REPLACEMENT ANALYSIS 5

5.1 Fundamentals of Replacement Analysis

Replacement analysis is carried out when there is a need to replace the currently owned equipment or any asset. There are various reasons that result in replacement of a given equipment. One of the reasons is the reduction in the productivity of currently owned equipment. This occurs due to physical deterioration of its different parts and there is decrease in operating efficiency with age. **Necessities of replacement of existing equipments are:**

- Increase in operating and maintenance cost for the construction equipment due to physical deterioration.
- Production demands for meeting the required demand.
- Existing equipment is obsolescence.
- Due to rapid change in the technology, the new model with latest technology is more productive than the currently owned equipment.

In replacement analysis, the existing i.e. currently owned asset is referred as **defender** whereas the new alternatives are referred as **challengers**. In this analysis the outsider perspective is taken to establish the first cost of the defender.

5.1.1 Basic Concepts and Terminology

Some Important Terminology

- **Economic Life:** The period of time (years) that yields the minimum equivalent uniform annual cost (EUAC) of owning and operating an asset.
- **Ownership Life:** The period between acquisition and disposal by a specific owner.
- **Physical Life:** Period between original acquisition and final disposal over the entire life of an asset.

- **Useful Life:** The time period an asset is kept in productive service.
- **Defender:** Old asset/machine.
- **Challenger:** New asset/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 new equipment.
- **Market value (MV)** – Value of defender if sold in open market.
- **Economic service life** – No. of years at which lowest annual worth (AW) of cost occurs.
- **Sunk Cost:** Prior expenditure not recoverable from challenger cost.
- **Non-owner's Viewpoint:** Outsider's (consultant's) viewpoint for objectivity.

5.1.2 Approaches for Comparing Defender and Challenger

1. Cash flow approach
2. Opportunity cost approach

1. Cash Flow Approach

- Treat the proceeds from sale of the old machine as down payment toward purchasing the new machine.
- Can be used in the analysis period is same for all alternatives.
- Use NPW or AE analysis to decide.

Example 5.1

For the replacement analysis of an asset of a company, the following information is available. By using cash flow approach, decide whether replacement is justified or not. Take MARR = 12%

Defender		*Challenger*	
Market Price	*Rs 15,000*	*Initial Costs*	*Rs 20,000*
Remaining Useful Life	*3 years*	*Useful Life*	*4 years*
Salvage Value	*Rs 3,000*	*Salvage Value*	*Rs 6,000*
O & M Costs	*Rs 9,500*	*O & M Costs*	*Rs 6,500*

Solution:

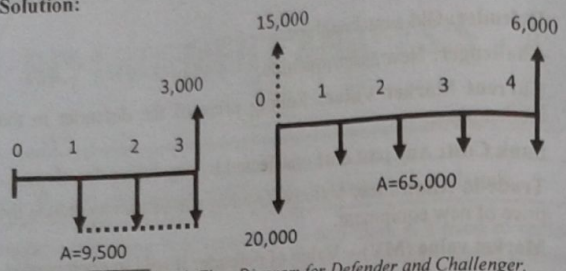


Fig. 5.1: *Cash Flow Diagram for Defender and Challenger.*

Defender:

$PW_D = 3,000\ (P/F, 12\%, 3) - 9,500\ (P/A, 12\%, 3)$
$= 3,000\ (0.7118) - 9,500\ (2.4018)$
$= -$ **Rs 20681.7**

$AEC_D = PW_D\ (A/P, 12\%, 3)$
$= 20,681.7(0.4163)$
= **Rs 8,609.79**

Challenger:

$PW_C = -5,000 + 6,000\ (P/F, 12\%, 4) - 6,500\ (P/A, 12\%, 4)$
$= -5,000 + 6,000(0.6355) - 6,500\ (3.0373)$
$= -$ **Rs 20,929.45**

$AEC_C = PW_C\ (A/P, 12\ \%, 4)$
$= 20,929.45\ (0.3292) =$ **Rs 6,889.97**

Since, $AEC_D > AEC_C$.

Therefore, replace the defender now **Ans.**

2. Opportunity Cost Approach

- Treat the proceeds from sale of the old machine as the investment required to keep the old machine.

Example 5.2

For the replacement analysis of an asset of a company, the following information is available. By using cash flow approach, decide whether replacement is justified or not. Take MARR = 12%

Defender		Challenger	
Market Price	Rs 15,000	Initial Costs	Rs 20,000
Remaining Useful Life	3 years	Useful Life	4 years
Salvage Value	Rs 3,000	Salvage Value	Rs 6,000
O & M Costs	Rs 9,500	O & M Costs	Rs 6,500

Solution:

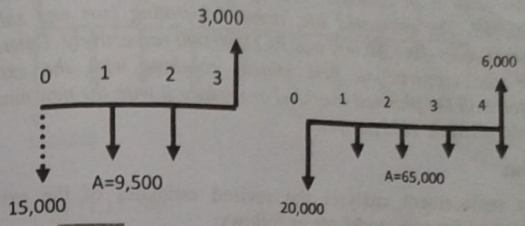


Fig. 5.2: *Cash Flow Diagram for Defender and Challenger.*

Defender:

$PW_D = -15,000 - 9,500(P/A, 12\%, 3) + 3,000(P/F, 12\%, 3)$
$= -15,000 - 9,500\ (2.4018) + 3,000(0.7118)$
$= -$ **Rs 35681.7**

$AEC_D = PW_D\ (A/P, 12\%, 3)$
$= 35,681.7\ (0.4163)$
= **Rs14,854.29**

Challenger:

$PW_C = -20,000 - 6,500(P/A, 12\%, 4) + 6000(P/F, 12\%, 4)$
$= -20,000\text{-}6,500(3.0373) + 6,000\ (0.6355)$
$= -$ **Rs 35,929.45**

$AEC_C = PW_C\ (A/P, 12\%, 4) = 35,929.45(0.3292)$
= **Rs 11,827.97**

Since, $AEC_D > AEC_C$. Therefore, replace the defender now **Ans.**

Example 5.3

A construction firm has purchased an excavator 3 years ago at a cost of Rs.60,00,000 and the estimated life and salvage value at the time of purchase were 11 years and Rs.16,00,000 respectively. The annual operating cost was Rs.1,95,000. The current market value of the equipment is Rs.44,00,000. The construction firm is planning for a major

overhaul of the equipment now at a cost of Rs.10,00,000. After overhaul, the revised estimate of salvage value, annual operating cost and remaining life of the excavator are Rs.12,50,000, Rs.1,75,000 and 9 years respectively.

However the construction firm has the option to replace the current excavator with a new model. The initial cost of the new model is Rs.63,00,000. The estimated life, annual operating cost and salvage value are 9 years, Rs.1,50,000 and Rs.18,00,000 respectively. Determine whether the construction firm should continue with the existing excavator with the planned overhaul or replace it with the new model if the firm's MARR is 10% per year.

Solution:

For the replacement analysis the revised estimates of the existing excavator and for new model are as follows:

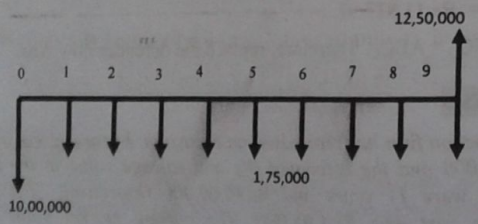
Defender		Challenger	
Market Price	Rs 44,00,000	Initial Costs	Rs 63,00,000
Useful Life	9 years	Useful Life	9 years
Salvage Value	Rs 12,50,000	Salvage Value	Rs 18,00,000
Cost of Major Overhaul	Rs 1,75,000	O & M Costs	Rs 1,50,000
MARR	10%	MARR	10%

For Defender

AW_D = – 44,00,000 (A/P, 10%, 9) – 10,00,000 (A/P, 10%, 9) – 17,50,000 + 12,50,000 (A/F 10%, 9)

= – 44,00,000 (0.1736) – 10,00,000 (0.1736) – 1,75,000 + 12,50,000 (0.0736)

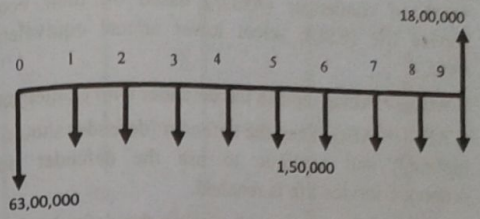
AW_D = – Rs 10,20,440



For Challenger

AW_C = – 63,00,000 (A/P, 10%, 9) – 1,50,000 + 18,00,000 (A/F 10%, 9)

= – 63,00,000 (0.1736) – 1,50,000 + 18,00,000 (0.0736)



AW_C = – Rs 11,11,200

From the above calculations, it is noted that $AW_D < AW_C$. Therefore, the company should continue with the existing excavator **Ans.**

5.2 Economic Service Life of Challenger and Defender

We should use the respective economic service lives of the defender and the challenger when conducting a replacement analysis.

Economic Service Life of Defender

Economic service life is the useful life of a defender, *or* a challenger, that results in the minimum equivalent annual cost.

5.3 Replacement Analysis When Required Service Life is Long

5.3.1 Required Assumptions and Decision Framework

- The annual worth (annual equivalent) method provides a more direct solution when planning horizon is infinite.
- Similarly, when the planning horizon is finite the present worth method is convenient to be used.

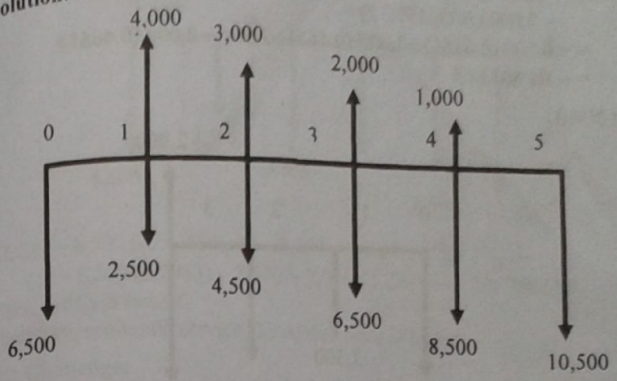
5.3.2 Replacement Analysis under Infinite Planning Horizon Marginal Analysis Approach

1. Calculate annual worth of defender (AED_D) and annual worth of challenger (AED_C) based on their economic service life (ESL); select lower annual equivalent cost (AEC).
2. If $AEC_D > AEC_C$ replace the defender with challenger.
3. If $AEC_D < AEC_C$ keep the defender (defender should not be replaced) and continue to use the defender until its economic service life is reached.
4. Then calculate the cost of running the defender (marginal cost of defender) for one more year after its economic service life. If marginal cost of defender > AEC the defender should be replaced at the end of economic life. Otherwise, we should calculate the cost of running the defender for second year.
5. If marginal cost of defender > AEC_C the defender should be replace one year after its economic service life.
6. This process should be continued until we find the optimal replacement time.

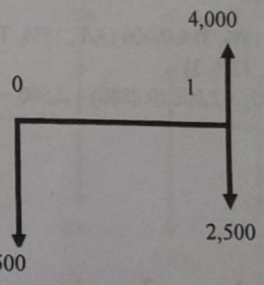
Example 5.4

A company is considering the replacement of the old machine. If the machine be repaired now, can be used for 5 more years that will require Rs 1,500 to overhaul repair. The operating cost is estimated Rs 2,500 during first year and expected to increase by Rs 2,000 per year thereafter. The company can sell the machine now in Rs 5,000 and the future market value is expected to decline by Rs 1,000 per year. The new machine cost is Rs 15,000 and will have operating costs of Rs 3,000 in the first year and expected to increase by 1,000 per year thereafter. Salvage value is Rs 8,000 after one year will decline by 10% each year for 5 years. Determine economic life for each option and determine when the defender should be replaced. MARR= 15%.

Solution: For Old Machine



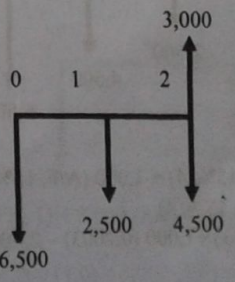
N = 1



$AEC_1 = -6,500\ (A/P, 15\%, 1) + 4,000 - 2,500$

$= -6,500\ (1.15) + 4,000 - 2,500 =$ **– Rs 5,975**

At N = 2

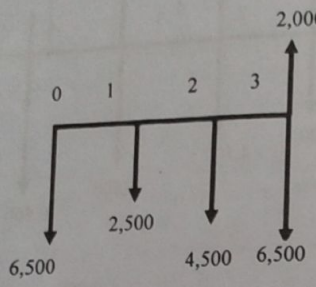


$AEC_2 = -6,500\ (A/P, 15\%, 2) + 3,000\ (A/F, 15\%, 2) - 2,500 - 2,000\ (A/G, 15\%, 2)$

$= -6,500\ (0.6151) + 3,000\ (0.4651) - 2,500 - 2,000\ (0.4651)$

$= -$ **Rs 6033.05**

At N = 3

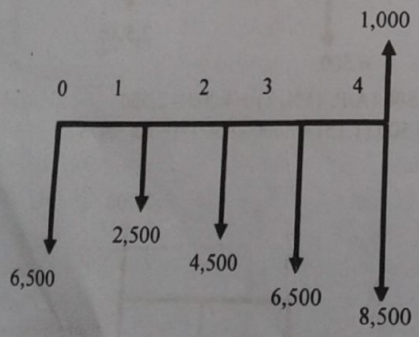


$AEC_3 = -6,500\ (A/P, 15\%, 3) + 2,000\ (A/F, 15\%, 3) - 2,500 - 2,000\ (A/G, 15\%, 3)$

$= -6,500\ (0.4380) + 2,000\ (0.2880) - 2,500 - 2,000\ (0.9071)$

$=$ **– Rs 6,585.2**

At N = 4

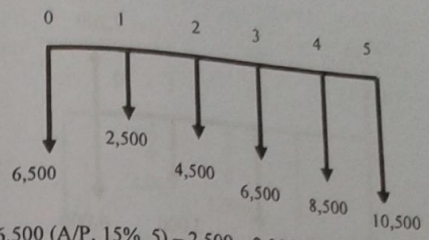


$AEC_4 = -6,500\ (A/P, 15\%, 4) + 1,000\ (A/F, 15\%, 4) - 2,500 - 2,000\ (A/G, 15\%, 4)$

$= -6,500\ (0.3503) + 1,000\ (0.2003) - 2,500 - 2,000\ (1.3263)$

$=$ **– Rs 7,229.25**

At N = 5



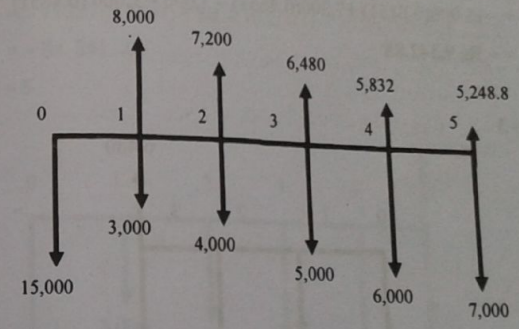
$AEC_5 = -6,500\ (A/P, 15\%, 5) - 2,500 - 2,000\ (A/G, 15\%, 5)$

$= -6,500\ (0.2983) - 2,500 - 2,000\ (1.7228) =$ **– Rs 7884.55**

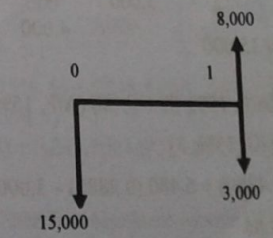
Since, AEC_1 is lowest.

Therefore, economic service life of defender is 1 year.

For Challenger



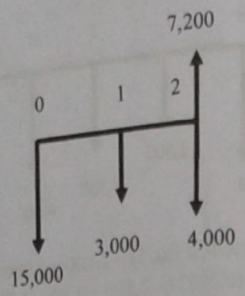
At N = 1



$AEC_1 = -15,000\ (A/P, 15\%, 1) + 8,000\ (A/F, 15\%, 1) - 3,000\ (A/F, 15\%, 1)$

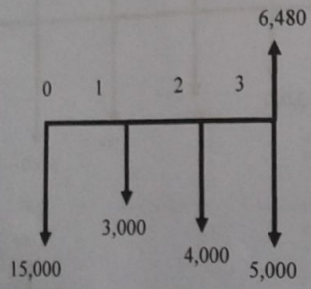
$= -15,000\ (1.15) + 8,000\ (1.0) - 3,000\ (1.0) =$ **– Rs 12,250**

At N=2



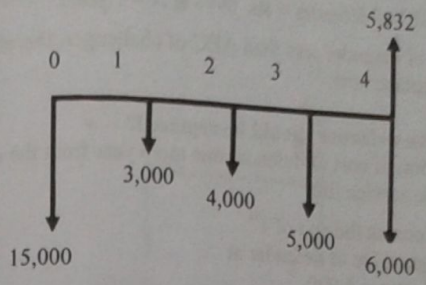
AEC_2 = – 15,000 (A/P, 15%, 2) + 7,200 (A/F, 15%, 2) – 3,000
– 1,000 (A/G, 15%, 2)
= –15,000(0.6151) +7,200(0.4651) – 3,000 – 1,000 (0.4651)
= – **Rs 9,342.88**

At N = 3



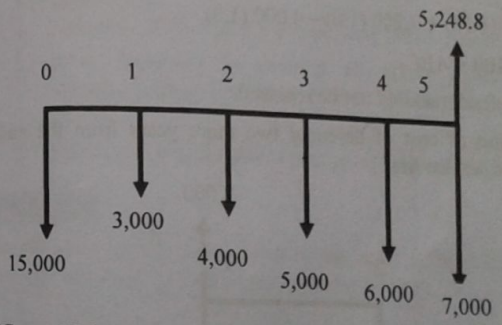
AEC_3 = – 15,000 (A/P, 15%, 3) + 6,480 (A/F, 15%, 3) – 3,000
– 1,000 (A/G, 15%, 3)
= –15,000(0.4380) + 6,480 (0.2880) – 3,000 –1,000 (0.9071)
= – **Rs 8,610.86**

At N = 4



AEC_4 = – 15000 (A/P, 15%, 4) + 5832 (A/F, 15%, 4) – 3000
– 1000 (A/G, 15%, 4)
= – 15000 (0.3503) + 5832 (0.2003) – 3000 – 1000 (1.3263)
= – Rs. 8412.65

At N = 5



AEC_5 = – 15,000 (A/P, 15%, 5) + 5,248.8 (A/F, 15%, 5) – 3,000
– 1,000 (A/G, 15%, 5)
= –15,000(0.2983) + 5,248.8(0.1483) – 3,000 –1,000 (1.7228)
= – **Rs8,418.90**

Since, AEC_4 is lowest. Therefore economic service life of challenger is 4 year.

AEC_4 = **Rs 8,412.65**
AED_1 = **Rs 5,975**

Here, minimum AEC of challenger = Rs. 8,412.65 at N = 4 years.

Minimum AEC of defender = Rs. 5975 at N = 1 years

Since, AEC of defender less than AEC of challenger, therefore defender should not replace now.

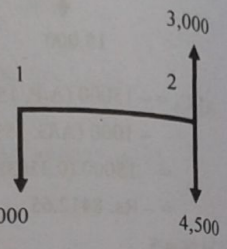
If so when the defender should be replaced?

a. Calculation of cost of defender one more year from the end of economic service life.

Opportunity cost at the end of 1st year = Salvage value of defender at the end of 1st year = 4,000

Operating cost of 2nd year = 4,500

Salvage value of defender at the end of 2nd year = 3,000



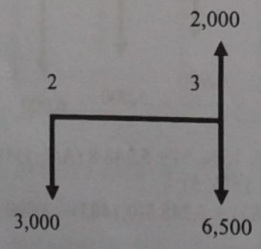
= – 4,000 (A/P, 15%, 1) + 3,000 (A/F, 15%, 1) – 4,500 (A/F, 15%, 1)

= – 8,000 (1.15) + 7,200 (1.0) – 4,000 (1.0)

= – **Rs 6,100** < AEC_4.

Therefore, defender should not be replaced.

b. Calculation of cost of defender two more years from the end of economic service life.

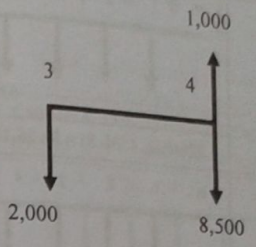


= – 3,000 (1.15) + 2,000 (1.0) – 6,500 (1.0)

= – **Rs 7,950** < AEC_4.

Defender should not be replaced.

c. Calculation of cost of defender three more years from the end of economic service life.



= –2,000 (1.15) + 1000 – 8,500 (1.0)

= – **Rs 9800 > AEC_4** [in the sense of cost]

Therefore, the defender should be replaced at the end of third year **Ans.**

5.3.3 Replacement Analysis under the Finite Planning Horizon

PW Approach

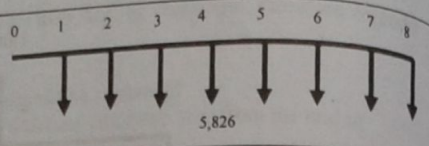
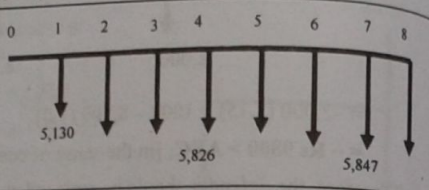
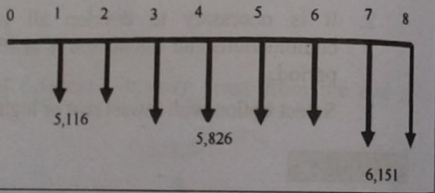
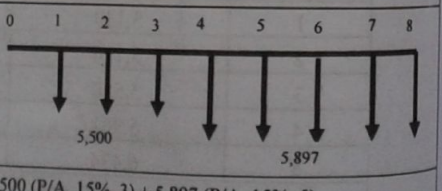
1. Calculate AW_D and AW_C over study period; select lower AW.
2. It is necessary to develop all viable defender-challenger combinations and calculate AW or PW for each one over study period.
3. Select option with lowest cost or highest income.

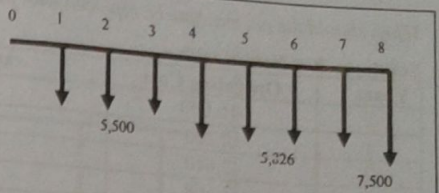
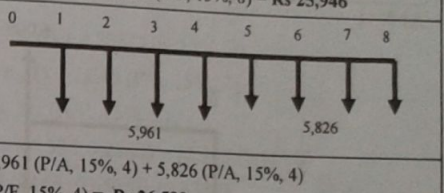
Example 5.5

For the data given below, what is the most economical replacement scenario/ strategy? Take 8 years planning horizon.

Years	Defender (D)	Challenger (C)
1	5,130	7,500
2	5,116	6,151
3	5,500	5,847
4	5,961	5,826
5	6,434	5,897
AEC 15%		

Solution:

Options	Combinations	Present Worth (PW)
1	(D, 0), (C, 4), (C, 4)	 5,826(P/A, 15%, 8) = **Rs 26,143**
2	(D, 1), (C, 4), (C, 3)	 5,130 (P/F, 15%, 1) + 5,826 (P/A, 15%, 4) (P/F, 15%, 1) + 5,847 (P/A, 15%, 3) (P/F, 15%, 5) = **Rs 25,563**
3	(D, 2), (C, 4), (C, 2)	 5,116 (P/A, 15%, 2) + 5,826 (P/A, 15%, 4) (P/F, 15%, 2) + 6,151 (P/A, 15%, 2) (P/F, 15%, 6) = **Rs 25,216**
4	(D, 3), (C, 5)	 5,500 (P/A, 15%, 3) + 5,897 (P/A, 15%, 5) (P/F, 15%, 3) = **Rs 25,555**

5	(D, 3), (C, 4), (C, 1)	 5,500 (P/A, 15%, 3) + 5,826 (P/A, 15%, 4) (P/F, 15%, 3) + 7,500 (P/F, 15%, 8) = **Rs 25,946**
6	(D, 4), (C, 4)	 5,961 (P/A, 15%, 4) + 5,826 (P/A, 15%, 4) (P/F, 15%, 4) = **Rs 26,530**

From the above calculations, the present equivalent cost of option 3 is least. Therefore, best replacement strategy would be (D, 2), (C, 4), (C, 2) **Ans.**

Additional Solved Examples

Example 5.1

The new machine costs 10,000 operating cost 2,200 in first year, then increases by 20% per year. Market value is 6,000 after one year and will decline by 15% each year N= 5 years. If required old machine can work another 3 years. Market value now is 5,000 and will decline by 25% each year. Immediate overhauling to restore to operable condition costs 1,200. Operating costs 2,000 in the first year increases by 1,500 per year thereafter. **TU-2070**

MARR= 15%

i. Find the economic service life of this machine (new).

ii. AEC of defender is as follows:

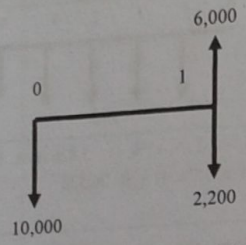
N	*1*	*2*	*3*	*4*
AEC	*5,380*	*5,203*	*5,468*	*5,845*

When should the old machine be replaced with the new machine?

Solution: For New Machine

Years	Operating Cost	Market Value
0	-10,000	
1	-2,200	6,000
2	-2,640	5,100
3	-3,168	4,335
4	-3,801.6	3,684.75
5	-4,561.92	3,132.03

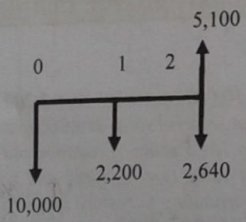
At N=1



$AEC_1 = -10,000\ (A/P, 15\%, 1) + 6,000\ (A/F, 15\%, 1) - 2,200\ (A/F, 15\%, 1)$

$= -10,000\ (1.15) + 6,000\ (1.0) - 2,200\ (1.0) = -$ Rs 7,700

At N = 2

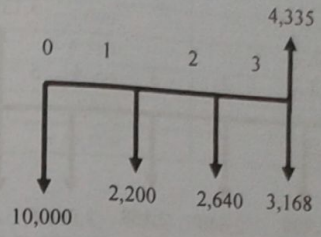


$AEC_2 = -10,000\ (A/P, 15\%, 2) + 5,100\ (A/F, 15\%, 2) - \{2,200\ (P/F, 15\%, 1) + 2,640\ (P/F, 15\%, 2)\}\ (A/P, 15\%, 2)$

$= -10,000(0.6151) + 51,00\ (0.4651) - \{2,200(0.8696) + 2,640\ (0.7561)\}\ (0.6151)$

$= -$ Rs 6,183.55

At N = 3

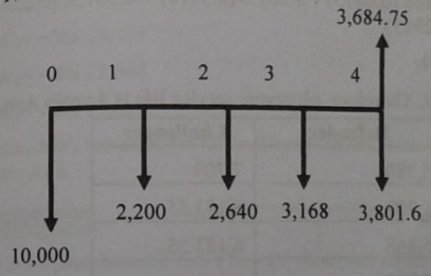


$AEC_3 = -10,000\ (A/P, 15\%, 3) + 4,335(A/F, 15\%, 3) - \{2,200\ (P/F, 15\%, 1) + 2,640\ (P/F, 15\%, 2) + 3,168(P/F, 15\%, 3)\}\ (A/P, 15\%, 3)$

$= -10,000\ (0.4380) + 4,335(0.2880) - \{2,200\ (0.8696) + 2,640\ (0.7561) + 3,168\ (0.6575)\}\ (0.4380)$

$= -$ Rs 5,756.09

At N = 4

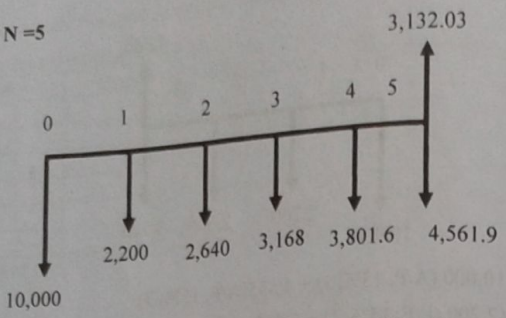


$AEC_4 = -10,000\ (A/P, 15\%, 4) + 3,684.75\ (A/F, 15\%, 4) - \{2,200\ (P/F, 15\%, 1) + 2,640\ (P/F, 15\%, 2) + 3,168\ (P/F, 15\%, 3) + 3,801.6\ (P/F, 15\%, 3) + 3,801.6\ (P/F, 15\%, 4)\}\ (A/P, 15\%, 4)$

$= -10,000\ (0.3503) + 3,684.75\ (0.2003) - \{2,200\ (0.8696) + 2,640\ (0.7561) + 3,168\ (0.6575) + 3,801.6(0.5718)\}\ (0.3503)$

$= -$ Rs 5,625.48

At N =5



$AEC_5 = -10{,}000\ (A/P, 15\%, 5) + 3{,}684.75\ (A/F, 15\%, 5)$
$- \{2{,}200\ (P/F, 15\%, 1) + 2{,}640\ (P/F, 15\%, 2)$
$+ 3{,}168 (P/F, 15\%, 3) + 3{,}801.6\ (P/F, 15\%, 3)$
$+ 3{,}801.6\ (P/F, 15\%, 4) + 4{,}561.9\ (P/F, 15\%, 5)\}\ (A/P, 15\%, 5)$
$= -10{,}000\ (0.2983) + 3{,}132.03\ (0.1483) - \{2{,}200\ (0.8696) + 2{,}640\ (0.7561) + 3{,}168\ (0.6575) + 3{,}801.6\ (0.5718) + 4{,}561.9\ (0.4972)\}\ (0.2983)$
$= -$ Rs 5,631.01

Since, AEC_4 is lowest. Therefore, economic service life is 4 years **Ans.**

	Defender	Challenger
1	5,380	7,700
2	5,203	6,183.55
3	5,468	6,183.55
4	5,845	**5,625.48**

Since, $AEC_D > AEC_C$ at fourth year. Therefore, keep the defender to third year and replace it at the end of third year **Ans.**

Example 5.2

Determine the economic service life (ESL) of an asset which has the costs shown below. Let i = 10%.

Year	Cost/yr	Salvage Value
0	– 20,000	–
1	– 5,000	10,000
2	– 6,500	8,000
3	– 9,000	6,000
4	– 11,000	5,000
5	– 15,000	3,000

Solution:

$AW_1 = -20{,}000\ (A/P, 10\%, 1) - 5{,}000\ (P/F, 10\%, 1)\ (A/P, 10\%, 1) + 10{,}000\ (A/F, 10\%, 1)$
$= -20{,}000\ (1.1) - 5{,}000\ (0.9091)\ (1.1) + 10{,}000\ (1)$
$= -$ Rs 17,000.05

$AW_2 = -20{,}000\ (A/P, 10\%, 2) - 5{,}000\ (P/F, 10\%, 1) + 6{,}500\ (P/F, 10\%, 2)\ (A/P, 10\%, 2) + 8{,}000\ (A/F, 10\%, 2)$
$= -20{,}000\ (0.5762) - 5{,}000\ (0.9091) - 6{,}500\ (0.8264)\ (0.5762) + 8{,}000(0.4762)$
$= -$ Rs 15,355.01

Similarly,

$AW_3 = -$ Rs 13,439

$AW_4 = -$ **Rs 12,864**

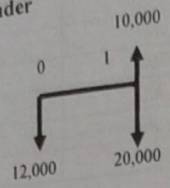
$AW_5 = -$ Rs 13,623

Since, AW_4 has smallest value. Therefore, economic service life is 4 years **Ans.**

Example 5.3

An asset purchased 2 years ago for Rs40,000 is harder to maintain than expected. It can be sold now for Rs12,000 or keep for a maximum of 2 more years, in which case its operating cost will be Rs20,000 each year, with a salvage value of Rs 10,000 after 1 year and Rs 9,000 after two years. A suitable challenger will have an annual worth of Rs -24,000 per year. At an interest rate of 10% per year, should the defender be replaced now, one year from now, or two years from now?

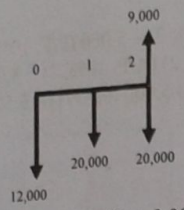
Solution: ESL for Defender



At n=1

$AW_{D1} = -12,000\ (A/P, 10\%, 1) - 20,000 + 10,000\ (A/F, 10\%, 1)$
$= -12,000\ (1.1) - 20,000 + 10,000\ (1)$
$= -$ **Rs 23,200**

At n = 2



$AW_{D2} = -12,000\ (A/P, 10\%, 2) - 20,000 + 9,000\ (A/F, 10\%, 2)$
$= -12,000\ (0.5762) - 20,000 + 9,000\ (0.4762)$
$= -$ **Rs 22,628.60**

Since, AW_{D2} has lowest value. Therefore, ESL is 2 years.

For Challenger

$AW_C = -$ Rs 24,000

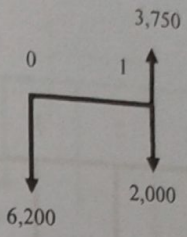
Since, $AW_{D2} < AW_C$. Therefore, the defender be replaced two years from now **Ans.**

Example 5.4

An old machine can sell it now for $ 5,000. If repaired now can be used for another 6 years. If will require and immediate $1,200 for overhaul to restore it to operable condition. Future market values are expected to decline by 25% each year over the previous year's value. Operating costs are estimated at $2,000 during the first year and these are expected to increase by $1,500 per year thereafter. Determine economic service life of this machine. MARR=10% **TU-2072**

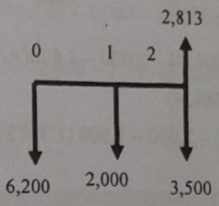
Solution: Given

At n=1



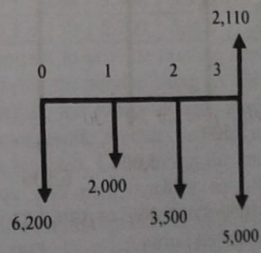
$AW_{D1} = -6,200\ (A/P, 10\%, 1) - 2,000 + 3,750\ (A/F, 10\%, 1)$
$= -6,200\ (1.1) - 2,000 + 3,750\ (1) = -$ **$ 5,070**

At n =2



$AW_{D2} = -6,200\ (A/P, 10\%, 2) - 2,000 - 1500\ (A/G, 10\%, 2)$
$+ 2813\ (A/F, 10\%, 2)$
$= -6,200\ (0.5762) - 2,000 - 1500(0.4762) + 2813(0.4762)$
$= -$ **$ 4,947.19**

At n = 3

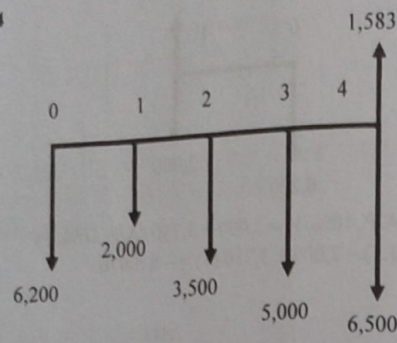


$AW_{D3} = -6,200\ (A/P, 10\%, 3) - 2,000 - 1,500(A/G, 10\%, 3)$
$+ 2,110\ (A/F, 10\%, 3)$

$= -6,200\ (0.4021) - 2,000 - 1,500\ (0.9366) + 2,110\ (0.3021)$

$= -\$\ 5,260.49$

At n = 4

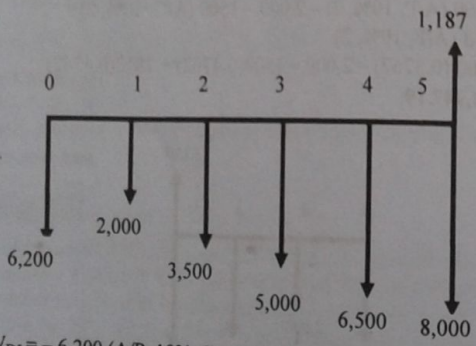


$AW_{D4} = -6,200\ (A/P, 10\%, 4) - 2,000 - 1,500(A/G, 10\%, 4) + 2,110\ (A/F, 10\%, 4)$

$= -6,200\ (0.3155) - 2,000 - 1,500\ (1.3812) + 1,583(0.2155)$

$= -\$5,686.76$

At n = 5

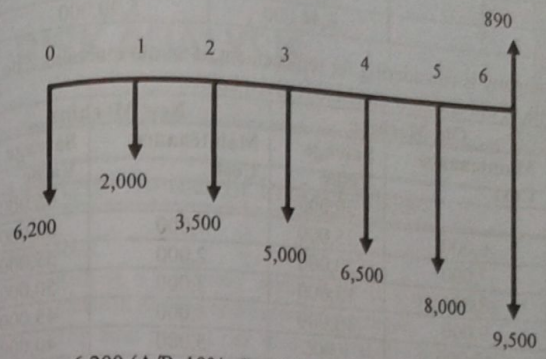


$AW_{D5} = -6,200\ (A/P, 10\%, 5) - 2,000 - 1,500(A/G, 10\%, 5) + 1,187\ (A/F, 10\%, 5)$

$= -6,200\ (0.2638) - 2,000 - 1,500\ (1.8101) + 1,187\ (0.1638)$

$= -\$\ 6,156.28$

At n = 6



$AW_{D6} = -6,200\ (A/P, 10\%, 6) - 2,000 - 1,500(A/G, 10\%, 6) + 890\ (A/F, 10\%, 6)$

$= -6,200\ (0.2296) - 2,000 - 1,500\ (2.2236) + 890\ (0.1296)$

$= -\$\ 6,643.57$

Since, AW_{D2} has lowest value.

Therefore, ESL is 2 years **Ans.**

Questions

1. The annual equivalent cost (AEC) of the defender and challenger are given in the table below. What is the best replacement strategy? Use MARR=12%. The planning horizon of the project is 8 years.

EOY	1	2	3	4	5	6
AEC_D	5,300	5,250	5,400	5,750	6,200	6,550
AEC_C	7,700	6,150	5,700	5,600	5,675	5,800

2. A firm has a contract to provide printing service to IOE for next 8 years. It can provide the service using its old printing machine (the current defender) or the newly bought machine (the challenger). After the contract work neither the old machine nor the new machine will be retained. Considering the annual equivalent cost of the old machine and new machine as follows, what are their economic service life? What is the best replacement strategy?

Number of Years	Annual Equivalent Cost (Rs)	
	Old Machine	New Machine
1	5,15,000	7,50,000
2	5,10,000	6,15,000

3	5,50,000	5,86,000
4	5,96,000	5,83,000
5	6,44,000	5,90,000

3. A company is considering for replacement of an old machine. The details of old and new machine is given below.

Year	Old Machine		New Machine	
	Maintenance Cost	Salvage Value	Maintenance Cost	Salvage Value
0		30,000		65,000
1	6,000	25,000	1,000	60,000
2	7,000	20,000	2,000	55,000
3	8,000	15,000	3,000	50,000
4	9,000	10,000	4,000	45,000
5	10,000	5,000	5,000	40,000

Find economic service life for defender and challenger.
Use MARR= 10%
Given the initial investment, annual cost and salvage value for defender are Rs 25,000, Rs 10,000 and Rs 5,000 respectively. For challenger initial investment is Rs 35,000, annual cost Rs 8,000 and salvage value Rs 12,000. Determine the choice between defender and challenger when useful life is 5 years and MARR is 10%.

4. An existing machine has market value of Rs 10,000 and decreases by Rs 2,000 per year. Its operating cost is Rs 2,500 in year 1 and increases by 20% each year for 4 years. New machine cost Rs 20,000 now and its market value will decreases by Rs 20% per year for 4 years. Operating cost is Rs 1,500 in first year and increase by 30% per year. Calculate equivalent uniform annual cost of both existing machines. MARR = 15% formulate the best replacement strategy if we need the machine for four years only.

5. Explain the required assumptions and decision framework for replacement analysis when required service life is long.

6. What do you understand by replacement analysis? Why replacement of existing equipment is necessary?

7. Explain the approaches for comparing defender and challenger.

8. What is economic service life of an asset?

9. Explain some important terminologies of replacement analysis.