IHS ECONOMICS

The Economic Impact of Crude Oil Pipeline Construction and Operation

Consulting Report

ECR | Private Report

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THE ECONOMIC IMPACT OF CRUDE OIL PIPELINE CONSTRUCTION AND OPERATION

The rapid increase in domestic oil production is reshaping the U.S. economy and redefining America's competitive advantages within the global economy, especially within the manufacturing sector. Beyond exploration and production companies, many firms across a diverse set of industry sectors are beneficiaries of billions of dollars in capital expenditures and operation and maintenance expenditures made annually across the hydrocarbon value chain. Pipelines create jobs across the construction and manufacturing supply chain and create significant economic value.

The objectives of this study are to:

- Describe the mix of goods and services used in constructing and operating oil pipelines, with a specific emphasis on those provided by the manufacturing sector
- Present unit cost estimates (i.e., dollars per mile) to build and operate typically-sized crude oil pipelines, and
- Estimate the total economic impacts to the U.S. economy of projected construction and operation of crude oil pipelines in 2015.

IHS estimates that approximately $11.57 billion will be spent in the United States in 2015 to construct new crude oil transmission pipelines and $9.6 billion to operate and maintain almost 61,400 miles of onshore crude oil pipelines. We continually monitor the status of major crude oil and natural gas pipeline projects across the country, so the expenditure figure is based on actual data. The projected construction spending would create a temporary increase in U.S. employment of 164,111 jobs in 2015, of which 13.3 percent would occur in the manufacturing sector. Similarly, the proposed new pipeline construction spending is expected to contribute $15.6 billion to total U.S. gross domestic product (GDP), with just above 19 percent of the contribution flowing to the manufacturing sector. We expect an increase of $10.2 billion to labor income in 2015, with 16.7 percent occurring in the manufacturing sector.[1] In total, construction and operation & maintenance spending for crude oil transmission pipelines created 276,497 jobs and contributed $31.4 billion in GDP in 2015 alone.

Inputs Used in Pipeline Construction and Operation

The first step in estimating the economic impacts of crude oil pipelines is to identify the mix of goods and services, or intermediate inputs, used in their construction and operation. The types of intermediate inputs, and their purchase from the economic sectors that provide them, are known as backward linkages. The total increase in economic activity produced via backward linkages (i.e., the indirect multiplier effect) depends on the types of intermediate inputs required and the extent to which they can be purchased from within a regional economy. The economic impacts will be presented as total changes in economic activity as indicated by such variables as employment, gross domestic product, output and labor income.

IHS's approach for estimating pipeline capital and operating costs included several tasks summarized below. First, IHS analyzed data[2] on the existing mileage of onshore crude oil pipelines in 2014 by nominal diameter to determine the most frequent diameters of crude oil transmission pipelines. Based on this analysis, IHS then selected two diameters—12 -inches and 20 -inches—to represent typical crude oil

[1] The share of the total U.S. economic impacts occurring in the manufacturing sector is lowest for employment because of the sector's high level of worker productivity (i.e., high values of output and GDP per worker) and its above-average wage levels.

[2] U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, August 2015, "Distribution, Transmission & Gathering, LNG, and Liquid Annual Data".
http://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=a872dfa122a1d110VgnVCM1000009ed07898CRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print

pipelines. Current design and performance standards were established for the two typical pipelines by IHS.

Construction and operation costs for crude oil pipelines vary based on a number of factors, including the following:

- Nominal diameter
- Length
- Depth of soil cover
- Volumetric flow and operating pressure
- Spacing and capacity of pumping stations
- Physical and environmental conditions along the right-of-way, especially terrain and soils
- Climate
- Types of land uses in and adjacent to the ROW
- Number of crossings required for rivers, highways, railroads, etc.
- Costs for obtaining permits, engineering design fees, insurance and other services

ROW acquisition costs are not typically major components of the total cost of a pipeline, generally ranging between 5 percent and 7 percent of total costs.[3] The cost of acquiring ROW is not considered in this analysis as it is difficult to estimate and varies widely from project to project. The local economic impacts of ROW acquisition expenditures can differ in magnitude and timing from those of local purchases of construction materials and payment of wages, depending on where the payment flows and when and how the landowner spends the proceeds.

Once the design assumptions were finalized, IHS then used publicly available pipeline cost information from historical and proposed crude oil pipeline projects along with its proprietary estimating tool, IHS QUE$TOR™ software, to produce a detailed breakdown of capital and operation costs for typical crude oil pipelines. A description of IHS QUE$TOR™ is provided in Appendix B. Average price levels for United States were assumed and cost information is presented in 2015 dollars. As a result, the capital and operating costs presented below for typical crude oil pipelines are based on actual project information as compiled by IHS.

Length of Onshore Crude Oil Pipelines, by State, in 2014

State	Miles of Pipeline
Texas	16,788
Oklahoma	5,844
Wyoming	3,765
California	3,687
Kansas	3,478
Louisiana	3,200
North Dakota	2,818
Minnesota	2,659
Illinois	2,575
Montana	2,380
Missouri	1,847
Michigan	1,437
New Mexico	1,372
Mississippi	1,306
Wisconsin	1,181
Alaska	1,109
Nebraska	758
Colorado	715
Ohio	552
Kentucky	550
All Other States	3,360
Total U.S. Length	61,379

U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, 2015, Distribution, Transmission & Gathering, LNG, and Liquid Annual Data. <http://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=a872dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print>

Crude Oil Pipeline System

Crude oil transmission pipelines convey crude oil from production locations, such as conventional crude oil deposits and shale formations containing tight oil, to processing locations such as refineries. From there, specialty pipelines carry the refined products to customers, including manufacturers that use refined products as an intermediate input, and final consumers.

[3] Pipeline Equities, September 2010, "Methods for Determining the Value of Pipelines, Part 1." http://www.pipelineequities.com/methods-determining-value-of-pipelines-pt1.php

There were 61,379 miles of onshore crude oil pipelines in the United States in 2014, about 68.6 percent of which were defined as interstate lines. Onshore crude oil pipelines are located in 35 states, but almost 95 percent of the total mileage is concentrated in the 20 states listed in the table above.

As the accompanying table shows, most of the recently completed (i.e., since 2009) and proposed major crude oil pipeline projects often begin in states where high levels of unconventional oil production is occurring. Such locations include the Eagle Ford shale formation in Texas, the Bakken shale formation in North Dakota and Montana, the Haynesville shale play in Texas and Louisiana, the Permian Basin in Texas, the Powder River Basin in Wyoming and the Marcellus and Utica shale formations in eastern Ohio and western Pennsylvania. Existing and proposed projects are located in 26 states, and the accompanying table shows the top 10 states based on distance.

Major Crude Oil Pipeline Projects, Top 10 States, In-service Date 2009-2019

	Existing Projects			Proposed Projects		
Destination State	# of Projects	Capacity (1,000s of Barrels per Day)	Distance in Miles	# of Projects	Capacity (1,000s of Barrels per Day)	Distance in Miles
Texas	103	14,795	17,650	6	820	1,254
Oklahoma	21	2,920	9,383	6	1,000	2,202
Illinois	16	6,256	7,871	2	575	2,032
Wyoming	12	846	2,888			
Montana	9	580	1,785	1	100	-
North Dakota	8	639	417			
Louisiana	4	2,095	935	3	600	1,550
Ohio	3	548	470	3	240	249
Minnesota	5	892	2,434	1	225	380
California	3	547	832	2	390	1,121
U.S. Totals	**211**	**35,270**	**53,168**	**29**	**5,985**	**11,070**

Source: IHS Energy, 2015.

Notes: Rankings based on mileage. Forecasted in-service dates range from 2010 to 2018.

These projects bring the crude oil to strategic hubs for refining. For example, the 600-mile long-Sandpiper pipeline will carry crude oil from the Bakken formation to Superior, Wisconsin; existing pipelines will convey the oil south from there to several refineries located near Chicago. Illinois is also a transfer point where crude oil is shipped south to the U.S. Gulf Coast, or east to major East Coast refineries in the New York and Philadelphia metropolitan areas.

Capital and operation costs are fairly standard across regions but can vary somewhat based on conditions along the ROW. For example, in mountainous regions the number and capacity of pumping stations will be higher to move the crude oil vertically. Similarly, building through densely populated regions will result in additional costs for crossings of linear transportation infrastructure, such as highways, railroads and other pipelines.

The costs for capital equipment used in crude oil pipelines, such as steel pipe, coatings, equipment, pumps, etc., are similar across the United States for most pipeline projects at the factory or the point of production. Similarities in costs also occur as there may be only a small number of manufacturers of the specialized equipment across the United States. However, the delivered costs of components will vary based on the distance to the construction site and the transport mode used. Typically, companies that design and build crude oil and refined petroleum pipelines have the experience and capability to work under the local construction regulations and labor laws and can smoothly work with the applicable government agencies and labor organizations. These companies provide planning, engineering, construction and project management services utilizing their fleet of specialty construction equipment on a country-wide basis.

One of the largest potential sources for regional variations in the cost of building crude oil pipelines is labor. Companies that build crude oil pipelines will first hire local workers with the required skills, thus paying local, market-based wage rates. IHS examined state-level median wage data from the Bureau of Labor Statistics[4] for 2014 to determine the extent to which wage levels varied across the U.S. We used 25 occupations that we had identified in other recent energy projects as being essential in the construction of oil pipelines. Our analysis showed that the median wage level for an identical set of construction labor inputs could vary by almost 35 percent across the U.S., with highest levels in Middle Atlantic, Pacific and New England census divisions. We also analyzed wage levels in five representative states. In Colorado

[4] Bureau of Labor Statistics, 2015, Occupational Employment Statistics in 2014 for the U.S. and States.

and Massachusetts wage levels were 5.3 percent and 22 percent above the U.S. figure, while they were 3 percent lower in Arizona, 5.4% lower in Virginian and 9 percent lower in Michigan. The wage levels used our analysis are not based only on construction occupations, but also include other occupations such as surveyors, engineers, construction managers, truck drivers, geologists, environmental scientists, and machinery mechanics that are needed to install a pipeline.

Construction and Operating Costs for Typical Crude Oil Pipelines

IHS identified typical crude oil pipeline characteristics using current and historical pipeline construction trends and national statistics on pipeline characteristics published by the PHMSA. We also used actual detailed data for the approximately 240 recent and proposed pipelines that form the basis for the table of major crude oil pipeline projects by state presented above. Pipeline capital costs were developed for a range of diameters, expressed on a unit basis as the cost per diameter -inch, to provide high- and low-cost estimates. For the two diameters representing typical crude oil pipeline sizes, additional design assumptions were then made about terrain–assumed to be level, distance, number and spacing of pump stations, construction methods, coatings, etc.-to derive costs on a unit distance basis, or the construction cost per mile. As mentioned earlier, the construction costs do not include the cost of acquiring ROW as it is highly project-specific.

Costs for 12-inch diameter crude oil pipeline were based upon an assumed capacity of 70,000 barrels per day, and a length of 200 miles, while the corresponding assumptions for the 20-inch diameter pipeline were 300,000 barrels per day and a length of 450 miles. Both sizes of pipelines were assumed to be built on level terrain. The length and capacity assumptions for the two pipeline sizes were based on modal characteristics of recently completed projects with these diameters. Larger pipelines are more likely to be built over longer distances and our pipeline length assumptions took this fact into consideration. Level terrain was assumed for the crude oil pipelines to provide a cost comparison based solely on differences in diameter. Unit construction costs will be higher if pipelines are constructed in areas with steep terrain as the pipeline will be longer, more hours of construction labor will be required, and additional pump stations will be needed.

Capital costs, which include equipment and materials, account for 35.3 percent and 40.9 percent of the total cost of constructing the two sizes, equivalent to $548,000 and $763,000 per mile. The capital components with the largest cost shares are line pipe and equipment, accounting for 23.8 percent and 27.2 percent respectively of the total unit cost for the two diameters.

The construction cost figures include labor (i.e., wages and fringe benefits) and comprise 30.9 percent and 30.2 percent respectively of the total cost for the 12-inch and 20-inch lines. The total unit construction costs are $1,551,000 per mile for the 12-inch diameter crude oil pipeline and $1,867,000 for the 20-inch diameter crude oil pipeline.

IHS estimated that the annual operation and maintenance (O&M) expenditures for crude oil transmission pipelines are $136,000/mile and $175,000/mile for the two sizes. Given the large aggregate distance of the existing oil pipeline system, and the types of activities needed to operate and maintain it, the bulk of the annual O&M expenditures are composed of logistics and consumables–61.9 percent and 66.1 percent and operating labor–21.3 percent and 16.5 percent respectively.

U.S. Economic Impacts of Pipeline Construction

IHS estimates that approximately $11.57 billion will be spent in the United States in 2015 to construct new crude oil transmission pipelines. The accompanying table shows that the projected construction spending would create a temporary increase in employment of 164,111 jobs, of which 13.3 percent is expected to occur in the manufacturing sector. Similarly, the proposed spending is expected to contribute $15.6 billion to total U.S. gross domestic product (GDP), with just above 19 percent of the contribution flowing to the manufacturing sector. We expect a contribution of $10.2 billion to labor income in 2015, with 16.7 percent occurring in the manufacturing sector. The share of the total U.S. economic impacts occurring in the manufacturing sector is lowest for employment because of the sector's high level of worker productivity (i.e., high values of output and GDP per worker) and its above-average wage levels. The high wage levels result in the 19.1 percent of labor income occurring in the manufacturing sector.

U.S. Economic Impacts of Construction Spending for Crude Oil Pipelines in 2015

Impact Measure	Total Change in Economic Activity	% in the Mfg. Sector	Impact/$1 Billion of Construction Spending
Employment (Number of Jobs)	164,111	13.3%	14,185.8
Direct	55,136	17.6%	4,766.0
Indirect	47,260	19.7%	4,085.2
Induced	61,714	4.5%	5,334.6
Labor Income (Millions of US$)	$ 10,250.3	16.7%	$ 886.0
Direct	$ 3,819.1	20.2%	$ 330.1
Indirect	$ 3,265.1	22.1%	$ 282.2
Induced	$ 3,166.1	6.8%	$ 273.7
Output (Millions of US$)	$ 32,267.9	31.9%	$ 2,789.3
Direct	$ 11,602.4	31.0%	$ 1,002.9
Indirect	$ 10,990.3	44.7%	$ 950.0
Induced	$ 9,675.1	18.3%	$ 836.3
Contribution to GDP (Million of US$)	$ 15,584.1	19.1%	$ 1,347.1
Direct	$ 4,641.0	26.0%	$ 401.2
Indirect	$ 5,283.6	25.5%	$ 456.7
Induced	$ 5,659.5	8.2%	$ 489.2

Note: The total construction spending figure used to derive the impacts was $11.57 billion.

Source: IHS, 2015

The table shows that a total of 24.1 jobs per mile would be created in the U.S. from crude oil pipeline construction, including 3.2 manufacturing jobs per mile.

A primary focus of this study is to measure how the construction of crude oil pipelines affects the manufacturing sector. The shares of economic benefits flowing to the manufacturing sector from the construction of the 20-inch pipeline are slightly higher than for the 12-inch pipeline because expensive capital equipment, such as steel pipe, pumps, and other equipment comprise a higher share of the unit cost of the 20-inch pipeline. As a point of comparison, from 25 percent and 40 percent of the total increases in statewide economic activity from construction spending, depending on the variable, occur in the construction sector. The increases in statewide economic activity from building a 20-inch diameter pipeline are slightly lower than for the 12-inch line due to economies of scale that occur when building a larger pipeline, and because a higher share of inputs for the smaller pipeline can usually be purchased from within the host state. There is very little difference in the amount of labor required to dig a trench for a 12-inch diameter pipeline and the amount needed for a 20-inch line, so building a smaller diameter pipeline is slightly more labor intensive as noted above.

IHS estimated the total U.S. economic impacts by four-digit NAICS code sub-sector within manufacturing. Appendix A contains a table presenting economic impacts for each of the 86 4-digit sub-sectors. While the appendix shows that all of the manufacturing sub-sectors will benefit to some extent, between 65 percent and 70 percent of the economic impacts, depending on the impact measure, will occur in the following 11 sub-sectors:

- 3241 Petroleum and Coal Prod. Mfg.
- 3251 Basic Chemical Mfg.
- 3255 Paint, Coating, and Adhesive Mfg.

- 3261 Plastic Product Mfg.
- 3273 Cement and Concrete Products
- 3311 Iron and Steel Mills
- 3323 Architectural and Structural Mfg.
- 3327 Machine Shops Mfg.
- 3329 Other Fabricated Metal Products
- 3331 Ag., Construction, and Mining Machinery
- 3339 Other Machinery Mfg.

The total U.S. economic impacts presented above, and in more detail in the tables that follow below, are the sum of the direct spending, the indirect multiplier effect and the induced multiplier effect.

U.S. Economic Impacts of Pipeline Operation and Maintenance

The current, annual unit cost of operating and maintaining (O&M) crude oil transmission pipelines ranges between $136,000 and $175,000/mile depending on diameter. Based on the total length of onshore crude oil pipelines in the United States in 2014 presented above, total annual O&M spending for crude oil pipelines is estimated at $9.6 billion. IHS estimated the total U.S. economic impacts from the annual O&M spending, which are presented in the accompanying table.

U.S. Economic Impacts of Operation & Maintenance Spending for Crude Oil Pipelines in 2015

Impact Measure	Total Change in Economic Activity	% in the Mfg. Sector	Impact per Mile
Employment (# of Jobs)	112,386	4.5%	1.6
Direct	18,569	0.0%	0.3
Indirect	25,284	7.6%	0.4
Induced	68,533	4.5%	1.0
Labor Income (Millions of US$)	$ 11,663.5	3.5%	0.2
Direct	$ 6,407.6	0.0%	0.1
Indirect	$ 1,683.3	10.0%	0.0
Induced	$ 3,572.7	6.8%	0.1
Output (Millions of US$)	$ 26,044.0	14.3%	0.4
Direct	$ 9,633.6	0.0%	0.1
Indirect	$ 5,494.3	32.2%	0.1
Induced	$ 10,916.2	17.9%	0.2
Contribution to GDP (Millions of US$)	$ 15,827.0	6.3%	0.2
Direct	$ 6,572.5	0.0%	0.1
Indirect	$ 2,875.1	16.3%	0.0
Induced	$ 6,379.4	8.2%	0.1

Note 1: Assumes a total of 61,379 miles of pipeline operated in 2015.

Note 2: The absence of direct effects in the mfg. sector is because the direct spending would occur outside it, primarily in the pipeline transportation sector. As result, the increases in economic activity in the mfg. are generated by the indirect purchases.

We estimate that the total increase in U.S. employment would be 112,386 jobs, including 5,017 in manufacturing alone, and an increase in gross domestic product of $15.8 billion. The impact on the manufacturing sector from crude oil pipeline O&M spending is lower than for construction spending as the value of goods needed from the manufacturing sector will be much smaller. In addition, manufactured goods, such as replacement parts, machinery, equipment, etc., are more likely to be purchased or leased by the firms operating and maintaining the crude oil pipeline system, so a portion of the increase in demand for manufacturing inputs will be indirect.

In contrast to construction spending, the share of the total increase in labor income accruing to the manufacturing sector from annual O&M spending is only 3.5% due to indirect nature of the demand for manufactured goods, and the high wages paid to skilled, non-manufacturing workers that will operate and maintain the pipelines.

A comparison of the construction and O&M economic impacts per $1 billion in direct spending shows that the latter generates fewer jobs, but more labor income, suggesting that the annual wage levels of workers operating and maintaining crude oil pipelines is higher than the wage levels of workers building them. O&M spending generates an increase of only 521 manufacturing jobs per $1 billion in direct spending versus 1,884 manufacturing jobs per $1 billion in construction spending due to the high value of purchases of steel, equipment, machinery, etc., during construction.

Annual O&M spending generates permanent increases in state and local economic activity, such as employment and value added, as the crude oil pipeline system has to be continually operated and maintained. At the state and local levels, the economic multiplier effects of O&M spending are usually comparable to or slightly higher than during construction as higher shares of inputs, including labor, maintenance and repair services, supplies, etc., are purchased locally. Finally, the economic impacts of O&M spending per mile shown in the accompanying table are much lower than for construction as the spending is for approximately nine times more pipeline miles.

Projections for Continued Growth

U.S. crude oil production has expanded significantly since 2006[5], rising from 5.1 million barrels per day (b/d) to 5.5 million b/d in 2010 and reaching 8.7 million b/d in 2014. Pipeline capital spending grew significantly over this eight year period to support U.S. upstream oil activity and production plans. U.S. oil and natural gas transmission pipeline project spending increased from approximately $10.1 billion in 2010 to almost $37.4 billion in 2015. The average U.S. onshore crude oil capital spending run rate over this period was approximately $20.5 billion with $14 billion spent on expanding natural gas transmission lines and the balance to crude oil pipelines.

IHS estimates total U.S. crude oil production peaked at 9.6 million b/d in April 2015 and has been declining since then to 9.0 million b/d in November 2015. We forecast the annualized production rate of crude oil in the U.S. will reach a temporary maximum of 9.3 million b/d in 2015 before falling gradually to 8.9 million b/d by 2017. Pipeline project spending was underpinned by the upstream production plans established in prior periods. While the rate of capacity additions could slow over the short term, additions will still be needed over the medium to long term to meet our view of supply and demand fundamentals. IHS expects U.S. crude oil production will resume growing gradually after 2017 in order to meet demand, approaching an annualized production rate of 10 million b/d in 2020. Correspondingly U.S. major crude oil capital project spending in the coming years will be comparable to history. U.S. onshore oil transmission pipeline capital spending is expected to have an annual run rate of $11.5 billion between 2016 and 2018 as both markets rebalance and then resume growth.

[5] IHS, November 30 2015, "North American Crude Oil Market Outlook".

Appendix A

U.S. Economic Impacts of Crude Oil Pipeline Construction in 2015 by Four-Digit Mfg. sector

NAICS Code and Description	Employment	Labor Income (Millions of US$)	Output (Millions of US$)	Contribution to GDP (Millions of US$)
3111 Animal Food Manufacturing	28	$ 2.2	$ 40.5	$ 6.3
3112 Grain and Oilseed Manufacturing	29	$ 2.7	$ 59.6	$ 7.4
3113 Sugar and Products Manufacturing	35	$ 2.3	$ 19.7	$ 4.2
3114 Fruit and Vegetable Preserving	90	$ 5.4	$ 40.7	$ 8.5
3115 Dairy Product Manufacturing	70	$ 5.1	$ 73.9	$ 9.7
3116 Animal Slaughtering and Processing	238	$ 10.9	$ 95.2	$ 12.9
3117 Seafood Product Preparation	21	$ 1.2	$ 8.1	$ 1.3
3118 Bakeries and Tortilla Manufacturing	151	$ 7.5	$ 37.6	$ 10.7
3119 Other Food Manufacturing	89	$ 6.6	$ 70.8	$ 21.8
3121 Beverage Manufacturing	103	$ 9.1	$ 84.7	$ 23.6
3122 Tobacco Manufacturing	7	$ 1.0	$ 21.8	$ 14.6
3131 Fiber, Yarn, and Thread Mills	12	$ 0.5	$ 4.3	$ 0.7
3132 Fabric Mills	22	$ 1.2	$ 7.4	$ 1.8
3133 Textile and Fabric Mills	19	$ 1.0	$ 5.5	$ 1.3
3141 Textile Furnishings Mills	32	$ 1.5	$ 8.4	$ 2.1
3149 Other Textile Product Mills	49	$ 2.1	$ 7.7	$ 2.6
3151 Apparel Knitting Mills	9	$ 0.3	$ 1.1	$ 0.4
3152 Cut and Sew Apparel Manufacturing	86	$ 3.6	$ 11.6	$ 4.3
3159 Accessories and Other Apparel Mfg.	5	$ 0.2	$ 0.9	$ 0.3
3161 Leather and Hide Finishing	1	$ 0.1	$ 0.5	$ 0.1
3162 Footwear Manufacturing	6	$ 0.3	$ 1.1	$ 0.4
3169 Other Leather Products	5	$ 0.2	$ 1.0	$ 0.3
3211 Sawmills and Wood Preservation	192	$ 10.1	$ 52.2	$ 11.9
3212 Plywood and Engineered Wood Mfg.	138	$ 7.3	$ 32.7	$ 11.2
3219 Other Wood Manufacturing	370	$ 17.8	$ 64.8	$ 21.1
3221 Pulp, Paper and Paperboard Mills	71	$ 7.9	$ 61.8	$ 17.2
3222 Converted Paper Products	211	$ 17.0	$ 96.2	$ 25.2
3231 Support Activities (Printing)	324	$ 17.7	$ 55.0	$ 20.0
3241 Petroleum and Coal Prod. Mfg.	211	$ 49.8	$ 1,101.8	$ 335.5
3251 Basic Chemical Mfg.	169	$ 24.0	$ 484.8	$ 66.2
3252 Resin, Rubber, and Fiber Mfg.	83	$ 10.9	$ 127.9	$ 18.1
3253 Agricultural Chemical Mfg.	31	$ 3.6	$ 50.9	$ 7.7
3254 Pharmaceutical and Medicine Mfg.	118	$ 20.8	$ 164.2	$ 54.5
3255 Paint, Coating, and Adhesive Mfg.	834	$ 89.2	$ 652.9	$ 135.9
3256 Soap, Cleaning, and Toiletry Mfg.	51	$ 5.1	$ 61.0	$ 19.5
3259 Other Chemical Product Mfg.	63	$ 6.5	$ 41.4	$ 9.4
3261 Plastic Product Mfg.	594	$ 38.9	$ 209.3	$ 67.1
3262 Rubber Product Mfg.	121	$ 8.6	$ 46.1	$ 15.4
3271 Clay Product and Refractory Mfg.	73	$ 4.7	$ 15.0	$ 6.2
3272 Glass and Glass Product	53	$ 3.7	$ 15.8	$ 5.5
3273 Cement and Concrete Products	755	$ 49.0	$ 206.6	$ 67.0
3274 Lime and Gypsum Products	34	$ 2.7	$ 16.8	$ 4.9
3279 Other Nonmetallic Mineral Products	183	$ 12.0	$ 62.9	$ 21.9

U.S. Economic Impacts of Crude Oil Pipeline Construction in 2015 by Four-Digit Mfg. sector

NAICS Code and Description	Employment	Labor Income (Millions of US$)	Output (Millions of US$)	Contribution to GDP (Millions of US$)
3311 Iron and Steel Mills	360	$ 38.4	$ 454.6	$ 62.2
3312 Steel Product Mfg. From Purchases	222	$ 18.4	$ 174.1	$ 23.9
3313 Alumina and Aluminum Production	64	$ 5.4	$ 49.7	$ 6.8
3314 Other Nonferrous Metal Production	94	$ 7.9	$ 121.1	$ 12.9
3315 Foundries	342	$ 24.5	$ 97.8	$ 28.7
3321 Forging and Stamping	203	$ 15.9	$ 88.3	$ 23.1
3322 Cutlery and Handtool Mfg.	38	$ 3.0	$ 10.5	$ 4.5
3323 Architectural and Structural Mfg.	1,139	$ 75.0	$ 304.0	$ 100.0
3324 Boiler, Tank and Container Mfg.	192	$ 14.8	$ 79.9	$ 23.0
3325 Hardware Manufacturing	17	$ 1.3	$ 5.8	$ 2.1
3326 Spring and Wire Product Mfg.	89	$ 5.6	$ 23.2	$ 8.7
3327 Machine Shops Mfg.	729	$ 48.8	$ 136.8	$ 60.8
3328 Coating, Engraving, and Heat Metals	302	$ 18.2	$ 74.7	$ 27.0
3329 Other Fabricated Metal Products	8,662	$ 643.8	$ 2,447.6	$ 893.4
3331 Ag., Construction, and Mining Machinery	560	$ 57.8	$ 584.6	$ 158.5
3332 Industrial Machinery Mfg.	28	$ 2.4	$ 11.6	$ 4.1
3333 Commercial and Service Industrial Machinery	76	$ 6.1	$ 35.4	$ 12.5
3334 HVAC and Commercial Refrig. Equipment	136	$ 9.2	$ 39.5	$ 14.3
3335 Metalworking Machinery	82	$ 6.0	$ 16.7	$ 7.9
3336 Turbine and Power Transmission Equip.	76	$ 7.3	$ 60.7	$ 15.7
3339 Other Machinery Mfg.	976	$ 88.8	$ 452.3	$ 156.5
3341 Computer and Peripheral Eq. Mfg.	35	$ 6.3	$ 40.6	$ 12.4
3342 Communications Eq. Mfg.	64	$ 7.2	$ 30.8	$ 10.9
3343 Audio and Video Eq. Mfg.	7	$ 0.7	$ 3.7	$ 0.9
3344 Semiconductor and Comp. Mfg.	217	$ 23.9	$ 169.4	$ 76.1
3345 Electronic Instrument Mfg.	60	$ 5.9	$ 23.4	$ 9.1
3346 Magnetic Media Mfg.	9	$ 1.2	$ 4.9	$ 1.8
3351 Electric Lighting Eq. Mfg.	89	$ 7.6	$ 32.4	$ 10.6
3352 Household Appliance Mfg.	29	$ 2.4	$ 16.0	$ 4.1
3353 Electrical Equipment	151	$ 14.0	$ 63.1	$ 21.1
3359 Other Electrical Eq. and Comp. Mfg.	125	$ 10.9	$ 55.5	$ 17.4
3361 Motor Vehicle Mfg.	39	$ 4.4	$ 76.3	$ 6.5
3362 Motor Vehicle Body and Trailer Mfg.	39	$ 2.4	$ 12.3	$ 2.4
3363 Motor Vehicle Parts Mfg.	242	$ 18.2	$ 128.1	$ 18.7
3364 Aerospace Product and Parts Mfg.	16	$ 1.9	$ 7.6	$ 2.1
3365 Railroad Rolling Mfg.	11	$ 1.0	$ 6.3	$ 1.2
3366 Ship and Boat Building	14	$ 0.9	$ 3.8	$ 1.0
3369 Other Transportation Eq. Mfg.	12	$ 0.9	$ 8.7	$ 1.4
3371 Household and Institutional Furniture Mfg.	138	$ 6.6	$ 24.4	$ 9.7
3372 Office Furniture and Fixtures Mfg.	17	$ 1.0	$ 4.5	$ 1.7
3379 Other Furniture-Related Mfg.	18	$ 1.0	$ 5.3	$ 1.9
3391 Medical Eq. and Supplies Mfg.	108	$ 9.0	$ 28.4	$ 17.9
3399 Other Misc. Mfg.	179	$ 12.5	$ 41.1	$ 20.7
Total Impact in Manufacturing	**21,795**	**$ 1,711.1**	**$ 10,278.0**	**$ 2,972.9**

Note: Impacts are the sum of the 12" and 20" transmission crude pipelines.

Source: IHS, 2015

Appendix B

IHS QUE$TOR™ Model

Over the years, IHS has developed and continuously refines a software tool called QUE$TOR that is used for analyzing the costs of new oil and gas projects. It was used to determine the crude oil pipeline construction and operating costs contained in the tables above. The program has recently undergone a complete software rewrite, retaining all the former capabilities but adding a significant increase in speed and functionality. QUE$TOR™ is a project modeling, evaluation and decision-support system for global application in the oil and gas industry. The program enables users to estimate and run sensitivities on the capital and operation expenditures of alternative field development plans. Using detailed technical algorithms and regional databases, QUE$TOR™ provides a consistent methodology for generating cost estimates and optimizing development plans. At the heart of QUE$TOR™ are cost and technical databases (user accessible and customizable) covering all producing regions of the world. These databases are updated every six months with costs gathered from actual projects, fabricators, vendors and service companies. For example, the individual crude oil pipeline projects used to derive the figures presented above in the table summarizing major crude oil project capacities and distances by state are inputs into the QUE$TOR™ database. Using primary input data (recoverable reserves, reservoir depth, and water depth), a production profile is generated, the development concept is defined, and design flowrates are calculated. The program then sizes facilities, pipelines and substructures and calculates capital costs, drilling costs, operating costs and abandonment costs. These costs are then scheduled to provide project cash flows. The regional databases are populated with unit rates for equipment items, materials, fabrication installation, hook-up and commissioning and other project costs. QUE$TOR™ has been benchmarked against actual project costs and is continuously maintained to reflect the latest changes in technology.