Screening Cost Estimation

Costs Associated with Constructed Facilities

Capital cost expenses relating to the following:

- Land acquisition, including assembly, holding, and improvement
- Planning and feasibility studies
- Architectural and engineering design
- Construction, including materials, equipment, and labor
- Field supervision of construction
- Construction financing
- Owner’s general office overhead
- Equipment and furnishings not included in construction
- Inspection and testing

Screening Cost Estimation

Costs Associated with Constructed Facilities

Operation and maintenance cost in subsequent years over the project life cycle includes the following expenses:

- Land rent, if applicable
- Operating staff
- Labor and material for maintenance and repairs
- Periodic renovations
- Insurance and taxes
- Financing costs (which can be substantial)
- Utilities
- Owner’s other expenses

Screening Cost Estimation

Cost Estimation In General

- Cost estimating is one of the most important steps in project management
- A cost estimate establishes the base line of the project cost at different stages of development of the project. A cost estimate at a given stage of project development represents a prediction provided by the cost engineer or estimator on the basis of available data.
- A competent level of engineering judgment and experience is necessary
- Required levels of accuracy vary at different stages of project development
- Cost estimates made at earlier stages can be expected to be less accurate

Screening Cost Estimation

Types of Construction Cost Estimates

Estimates made during the various stages of the design. For each of these estimates, the amount of design information available typically increases

- Screening estimates (or order of magnitude estimates)
- Preliminary estimates (or conceptual estimates)
- Detailed estimates (or definitive estimates)
- Engineer’s estimates base on plans and specifications

Screening Cost Estimation

Types of Construction Cost Estimates

Screening Estimates

The screening estimates is usually made before the facility is designed and must therefore rely on the cost data of similar facilities built in the past

A rough estimate of the investment required

Little formal calculations, experience with previous similar works

Such ballpark figures provide a measure of likely profitability of venture

If rough estimate generates further interest, client then usually appoint professional advisers to prepare preliminary designs and estimates

Screening Cost Estimation

Types of Construction Cost Estimates

Preliminary Estimates (or Conceptual Estimates)

The preliminary estimates is based on the conceptual design of the facility at the state when the basic technologies for the design are known

The project is decomposed into major structural systems or production equipment items,
e.g. the entire floor of a building or a cooling system for a processing plant

Various approximate methods may be used:

- Unit Cost Method
- Square Method
- Cube Method

Screening Cost Estimation

Types of Construction Cost Estimates

Preliminary Estimates (or Conceptual Estimates)

Unit Cost Method

Based on cost of a functional unit

Examples:

cost per car in a parking garage

cost per bed in a hospital

Estimate = proposed number of units x cost per unit

Fast, but not accurate

Difficult to make adjustments for changes in size, shape, quality or type of construction

Screening Cost Estimation

Types of Construction Cost Estimates

Preliminary Estimates (or Conceptual Estimates)

Square Method

Most commonly used

Based on the floor area of the proposed building

Needs considerable experience and judgment

Due allowance for quality, workmanship, material, location, availability of resources etc.

Useful for evaluation of alternative designs and for budgeting purposes of client

Definitely not to be used by a contractor for a competitive tender

Screening Cost Estimation

Types of Construction Cost Estimates

Preliminary Estimates (or Conceptual Estimates)

Cube Method

Hardly used these days

Based on floor area x height of proposed building

Height of building does not tell much about its usefulness

Screening Cost Estimation

Types of Construction Cost Estimates

Detailed Estimates (or Definitive Estimates)

The detailed estimates is made when the scope of work is clearly defined and detailed design is in progress so that the essential features of the facility are identifiable

The project is decomposed into components of various major systems, i.e. into footings, foundation walls and elevator pit

Screening Cost Estimation

Types of Construction Cost Estimates

Detailed Estimates (or Definitive Estimates)

Example: Decomposition of a building Foundation into Design and Construction Elements

	Contract Elements			
Design elements	Formwork	Rebars	Concrete	Total Cost
Footings	$5,000	$10,000	$13,000	$28,000
Foundation walls	$15,000	$18,000	$28,000	$61,000
Elevator pit	$9,000	$15,000	$16,000	$40,000
Total cost	**$29,000**	**$43,000**	**$57,000**	**$129,000**

Screening Cost Estimation

Types of Construction Cost Estimates

Engineer’s Estimates (base on plans and specifications)

The engineer’s estimate is based on the completed plans and specifications when they are ready for the owner to solicit bids from construction contractors

The project is decomposed into detailed items of various components as warranted by the available cost data e.g.slabs and beams in a floor panel or the piping and connections for a heat exchanger

In preparing these estimates, the design professional will include expected amounts for contractors’ overhead and profits

Screening Cost Estimation

Use of Historical Cost Data in Screening Estimates

Useful for cost estimation only if they are collected and organized in a way that is compatible with future applications

Organizations which are engaged in cost estimation continually should keep a file for their use. The information must be updated with respect to changes that will inevitably occur

The format of cost data, such as unit costs for various items, should be organized according to the current standard of usage in the organization

Construction cost data are published in various forms by a number of organizations. These publications are useful as references for comparison

Screening Cost Estimation

Cost Data Published by Various Organisations

“Sweets’ “ Catalog published by McGraw-Hill Information Systems Company

“Engineering News Record”, the McGraw-Hill

“Cost Engineering”, a journal of the American Association of Cost Engineers

“Building Construction Cost Data” published annually by R.S. Means Company, Inc.

“Hanscomb”

“Helyar”

The “Dodge Digest of Building Costs and Specifications”

Screening Cost Estimation

Example on Screening Estimates

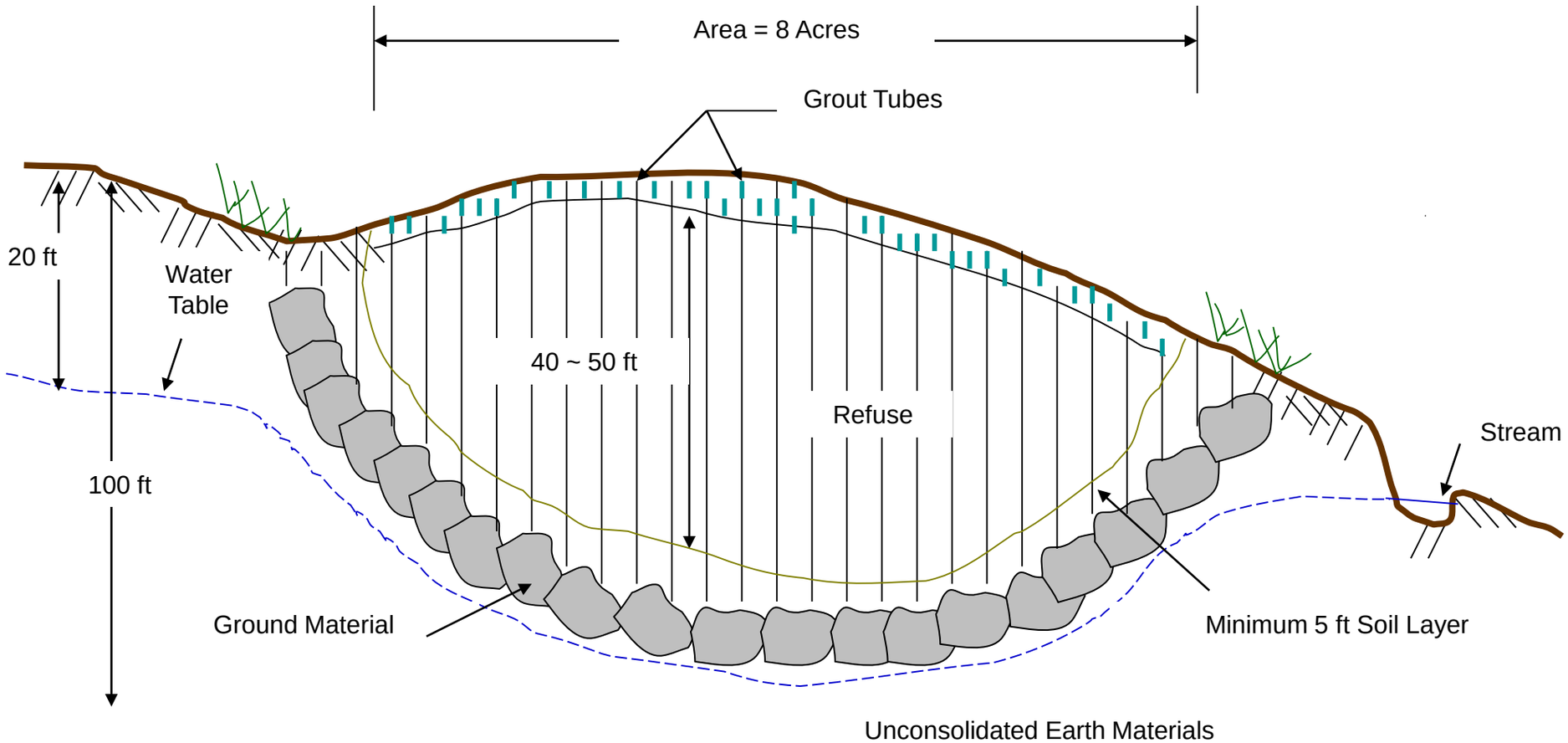
Grouting Seal Beneath a Landfill

One of the methods of isolating a landfill from groundwater is to create a bowl shaped bottom seal beneath the site as shown in the figure. The seal is constructed by pumping or pressure-injecting grout under the existing landfill. Holes are bored at regular intervals throughout the landfill for this purpose, and the grout tubes are extended from the surface to the bottom of the landfill.

A layer of soil at a minimum of 5ft thick is left between the grouted material and the landfill contents to allow for irregularities in the bottom of the landfill. The grout liner can be between 4 and 6 ft thick. A typical material would be Portland cement grout pumped under pressure through tubes to fill voids in the soil. This grout would the harden into a permanent impermeable liner.

Screening Cost Estimation

Example: Screening Estimate of a Grouting Seal Beneath a Landfill



Screening Cost Estimation

Example of a Screening Estimate

The work items in this project include

(1) drilling exploratory bore holes at 50ft intervals for grout tubes

(2) pumping grout into the voids of a soil layer between 4 and 6 feet thick. The quantities for these two items are estimated on the basis of the landfill area:

8 acres = 8 x (43,560 ft^2/acre) = 348,480 ft^2

(As an approximation, use 360,000 ft^2 to account for the bowl shape)

The number of bore holes in a 50ft by 50ft grid pattern covering 360,000 ft^2 is given by

$$\frac{360{,}000\ ft^2}{(50\ ft)\ (50\ ft)} = 144$$

Screening Cost Estimation

Example of a Screening Estimate

The average depth of the bored holes is estimated to be 20 ft.
Hence, the total amount of drilling is (144) (20) = 2,880 ft

The volume of the soil layer for grouting is estimated to be :

For a 4 ft layer, volume = (4 ft) (360,000 ft^2) = 1,440,000 ft^3
For a 6 ft layer, volume = (6 ft) (360,000 ft^2) = 2,160,000 ft^3

It is estimates from soil tests that the voids in the soil layer are between 20 and 30 percent of the total volume. Thus for a 4ft soil layer:

Grouting in 20% voids = (20%)(1,440,000) = 288,000 ft^3
Grouting in 30% voids = (30%)(1,440,000) = 432,000 ft^3

Screening Cost Estimation

Example of a Screening Estimate

For a 6 ft soil layer:
Grouting in 20% voids = (20%)(2,160,000) = 432,000 ft^3
Grouting in 30% voids = (30%)(2,160,000) = 648,000 ft^3

The unit cost for drilling exploratory bore holes is estimated to be between $3 and $10 per foot, including all expenses. Thus, the total cost of boring will be between
(2,880) ($3) = $8,640 and (2,880) ($10) = $28,800

The unit cost of Portland cement grout pumped into place is between $4 and $10 per cubic foot including overhead and profit. In addition to the variation in the unit cost, the total cost of the bottom seal will depend upon the thickness of the soil layer grouted and the proportion of voids in the soil.

Screening Cost Estimation

Example of a Screening Estimate

That is,

For a 4 ft layer with 20% voids, grouting cost = $1,152,000 to $2,880,000
For a 4 ft layer with 30% voids, grouting cost = $1,728,000 to $4,320,000
For a 6 ft layer with 20% voids, grouting cost = $1,728,000 to $4,320,000
For a 6 ft layer with 30% voids, grouting cost = $2,592,000 to $6,480,000

The total cost of drilling bore holes is so small in comparison with the cost of grouting that the former can be omitted in the screening estimate.

Furthermore, the range of unit cost varies greatly with soil characteristics, and the engineer must exercise judgment in narrowing the range of the total cost.

Alternatively, additional soil tests can be used to estimate better the unit cost of pumping grout and the proportion of voids in the soil.

Screening Cost Estimation

Example of a Screening Estimate

Suppose that, in addition to ignoring the cost of bore holes, an average value of a 5 ft soil layer with 25% voids is used together with a unit cost of \$7 per ft^3 of Portland cement grouting. In this case, the total project cost is estimated to be:

(5ft) (360,000 ft^2) (25%) (\$/ft^3) = \$3,150,000

An important point to note is that this screening estimate is based to a large degree on engineering judgment of the soil characteristics, and the range of the actual cost may vary from \$1,152,000 to \$6,480,00

Screening Cost Estimation

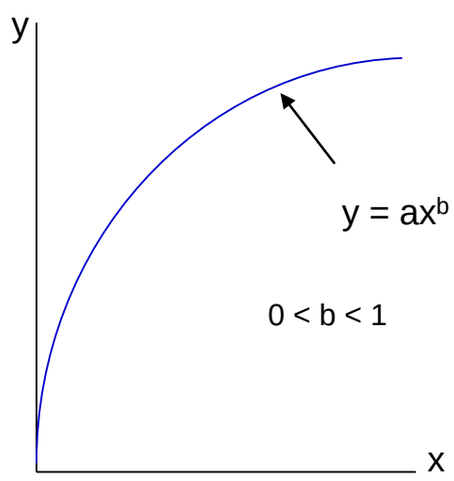
Effects of Scale on Screening Cost Estimates

Generally, screening cost estimates are often based on a single variable representing the capacity or some physical measure of the design, e.g. floor area in buildings, length of highways, volumes of storage bins, and production volumes of processes plants

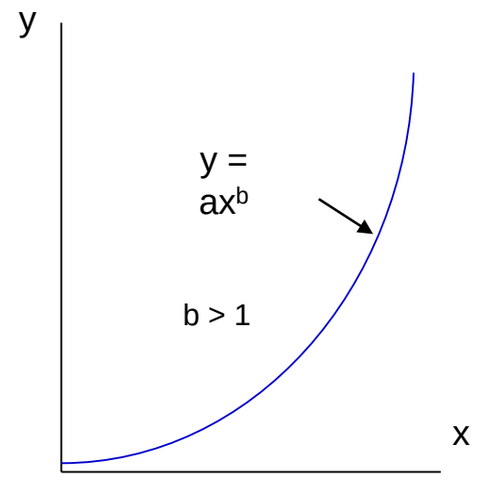
Costs, however, do not always vary linearly with respect to different facility sizes

If the average cost per unit of capacity is declining, then scale economies exist

Conversely, scale diseconomies exist if average costs increase with greater size



Increasing Return to Scale



Decreasing Return to Scale

Screening Cost Estimation

Derivation of Cost Indices in Screening Estimates

If y_n is the known cost of an existing facility with a capacity of Q_n

Estimated cost of new facility with new capacity Q is $y = y_n (Q/Q_n)^m$

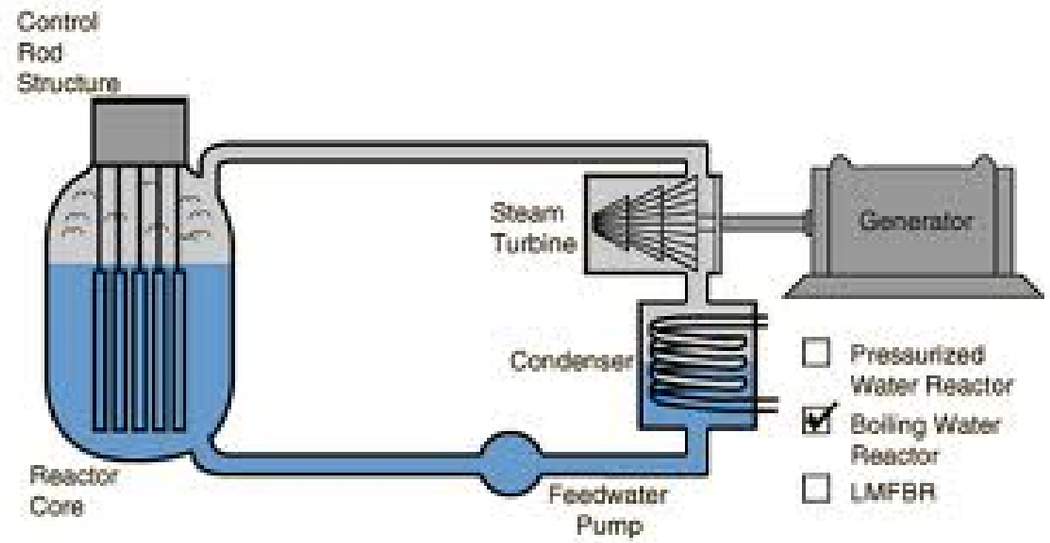
If we reduce $y = y_n (Q/Q_n)^m$ to a linear relationship, we get

$$\log y = \log y_n + m \log (Q/Q_n)$$

leading to

$$\log y - \log y_n = m (\log Q - \log Q_n)$$

We need to find m, the Cost Index, from past historical data

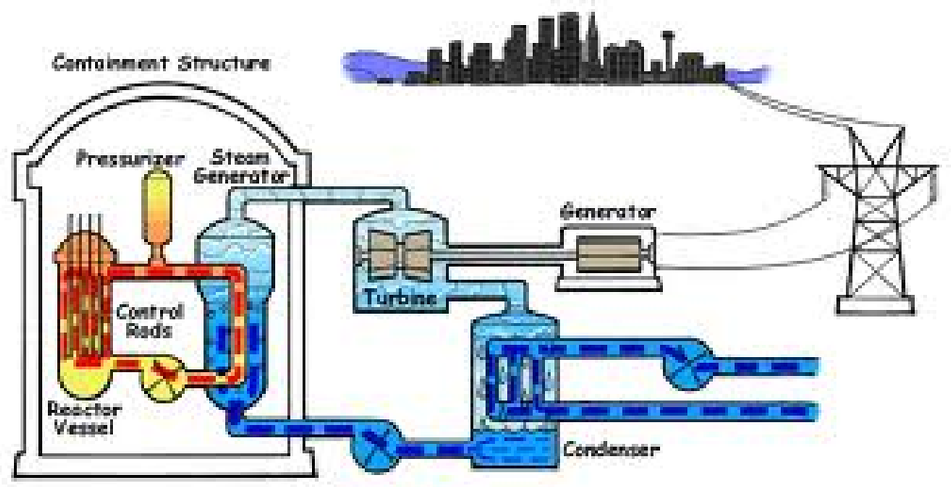


Screening Cost Estimation

Derivation of Cost Indices in Screening Estimates

Suppose we have the following historical data for 5 nuclear reactors that have been built

Reactor	Cost	Capacity (GW)
1	$ 14,000	200
2	$ 18,000	300
3	$ 21,500	400
4	$ 25,000	500
5	$ 28,000	600



Screening Cost Estimation

Derivation of Cost Indices in Screening Estimates

A pair wise comparison between the five reactors yields the following data

y_n	y	Q_n	Q	log y - log y_n	log Q - log Q_n
$ 14,000	$ 18,000	200	300	0.109	0.176
$ 18,000	$ 21,500	300	400	0.077	0.125
$ 21,500	$ 25,000	400	500	0.066	0.096
$ 25,000	$ 28,000	500	600	0.049	0.079

The linear regression equation is log y - log y_n = 0.628 (log Q - log Q_n)

m = 0.628 with R^2 = 0.983

Screening Cost Estimation

Use of Cost Indices in Screening Estimates

The general conditions for the application of cost indices are:

(1) Exclude special local conditions in historical data
(2) Determine new facility cost on basis of specified size or capacity
(3) Adjust for inflation index
(4) Adjust for local index of construction costs
(5) Adjust for different regulatory constraints
(6) Adjust for local factors for the new facility

Some of these adjustments may be done using compiled indices. Others may require field investigation and considerable professional judgment to reflect differences between a given project and standard projects performed in the past

Screening Cost Estimation

Example on Application of Cost Indices to Estimating

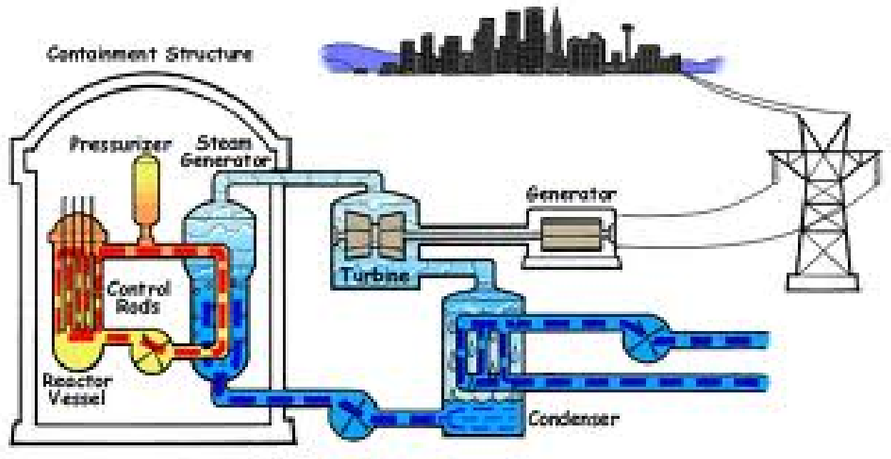
Screening Estimate for a Refinery

The total construction cost of a refinery with a production capacity of 200,000 bbl/day in Edmonton, Alberta, completed in 2012 was $100 million. It is proposed that a similar refinery with a production capacity of 300,000 bbl/day be built in Toronto for completion in 2016. For the additional information given here, make an order of magnitude estimate of the cost of the proposed plant.

(1) In the total construction cost for the Edmonton plant, there was an item of $5 million for site preparation which is not typical for other plants

(2) The variation of sizes of the refineries can be approximated by the exponential rule, $y = y_n (Q/Q_n)^m$ with m = 0.60

(3) The inflation rate is expected to be 8% per year from 2012 to 2016



Screening Cost Estimation

Example on Application of Cost Indices to Estimating

Screening Estimate for a Refinery

(4) The location index was 0.92 for Edmonton, Alberta, and 1.14 for Toronto in 2012.These indices are deemed to be appropriate for adjusting the costs between these two cities

(5) New air pollution equipment for the Toronto plant will cost $7 million in 2016 dollars (not required in the Edmonton plant)

(6) The contingency cost due to inclement weather delay will be reduced by the amount of 1% of total construction cost because of the favorable climate in Toronto (compared to Edmonton)

Screening Cost Estimation

Example on Application of Cost Indices to Estimating

Screening Estimate for a Refinery

The estimate for the new project:

1. Typical cost excluding special item at Edmonton, Alberta is $100 m - $5 m = $95 million

2. Adjustment for capacity based on the exponential law yields

$$(\$95)\left(\frac{300{,}000}{200{,}000}\right)^{0.6} = (95)(1.5)^{0.6} = \$\ 121.2 \text{ million}$$

3. Adjustment for inflation leads to the cost in 2016 dollars as

$$(\$121.2)(1.08)^4 = \$\ 164.6 \text{ million}$$

Screening Cost Estimation

Example on Application of Cost Indices to Estimating

Screening Estimate for a Refinery

4. Adjustment for location index gives ($164.6) ($\frac{1.14}{0.92}$) = $204.6 million

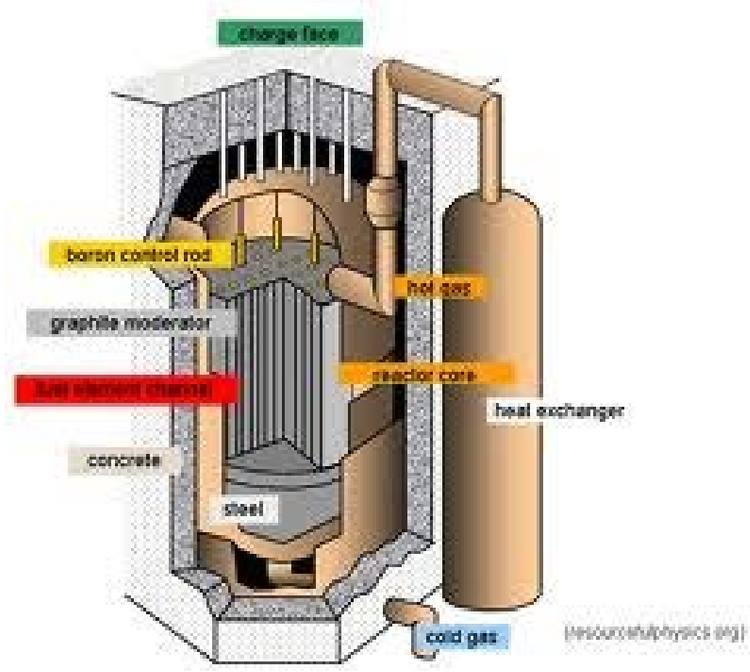
5. Adjustment for new pollution equipment at the Toronto plant gives

$$\$ 204.6 + \$ 7 = \$ 211.6 \text{ million}$$

6. Reduction in contingency cost yields ($211.6) (1 - 0.01) = $ 209.5 million

Since there is no adjustment for other construction costs, the order of magnitude estimate for the new project is $209.5 million

In actual real cost, probably in billions of dollars!



Screening Cost Estimation

What Else Is Important In Cost Estimating?

Very important to visit site and collate the following:

Description of the project and its precise location, information concerning the client, consultants, local authorities, their addresses and phone numbers, and named individuals whom direct contact can be made

Access to site including any temporary access for conveying materials, heavy plant, etc

Details of services available or not available

Details of geography, boreholes, groundwater levels, past uses and any local knowledge

Screening Cost Estimation

What Else Is Important In Cost Estimating?

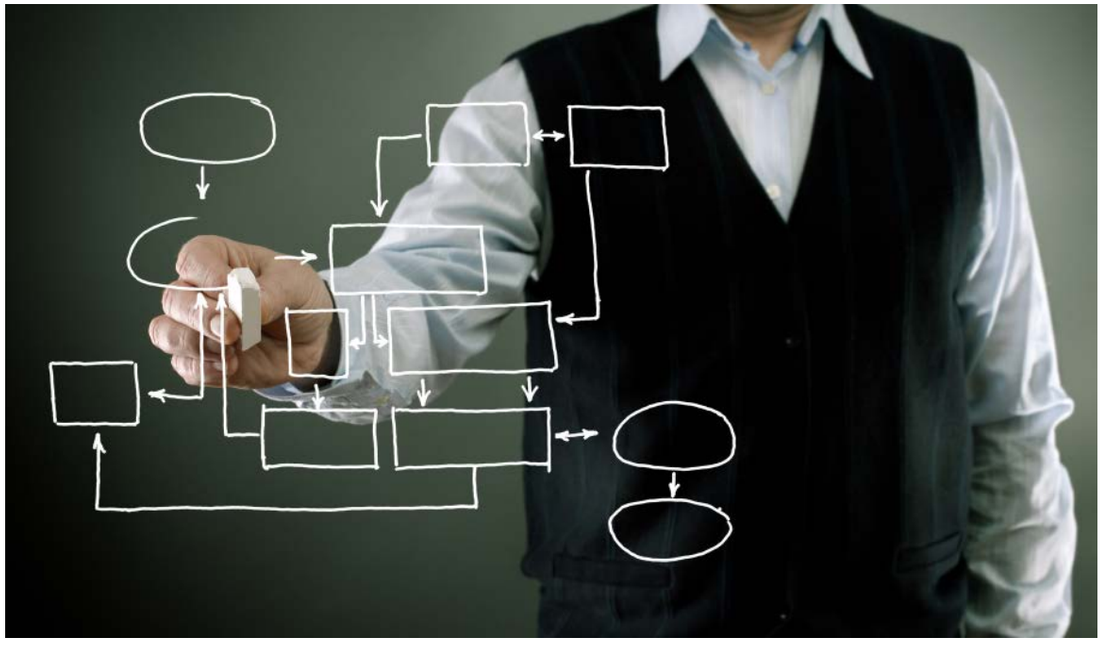
Location of tips, existing quarries, suppliers

Availability of labour, whether similar works are starting or winding down

Type of weather that will occur over the period

Details of possible subcontractors

The contractors' bid estimates often reflect the desire of the contractor to secure the job as well as the estimating tools at its disposal



Screening Cost Estimation

What Else Is Important In Cost Estimating?

Risks Contractor Takes!

- Productivity of resources allowed for is achieved
- Bad weather
- Availability of material and labour
- Industrial disputes
- Financial stability of the client