

Project Cost Management

PMG 213

Lecture 5

**Prepared by
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Cost Estimating





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3.2 OPERATING COST ESTIMATION

3.2.1 Definitions

Operating Cost (or manufacturing cost): the expenses incurred during the normal operation of a facility, or component, including labor, materials, utilities, and other related costs.

Overhead: a cost or expense inherent in the performing of an operation, i.e., engineering, construction, operating or manufacturing, which cannot be charged to or identified with a part of the work, product or asset and, therefore, must be allocated on some arbitrary base believed to be equitable, or handled as a business expense independent of the volume of production. Plant overhead is also called factory expense.

Direct Costs: the portion of the operating costs that is generally assignable to a specific product or process area.

Indirect Costs: costs not directly assignable to the end product or process, such as overhead and general purpose labor, or costs of outside operations, such as transportation and distribution.

Examples:

Operating Cost:

The plant spends \$1,500,000 annually on raw materials, utilities, and labor to run the facility

Overhead: Plant security, general facility lighting, and administrative salaries total \$150,000/year. These cannot be linked to a single batch of product

Direct Costs: \$800,000 spent directly on purchasing raw material.

Indirect Costs: \$60,000 paid to an external trucking logistics provider to deliver final products to regional distributors

3.2.2 Purposes of Operating Cost Estimates:

Operating cost estimates can be important from several standpoints:

They are necessary in order to **determine the potential profitability of a product or process**, and are very useful for **screening alternative project possibilities**.

Frequently they can act as a guide to **pinpoint potential areas in which to conduct research** and **to evaluate the commercial viability of research results**. And they **provide a tool for sensitivity analysis for individual components**. It is very important to remember to perform operating cost estimates at both ***full and reduced capacities*** for the operating system in question.

3.2.2 Purposes of Operating Cost Estimates (continued):

It is not uncommon for a system to be highly efficient at full capacity, but very inefficient when operating at less than design capacity. The important question to be answered is what range of operations can a plant operate over and still make a profit. Such costs can be calculated either as **stand-alone estimates** or as **incremental costs** for specified projects. Depending upon the situation, these different viewpoints could result in different decisions.

-Capacity Example:

At 100% capacity (5,000 tons), total operating cost is \$1,500,000, making the unit cost \$300 per ton.

At 50% capacity (2,500 tons), fixed expenses remain high, so the operating cost only drops to \$1,125,000, driving the unit cost up to \$450 per ton.

This demonstrates why estimating at reduced capacity is vital to finding the true profit range.

Commonly, three differing bases for comparison are used, although others may be used for special applications. The most common three are:

- Daily cost
- Cost per unit-of-production
- Annual cost

Using our previous 100% capacity data:

Annual Cost: \$1,500,000 per year (capturing summer peak utility rates and scheduled winter maintenance shutdowns)

Daily Cost: \$1,500,000 divided by 300 operating days = \$5,000 per day.

Cost per Unit-of-Production: \$1,500,000 divided by 5,000 tons = \$300 per ton

For some manufacturing considerations, a cost-per-unit analysis can be *valuable*.

When making comparisons, it is very important to make sure each calculation is made using the same techniques and assumptions. Otherwise, comparisons may not be valid.

All other factors being equal, making comparisons using an annualized basis instead of on shorter time increments **has a number of advantages**:

- Seasonal variations are evened out.
- On-stream time factors are considered.
- More accurate analysis of less-than-full capacity situations is obtained.
- Infrequently occurring large expenses are factored in (scheduled maintenance, vacation shutdowns, catalyst changes, etc.).
- The output is in a form easily used in **standard profitability analysis**.
- The annual basis is readily convertible to the other bases, daily cost and unit-of-production, yielding mean annual figures rather than a potentially high or low figure for an arbitrarily selected time of year.

Lecture 5**3.2.3 Raw Materials and Utilities**

Raw materials and/or utilities are frequently the largest operating cost being considered in an estimation. The estimations involving raw materials are not always straightforward, as the following list of considerations shows:

- Raw materials frequently are the largest operating cost.
- By-products and scrap may be a debit or credit.
- Prices may be obtained either from suppliers or from published data.
- Raw materials costs may vary significantly depending upon the quality required (concentration, acceptable impurity levels, etc.).

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3.2.3 Raw Materials and Utilities (continued):

- Raw materials costs entail quantity discounts in many cases leading to a trade-off of lower prices for purchase of large quantities vs. storage and inventory cost for raw materials that cannot be used immediately.
- Raw materials costs vary significantly depending upon the mode of purchase and transport (bulk quantities, truck lots, rail car lots, pipeline delivery, bags, boxes, etc).
- Supplies and catalysts are sometimes considered to be raw materials.
- Fuels may be either raw materials or utilities.
- Freight and handling costs must be included in pricing raw materials.

As this list illustrates, accepted local practice can have a large impact on the operating cost estimate.

The cost of utilities can vary widely with the location, with the size of the service required, with the national and local economy, and even with the season.

Utilities must be examined closely on a local basis, especially if they form a major part of the operating costs.

Generally utility pricing is regulated and the approved tariffs are readily available from the utility company or the cognizant regulatory agency.

However, if the utilities are internally generated within a process, a separate estimate of the utility cost must be performed.

Raw Materials: Buying raw chemical elements in small bags costs \$150/ton. However, the plant utilizes a quantity discount by ordering rail car lots, dropping the price to \$120 per ton

Freight and Handling: \$10 per ton is added for rail transport and unloading labor

Utilities: Local regulated industrial electricity tariff is \$0.10 per kWh during regular seasons but rises to \$0.14 per kWh during the peak summer season

3.2.4 Operating Labor

The best estimates of operating labor are based on a complete staffing table. This table should indicate the following:

- The particular craft or skill required in each operation
- Labor rates for the various types of operations
- Supervision required for each process step
- Maintenance personnel required
- Overhead personnel required.

In the absence of a staffing table, an order-of-magnitude approximation of labor requirements can be made using the Wessell equation. The Wessell equation is

$$\frac{\text{Operating workhours}}{\text{Tons of product}} = T \left[\frac{\text{number of process steps}}{(\text{capacity, tons/day})^{0.76}} \right] \quad (3.6)$$

where

$T=23$ batch operations with maximum labor

$T=17$ for operations with average labor requirements

$T=10$ for well-instrumented continuous process operations

Supervision costs may vary from 10% to 25% of operating labor cost. On average, an allowance of 15 to 20% of operating labor cost is usually satisfactory for early-on estimates.

Staffing Table: The plant requires 4 operators per shift (\$25/hour) plus 1 shift supervisor

Total Operating Labor (Base): Let's assume the total base operating labor is \$200,000 per year

Supervision Cost: Applying a standard 15% allowance of the operating labor cost adds \$30,000 per year ($\$200,000 \times 0.15$) for supervisors

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3.2.5 Maintenance

Few published data on maintenance data are available. Maintenance cost can vary from 1 or 2% to over 15% of the project capital cost per year. For simple plants with relatively mild, noncorrosive conditions, an allowance of 3 to 5% should be adequate. For complex plants and severe corrosive conditions, this factor can be 10 to 12% or even higher.

Maintenance costs consist of labor and material components with the total maintenance cost divided 50 to 60% labor and 40 to 50% material.

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3.2.5 Maintenance (continued)

For most early-on estimates, it is sufficient to assume a 50:50 split. Maintenance varies with rate of operation, but not linearly. When operating at less than 100% of capacity, maintenance costs generally increase per unit of production as follows:

% of capacity	Maintenance cost as a percentage of cost at 100% of capacity
100	100
75	85
50	75
0	30

Maintenance costs increase with equipment or system age, but the average values are normally used in estimates.

Lecture 5**Adequate Allowance:**

For this standard plant operating under mild, non-corrosive conditions, maintenance is estimated at 4% of the capital cost per year

Calculation: $\$10,000,000 \times 4\% = \$400,000$ per year

Labor/Material Split: This \$400,000 is split 50:50, meaning \$200,000 for maintenance labor and \$200,000 for replacement materials

Reduced Capacity Effect: If the plant operates at 50% capacity, the maintenance cost does not drop by half. As the table, it stays at 75% of the full capacity cost ($\$400,000 \times 0.75 = \$300,000$)

3.2.6 Indirect Payroll Cost

Indirect payroll cost includes workers' compensation, pensions, group insurance, paid vacations and holidays, social security, unemployment taxes, fringe benefits, and so on. It is generally based on labor cost, usually at about 30 to 45% of the labor cost in the United States. In other countries, this percentage may vary greatly and should be verified locally.

3.2.7 Operating Supplies

Operating supplies include lubricants, instrument charts, brooms, and so on, and may be generally assumed to be 6% of the operating labor or as 0.5% to 1% of the capital investment per year. For highly automated, complex operations these costs can increase substantially as a percentage of labor costs.

3.2.8 Laboratory and Other Service Costs

Laboratory and other service costs can be based on one or more of the following:

1. Experience
2. Workhours required
3. A percentage of operating labor cost (3 to 10% is common, but it may be as high as 20%).

Indirect Payroll, Operating Supplies, & Laboratory :

Indirect Payroll Cost Calculated at 35% of the labor cost to cover workers' compensation and medical insurance

Calculation: $\$200,000 \text{ labor} \times 35\% = \$70,000/\text{year}.$

Operating Supplies: Lubricants, tools, and charts estimated at 6% of operating labor:

Calculation: $\$200,000 \times 6\% = \$12,000/\text{year}.$

Laboratory Costs: Quality testing of chemical batches estimated at 10% of operating labor:

Calculation: $\$200,000 \times 10\% = \$20,000/\text{year}$

3.2.9 Royalties and Rentals

Royalties and rentals are generally an operating expense but may be part of capital investment. Single-sum payments for royalties, rental, or license payments are properly considered as capital investment items, whereas payments in proportion to production or fixed payments per annum are treated as direct operating costs. Royalty payments may range between 1% and 5% of product sales price.

3.2.10 Indirect Costs

Factory overhead is the indirect cost of operating a plant. It is dependent upon both investment and labor. Some data on the allocation for new plants follow (Black, 1991). The figures represent what percentage of the investment and labor, respectively, can be used for estimating the factory overhead.

Royalties: The plant pays a proportional cost of 3% of the product sales price to use a patented chemical blending technique, If the selling price is \$500/ton, the royalty is \$15 per ton

Factory Overhead: Using the table on next Slide for a "Heavy chemical plant, small capacity"

Investment factor: 4.0% of capital per year $\rightarrow 4.0\% \times \$10,000,000 = \$400,000/\text{year}$

Labor factor: 45% of labor per year $\rightarrow 45\% \times \$200,000 = \$90,000/\text{year}$

	Investment factor, % per year	Labor factor, per year
Heavy chemical plants, large capacity	1.5	45
Power plants	1.8	75
Electrochemical plants	2.5	45
Cement plants	3.0	50
Heavy chemical plants, small capacity	4.0	45

Factory overhead may also be called *general works* expense, but it is *not general and administrative expense (G&A)*. G&A covers plant administrative costs, accounting, auditing, research and development, marketing and sales expense, etc).

3.2.11 Distribution Costs

Distribution costs include handling and transportation costs. These costs vary with the types of containers and with methods of shipment. Cost without distribution cost is called bulk cost.

3.2.12 Avoidance of Nuisances

Nuisances include waste disposal and pollution control costs. Each case must be calculated individually. The topic is becoming increasingly more expensive and includes such items as product liability. These cost are mounting rapidly.

3.2.13 Contingencies

As is true for the capital cost estimate, an operating cost estimate should include a contingency allowance to account for those costs that cannot readily be determined or are too small to be readily determined or defined, but may be significant in the aggregate. The contingency allowance applies to both direct and indirect costs and ranges from 1% to 5% or more in some cases.

Distribution Costs: Specialized shipping containers cost \$15 per unit, plus freight carrier fees.

Avoidance of Nuisances: Environmental waste compliance and wastewater filtration cost \$45,000 annually

Contingencies: Following Hackney's guidelines for an installation common to the industry with reliable data, a 2% contingency is applied to the total operating estimate

Hackney (1971) has suggested the following guidelines for operating cost contingency:

1. Installations similar to those currently used by the company and for which standard costs are available: 1%
2. Installations common to the industry for which reliable data are available: 2%
3. Novel installations that have been completely developed and tested: 3%
4. Novel installations that are in the development stage: 5%

3.2.14 Shortcut Methods

Table 3.10 will help in making preliminary operating cost estimates.

Table 3.10 Preliminary Operating Cost Estimate

A. Direct production cost

1. **Materials**
 - a. Raw materials—estimate from quotations or price lists
 - b. By-product and scrap credit—estimate from price lists
2. **Utilities**—from regulatory tariffs
3. **Labor**—from manning tables, literature, or similar operations

4. Supervision—15 to 20% of labor
 5. Payroll charges—30 to 45% of labor plus supervision plus maintenance labor
 6. Maintenance—3 to 5% of investment per year for mild conditions; for severe corrosive conditions, 10 to 12%. Maintenance costs are approximately 50% labor, 50% materials.
 7. Operating supplies—0.5 to 1.0% of investment per year
 8. Laboratory—3 to 20% of labor per year depending upon complexity; 5 to 10% in average situations.
 9. Waste disposal—from literature, similar operations, or separate estimate
 10. Royalties—1 to 5% of sales
 11. Contingencies—1 to 5% of operating costs
- B. Indirect costs
1. Depreciation—assume 10-year straight-line
 2. Real estate taxes—1 to 2% of investment per year
 3. Insurance—0.5 to 1.0% of investment per year
 4. General plant overhead—40 to 60% of labor, supervision, and maintenance
- C. Distribution costs
1. Packaging—estimate from container costs
 2. Shipping—from carriers

3.2.15 Components of Total Product Cost

Table 3.11 illustrates the connection between the component cost items that enter the total product cost. There are variations from company to company, but this tabulation is still a good guide.

Table 3.11 Components of Total Product Cost

- I. Operating cost or manufacturing cost
 - A. Direct production costs
 - 1. Materials
 - a. Raw materials
 - b. Processing
 - c. By-product and scrap credit
 - d. Utilities
 - e. Maintenance materials
 - f. Operating supplies
 - g. Royalties and rentals
 - 2. Labor
 - a. Direct operating labor
 - b. Operating supervision
 - c. Direct maintenance labor
 - d. Maintenance supervision
 - e. Payroll burden on all labor charges

- e. Payroll burden on all labor charges
 - i. Social security tax
 - ii. Medicare tax
 - iii. Workers' compensation coverage
 - iv. Contributions to pensions, life insurance, hospitalization, and dental plans
 - v. Vacations, holidays, sick leave, overtime premium
 - vi. Company contribution to profit sharing
- B. Indirect production costs**
 - I. Plant overhead or burden
 - a. Administration
 - b. Indirect labor
 - i. Laboratory
 - ii. Technical service and engineering
 - iii. Shops and repair facilities
 - iv. Shipping department

- c. Purchasing, receiving, and warehousing
 - d. Personnel and industrial relations
 - e. Inspection, safety, and fire protection
 - f. Automotive and rail switching
 - g. Accounting, clerical, and stenographic
 - h. Communications—telephone, mail, and teletype
 - i. Plant custodial and protective
 - j. Plant hospital and dispensary
 - k. Cafeteria and clubrooms
 - l. Recreational activities
 - m. Local contributions and memberships
 - n. Taxes on property and operating licenses
 - o. Insurance—property, liability
-

Table 3.11 *Continued*

- p. Nuisance elimination—waste disposal and pollution control
- 2. Depreciation
- C. Contingencies
- D. Distribution costs
 - 1. Containers and packages
 - 2. Freight
 - 3. Operation of terminals and warehouses
 - a. Wages and salaries—plus payroll burden
 - b. Operating materials and utilities
 - c. Rental or depreciation

II. General expense

A. Marketing or sales costs

1. Direct

- a. Salespersons' salaries and commissions
- b. Advertising and promotional literature
- c. Technical sales service
- d. Samples and displays

2. Indirect

- a. Sales and supervision
- b. Travel and entertainment
- c. Market research and sales analysis
- d. District office expenses

B. Administrative expense

- 1. Salaries and expenses of officers and staff
- 2. General accounting, clerical, and auditing
- 3. Central engineering and technical
- 4. Legal and patent
 - a. Inside company
 - b. Outside company
 - c. Payment and collection of royalties

5. Research and development
 - a. Own operations
 - b. Sponsored, consultant, and contract work
 6. Contributions and dues to associations
 7. Public relations
 8. Financial
 - a. Debt management
 - b. Maintenance of working capital
 - c. Credit functions
 9. Communications and traffic management
 10. Central purchasing activities
 11. Taxes and insurance
-

Applying the Table 3.10 formulas for indirect costs quick calculations:

Depreciation (10-year straight-line): $\$10,000,000 \div 10 = \$1,000,000/\text{year}$.

Real Estate Taxes (1% of investment): $\$10,000,000 \times 1\% = \$100,000/\text{year}$

Insurance (0.5% of investment): $\$10,000,000 \times 0.5\% = \$50,000/\text{year}$

Summarizing and aggregating the values into the formal structure :

I. Operating / Manufacturing Cost: Sum of raw materials, utilities, labor, maintenance, and depreciation = \$2,500,000

II. General Expense:

Marketing/Sales costs: Advertisements and sales team travel = \$50,000

Administrative Expense: Executive salaries and legal fees = \$80,000.

Research & Development (R&D): Creating new product lines = \$40,000.

Total Product Cost: \$2,500,000 + \$170,000 = \$2,670,000 per year

The basic cost estimating procedure is as follows:

1. Scope the job or problem.
2. Establish the estimate format; use a code of accounts.
3. Prepare your estimate area by area and category by category.
4. Check your work; verify your data.
5. Review and adjust.
6. Finalize.
7. Complete the documentation.
8. File.

In general, • Understand the overall picture.

- Document well.
- Analyze your figures.
- Tailor your estimate to the job.
- Plan ahead.



3.3 SUMMARY

Applying the 8-step estimation lifecycle to our plant :

Scope: Estimate the operating cost of the new 5,000-ton plastic production line.

Format: Organize costs into the Table 3.11 ledger structure.

Prepare: Calculate step-by-step raw materials first, then labor, then utilities.

Check: Cross-verify calculated electricity tariffs against current regulatory approved rates.

Review: Adjust the raw materials budget upward by 4% to account for winter supply chain risks.



**3.3
SUMMARY**

Applying the 8-step estimation lifecycle to our plant : (continued)

Finalize: Approve the finalized operating cost of \$2.67M.

Document: Save all calculation logs and vendor quote sheets.

File: Store the document in the central PMO directory for future historical benchmarking.



3.3 SUMMARY



Thank You