

Estimating the Fixed (FCI) and Total Capital Investments (TCI)

See T&S Section 6.3

1. Prepare preliminary flowsheet and mass and energy balances. Select materials of construction.
2. Size equipment using the mass and energy balances.
3. Estimate the purchased equipment cost (PEC) for each major piece of equipment using Table 6.6 on page 319 of the T&S text. If equipment size is outside of the correlation then it is either too big or too small – either make larger or break into multiple units. If your specific equipment piece is not listed in Table 6.6, you can build it using the components – distillation columns are done this way.

Adjust for current cost index. The cost values from Table 6.6 are given for U.S. Gulf Coast (USGC), January 2006, CE Index = 478.6.

Cost values shown in Table 6.6 are for equipment costs (including delivery) to the U.S. Gulf Coast. Please see location factors in Table 6.7 and notes on page 327.

For reactor vessels and distillation columns, the installation costs are higher due to the additional costs for nozzles, piping connections, stirring equipment, instrumentation, maintenance access, etc. For these units, multiply the PEC by a factor of 3.

4. Use the table below for each piece of equipment to estimate the ISBL + OSBL installed capital cost and the fixed capital investment (FCI). Do not use Table 6.4 in T&S since this has typos and only applies to a material factor of unity. The ISBL and OSBL factors are defined differently:

ISBL investment = ISBL factor \times PEC

OSBL investment = Fraction of ISBL investment = $(1 + \text{OSBL factor}) \times \text{ISBL investment}$

If all of the equipment is made of the same material of construction, then you can do the calculation collectively on all the equipment. In this case, sum the PECs for all of the equipment and multiply by a single factor based on the specific material of construction:

$$\begin{aligned} \text{FCI} &= (\sum \text{PEC}_i) (\text{Fixed Capital Investment Factor}) \\ &= (\sum \text{PEC}_i) (\text{ISBL Factor}) (1 + \text{OSBL Factor}) (1 + \text{DE Factor} + \text{Contingency Factor}) \\ &= (\text{ISBL} + \text{OSBL Installed Capital Cost}) (1 + \text{DE Factor} + \text{Contingency Factor}) \end{aligned}$$

5. Estimate the working capital. The working capital is the money needed to purchase raw materials and to operate the plant for a short while until product is sold. See details on pages 301 – 302 of T&S. It is roughly 7 weeks cost of production minus two weeks of raw materials costs. A less accurate approximation is 10 – 20% of the FCI (page 317, T&S).
6. Add FCI and working capital to get **Total Capital Investment (TCI)**.

Type of Plant:	Fluids	Fluids – Solids	Solids
Item:			
Equipment Piece, Purchased Equipment Cost (PEC), delivered	C_e	C_e	C_e
Material Cost Factor, Table 6.5 in T&S	f_m	f_m	f_m
Installation Factors:			
Piping, f_p :	$0.8 f_m$	$0.6 f_m$	$0.2 f_m$
Equipment Erection, f_{er} :	0.3	0.5	0.6
Instrumentation and Control, f_i :	0.3	0.3	0.2
Electrical, f_{el} :	0.2	0.2	0.15
Civil, f_c :	0.3	0.3	0.2
Structures and Buildings, f_s :	0.2	0.2	0.1
Insulation, Coating, and Paint, f_t :	0.1	0.1	0.05
ISBL Factor = sum of installation factors plus material cost factor:	$1.4 + 1.8 f_m$	$1.6 (1 + f_m)$	$1.3 + 1.2 f_m$
OSBL Factor:	See note below	See note below	See note below
Design and Engineering Factor (DE):	0.3	0.25	0.2
Contingency Factor (X):	0.1	0.1	0.1
Fixed Capital Investment Factor, $(1+OSBL)(1+DE+X)(ISBL)$:	$1.4(1+OSBL) \times (1.4 + 1.8 f_m)$	$2.16(1+OSBL) \times (1 + f_m)$	$1.3 (1+OSBL) \times (1.3 + 1.2 f_m)$
Fixed Capital Investment Factor for $f_m = 1$.	$4.48 (1+OSBL)$	$4.32 (1+OSBL)$	$3.25 (1+OSBL)$

The OSBL component of the FCI is dependent on the situation (ranging from 10 to 100% of the ISBL investment). The following more detailed guidelines are provided below:

- The values for the OSBL Factor shown in Table 6.4 of T&S are average values.
- A plant expansion on an existing site would normally include both ISBL and OSBL investments (as the expansion would require additional off-site loads, e.g., more boilers, waste water processing, cooling water, power lines, etc.).
- The OSBL (offsite) investment is negligible for a "brownfield" site where an old plant has closed and the offsite infrastructure can meet the new plant's needs.

For all other plants, except brownfield, use the following guidelines for the OSBL Factor:

- Assume 30-40% offsite costs for world-scale fuels/petrochemicals plants.
- Smaller plants, and plants that handle solids, require more OSBL investment, and for these 100% of the ISBL investment (as recommended by PT&W) is a good assumption.
- Offsite costs of ~20% or less are required for very small volume fine chemical and pharmaceutical plants that do not have large inventories of feeds and products and do not warrant much of a utility system.
- Offsite costs of ~10% are typical for gas processing plants that have no feed and product inventories. The only offsite costs are usually electrical infrastructure, roads, and (sometimes) buildings.

Other calculations, see page 305 in T&S:

Cost of Production = Operating (Variable) Costs + Fixed Costs

Gross Profit = Main Product Revenues – Cost of Production

Net Profit = Gross Profit – Taxes

Gross Margin or Margin = Main Product Revenues – Raw Material Costs

CASH FLOW SCHEDULE – Use the schedule shown below. See Table 6.10 in T&S.

Year	Costs	Revenues	Explanation
1	30% FCI	0	Engineering + long lead items
2	50% of FCI	0	Procurement and construction
3	20% of FCI + Working Capital + Fixed Costs + 30% of Operating Costs	30% of Design Basis Revenue	Finish construction and initial production.
4	Fixed Costs + 70% of Operating Costs	70% of Design Basis Revenue	Shake-down of plant
5 and i-th year	Operating Costs + Fixed Costs	100% of Design Basis Revenue	Full production at design rates
Project Life Year	Operating Costs + Fixed Costs	100% of Design Basis Revenue + Working Capital	Full production at design rates

Note: Cost and revenue values shown are average values to use in your cash flow table. Both can vary widely in practice:

Year 2 Costs: 40% to 60% of FCI

Year 3 Costs: 10% to 30% of FCI

Year 4 Costs: 50% to 90% of FCI; Revenues from 50% to 90 % of design basis.