1. Three new pieces of equipment will be installed in an existing factory: a reactor with agitation, a shell and tube heat exchanger and a centrifugal pump. The reactor has vitreous coating, its cost can be considered 3 times higher than a carbon steel reactor. The heat exchanger, the pump and the associated piping are all high-*grade* chromium stainless steel. The equipment will operate at moderate pressure and temperature. The volume of the reactor is 9 m^3, the heat transfer area of the heat exchanger is 50m^2 and the pump power is 5kw. No significant investment is required in utilities, buildings, support infrastructures (*off Sites*), site preparation and working capital. Using the equations,

$$C_E = C_B\left(\frac{Q}{Q_B}\right)^M \qquad \frac{C_1}{C_2} = \frac{I_1}{I_2}$$

$$C_F = \sum_i \left[f_M f_P f_T (1 + f_{PIP})\right]_i C_{E,i} + (f_{EP} + f_{INST} + f_{ELEC} + f_{UTIL} + f_{OS} + f_{BUILD} + f_{SP} + f_{DEC} + f_{CONT} + f_{WC})\sum_i C_{E,i}$$,

table 2.1 (values corresponding to the year 2000; Use the CEI in the attached chart) and tables 2.2 to 2.7, estimate the cost of the project.

2. A company ponders investing in one of two projects A and B. The capital cost of both projects is €10^6. The annual cash flows are in table 1. For each project, determine:
   a) The Payback Time
   b) The Return on investment (ROI)
   c) The Discounted cash flow rate of return (DCFRR)

What would you conclude from the results?

Table 1

Year	Cash Flow/10^3€ Project A	Cash Flow/10^3€ Project B
0	-1000	-1000
1	150	500
2	250	450
3	350	300
4	400	200
5	400	100

3. One company evaluates two competing projects whose cash flow is presented in table 2. For each project, determine:

a) The Payback Time
b) The Net Present value (NPV) with a depreciation rate of 10%.
d) The Discounted cash flow rate of return (DCFRR)

Based on the comparison of these values, what project should be chosen? Justify the decision?

Table 2

Year	Cash Flow/€	
	Project A	Project B
0	-210000	-50000
1	70000	20000
2	70000	20000
3	70000	20000
4	70000	20000
5	70000	20000

Attachments:

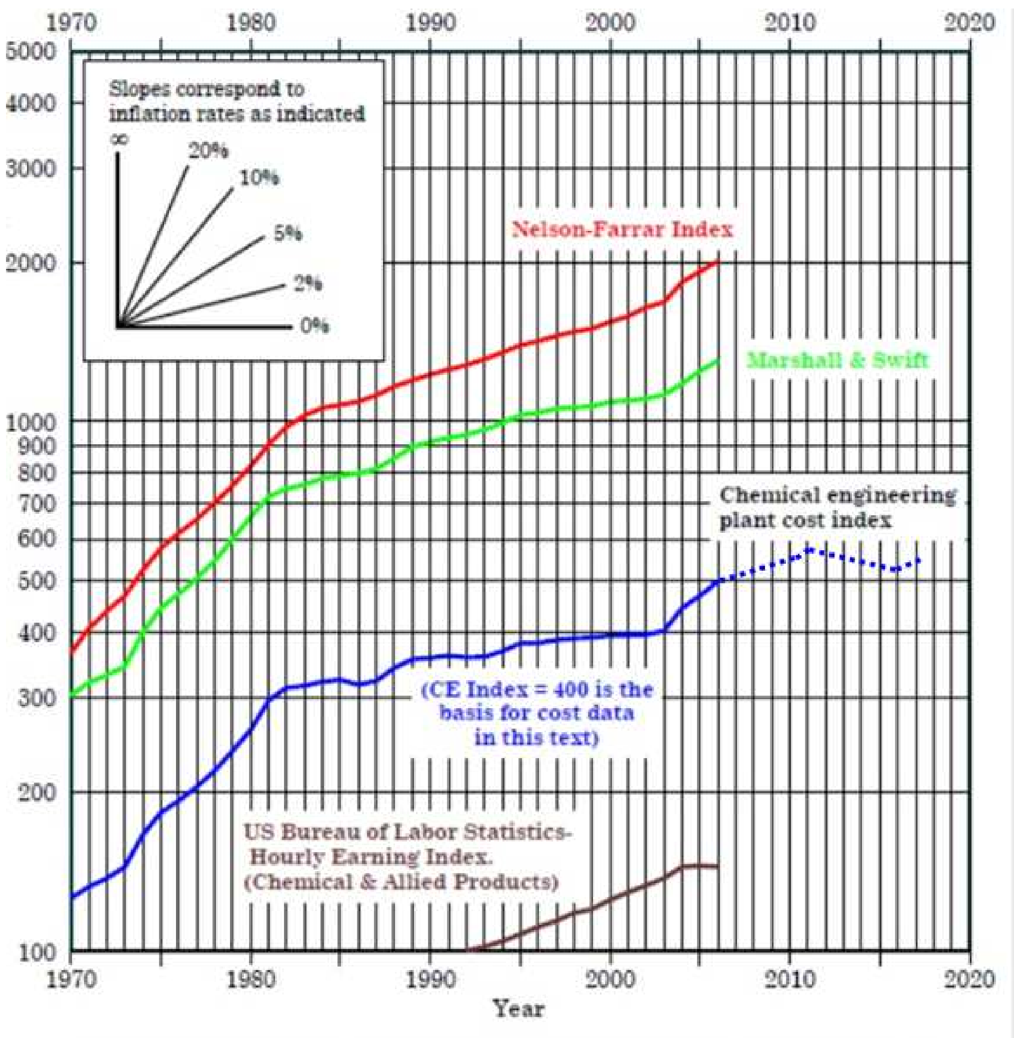

Table 2.1 Typical equipment capacity delivered capital cost correlations.

Equipment	Material of construction	Capacity measure	Base size Q_B	Base cost C_B ($)	Size range	Cost exponent M
Agitated reactor	CS	Volume (m^3)	1	1.15×10^4	1–50	0.45
Pressure vessel	SS	Mass (t)	6	9.84×10^4	6–100	0.82
Distillation column (Empty shell)	CS	Mass (t)	8	6.56×10^4	8–300	0.89
Sieve trays (10 trays)	CS	Column diameter (m)	0.5	6.56×10^3	0.5–4.0	0.91
Valve trays (10 trays)	CS	Column diameter (m)	0.5	1.80×10^4	0.5–4.0	0.97
Structured packing (5 m height)	SS (low grade)	Column diameter (m)	0.5	1.80×10^4	0.5–4.0	1.70
Scrubber (Including random packing)	SS (low grade)	Volume (m^3)	0.1	4.92×10^3	0.1–20	0.53
Cyclone	CS	Diameter (m)	0.4	1.64×10^3	0.4–3.0	1.20
Vacuum filter	CS	Filter area (m^2)	10	8.36×10^4	10–25	0.49
Dryer	SS (low grade)	Evaporation rate (kg $H_2O{\cdot}h^{-1}$)	700	2.30×10^5	700–3000	0.65
Shell-and-tube heat exchanger	CS	Heat transfer area (m^2)	80	3.28×10^4	80–4000	0.68
Air-cooled heat exchanger	CS	Plain tube heat transfer area (m^2)	200	1.56×10^5	200–2000	0.89
Centrifugal pump (Small, including motor)	SS (high grade)	Power (kW)	1	1.97×10^3	1–10	0.35
Centrifugal pump (Large, including motor)	CS	Power (kW)	4	9.84×10^3	4–700	0.55
Compressor (Including motor)		Power (kW)	250	9.84×10^4	250–10,000	0.46
Fan (Including motor)	CS	Power (kW)	50	1.23×10^4	50–200	0.76
Vacuum pump (Including motor)	CS	Power (kW)	10	1.10×10^4	10–45	0.44
Electric motor		Power (kW)	10	1.48×10^3	10–150	0.85
Storage tank (Small atmospheric)	SS (low grade)	Volume (m^3)	0.1	3.28×10^3	0.1–20	0.57
Storage tank (Large atmospheric)	CS	Volume (m^3)	5	1.15×10^4	5–200	0.53
Silo	CS	Volume (m^3)	60	1.72×10^4	60–150	0.70
Package steam boiler (Fire-tube boiler)	CS	Steam generation ($kg{\cdot}h^{-1}$)	50,000	4.64×10^5	50,000–350,000	0.96
Field erected steam boiler (Water-tube boiler)	CS	Steam generation ($kg{\cdot}h^{-1}$)	20,000	3.28×10^5	10,000–800,000	0.81
Cooling tower (Forced draft)		Water flowrate ($m^3{\cdot}h^{-1}$)	10	4.43×10^3	10–40	0.63

CS = carbon steel; SS (low grade) = low-grade stainless steel, for example, type 304; SS (high grade) = high-grade stainless steel, for example, type 316

Table 2.2 Typical average equipment materials of construction capital cost factors.

Material	Correction factor f_M
Carbon steel	1.0
Aluminum	1.3
Stainless steel (low grades)	2.4
Stainless steel (high grades)	3.4
Hastelloy C	3.6
Monel	4.1
Nickel and inconel	4.4
Titanium	5.8

Table 2.3 Typical materials of construction capital cost factors for pressure vessels and distillation columns[9,10].

Material	Correction factor f_M
Carbon steel	1.0
Stainless steel (low grades)	2.1
Stainless steel (high grades)	3.2
Monel	3.6
Inconel	3.9
Nickel	5.4
Titanium	7.7

Table 2.4 Typical materials of construction capital cost factors for shell-and-tube heat exchangers[2].

Material	Correction factor f_M
CS shell and tubes	1.0
CS shell, aluminum tubes	1.3
CS shell, monel tubes	2.1
CS shell, SS (low grade) tubes	1.7
SS (low grade) shell and tubes	2.9

Table 2.5 Typical equipment pressure capital cost factors.

Design pressure (bar absolute)	Correction factor f_P
0.01	2.0
0.1	1.3
0.5 to 7	1.0
50	1.5
100	1.9

Table 2.6 Typical equipment temperature capital cost factors.

Design temperature (°C)	Correction factor f_T
0–100	1.0
300	1.6
500	2.1

Table 2.7 Typical factors for capital cost based on delivere equipment costs.

Item	Type of process	
	Fluid processing	Solid processir
Direct costs		
Equipment delivered cost	1	1
Equipment erection, f_{ER}	0.4	0.5
Piping (installed), f_{PIP}	0.7	0.2
Instrumentation & controls (installed), f_{INST}	0.2	0.1
Electrical (installed), f_{ELEC}	0.1	0.1
Utilities, f_{UTIL}	0.5	0.2
Off-sites, f_{OS}	0.2	0.2
Buildings (including services), f_{BUILD}	0.2	0.3
Site preparation, f_{SP}	0.1	0.1
Total capital cost of installed equipment	3.4	2.7
Indirect costs		
Design, engineering and construction, f_{DEC}	1.0	0.8
Contingency (about 10% of fixed capital costs), f_{CONT}	0.4	0.3
Total fixed capital cost	4.8	3.8
Working capital		
Working capital (15% of total capital cost), f_{WC}	0.7	0.6
Total capital cost, f_I	5.8	4.4