ISE 307: Engineering Economic Analysis

Lecture 16: Annual Equivalence II — Unit Costs, Make-or-Buy, Break-Even (Ch 6)

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Lecture 16

Unit Costs, Make-or-Buy Decisions,
Break-Even, and Unequal Lives

Lecture 16 Objectives

1. Compute **unit cost / unit profit**: $AE \div$ annual volume
2. Determine a **minimum sustainable price**
3. Settle a **make-or-buy** decision on a per-unit basis
4. Find the **break-even volume**: the usage where two AECs tie
5. Compare **unequal-life** alternatives by one-cycle AE (no LCM needed)

Minimum Price Example

A line bags **40,000 kg/yr** of flotation reagent (MARR = 15%):

- invest **300,000 SAR**; salvage **30,000 SAR** after 8 years
- operating **90,000 SAR/yr**

1. **Capital:** $CR = (300{,}000 - 30{,}000)(A/P,\ 15\%,\ 8) + 0.15\,(30{,}000)$
   $= 270{,}000\,(0.2229) + 4{,}500 = 64{,}670$
2. **Total:** $AEC = 64{,}670 + 90{,}000 = 154{,}670$ SAR/yr
3. **Per unit:** minimum price $= \dfrac{154{,}670}{40{,}000} = \boxed{3.87\ \text{SAR/kg}}$

Below 3.87 SAR/kg the line *destroys* value at a 15% MARR; above it, every kg contributes surplus.

Make-or-Buy

A tolling contractor offers to bag the reagent for **4.50 SAR/kg**. The in-house cost (last slide): **3.87 SAR/kg**.

Make, and save 0.63 SAR/kg $\times$ 40,000 kg = **25,200 SAR/yr**.

The requirements of a fair comparison:

- Same **volume** and **quality** on both sides
- The in-house side must carry *all* ownership costs — $CR(i)$, not just operating
- The decision can **flip with volume**: at low kg/yr, the vendor's purely variable price beats fixed capital (next slide)

Break-Even Volume Example

Two sample grinders for the assay lab ($i = 6\%$, 10-yr lives, no salvage); maintenance $= 15\%$ of first cost per year; let $h =$ hours/yr:

	First cost	Energy
G1	4,500	0.52 SAR/hr
G2	3,600	0.60 SAR/hr

$$AE_1(h) = 4{,}500\,(A/P, 6\%, 10) + 675 + 0.52h = 1{,}286.4 + 0.52h$$

$$AE_2(h) = 3{,}600\,(A/P, 6\%, 10) + 540 + 0.60h = 1{,}029.1 + 0.60h$$

Set equal: $0.08h = 257.3 \;\Rightarrow\; \boxed{h^* \approx 3{,}216 \text{ hrs/yr}}$

Run **more** than $h^* \rightarrow$ the pricier, efficient G1 wins; **less** $\rightarrow$ G2.

Unequal Lives by AE

Lecture 14's tank coatings, $i = 10\%$: **epoxy** 5,000 SAR lasts 10 years; **standard** 3,000 SAR lasts 5 years. With AE, annualize each over *its own* life:

$$AE_{\text{epoxy}} = 5{,}000\,(A/P,\ 10\%,\ 10) = 5{,}000\,(0.1627) = \boxed{813.7 \text{ SAR/yr}}$$

$$AE_{\text{std}} = 3{,}000\,(A/P,\ 10\%,\ 5) = 3{,}000\,(0.2638) = \boxed{791.4 \text{ SAR/yr}}$$

Standard wins by about 22 SAR/yr — the same verdict as the 10-yr LCM comparison in Lecture 14 (4,863 vs. 5,000 in PW).

Valid when each alternative is **repeated identically** over the service period. A stated study period still overrides (then compare PW over that period).

Practice Problem 1

A lubricant-bottling machine at the mine's supply depot (MARR $= 12\%$):

- costs **150,000 SAR**; salvage **15,000 SAR** after 6 years
- operating **40,000 SAR/yr**; output **20,000 units/yr**
- each unit sells at **4.50 SAR**

Find the **unit cost** and the **unit profit**.

Practice Problem 1: Solution

1. $CR = (150{,}000 - 15{,}000)(A/P,\ 12\%,\ 6) + 0.12\,(15{,}000)$
$= 135{,}000\,(0.2432) + 1{,}800 = 34{,}636$

2. $AEC = 34{,}636 + 40{,}000 = 74{,}636$ SAR/yr $\Rightarrow$ unit cost $= \dfrac{74{,}636}{20{,}000} =$ $\boxed{3.73 \text{ SAR/unit}}$

3. Unit profit $= 4.50 - 3.73 =$ $\boxed{0.77 \text{ SAR/unit}}$ $\approx 15{,}400$ SAR/yr of surplus at full volume

Practice Problem 2

A water-bottling line will produce **3,000,000 bottles/yr** for **10 years** (MARR $= 15\%$):

- investment **2,000,000 SAR**; salvage **400,000 SAR**
- operating **700,000 SAR/yr**

Determine the **minimum price per bottle** the company should charge.

Practice Problem 2: Solution

1. **Capital:** $CR = (2{,}000{,}000 - 400{,}000)(A/P,\ 15\%,\ 10) + 0.15\,(400{,}000)$
   $= 1{,}600{,}000\,(0.1993) + 60{,}000 = 318{,}803 + 60{,}000 = 378{,}803$
2. **Total:** $AEC = 378{,}803 + 700{,}000 = 1{,}078{,}803$ SAR/yr
3. **Per unit:** minimum price $= \dfrac{1{,}078{,}803}{3{,}000{,}000} = \boxed{0.36 \text{ SAR/bottle}}$

At 0.36 SAR/bottle the line earns *exactly* 15%; any higher price is surplus.

Quick Check

In a make-or-buy analysis, the most common error that makes "make" look artificially cheap is:

(A) Using the same volume on both sides

(B) Omitting the capital recovery cost from the in-house side

(C) Including the vendor's price per unit

(D) Discounting at the MARR

Answer: (B). Counting only operating costs hides what ownership costs per year. The in-house side must carry $CR(i)$ in full.

Summary

- **Unit cost** = $AEC \div$ annual volume; **minimum price** = the unit cost at the MARR
- **Unit profit** = price − unit cost; surplus beyond the MARR return
- **Make-or-buy**: per-unit comparison at equal volume/quality; in-house carries full $CR(i)$
- **Break-even**: write $AE(h)$ for each option, equate, solve for usage h^*
- **Unequal lives**: compare one-cycle AEs (identical repetition); a stated study period still overrides

Before Class

To do before our class meeting:

1. **Finish Chapter 6** (Section 6.3)
2. Complete the **Lecture 16 pre-class quiz** on Blackboard before class
3. Reminder: **HW3 (Ch. 5) is due** — check the deadline on Blackboard