Fixed Capital Investment: Cost of equipment and facilities

FCI = (Direct Costs) + (Indirect Costs)

## Direct Costs:

1. Purchased equipment: Columns, Heat Exchangers, pumps, tanks, etc.

- 2. Equipment Installation
- 3. Piping (includes insulation)
- 4. Instruments and Control
- 5. Electrical Equipment.
- 6. Buildings: Process, Administration, Maintenance shops, etc.
- 7. Site Preparation
- 8. Service Facilities: steam, water, air, fuel, etc. Waste treatment, fire control, offices, etc.

9. Land



#### Indirect Costs:

1. Engineering and Supervision: Administrative and Design. Supervision and Inspection.

- 2. Construction Expenses
- 3. Contractor's fee
- 4. Contingency.
- 5. Start up expenses



#### Types Of Cost Estimates

- 1. <u>Order of Magnitude estimate</u>. Extrapolate similar plant cost Accuracy: over 30%
- 2. <u>Study Estimate</u>. Knowledge of major pieces of equipment Accuracy: ± 30%
- 3. <u>Preliminary Estimate</u>. Enough for budget authorization. Accuracy: ± 20%
- 4. <u>Definitive Estimate</u>. Based on basic Engineering and quotes from suppliers and contractors.

```
Accuracy: \pm 10\%
```

5. <u>Detailed Estimate</u>.Based on Detailed Engineering. Accuracy:  $\pm$  5%



Cost Indexes

Present Cost=(original cost at time t)\*  $\left(\frac{index \ value \ now}{index \ value \ at \ time \ t}\right)$ 

Marshall and Swift.

1. All industry-equipment index. Arithmetic average of 47 equipment types.

2. Process-industry equipment index. Weighted average of 8 of these:

cement	2%	paint	5%
chemicals	48%	paper	10%
clay products	2%	petroleum	22%
glass	3%	rubber	8%

M&S was 100 in 1926. Published in "Chemical Engineering".



### COST INDEXES

<u>Engineering News-Record</u> Construction Cost index.

Steel, lumber, labor, concrete. Published in "Engineering News-record". ENR value reported based on 100 in 1913, 1949 or 1967.

<u>Nelson-Farrar</u> Refinery Construction Cost index.

Skilled and common labor, iron and steel, building materials, miscellaneous equipment. Published in "Oil and Gas Journal".

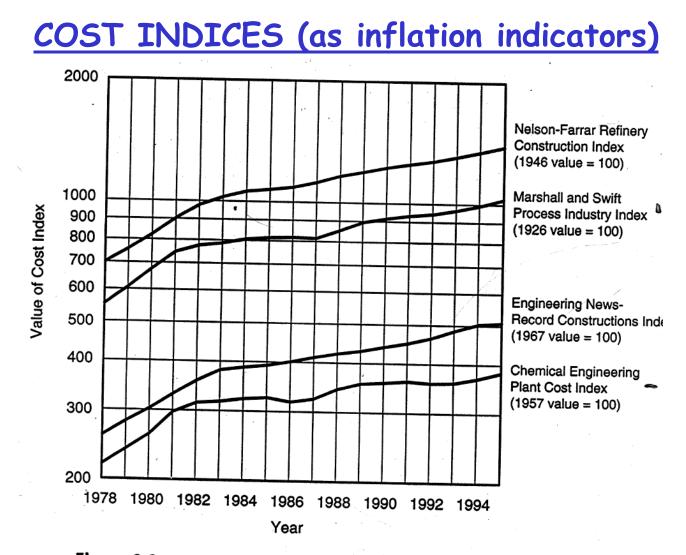
N-R value of 100 in 1946.

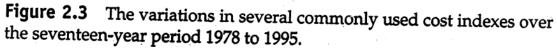
• <u>Chemical Engineering Plant Cost Index</u>. Chemical Plants.

Equipment, machine	ry	Engineering and supervisio	n
supports	61%	Buildings, material, labor	10%
Installation labor	22%		7%

Published in "Chemical Engineering". PCI value of 100 in 1957-59.

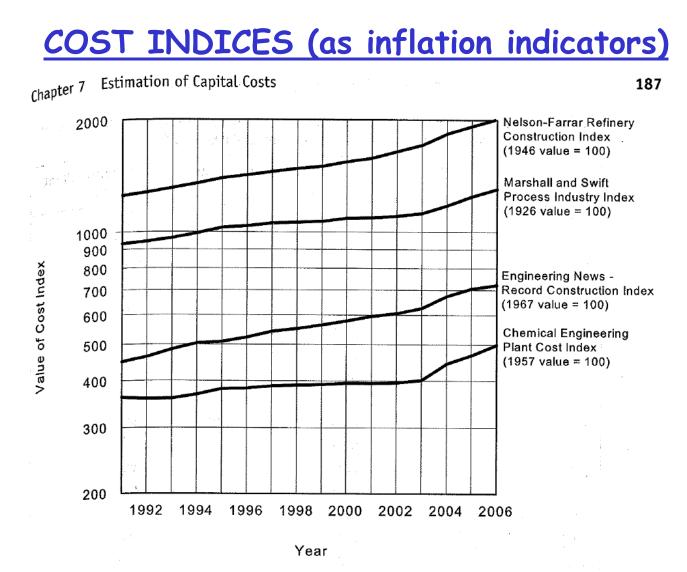












**Figure 7.3** The Variations in Several Commonly Used Cost Indexes Over 15 Years (1992–2006)



From Turton et al., 2009

### <u>Methods For Estimating Capital Investment</u>

# 1. <u>Detailed-Item Estimate.</u>

All items in the direct and indirect cost are evaluated with as much detail as possible. All specs are known.  $(\pm 5\%$  accuracy, contractor's estimate)



# Methods For Estimating Capital Investment

# 2. <u>Unit-Cost Estimate</u>.

Prices from quotations or index-corrected records.

$$C = \left[\sum (E + E_L) + \sum (f_x M_x + f_y M_L) + \sum f_e H_e + \sum f_d d_n\right] f_F$$

See p. 250 in Peters et al., 2003). (10-20% accuracy, definitive or preliminary estimate)

E: delivered equip. cost

 $E_L$ : labor for equipment cost for field labor

- $f_x$ : material unit cost
- $f_e$ : unit cost for engineering
- f<sub>d</sub>: drawing cost
- $f_F$ : field expense factor

# Methods For Estimating Capital Investment

## 3. <u>Percentage of Delivered-Equipment Cost.</u>

All items in the direct and indirect cost are evaluated as a percentage of the delivered-equipment cost. (definitive estimate in certain cases,  $\pm$  10% )

$$C = \left[\sum E + \sum (f_1 E + f_2 E + f_3 E + \ldots)\right] f_I$$

See Table 7-8, p. 194 in TBW&S

4. Estimation based on "Lang" factors.

Named after Lang (1947). The Fixed Capital Investment is found by multiplying equipment cost by a factor (see Table 7-7, p. 192 in TBW&S) (± 30% accuracy, order of magnitude estimate)



### Methods For Estimating Capital Investment

Methods for Estimating Capital Investment

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#### Table 6-9 Ratio factors for estimating capital investment items based on delivered-equipment cost

Values presented are applicable for major process plant additions to an existing site where the necessary land is available through purchase or present ownership.<sup>†</sup> The values are based on fixed-capital investments ranging from under \$1 million to over \$100 million.

A second s	Percent of delivered-equipment cost for		
	Solid processing plant <sup>‡</sup>	Solid-fluid processing plant <sup>‡</sup>	Fluid processing plant <sup>‡</sup>
Direct costs			
Purchased equipment delivered (including fabricated			
equipment, process machinery, pumps, and compressors)	100	100	100
Purchased-equipment installation	45	39	47
Instrumentation and controls (installed)	18	26	36
Piping (installed)	16	31	68
Electrical systems (installed)	10	10	11
Buildings (including services)	25	29	18
Yard improvements	15	12	10
Service facilities (installed)	40	55	70
Total direct plant cost	269	302	360
Indirect costs			
Engineering and supervision	33	32	33
Construction expenses	39	34	41
Legal expenses	4	4	4
Contractor's fee	17	19	22
Contingency	35	· 37	44
Total indirect plant cost	128	126	144
Fixed-capital investment	397	428	504
Working capital (15% of total capital investment)	70	75	89
Total capital investment	467	503	593

<sup>†</sup>Because of the extra expense involved in supplying service facilities, storage facilities, loading terminals, transportation facilities, and other necessary utilities at a completely undeveloped site, the fixed-capital investment for a new plant located at an undeveloped site may be as much as 100 percent greater than that for an equivalent plant constructed as an addition to the existing plant.



Fixed Capital Investment Cost (Peters et al, 2003)			
<b>Direct Costs</b> <i>Onsite</i> Purchased Equipment Installation Instrumentation Piping Electrical		Fluid Processing Plant	E=15-40% I <sub>F</sub> 25-55 % E 8-50 % E 10-80 % E 10-40 % E
<i>Offsite</i> Buildings Yard Improvement Service Facilities Land <i>Offsite</i> <b>ChE 4253 - Desig</b>	2-18% I <sub>F</sub> 2-5% I <sub>F</sub> 8-30% I <sub>F</sub> 1-2% I <sub>F</sub>	18 % E 10 % E 70 % E 6 % E	10-70 % E Included in Service Facilities 40-100 % E 1-2 % I <sub>F</sub> (or 4-8 %E)

<b>Fixed Capital Investment Cost</b>			
Indirect Costs Engineering Construction Contractor's Fee Contingency	4-20% I <sub>F</sub> 4-17 % I <sub>F</sub> 2-6 % I <sub>F</sub> 5-15% I <sub>F</sub>	Fluid Processing Plant 33 % E 41% E 22 % E 44 % E	5-30% D Included in Contractor's fee $10-20 \% I_F$ $5-15\% I_F$
Working Capital	10-20% I <sub>F</sub>	15 % TCI	10-20% TCI



## METHODS OF PROFITABILITY EVALUATION

Return of Investment (ROI)

The formula is:

$$ROI = \frac{CF}{TCI}$$



METHODS OF PROFITABILITY EVALUATION

Net Present Worth

The formula is:

$$NPW = \sum_{k=1}^{n-1} \frac{CF_k}{(1+i)^k} + \frac{CF_n + V_s + WC}{(1+i)^n} - TCI$$

IRR it is the interest rate that makes NPW=0



METHODS OF PROFITABILITY EVALUATION

Pay Out Time, POT

Minimum time needed to recover the investment.

$$POT = \frac{FCI - V_s}{Average \quad Cash \quad Flow}$$

Other names: Payback time, Cash Recovery Period.

Time value of money can be taken into account with the inclusion of a minimum acceptable rate of return on TCI:

$$POT = \frac{(FCI - V_S) + TCI * i * n}{(Average Cash Flow)_{Annuity}}$$

In this case the annual cash flow is viewed as an annuity

