

COST ESTIMATION AND ECONOMICS

Cost of Soda ash plant of capacity **750 TPD** in 1971 is Rs. **1.75×10^8** .

Chemical Engineering Plant Cost Index:

Cost index in 1971 = 132

Cost index in 2002 = 402

Thus, Present cost of Plant = (original cost) \times (present cost index)/(past cost index)
 $= (1.75 \times 10^8) \times (402/132) = \text{Rs. } 5.33 \times 10^8$

i.e., Fixed Capital Cost (FCI) = Rs. 5.33×10^8

Estimation of Capital Investment Cost:

I. **Direct Costs:** material and labour involved in actual installation of complete facility (70-85% of fixed-capital investment)

a) Equipment + installation + instrumentation + piping + electrical + insulation + painting (50-60% of Fixed-capital investment)

1. **Purchased equipment cost (PEC):** (15-40% of Fixed-capital investment)

Consider purchased equipment cost = 25% of Fixed-capital investment

i.e., $\text{PEC} = 25\% \text{ of } 5.33 \times 10^8 = 0.25 \times 3.0455 \times 10^8 = \text{Rs. } 1.3325 \times 10^8$

2. **Installation, including insulation and painting:** (25-55% of purchased equipment cost.)

Consider the Installation cost = 40% of Purchased equipment cost

$= 40\% \text{ of } 1.3325 \times 10^8 = 0.40 \times 1.3325 \times 10^8 = \text{Rs. } 0.553 \times 10^8$

3. **Instrumentation and controls, installed:** (6-30% of Purchased equipment cost.)

Consider the installation cost = 20% of Purchased equipment cost

$= 20\% \text{ of } 1.3325 \times 10^8 = 0.20 \times 1.3325 \times 10^8 = \text{Rs. } 0.2665 \times 10^8$

4. **Piping installed:** (10-80% of Purchased equipment cost)

Consider the piping cost = 40% Purchased equipment cost

$$= 40\% \text{ of Purchased equipment cost} = 0.40 \times 1.3325 \times 10^8$$

$$= \text{Rs. } 0.533 \times 10^8$$

5. **Electrical, installed:** (10-40% of Purchased equipment cost)

Consider Electrical cost = 25% of Purchased equipment cost
 $= 25\% \text{ of } 1.3325 \times 10^8 = 0.25 \times 1.3325 \times 10^8 = \text{Rs. } 0.3331 \times 10^8$
Hence, cost = Rs. 2.9981×10^8 --- (56.25% of FCI)

B. Buildings, process and Auxiliary: (10-70% of Purchased equipment cost)

Consider Buildings, process and auxiliary cost = 40% of PEC
 $= 40\% \text{ of } 1.3325 \times 10^8 = 0.40 \times 1.3325 \times 10^8 = \text{Rs. } 0.533 \times 10^8$

C. Service facilities and yard improvements: (40-100% of Purchased equipment cost)

Consider the cost of service facilities and yard improvement = 60% of PEC
 $= 60\% \text{ of } 1.3325 \times 10^8 = 0.60 \times 1.3325 \times 10^8 = \text{Rs. } 0.7993 \times 10^8$

D. Land: (1-2% of fixed capital investment or 4-8% of Purchased equipment cost)

Consider the cost of land = 6% PEC = 6% of $1.3325 \times 10^8 = 0.06 \times 1.3325 \times 10^8$
 $= \text{Rs. } 0.07995 \times 10^8$

Thus, Direct cost = Rs. 4.41×10^8 ----- (82.74% of FCI)

II. **Indirect costs:** expenses which are not directly involved with material and labour of actual installation of complete facility (15-30% of Fixed-capital investment)

A. Engineering and Supervision: (5-30% of direct costs)

Consider the cost of engineering and supervision = 10% of Direct costs
i.e., cost of engineering and supervision = 10% of 4.41×10^8
 $= 0.1 \times 4.41 \times 10^8 = \text{Rs. } 0.441 \times 10^8$

B. Construction Expense and Contractor's fee: (6-30% of direct costs)

Consider the construction expense and contractor's fee = 10% of Direct costs
i.e., construction expense and contractor's fee = 10% of 4.41×10^8

$$= 0.1 \times 4.41 \times 10^8 = \text{Rs. } 0.441 \times 10^8$$

C. Contingency: (5-15% of Fixed-capital investment)

Consider the contingency cost = 10% of Fixed-capital investment

$$\begin{aligned} \text{i.e., Contingency cost} &= 10\% \text{ of } 5.33 \times 10^8 = 0.12 \times 5.33 \times 10^8 \\ &= \text{Rs. } 0.6396 \times 10^8 \end{aligned}$$

Thus, Indirect Costs = Rs. 1.5216×10^8 --- (28.54% of FCI)

III. Fixed Capital Investment:

$$\begin{aligned} \text{Fixed capital investment} &= \text{Direct costs} + \text{Indirect costs} \\ &= (4.41 \times 10^8) + (1.5216 \times 10^8) \end{aligned}$$

$$\text{i.e., Fixed capital investment} = \text{Rs. } 5.9316 \times 10^8$$

IV. Working Capital: (10-20% of Fixed-capital investment)

Consider the Working Capital = 15% of Fixed-capital investment

$$\begin{aligned} \text{i.e., Working capital} &= 15\% \text{ of } 5.9316 \times 10^8 = 0.15 \times 5.9316 \times 10^8 \\ &= \text{Rs. } 0.8897 \times 10^8 \end{aligned}$$

V. Total Capital Investment (TCI):

$$\begin{aligned} \text{Total capital investment} &= \text{Fixed capital investment} + \text{Working capital} \\ &= (5.9316 \times 10^8) + (0.8897 \times 10^8) \end{aligned}$$

$$\text{i.e., Total capital investment} = \text{Rs. } 6.8213 \times 10^8$$

Estimation of Total Product cost:

I. Manufacturing Cost = Direct production cost + Fixed charges + Plant overhead cost.

A. Fixed Charges: (10-20% total product cost)

i. Depreciation: (depends on life period, salvage value and method of calculation-about 13% of FCI for machinery and equipment and 2-3% for Building Value for Buildings)

Consider depreciation = 13% of FCI for machinery and equipment and 3% for Building Value for Buildings)

$$\begin{aligned} \text{i.e., Depreciation} &= (0.13 \times 10^8) + (0.03 \times 0.533 \times 10^8) = \\ &= \text{Rs. } 0.7711 \times 10^8 \end{aligned}$$

ii. Local Taxes: (1-4% of fixed capital investment)

Consider the local taxes = 3% of fixed capital investment

$$\text{i.e. Local Taxes} = 0.03 \times 5.9316 \times 10^8 = \text{Rs. } 0.178 \times 10^8$$

iii. Insurances: (0.4-1% of fixed capital investment)

Consider the Insurance = 0.7% of fixed capital investment

$$\text{i.e. Insurance} = 0.007 \times 5.9316 \times 10^8 = \text{Rs. } 0.0415 \times 10^8$$

iv. Rent: (8-12% of value of rented land and buildings)

Consider rent = 10% of value of rented land and buildings

$$= 10\% \text{ of } ((0.07995 \times 10^8) + (0.533 \times 10^8))$$

$$= 0.10 \times ((0.07995 \times 10^8) + (0.533 \times 10^8))$$

$$\text{Rent} = \text{Rs. } 0.06129 \times 10^8$$

$$\text{Thus, Fixed Charges} = \text{Rs. } 1.05189 \times 10^8$$

B. Direct Production Cost: (about 60% of total product cost)

Now we have Fixed charges = 10-20% of total product charges – (given)

Consider the Fixed charges = 15% of total product cost

$$\Rightarrow \text{Total product charge} = \text{fixed charges}/15\%$$

$$\Rightarrow \text{Total product charge} = 1.05189 \times 10^8 / 15\%$$

$$\Rightarrow \text{Total product charge} = 1.05189 \times 10^8 / 0.15$$

$$\Rightarrow \text{Total product charge (TPC)} = \text{Rs. } 7.0126 \times 10^8$$

i. Raw Materials: (10-50% of total product cost)

Consider the cost of raw materials = 25% of total product cost

$$\Rightarrow \text{Raw material cost} = 25\% \text{ of } 7.0126 \times 10^8 = 0.25 \times 7.0126 \times 10^8$$

⇒ Raw material cost = Rs. 1.753×10^8

ii. Operating Labour (OL): (10-20% of total product cost)

Consider the cost of operating labour = 12% of total product cost

⇒ operating labour cost = 12% of $7.0126 \times 10^8 = 0.12 \times 7.0126 \times 10^8$

⇒ Operating labour cost = Rs. 0.8415×10^8

iii. Direct Supervisory and Clerical Labour (DS & CL): (10-25% of OL)

Consider the cost for Direct supervisory and clerical labour = 12% of OL

⇒ Direct supervisory and clerical labour cost = 12% of 0.8415×10^8
 $= 0.12 \times 0.8415 \times 10^8$

⇒ Direct supervisory and clerical labour cost = Rs. 0.1×10^8

iv. Utilities: (10-20% of total product cost)

Consider the cost of Utilities = 12% of total product cost

⇒ Utilities cost = 12% of $7.0126 \times 10^8 = 0.12 \times 7.0126 \times 10^8$

⇒ Utilities cost = Rs. 0.8415×10^8

v. Maintenance and repairs (M & R): (2-10% of fixed capital investment)

Consider the maintenance and repair cost = 5% of fixed capital investment

i.e. Maintenance and repair cost = $0.05 \times 5.9316 \times 10^8 = \text{Rs. } 0.2965 \times 10^8$

vi. Operating Supplies: (10-20% of M & R or 0.5-1% of FCI)

Consider the cost of Operating supplies = 15% of M & R

Operating supplies cost = 15% of $0.2965 \times 10^8 = 0.15 \times 0.2965 \times 10^8$

Operating supplies cost = Rs. 0.0444×10^8

vii. Laboratory Charges: (10-20% of OL)

Consider the Laboratory charges = 15% of OL

Laboratory charges = 15% of $0.8415 \times 10^8 = 0.15 \times 0.8415 \times 10^8$

⇒ Laboratory charges = Rs. 0.1262×10^8

viii. Patent and Royalties: (0-6% of total product cost)

Consider the cost of Patent and royalties = 4% of total product cost

$$\Rightarrow \text{Patent and Royalties} = 4\% \text{ of } 7.0126 \times 10^8 = 0.03 \times 7.0126 \times 10^8$$

$$\Rightarrow \text{Patent and Royalties cost} = \text{Rs. } 0.2805 \times 10^8$$

Thus, Direct Production Cost = Rs. 4.2836×10^8 ----- (61% of TPC)

C. Plant overhead Costs (50-70% of Operating labour, supervision, and maintenance or 5-15% of total product cost); includes for the following: general plant upkeep and overhead, payroll overhead, packaging, medical services, safety and protection, restaurants, recreation, salvage, laboratories, and storage facilities.

Consider the plant overhead cost = 60% of OL, DS & CL, and M & R

$$\text{Plant overhead cost} = 60\% \text{ of } ((0.8415 \times 10^8) + (0.1 \times 10^8) + (0.2965 \times 10^8))$$

$$\text{Plant overhead cost} = 0.60 \times ((0.8415 \times 10^8) + (0.1 \times 10^8) + (0.2965 \times 10^8))$$

$$\text{Plant overhead cost} = \text{Rs. } 0.7428 \times 10^8$$

Thus, Manufacture cost = Direct production cost + Fixed charges + Plant overhead costs.

$$\text{Manufacture cost} = (4.2836 \times 10^8) + (1.05185 \times 10^8) + (0.7428 \times 10^8)$$

$$\text{Manufacture cost} = \text{Rs. } 6.07825 \times 10^8$$

II. General Expenses = Administrative costs + distribution and selling costs + research and development costs

Administrative costs:(2-6% of total product cost)

Consider the Administrative costs = 5% of total product cost

$$\Rightarrow \text{Administrative costs} = 0.0277 \times 7.0126 \times 10^8$$

$$\Rightarrow \text{Administrative costs} = \text{Rs. } 0.35063 \times 10^8$$

A. Distribution and Selling costs: (2-20% of total product cost); includes costs for sales offices, salesmen, shipping, and advertising.

Consider the Distribution and selling costs = 15% of total product cost

$$\text{Distribution and selling costs} = 15\% \text{ of } 7.0126 \times 10^8$$

$$\Rightarrow \text{Distribution and selling costs} = 0.15 \times 7.0126 \times 10^8$$

$$\Rightarrow \text{Distribution and Selling costs} = \text{Rs. } 1.0519 \times 10^8$$

C. Research and Development costs: (about 5% of total product cost)

Consider the Research and development costs = 5% of total product cost

$$\text{Research and Development costs} = 5\% \text{ of } 7.0126 \times 10^8$$

$$\Rightarrow \text{Research and development costs} = 0.05 \times 7.0126 \times 10^8$$

$$\Rightarrow \text{Research and Development costs} = \text{Rs. } 0.3506 \times 10^8$$

D. Financing (interest): (0-10% of total capital investment)

Consider interest = 5% of total capital investment

$$\text{i.e. interest} = 5\% \text{ of } 5.9316 \times 10^8 = 0.05 \times 5.9316 \times 10^8$$

$$\text{Interest} = \text{Rs. } 0.2965 \times 10^8$$

Thus, General Expenses = Rs. 2.04971×10^8

IV. Total Product cost = Manufacture cost + General Expenses

$$= (6.07825 \times 10^8) + (2.04971 \times 10^8)$$

$$\text{Total product cost} = \text{Rs. } 8.1279 \times 10^8$$

V. Gross Earnings/Income:

Wholesale Selling Price of Soda ash per ton = \$ 85 (USD)

Let 1 USD = Rs. 50.00

Hence Wholesale Selling Price of Soda ash per ton. = $85 \times 50 = \text{Rs. } 4250$

Total Income = Selling price \times Quantity of product manufactured

$$= 4250 \times (750 \text{ T/day}) \times (330 \text{ days/year})$$

$$\text{Total Income} = \text{Rs. } 10.518 \times 10^8$$

Gross income = Total Income – Total Product Cost

$$= (10.518 \times 10^8) - (8.127 \times 10^8)$$

Gross Income = Rs. 2.391×10^8

Let the Tax rate be 45% (common)

Taxes = 45% of Gross income

$$= 45\% \text{ of } 2.391 \times 10^8 = 0.45 \times 2.391 \times 10^8$$

Taxes = Rs. 1.076×10^8

Net Profit = Gross income - Taxes = Gross income \times (1 - Tax rate)

$$\text{Net profit} = (2.391 \times 10^8) - (1.076 \times 10^8) = \text{Rs. } 1.315 \times 10^8$$

Rate of Return:

Rate of return = Net profit \times 100 / Total Capital Investment

$$\text{Rate of Return} = 1.315 \times 10^8 \times 100 / (6.8213 \times 10^8)$$

Rate of Return = 19.27%

Break even Analysis:

Data available:

Annual Direct Production Cost = Rs. 4.2836×10^8

Annual Fixed charges, overhead and general expenses = Rs. 2.7925×10^8

Total Annual sales = Rs. 10.518×10^8

Wholesale Selling Price of Soda ash per ton. = Rs. 4250

Direct production cost per ton of Soda ash = $(4.2836 \times 10^8) / (10.518 \times 10^8 / 4250)$

$$= \text{Rs. } 1730.87 \text{ per ton}$$

Let 'n' TPA be the break even production rate.

Number of tons needed for a break-even point is given by

$$(2.7925 \times 10^8) + (1730.87 \times n) = (4250 \times n)$$

$$\Rightarrow n = 110851.76 \text{ tons/year}$$

$$n = 335.914 \text{ tons/day} = 335.914 \text{ TPD}$$

Hence, the break-even production rate is 335.914 TPD or 44.78% of the considered plant capacity.