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DEVELOPMENT OF COST ESTIMATE PLANS –
AS APPLIED IN ENGINEERING, PROCUREMENT, AND
CONSTRUCTION FOR THE PROCESS INDUSTRIES
TCM Framework: 7.3 – Cost Estimating and Budgeting

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INTRODUCTION

Purpose

This recommended practice (RP) of AACE International (AACE) is a guideline for development of cost estimate preparation plans for engineering, procurement and construction (EPC) projects in the process industries.

The purpose of a cost estimate preparation plan (herein referred to as “estimate plan”) is to establish and communicate how the preparation, development, review and approval of the estimate will be completed.

Background

AACE International’s *Total Cost Management (TCM) Framework*^[4] section 7.3.2.1 “Plan for Cost Estimating and Budgeting” highlights the need to develop estimate plans. This RP delineates industry-specific practices for development of an estimate plan as they are applied to EPC projects in the process industries. (A future AACE International RP will provide a guideline for development of a generic cost estimate plan.)

Cost estimating in the hydrocarbon processing industries (e.g.; chemical, refining, petroleum production facilities, etc.) has evolved to a relatively advanced state over more than four decades of application. These industries have developed many common practices and identified industry-specific best practices through benchmarking and knowledge-sharing. The practices reflected in this document are a result of compiling notes made by industry practitioners, lessons learned and publicly available documents.

Scope

With reference to the *TCM Framework*, this document addresses the steps before and after the “Plan for Estimating and Budgeting” step to the extent necessary for an effective estimate plan.

This document is primarily focused on estimates prepared for project sanction purposes of land-based facilities. Typically, project sanction is based on a Class 3 estimate. Estimate plans for other classes of estimates may be adapted from this document.

The basic principles are applicable to all contracting strategies and asset owner (herein referred to as “owner”) configurations. For example, contracting strategies may be in the form of reimbursable engineering with fixed price procurement and construction and/or EPC alliances, etc. Owner configurations may include self-perform, partnerships with a named “operating company” or consortiums responsible for managing the project/program and so on. Some key principles are:

- Preparation of an estimate plan helps to ensure successful estimate completion in an effective and timely manner.
- Engaging key stakeholders in the estimate planning process prior to the start of the estimate development process, improves the likelihood of meeting estimate objectives.
- The estimate plan defines what information is required from who and when.
- An approved estimate plan provides a duly authorized basis to proceed with the estimating effort, clarifies requirements and responsibilities.

RECOMMENDED PRACTICE

This recommended practice is divided into three main sections:

1. The **Estimate Development Plan Process** defines the main steps and discusses issues to be considered in preparing an estimate plan.
2. The **Estimate Plan Format and Content** provides a suggested format for an estimate plan along with annotations. It is designed to allow practitioners to use and modify it as needed for their specific situation.
3. **Appendices** contain sample formats which are used in conjunction with the estimate plan.

ESTIMATE DEVELOPMENT PLAN PROCESS

Figure 1 illustrates a summary of the estimate development plan process.

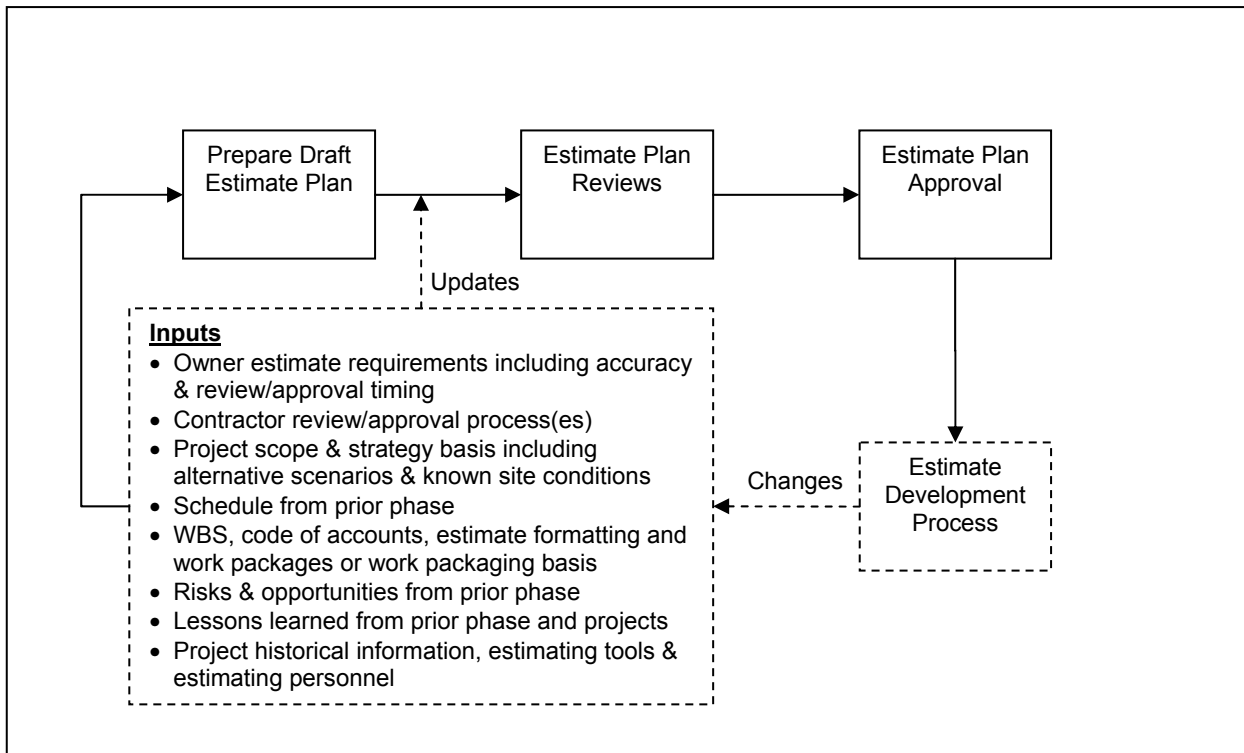


Figure 1. – Estimate Plan Development Process

Inputs to Estimate Plan Development

It is recommended that owners furnish specifications for estimate plans within the contract or prior to the contractor(s) preparing an estimate plan. In any case, the onus is with the lead estimator of each organization to develop an estimate plan which will satisfy the owner’s needs. Where multiple contractors are involved, the owner is ultimately responsible to ensure that all organizations involved are properly coordinated in terms of scope delineation, estimate delivery timing and consolidation. In cost reimbursable situations, owner agreement on how the estimate will be prepared before developing the estimate is crucial. If this is not done, accusations of wasting the owner’s money may be directed toward the contractor and it may result in the owner’s refusal to pay for the “wasted effort”. It is not only important in terms of keeping good client relations but also in terms of helping to ensure the owner has properly

understood and clarified what is required. Mature project management organizations have appropriate estimate review processes in place to provide executives with an understanding of the estimate variability (risks, uncertainty, etc). Buy-in up front from the owner saves valuable time at the end of the estimating cycle when the owner project team is under pressure to deliver the estimate to their management. Ideally, the owner estimator only needs to verify that the contractor performed what was agreed beforehand and conduct a final benchmarking analysis of the results before recommending approval to owner project management. Contractor completion of an estimate is only the beginning of the owner's approval process, therefore it is critical, regardless of contract form, to ensure alignment on timing of estimate review and delivery requirements at the outset. Owner organizations typically have predetermined dates when board meetings are held and their agendas are set several months in advance. Larger projects tend to be separate agenda items. Delays in the estimating process may cause the project to miss a critical window of opportunity. For smaller projects, the timing and process for owner annual budgeting decisions need to be understood.

Despite all the effort that goes into cost estimates and the resulting volume of documentation for project sanction, estimates are usually summarized into a single line input to project economics in the form of a cash flow. The basis for the time-spread of cash flows must be given careful thought when prepared, and adequate scrutiny when reviewed. Some organizations designate cash flow development as a function of scheduling due to the interrelationship between activity timing and costs. In any case, it is advisable to assign this important task to an experienced person who is knowledgeable in how invoices are paid relative to work completion and areas where the schedule may not contain activities which reflect significant cost items. For example, insurance premiums, typical payment terms for large value equipment (prior to knowing actual terms), or the fact that "variable indirects" tend to be front and back loaded rather than spread evenly over time. Cash flows developed without adequate analysis and/or hastily under tight time pressures to support project approval processes may result in economic projects being cancelled or uneconomic projects being approved. Cash flows are also used for determining escalation and are therefore a key deliverable to be identified in estimate plans. Owners using the accrual-based accounting method usually require a cost flow (incurred cost timing) in addition to cash flow (payment timing). Costs are typically incurred about two months earlier than they are paid but it varies significantly depending on owner and contractor procedures as well as vendor invoicing habits. The necessity of an incurred cost flow to accompany the estimate should be clarified prior to completion of the estimate plan.

Updated scope and project execution plan information are critical to planning estimate development. The project execution plan describes contracting strategies, work schedules/shifts/overtime, labor sources, fabrication and modularization, and so on. Checklists are an effective aid to ensure portions of scope are not omitted. A more advanced approach is to ensure that the estimating deliverables and controlling documentation are identified for each portion of scope and corresponding execution plans.

The most current schedule information is needed to analyze resource requirements and peaks in addition to any weather windows, planned outages, tie-in opportunities, etc. This may include potential cost impacts of plans to perform work less efficiently than normal, or constraints, or innovation.

Estimate data (quantities, hours, costs) should be coded in a manner that considers how the estimate is prepared (including related source data), reviewed (including benchmarking) and how it will be used for cost control. Recasting an estimate consumes valuable resources and poorly formatted estimates may result in situations where the control team takes several months to establish control. The contractor may need to submit its project code of accounts to the owner for development of cross-reference mapping to owner's code of accounts. The contractor may be required to provide summarization of project costs according to owner-specified formats. Any other special requirements must be considered such as: pre-investment cost breakout; property tax cost breakout; separation of facility ownership values; asset valuation; asset financial value depreciation and income tax classes; final cost report formats; partner reporting requirements; currency conversions; etc.

Risks and opportunities from the prior phase and any updates should be addressed (mitigated, accepted, etc.) such that their disposition is known for the follow-on estimating and risk analysis. Ideally, this is

done in an aggressive manner to improve the chances of producing a good estimate and project success.

Lessons learned from the prior phase can be a source of opportunities to reduce costs or highlight significant gaps in past practices which need to be addressed prior to completing the estimate. Any assumptions that can be removed or clarified should be.

Stating the planned sources of estimating basis such as project historical data is important for obtaining owner and contractor alignment and confirming validity. This also applies to the estimating tools, processes, and estimator qualifications.

In summary, all inputs to the estimate and required outputs should be identified and included in the estimate plan. If requirements are not clear, meetings should be held to outline the estimate planning process and obtain alignment.

Prepare Draft Estimate Plan

A draft estimate plan is prepared based on all the inputs available including any related clarifications. If the estimate is to be delivered as part of a larger package which includes other deliverables such as the scope document, engineering design basis, schedule, execution plan, risk analysis, etc., it should be reflected accordingly within the estimate plan.

The level of project definition and facility process complexity will have a significant impact on estimate plan content and volume. For example, a project with a mine or subsurface components, several processing units, storage facilities, offloading/export facilities, and pipelines will require much more documentation than a project to install a single process unit or replace a piece of equipment. A multiple small projects environment where facilities are installed and estimated on a routine basis, may require less formality and planning than suggested by this guideline if executed by a team of people who have done so together over several years.

Publishing a team contact list with the estimate plan and/or as part of an estimate responsibility matrix is recommended.

Word-processing software is best suited for documenting the estimate plan. It can be supplemented with spreadsheet software for more complex tables and numerical/date information management. For complex projects, scheduling software is suggested for planning the specific work activities necessary to complete the estimate including the estimate plan, estimate basis, and deliverables to estimating. The estimate planning and development activities should be an integral part of the project schedule for that phase.

Estimate Plan Reviews

Once a draft estimate plan and corresponding schedule are complete, a set of review meetings are held with all key stakeholders to communicate any defined requirements and responsibilities. It is imperative during this review that everyone with a key deliverable commits to meeting their assigned dates or else the entire plan will be in jeopardy of slipping, including the final due date to the owner. Issues and concerns relative to the estimate plan are documented along with plans to resolve them.

Estimate Plan Approval

Once an estimate plan is satisfactory to the owner, the authorized owner and contractor representative(s) should endorse it with signatures to indicate alignment and approval. Preferably, this occurs after other key stakeholders have signed to indicate buy-in and committed to be accountable.

Upon approval of the estimate plan, roll-out sessions are held to communicate the approved basis for proceeding with estimate development.

Estimate Development Process

A good estimate plan will make the estimating process more efficient. If conditions change significantly, updates to the estimate plan are necessary to maintain alignment. Changes are integrated and dealt with through the project change management process.

The final version of the estimate plan may be used as the starting point for the basis of estimate by carrying over common elements and wording from the estimate plan. Preparation of the basis of estimate document while the estimate is being prepared is preferred to completing it after the estimate when time is short and key information may have been forgotten or gone missing along with personnel that are no longer available.

ESTIMATE PLAN FORMAT AND CONTENT

The extent to which each of the sections below can be completed as indicated is highly dependent on the level of definition available. Since it is a recommended practice to define as much of the project as possible up front, that is assumed to be the case. It may be necessary to explain what information is not available at the time of estimate plan preparation, when it will be available and how it will be handled. Alternatively, there may be a plan to update the estimate plan at an appropriate point before substantial work is done on the estimate. Be aware that if several “workarounds” are planned, it may be a sign there is misalignment between available project definition and estimate objectives.

Purpose of Estimate

The purpose of the estimate sets the focus for the remainder of the document. Summarize what the estimate will be used for and by who. For example, describe the overall facility type and location. Identify whether the estimate is a part of requirement for approval to proceed to the next phase of the project (i.e.: AFE, company-specific stage gate, etc.), a special study, to update the cost control baseline and so on. Secondary purposes are to establish a basis for project control, to quantify resource requirements and provide owner decision-makers with an appropriate level of confidence in the estimate.

Based on level of project definition, state the expected accuracy range and AACE International Estimate Class^[7]. (E.g.: It will be a Class 3 estimate and the final cost is expected to be within -10% to + 15% of the estimate after applying contingency.)

Key Estimate Development Milestones

As discussed above, the estimate plan activities should be an integral part of the project schedule for that phase. The detailed estimate plan schedule is discussed later in the document. A table of the key deliverables and planned dates based on the detailed schedule of the estimate plan should be prepared for management summary purposes. The table may be expanded to contain details such as the expected status of each deliverable or an estimator site visit. Table 1 is provided as an example. The table may be extracted for reporting estimate development status to management by adding a column for actual date completed.

Milestone	Date
Estimate plan approval	ddMMMy
Agree estimating basis with owner (software, methodology, labor productivity, labor rates, equipment/material pricing, MTOs, allowances, indirects, engineering, scope allocation)	
Scope cut-off date for estimate <i>This is when key engineering and execution basis documents are frozen for estimating purposes. (e.g.: PFDs, P&IDs, equipment list, piping line list, electrical single-line diagram, specifications, instrument index tie-in list). Some may be available earlier than others but none should be after the cutoff date to maintain a consistent basis.</i>	
MTO's issued to estimating (expand by discipline and WBS as required)	
Engineering, fabrication and construction hours provided for planning/scheduling	
Execution schedule and labor profiles input to estimating	
Contractor (or integrated EPC/owner) risk analyses complete	
Contractor corporate review/approval of estimate (if allowed by owner)	
Owner project management review of cost estimate, estimate basis and cash flow	
Contractor revisions to estimate, basis and cash flow	
Owner corporate review of cost estimate	
Owner estimate and/or phase gate approval	
Final contractor revisions to estimate and cash flow (if required)	
Owner cost estimate approval	
Cost control base recast issue for approval (for reference)	
Cost control base approval (for reference)	

Table 1. – Examples of Estimate Development Milestones

Project Scope and Execution Plan Summary

Summarize the project scope and execution plan for each project phase and make reference to the primary documents. Identify each process unit, offsites, utilities, subsurface facilities, etc. Indicate capacities and any other significant factors such as contracting, fabrication and modularization strategies. Explain the labor type (union, open shop, mixed, or other) and quantify expected sources (number of local, travel cards, temporary foreign workers, etc.) Provide an estimated overall progress completion percentage for engineering at the estimate cut-off point.

Construction, Fabrication, and Operating Parameters

Refer to an authoritative source of average annual weather conditions at the job site along with maximums, minimums and time of year they occur. Corresponding design basis criteria such as pressures, amount of alloy materials, minimum and maximum ambient design temperature should be stated. Known soil conditions are summarized (e.g.: clay/rock, topsoil depth, permafrost, water table, underground aquifers, etc.) Distance to nearest major population centers, infrastructure availability, and distances are worth stating.

Project Execution Schedule Basis

At the estimate planning stage, a summary execution schedule (by facility, phase, unit, and commodity/discipline) is included with the estimate plan. Any special schedule events that impact costs are shown on the schedule and/or described further in the narrative. Examples are: weather windows (shipping and site); operating plant outages; tie-ins: shift work; extended overtime; union contract

expiration dates; peak manpower periods; planned downtime (e.g.: holidays, planned evacuations in existing facilities); and known and pending regulatory/environmental issues.

Estimating Methodology

Cover items such as estimate type (capacity ratio, equipment factored, detailed, etc.) Refer to the expected accuracy range stated in the purpose section and summarize how it will be accomplished with any applicable discussion of risk analysis to be completed.

Estimating Software

Describe all software and versions to be used including how it is to be used. (E.g.: simulated quantities, internal database, interface software to load productivity rates into estimating program, etc.)

Coding and Formatting

Attach project code of accounts and project work breakdown structure (WBS) or other specified coding and formatting requirements as an appendix to the plan or refer to it. The formats to be used in presentation of the estimate should be clearly identified and agreed with the owner before starting the estimate. This includes the detailed and summary forms. The cost estimate must show all calculations. Quotes from vendors and in-house cost databases do not necessarily need to be included with the estimate but should be referenced and available for viewing by the owner throughout the life of the project. As a minimum, the detailed forms will contain quantities, unit of measure, hours per unit, labor hours, labor cost per hour, labor cost, material cost per unit, material cost, equipment cost per piece, and total equipment cost. Subcontract units, hours, and costs should be broken down in the same manner to determine camp space (if applicable) and worker densities.

Cost estimate summaries may be specified by the owner. Costs for each inside battery limits (ISBL) process unit as well as outside battery limits (OSBL) costs should be separated. Allocation of indirect costs to each ISBL unit and OSBL unit for estimating purposes depends on the execution strategy. If a single contractor is involved with more than one process unit, then indirect costs should be separated by the contractor. If a contractor is only responsible for one process unit, the indirect costs will be part of the total costs for that unit.

Filing Structure

The estimate material including all backup is to be primarily filed and maintained according to the WBS and code of accounts referenced in the *Coding and Formatting* section. Other information is to be filed according to the format of the estimate basis. Additional sections may need to be created for the following:

- *Request for Proposal*
- *Review Comments and Minutes*
- *Competition*
- *Drawing List*
- *Addenda*
- *Miscellaneous*

Units of Measure

State the type of units of measure (i.e.; metric, imperial) and any exceptions that may apply.

Currency and Exchange Rates

State the currency to be used (e.g. US Dollars - USD). Indicate the exchange rates for foreign purchases as applicable.

Process Equipment Pricing

Indicate expected rough percent of equipment costs to be based on budget quotes, firm bids, in-house pricing or other basis. This varies depending on desired estimate accuracy and level of engineering development. A summary of the bidding process may be included such as minimum number of bidders, how bids are normalized for evaluation purposes including exchange rate basis of foreign currencies and bid validity periods. The planned method of estimating shop inspection, testing, witnessing, and related travel requirements should be described. Identify whether electrical and instrumentation/automation equipment are covered under the respective bulk commodity material sections. This should be consistent with the coding/formatting requirements. Freight and vendor representatives for construction, commissioning, and start-up should be separately identified whether or not they are part of the equipment account. Specify whether ladders and platforms will be included with the equipment, “dressed” onsite or offsite and other similar clarifications. E.g.: equipment insulation is in bulk materials if not supplied by the equipment vendor. Provide a current version of the equipment list with targeted items for firm quotes identified. A “priced equipment list” should be specified as an estimate deliverable. Discuss how any design allowances for equipment will be developed such as guidance from the discipline specialists, project execution and procurement personnel. Design allowances for equipment are discussed here and included with the table of bulk commodity material allowances shown in **Appendix A**.

Spares

Spares require consideration of financial accounting rules and operating philosophy. This includes freight for spares when practical to separate.

Capital spares should be identified by individual piece of equipment. Refer to owner definition of capital spares.

Explain the basis for estimating commissioning and start-up spares such as vendor recommendation or if it will be done by the start-up team. Refer to owner definition of commissioning and start-up spares.

Operating spares and initial stores stock inventory should either be identified as excluded or included as directed by owner. Agreement with the owner accounting controller is advised regarding categorization of spares, initial stores stock, and non-capital expense (“OPEX”) versus capital (“CAPEX”).

Describe how the costs will be determined for each type of spare such as historical data, reference data and/or discussion with discipline specialists or experts.

Non-Process Equipment Pricing

Refer to the project code of accounts as a guide for segregation of process equipment versus non-process equipment purchased for use during operation of the permanent facilities. Mobile equipment (front-end loaders, bucket wheels, excavators, etc.); rolling stock (rail locomotives, cars, etc.); cranes; personnel vehicles (cars, vans, busses, etc.); maintenance vehicles (flat bed, fork lift, man lift, bundle pullers, etc.); emergency vehicles (fire truck, foam wagon, ambulance, etc.); fire protection and safety equipment (extinguishers, hose reels, etc.); lab equipment; office computers; supply boats; and so on.

Vendor Representatives

Identify separately vendor representatives estimated for each piece of equipment or tagged item. If it is an overall allowance then state the basis for the allowance.

Bulk Commodity Material Quantities

For each commodity, describe the methods to be used such as: detailed material take-offs, based on sketches, standard detail designs, computer-simulated take-offs, or factored. The extent of planned input from vendors, discipline specialists/experts and project execution personnel should be stated. The portion of quantities expected to be available from a 3D computer design model are provided as applicable for each commodity. Examples of further details needed to adequately explain quantity basis for each commodity are provided in **Appendix C**. A table summarizing the planned quantity development and take-off basis for each commodity can be a helpful quick reference as shown in **Appendix B**.

Bulk Material Quantity Take-Off Allowances (Design Development Allowance)

Material take-off allowances are based on an estimate of the known but undefined quantities. For each commodity, describe the rationale for estimate allowances in relation to the level of engineering definition and the methods to be used to develop quantities. A table listing the estimated allowance for each commodity and percentage of the base is to be included for quick reference. Refer to **Appendix A**.

Bulk Material Construction Waste Allowances

Explain the basis to be used for construction waste allowance (e.g.: discussion with specialists, historical data) by commodity. For quick reference, this is shown with design development allowances in a summary table. Refer to example in **Appendix A**.

Bulk Commodity Material Pricing

Indicate expected percent of bulk material costs which will be budget quotes, firm quotes, in-house pricing or other sources. Include basis for equipment (process, non-process, electrical, instrumentation) shop inspections and testing. Separately address material supplied to fabricators and material for site installation. A table could be used to summarize this as well.

Address any special considerations such as whether a concrete batch plant will be used at site.

Offsite Fabrication

The planned amount of offsite fabrication of bulk materials (if available) and the estimating methodology should be explained (e.g.: unit rate, by weight, by pipe class, fabricator quotes, etc.)

Offsite Module Assembly

Describe the extent of offsite module assembly planned to be done and the geographical locations of the assembly facilities. Briefly discuss whether modules are placed directly on foundations or at an interim staging area for further work to be done before moving to final location. Provide the basis for estimating module yard labor hours and cost rates. Address assembly of pipe rack modules and equipment modules here. Equipment purchases and “skid packages” are covered under equipment.

Freight

Cost of freight for process equipment should be identified separately from other freight. Indicate how domestic freight for bulk material will be calculated. Describe availability and pricing source of special module transportation equipment and other “heavy hauls”. Reference the discussion above regarding placement of modules directly onto foundations and impact on freight cost. Foreign freight costs should clearly state how the ocean-, air-, and land-based shipping are to be priced as well as any export preparation/crating and applicable duties.

Construction Labor Productivity

Explain how labor productivity will be determined for each commodity and equipment. It should address items such as: adjustments to a base productivity for labor density, facility complexity, excessive overtime, weather, shifts, labor quality, labor availability, worker facilities (e.g.: lockers, washrooms, lunchrooms) proximity to ISBL and OSBL work areas and support facilities (e.g.: tool crib, warehouse, material staging area), greenfield versus brownfield versus revamp versus shutdown conditions, soil conditions, elevated work, geographic location, and any other factors affecting productivity. Provide a description of the base productivity including the types of projects included, such as company USGC, 3rd party software database, in-house data, etc. A table should be provided in the estimate plan showing how each factor will be applied and its affect on the rate to be used in the estimate.

Construction Work Week and Overtime

Indicate the construction work week basis and applicable shift schedules (e.g.: 8 hours per day x 5 days per week.) Explain how overtime hours and related cost allowances will be determined.

Construction Labor wage rates

Describe how crew mixes, union contracts, non-union wages, benefits and other factors will be used to build-up the labor rates. Obtain a copy of the craft labor agreements when available. Crew mixes includes portions of apprentices, foremen, general foremen, journeymen. For each commodity, crew mix also refers to portion of total for each trade (e.g.: pipefitters, welders, carpenters, electricians, etc.)

Construction Subcontracts

It is preferable to quantify all subcontractor hours for construction infrastructure planning and worker density analysis purposes. Subcontractor materials are to be separately identified as owner, contractor, or sub-contractor supplied. State the construction strategy pricing basis (unit-price, lump-sum, etc.) for each subcontract. E.g.: piling based on firm unit rates including aggregate and all embeds but excludes pile caps and dewatering beyond a predetermined amount; insulation based on budget quotes; painting is included with steel, pipe and equipment pricing except field touch-up which will be based on in-house data; and so on.

Construction Indirect Costs

The cost basis for construction indirect costs should be broken down according to the code of accounts as per the following example:

Construction Management – To be developed using a personnel plan by position or by discipline spread over the project duration. Explain how office and travel costs are covered including courier, temporary office furniture, office equipment, supplies, computers, and telephone charges. Consider design and

drafting be done at the construction site including as-built drawings. Specify what is part of the as-built scope e.g.: process flow diagrams (PFD); process and instrument diagrams (P&ID); undergrounds; junction box wiring diagrams; single line diagrams; load lists; schematics; 3D model updates; etc.

Personnel costs are normally kept separate from office costs in detail cost accounts but they may be discussed together in the estimate plan. Construction insurance may be included here if it is not covered by owner project overheads. Bond costs may be included if applicable.

Camp (if applicable) – Identify who will stay in the camp and related construction manpower peaks. Include catering and what is to be part of the price such as lunches for personnel not staying in camp, whether any utilities (water, gas, power, etc.) are part of the cost. Consider whether it will be pre-fab, built on site and if personnel will be housed single, double, or otherwise. State amenities to be included such as laundry facility, exercise room, indoor/outdoor recreation, etc.

Temporary Facilities - Describe onsite or offsite locations for temporary buildings, roads, parking, laydown areas and material staging, etc. State how requirements for temporary offices and other facilities will be determined. Document any existing utility facilities available for construction use and/or source.

Utility Consumption – It is recommended utility consumption (gas, power, water, sewer) be kept separate from the related facilities cost for estimating and control purposes. These costs can vary significantly and may be provided from various sources such as existing plant, temporary facilities, and/or new permanent facilities. Identify construction power requirements for electric welding machines, warehousing, construction offices, parking lot lighting and plug-ins, onsite fabrication shops, etc. The same applies for fuel, gas, potable water, and sewer.

Temporary Services – Note any special safety requirements and who is responsible (e.g.: Nomex, gas sniffers, fire watch, etc.) Weather protection may be based on a percentage of concrete and piping per historical data. An allowance for general site dewatering will be based on average annual rainfall and water table data. Drinking water supply source and pricing basis are described.

Construction Equipment – Typically, a table is developed showing monthly requirements for cranes, man lifts, and other construction equipment. Availability and pricing basis to be used for cranes should be discussed. Describe the number and type of cranes needed for heavy lifts. Include freight/shipping, and mobilization/demobilization. Include assembly/disassembly if not covered elsewhere.

Small Tools – Delineate how cost of small tools is allocated between indirects and subcontractor rates as applicable. A brief discussion of the source (e.g.: tool crib rental, purchase, etc.) should be included. Refer to any definition of small tools. Discuss small tool replacement and repair requirements.

Scaffolding – Explain whether scaffolding labor will be factored from specific direct accounts based on historical data and adjusted for height in conjunction with discussion with construction specialists. Scaffold material requirements basis is provided by construction and/or historical data.

Consumables – Provide basis to be used in estimating consumables and refer to any definition of consumables including differentiation with “construction aids” which tend to be consumable over the life of a long project but re-usable within that time. E.g.; tarps, rope, etc.

Craft Benefits and Burdens - Normally part of the craft wage rate build-up but may be separately identified if required by the owner or contractor estimating methodology and execution strategy. Obtain a copy of the craft labor agreements for determining benefits and special conditions such as: mileage payments, health care expenses, payroll taxes, workers compensation, etc.

General Demolition

This addresses general demolition of decommissioned and/or abandoned facilities. Demolition for revamps is typically included with each commodity/discipline. Describe the general demolition scope and

how it will be estimated. Where possible, it should be based on field-verified quantities and quoted subcontract rates. The owner should provide any direction required on treatment of expense versus capital for demolition.

Commissioning and Start-Up

Explain how commissioning and start-up costs will be determined and briefly describe the related scope (e.g.: crew-based, factored from historical data, etc.) Refer to owner-approved definition of mechanical completion to distinguish between commissioning work and construction work. Reference spares discussion above. Quantities of initial fills of lube oil, heating/cooling mediums, chemicals, etc. to be estimated by process group based on equipment sizing, vendor information, and process conditions. Catalyst and packing pricing may be based on discussions with licensors, engineering contractors, and vendors.

Engineering and Home Office Hours

For each discipline, describe how the labor hours will be determined (e.g.: deliverables, commodity quantities, time-based, etc.) Estimating of work week and overtime for head office personnel should be discussed. Include construction support to home office, home office support to construction, engineering site visits, vendor shop inspections, start-up support, preparation of operating manuals, engineering services such as reliability and maintainability (RAM) studies, heavy lift studies (if applicable), environmental consultants, HAZOP (hazardous operations reviews) facilitators, constructability consultants, module coordinators, etc. State whether field engineering and site based “as-built drafting” work are included with construction indirect costs. Project management may be separately addressed depending on how the cost account structure is organized.

Engineering and Home Office Costs

Show how the engineering labor rates are to be built-up. Describe how other office costs and fees will be covered and refer to any contracts in place. Identify prior project phases to be included in the estimate such as front end loading 2 (FEL2) and FEL3.

Clarifications, Qualifications and Assumptions (to be included under discussion of each commodity or in general)

Clarifications and assumptions which apply to more than one commodity or are more effectively identified separately are addressed in this section. The rationale for any assumptions to be used should be provided. Consider the items in **Appendix D** which are often omitted but should be clarified. This section may be combined with *Exclusions*.

Exclusions

Contractors often state anything not specifically identified is assumed to be out of scope. Owners assume everything required is included in contractor estimates unless they have specified otherwise. Neither approach provides sufficient information to prepare a good estimate. All known estimate exclusions should be listed with an explanation of why. For example:

- Financing charges will not be included because they will not be allocated back to the project.
- Operating and maintenance spares are excluded. They will be purchased by operations.
- Recoverable taxes and duties are excluded (identify which taxes e.g.: sales tax.) These costs will be paid by the project but credited upon recovery.

Owner Costs

Do not create a separate section for owner costs. Owners may execute all of the project scope or none and all options in between. Therefore, owner scope should be addressed in the appropriate section of estimate plans or clarified in contractor estimate plans by listing each specific owner scope item excluded. Refer to **Appendix H** for typical items to be clarified for each estimate.

Late Changes

Explain how late changes subsequent to the estimate cut-off date will be handled. A log should be kept of all changes and integrated with the project change management procedures. The log will be part of the estimate package. Consider any owner formatting requirements for late changes.

Escalation

Include a description of escalation calculations and sources. As a minimum it should be broken down into the major categories of equipment, bulk material, construction labor, and engineering. Known wage rate increases after the point in time of the estimate basis are covered by escalation and should not be included in the base estimate to maintain consistency.

Risk Analysis and Recommended Contingency

Contingency is typically recommended by contractors but determined by owner management based primarily on the results of the cost estimate and schedule risk analyses. State the software and methodology to be used. A different contingency may be appropriate for each process unit or area of the facility due to varying levels of definition and confidence in the base estimate. A summary of the risk analyses results should be included in a separate section of the basis of estimate with a cost risk profile chart. The chart should show the P10, P50, expected value and P90 points on the curve or other points specified by the owner. On larger projects, a tornado diagram showing the top ten risks and opportunities may be included.

Benchmarking

As part of the estimate review and validation process, benchmarking should be performed. The intended source(s) of benchmark data is stated as well as the metrics to be used in benchmarking. Key metrics should be included with the estimate basis for quick reference. These will vary depending on the class of estimate. Refer to **Appendix E** for an example list of metrics.

Cash Flow/Cost Flow

Provide a sample cash flow in table format according to the intervals required by the owner (monthly, quarterly, etc.) Describe how the cash flow will be determined for each category breakdown such as: historical data, project-specific progress and manpower profiles, standard payment terms, etc.

Estimate Development Schedule

The estimate development schedule should be an integral part of the project schedule for the applicable phase. For large projects, it will be within a CPM schedule which can be used for integrating the estimate plan with other phase deliverables and for tracking. This approach keeps focus on the engineering and execution development activities required to meet the objectives for that phase and the desired estimate

accuracy. AACE International RP 18R-97 (Cost Estimate Classification System – As Applied In Engineering, Procurement, And Construction For The Process Industries)^[7] provides a summarized estimate input checklist and maturity matrix. A detailed estimate development schedule is produced to show the timing of activities required. Refer to **Appendix F** for example list of activities shown in no particular order.

Estimate Responsibility Matrix

An estimate responsibility matrix is a useful tool in planning and managing the key estimating deliverables. Develop a matrix indicating which documents will be used in the estimating process, who will provide them (including organization), the expected level of completion (i.e.: preliminary, IFD, etc.) and the date. The matrix can be an extract from the project schedule or in spreadsheet format. Providing contact information for each person shown in the matrix is helpful. Refer to **Appendix G** for an example matrix. An improvement to this format would be to add a column for who will estimate the items.

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APPENDICES

APPENDIX A – Example Table of Allowances

Commodity	Design/Material Take-Off (MTO) Allowance	Construction Waste Allowance
Earthwork	10%	12%
Site Work	12%	10%
Piling – Drilled Caisson	5%	7%
Piling – Sheet	3%	1%
Concrete	7%	10%
Steel – Fabrication	8%	10%
Steel – Module	8%-10%	15%
Steel – Stick-Build	5%-10%	12%
Architectural/Buildings	6%-10%	8%
Equipment	5%	0%
Piping – Fabrication	5%-10%	10%
Piping – Module	5%-10%	10%
Piping – Stick-Build	5%-10%	10%
Steam Tracing	15%	8%
Electrical Equipment	5%	0%
Electrical Tray/Conduit	10-20%	10%
Electrical Wire/Cable	10-20%	15%
Electrical Heat Tracing	15-30%	5-20%
Instrument – Control Valves	5-15%	0%
Instrumentation – Panels/Racks	5-10%	0%
Instrumentation – Tubing	10-30%	10%
Instrumentation – Instruments	5-15%	0%
Insulation – Piping	10-30%	10%
Insulation – Equipment	5-15%	10%
Fireproofing – Equipment	15-25%	5%
Fireproofing – Steel		
Painting	10-25%	3%



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APPENDIX B – Example Summary Format for Quantity Take-Off and Pricing

Commodity/Activity	Take-Off Method	Pricing Method
Earthwork		Quoted subcontract rates.
Site Work		Quoted unit rates.
Hydrovac		Quoted day rate.
Piling		Quoted unit rates.
Concrete	Civil design drawings, vendors shop drawings and soil tests.	Quoted rates for materials and/or subcontracts.
Steel		
Architectural/Buildings		Quoted subcontract rates.
Equipment	Equipment list.	80% budget quotes.
Piping	Supplied by piping engineering.	
Heat Tracing	Heat tracing and insulation specifications, piping take-offs and vendor quotations. Steam supply and condensate return headers are to be estimated based on heat load requirements and in accordance with company specifications.	
Electrical Equipment		Formal vendor quotations.
Electrical Tray/Conduit	Supplied by electrical engineering department.	Quoted subcontractor rates for labor, materials, field indirects and contractor overhead and profit.
Electrical Wire/Cable	Supplied by electrical engineering department.	Quoted subcontractor rates for labor, materials, field indirects and contractor overhead and profit.
Electrical Heat Tracing	Averaged from samples and quantified by line list.	Subcontractor budget quote with allowance.
Instrument – Control Valves	Count from P&IDs.	
Instrumentation – Panels/Racks	I/O count.	
Instrumentation – Tubing	Factored from tagged item count.	
Instrumentation – Instruments	Tagged item and I/O count.	
Insulation – Piping	Supplied by piping engineering. Allowances for valves, fittings and specialties based on the equivalent length method.	Quoted subcontract unit rates.
Insulation – Equipment		
Fireproofing – Equipment		
Fireproofing – Steel		
Painting		
Scaffolding		Factored from direct labor accounts.

APPENDIX C – Examples of Planned Bulk Material Quantity Basis

Earthwork and Site Work – Reference geotechnical data, topographical drawings, or photogrammetric maps, to be used. State whether tree/brush clearing/grubbing is required in addition to topsoil removal and general cut and fill operations to level site. Explain whether excavation and backfill quantities are to be developed from standard foundation details, underground trench sketches, or other method. E.g., dewatering for excavation of permanent facilities will be a percentage of excavation of backfill quantities. Address whether quantities will be generated for permanent fencing, signage, and landscaping and how. Similarly discuss road, railway, and marine work.

Piling – Explain how quantities are determined for each type of pile. E.g., diameter and depth for drilled caissons. Include any clarifications for quantifying rebar, aggregate, sonotube, etc.

Concrete – Reference any standard foundation designs which may exist and describe how quantities are developed for cast in place concrete formwork, insulation, aggregate, embeds (rebar, anchor bolting, etc.) Also address specialty items such as curing agents or cementitious grout. Explain any strategies regarding quantities of pre-cast concrete whether purchased or precast at site. Reusable forms may be addressed here or in indirects depending on the code of accounts in effect.

Structural Steel – Separate module assembly quantities from site-installed quantities. If MTO's are desired by light, medium and heavy this needs to be stated. Define whether tube-shape pipe supports are part of piping quantities or structural steel account.

Buildings – Sizing basis such as equipment layouts/sizes shown on issue for design (IFD) revision of plot plan. Determine extent of furnishings and fixtures included for each building as well as single or multiple floors. Categorize buildings as process, electrical, maintenance shops, warehouse/storage or administration for estimating and financial treatment.

Piping – Define the sizes included in small bore versus large bore piping (e.g., >2") and criteria for physical allocation of bulk material across more than one process unit (e.g., 1st valve downstream, exactly at battery limit coordinates, etc.) Reference specifications, P&ID's, plot plans, and routing basis used for determining lengths. State that steam trace tubing length calculation basis excludes "hard piped" supply/return lines and headers for clarity. Provide rationale for factors to be used in determining steam tracing, small bore, shoes, guides and hangers.

Electrical – State expected use of equipment load list, single line diagram and area classifications. If instrument wiring is part electrical account, include basis such as I/O count, instrument count and routing used for determining lengths. Refer to wire and cable specifications. State junction box location assumptions for quantifying terminations. Electric heat tracing specifications should state how equipment and piping (by pipe spec/size) affect tracer type and routing as well as controllers.

Instrumentation – Identify revision of P&ID's to be used for instrument counts, control systems, panels, etc. Clarify whether items shown on P&ID's within vendor packages are part of vendor pricing and extent to which the related wiring or tubing are part of vendor packages. If vendor supplied, state if already installed in "package" (only requiring testing & calibration where applicable) or if vendor supplied but shipped loose, for contractor to install. All other quantities are assumed to be required from vendor skid back to control points or junction boxes. State the basis for any allowances for installed spares and spare card slots. Sizing of control systems may be from I/O count or vendor.

Painting – State how field and touch-up painting will be quantified (e.g., factored based on historical data.)

Fireproofing – Explain whether any structural steel or vessel fireproofing is required and if it will be applied at site or in vendor’s shop or at site. Outline how any site cast fireproofing will be quantified.

Insulation – Describe the methods to be used for equipment and pipe insulation with reference to specifications (blanket, formed, material, jacket, removable, valve/flange covers, etc.)

APPENDIX D – Examples of Clarifications, Qualifications and Assumptions

Direct Site Costs

- Interface with 3rd party suppliers, contractor interfaces, fabricators, and vendor reps.
- Special comments regarding specifications. E.g., calcium silicate versus mineral wool insulation.
- Lack of engineering and design clarity. For instance if soil borings were not available.

Indirect Site Costs

- Availability of space for parking at construction site or bus pick-up locations.
- Any known interactions with other projects and operating facilities for roads, access, emergency response, resource availability, hazardous environments, evacuation, etc.
- Allowances for emergency evacuations.
- Offloading facilities.

General Site Costs

- Jobsite access restrictions/expectations.
- Availability of permanent facilities to be used for construction purposes including timing for owner use. E.g.: admin building, storage, paved areas.
- Use of any existing facilities/equipment for the current project (construction or permanent.)
- Assumptions for calculations used. E.g., Load-carrying capacity of existing structures/buildings/pipe-racks.
- Who is responsible for EP&C of the electrical substation, electrical feeders, etc.
- Hot and cold work permitting requirements and procedures.
- Lighting and power requirements around new equipment, temporary facilities and construction parking.
- Transportation infrastructure for large shipments and modules. Includes road repairs.
- Approach to shop fabrication and field erection to minimize field labor, to allow for greater quality control, and to minimize schedule disruptions.

Procurement, Fabrication and Offsite Assembly

- Extent of offsite fabrication for each commodity.
- Determination of commodities to be included with module assembly versus “stick-build”.
- Degree of shop inspection (e.g.: heavy to avoid field rework, or normal to low risk due to owner alliance with vendors.)

General Project Costs and Overheads

- Purchase of operations or maintenance equipment.
- Separately identify pre-investment cost of future facilities including pro-rata share of civil/structural.
- Environmental and regulatory permitting fees.
- Known and unknown environmental issues such as contaminated soil, lead, asbestos, etc.
- Licensor fees, licensor engineering, licensor royalties.
- Reimbursable versus non-reimbursable costs.
- Assumed to be capital cost except where owner has otherwise specified.
- Non-recoverable taxes are included. (Identify which taxes.) They will be paid by the project.
- Non-recoverable duties are included. They will be paid by the project.
- Owner to confirm if wasted/consumed feedstock or spoiled product cost will be charged to the project.

APPENDIX E – Examples of Key Metrics

- Hours per Quantity (by commodity)
- Detailed Engineering Cost / Total Project Cost (TPC)
- Construction Management Cost / TPC
- Bulk Material Cost / TPC
- Construction Labor Cost / TPC (construction labor includes indirect labor)
- Construction Direct Labor Cost / TPC
- Construction Indirects / TPC
- Total Field Material Cost / TPC (field material includes equipment, bulks and domestic freight)
- Total Field Costs / TPC
- Start-Up / TPC
- TPC / Total Equipment Cost (excludes equipment installation)
- Detailed Engineering / Total Equipment Cost (excludes equipment installation)
- Construction Labor Cost / Total Equipment Cost (excludes equipment installation)
- Construction Indirects / Total Equipment Cost (excludes equipment installation)
- Total Field Labor / Total Equipment Cost (excludes equipment installation)
- Total Field Cost / Total Equipment Cost (excludes equipment installation)
- Start-Up Cost / Total Equipment Cost (excludes equipment installation)
- Engineering hours per piece of equipment
- Engineering hours per quantity of material by discipline
- Engineering all-in rate per hour
- Ratio of bulk material cost to equipment cost
- All-in construction rate [total labor cost + indirect cost] / [direct labor hours including subcontractor hours]
- Percent scaffold labor of direct labor hours including subcontractors
- Percent offsite fabrication hours and construction hours of total hours by commodity

APPENDIX F – Examples of Activities to Include in the Estimate Development Schedule

- Develop and finalize estimate plan
- Place long lead PO's
- Incorporate COMPANY specifications
- Obtain quotes for equipment
- Obtain pricing for bulk materials
- Calibrate estimating databases and systems as required
- Confirm level of engineering and execution definition required to meet estimate accuracy with key personnel
- Finalize estimate deliverable responsibility matrix
- HAZOP reviews complete
- Develop execution phase coding and control structure
- Determine productivity factors
- Determine construction labor wage rates
- Determine engineering wage rates
- Determine basis for calculating design and material allowances
- Prepare project execution plan
- Preliminary start-up sequence
- Clarify scope elements to be estimated by owner and/or contractor
- Construction labor productivity rates
- Construction labor wage rate build-up
- Subcontract pricing methodology
- Material, equipment, and fabrication pricing
- Construction indirect estimating methodology
- Engineering estimate methodology (hours, labor rates, services, expenses, fees, profit, other "home office" costs)
- Estimate coding and formatting for development, review, and control
- Develop execution schedule and resource loading
- Constructability review
- Freeze process basis for estimate
- Freeze scope development basis estimate including plot plan
- Freeze execution basis for estimate
- Obtain input from vendors, subcontractors, and fabricators
- Estimate engineering hours and costs
- Estimate bulk material costs
- Estimate equipment costs
- Estimate construction labor hours and costs
- Estimate fabrication hours and costs
- Determine construction indirect costs
- Estimate escalation
- Incorporate late changes
- Perform risk analysis and contingency recommendation
- Incorporate activities of risk consultants – if applicable
- Prepare cash flow
- Calculate key cost estimate metrics
- Complete cost estimate basis
- Prepare for cost estimate reviews
- Owner estimating/project controls review of cost estimate
- Owner project management review of cost estimate
- Owner cost estimate and gate approval



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APPENDIX G – Example Estimate Responsibility Matrix Format (Adapted from RP 18R-97^[7])

Document	Rev.	Level of Completion	Estimating Responsibility	Source Information	Date
Project Scope Description		Defined	PM	Owner PM	
Production Capacity		Defined	Process	Process Engineer	
Plant Location		Specific	PM	Owner PM	
Soils & Hydrology		Defined	Civil Engineer	Owner Civil Engineer	
Project Execution Plan		Defined			
Project Master Schedule		Defined			
Start-Up Sequence		Preliminary			
Escalation Strategy		Defined			
Work Breakdown Structure		Defined			
Project Code of Accounts		Defined			
Contracting Strategy		Defined			
Subcontracting Plan		Defined			
Constr. Work Packages		Complete or Near			
Constr. Mgmt Manpower		Defined			
Construction Indirects		Defined			
Scaffolding		Factored			
Construction Productivity (expand by commodity if applicable)		Defined			
Construction Wage Rates (by discipline)		Defined			
Engineering Hours by Discipline		Factored			
Engineering Wage Rates		Defined			
PM & Support Hours		Factored			
PM & Support Wage Rates		Defined			
ODC & FEE		Per Contract			
Block Flow Diagrams		Complete			
Plot Plans		Complete or Near			
Process Flow Diagrams		Complete or Near			
Utility Flow Diagrams		Complete or Near			
P&ID's		Complete or Near			
Line List		Complete or Near			
Tie-In List		Complete or Near			
Heat & Material Balances		Complete or Near			
Process Equipment List		Complete or Near			
Utility Equipment List		Complete or Near			
MTO's (by each commodity)		Partial			
Instrument Index		Complete or Near			
Instrument Allowance		Factored			
Electrical One-Line Drawings		Complete or Near			
Spec's & Datasheets		Complete or Near			
General Arrangement Drawings		Complete or Near			
Spare Parts List		Started or Partial			
Mechanical Discipline Drawings		Started/Sketches			
Electrical Discipline Drawings		Started/Sketches			
Instrumentation/Control System Discipline Drawings		Started/Sketches			
Civil/Site Discipline Drawings		Started/Sketches			
Structural Discipline Drawings		Started/Sketches			

APPENDIX H – Checklist of Potential Owner Cost Items

Direct Costs

- Breakdown as per normal for direct costs (owner is a resource like a contractor or subcontractor)

Construction Indirect costs

- Breakdown as normal for indirect costs
- Owner construction management staff (construction supervision, safety, field engineering, warehousing/material control, operations support)
- Personal protective equipment and clothing. E.g.: hard hats, boots, fire retardant suits, etc. (clarify whether owner supplies any of these for contractors or vice versa)
- Cranes, scaffolding, tools, construction services, drinking water, etc.

Demolition (if not included above)

Project Management Staff and Expenses

- Project management (breakdown and include project controls, accounting, procurement/contracts, admin, document control, travel, contractors, consultants, etc.)

Project Engineering and Design (breakdown by discipline)

- Owner direct hire staff and expense
- External contractors/services hired by owner (excluding EPC, EPCM, prime contractor, etc.)
- Licensor engineering development and design not included in licensor fees or royalties
- Specification writing/purchase, if required

Operations Staff and Expenses

- Permitting (daily construction hot and cold work permits)
- Design reviews
- Facility shutdown/start-up costs if charged to project (e.g.: for blinding, purging, steaming, flushing, etc.)

Commissioning and Start-Up

- Staff and contractors organization
- Services and consultants
- Materials and supplies
- Equipment and tool rentals
- Initial feedstock costs and process waste costs, if applicable
- Lubricants, chemicals, dessicants, etc.

Information Technology (leased versus purchased to be considered)

- Network infrastructure and telecommunications
- Desktop hardware
- Standard desktop software
- Special software applications (Primavera, CAD, document control, etc.)
- Radio towers, base stations and licensing (radios can be here or indirects if rented)

Land

- Land purchase only - rental/lease cost during project should be indirect construction cost

Project Overheads

- Regulatory process and approvals
- Public relations and promotional events
- Right of way access and permits with governments and/or landowners
- Licensor fees, licensor royalties
- Insurance premiums and allowances for deductible occurrences
- Financing and interest charges
- Foreign exchange costs not captured by specific purchase or contract item
- Currency hedging costs charged to project
- Corporate overhead allocations
- Property taxes (if paid during construction)
- Legal services
- Non-recoverable duties should be charged to the individual foreign-purchased items and recoverable duties should be credited to the individual items
- Training of and development of local citizens on international projects

Purchased Assets (if not treated as a direct or indirect)

- Spares (capital, start-up, operating)
- Initial stores stock
- Furniture - if not covered within buildings account
- Mobile equipment
- Catalyst and chemicals if not covered elsewhere

Capital Contributions to Utility Infrastructure or 3rd Party Facilities

- Power/electricity
- Water supply
- Gas
- Waste/effluent disposal, water treatment
- Process units (e.g., hydrogen plant)

Environmental Remediation and Monitoring

- Contaminated/hazardous soil excavation and clean-up
- Hauling and disposal costs
- Monitoring (air, soil, water)
- Asbestos and lead paint removal

International Freight

- International freight and related costs, including taxes and duties, should be captured with the items where possible. This allows accurate cost comparison versus more local sourcing. Special tracking codes may be required for separation of asset values versus related shipping costs.