



COMPASS
INTERNATIONAL INC.



SAN

2021

Front-End / Conceptual Estimating Yearbook

20TH EDITION



V ACKNOWLEDGEMENTS

01

1

SECTION 1: GENERAL INFORMATION

Introduction to Front End / Conceptual Estimating:
The General Forecast for 2021 and beyond
The Project Control Cycle / Issues and Factors
Cost breakdown of a Typical Chemical Process Facility
The CAPEX Estimating Process
Capital Cost Estimating the Four Basic Steps
Presenting the Estimate to Senior Management
Optimizing the Estimating effort
Cost Estimating / Engineering terms
Developing An Estimate Plan
Estimating Methods

65

2

SECTION 2: COST-ESTIMATING CONCEPTUAL FRONT-END DATA

Blue Sky / O.O.M. Order of Magnitude Estimate / Factored / Ratio Estimates
/ Exponent Estimates / Square Foot.
Capacity / Exponent Estimates (6/10th rule) Method
(+/- 25% - 30% Accuracy)
Lang, Wroth, Guthrie, Chilton and Hand factors
50+ Typical Ratio Factored / Percentage Values / Historical Facility Cost Close
Out Reports
Cost-Capacity equations / exponents (180 +)

167	<p>3</p> <p>SECTION 3: SQUARE FOOT / SQUARE METER COST DATA</p> <p>New Industrial / Commercial Sq. Ft. – M2 Building Costs (100 + facility examples)</p> <p>Major Revamp / Rehabilitation Issues</p> <p>Moderate Revamp / Rehabilitation Issues</p> <p>Minor Revamp / Superficial Facelift Issues</p> <p>25 floors - 200 apartments Major N.E. USA City</p>
177	<p>4</p> <p>SECTION 4: SEMI-DETAILED COST-ESTIMATING DATA</p> <p>General Conditions / Demolition work</p> <p>Site Construction work</p> <p>Civil, Foundations / U.G. Utility work</p> <p>Structural Steel Framing / Platforms</p> <p>External Wall Systems</p> <p>Roofing, Siding & Miscellaneous items</p> <p>Internal walls / Doors / Ceilings / Flooring / Glass</p> <p>Material Handling Equipment and Specialized Equipment</p> <p>Mechanical Equipment / Plumbing / HVAC & Fire protection</p> <p>Electrical / Instrumentation systems</p> <p>Clean room construction items</p> <p>Home Office Engineering, Procurement and Construction (EPC) Staff Rates</p> <p>Typical Engineering Production Hours</p> <p>Process Piping Systems</p> <p>Piping Material adjustments</p> <p>Major Equipment Insulation</p> <p>“All In” Unit Material Price Checklist</p> <p>Budget Pricing Stainless Steel Tubing / Piping</p> <p>Average Number of Fittings / Valves</p> <p>Major Equipment and Piping Insulation</p> <p>Instrumentation Costs</p> <p>Welding metrics</p> <p>Pipeline(s) Metrics</p> <p>Rail Road Cost Benchmarks</p> <p>Robotic systems</p> <p>In-direct Labor Open Shop Benchmarks and Assumptions</p> <p>Warehouse Miscellaneous Equipment</p>

273	5	SECTION 5: ESTIMATING MISCELLANEOUS SUPPORTING DATA
		Check-list of Front End Estimating / Site Management Issues
		Excavation Equipment Production Rates
		Reinforced Concrete 3,500 PSI / 25 MPA Budget Pricing
		Value Engineering / Cost Optimization Methods (COM)
		USA & International Location Factors
		Engineering Productivity V'S USA Standards
		Detailed Design / Engineering / Architectural & CM Fees
		Open Shop / Non - Union Labor Costs
		Material Adjustment Values (Piping)
		Sales Tax (50 US states and 10 Canadian Provinces)
		Production / Utility Equipment Benchmarks (90 + Cost models)
		Inflation / Compass Cost Index
441	6	SECTION 6: EPC HISTORICAL COST MODELS & BENCHMARKS
		General Production Benchmarks (80 +)
		Estimate Assessment Sheet / Ratio Analysis
		Major Equipment delivery times / USA Construction Productivity
461		ABOUT THE FIRM

vendor assistance and off-sites, percentages / multipliers include contingency funds because the above stated values are based on numerous "historical" return cost data, where the contingency was expended / incorporated into the capital cost of the completed facility. Engineering, Procurement Activities and Construction Management costs are included in the indirect costs. EPC Office includes engineering and design, procurement, project management / control and required administration. Owner C.M. is not

included in the EPC office percentage.

Note: the factors for piping, electrical and instrumentation work indicated in (2) and (3) above could be reduced by 20 – 40% (use 30%) if work is fabricated as modules / pre-assemblies / skid, structural steel values should be increased by 10 – 20 % if work is completed as modules / pre-assemblies / skid (use 15%).

Table 3
AVERAGE HISTORICAL (MULTIPLIER) FACTORS – SOLIDS PLANTS

REF	DIRECT CONSTRUCTION COSTS	TYPICAL % OF M.E.	% BULK MATERIALS	% LABOR - S/C	TOTAL	REMARKS
1	Major Equipment (M.E.)	0	1.00*	0.00	1.00	Assume \$1.00 million
2	Freight (used 4%)	2.5 - 5	0.02	0.02	0.04	50/50 split
3	Overseas Freight	5 - 8	N/A	N/A		N/A for this example
4	M.E. Setting (Millwright work)	1 - 7	0.01	0.05	0.06	Heavy lift cranes in line 15
5	Site work / civil (excavation / roads)	3 - 10	0.03	0.04	0.07	Site clearance / minor demolition
6	Concrete work	10 - 50	0.04	0.12	0.16	SOG & elevated
7	Structural steel	20 - 50	0.13	0.15	0.28	Including platforms
8	Facilities / Buildings (including services)	3 - 20	0.03	0.02	0.05	
9	Piping** (includes hangars & testing)	25 - 100	0.25	0.40	0.65	ISBL only
10	Electrical	15 - 45	0.09	0.13	0.22	Including tracing
11	Instrumentation / Controls	15 - 60	0.13	0.12	0.25	
12	Insulation	3 - 25	0.02	0.03	0.05	
13	Painting	2 - 10	0.01	0.01	0.02	
14	Safety / F P / Misc. (A)	4 - 12	0.02	0.03	0.05	
	TOTAL DIRECT COST		1.78	1.12	2.90	
INDIRECT PROJECT COSTS						
15	Field Establishment Costs ***				0.25	22% of labor / S.C. costs
16	EPC Office H.O. range 20% - 30%				0.67	23% of total direct costs
17	Construction Management range 20% - 45% of line 16				0.17	25% of EPC H.O
18	Owner Engineering & CM 5% - 15% of line 16 & 17				0.08	10% of line 16 & 17
19	TOTAL INDIRECT COSTS				1.17	
20	TOTAL COST MULTIPLIER				4.07	

(A) = Start up costs, initial chemicals, expense items and other minor items.

* 1.00 = Total value of Major Equipment / Assume 25 items (M.E.)

** 25% - 100% is based on using a 60 - 40 split of Carbon Steel and 304-316 SS. This value could in some situations exceed 100% in circumstances where exotic / expensive piping materials are utilized, i.e. Glass / Kynar / Teflon lined / Alloy 20 / Nickel, etc., or high percentage of 304 - 316 SS etc. is used due to hazardous / highly corrosive chemical applications.

*** Field establishment includes, construction equipment, field offices, field in directs, G.C.'s & S/C trailers, temporary warehouses, Division 1 (Preliminaries) etc. If the proposed project is a hybrid of a liquids and solids plant, use an average of both plants / facilities.

Table 30
CEMENT MANUFACTURING FACILITY
BASIS OF COST - 2015 COST DATA FROM 7 # COMPLETED & OPERATING FACILITIES IN USA AND MEXICO

CAPEX / OPEX CATEGORY	250,000 TON OF PRODUCTION PER YEAR CAPEX COST	500,000 TON OF PRODUCTION PER YEAR CAPEX COST	750,000 TON OF PRODUCTION PER YEAR CAPEX COST
Cement Production Equipment	40% to 50%	40% to 50%	40% to 50%
Construction Bulk Materials	15% to 25%	15% to 25%	15% to 25%
Construction Labor & Indirects	15%-20%	15% to 20%	15% to 20%
Detailed Design & Procurement of Capital Equipment & Bulks	7% to 11%	7% to 11%	7% to 11%
Construction Management	3.5% to 5%	3.5% to 5%	3.5% to 5%
Total CAPEX Value Average	\$83,776,000	\$161,660,000	\$233,550,000
Total CAPEX Value Range Low	\$67,020,800	\$129,328,000	\$186,840,000
Total CAPEX Value Range High	\$100,531,200	\$193,992,000	\$280,260,000
Cost per Ton (Average)	\$335,104	\$323,320	\$311,400
OPEX costs per year, facility operating personnel, fuel, property taxes, electricity, water, maintenance and spares	\$10 Million - \$25 million (average \$15 million per year)	\$15 Million - \$30 million (average \$20 million per year)	\$20 Million - \$35 million (average \$25 million per year)
For facilities with extensive pollution / air quality requirements such as ESP, Baghouses, SDA & NOX systems	Increase Total CAPEX values by 20% to 45%	Increase Total CAPEX values by 20% to 45%	Increase Total CAPEX values by 20% to 45%

Table 49

USA ETHYLENE PRODUCTION FACILITY: AVERAGE OF UNION / NON-UNION CONSTRUCTION: COST BASIS 2019

PRODUCTION CAPACITY (TONS PER ANNUM TPA)	NUMBER OF MAJOR EQUIPMENT ITEMS (M.E.)	NUMBER OF TAGGED INSTRUMENTATION EQUIPMENT ITEMS (M.E.)	TOTAL EPC AVERAGE COST PER TON ISBL	TOTAL EPC AVERAGE COST PER TON OSBL	TOTAL EPC AVERAGE COST PER TON ISBL & OSBL	ACCURACY OF DATA
500,000	145	1,760	\$3,425	\$381	\$3,806	+/- 15%
750,000	215	2,645	\$3,360	\$415	\$3,775	+/- 15%
1,000,000	323	3,510	\$3,297	\$450	\$3,747	+/- 15%
1,250,000	345	4,388	\$3,172	\$516	\$3,688	+/- 15%
1,500,000	427	5,260	\$3,090	\$545	\$3,635	+/- 15%

NOTES:

- Typical Cost of Major Equipment Item = \$1,575,000 to \$1,675,000
- Typical Cost of Tagged Instrument Item = \$8,700 to \$9,250
- Costs exclude Feed Studies, Land Purchase, Owner Engineering & Construction Management.
- Furnaces Represent 53% of M.E. Engineering & Fees = 14.2% of EPC cost
- Typical Owner Costs (10 to 20 professionals) Project Manager, Deputy Project Manager, Mechanical, Chemical, Electrical and Civil Engineers, Purchasing, QA QC, Estimators, Planners, Construction Manager, Inspectors, Document Control, Secretary- 10 to 20 people x 24 months:

Typical Open Shop (Non Union) Skilled Worker (PIPEFITTER, ELECTRICIAN ETC. ALL-IN HOURLY RATE BILL OUT RATE):

DESCRIPTION	% OF BASE RATE	\$ COST
BASE SKILLED JOURNEYMAN RATE (2Q – 2019)		\$29.25
PAYROLL TAXES & INSURANCES		
WORKERS COMPENSATION INSURANCE	17.3	\$5.06
GENERAL LIABILITY INSURANCE	4.2	\$1.23
FICA	14.3	\$4.18
FUI / SUI	4.3	\$1.26
BUILDERS ALL RISK INSURANCE	7.6	\$2.22
FRINGE BENEFITS	21.2	\$6.20
PREMIUM TIME	7.7	\$2.25
FIELD OFFICE / TEMP FACILITIES	8.3	\$2.43
FIELD OFFICE SUPPLIES / COMPUTERS / COPY MACHINES / COMMUNICATIONS	4.3	\$1.26
SAFETY ITEMS / FIREWATCH	8.6	\$2.52
SMALL TOOLS / CONSUMABLES	10.9	\$3.19
FIELD STAFF / PROCUREMENT / MATERIAL LOGISTICS	22.8	\$6.67
SCAFFOLDING	6.7	\$1.96
EQUIPMENT RENTAL (excludes Heavy Lift Cranes)	18.5	\$5.41
HOME OFFICE SUPPORT / COORDINATION	8.6	\$2.52
PER DIEM	5.3	\$1.55
PROFIT / CONTRACTOR FEE	15.5	\$4.53
OTHER / MISCL ITEMS	9.5	\$2.78
TOTAL ALL-IN FIELD WAGE RATE	195.6	\$86.46

Table 53**500 MW HYDRO POWER PLANT USA N.E. USA (2020 COST BASIS)**

	DESCRIPTION	\$ MILLIONS	% OF TOTAL COST
1	General Conditions / Preliminaries / Site Establishment	91,814,580	3.76%
2	Site Work	307,966,230	12.63%
3	Civil work	364,343,760	14.94%
4	Rip Wrap	55,845,900	2.29%
5	Concrete Walls / Dam	373,162,680	15.30%
6	O & M Building & Controls - Monitoring	24,750,535	1.01%
7	Intake Structure	23,760,535	0.97%
8	Shafts / Tunnels / Penstock	110,887,603	4.55%
9	Mechanical Equipment / Turbines / Generators	416,790,000	17.09%
10	Electrical Systems / Switch Yard / Sub Stations	76,230,000	3.13%
11	Site In-Directs (Supervision, Construction Equipment, Scaffolding, Testing)	199,980,000	8.20%
12	S/T CONSTRUCTION COST	2,045,531,822	
13	Engineering / Detailed Design / Procurement	193,965,000	7.95%
14	Project & Construction Management	11,055,000	0.45%
15	Fees / O-H & P	181,905,000	7.46%
16	Owner Engineering & Construction Oversight	6,633,000	0.27%
17	S/T ENGINEERING / PM & CM + FEES + OWNER COSTS	393,558,000	
18	TOTAL COST	2,439,089,822	100.00%
19	COST PER MW	4,878,180	
20	LOWER COST RANGE PER MW -15%	4,146,453	
21	HIGH COST RANGE PER MW +15%	5,609,907	
	Exclude land purchase		

Table 54**POWER PLANT COST METRICS USA (2020 COST BASIS)**

#	POWER PLANT TYPE	TYPICAL SIZE IN MW	\$ COST PER MW MINIMUM	\$ COST PER MW MAXIMUM	\$ OPEX PER MW ANNUAL FIXED & VARIABLE COSTS MINIMUM	\$ OPEX PER MW ANNUAL FIXED & VARIABLE COSTS MAXIMUM
1	Coal	150 - 250	2,330,000	2,950,000	25,000	50,000
2	Coal	250 - 500	2,230,000	2,770,000	25,000	50,000
3	Gas - Combined Cycle	150 - 250	970,000	1,385,000	10,000	15,000
4	Gas - Combined Cycle	250 - 500	900,000	1,245,000	10,000	15,000
5	Gas - Simple Cycle	150 - 250	885,000	1,175,000	10,000	15,000
6	Gas - Simple Cycle	250 - 500	850,000	1,130,000	10,000	15,000
7	Fuel Cell	150 - 250	2,570,000	6,220,000	20,000	40,000
8	Fuel Cell	250 - 500	2,530,000	6,140,000	20,000	40,000
9	Wind Power Onshore	50 - 75	2,600,000	2,850,000	1,000	2,500
10	Wind Power Onshore	75 - 150	2,450,000	3,330,000	1,000	2,500
11	Wind Power Offshore	50 - 75	3,150,000	3,450,000	2,500	5,000
12	Wind Power Offshore	75 - 150	3,000,000	3,250,000	2,500	5,000
13	Solar PV	25 - 50	2,750,000	4,800,000	1,000	2,500
14	Solar PV	50 - 100	2,600,000	4,550,000	1,000	2,500

DIAMETER	\$ MATERIAL COST PER LF	\$ M-H COST PER LF	\$ COST PER LF	\$ MATERIAL COST PER M	\$ M-H COST PER M	\$ COST PER M
FRP - Furan Complicated / Intricate (ISBL - Inside Facility) Piping - Numerous changes in direction (CONTINUED)						
4" / 100 mm	172.71	114.24	286.95	566.49	374.71	941.20
6" / 150 mm	177.37	207.71	385.08	581.77	681.30	1,263.07
8" / 200 mm	210.05	257.77	467.82	688.97	845.47	1,534.44
10" / 250 mm	281.62	304.97	586.59	923.72	1,000.30	1,924.02
12" / 300 mm	348.52	362.56	711.08	1,143.15	1,189.19	2,332.34
Add 4.5% - 7.5% to labor & material costs for hangars, bolts, gaskets & testing						
FRP - Furan Straight run / OSBL Piping						
2" / 50 mm	54.46	23.60	78.06	178.64	77.41	256.05
3" / 75 mm	68.54	32.78	101.32	224.81	107.52	332.32
4" / 100 mm	82.23	42.14	124.37	269.73	138.21	407.94
6" / 150 mm	105.08	70.22	175.30	344.65	230.33	574.98
8" / 200 mm	158.37	103.00	261.37	519.46	337.84	857.31
10" / 250 mm	204.06	126.41	330.47	669.31	414.62	1,083.93
12" / 300 mm	255.84	154.51	410.35	839.15	506.79	1,345.95
Add 4.5% - 7.5% to labor & material costs for hangars, bolts, gaskets & testing						
FRP - Epoxy - Double Walled Pipe Complicated / Intricate (ISBL - Inside Facility) Piping - Numerous changes in direction						
1" dia. inside a 3" dia.	179.29	122.22	301.51	588.07	400.89	988.96
2" dia. inside a 4" dia.	259.51	211.53	471.04	851.18	693.82	1,545.00
3" dia. inside a 6" dia.	284.67	352.56	637.23	933.72	1,156.39	2,090.11
4" dia. inside a 8" dia.	344.43	455.99	800.42	1,129.75	1,495.64	2,625.39
6" dia. inside a 10" dia.	429.36	629.91	1,059.27	1,408.31	2,066.11	3,474.42
Add 4.5% - 7.5% to labor & material costs for hangars, bolts, gaskets & testing						
FRP - Epoxy - Double Walled Pipe Straight run / OSBL Piping						
1" dia. inside a 3" dia.	67.61	51.72	119.33	221.77	169.63	391.40
2" dia. inside a 4" dia.	92.77	61.11	153.88	304.27	200.44	504.71
3" dia. inside a 6" dia.	117.92	108.11	226.03	386.77	354.61	741.39
4" dia. inside a 8" dia.	146.21	155.69	301.91	479.58	510.68	990.25
6" dia. inside a 10" dia.	238.95	220.94	459.89	783.77	724.69	1,508.45
Add 4.5% - 7.5% to labor & material costs for hangars, bolts, gaskets & testing						

CONCRETE GENERAL ESTIMATING DATA

TYPE	PER SF	PER M2
Bush hammer concrete	\$0.65 - \$1.30	\$7.00 - \$14.00
Acid wash concrete	\$0.23 - \$0.40	\$2.47 - \$4.30
Pattern concrete slabs	\$0.50 - \$0.84	\$5.38 - \$9.04
Colorize concrete slab	\$0.63 - \$1.05	\$6.80 - \$11.30
Bag / Dress concrete walls	\$0.30 - \$0.75	\$3.23 - \$8.07

Estimating Thoughts for Structural Steel and Miscellaneous Steel

Obtain and review any available engineering deliverables / drawings or sketches. Take off lengths of steel section and multiply by appropriate weight in pounds per LF, determine pounds / tons of steel that is depicted on the drawings. Structural steel is usually fabricated in a vendors shop, and delivered to the site for eventual erection. Structural steel has a number of differing specifications / materials of construction, that have differing cost consequences the most widely used is A36.

Issues that may perhaps impact the erection activity of new structural steel are:

- Lifting equipment / cranes / hoists
- Mobilization / de-mobilization of crane (crane are typically rented by the day or week)
- Crane reach
- Lifting capacity

- Number of floors
- Bolted connections
- Welded connections
- Painting / touch up painting

Platforms, ladders, handrails, stair risers and other miscellaneous: perform take off and establish pounds / tons of material and assign appropriate installation man-hours. Checker plate, grating and floor plate and metal decking: perform take off and establish square feet of material and assign appropriate installation man-hours, allow at least 5% for waste in the cutting / fit up activity.

Order of Magnitude Structural Steel Estimating Data

Structural Steel weights per SF:

- Manufacturing Building = 10 - 15 lb / S.F.
- 5 Floor Office Building = 15 - 25 lb / S.F.
- Heavy industrial Facility = 25 - 75 lb / S.F.
- Process Structures: Preliminary weights of

structures can vary from 1.5 lb to 3.5 lb (Cubic Foot of enclosed area).

Structural Steel as percentage of major equipment cost: usually falls in the 5% to 8% of major equipment cost. The following pie chart delineates the various cost / fabrication and installation activities associated with structural steel.

PERCENTAGE BREAKDOWN OF STRUCTURAL STEEL BASED ON 500-TON, 3-STORY BUILDING:

