

FDE 401 PROCESS DESIGN

Cost Analysis



Cost Analysis

- ▶ There are two important quantities to determine in the economic analysis of a process:
 - Total Capital Cost (toplam sermaye maliyeti)
 - is the amount of money to build a plant or facility and includes all equipment and labor associated with installation of the equipment.
 - Operating cost (işletme maliyeti)
 - represents the annual expenses to keep a plant or facility in full production. (cost of feedstock, fuel, labor to operate the plant and payment of principal and interest on loans)

Total Capital Cost

- ▶ It is equal to sum of fixed capital cost (Sabit Sermaye Maliyeti) and working capital cost (işletme Sermayesi).

Fixed Capital Cost

- ▶ Fixed capital cost can be categorized into 4 groups:
 - Direct project expenses (doğrudan proje giderleri)
 - Indirect project expenses (dolaylı proje giderleri)
 - Contingency (beklenmeyen giderler)
 - Auxiliary facilities (yardımcı birim giderleri)

Direct project expenses (doğrudan proje giderleri)

1) Equipment cost

- FOB (free on board)
 - Tedarikçinin malzemeyi nakliye yapılacağı geminin güvertesine taşıyana kadar olan sorumluluğunu içerir.

Direct project expenses (doğrudan proje giderleri)

2)Materials for installation

- Installation can require considerable materials: steel, concrete, electric wiring and control panels for motors and piping and valves for water, gas and steam utilities.

3)Direct labor cost (Kurulum için gerekli olan işçilik giderleri)

Indirect project expenses (dolaylı proje giderleri)

- 1) Tax: Ekipmanın vergisi
- 2) Construction overhead: inşaatın ek giderleri → inşaat için kiralanan makineler vb.
- 3) Engineering expenses: Mühendislik giderleri → tasarım mühendislerinin maaşları, ofis giderleri

Contingency (beklenmeyen giderler)

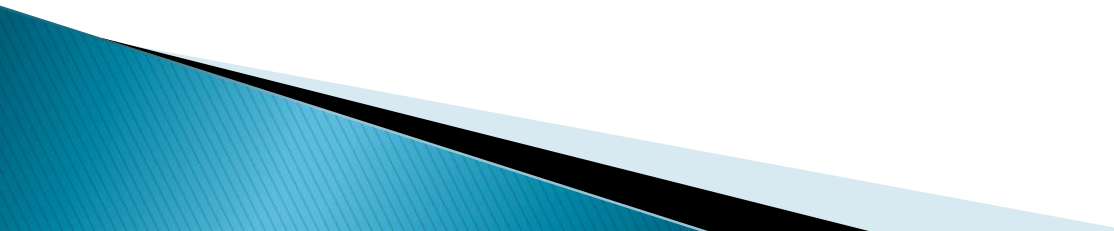
- ▶ It refers to unexpected expenses on a project (weather related delays, construction errors, poor estimation of costs etc.)

Auxiliary facilities (yardımcı birim giderleri)

- ▶ Administrative offices
- ▶ Laboratory
- ▶ Maintenance shop
- ▶ Warehouses

These costs may not be required for every project.

Working Capital Cost

- ▶ In addition to fixed capital cost for the project, a sum of money called the working capital must be invested to get the plant into operation.
 - ▶ It represents inventory of raw material and usually 10–15% of fixed capital cost.
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Summary of capital cost

Table 10.11. Summary of capital costs

	Cost	Calculation	Description
Direct project expenses			
Equipment (f.o.b.)		C_p	"Free on board"—cost when placed aboard the shipping carrier. Obtained from suppliers or estimated from tabulations of purchased equipment costs or installed bare module costs (for example, Ref. 3). Adjusted for size and inflation.
Materials for installation		$C_M = MMF \times C_p$	Based on tabulated materials module factors (MMF) found in References 1 and 2; expressed as fraction of C_p
Direct labor		$C_L = LMF \times (C_p + C_M)$	Based on tabulated labor module factors (LMF) found in References 1 and 2; expressed as fraction of $C_p + C_M$
Total direct		$C_D = C_p + C_M + C_L$	
Indirect project expenses			
Freight, insurance, taxes		$C_{FIT} = 0.08C_p$	Estimated as 8% of total purchased equipment costs
Construction overhead		$C_O = 0.7C_L$	Estimated as 70% of total labor installation costs
Engineering expenses		$C_E = 0.15(C_p + C_M)$	Estimated as 15% of total equipment and materials costs
Total indirect		$C_{ID} = C_{FIT} + C_O + C_E$	
Bare module cost			
		$C_{BM} = C_D + C_{ID}$	Defined as combined direct and indirect costs
Contingency & fee		$C_{CF} = 0.18C_{BM}$	Estimated at 18% of bare module cost
Total module cost		$C_{TM} = C_{BM} + C_{CF}$	Defined as bare module cost plus contingency and fee
Auxiliary facilities		$C_{AF} = 0.3C_{TM}$	Estimated as 30% of total module cost (when auxiliary facilities are required)
Grassroots capital		$C_{GR} = C_{TM} + C_{AF}$	Defined as total module cost plus auxiliary facilities cost

Grassroots
capital =sabit
sermaye
maliyeti

Table 10.12. Unit costs, scaling exponents, materials module factors (MMF), and labor module factors (LMF) for various kinds of plant equipment

Device	Sizing Parameter	Unit	Unit Cost* (\$)	Sizing Exponent	MMF	LMF
Process furnaces	Heating rate	kW	810	0.85	0.34	0.22
Direct-fired heaters	Heating rate	kW	73	0.85	0.31	0.22
Shell & tube heat exchangers	Heat transfer area	m ²	2,400	0.65	0.72	0.37
Process vessel (vertical)	Volume	m ³	6,000	0.71	1.04	0.49
Process vessel (horizontal)	Volume	m ³	6,200	0.6	0.65	0.39
Pump & driver	Flow rate × pressure head	m ³ kPa/min	350	0.52	0.71	0.42
Compressor & driver	Power	kW	5,300	0.75	0.60	0.39
Agitators (propeller)	Power	kW	2,100	0.5	0.28	0.27
Air dryers	Volumetric flow rate	m ³ /min	7,600	0.56	0.27	0.37
Blowers & fans	Volumetric flow rate	m ³ /min	79	0.68	0.27	0.25
Blenders	Volumetric flow rate	m ³ /min	28,000	0.52	0.27	0.27
Boilers (100 kPa)	Mass flow rate steam	kg/h	3,100	0.5	0.19	0.26
Boilers (4000 kPa)	Mass flow rate steam	kg/h	4,300	0.5	0.19	0.26
Centrifuges	Diameter	m	63,000	1	0.28	0.23
Conveyer belt (0.6 m width)	Length	m	6,000	0.65	0.27	0.33
Conveyer bucket (30 tph)	Length	m	2,500	0.65	0.28	0.44
Conveyer screw (0.3 m dia.)	Length	m	3,600	0.8	0.27	0.25
Crushers (pulverizer)	Mass flow rate	kg/h	3,500	0.35	0.27	0.25
Crystallizers (forced circulation)	Mass flow rate	tpd	43,000	0.55	0.27	0.38
Dryers (rotary, direct)	Volume	m ³	16,000	0.42	0.28	0.36
Dryers (rotary, vacuum)	Volume	m ³	36,000	0.69	0.28	0.36
Duct work, shop-fabricated, aluminum	Length	m	54	0.55	0.00	0.87
Duct work, shop-fabricated, galvanized	Length	m	80	0.55	0.00	0.84
Duct work, shop-fabricated, stainless steel	Length	m	150	0.55	0.00	0.44
Evaporator (forced circulation)	Area	m ²	160,000	0.7	0.41	0.35
Filter (plates & press)	Area	m ²	6,800	0.58	0.26	0.42
Filter (rotary drum)	Area	m ²	32,000	0.63	0.26	0.27
Hoppers (conical)	Volume	m ³	58	0.68	0.00	0.04
Mills (ball)	Mass flow rate	tph	3,000	0.65	0.27	0.34
Mills (hammer)	Mass flow rate	tph	2,800	0.85	0.27	0.34
Screens (vibrating)	Area	m ²	18,000	0.58	0.12	0.18
Storage tanks	Volume	liters	870	0.3	0.20	0.23

Source: From reference [1] except for unit cost and sizing exponent for dryers, which are adapted from reference [3]; all data adjusted to 2002 dollars.

*Special materials of construction, operation at elevated pressures, and other factors may increase these unit costs.

Total Capital Cost

- ▶ Working capital=
 $(10\% - 15\%) * \text{Fixed cost}$
- ▶ Total Capital Cost= Fixed Cost+ Working Capital

Operating Cost

- ▶ Once a plant is constructed, funds are required to operate the plant.
- ▶ Operating costs are determined on an annual basis. Once the total operating cost is determined, it is divided by the annual production output to determine the annual production cost.
- ▶ (Hesaplanan yıllık işletme maliyeti, işletmenin ürettiği yıllık ürün miktarına bölünürse → birim ürün maliyeti hesaplanmış olur.)

Operating Cost

- ▶ Direct Operating Cost
 - Raw Material (Ham madde)
 - Operating Labor (İşçilerin maaşları)
 - Supervisory Labor (Yönetici maaşları)
 - Utilities (Altyapı hizmetleri)
 - Elektrik, su, doğal gaz, buhar giderleri
 - Maintenance & repairs (bakım onarım)
 - Operating supplies (Sarf malzemeler)
 - Laboratory charges (Laboratuvar giderleri)
 - Patents and royalties (Patent ve lisans giderleri)

Operating Cost

▶ Indirect Expenses

- Overhead: işletme ek giderleri (işçilerin ücret dışı ek ödemeleri ile ilgili)
- Taxes (Vergiler)
- Insurance (İşletmenin sigortası)
- General Expenses (Genel giderler) (yönetim ve pazarlama ile ilgili)

Table 10.14. Summary of operating costs

Fixed capital		Equal to gross-roots capital
Working capital		10–15% of fixed capital
Total capital		Sum of fixed capital and working capital
Plant capacity factor (f_0)		Fraction of year that plant or facility operates
Production output (units/yr)		Annual production in kilowatts, gallons, etc. (adjusted to account for capacity factor)
	Cost (\$/yr)	
Direct		
Raw materials		Calculated as: $C_R(\$/\text{kg}) \times \dot{m} (\text{kg/s}) \times 31.5 \times 10^6 \text{ s/yr} \times f_0$
By-product credits		Value enclosed in parentheses and subtracted from other costs.
Operating labor		See Table 10.15
Supervisory labor		10–20% of operating labor.
Utilities		See Reference 7.
Maintenance & repairs		2–10% of fixed capital
Operating supplies		10–20% of maintenance & repairs
Laboratory charges		15% of operating labor
Patents and royalties		3% of the sum of other direct expenses
Direct subtotal		Sum of all direct operating expenses
Indirect & General Expenses		
Overhead		50–70% of the sum of operating labor, supervision, and maintenance & repair
Local taxes		1–2% of fixed capital
Insurance		0.4–1.0% of fixed capital
General expenses		15% of operating labor + 5% of direct expenses
Indirect subtotal		Sum of all indirect operating expenses
Annual capital charges		Annual payment of interest and principal on loan for total capital $C_{TC} i(1+i)^n / [(1+i)^n - 1]$
Annual operating cost		Sum of direct costs, indirect costs, and annual capital charge
Product cost (\$/unit production)		Annual operating cost divided by annual production output

Eğer işletmenin kuruluşu için kredi alınmadıysa → annual capital charges = 0