Faculty of Engineering
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Replacement Study

Introduction

- One of the most commonly performed engineering economy studies is that of replacement or retention of an asset or system that is currently installed.
- This differs from previous studies where all the alternatives are new.
- The fundamental question answered by a replacement study about a currently installed asset or system is, *Should it be replaced now or later?*
- When an asset is currently in use and its function is needed in the future, it will be replaced at some time.

Introduction

- In reality, a replacement study answers the question of *when*, not *if*, to replace.
- A replacement study is usually designed to first make the economic decision to retain or replace *now*.
- If the decision is to replace, the study is complete.
- If the decision is to retain, the cost estimates and decision will be revisited each year to ensure that the decision to retain is still economically correct.

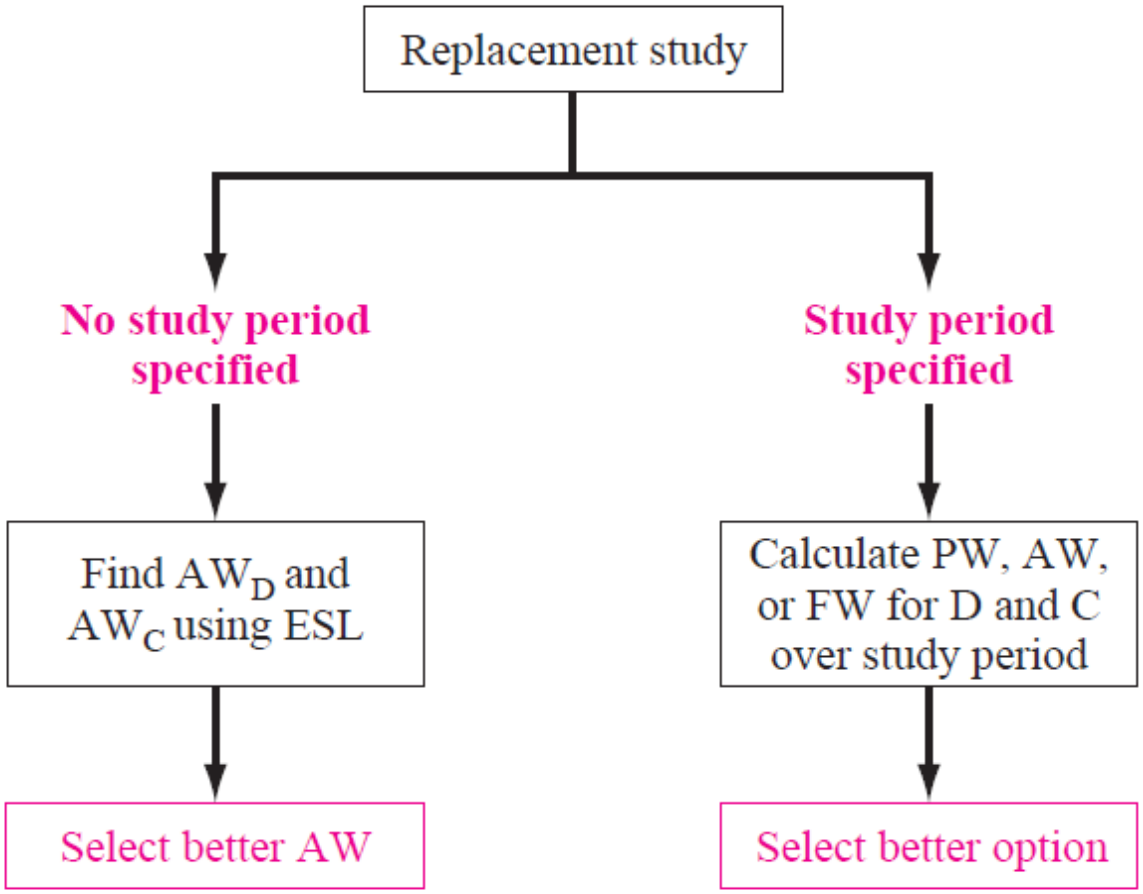
Basics of a Replacement Study

- It is very common to face the situation that the currently used asset (or system) could be either replaced with a more economical alternative or retained as is.
- This is called a replacement study, which may be necessary for several reasons such as unacceptable performance or reliability, physical deterioration, competitive or technological obsolescence, or changed requirements.
- A replacement study provides an answer to the question: Is replacement with a specified alternative economical at this point?

Basics of a Replacement Study

- The in-place asset is referred to as the ***defender***, and the replacement alternative is called the ***challenger***.
- The replacement analysis assumes that neither of the alternatives is owned currently.
- **An annual worth** analysis is most commonly used for the replacement analysis.
- The length of the replacement study period is either *unlimited* or *specified*.

Replacement Study Approaches



Economic Service Life

- An asset should be retained for a time period that minimizes its cost to the owner.
- This time is called the *economic service life* (ESL) or minimum cost life.
- The smallest total AW of costs identifies the ESL value.

$$(\text{AW of AOC})_k = [\text{AOC}_1(P/F,i,1) + \text{AOC}_2(P/F,i,2) + \ldots + \text{AOC}_k(P/F,i,k)](A/P,i,k)$$

Example 1

- A device that monitors rotational vibration changes in turbines may be purchased for use in southern California wind farms. The first cost is $40,000 with a constant AOC of $15,000 over a maximum service period of 6 years. Use the decreasing future market values below and i = 20% per year to find the best n value for an economic evaluation.

After k years of service	1	2	3	4	5	6
Estimated market value is	$32,000	30,000	24,000	20,000	11,000	0

Example 1

- **Solution**

- Determine the total AW of costs for years 1 through 6. The AW of AOC is constant at $15,000. For one year of retention, $k = 1$:

$$\text{Total AW}_1 = -40{,}000(A/P,20\%,1) + 32{,}000(A/F,20\%,1) - 15{,}000$$
$$= -16{,}000 - 15{,}000$$
$$= \$-31{,}000$$

- For two years of retention, $k = 2$.

$$\text{Total AW}_2 = -40{,}000(A/P,20\%,2) + 30{,}000(A/F,20\%,2) - 15{,}000$$
$$= -12{,}546 - 15{,}000$$
$$= \$-27{,}546$$

Example 1

- The table below shows the AW values over all possible 6 years of service. The smallest total AW cost value is the ESL, which occurs at $-26,726 for $k = 4$.

Years of Retention	1	2	3	4	5	6
Capital recovery, $/year	−16,000	−12,546	−12,395	−11,726	−11,897	−12,028
AW of AOC, $/year	−15,000	−15,000	−15,000	−15,000	−15,000	−15,000
Total AW, $/year	−31,000	−27,546	−27,395	−26,726	−26,897	−27,028

Replacement Study Over a Specified Study Period

- Replacement studies are performed when the time period for the replacement study is limited to a specified study period or planning horizon, for example, 3 years.
- In this case, the only relevant cash flows are those that occur within the 3-year period.
- In general, the AW, PW, or FW is determined based on the estimates that apply only from the present time through the end of the study period.

Example 2

- For the data shown in the next table, determine which alternative is better at $i = 10\%$ per year, if the study period is:
  (a) 1 year; and
  (b) 3 years.

Challenger		
Challenger Year *k*	**Market Value**	**AOC**
0	$50,000	—
1	40,000	$ −5,000
2	32,000	−7,000
3	25,600	−9,000
4	20,480	−11,000
5	16,384	−13,000

Defender		
Defender Year *k*	**Market Value**	**AOC**
0	$15,000	—
1	12,000	$−20,000
2	9,600	−8,000
3	7,680	−12,000

Example 2

- **Solution**

a. Use AW relations for a 1-year study period:

AW_C = -50,000(A/P,10%,1) + 40,000(A/F,10%,1) - 5000
= $-20,000

AW_D = -15,000(A/P,10%,1) + 12,000(A/F,10%,1) - 20,000
= $-24,500

- Select the **challenger**.

Example 2

- **Solution**

b. For a 3-year study period, the AW equations are:

$$AW_C = -50{,}000(A/P,10\%,3) + 25{,}600(A/F,10\%,3) - [5000 + 2000(A/G,10\%,3)]$$
$$= \$-19{,}245$$

$$AW_D = -15{,}000(A/P,10\%,3) + 7680(A/F,10\%,3) - [20{,}000(P/F,10\%,1) + 8000(P/F,10\%,2) + 12{,}000(P/F,10\%,3)](A/P,10\%,3)$$
$$= \$-17{,}307$$

- Select the **defender**.