US ETHYLENE COMPLEX CONSTRUCTION COSTS DATA 2018 – 2020

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PETROCHEMICAL UPDATE

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CONSTRUCTION DATA PROVIDED BY

COMPASS INTERNATIONAL INC.

Compass International, Inc. is a professional commercial construction cost estimating and consulting firm established in 1992 to provide services to Owners, Financial Institutions, Design Professionals and Construction Organizations.

Compass International services include the publication of seven annual Industrial and Commercial construction cost data yearbooks, project and construction management, estimation reviews, audits, and validation services, as well as value engineering, strategic planning, and in-house training for up to 25 mid-senior level staff.

ANALYSIS PROVIDED BY PATHFINDER LLC

Pathfinder LLC is an international Project Management consulting firm established in 1985 to provide Process Industry owner organizations with the highest quality Capital Project Management support available in the industry. This support includes services such as Project Execution Planning, Contact Strategy Development, Cost/Schedule Risk Analysis, Independent Project Reviews, Project Readiness Reviews, Project Management and related topic training and resource augmentation of owner project teams.

Disclaimer

Introduction

Petrochemical Update has asked Pathfinder LLC to provide observations and recommendations for estimating Ethylene Projects in the upcoming 5-year timeframe by evaluating collected relevant data associated with recent Ethylene projects. The following is Pathfinder's analysis:

Over the past five years, US Ethylene projects have ridden a wave of new construction spurred on by US shale gas production and cheap ethane and propane which are ethylene production feedstocks. Most of the additional capacity is produced for export to Asia (China and India) to cover plastic (polyethylene) demand. In support of this demand, there has been and dramatic increase in capital project execution over this same time period. The number of petrochemical projects constructed simultaneously had significant impact in the marketplace. "Time to market" was the primary driver for these projects as everyone wanted to capture the early market opportunity. This resulted in a fast track planning and Construction driven project environment. This strategy caused many plants to be built with higher cost and schedule delays. Specific impacts resulted from:

- Labor shortages
- Raw material shortage (steel, alloys)
- Immature design (Weak FEL) with implications in EPC scope and change orders
- Poor planning during construction which impacted labor productivity
- Competitive labor market to hire skilled workers

During the first two years of the wave, the US petrochemical industry maintained an advantage with its shale gas price. Plants in Asia and Europe mostly use Naphtha as feedstock which is a derivative of crude oil. With the decline of crude oil prices in 2014 - 2015, some projects were delayed or canceled with the changing economics of Naphtha vs Shale Gas. Recent stability of crude oil pricing coupled with a forecast increase in demand is motivating a new wave of ethylene and propylene derivatives. Petrochemical producers are confident that the availability of cheap gas is a long term event. Even though, potential return from new ethylene plants is not as high as previous periods, there are still market opportunities that can be covered from new US projects. Even with the above described improved outlook, producers must be aware that factors which impacted previous project cost are still there and must be considered in planning new projects.

The Construction Industry consistently struggles with an upward trend in cost. The trend results from multiple contributing factors including those listed above. The trend has driven many Owner organizations to defer, suspend, or cancel capital projects. In other down periods, reduced activity has stimulated a "buyers' market" wherein Suppliers and Contractors react to reduced activity with competitively priced proposals and willingness to share risk/reward. This does not appear to be the case during the recent extended period when rather than reducing prices, contractors have cutback staffing and capabilities to reduce losses until the long term effect of changing economics becomes more predictable.

In any event, cost impacts can be confusing. Reduced activity in some areas, is being replaced by new projects associated with the shift toward other more profitable energy sources and

emerging new opportunities related to the availability of reasonably priced sources of oil and gas. New projects include multiple Business Sectors. It now appears that the Power and Energy and Petrochemical Industries are poised to take advantage of currently attractive natural gas prices with a flurry of new plant construction. While new projects would seemingly be good news for the industry, the current increase is having the immediate impact of adding to the labor shortage which in turn adds to project cost and schedule delay.

In 2017, the cost of labor and material escalated both due to short term events, and continuing longer term impacts like declining or varied capital investment. These impacts have caused craft labor to seek alternative industries, reducing the labor pool associated with the hydrocarbon industries, necessitating Owners and Contractors to offer attraction and retention premiums to secure the levels required to support large to mega-scale capital projects. In addition, while wage rates have remained reasonably stable, there has been a notable decrease in productivity leading to the need to spend more hours on both direct and indirect activities.

Foreseeable marketplace and feedstock cost conditions have stimulated particular interest in sponsorship, investment and construction of large to mega-scale Petrochemical facilities such as Ethylene Plants. Given the level of interest, this attached cost estimate(s) were prepared by the Compass Organization to provide a point of reference for participants in Ethylene projects. The data was prepared by normalizing six recent estimates and should provide insight into how cost has been impacted by 2017 events and how current trends may impact the future. This research focuses on evaluating the anticipated cost of constructing a 1.5 M Ton per year Ethylene facility in either the Gulf Coast or in the North East region of the United States. By definition, this type of analysis is challenging in that available reference information is subject to variations in plant size, process design, ultimately selected site conditions, technical standards and other considerations such as tax abatement incentives, proximity to feedstock supply, customer base/consumers, logistics, etc. With that said, the team collected relevant data associated with recent Ethylene projects, to represent the best estimating experience and data of the organizations involved in the reference projects. The data has been normalized to align construction timing and plant size to establish a representative base case for a hypothetical 1.5 M Ton facility based on current market conditions and cost trends.

The above mentioned variations in plant scope and conditions makes it impossible to produce a highly accurate single point estimate without pinpointing a particular plant configuration. However, using estimates for clear scope variances and "most common" design information, the team was able to establish a minimum / maximum cost range for the 1.5 M Ton facility and subsequently able to condition the cost to fit two distinct geographic locations in the United States.

The following table presents a representative base case for constructing a mega-scale Ethylene production facility on the Gulf Coast of the United States in 2017 dollars.

1.50 Million Ton per year USA Gulf Coast Ethylene Facility 1/1/2017 to 12/31/2017

Cost Categories	Qty	UoM	Material	M-H's	M-H Rate	Labor Cost	Minimum Total	Material	M-H's	M-H Rate	Labor Cost	Maximum Total
Major Equipment (M.E.)												
Columns c/w trays	70	EA	292,388,671	31,850	31.40	1,000,090	293,388,761	380,105,272	41,405	40.82	1,690,152	381,795,424
Drums / Vessels	67	EA	16,536,026	26,850	31.40	843,090	17,379,116	21,496,833	34,905	40.82	1,424,822	22,921,655
Pumps	98	EA	14,586,472	13,800	31.40	433,320	15,019,792	18,962,413	17,940	40.82	732,311	19,694,724
Compressors / Fans / Blowers	25	EA	79,711,416	100,600	31.40	3,158,840	82,870,256	103,624,840	130,780	40.82	5,338,440	108,963,280
Heat Exchangers	91	EA	17,386,317	12,750	31.40	400,350	17,786,667	22,602,212	16,575	40.82	676,592	23,278,803
Tanks	7	EA	12,123,821	2,850	31.40	89,490	12,213,311	15,760,967	3,705	40.82	151,238	15,912,205
Material Handling	4	EA	13,595,999	3,600	31.40	113,040	13,709,039	17,674,799	4,680	40.82	191,038	17,865,836
Water Treatment	10	EA	4,189,213	1,900	31.40	59,660	4,248,873	5,445,977	2,470	40.82	100,825	5,546,802
Miscellaneous Equipment	19	EA	46,584,699	15,350	31.40	481,990	47,066,689	60,560,109	19,955	40.82	814,563	61,374,672
Electrical Equipment	29	EA	12,556,814	5,750	31.40	180,550	12,737,364	16,323,859	7,475	40.82	305,130	16,628,988
Instrumentation Devices (Tagged)	5,400	EA	14,725,360	129,000	31.40	4,050,600	18,775,960	19,142,968	167,700	40.82	6,845,514	25,988,482
Freight		ALLOW	16,003,650				16,003,650	20,804,745				20,804,745
Vendor Assistance		ALLOW	1,287,140				1,287,140	1,673,282				1,673,282
Total Major Equipment (M.E.)			541,675,597	344,300		10,811,020	552,486,617	704,178,276	447,590		18,270,624	722,448,900
Removals / Demolition		ALLOW	6,524,716	60,000	29.63	1,777,800	8,302,516	8,482,130	78,000	38.52	3,004,482	11,486,612
Site Earthmoving / Improvements	1,200,000	CY	25,629,032	600,000	29.63	17,778,000	43,407,032	33,317,742	780,000	38.52	30,044,820	63,362,562
Piling	6,000	LF	6,446,014	120,000	29.63	3,555,600	10,001,614	8,379,818	156,000	38.52	6,008,964	14,388,782
Buildings	60,000	SF	6,446,014	180,000	29.63	5,333,400	11,779,414	8,379,818	234,000	38.52	9,013,446	17,393,264
Concrete	84,000	CY	34,486,785	140,000	29.63	4,148,200	38,634,985	44,832,820	182,000	38.52	7,010,458	51,843,278
Refractory / Fireproofing		ALLOW	4,680,291	6,000	29.63	177,780	4,858,071	6,084,379	7,800	38.52	300,448	6,384,827
Structural Steel / Platforms	9,000	TON	28,019,649	240,000	29.63	7,111,200	35,130,849	36,425,543	312,000	38.52	12,017,928	48,443,471
Piping systems	780,000	LF	160,018,669	3,000,000	29.63	88,890,000	248,908,669	208,024,270	3,900,000	38.52	150,224,100	358,248,370
Insulation		ALLOW	38,776,998	48,000	29.63	1,422,240	40,199,238	50,410,097	62,400	38.52	2,403,586	52,813,683
Electrical / Instrumentation	4,200,000	LF	10,079,971	1,200,000	29.63	35,556,000	45,635,971	13,103,963	1,560,000	38.52	60,089,640	73,193,603
Painting / Coatings		ALLOW	2,583,365	72,000	29.63	2,133,360	4,716,725	3,358,375	93,600	38.52	3,605,378	6,963,753
Other Miscl Costs		ALLOW	13,418,642	120,000	29.63	3,555,600	16,974,242	17,444,234	156,000	38.52	6,008,964	23,453,198
Bulk Material Costs			337,110,145	5,786,000		171,439,180	508,549,325	438,243,188	7,521,800		289,732,214	727,975,402
Fringe Benefits / Payroll Burdens						50,817,185	50,817,185				66,062,341	66,062,341
Consumables / Small Tools						19,448,880	19,448,880				25,283,544	25,283,544
Field Supervision & Expenses				1,215,000	37.81	45,939,150	45,939,150		1,579,500	49.15	59,720,895	59,720,895
Field Establish't (Trailers, Toilets)			7,768,910	240,000	29.16	6,998,400	14,767,310	10,099,583	312,000	37.91	11,827,296	21,926,879
Support Labor (logistics / clean up)			1,293,045	600,000	30.24	18,145,620	19,438,665	1,680,959	780,000	39.32	30,666,098	32,347,056
Construction Equipt Rental / Fuel			77,795,525	175,000	30.24	5,292,473	83,087,998	101,134,183	227,500	39.32	8,944,279	110,078,461
Heavy Lift Cranes			6,491,830	6,000	30.24	181,456	6,673,287	8,439,380	7,800	39.32	306,661	8,746,040
Scaffolding			649,185	300,000	29.16	8,746,980	9,396,165	843,941	390,000	37.90	14,782,396	15,626,337
Temporary field utilities						6,491,830	6,491,830				8,439,380	8,439,380
Taxes on Plant Hire consumables						6,491,830	6,491,830				8,439,380	8,439,380
H O Construction Support				120,000	81.02	9,722,400	9,722,400		156,000	105.33	12,639,120	12,639,120
Contractor Fee						64,652,235	64,652,235				84,047,906	84,047,906
Overtime - Shiftwork						12,930,445	12,930,445				16,809,579	16,809,579
BAR Insurance & Performance Bonds						19,422,275	19,422,275				25,248,957	25,248,957
Other Costs						6,491,830	6,491,830				8,439,379	8,439,379
Freight (Bulk Materials)						9,045,990	9,045,990				11,759,787	11,759,787
Contingency						128,405,630	128,405,630				166,927,319	166,927,319
Indirect Costs			93,998,495	2,656,000		419,224,611	513,223,106	122,198,044	3,452,800		560,344,316	682,542,360
Total Construction Cost			972,784,237	8,786,300		601,474,811	1,574,259,048	1,264,619,508	11,422,190		868,347,154	2,132,966,662
Detail Design / Engineering		M-H's		1,200,000		195,432,850	195,432,850		1,560,000		254,062,705	254,062,705
Project Management & Controls		M-H's		100,000		19,543,285	19,543,285		130,000		25,406,270	25,406,270
Procurement - Subcontracts & P.O.'s		M-H's		100,000		19,543,285	19,543,285		130,000		25,406,270	25,406,270
EPC Warranty						12,921,180	12,921,180				16,797,534	16,797,534
EP Fee						65,144,285	65,144,285				84,687,570	84,687,570
S/T				1,400,000		312,584,885	312,584,886		1,820,000		406,360,349	406,360,349
Total Project Cost			972,784,237	10,186,300		914,059,695	1,886,843,933	1,264,619,508	13,242,190		1,274,707,503	2,539,327,011
EPC Cost per Ton							$1,258					$1,693
Cost per Major Equipment 420 Items							$4,492,486					$6,046,017
Cost per Major Equipment 5,820 Tagged Items (includes Instrumentation Devices).							$324,200					$436,310

Etimate Basis & Remarks:

Exclusions & Qualifications

Owner Costs (Engineering, Oversight & 3rd party Inspection)
Spare Parts
Initial Start Up Materials
Soil Testing
Based on 45 hour workweek
Above costs reflect 4th Q 2017 values

This cost model assumes that the plant is being built on the Gulf Coast of the United States using nonunion labor. Industry experience demonstrates that building the same facility at other locations will impact the cost and differences must be evaluated on a case by case basis. For example, building the plant in the North East United States using union labor will result in higher wage rates, and additional work hours associated with work rules, variations in craft productivity, etc. But with the poorer productivity mow being experienced in the Gulf Coast these tend to even themselves out.

The selection of the US Gulf Coast for the base case is consistent with industry trends. Typically, the Gulf Coast is used for this type of modeling with the intent of applying variations in craft productivity, wage rates and other factors associated with large scale construction. This practice/trend is based on the assumption that the Gulf Coast offers good weather conditions, ability to attract a qualified work force and an adequate level of Construction support and logistical access. In simple terms, the Gulf Coast offers a standard case that can be contrasted with other locations to identify the impact of less desirable conditions. Compass International has produced the following tables that can be used to tailor an estimate to a particular location, work force makeup and projected productivity based on a composite of industries, including heavy and light industrial, pharmaceutical, commercial buildings.

State / City	Open Shop / Non-Union Workers	Union Workers
Louisiana	1.00	1.10 – 1.15
Ohio (Cleveland)	1.05 – 1.10	1.15 – 1.20
Ohio	1.05	1.10 - 1.15
Pennsylvania (Philadelphia / Pittsburgh)	1.10 - 1.15	1.20 – 1.30
Pennsylvania	1.05 - 1.10	1.10 - 1.20
Texas (Dallas / Houston)	1.05 - 1.10	1.10 - 1.20
Texas (Gulf Coast) - Base Case this includes Gulfport, Baton Rouge, New Iberia, Lake Charles, Beaumont, Port Arthur, Baytown, Texas City and Victoria: (Note: in certain cases i.e. large projects with a lot of repeat / similar work activities: productivity could be 0.90 – 1.00 say an average of 0.95)	**1.00**	**1.10 – 1.15 (typically all work is completed on open shop basis)**
West Virginia	1.00 - 1.05	1.00 - 1.15

Average Open Shop Wage Rates US Gulf Coast): 3rd Q 2017:

Abbreviations
FB/H = Fringe Benefits - Holidays
WCI = Workers Compensation Insurance Average
F&S / FICA = Federal & State Unemployment / FICA
ST&C = Small Tools & Consumables
SS = Safety Supplies
ST = Sub Total
HO & S & P = Home Office Support & Profit
THR (W/O per Diem)* = Total Hourly Rate without per diem per Diem)

	Trade / Skill	Base Hourly Rate	FB/HWP Average 3.25%	WCI Average 16.50%	F&S / FICA Average 15%	ST&C $3.85	SS 2.5%	ST	HOS & P 15%	THR (W/O)* per diem)
1	Carpenter (Journeyman)	28.82	0.94	4.76	4.32	3.85	0.72	43.41	6.51	49.92
2	Mason / Bricklayer (Journeyman)	28.66	0.93	4.73	4.30	3.85	0.72	43.19	6.48	49.66
3	Concrete Finisher	21.90	0.71	3.61	3.29	3.85	0.55	33.91	5.09	38.99
4	Equipment Operator (Heavy Crawlers / Cranes)	29.19	0.95	4.82	4.38	3.85	0.73	43.91	6.59	50.50
5	Electrician (Journeyman))	32.12	1.04	5.30	4.82	3.85	0.80	47.93	7.19	55.12
6	Instrumentation Installer (Journeyman)	32.12	1.04	5.30	4.82		0.80	44.08	6.61	50.70
7	Insulator (Journeyman)	27.39	0.89	4.52	4.11	3.85	0.68	41.44	6.22	47.66
8	Ironworker (Journeyman)	29.14	0.95	4.81	4.37	3.85	0.73	43.84	6.58	50.42
9	Laborer	19.57	0.64	3.23	2.94	3.85	0.49	30.71	4.61	35.32
10	Millwright (Journeyman)	31.33	1.02	5.17	4.70	3.85	0.78	46.85	7.03	53.88
11	Oiler / Mechanic (Journeyman)	29.40	0.96	4.85	4.41	3.85	0.74	44.20	6.63	50.83
12	Pipefitter (Journeyman)	31.37	1.02	5.18	4.71	3.85	0.78	46.91	7.04	53.94
13	Painter	24.37	0.79	4.02	3.66	3.85	0.61	37.30	5.59	42.89
14	Refractory (Journeyman)	28.90	0.94	4.77	4.34	3.85	0.72	43.52	6.53	50.04
15	Rebar Installer	28.53	0.93	4.71	4.28	3.85	0.71	43.01	6.45	49.46
16	Scaffolder	24.03	0.78	3.96	3.60	3.85	0.60	36.83	5.52	42.36
17	Truck Driver / JLG Lift	21.83	0.71	3.60	3.27	3.85	0.55	33.81	5.07	38.88
18	Welder (Journeyman)	31.42	1.02	5.18	4.71	3.85	0.79	46.97	7.05	54.02

Average Union Wage Rates (Pennsylvania): 3rd Q 2017:

Abbreviations
FB/H = Fringe Benefits - Holidays
WCI = Workers Compensation Insurance Average
EA = Each
LF = Lineal Feet
F&S / FICA = Federal & State Unemployment / FICA
M-H = Man Hours
ST&C = Small Tools & Consumables
SS = Safety Supplies
ST = Sub Total
HO & S & P = Home Office Support & Profit
****THR (W/O per Diem) =** Total Hourly Rate without per diem per Diem)

	Trade / Skill	Base Hourly Rate	FB/HWP Average 4.25%	WCI Average 16.50%	F&S / FICA Average 15%	ST&C $4.35	SS 2.5%	ST	HOS & P 15%	THR (W/O)** per diem)
1	Carpenter (Journeyman)	35.30	1.50	5.83	5.30	4.35	0.88	53.16	7.97	61.13
2	Mason / Bricklayer (Journeyman)	35.15	1.49	5.80	5.27	4.35	0.88	52.94	7.94	60.88
3	Concrete Finisher	26.83	1.14	4.43	4.02	4.35	0.67	41.44	6.22	47.65
4	Equipment Operator (Heavy Crawlers / Cranes)	35.76	1.52	5.90	5.36	4.35	0.89	53.79	8.07	61.85
5	Electrician (Journeyman))	39.35	1.67	6.49	5.90	4.35	0.98	58.75	8.81	67.56
6	Instrumentation Installer (Journeyman)	39.35	1.67	6.49	5.90	4.35	0.98	58.75	8.81	67.56
7	Insulator (Journeyman)	33.45	1.42	5.52	5.02	4.35	0.84	50.60	7.59	58.19
8	Ironworker (Journeyman)	35.80	1.52	5.91	5.37	4.35	0.89	53.84	8.08	61.91
9	Laborer	23.99	1.02	3.96	3.60	4.35	0.60	37.52	5.63	43.15
10	Millwright (Journeyman)	38.44	1.63	6.34	5.77	4.35	0.96	57.49	8.62	66.12
11	Oiler / Mechanic (Journeyman)	36.06	1.53	5.95	5.41	4.35	0.90	54.20	8.13	62.33
12	Pipefitter (Journeyman)	38.43	1.63	6.34	5.76	4.35	0.96	57.48	8.62	66.10
13	Painter	29.85	1.27	4.93	4.48	4.35	0.75	45.62	6.84	52.47
14	Refractory (Journeyman)	35.40	1.50	5.84	5.31	4.35	0.89	53.29	7.99	61.29
15	Rebar Installer	34.95	1.49	5.77	5.24	4.35	0.87	52.67	7.90	60.57
16	Scaffolder	29.48	1.25	4.86	4.42	4.35	0.74	45.10	6.77	51.87
17	Truck Driver / JLG Lift	26.94	1.15	4.45	4.04	4.35	0.67	41.60	6.24	47.84
18	Welder (Journeyman)	38.47	1.63	6.35	5.77	4.35	0.96	57.53	8.63	66.16

1.50 Million Ton per year USA North East Ethylene Facility 1/1/2017 to 12/31/2017

Cost Categories	Qty	UoM	Material	M-H's	M-H Rate	Labor Cost	Minimum Total	Material	M-H's	M-H Rate	Labor Cost	Maximum Total
Major Equipment (M.E.)												
Columns c/w trays	70	EA	292,388,671	38,220	34.26	1,309,325	293,697,996	380,105,272	49,686	44.53	2,212,760	382,318,032
Drums / Vessels	67	EA	16,536,026	32,220	34.26	1,103,780	17,639,805	21,496,833	41,886	44.53	1,865,388	23,362,221
Pumps	98	EA	14,586,472	16,560	34.26	567,306	15,153,778	18,962,413	21,528	44.53	958,747	19,921,160
Compressors / Fans / Blowers	25	EA	79,711,416	120,720	34.26	4,135,577	83,846,993	103,624,840	156,936	44.53	6,989,126	110,613,966
Heat Exchangers	91	EA	17,386,317	15,300	34.26	524,141	17,910,458	22,602,212	19,890	44.53	885,799	23,488,011
Tanks	7	EA	12,123,821	3,420	34.26	117,161	12,240,982	15,760,967	4,446	44.53	198,002	15,958,969
Material Handling	4	EA	13,595,999	4,320	34.26	147,993	13,743,992	17,674,799	5,616	44.53	250,108	17,924,907
Water Treatment	10	EA	4,189,213	2,280	34.26	78,107	4,267,320	5,445,977	2,964	44.53	132,001	5,577,978
Miscellaneous Equipment	19	EA	46,584,699	18,420	34.26	631,025	47,215,724	60,560,109	23,946	44.53	1,066,432	61,626,541
Electrical Equipment	29	EA	12,556,814	6,900	34.26	236,377	12,793,192	16,323,859	8,970	44.53	399,478	16,723,337
Instrumentation Devices (Tagged)	5,400	EA	14,725,360	154,800	34.26	5,303,076	20,028,436	19,142,968	201,240	44.53	8,962,199	28,105,167
Freight		ALLOW	16,003,650				16,003,650	20,804,745				20,804,745
Vendor Assistance		ALLOW	1,287,140				1,287,140	1,673,282				1,673,282
Total Major Equipment (M.E.)			541,675,597	413,160		14,153,870	555,829,467	704,178,276	537,108		23,920,040	728,098,316
Removals / Demolition		ALLOW	6,720,457	72,000	31.92	2,298,218	9,018,675	8,736,594	93,600	41.50	3,883,989	12,620,583
Site Earthmoving / Improvements	1,200,000	CY	26,397,903	720,000	31.92	22,982,184	49,380,087	34,317,274	936,000	41.50	38,839,891	73,157,165
Piling	6,000	LF	6,639,394	144,000	31.92	4,596,437	11,235,831	8,631,212	187,200	41.50	7,767,978	16,399,190
Buildings	60,000	SF	6,639,394	216,000	31.92	6,894,655	13,534,049	8,631,212	280,800	41.50	11,651,967	20,283,179
Concrete	84,000	CY	35,521,388	168,000	31.92	5,362,510	40,883,898	46,177,805	218,400	41.50	9,062,641	55,240,446
Refractory / Fireproofing		ALLOW	4,820,700	7,200	31.92	229,822	5,050,522	6,266,910	9,360	41.50	388,399	6,655,309
Structural Steel / Platforms	9,000	TON	28,860,238	288,000	33.90	9,762,422	38,622,661	37,518,310	374,400	44.07	16,498,494	54,016,804
Piping systems	780,000	LF	164,819,229	3,600,000	33.90	122,030,280	286,849,509	214,264,998	4,680,000	44.07	206,231,173	420,496,171
Insulation		ALLOW	39,940,308	57,600	31.92	1,838,575	41,778,883	51,922,400	74,880	41.50	3,107,191	55,029,592
Electrical / Instrumentation	4,200,000	LF	10,382,370	1,440,000	33.90	48,812,112	59,194,482	13,497,081	1,872,000	44.07	82,492,469	95,989,551
Painting / Coatings		ALLOW	2,660,866	86,400	31.92	2,757,862	5,418,728	3,459,126	112,320	41.50	4,660,787	8,119,913
Other Miscl Costs		ALLOW	13,821,201	144,000	31.92	4,596,437	18,417,638	17,967,561	187,200	41.50	7,767,978	25,735,539
Bulk Material Costs			347,223,449	6,943,200		232,161,514	579,384,963	451,390,484	9,026,160		392,352,958	843,743,442
Fringe Benefits / Payroll Burdens						52,595,786	52,595,786				68,374,522	68,374,522
Consumables / Small Tools						20,129,591	20,129,591				26,168,468	26,168,468
Field Supervision & Expenses				1,458,000	42.21	61,538,243	56,410,056		1,895,400	54.87	79,999,716	73,333,073
Field Establish't (Trailers, Toilets)			8,040,822	288,000	32.30	9,303,077	17,343,899	10,453,068	374,400	41.99	15,722,200	26,175,268
Support Labor (logistics / clean up)			1,338,302	720,000	34.08	24,539,436	25,877,738	1,739,792	936,000	44.31	41,471,647	43,211,439
Construction Equipt Rental / Fuel			80,518,368	210,000	34.08	7,157,336	87,675,704	104,673,879	273,000	44.31	12,095,897	116,769,776
Heavy Lift Cranes			6,719,044	7,200	34.08	245,394	6,964,439	8,734,758	9,360	44.31	414,716	9,149,474
Scaffolding			671,906	360,000	32.30	11,628,846	12,300,752	873,478	468,000	41.99	19,652,750	20,526,228
Temporary field utilities						6,719,044	6,719,044				8,734,758	8,734,758
Taxes on Plant Hire consumables						6,719,044	6,719,044				8,734,758	8,734,758
H O Construction Support				144,000	81.19	11,690,698	11,690,698		187,200	105.54	15,197,907	15,197,907
Contractor Fee						66,915,064	66,915,064				86,989,583	86,989,583
Overtime - Shiftwork						13,383,011	13,383,011				17,397,914	17,397,914
BAR Insurance & Performance Bonds						20,102,055	20,102,055				26,132,671	26,132,671
Other Costs						6,719,044	6,719,044				8,734,757	8,734,757
Freight (Bulk Materials)						9,362,600	9,362,600				12,171,380	12,171,380
Contingency						132,899,827	132,899,827				172,769,775	172,769,775
Indirect Costs			97,288,443	3,187,200		461,648,096	553,808,352	126,474,976	4,143,360		620,763,420	740,571,752
Total Construction Cost			986,187,489	10,543,560		707,963,480	1,689,022,782	1,282,043,735	13,706,628		1,037,036,418	2,312,413,511
Detail Design / Engineering		M-H's		1,200,000		204,227,330	204,227,330		1,560,000		265,495,528	265,495,528
Project Management & Controls		M-H's		100,000		20,422,735	20,422,735		130,000		26,549,555	26,549,555
Procurement - Subcontracts & P.O.'s		M-H's		100,000		20,422,735	20,422,735		130,000		26,549,555	26,549,555
EPC Warranty						13,502,635	13,502,635				17,553,425	17,553,425
EP Fee						68,075,780	68,075,780				88,498,514	88,498,514
S/T				1,400,000		326,651,213	326,651,213		1,820,000		424,646,577	424,646,577
Total Project Cost			986,187,489	11,943,560		1,034,614,693	2,015,673,995	1,282,043,735	15,526,628		1,461,682,996	2,737,060,088
EPC Cost per Ton							$1,344					$1,825
Cost per Major Equipment 420 Items							$4,799,224					$6,516,810
Cost per Major Equipment 5,820 Tagged Items (includes Instrumentation Devices).							$346,336					$470,285

Etimate Basis & Remarks:

Exclusions & Qualifications

Owner Costs (Engineering, Oversight & 3rd party Inspection)
Spare Parts
Initial Start Up Materials
Soil Testing
Based on 45 hour workweek
Above costs reflect 4th Q 2017 values

Application of the appropriate location specific factors, provides a reasonable assessment of how costs will differ. In reviewing the resultant estimate, it is important to note that achieving a reasonable level of estimate accuracy will require not only consideration of high level adjustments, such as wage rates and estimated productivity, but also consideration of review of project specific conditions that can significantly impact cost. Perhaps the most significant factor to be considered is the availability of a qualified work force. In 2017, resource availability was a point of discussion for virtually any new project. Locating a new plant in an area already identifying labor shortages creates a multifaceted risk of cost increase including per diem cost, bonus wages, lost productivity, excess overtime, etc. This should all reflected in the Project Execution Plan (PEP) which is also an integral aspects of the estimate. The scope of work and supporting data outlined above provides the "what" will be built, but the PEP provides the "how" and in today's marketplace it is equally as important as the "what".

As the team analyzed the 2017 data, it was clear that a notable impact, (particularly on the Gulf Coast), is recent extreme weather resulting in both a shortage of qualified labor and an increased level of construction activity associated with repair work. While this impact can be viewed as temporary, a recent Compass International report estimates that the impact over the next six months will range from 5% to 10% for construction support equipment and other indirect costs, and 3.5% to 6.5% increase for craft labor. While the North East United States is not expected to see this level of increased labor cost, it is clear that there will be impact relative to bulk materials resulting from increased repair activity on a national basis. This impact is expected to range from 2.5 % to 5% for all projects, including those in the North East.

The team calculated equipment and material escalation rates for the project over 2017. For 2017 the escalation rates for major equipment were 3.5% for materials and 4.5% for labor, giving an average of rate of 4%. The escalation rates for bulk materials for 2017 were 3.5%, with a 0.7% increase in Q1, 0.7% for Q2, 0.7% for Q3 and 1.4% for Q4. Freight and vendor assistance both experienced escalation rates of 3% increase for all of 2017, with a 0.5% Q1 increase, 0.5% Q2 increase, 0.5% Q3 increase and 1.5% for Q4. The team established a look ahead escalation table that can be used to model potential escalation for calendar years 2018, 2019, and 2020.

2018, 2019 & 2020 Escalation Forecast

	1st Q 2018	2nd Q 2018	3rd Q 2018	4th Q 2018	Total for 2018	1st Q 2019	2nd Q 2019	3rd Q 2019	4th Q 2019	Total for 2019	1st Q 2020	2nd Q 2020	3rd Q 2020	4th Q 2020	Total for 2020
US Gulf Coast															
Materials	1.50	1.50	1.25	1.00	**5.25**	1.00	1.00	1.00	1.00	**4.00**	0.90	0.90	0.90	0.80	**3.50**
Labor	1.50	1.50	1.25	1.25	**5.50**	1.25	1.00	1.00	1.00	**4.25**	0.90	0.90	0.90	0.80	**3.50**
US North East															
Materials	1.25	1.00	1.00	1.00	**4.25**	1.00	1.00	1.00	1.00	**4.00**	0.80	0.80	0.80	0.80	**3.20**
Labor	1.25	1.00	1.00	1.00	**4.25**	1.00	1.00	1.00	1.00	**4.00**	0.80	0.80	0.80	0.80	**3.20**

While the level for the Gulf Coast is slightly higher than that in the North East, reflecting the more direct impact of recent weather events, both geographic locations reflect a level of increase that represents further challenges for the industry. It is clear that that the seemingly endless escalation of Construction costs is not limited to a single event or short term impacts but also includes potentially more significant circumstances such as a diminishing pool of experienced/qualified work force, the industry's failure to anticipate and accommodate cyclical marketplace conditions and a failure to apply innovation and technology in an effective manner. These topics have a negative influence on industry participants that manifests itself as a continual deterioration in construction productivity, performance and associated cost effects.

While the overall prognosis is somewhat disconcerting, given decades of deteriorating, or, at best unchanged performance, it is becoming clear to industry leadership that focus on improvement and innovative solutions is appropriate. Owners, Contractors and Industry Associations are all actively involved in initiatives that are starting to show results. Unfortunately, long term solutions such as technology advancement and revised Construction processes, will take time and are unlikely to have any material impact on the current generation of Ethylene projects. A look at current conditions leads to the conclusion that the rate of escalation will slow or at least stabilize as the impact of recent weather events is fully absorbed and the three year outlook is expected to be as presented in exhibit 7.

In any event, while the analysis presented in this article may be utilized as a basis/input to development of Ethylene Project Cost Estimates, there is no substitute for thorough marketplace and labor availability assessments, realistic consideration of project specific risk factors and effective application of Risk Analyses, such as Monte Carlo Simulation based techniques to arrive at a reasonable level of Cost Estimate accuracy and predictability upon which alternatives can be analyzed and informed business decisions can be made.