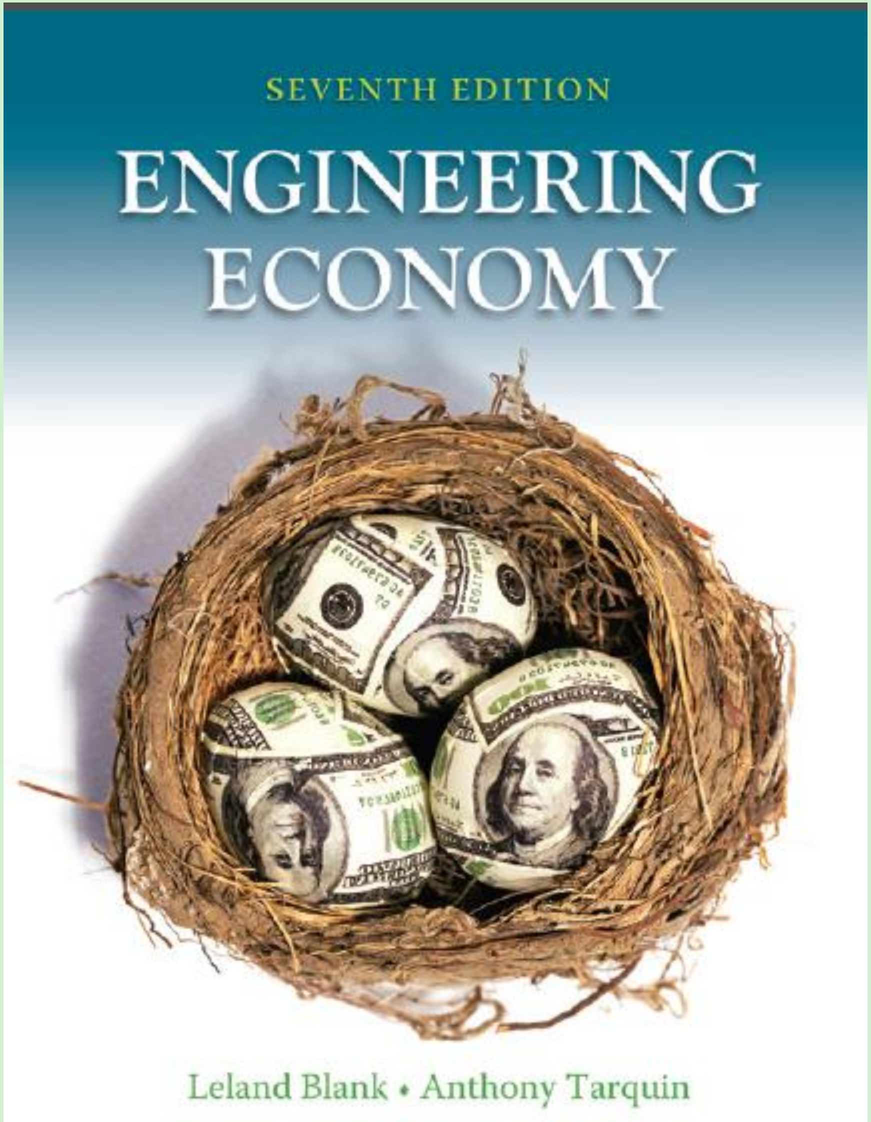


Chapter 6

Annual Worth Analysis

Lecture slides to accompany

Engineering Economy

7th edition

Leland Blank

Anthony Tarquin

McGraw Hill Higher Education

LEARNING OUTCOMES

1. **Advantages of AW**
2. **Capital Recovery and AW values**
3. **AW analysis**
4. **Perpetual life**
5. **Life-Cycle Cost analysis**

Advantages of AW Analysis

- **Popular with some managers who tend to think in terms of "$/year, $/months, etc.**

- The annual worth method offers a prime computational and interpretation advantage because the AW value needs to be calculated for **only one life cycle. The AW value determined over** one life cycle is the AW for all future life cycles. Therefore, it is **not necessary to use the LCM of lives to satisfy the equal-service requirement.**

AW Analysis Assumptions for different life alternatives

1. **The services provided are needed for at least the LCM of the lives of the alternatives.**

2. **The selected alternative will be repeated for succeeding life cycles in exactly the same manner** as for the first life cycle.

3. **All cash flows will have the same estimated values in every life cycle.**

Alternatives usually have the following cash flow estimates

- **Initial investment, P** – First cost of an asset
- **Salvage value, S** – Estimated value of asset at end of useful life
- **Annual amount, A** – Cash flows associated with asset, such as annual operating cost (AOC), etc.

Relationship between AW, PW and FW

AW = PW(A/P,i%,n) = FW(A/F,i%,n)

n is years for equal-service comparison (value of LCM or specified study period)

Calculation of Annual Worth

AW for one life cycle is the *same for all* life cycles!!

An asset has a first cost of \$20,000, an annual operating cost of \$8000 and a salvage value of \$5000 after 3 years. Calculate the AW for one and two life cycles at i = 10%

$$AW_{one} = -20{,}000(A/P,10\%,3) - 8000 + 5000(A/F,10\%,3)$$
$$= \$\text{-}14{,}532$$

$$AW_{two} = -20{,}000(A/P,10\%,6) - 8000 - 15{,}000(P/F,10\%,3)(A/P,10\%,6) + 5000(A/F,10\%,6)$$
$$= \$\text{-}14{,}532$$

Capital Recovery and AW

Capital recovery (CR) is the equivalent annual amount that an asset, process, or system must earn each year to just recover the first cost and a stated rate of return over its expected life. Salvage value is considered when calculating CR.

$$CR = -P(A/P,i\%,n) + S(A/F,i\%,n)$$

Use previous example: (note: AOC not included in CR)

$$CR = -20{,}000(A/P,10\%,3) + 5000(A/F,10\%,3) = \$ -6532 \text{ per year}$$

Now $AW = CR + A$

$$AW = -6532 - 8000 = \$ -14{,}532$$

Selection Guidelines for AW Analysis

- **One alternative: If AW ≥ 0, the requested MARR is met or exceeded and the alternative is** economically justified.

- **Two or more alternatives: Select the alternative with the AW that is numerically largest,** that is, less negative or more positive. This indicates a lower AW of cost for cost alternatives or a larger AW of net cash flows for revenue alternatives.

ME Alternative Evaluation by AW

Not necessary to use LCM for different life alternatives

A company is considering two machines. Machine X has a first cost of \$30,000, AOC of \$18,000, and S of \$7000 after 4 years.
Machine Y will cost \$50,000 with an AOC of \$16,000 and S of \$9000 after 6 years.
Which machine should the company select at an interest rate of 12% per year?

Solution: AW_X = -30,000(A/P,12%,4) –18,000 +7,000(A/F,12%,4)
= \$-26,412

AW_Y = -50,000(A/P,12%,6) –16,000 + 9,000(A/F,12%,6)
= \$-27,052

Select Machine X; it has the numerically larger AW value

AW of Permanent Investment

Use A = Pi for AW of *infinite* life alternatives
Find AW over *one life cycle* for *finite* life alternatives

Compare the alternatives below using AW and i = 10% per year

	C	D
First Cost, $	-50,000	-250,000
Annual operating cost, $/year	-20,000	-9,000
Salvage value, $	5,000	75,000
Life, years	5	∞

Solution: **Find AW of C over 5 years and AW of D using relation A = P*i***

$$AW_C = -50{,}000(A/P,10\%,5) - 20{,}000 + 5{,}000(A/F,10\%,5)$$
$$= \$-32{,}371$$

$$AW_D = Pi + AOC = -250{,}000(0.10) - 9{,}000$$
$$= \$-34{,}000$$

Select alternative C

Example

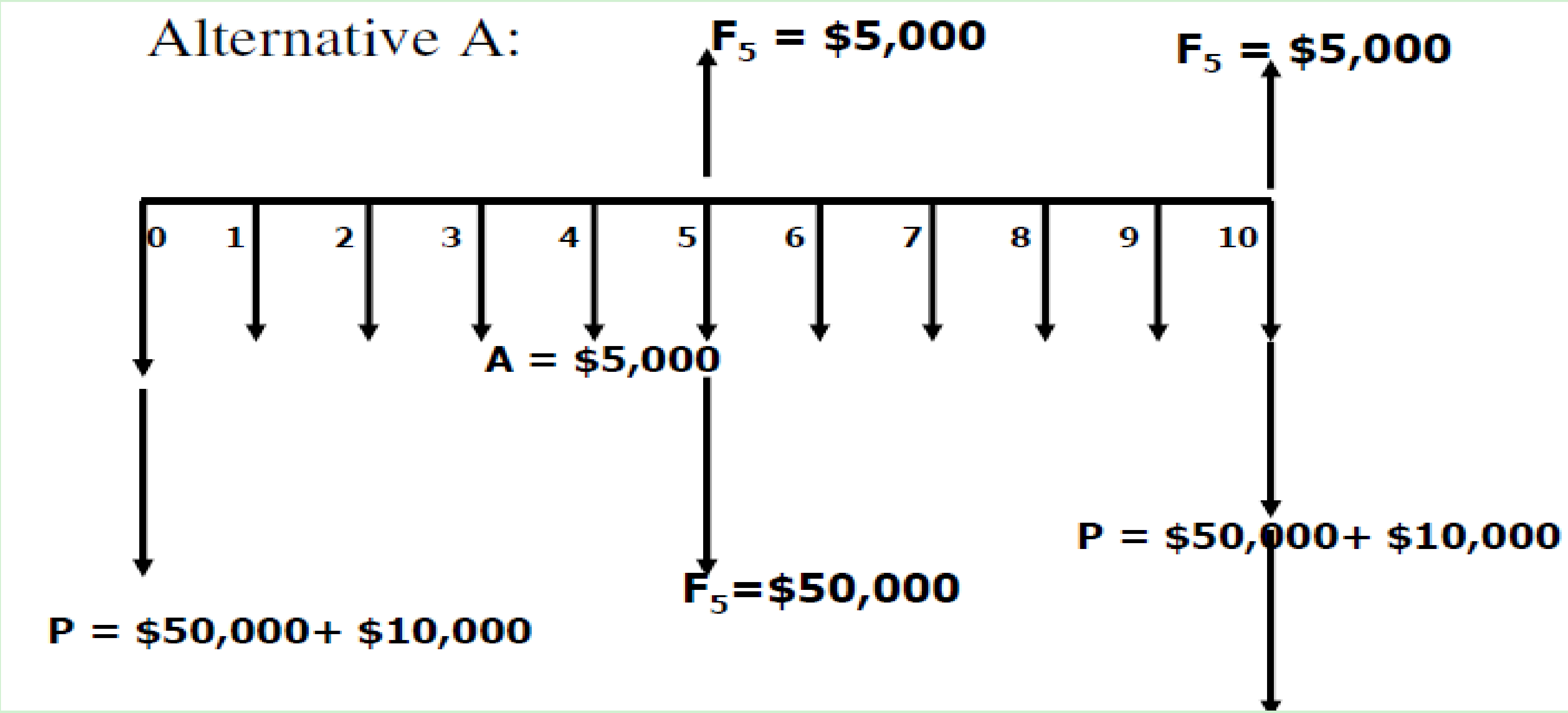
Two alternatives are considered for covering a Hockey Ground. The first is to plant natural grass and the second is to install AstroTurf. Interest rate is 10% per year. Assume the field is to last a "long time".

Alternative A:

Natural Grass - Replanting will be required each 10 years at a cost of $10,000. Annual cost for maintenance is $5,000. Equipment must be purchased for $50,000 which will be replaced after 5 years with a salvage value of $5,000.

Alternative B:

AstroTurf: Initial investment of $150,000 and $5,000/year maintenance costs



A=-50,000(A/P,10%,5)- 10,000(A/P,10%,10)-5000+ 5000(A/F,10%,5) =-$18998.5/Year

Alternative B

Annual Cost of Installation:

A = P(i) =-$150,000 (.10) = -$15,000/ year

Annual Maintenance =- $5,000/year

Total: -$15,000 - $5,000 = -$20,000/Year

Choose A, cost less per year!

Life-Cycle Cost Analysis

Life-Cycle Cost

Life-cycle cost (LCC) analysis utilizes AW or PW methods to evaluate cost estimates for the entire life cycle of one or more projects.

Estimates will cover the **entire life span** **from the early** conceptual stage, through the design and development stages, throughout the operating stage, and even the phase out and disposal stages.

Both **direct and indirect costs are included.**

Life-Cycle Cost Phase

Acquisition phase: all activities prior to the delivery of products and services.

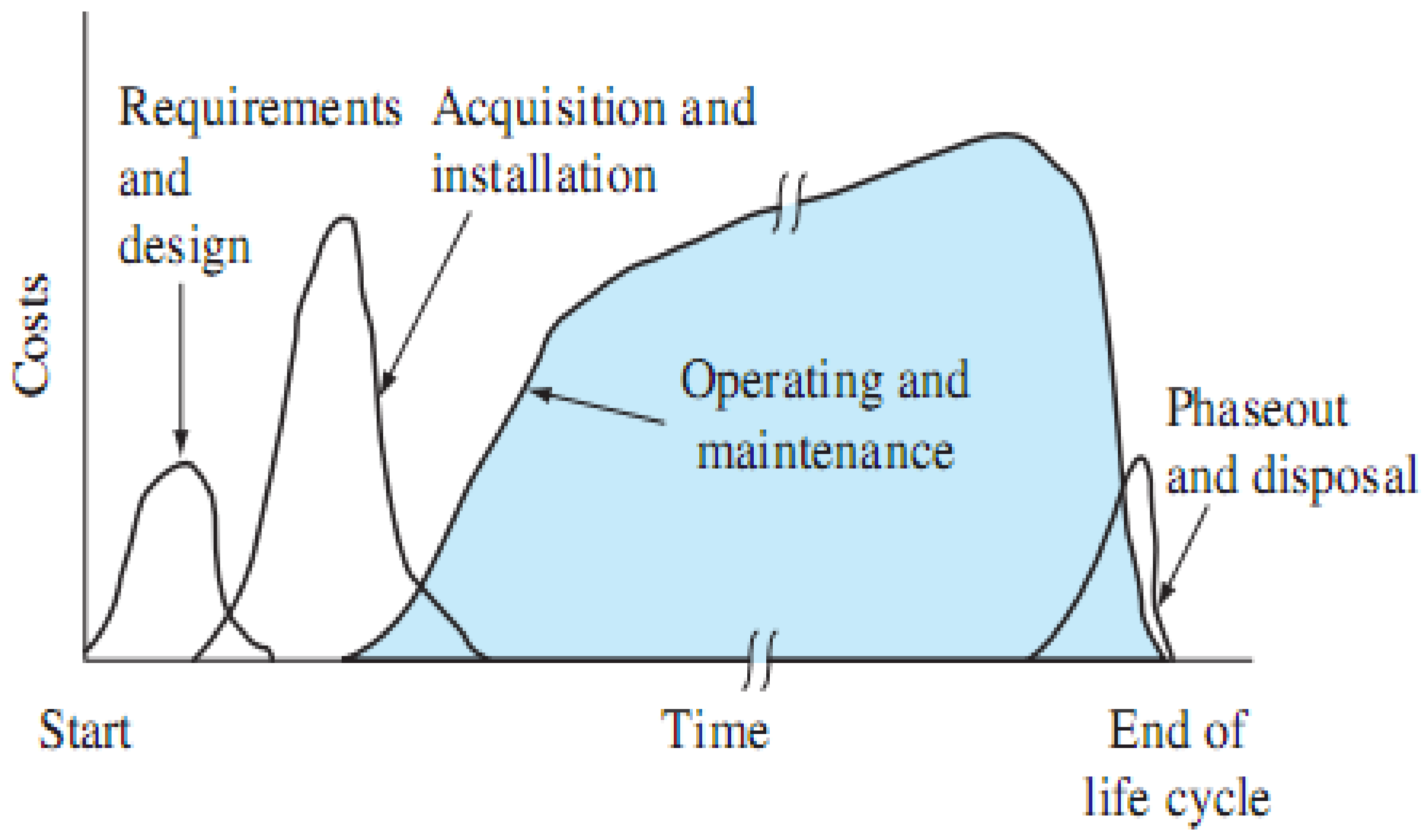
- Requirements definition stage—Includes determination of user/customer needs, assessing them relative to the anticipated system, and preparation of the system requirements documentation.
- Preliminary design stage— Includes feasibility study, conceptual, and early-stage plans; final go–no go decision is probably made here.
- Detailed design stage— Includes detailed plans for resources—capital, human, facilities, information systems, marketing, etc.; there is some acquisition of assets, if economically justifiable.

Operation phase: all activities are functioning, products and services are available.

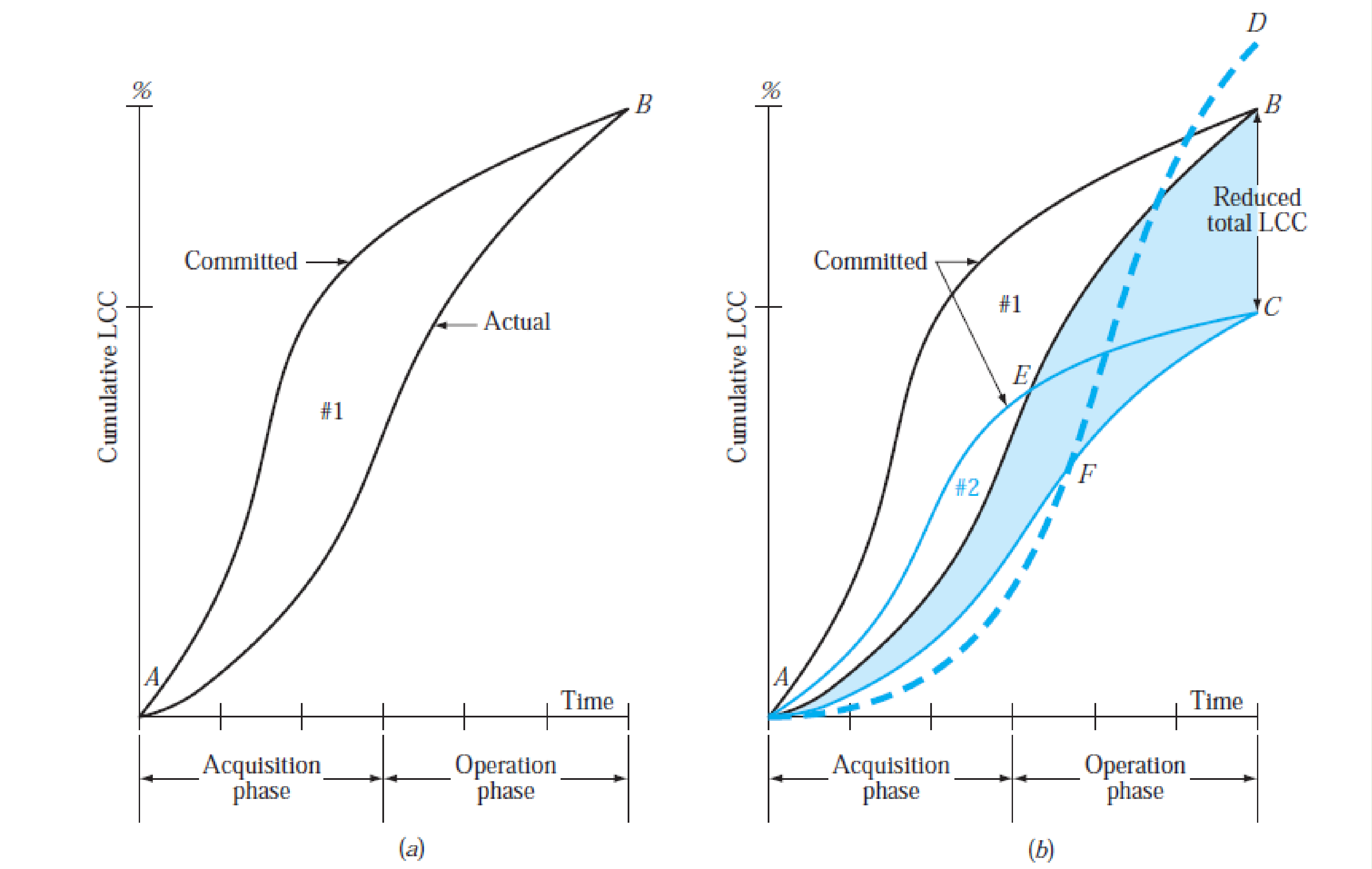
- Construction and implementation stage— Includes purchases, construction, and implementation of system components; testing; preparation, etc.
- Usage stage— Uses the system to generate products and services; the largest portion of the life cycle.

Phaseout and disposal phase: covers all activities to transition to a new system; removal/ recycling/disposal of old system.

Typical Life-Cycle Cost Distribution by Phase



LCC envelopes for committed and actual costs: (*a*) *design 1*, (*b*) *improved design 2.*



LCC envelopes for committed and actual costs

Even though an effective LCC envelope may be established early in the acquisition phase, it is not uncommon that unplanned cost-saving measures are introduced during the acquisition phase and early operation phase. These apparent "savings" may actually increase the total LCC, as shown by curve *AFD . This style of ad hoc cost savings, often imposed by management* early in the design stage and/or construction stage, can substantially increase costs later, especially in the after-sale portion of the use stage. For example, the use of inferior-strength concrete and steel has been the cause of structural failures many times, thus increasing the overall life span LCC.

Summary of Important Points

- AW method converts all cash flows to *annual value at MARR*
- Alternatives can be *mutually exclusive, independent, revenue, or cost*
- AW comparison is *only one life cycle of each alternative*
- For infinite life alternatives, annualize *initial cost as A = P(i)*
- Life-cycle cost analysis includes *all costs* over a project's life span