Techniques for estimating the capital cost of a rebuild

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Three estimates—feasibility, appropriation, and budget control—define essential phases of a rebuild project and determine if more study is appropriate, what the financing will be, and what cost controls are appropriate.

This paper discusses three essential phases of a rebuild project and the estimates required for each phase. Each estimate is prepared with a different objective and, to be efficient, each uses different techniques. The name of the estimate defines its objective:

- Feasibility estimate
- Appropriation estimate
- Budget control estimate.

While developing each estimate, we must keep its objective in mind continuously. When the techniques presented are used, the objective of each estimate can be attained. The feasibility estimate will determine if it is feasible to proceed with further study. Financing will be provided on the basis of the appropriation estimate. Cost control can be started as a result of the budget control estimate.

The feasibility estimate

The primary objective of a feasibility estimate is to determine if the approximate cost and scope of the rebuild project will meet management's objectives. When it does, further study is justified. The accuracy of this type of estimate is generally accepted to be ±25%.

We are concerned here with the capital cost only and with estimating this cost in the most efficient manner possible. The return on investment (ROI) analysis is normally prepared by the owner.

To get started, the process team will determine the scope of the project and then develop a block flow diagram and an equipment list. The most important document for the estimator of a rebuild project is the equipment list. It is the essential element of any scope development document. It should show all new, relocated, and existing equipment for stock preparation and the paper machine. The process engineers should price the major equipment on the list, since it is their responsibility to develop a system that meets management's objectives.

Existing equipment should be listed and clearly labeled "no work" if none is required. Relocated equipment should be placed in its new process flow location on the list and clearly labeled "relocated." A list of equipment to be demolished also should be developed. The demolition list should differentiate between equipment to be scrapped and that to be salvaged (**Table I**).

The equipment prices used for a feasibility estimate generally can be either telephone budget quotes from vendors, in-house quotes for similar pieces of equipment (adjusted for capacity as required), or allowances based on the process engineer's judgement.

When equipment costs have been totaled, a quick judgmental check of the total project cost can be made. This is done by multiplying the equipment cost by a factor between 2.0 and 3.0. The factor depends upon the extent of existing equipment relocation, piping, instrumentation, demolition work, building renovation, and site work required. When the total project cost has been determined, it can be used in the ROI analysis to determine the feasibility of the proposed project.

This is an important decision point for the project; if the estimate does not meet the management target, then the scope should be reviewed to see if it can be reduced practically and still meet management's objective. It is at this point that alternatives, options, and deductions generally will be proposed. When reasonable compromises are reached, one target scope should be selected for further estimates.

When the target scope has been agreed upon and the equipment list revised, the estimator can finalize the feasibility estimate by factoring equipment installation costs, piping costs, instrumentation costs, and electrical costs. Equipment relocation and demolition costs generally will be estimated based on experience. New building or control room costs, if any, can be estimated by the square foot or cubic foot method. Building modifications and any site work must be estimated from the information available. Indirect costs can be applied as a percent of total direct costs. The estimator should avoid wasting time on irrelevant detail estimating.

If the feasibility estimate indicates a favorable ROI, it is time to proceed to the appropriation estimate.

I. Typical equipment list

Equip. no.	Equipment items: Description	HP	RPM	Equip. cost, US$	Remarks
24	Pump, headbox fan, low pulse			100,000	Vendor Model No. 1234 Reuse existing foundation
28	Motor, headbox fan pump	1,000	DC	189,000	Cost includes DC drive
32	Screen, primary machine			300,000	Per vendor proposal
36	Motor, primary machine screen	200	900	22,000	
40	Headbox			1,750,000	Per vendor proposal
44	Actuators, headbox slice			500,000	Per vendor proposal
48	Fourdrinier			Existing	No work
52	Press, sections 1 through 3			Existing	No work
56	Press, 4th section			1,500,000	Per vendor proposal
60	Motor, 4th press section	500	DC	Included	Cost with machine drive

Client: USA Paper Co.
Project No. 4400
Project: No. 1 Paper Machine Rebuild
Area: Paper Machine

The appropriation estimate

Pulp and paper corporate requirements for an appropriation estimate vary widely. Depending upon corporate policy, time and money constraints, equipment delivery, and the competitive environment, a corporation may appropriate funds from a feasibility estimate, or it may not give final funding approval until all major equipment has been purchased and engineering is 20–30% complete.

Despite this variance, the requirements for an appropriation estimate scope are generally as outlined by Boriin.* To have adequate funds approved there should be sufficient detail to define the scope of the project (a) for the estimator to estimate the total capital cost and (b) to provide sufficient information for the board of directors to make a decision regarding the project.

During the appropriation estimate, it is best to keep related costs identified with each line item of equipment. This will allow easy recognition of related costs and subsequent deletions and additions during the inevitable changes that occur during a paper machine rebuild study.

Table II shows an example of this type of equipment estimate worksheet.

In this example, equipment installation costs and equipment foundation costs are on the same line with the equipment item. Motors with their motor control center (MCC), installation, and wiring costs immediately follow the equipment item. With the use of a database for standard items (i.e., motors, MCCs, wiring), the estimator is free to concentrate on estimating the installation and foundation costs of each individual piece of equipment.

The estimator must apply his or her knowledge and experience to estimating the cost of equipment relocation and demolition. This knowledge will be enhanced by the site survey and by referring to recently completed projects with similar equipment. Sometimes it is prudent to have a contractor familiar with mill conditions to estimate certain phases of the project.

In the early stages of design, the piping scope of work is difficult to define. Therefore, the level of piping design must be determined beforehand. As a minimum, this should be process flow diagrams which generally show the new piping required. If the project scope is from the headbox to the winder and there are minimum changes to the vacuum system, repulpers, and dryer drainage systems, then process flow diagrams may provide sufficient information for an experienced estimator to estimate piping costs.

However, as the complexity and relative significance of piping scope increase (e.g., stock preparation area work or a new or revised vacuum, repulper, or dryer drainage system) a more detailed accounting of the piping systems may be justified. Additional detail is usually provided by piping and instrument diagrams (P&IDs), which show line sizes and materials of construction. If study time permits, the most definitive estimate is based on a material take-off by a piping designer or estimator. This involves using the piping information that has been developed for the project. The estimator then applies current material and labor costs to the quantity summaries.

The piping designer or estimator normally will be making many assumptions and allowances for items not necessarily shown on the early P&IDs. Examples are small-bore piping, duplicate or spare pumps, control valve by-passes, service piping, and the complexity of the piping arrangement. Piping take-off is costly and time consuming. Before making the decision to include piping take-off in a study, the benefits versus cost and time should be considered carefully.

For machine rebuild projects, the instrumentation estimate is dominated by the question: "To DCS or Not to DCS?" If a machine does not have a distributed control system (DCS), it will almost surely have one after a major rebuild. The significant instrumentation costs are the new or modified DCS equipment,

*Boriin, P.R., *TAPPI 1992 Paper Machine Rebuilds Seminar*, TAPPI PRESS, Atlanta.

II. Equipment estimate worksheet

Equipment items										
Description	*HP*	*RPM*	*Equip. cost*	*Control equip.*	*Equip. erect.*	*FNDNS*	*Misc.*	*Demo.*	*Insul. and coat*	*Wiring*
Pump, headbox fan, low pulse			100,000		12,000	Exist				
Motor, headbox fan pump	1,000	DC	189,000		4,400					19,200
Screen, primary machine			300,000		9,000	1,500				
Motor, primary machine screen	200	900	22,000	7,500	1,600					10,800
Headbox			1,750,000		150,000	50,000				
Actuators, headbox slice			500,000		40,000					20,000
Fourdrinier			Existing							
Press, section 1 through 3			Existing							
Press, 4th section			1,500,000		200,000	50,000		20,000		

All costs in US$.

the software configuration or reconfiguration, and other control equipment interfacing. These costs normally are estimated by budget quotes from the appropriate vendors. Other major instrumentation items (machine gauge, streak detection, etc.) also should have vendor quotes.

The remaining instrumentation costs—field instrument costs, installation and calibration costs, and tubing and wiring costs—can be estimated from a control loop count and input/output count. This procedure usually is satisfactory for an appropriation-grade estimate. However, if more detail is needed, a priced instrument list is required. Factors for installation, tubing, and wiring costs then can be used.

The next category to be estimated is electrical work. Substations will be sized on the preliminary electrical single-line diagram. Telephone vendor quotes or in-house pricing normally is adequate for the appropriation-grade estimate. Also, from the single-line diagram and general arrangement drawings, the size and length of the major (15 kV and 4.6 or 2.3 kV) feeders can be estimated. As mentioned previously, motor, MCC, and individual motor wiring costs are estimated on the equipment estimate worksheet.

The cost of wiring new machine drive motors must be given special consideration due to the additional control features that these motors require. The summary of these electrical costs should be included in the electrical section of the estimate. The cost of building lighting and service outlets should be kept separate and included with the building section of the estimate because eventually these costs will be depreciated with building costs and not equipment. When considering the cost of electrical demolition, one must make allowances for the cost of performing the work while other machines are still running

For many machine rebuild projects, there are no building or site costs. This is one of the major advantages in rebuilding an existing machine. The scope of work should define the building and site work, which then can be estimated in a normal manner, with due consideration given to performing the work on the run or during a shutdown. Allowances must be made for limited access.

Other direct costs which need to be estimated include:

- Manufacturer's erection and start-up assistance
- Freight
- Sales/use tax (to be determined by mill tax advisor)
- Miscellaneous equipment installation materials
- Painting and insulation
- Miscellaneous platforms and supports
- Equipment guards
- Motor cooling ductwork
- Office and laboratory equipment
- Machine fire protection and lighting system under the hood
- Major capital spares
- Shutdown premium time.

There are two generally accepted methods of treating contractor indirect costs (taxes and insurance, equipment rental, supervision, overhead, etc.). The method used here is to include all contractor costs as direct costs. The other method would place contractor indirect costs below the direct cost line.

Once the total direct costs have been estimated, the indirect costs can be estimated. For a rebuild project, engineering usually runs between 8% and 12% of direct costs, depending upon the amount of existing equipment relocated and the services required. Construction management will range between 2% and 5%, again depending upon the services provided. Owner's costs can range between 2% and 5%, depending upon what services they provide and how costs will be allocated to the project. The sum total of these costs should rarely exceed 18%.

All of the project costs are subject to escalation. The simplest approach has proven to be: use the project schedule and cash flow curve, estimate the mean spending point duration for the project, and apply the estimated annual inflation rate to this duration.

There are many methods for estimating contingency. The most often used is to apply experience, a knowledge of the amount of engineering developed, and the firmness of the equipment vendor quotes to arrive at a percentage of estimated costs for contingency.

Another method uses range estimating to analyze the significant items in the estimate. With the aid of a computer and some statistical analysis, a plot of various contingency levels versus percent probability of an overrun can be made. From this plot, project management can determine the amount of contingency required, depending upon the percent probability of overrun they are willing to risk.

With contingency added, the total capital cost of the project is now determined. When the total, the "bottom line," is reached, it should be immediately reviewed with the project team to get concurrence on scope and completeness. If the project cost does not meet the ROI target, there should be scheduled time before final submittal to develop the additional information required to refine and reduce the costs.

Once the project team has reviewed and approved the estimate, it is ready for final printing (**Table III**) and inclusion in the scope document for approval.

Due to the many changes that occur during a study, it is very important to have a kick-off meeting and give all team members a copy of the final scope document and approved estimate prior to initiating detail design.

III. Example summary sheet

Direct cost	*Equipment*	*Material*	*Labor*	*Total*
Equipment	4,819,000	0	0	4,819,000
Equip. installation	0	135,000	498,000	633,000
Building	0	70,000	30,000	100,000
Piping	0	350,000	450,000	800,000
Instrumentation	160,000	30,000	55,000	245,000
Electrical	148,000	82,000	94,000	324,000
Site Prep. and Service	0	5,000	10,000	15,000
Total Direct Cost	5,127,000	672,000	1,137,000	6,936,000
	Spares			256,000
	Engineering			694,000
	Construction Management			277,000
	Owner's Cost			208,000
	Subtotal			8,371,000
	Contingency			837,000
	Escalation			502,000
	Total Project Cost			9,710,000

All costs in US$.
Client: USA Paper Co. Project No.: 4400
Project: No. 1 Paper Machine Rebuild
Area: Paper Machine

All numbers are examples only and do not represent actual costs

The cost control estimate

As soon as possible, the appropriation estimate must be converted to the cost control estimate. This requires converting the estimate to the cost control system with account numbers and as much breakdown of cost as available from the estimate. Commitments, expenditures, and revised estimates to complete will start right away. If a system is not in place to track these variances immediately, the total project capital cost can quickly get out of control.

The objective of the cost control estimate is to facilitate the reporting of money-related items on the project such as: commitments, expenditures, change orders, estimated cost to complete, and projected final costs. It must be set up with ease of control in mind, which means that it must be construction related. Owner-purchased equipment and direct contracts (such as field-erected tanks and chests) and other items (such as field instruments or bulk material purchases) should be identified.

Contractor purchased materials and labor-hour and billing rates must be identified. The contractor's indirect costs should be broken down (after contractor selection) and tracked in separate accounts. Frequently, items in the appropriation estimate are not in sufficient detail for proper control. One approach is to allocate these to "holding accounts." When engineering has progressed to construction release or "for bids" the details can be estimated for proper control.

Conclusion

Estimating is a continuous process throughout the project. It starts with the order-of-magnitude and feasibility estimates, reaches a peak with the appropriation estimate, and continues with the control estimate. Many parts of the budget control estimate, and in particular the labor-hour estimate, are required to prepare the schedules that tell us where we are going and how we are going to get there. ▮

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