PREPARATION OF PRELIMINARY CAPITAL COST ESTIMATES

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ABSTRACT

The preparation of preliminary capital cost estimates is of great importance to the chemical industry. They are normally required to make plant investment decisions.

This paper will look at the techniques available for the preparation of these estimates, the data required and the expected level of confidence.

The paper will place emphasis on the general concept of cost estimates rather than elaborating on a particular type of plant or process. Nevertheless, some examples will be given of recent projects and the success experienced in the application of the cost estimating techniques.

1. INTRODUCTION

Our staff at Prado & Associates gets involved quite frequently in the preparation of capital cost estimates for process plants. Different situations require different approaches regarding the speed, cost and accuracy of the estimate. The primary purpose of this paper is to outline the various types of capital cost estimates available and their relative features. However, emphasis will be given to the "preliminary" type estimates since, in our experience, they are the most commonly used and probably the most useful.

2. TYPES OF COST ESTIMATES

We generally recognize the following types, in ascending order of accuracy:

Order of magnitude
Preliminary
Detailed

2.1 "ORDER-OF-MAGNITUDE COST ESTIMATES"

This type of estimate is generally prepared at the very early stages of a proposed project, when the client wants a fast and inexpensive estimate, at a stage where project funding may not be available yet and little information exists on the detailed scope of the project. The degree of accuracy is approximately in the +/-40% to 60% range.

This type of estimate is prepared using scale-up and cost factors from the estimating literature. At minimum a basic process description and a plant capacity are needed. This estimate can be prepared in a few days at a cost ranging from $500 to $5,000 depending on complexity.

2.2 "PRELIMINARY COST ESTIMATES"

This type of cost estimate is generally prepared once a tentative decision has been made to proceed with the project and the client is willing to spend some money on preliminary engineering. In order to perform this type of cost estimate a preliminary engineering package is needed. This package typically includes a process description, preliminary process flow diagrams, preliminary P&I diagrams, preliminary arrangement drawings and a preliminary equipment list. For us, the equipment list is a critical item since we use it as the basis for the preparation of the cost estimate.

The estimate is prepared by obtaining costs for all the equipment items either from past quotes, recent literature or by requesting prices from vendors. The installed cost is obtained by using the factors published in the literature. The "non equipment" costs such as site preparation, utilities, fire protection, etc. can be obtained either by using factors or by preparing rough "take-offs".

The degree of accuracy is in the +/-20% to 25% range. One matter which must be emphasized is that the accuracy of this cost estimate depends on how well defined the scope of the project is. In our experience, whenever a project cost deviates significantly from the estimate, the usual reason is changes in scope that were not reflected in the initial estimate!

After the preliminary engineering package is ready, the cost estimate can be obtained in a few weeks at an additional cost that can range between $1,000 and $10,000, depending on complexity.

A spreadsheet (Quattro Pro) template has been prepared to facilitate the preparation of this type of estimate. As mentioned above, in order to use this form, a complete equipment list is necessary. A recent sample of a typical cost estimate is attached.

2.3 "DETAILED COST ESTIMATE"

A detailed cost estimate requires that the detailed engineering be underway, as a firm equipment list and a bulk material take-off are usually needed.

Generally, the purpose of this estimate is to have a final check before the client commits to equipment purchasing and contracting. It can also be used for budget monitoring and control purposes. This type of estimate is based on bid prices for all the equipment and bulk take-offs for all materials of construction. Typically detailed cost estimates are prepared after the decision to proceed with the project has been made.

The degree of accuracy is in the +/-10% to 15% range. The cost of preparing such an estimate can be considerable and would depend upon the complexity of the project as well as the degree of completion of the engineering. It cannot be overemphasized that the reliability of a detailed cost estimate depends upon the availability of the required information.

3. MISCELLANEOUS COMMENTS

We are often asked if it is possible to obtain costs estimates with an accuracy better than +/-10%. The answer is "yes" as well as "no". Yes, it is possible to obtain more accurate figures. But, no, it would no longer be a cost estimate but rather a control budget.

An accuracy better that 10% can generally be obtained after all equipment is bought, deliveries are committed and construction contracts are in place. To us this is not an estimate, since the concept of estimating implies both a future forecast and a degree of uncertainty. The implication of this is that this level of accuracy is not feasible in the early stages of a project since most of the information required for this level of accuracy would not available.

4. SOURCES OF INFORMATION

In preparing a preliminary capital cost estimate one of the most obvious needs is finding up-to-date and accurate cost data for the individual pieces of equipment involved. Getting numbers is easy; getting good numbers is something else.

Do not despair! Three general sources of information are available. The first one consists of calling equipment vendors and asking for "budget" prices. However, this technique should not be abused. While many vendors would be happy to provide this information, ethical considerations should be taken into account, which would tend to limit the usefulness of this method.

The second source of information would be old equipment quotes for equipment which has been previously acquired. The cost index published monthly in Chemical Engineering Magazine could be used to bring the price up to date. We must warn, however, that this technique should only be used for prices which are no more than five years old. While the cost curves go back all the way to 1986, older numbers may not be reliable because of relative changes in the price of materials of construction.

In general, the more recent the data, the better. One problem in using this technique is that old prices may not be available for exactly the same type of equipment that is needed.

The third resource consists of the cost estimating handbooks and articles which are available in the chemical engineering literature. Once again, the date of such information is crucial. The more recent, the better. We have found the following sources to be most useful:

Conceptual Cost Estimating, by John S. Page, published by Gulf Publishing Company, Houston, Texas, 1984.
This publication is excellent for chemical and petrochemical equipment but is weak in material handling. While the book is not recent and the cost figures can only be used with great caution, it does have erection manhour estimates which are still applicable.

Modern Cost Engineering, edited by the Staff of Chemical Engineering, McGraw-Hill Publications Co., New York, 1984. Again, this is out of date, but the methodology and general cost estimating information is excellent. This collection of articles which have appeared in Chemical Engineering Magazine would be good for educational purposes. We only wish McGraw-Hill would publish a more current edition!

Bureau of Mines Cost Estimating System Handbook, Information Circular 9243, Compiled by the Staff, US Bureau of Mines, 1987. A bit out of date, but excellent data on mining and material handling systems. Also good general methodology on cost estimating concepts.

Perry's Chemical Engineers' Handbook, Sixth Edition, McGraw-Hill, 1984. Section 25 "Process Economics" has excellent tables for installed cost factors for various types of equipment. There is also very useful information for preliminary estimates of various plant utility systems based on percent of total installed plant cost.

Process Plant Construction Estimating Standards, The Richardson Rapid System, Richardson Engineering Services, Mesa Arizona, 1993 Edition.
This reference is extraordinarily detailed, very comprehensive and completely up to date. Unfortunately, the amount of data presented is so massive that sometime it can be overwhelming for a preliminary cost estimate. We use it mostly for detailed cost estimates.

Last, but not least, Chemical Engineering Magazine publishes periodic articles on the subject of cost estimating. A good recent example is the article that appeared in the January 1993 issue "Piping Systems: How Installation Costs Stack Up". This type of article can be very useful since it represents up to date cost information. What we do is keep these articles in our own estimating handbook, broken down by equipment account code.

5. Epilogue

The only way to evaluate a cost estimating system is to compare the original cost estimate with the final constructed cost figures. Recently a preliminary cost estimate we did for a specialty chemical project in north Florida came within one percent of the actual final cost. We do not wish to brag about this; it was just plain good luck!

A less fortunate example is the chemical refinery we did on the West Coast a few years ago in which our cost estimate was off by 100%. The reason was that the final scope of the project bore no resemblance to the initial one. This reinforces our firm belief that proper project scoping is the single most important element in a successful cost estimate.

6. Graphs and Pictures

The Quattro Pro spreadsheets on the following pages illustrate actual cost estimates prepared recently. While the original spreadsheets were real, substantial modifications have been made to protect the confidentiality of our clients and projects.

6.1 Typical "Order of Magnitude" Cost Estimate

FILENAME: AICHE93.QW1 15-APR-93

EQUIPMENT DESCRIPTION	PURCHASE COST	INSTALLED COST
BLOWER	$3 800	$5 320
DRY MIX FEEDER	$37 900	$53 060
ZINC FEEDER	$26 380	$36 932
AGITATOR	$3 800	$5 320
AGITATOR	$4 750	$6 650
AGITATOR	$3 600	$5 040
LEACH I SLURRY PUMP	$1 100	$1 540
SURGE TANK PUMP	$1 100	$1 540
PURIFICATION FILTER PUMP	$1 100	$1 540
PRODUCT LIQUOR PUMP	$1 100	$1 540
RECYCLE PUMP	$1 100	$1 540
BZC SETTLER SLURRY PUMP	$2 100	$2 940
BZC SLURRY TRANSFER PUMP	$2 100	$2 940
STRIPPED BARREN LIQUOR PUMP	$2 100	$2 940
PUMP	$2 100	$2 940
WASH LIQUOR PUMP	$2 100	$2 940
FRESH LEACH LIQUOR PUMP	$2 100	$2 940
STRIPPER STAGE 1	$12 800	$17 920
STRIPPER STAGE 2	$12 800	$17 920
STRIPPER STAGE 3	$12 800	$17 920
STRIPPING COLUMN	$28 750	$40 250
NH3 ABSORPTION COLUMN	$31 700	$44 380
GAS SCRUBBER	$12 800	$17 920
DRY MIX BIN	$13 800	$19 320
LEACH TANK	$16 500	$23 100
LEACH TANK	$16 900	$23 660
PL SURGE TANK	$16 900	$23 660
PURIFICATION TANK	$16 900	$23 660
PRODUCT LIQUOR TANK	$16 900	$23 660
LIIL SURGE TANK	$15 700	$21 980
WASHING SURGE TANK	$13 300	$18 620
SURGE TANK	$18 250	$25 550
TANK	$16 750	$23 450
WASH LIQUOR TANK	$13 000	$18 200
STRAINER	$12 300	$17 220
FILTER SLURRY II	$102 800	$143 920
PURIFICATION FILTER	$112 800	$157 920
FILTER BZC	$100 000	$140 000
BZC SETTLER	$114 500	$160 300
CONDENSER	$9 500	$13 300
CONDENSER	$9 500	$13 300
EVAPORATOR	$17 000	$23 800
ABSORPTION SYSTEM COOLER	$13 600	$19 040
EQUIPMENT SUBTOTAL	$876 880	$1 227 632
MULTIPLIER	2.6	
TOTAL PLANT COST (+/-50%)	$2 279 888	

6.2 Typical "Preliminary" Cost Estimate

EQUIPMENT NAME OR FUNCTION	PURCHASED PRICE	INSTALLED PUERTO RICO
AIR COMPRESSOR	$6 500	$9 750
DISTILLATION COLUMN #1	$112 400	$337 200
COLUMN PACKING & SCREENS	$14 800	$19 240
DISTILLATION COLUMN #2	$126 200	$378 600
COLUMN PACKING & SCREENS	$16 792	$21 830
HCl ABSORBER PACKED COLUMN	$16 200	$48 600
PACKING & SCREENS	$12 132	$15 772
DISTILLATION COLUMN #3	$111 546	$334 638
COLUMN PACKING & SCREENS	$25 100	$32 630
DISTILLATION COLUMN #4	$111 546	$334 638
COLUMN PACKING & SCREENS	$25 100	$32 630
DISTILLATION COLUMN #5	$123 100	$369 300
COLUMN PACKING & SCREENS	$22 950	$29 835
MOLECULAR SIEVE DRYER #1	$15 000	$30 000
AGITATED DRYER	$35 000	$49 000
NITROGEN ELECTRIC HEATER	$5 286	$10 572
Boiler	$165 000	$180 500
VACUUM PUMP #1	$15 000	$21 000
REACTOR AGITATOR #1	$29 705	$38 617
CHLORINATION AGITATOR	$17 697	$23 006
FEED MIXER (STATIC)	$1 100	$1 430
DRYER AGITATOR	$8 427	$10 955
SCRUBBER	$18 500	$24 050
NaOH PUMP, PDP	$3 100	$5 270
FEED PUMP, PDP	$3 200	$5 440
CRUDE PUMP, PDP	$3 000	$5 100
WET PRODUCT PUMP, PDP	$2 073	$3 524
STILLPOT PUMP, PDP	$2 500	$4 250
HCl PUMP, PDP	$2 073	$3 524
DRY INTERMEDIATE PUMP, PDP	$2 073	$3 524
NEUTRALIZED INTERMEDIATE PMP,P	$2 073	$3 524
DECANTER DAY PUMP, CENTRIF	$2 500	$4 250
CHLORINATION REACTOR PUMP	$2 073	$3 524
RECYCLE PUMP, PDP	$2 073	$3 524
STILLPOT PUMP, PDP	$2 073	$3 524
OFFPRODUCT PUMP	$2 073	$3 524
ISOMER PUMP, PDP	$2 073	$3 524
STILLPOT PUMP, PDP	$2 073	$3 524
BOTTOMS PUMP, PDP	$2 073	$3 524
TOP CUT PUMP #1,PDP	$2 073	$3 524
ACETONE PUMP, PDP	$2 073	$3 524
BOTTOMS PUMP #2, PDP	$2 073	$3 524
REBOILER PUMP, CENT	$2 500	$4 250
STILLPOT PUMP, PDP	$2 073	$3 524
WATER PUMP, PDP	$2 073	$3 524
RECYCLE PUMP, PDP	$2 073	$3 524

GC PUMP, PDP	$1 669	$2 837
PRODUCT PUMP	$2 073	$3 524
DRUMMING PUMP	$2 073	$3 524
COOLING TOWER PUMPS (2ea)	$7 712	$13 110
CHILLER PUMP	$9 084	$15 442
FIRE PROTECTION SYSTEM	$114 000	$193 800
METHANOL CHILLER	$560 000	$616 000
COOLING TOWER	$28 700	$75 000
FEED TANK	$23 885	$45 382
CRUDE TANK	$58 700	$117 400
CHLORINATION TANK	$24 400	$51 240
TANK # 3	$45 000	$85 500
TANK #4	$6 473	$12 299
TANK # 5	$3 947	$7 499
TANK #6	$3 947	$7 499
RECYCLE TANKS (2ea)	$6 720	$10 080
VIRGIN TANK	$37 860	$87 078
NaOH TANK	$4 800	$11 040
RECYCLE TANKS (2ea)	$26 400	$39 600
WASTE ORGANIC TANK	$2 900	$6 670
WET TANKS (2 ea)	$10 560	$15 840
HCL TANK	$6 000	$9 000
WET CRUDE RECOV. TK	$3 360	$5 040
DRY CRUDE TANKS (2ea)	$10 560	$15 840
REWORK PORTABLE TANK	$9 120	$13 680
DECANTER DAY TANK	$5 280	$11 906
RECYCLED CRUDE TANK	$2 900	$4 350
ISOMER DRUM	$1 000	$1 500
ISOMER BACKCUT TANK	$1 000	$1 500
OFFCRUDE TANK #1	$5 280	$7 920
TOP CUT TANK #2	$3 360	$5 040
FEED TANK	$3 360	$5 040
VENT COND. TANK	$1 000	$1 500
ACETONE STORAGE TANK	$4 800	$11 040
BOTTOMS TANK #1	$4 320	$6 480
VENT CONDENSER TANK	$1 000	$1 500
BOTTOMS TANK	$5 280	$7 920
TOP CUT TANKS (2ea)	$8 640	$12 960
PROCESS WATER TANK	$1 000	$2 300
PRODUCT TANKS (3 ea)	$18 720	$28 080
BOTTOMS TANK	$9 120	$20 976
RECOVERED ACETONE TANK	$9 120	$20 976
DECANTER	$15 000	$21 000
POROUS METAL FILTR	$2 000	$2 800
CRUDE CONDENSER	$12 912	$27 115
COLUMN CONDENSER	$12 912	$28 406
VENT CONDENSER	$12 912	$28 406
CHLORINATION VENT CONDENSER	$12 912	$28 406
ABSORBER RECYCLE COOLER	$12 912	$27 115
COLUMN CONDENSER	$12 912	$28 406
REBOILER	$12 600	$26 460
COLUMN CONDENSER	$5 405	$11 351
FEED PREHEATER	$12 500	$26 250

BOTTOMS COOLER	$2 500	$5 250
REBOILER	$12 500	$26 250
PRODUCT COOLER	$5 750	$12 075
VENT CONDENSER	$4 580	$9 618
REFLUX SPLITTER	$1 000	$1 600
REFLUX SPLITTERS (2 ea)	$19 422	$29 133
CARBON DRUMS (3 ea)	$1 545	$3 090
REFLUX SPLITTER	$3 000	$4 500
SAMPLE CYLINDER	$800	$1 200
SHIPPING TO PR, EQUIPMENT		$74 100
TAX	$186 307	$186 307
EQUIPMENT SUBTOTAL	$2 544 626	$5 599 217
NON-EQUIPMENT ACCOUNTS:		
ARCHITECTURAL/STRUCT		$350 000
LABORATORY		$45 000
SHIPPING TO PR, STEEL		$25 000
VENTILATION, HVAC		$120 000
CONCRETE, FOUNDATIONS		$45 000
ELECTRICAL		$223 000
MAIN FEEDER RUN		$15 000
INSULATION		$5 000
INSTRUMENTS & CONTROLS		$250 000
ANALYTICAL INSTRUMENTS		$145 000
DATA COLLECTION COMPUTER		$50 000
GC's		$375 000
PRV's		$175 000
PAINTING		$75 000
PIPING		$1 526 776
UTILITY		$75 000
STEAM TRACING		$63 450
VALVES		$508 925
WASTE TREATMENT		$375 000
ARPE TAX (PUERTO RICO)		$450 000
SUBTOTAL, NON-EQUIPMENT:		$4 447 151
OFFICE COSTS:		
ENGINEERING		$1 134 200
PROCUREMENT		$48 500
CONSTRUCTION MANAGEMENT		$291 100
PERMITTING (by others)		$150 000
FDA VALIDATION		$622 220
OUT-OF-POCKET EXPENSES		$143 080
SUBTOTAL, OFFICE		$2 389 100
PROJECT SUBTOTAL		$12 435 468
CONTINGENCY @ 10%		$1 243 547
GRAND TOTAL:		$13 679 014