



REPLACEMENT ANALYSIS

Engineering Economy

Replacement Concept

- Facility or asset has **limited useful life**
- Economic value and useful life may have be first consideration
- **Estimating the right period to be replaced**

Reason why we need replacement:

- ✓ *Adding capacity*
- ✓ *Increasing production cost*
- ✓ *Deterioration/Decreasing productivity*
- ✓ *Obsolescence*

Replacement Analysis

“This analysis is related to existing facilities (current facilities) whether they **must be replaced with new ones or not**”

Replacement Terminology

- **Defender:** an old machine
- **Challenger:** a new machine
- **Current market value:** selling price of the defender in the market place
- **Sunk cost:** any past cost unaffected by any future decisions
- **Trade-in allowance:** value offered by the vendor to reduce the price of a new equipment

Defender-Challenger

Defender

- Current market value
- Operational cost (annually)
- Operational income
- Salvage value for future period
- Residual economic life

Challenger

- New investment
- Operational cost
- income
- Salvage value for future period
- Planned economic life

Defender-Challenger (2)

- **Practice Problem:**

A calculator SK-30, bought 2 years ago for **\$1600**, has *straight line depreciation with 4 years economic life.*

*It has **no salvage value.***

*The new type of calculator **makes the former version has decrease its value from \$1600 to \$995.***

A company has offered an exchange with EL-40 for **\$ 1200** and SK-30 for **\$ 300**.

the current market value for EL-40 is actually **\$ 1050** and SK-30 is around **\$ 200**.

“What is the right price for SK-30?”

Defender-Challenger (3)

- From the example, there are five values for SK-30 such as :
 - ❑ *initial value: calculator has bought for \$1600*
 - ❑ *current value: calculator will be sold for \$995*
 - ❑ *book value: $\$1600 - 2/4(1600 - 0) = \800*
 - ❑ *exchange value: \$300*
 - ❑ *market value: \$200*

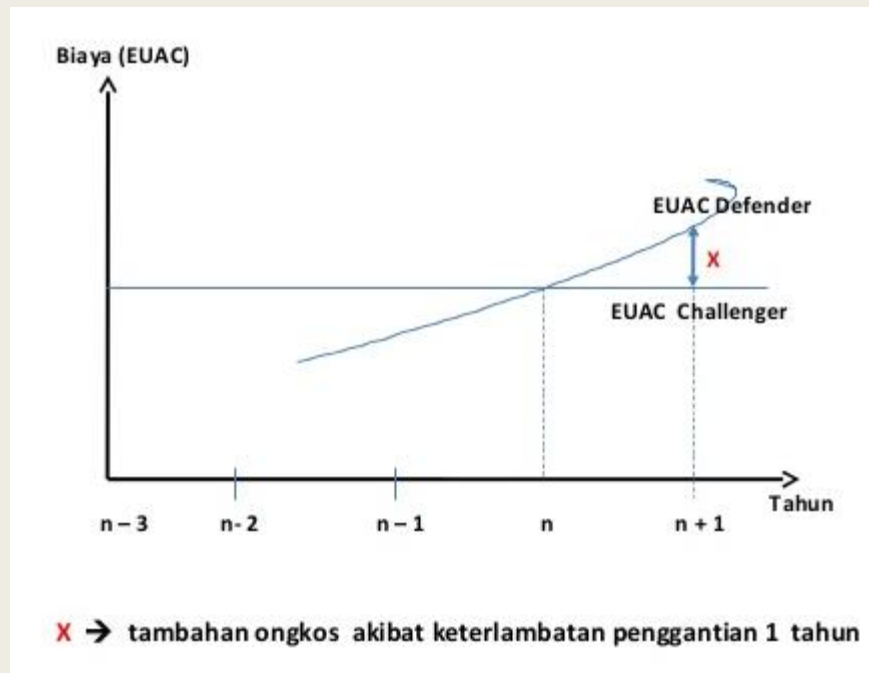
The right price for calculator is \$200.

This is the most relevant price!

Exchange value seems logical but actually we buy new calculator with **higher price than the original one**

Remaining useful life for Defender

- Remaining useful life for defender is determining how long the facility/asset can be used with minimum operational cost and minimum maintenance cost and owning cost (capital cost)
- **Economic service life = a period which EUAC is minimum**



Example : Defender's remaining useful life

An-11-years old facility can be sold now up to **\$2000**.

The salvage value is **10% from initial value** and remain the same for following years.

Operational&maintenance cost is **\$500** per annum and increase **\$100** per year for upcoming period.

Calculate economic service life if the interest rate is **10%!**

Example : Defender's remaining useful life (2)

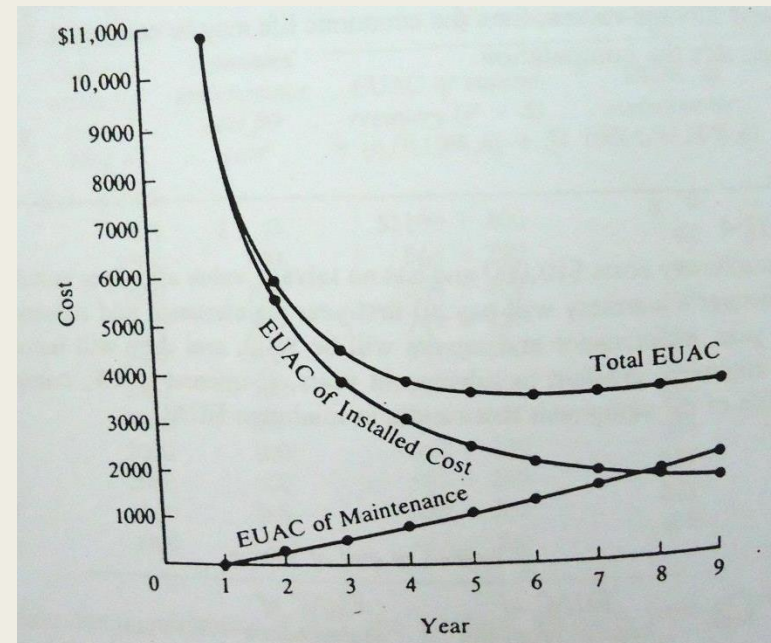
Total EUAC = EUAC capital + EUAC O&M (operational cost)

year	useful life	EUAC capital	EUAC O&M	Total EUAC
	n	= $S_i = 2000(10\%)$	= $500 + 100(A/G, 10\%, n)$	
1	12	\$ 200	\$ 500	\$ 700
2	13	200	548	748
3	14	200	594	794
4	15	200	638	838
5	16	200	681	881

- Economic service life is **1 year**
- this equipment must be replaced after 1 year usage

Example: Economic service life for Challenger

A machine with **\$ 10,000** has **no residual value**. Maintenance and operational cost in the first year **are being covered by the company**. The following years, the cost are spending gradually **for \$600**. If the interest rate is 8%, Find economic service life (earning minimum EUAC) for this machine?



Example: Economic service life for Challenger

if the machine is no longer used at the end of n period

Year	EUAC	EUAC O&M	Total
n	$\$10,000(A/P, 8\%, n)$	$\$600(A/G, 8\%, n)$	
1	\$ 10,800	\$ 0	\$10,800
2	5608	289	5897
3	3880	569	4449
4	3019	842	3861
5	2505	1108	3613
6	2163	1366	3529
7	1921	1616	3537
8	1601	1859	3599

EUAC is minimum when machine is used for 6 years

Replacement analysis Technique

Defender Remaining Life **Equals**
Challenger Useful Life

Defender Remaining Life **Different** from
Challenger Useful Life

A Closer Look at Challenger

Defender Remaining Life **Equals** Challenger Useful Life

- This condition is valid when defender remaining life (available asset) **equals** to challenger useful life (new asset)
- Method: *present worth, annual worth, rate of return, benefit-cost ratio*
- EUAC can be used to determine feasibility of project/investment
- Criteria: **finding the minimum EUAC based on benchmarked period**

Defender Remaining Life Equals Challenger Useful Life (2)

Example:

A plan has been released for changing old facility for a new one. **Calculator SK-30 will be replaced by EL-40**, the estimation is delivered as follow:

- ✓ Market value for SK-30 worth to **\$200** while EL-40 is **\$1050**
- ✓ Maintenance and operational cost for **SK-30 is \$80** per year. EL-40 **doesn't need** operational and maintenance cost
- ✓ Useful life for both calculator is **5 years**.
- ✓ **SK-30 has no salvage** value mean while EL-40 can be sold up to **\$50** until has no economic life
- ✓ EL-40 can produce annual saving **\$120 per year**

Defender Remaining Life Equals Challenger Useful Life (3)

- **EUAC for SK-30 :**

market value= \$200

salvage value= 0

annual operational cost= \$80/year

$$\text{EUAC} = (200-0)(A/P,10\%,5) + 80 = \mathbf{\$132,76}$$

- **EUAC for EL-40 :**

investment cost= \$1050

salvage value= \$250

annual benefit= \$120/year

$$\text{EUAC} = (1050-250)(A/P,10\%,5) - 120 = \mathbf{\$116,04}$$

➤ **EL-40 produces smaller EUAC than SK-30, then select EL-40**

Defender Remaining Life Different From Challenger Useful Life

- This condition is valid when defender remaining life (available asset) is **different** to challenger useful life (new asset)
- ***annual worth (EUAC)*** is suggested method when the analysis period is **different**
- In this condition, there are 2 alternatives replacement:
 1. ***Replace defender now***
 2. ***Maintain defender for a while***

Defender Remaining Life Different From Challenger Useful Life (2)

Example :

- A machine requires an overhaul at **a cost of \$ 4000**. Maintenance costs is **\$ 1800** for the next two years. However the maintenance costs increase gradually **\$ 1000 per year**.
- After the machine has already perform overhaul, the machine can be used again **for 5 years**. Mean while the defender has **no residual value**.
- The initial investment for **challenger** is **\$ 10.000** with **no residual** value. **The first** operational and maintenance cost are **being covered by the company** but after that is increasing gradiently for **\$600**. The useful life for each machine is 8 years.
- Calculate replacement analysis whether defender must be replaced or keep the old one! (APR is 8%)

Defender Remaining Life Different From Challenger Useful Life (3)

Tahun n	Jika tidak digunakan pada akhir tahun ke-n		Total EUAC
	EUAC <i>overhaul</i> \$4000(A/P,8%,n)	EUAC Perawatan \$1800+\$1000 meningkat secara gradien	
1	\$ 4320	\$ 1800	\$ 6120
2	2243	1800	4043
3	1552	1800 + 308*	3660
4	1208	1800 + 683**	3691
5	1002	1800 + 1079	3881

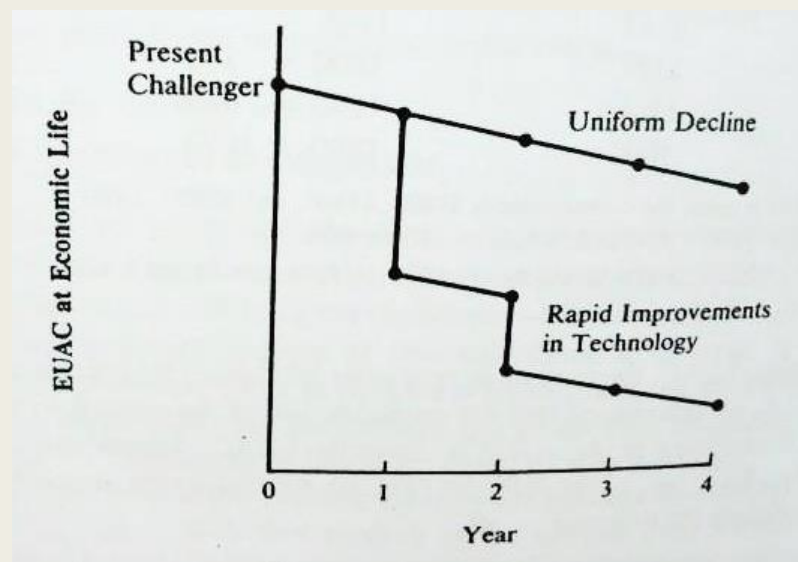
(*) $EUAC = 1800 + 1000(A/F, 8\%, 3)$

(**) $EUAC = 1800 + 1000(P/G, 8\%, 3)(P/F, 8\%, 1)(A/P, 8\%, 4)$

EUAC *challenger* : \$3529 (untuk 6 tahun mendatang), EUAC *defender* : \$3660 (untuk 3 tahun lagi) → sebaiknya ganti dengan *challenger* sekarang

A Closer Look at the Challenger

- Based on previous solution, the best alternative is replacing defender with challenger alternative.
- Due to technology innovation, this alternative **might be change**
- As a consequence, ***present challenger and future challenger concept may rise up***
- If *future challenger is better than present challenger*, is there any impact of replacement analysis?



A Closer Look at the Challenger (2)

Defender and challenger condition is on slide 18. Future challenger with 6 years useful life. EUAC decrease \$100 per year. The replacement analysis can be written as follow:

- A. Maintain defender*
- B. Change defender with challenger*
- C. Maintain defender for 1 year, then change into future challenger*
- D. Maintain defender for 2 years, then change into future challenger*
- E. Maintain defender for 3 years, then change into future challenger*
- F. Maintain defender for 4 years, then change into future challenger*

■ Which alternative should be taken?

Year

1

2

3

4

5

6

7

8

9

10

Present
Challenger

6 Year
Life

EUAC
\$3529

B

Defender
for 1 Year

Next Year
Challenger

6 Year
Life

EUAC
\$3429

C

Defender
for 2 Years

Challenger
Two
Years
Hence

6 Year
Life

EUAC
\$3329

D

Defender
for 3 Years

Challenger
Three
Years
Hence

6 Year
Life

EUAC
\$3229

E

Defender
for 4 Years

Challenger
Four
Years
Hence

6 Year
Life

EUAC
\$3129

F

A Closer Look at the Challenger (3)

■ EUAC for all alternatives:

A : EUAC minimum *defender* = \$3660 (slide 19)

B : EUAC minimum *challenger* = \$3529 (slide 12)

C : EUAC = $[6120(P/A, 8\%, 1) + 3429(P/A, 8\%, 6)(P/F, 8\%, 1)](A/P, 8\%, 7)$
= \$3909

D : EUAC = $[4043(P/A, 8\%, 2) + 3329(P/A, 8\%, 6)(P/F, 8\%, 2)](A/P, 8\%, 8)$
= \$3550

E : EUAC = $[3660(P/A, 8\%, 3) + 3229(P/A, 8\%, 6)(P/F, 8\%, 3)](A/P, 8\%, 9)$
= \$3407

F : EUAC =
 $[3691(P/A, 8\%, 4) + 3129(P/A, 8\%, 6)(P/F, 8\%, 4)](A/P, 8\%, 10)$
= \$3406

A Closer Look at the Challenger (4)

■ Analysis :

- *For a certain period, the best solution keeping the old machine and consider to be replaced in following years*
- *When defender is being benchmarked with challenger, the best solution is replacing defender to challenger.*
- *When future challenger is coming, the decision will change at all, and need to consider future challenger*
- *As a consequences, the replacement must be delayed, and do replacement analysis again to produce the best alternative*

Replacement Value

■ Example

Defender : useful life 3 years
 Operating cost Rp 9,5 million/year
 Salvage value Rp 3,5 milion
 can be used for 7 years

Challenger : *First cost* Rp 28 milion
 Operating cost Rp 5,5 milion/year
 Salvage value Rp 2 milion
 useful life 14 years

Rate of return : 15%

How much is the *minimum replacement value* for machine so that the replacement can be favorable?

Replacement Value (2)

- $$\begin{aligned} \text{EUAC defender} &= \text{RV}(A/P, 15\%, 7) + 9,5\text{juta} - 3,5\text{juta}(A/F, 15\%, 7) \\ &= 0,20436 \text{ RV} + 9.183.739 \end{aligned}$$
- $$\begin{aligned} \text{EUAC challenger} &= 28\text{juta}(A/P, 15\%, 14) + 5,5\text{juta} - 2\text{juta}(A/F, 15\%, 14) \\ &= 10.341.901 \end{aligned}$$

$$\text{EUAC defender} - \text{EUAC challenger} = 0$$

$$0,20436 \text{ RV} + 9.183.739 = 10.341.901$$

$$\text{RV} = \text{Rp } 4.818.447$$

Replacement Value (2)

We can conclude that, **if trade-in value for defender is:**

- $> \text{RV (Rp 4.818.447)}$ → change with a new one/ select challenger
- $< \text{RV (Rp 4.818.447)}$ → maintain the old one/ select defender