/20150908_Latest_IR_Presentation.pdf, and http://www.chk.com/investors/sec-filings
[8] https://www.fool.com/investing/2016/08/17/the-5-companies-dominating-the-utica-shale-play.aspx
[9] http://investors.riceenergy.com/phoenix.zhtml?c=252759&p=IROL-sec&secCat01Enhanced.1_rs=21&secCat01Enhanced.1_rc=10
[10] http://ascentresources.com/operations.html
[11] http://ir.eclipseresources.com/sites/eclipseresources.investorhq.businesswire.com/files/report/additional/ECR_AR_260150.pdf
[12] Estimated by applying the formulas from the midstream methodology section to the throughput as included in the company's investor presentations.
[13] Estimated by applying the rule-of-thumb cost for gathering system compressor stations found in the midstream methodology section. Also, additional costs based on throughput described in Ohio EPA permit information were estimated by applying a model for determining capital costs in glycol dehydration facilities as presented in Kidnay et al. (2011) that was adjusted for inflation. *See* Kidnay, A. J., & Parrish, W. R. (2006). *Fundamentals of natural gas processing*, pp. 315-317. Boca Raton, Fla.: CRC/Taylor & Francis.
[14] *Id*.
[15] *Id*.

Table 14: Midstream Gathering and Transmission Pipeline Investment January-June 2017 (in millions of dollars)

Company	Additions to Infrastructure	Total Amount ($mm)
Energy Transfer	• Rover Pipeline • Over 400 miles of 42-inch pipeline to deliver shale production to markets across the U.S. and Canada	3,142[16]
Kinder Morgan	• Utopia East Pipeline • 215 miles of 12-inch pipeline to transport refined or fractionated products to Canada	101[17]
Marathon Pipe Line	• Harpster-to-Lima Pipeline: 50 miles of 12-inch pipeline as part of build-out for transporting condensate to refineries	255[18]
Spectra Energy	• Access South, Adair Southwest, and Lebanon Extension • 15.8 miles of 36-inch pipeline	118[19]
TransCanada (Columbia Gas)	• Leach Xpress Pipeline • Approximately 132 miles of 36-inch pipeline • Two interstate pipeline compressor stations with 63,100 combined horsepower	1,093[20]
Utica Gas Services	• Kragel Pipeline, Phase II • New Somerset Pipeline, Phase II • Approximately 4 miles of 12-inch and 2 miles of 10-inch gathering pipeline across two projects	9[21]
	Total	$4,718

Investments in large scale operations like pipelines are ongoing, and construction costs may not all be incurred within the six-month window of this study. Nonetheless, because the investments cannot be easily separated and tracked while construction is ongoing, they are treated as though made entirely during the study period.

The general location of transmission pipeline additions for the first half of 2017 is presented below in Figure 4. Cumulative midstream investments to date in Ohio, including 2012-2016, are set forth in Table 18 in Appendix A.

[16] For the overall $4.2 billion project, Energy Transfer estimated $2.24 billion in costs for the Mainline from Cadiz, OH to Defiance, OH. Supply Lateral costs were estimated by Energy Transfer at $1.35 billion, two-thirds of this mileage occurring in Ohio. The rest of the overall cost was dedicated to the Michigan and Canadian Market Zones. *See* www.putnamtwp.us/notices/pipeline/Fact%20Sheet%209-2014.pdf. See also www.roverpipelinefacts.com/documents/Volume-I-Public/Public-Exh-K_02_20_15.pdf

[17] Researchers at Kent State University estimated that $84 million in labor was provided by Ohio workers and $17 million in materials were supplied by Ohio-based companies for the $500 million project. *See* utopiapipeline.com/wp-content/uploads/2016/08/FINAL-Utopia-EIS.pdf

[18] www.mplx.com/content/documents/mplx/investor_center/2017/MPLX%20Deutsche%20Bank%20May%202017%20-%20Final-web.pdf

[19] *Id*.

[20] Pipeline cost was estimated by applying formulas from the midstream methodology section in Appendix B to mileage found in Columbia's FERC application. *See* www.ferc.gov/industries/gas/enviro/eis/2016/09-01-16-eis/Appendix-B.pdf. Compressor cost estimated as the product of total horsepower from FERC application and a $/hp estimate for interstate systems presented in Zhao et al. (2014). *See* Zhao, Y., & Rui, Z. (2014). Pipeline compressor station construction cost analysis. *International Journal of Oil, Gas and Coal Technology*, *8*(1), 41-61.

[21] Estimated by applying formulas from the midstream methodology section to Ohio EPA permit information.

Figure 4: Pipeline Additions During the 1st and 2nd Quarters of 2017

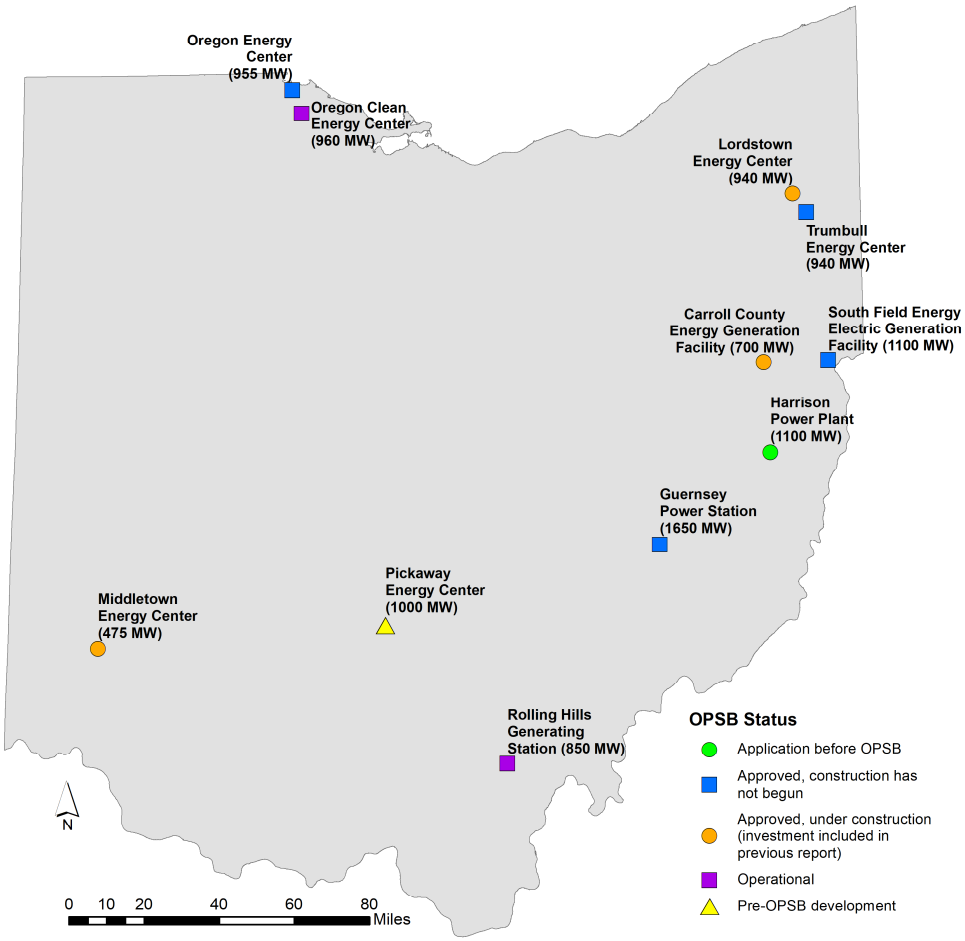
D. Downstream Development

1. Natural Gas Power Plants

Eleven new natural gas power plants were either under construction or in the planning stages across the state by the end of 2016. Four of these plants (in Oregon, Lordstown, Washington Township, and Middletown) were included as investments in prior Studies. The Oregon plant is

now operational while the other three are still under construction. As with pipeline investments, expenditures are considered as one-time investment during the six-month Study window by the builder, since it is impossible to separate the investments on an ongoing basis. The 11 current and projected natural gas power facilities across 9 locations, including their status as of December 2017, are set forth in Figure 5 below.[22]

Figure 5: Existing & Projected Power Plant Investment in Ohio through 2017



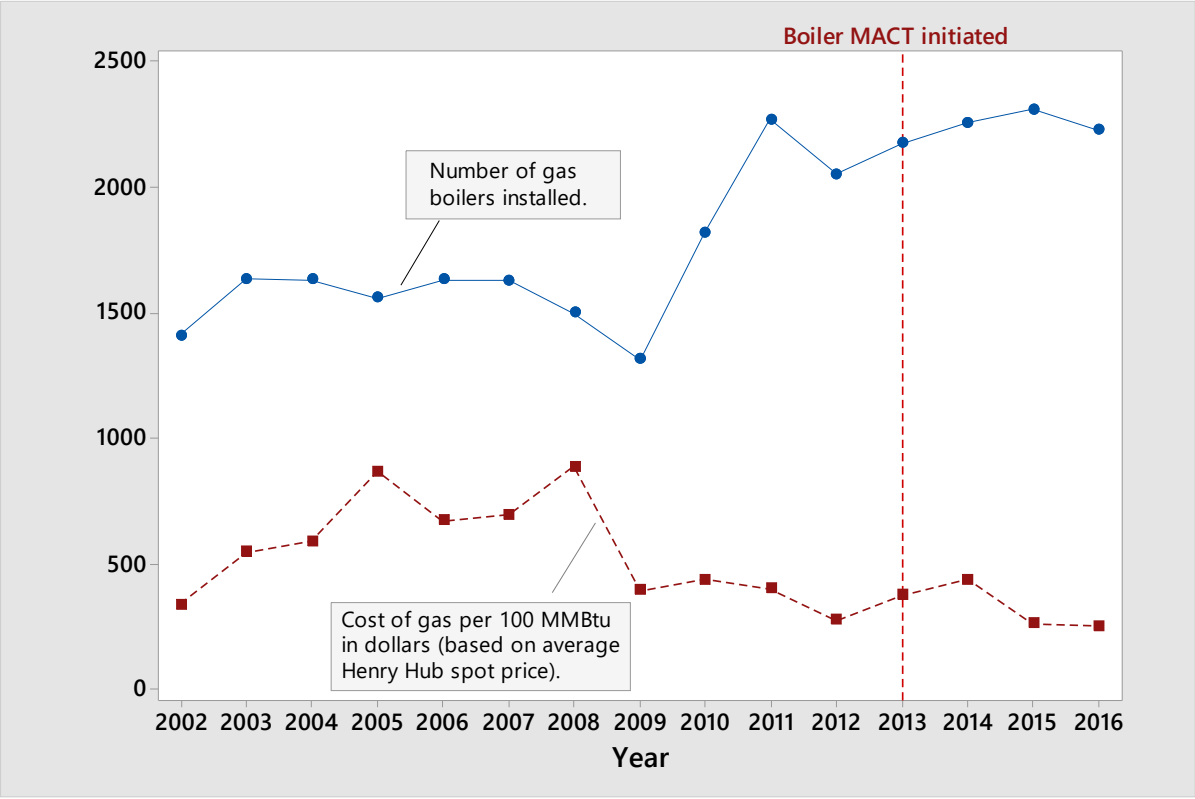
Source: Ohio Power Siting Board (2017)

[22] *See*: "Oregon Energy Center to begin construction in 2018 ($900 million);" http://www.toledoblade.com/Energy/2017/02/16/2nd-Oregon-natural-gas-power-plant-in-works-for-900M.html; "Trumbull to begin construction in Q4 2017 ($900 million);" http://www.tribtoday.com/news/local-news/2017/10/state-approves-2nd-energy-plant/; "Guernsey to begin construction in Q4 2017 ($1.4 billion);" https://www.construction-ic.com/; and "South Field Energy Electric Energy ($1.1 billion) will begin construction in second half of 2017;" http://www.morningjournalnews.com/news/local-news/2017/06/roads-readied-for-south-field-energy-project/. *See also:* http://www.elp.com/articles/2016/09/south-field-energy-wins-air-permit-for-1-150-mw-gas-fired-project-in-ohio.html

Continued low natural gas prices have also led to increased development of combined heat and power (CHP) plants. However, because the U.S. Department of Energy report on CHP construction had not yet been updated at the time of this Study, no new investment in CHP for the first half of 2017 is reported herewith. No independent media reports were found that established any CHP facilities were built during this time period.

CHP plants are usually designed for heat or steam generation, with electricity as a byproduct. Traditionally companies in Ohio have used coal-fired boilers to generate thermal load. However, new federal Boiler MACT laws have encouraged many companies to switch to natural gas-fired boilers. As shown in Figure 6 below, however, low natural gas prices have clearly also accelerated this transition. Nevertheless, because it is difficult to say that shale development has directly led to this change, boilers are not included in this Study. Future versions of this Study may evaluate boiler investment.

Figure 6: Comparison of the Price of Natural Gas and the Number of Boilers Installed in Ohio 2002-2016



Sources: Ohio Dept. of Industrial Compliance (2017) and U.S. Dept. of Energy (2017)

2. Natural Gas Transportation, Refineries, and Other Downstream Investment

Two new Compressed Natural Gas (CNG) refueling stations (in Canton and Sharonville) were constructed in the first half of 2017.[23] We estimated an investment of around $1 mm/station for these, using the formula developed for CNG stations in prior Studies.

No new refineries were developed in the first half of 2017, however PTT Global made a land acquisition for purposes of developing an ethane cracker plant in Belmont County.[24] In addition, a new methanol plant was built in Toledo, with an investment of around $55 million, in the first half of 2017.[25]

Total Estimated Downstream Investment: January-June, 2017

Ethane Cracker Plants	**$13,800,000**
Methanol Plants	**$55,000,000**
Natural Gas Refueling Stations	**$2,000,000**
Natural Gas Power Plants	**$0**
CHP Plants	**$0**
Total Estimated Downstream Investment	**$70,800,000**

Cumulative downstream investments to date in Ohio, including 2012-2016, are set forth in Table 19 in Appendix A.

3. CONCLUSION

Despite depressed hydrocarbon prices, upstream shale investment in Ohio continued to be active, with some 162 new wells in the first half of 2017, totaling approximately $4.04 billion in total investment. Upstream investment activity has moved to the southern counties, especially in Belmont and Monroe Counties. Carroll County, which still leads in overall total number of Utica wells drilled, had only five new wells drilled during the Study period, while forty-five wells were drilled in Belmont County. Production rates from the high pressured wells in the southern counties suggest that we can expect drilling investment in the next few years to continue to be focused in and around Belmont County.

Midstream investment picked up dramatically in the first half of 2017. New midstream investment has included $4.95 billion primarily in gathering system buildout and pipeline construction, though there have also been some additions to processing capacity.

Downstream development during the first half of 2017 slowed some, most likely due to depressed wholesale electricity prices, which has been driving the construction of new natural

[23] *See* U.S. Department of Energy's Alternative Fueling Station Locator at https://www.afdc.energy.gov/locator/stations/results?location=Ohio&fuel=CNG

[24] "Ohio Ethane Cracker Plant Closer to Reality on Former FirstEnergy Property," *Cleveland.com* (July 13, 2017). Retrieved from http://www.cleveland.com/metro/index.ssf/2017/07/ohio_ethane_cracker_plant_clos.html

[25] "Oregon ok's tax abatement for new chemical plant," *Press Publications* (January 3, 2017). Retrieved from http://www.presspublications.com/19140-oregon-ok-s-tax-abatement-for-new-chemical-plant

gas plants. However, a significant new investment has been made into acquiring land for a possible ethane cracker in Belmont County. Further, a major new methanol plant was built in Toledo, Ohio. This created a total investment of around $70.8 million in downstream shale related activities in Ohio. Total shale related investment in Ohio for the first half of 2017, including upstream, midstream and downstream was around $9 Billion.

About the Study Team

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About the Energy Policy Center

The Energy Policy Center is housed within the Maxine Goodman Levin College of Urban Affairs at Cleveland State University. The mission of the EPC is to help overcome social and institutional barriers to the implementation of solutions to energy challenges by providing an objective channel for the free exchange of ideas, the dissemination of knowledge, and the support of energy related research in the areas of public policy, economics, law, business and social science. For more information, go to http://urban.csuohio.edu/epc/.

4. APPENDICES

APPENDIX A. CUMULATIVE OHIO SHALE INVESTMENT

Figure 7: Total Utica Production in Bcfe (Gas Equivalence) by County through June 2017

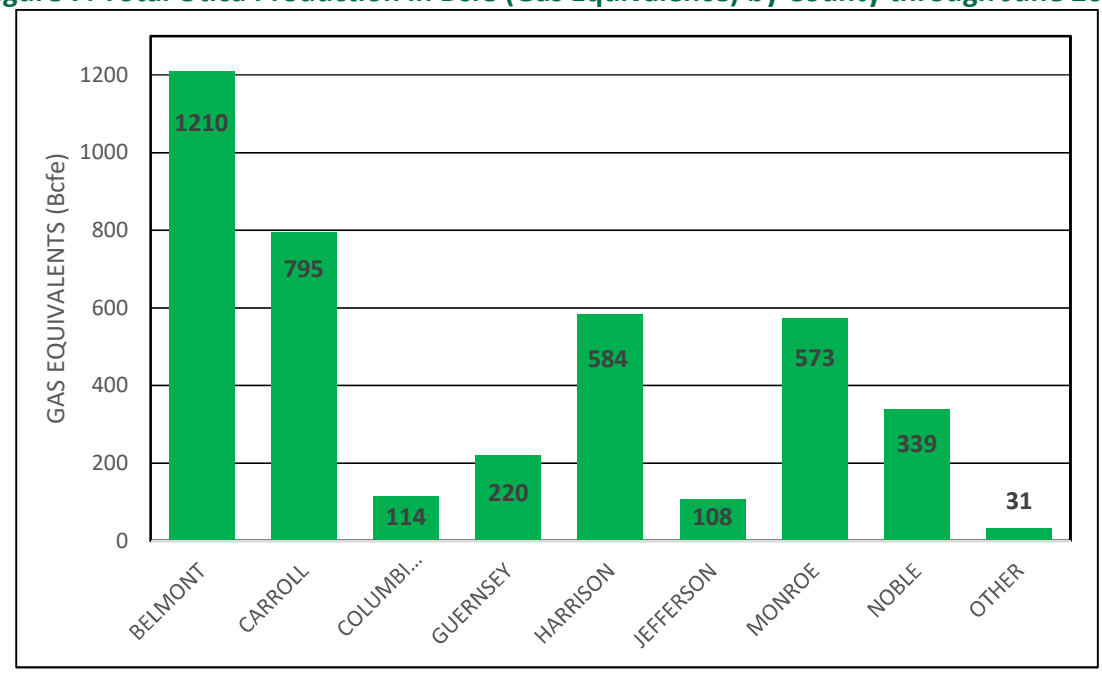


Figure 8: Total Utica Production in Bcfe by Operator through June 2017

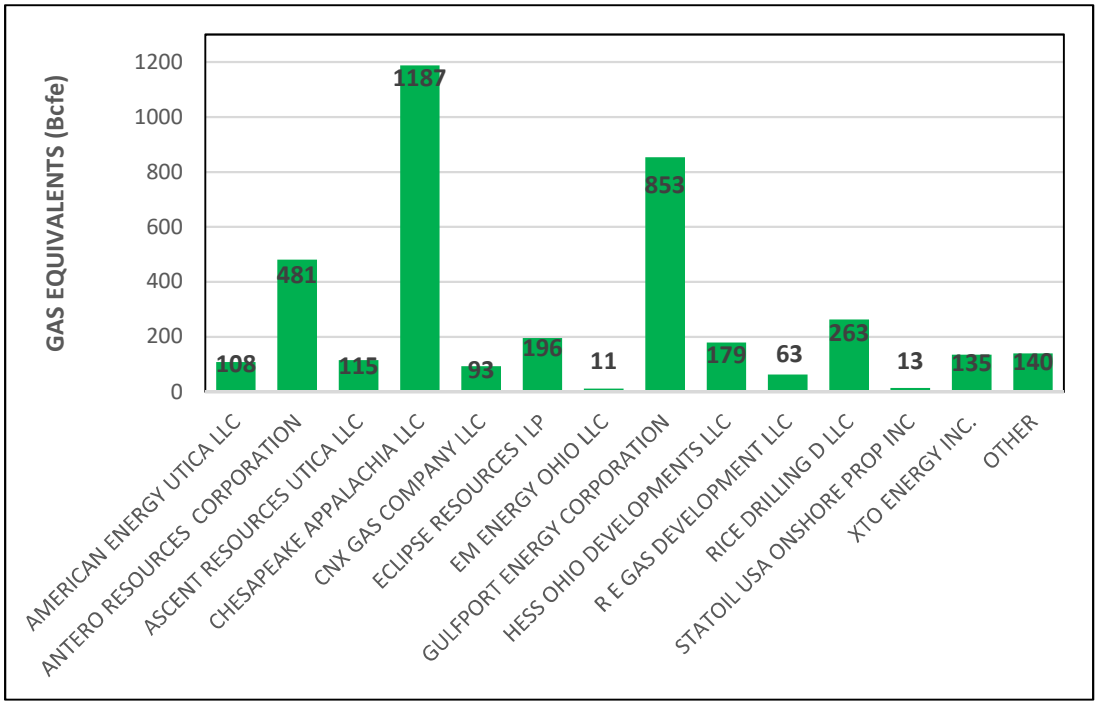
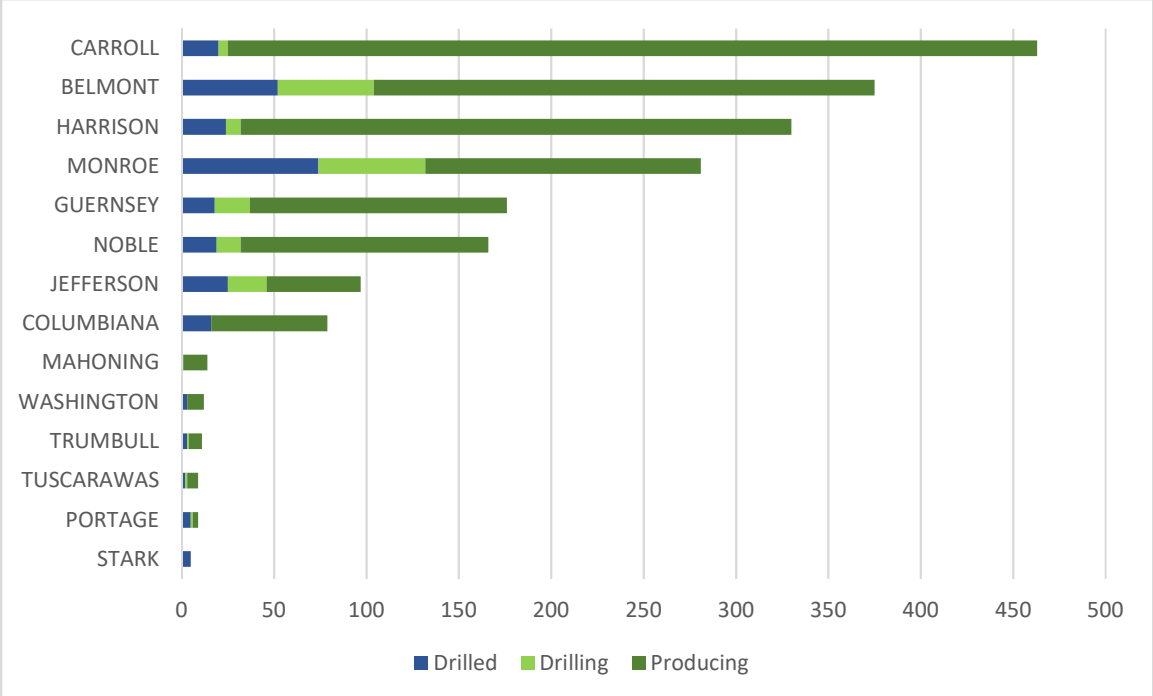


Figure 9: Cumulative Number of Wells by County



Source: Ohio Department of Natural Resource (July, 2017)

Figure 10: Distribution of Gas Equivalent Production for 2011 through June 2017

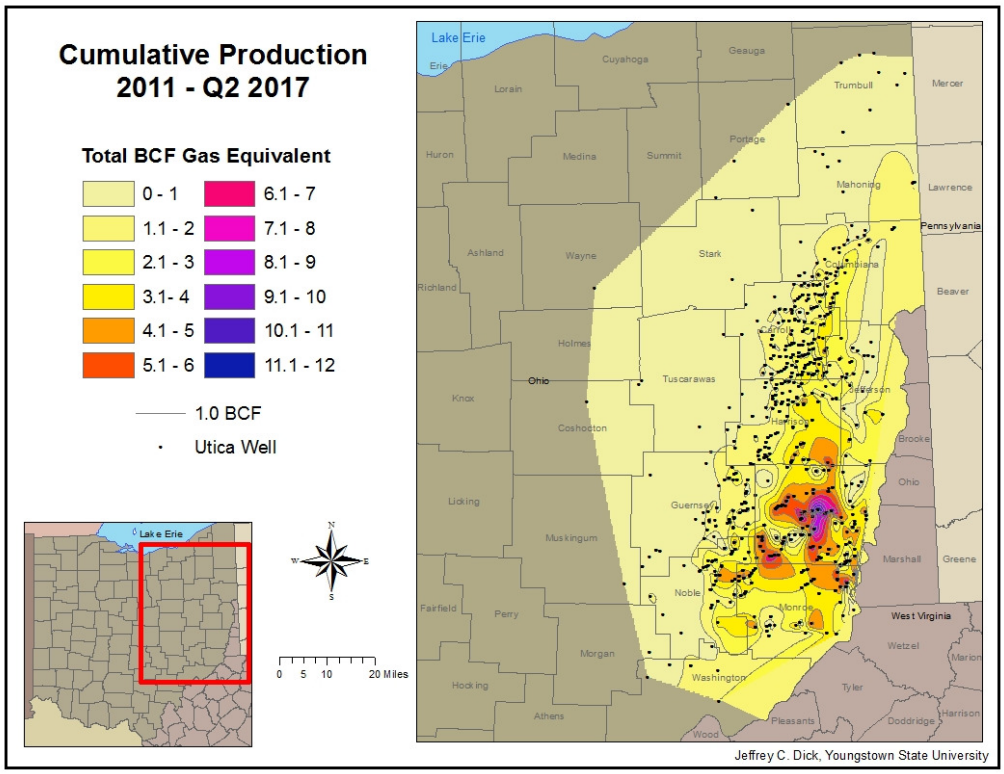


Figure 11: Distribution of Utica Wells by Status as of November 2017

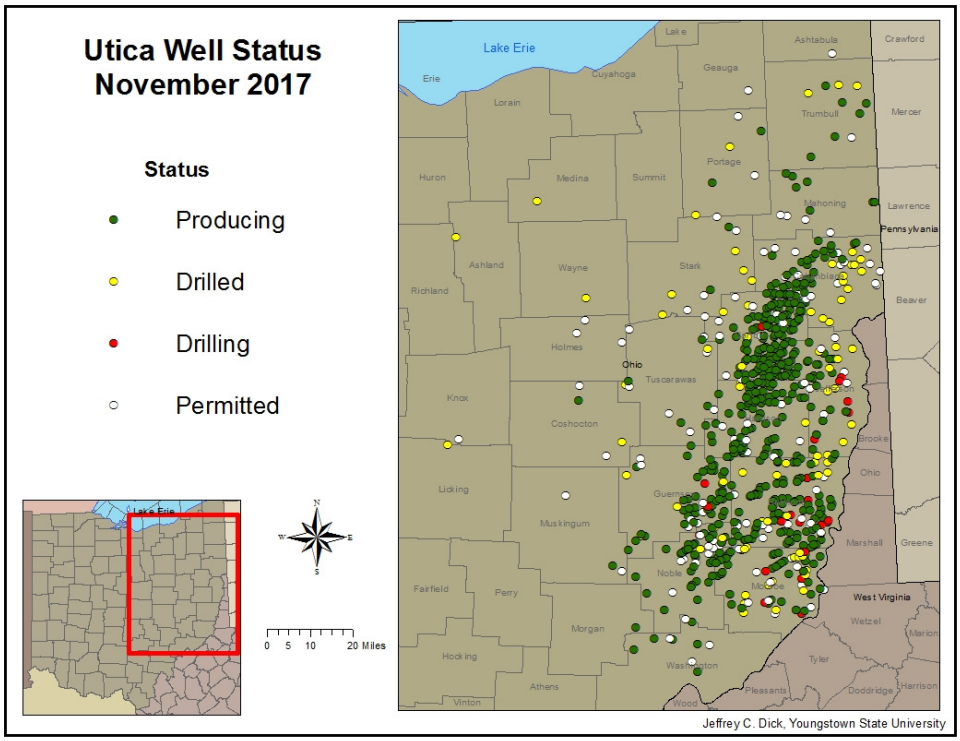


Table 15: Utica Upstream Companies Drilling in Ohio

Well Operators	Cumulative Number of Wells	Well Operators	Cumulative Number of Wells
CHESAPEAKE EXPLORATION LLC	719	HALCON OPERATING COMPANY INC	9
GULFPORT ENERGY CORPORATION	299	CHEVRON APPALACHIA LLC	8
ANTERO RESOURCES CORPORATION	223	EQT PRODUCTION COMPANY	8
ASCENT RESOURCES UTICA LLC	209	ARTEX OIL COMPANY	7
ECLIPSE RESOURCES I LP	100	CHESAPEAKE APPALACHIA LLC	6
RICE DRILLING D LLC	91	ENERVEST OPERATING LLC	6
CNX GAS COMPANY LLC	67	GULFPORT BUCKEYE LLC	6
HESS OHIO DEVELOPMENTS LLC	65	MOUNTAINEER KEYSTONE LLC	6
XTO ENERGY INC.	44	GEOPETRO LLC	5
PDC ENERGY INC	32	HG ENERGY LLC	5
R E GAS DEVELOPMENT LLC	31	DEVON ENERGY PRODUCTION CO LP	4
STATOIL USA ONSHORE PROP INC	19	AMERICAN ENERGY UTICA LLC	3
HILCORP ENERGY COMPANY	14	BRAMMER ENGINEERING INC	2
CARRIZO (UTICA) LLC	13	BP AMERICA PRODUCTION COMPANY	1
TRIAD HUNTER LLC	13	NGO DEVELOPMENT CORP.	1
ATLAS NOBLE LLC	12	PROTEGE ENERGY III LLC	1
EM ENERGY OHIO LLC	10		
		Total Number of Wells in 21 Counties:	**2,039**

Note: Cumulative Number of Wells are calculated based upon the total numbers of Drilled, Drilling, and Producing
Source: Ohio Department of Natural Resources (July 1, 2017).

Table 16: Total Lease Operating Expenses through June 2017 (in millions of dollars)

Year	Period	Production Wells	Lease Operating Expenses for Period ($mm)
2017	Q1 and Q2	1963	141.3
2016	Q3 and Q4	1406	101.2
2016	Q1 and Q2	1355	97.6
2015	Annual	1034	148.9
2014	Annual	612	88.1
2013	Annual	237	34.1
2012	Annual	82	30
2011	Annual	9	3
		Totals	644.2

Table 17: Cumulative Utica-Related Upstream Investments in Ohio through June 2017 (in millions of dollars)

Estimated Investments	Total Amount
Undeveloped Land	$16,153,370,000
Developed Land	$2,664,000,000

Lease Renewals	$3,230,800,000
Drilling	$17,552,000,000
Roads	$1,034,500,000
Near Lease Gathering Lines	$3,103,500,000
Lease Operating Expenses	$614,670,000
Royalties	$2,481,000,000
Total	$46,833,840,000

Table 18: Cumulative Utica-Related Midstream Investments in Ohio through June 2017 (in millions of dollars)

Estimated Investments	Total Amount
Midstream Gathering	$3,372,000,000
Processing Plants	$1,309,000,000
Fractionation Plants	$1,246,000,000
Storage Tankage	$234,000,000
Rail Loading Terminals	$117,000,000
Transmission Pipelines	$7,325,000,000
Total	$13,603,000,000

Table 19: Cumulative Utica-Related Downstream Investments in Ohio through June 2017 (in millions of dollars)

Estimated Investments	Total Amount
Petrochemical Plants (including refineries)	$383,800,000
Natural Gas Power Plants	$3,040,000,000
Combined Heat and Power (CHP) Plants	$41,000,000
CNG Stations	$40,000,000
Total	$3,504,800,000

APPENDIX B. METHODOLOGY

1. Upstream Methodology

Investment into the upstream for this third report has been broken down into four categories. The first category is investment into wells, and includes one-time investments into drilling, roads and close-to-the-lease gathering lines.[26] Drilling costs were estimated as:

- Drilling: Northern Counties - $7 mm/well; Southern Counties - $10 mm/well.[27]
- Roads: average investments - $500,000 per well. Based upon:
  - $1 mm/mile road improvement, with one mile per pad.
  - $250,000/bridge, $200,000/culvert, with one each per pad.
  - 3 wells per pad.[28]
- Near-Lease Gathering: $1.5 mm/well. Based upon:
  - 4 miles of 8-inch gathering lines per pad.
  - $140,000/inch-mile.
  - 3 wells per pad.

The second estimated upstream cost identified by operators is the "lease operating expense." This includes post-production costs such as the storage, processing and disposal of produced water, among other expenses. Lease operating expenses for Utica wells were estimated (based upon industry interviews) to be around $12,000/month, throughout the life of the well. For purposes of estimating the lease operating expenses for Q1 and Q2 2017, the Study Team assumed that all wells listed as "producing" by the Ohio Department of Natural Resources on January 1, 2017 were incurring this cost, and continued to do so through June 30, 2017. Lease operating expenses for wells that began production after January 1, 2017 were averaged at three months since they did not produce for all six months.[29]

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 hydrocarbon

[26] Operating companies do not make publicly available their "authorities for expenditure," the common accounting device used to estimate well costs. Further, while many operators provide average well costs in their public investment documents, they do not usually break it down into specific areas of investment. As a result, the study team used industry interviews to estimate investment into various portions of the well, and then compared this to the overall well costs set forth in the investment presentations. The estimates did not differentiate between those portions of the investments that go directly into the Ohio economy, and those that go elsewhere.

[27] The difference in costs between counties are a result of the Utica being deeper in the southern counties than in the north, requiring more expensive drilling in over-pressured formations. The northern counties are: Carroll, Harrison, Jefferson, Columbiana, Trumbull, Mahoning and Tuscarawas. The southern counties are: Noble, Guernsey, Belmont, Monroe and Washington.

[28] Pads are built for 6-8 wells, however early drilling is averaging around 3 wells per pad. This may change in the next several years as units are drilled out. Many operators are still putting resources into drilling and holding new units, thereby reducing the average number of wells per pad.

[29] *See fn 4, supra.*

were sold, together with adjustments required to account for transportation costs. Royalties were estimated on a per quarter basis for Utica production based upon the hydrocarbon content for a typical Utica well.

To estimate the royalties, the following assumptions were made based upon industry interviews, industry investor presentations, and Energy Information Agency reports:

- Production for each well was similar to that found in the wet gas region, and not the dry gas or condensate regions.
- The average production shrinkage after processing was 12%, thereby making the residue gas volume 88% of the total natural gas production.
- The residue energy content was around 1.1 MMBtu/Mcf.[30] Energy Information Agency prices were used to estimate royalties, which prices are based upon MMBtu at the Henry Hub market, and were adjusted accordingly.
- Residue gas in the Utica area was selling at prices around $0.65/Mcf below the Henry Hub market (local price differential).
- Transportation costs of around $0.65/Mcf were deducted from the royalty price.
- Around 44 barrels of liquids were recovered per million cubic feet of gas produced.
- Natural gas liquids were selling for around 30% of the EIA listed price for West Texas Intermediate (WTI) crude oil.
- Condensate and oil in the Utica region were selling for around $10 below the EIA listed price for West Texas Intermediate crude (local price differential).
- Royalty rates are 20% of gross production.

Finally, a fourth form of upstream investment was estimated: lease renewal bonuses. For this purpose, we assumed that the average renewal bonus paid was $5000/acre, and that the typical lease has a five-year primary term. Accordingly, we have assumed that approximately 20% of the undeveloped acreage identified in the first Study will need to be renewed each year.[31] Since this Study covered six months, we assumed that half of this 20% was renewed during the Study period. However, this estimate is based upon total undeveloped acreage, and not allocated on a per well basis. This estimate may be high insofar as companies are not renewing all their acreage, and some acreage will be developed and not need renewal. However, it is also likely to be low insofar as the prior Study only identified undeveloped acreage for the top six operators in Ohio, and insofar as new leases were not included.

2. Midstream Methodology

Midstream expenditures were estimated based upon a combination of midstream company investor reports, media reports, and industry "rules of thumb" obtained from industry interviews,

[30] 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.
[31] This estimate was confirmed through industry interviews. New operator undeveloped acreage reports are likely to be made available after the new year that may suggest these estimates could be either too high or too low.

government reports, and industry trade journals. Estimated investments were then compared against investor presentations and other information gleaned from public sources to confirm their accuracy. Interviews were also used to confirm ranges of expenditures.

For purposes of estimating the investments for midstream processing plants, rules of thumb were developed based upon throughput capacities for facilities. These rules of thumb were applied to the processing plants that have been built in Ohio, using the throughput capacity estimates made available from public literature. Likewise, rules of thumb based upon throughput capacity were used to estimate investments downstream of the processing plants, such as storage facilities and loading terminals. Dehydration processing plants were estimated using average cost per Mcf capacity for similarly designed and recently built plants in the Appalachian region.

Pipeline investments were estimated by using "inch-mile" cost estimates, and knowing the pipeline diameter and length. Interstate pipeline diameters and mileage can be determined from Federal Energy Regulatory Commission data; intrastate mileage and diameter were estimated based upon investor reports. These estimates were confirmed from investor presentations, when available. Table 20 provides an estimated cost for natural gas transmission pipelines published by the Oil and Gas Journal.

Table 20: Per Mile Cost Estimates for Natural Gas Pipelines

Size (in.)	Right of Way	Material	Labor	Misc.	Total
12	$ 68,779.00	$ 188,942.00	$ 737,056.00	$ 438,626.00	$ 1,433,403.00
16	$ 267,288.00	$ 415,979.00	$ 1,937,269.00	$ 1,473,663.00	$ 4,094,199.00
20	$ 199,333.00	$ 329,680.00	$ 2,728,127.00	$ 1,740,590.00	$ 4,997,730.00
24	$ 134,000.00	$ 337,650.00	$ 2,021,810.00	$ 836,247.00	$ 3,329,707.00
30	$ 736,129.00	$ 920,316.00	$ 4,919,086.00	$ 3,406,645.00	$ 9,982,176.00
36	$ 504,104.00	$ 895,253.00	$ 3,301,095.00	$ 2,763,844.00	$ 7,464,296.00

Source: Oil and Gas Journal (2016).

For purposes of this Study, we have differentiated between gathering lines on or near the lease (around 4 miles per pad) and gathering lines that pick up the production at some central location and deliver it to a processing plant (trunk lines) or to an interstate pipeline. The former tend to be smaller diameter pipelines (typically 8 inches), with lower pressures; the latter tend to be larger diameter pipelines (12 inches and greater), with higher pressures. The investment costs for the lower pressure lease lines are included in the upstream "post production" costs, while the high-pressure trunk lines are included in the midstream "gathering" costs. No investments into distribution lines were included in the Study, since it is assumed that these have not grown as a direct result of shale development.

For pipelines carrying liquids, the investment assumption is that expenditures will be comparable to those seen for gas pipelines. These were also corroborated by industry investor reports. Finally, no assumptions were made for fractionation plants, insofar as no new fractionation capacity was added during the Study period.

The following estimated costs were assumed for midstream infrastructure:

- Gathering (Trunk) Lines.
- 12 inch pipelines
    - $1.4 MM/mile
    - 170 miles per 1 Bcf/d throughput
  - 20 inch pipelines
    - $2.4 MM/mile
    - 30 miles per 1 Bcf/d throughput
  - Compressors
    - 3 compressor stations per 1 BCFD throughput
    - $10 mm/station
- Processing Plants.
  - $400,000 per MMcf/d throughput
  - $80 MM per 200 MMcf/d plant (typical skid size)
- Fractionation Plants.
  - $2800 per bbl/d
  - $100 mm per 36000 bbl/d unit (typical size of plant)
- Storage Tankage: $80 MM for 1 Bcf/d throughput
- Rail Loading Terminals: $40 MM for 1 Bcf/d throughput

3. Downstream Methodology

For estimating downstream expenditures, the Study Team relied upon publicly available reports gathered from news media, trade association publications, company websites and investor presentations. The Study Team also used interviews from time to time to support investment estimates.