CENG 6108 Construction Economics

Life Cycle Costing Analysis

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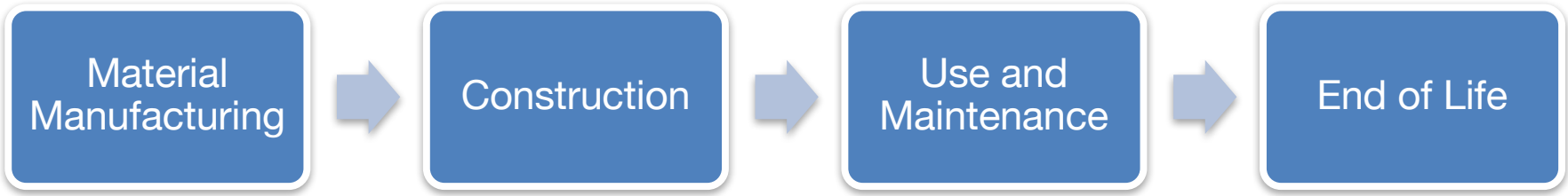
Life Cycle Costing

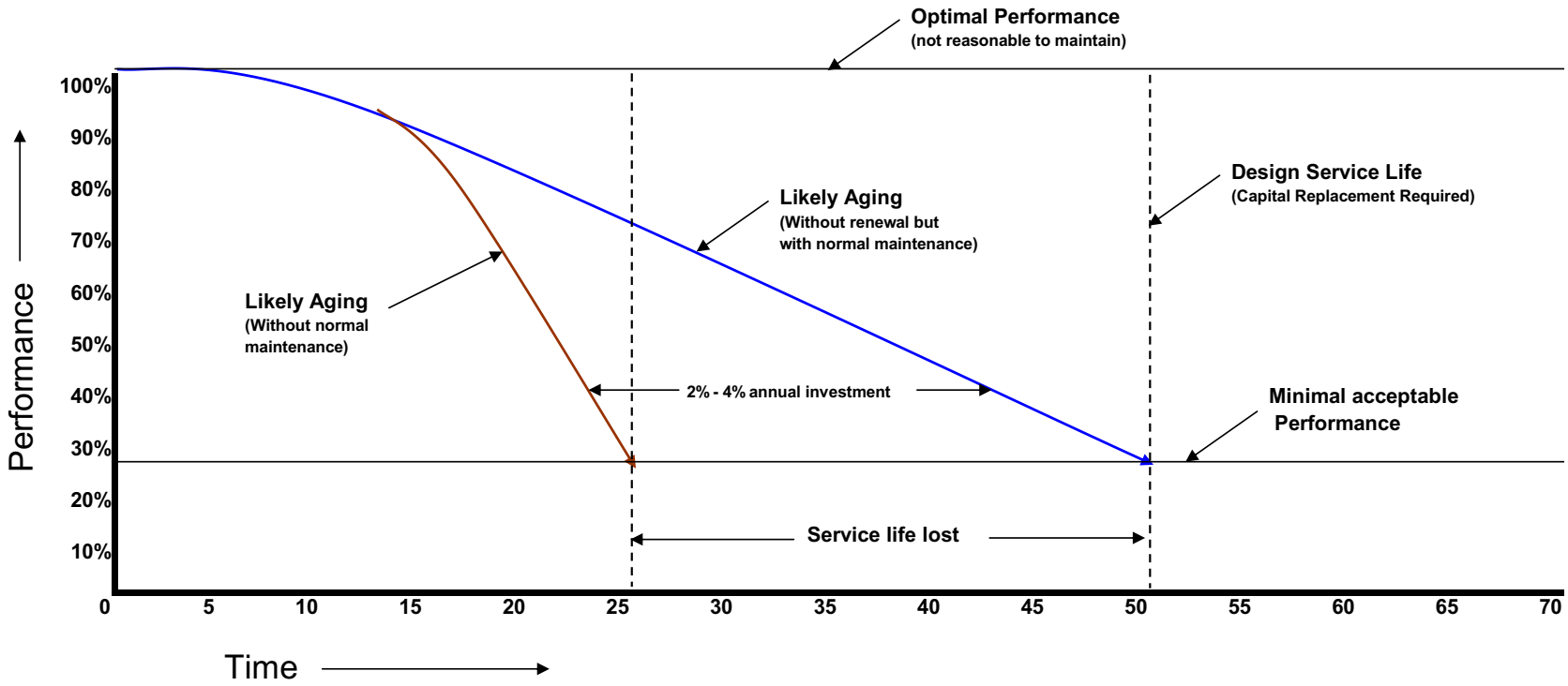
- Life Cycle Stages:



- Life-Cycle Cost Analysis (LCCA): is a process of evaluating the economic performance of a building over its entire life.
  - LCCA balances initial monetary investment with the long-term expense of owning and operating the building.
  - Government agencies have began implementing it to improve cost effectiveness of buildings and equipment procurement.
  - Usage has spread around the business world for project evaluation and management accounting.

Life Cycle Costing

Building Life Cycle



Source: Isola and Dutton, Faithful+Gould

Life Cycle Costing

- Life Cycle Costing Analysis (LCCA):
  - Compares execution options: Technically equally appropriate or Different costs
  - Takes into account the whole life-cycle of a building
  - Implemented early on, during concept planning and design

- Life Cycle Costs of Construction Projects include:
  - Initial costs - Purchase, Acquisition, Construction costs
  - Fuel Costs
  - Operation, Maintenance and Repair Costs
  - Replacement Costs
  - Residual Values - Resale or Salvage Values or Disposal Costs
  - Finance Charges - Loan Interest Payments
  - Non-Monetary Benefits or Costs

Life Cycle Costing

Life expectancy of building subsystems:

Subsystem Categories		Average Life Cycle
1a.	Roofing – Tile	80 years
1b.	Roofing – Metal, Concrete	50 years
1c.	Roofing – Membrane, Built-up, Shingle, Bitumen, Foam	20 years
2a.	Building Exteriors, Doors, and Windows (Hard)	80 years
2b.	Building Exteriors (Soft)	20 years
3.	Elevators and Conveying Systems	25 years
4.	HVAC – Equipment and Controls	20 years
5.	HVAC – Distribution Systems	40 years
6.	Electrical Equipment	30 years
7.	Plumbing Fixtures	30 years
8.	Plumbing – Rough-in	50 years
9.	Fire Protection Systems	40 years
10.	Fire Detection Systems	20 years
11.	Built-in Specialties and Equipment	25 years
12.	Interior Finishes	15 years
Other Categories		
13.	Foundations	Lifetime
14.	Subgrade drainage and waterproofing	As needed
15.	Vertical Elements	Lifetime
16.	Horizontal Elements	Lifetime
17.	Interior Partitions	As needed
18.	Electrical – Rough-in	Lifetime
19.	Site Preparation	Lifetime
Categories Included as Infrastructure		
20.	Site Development – Softscape	Infrastructure
21.	Site Development – Hardscape	Infrastructure
22.	Site Development – Distribution	Infrastructure
23.	Site Utilities	Infrastructure

Life Cycle Costing

- LCCA Process:

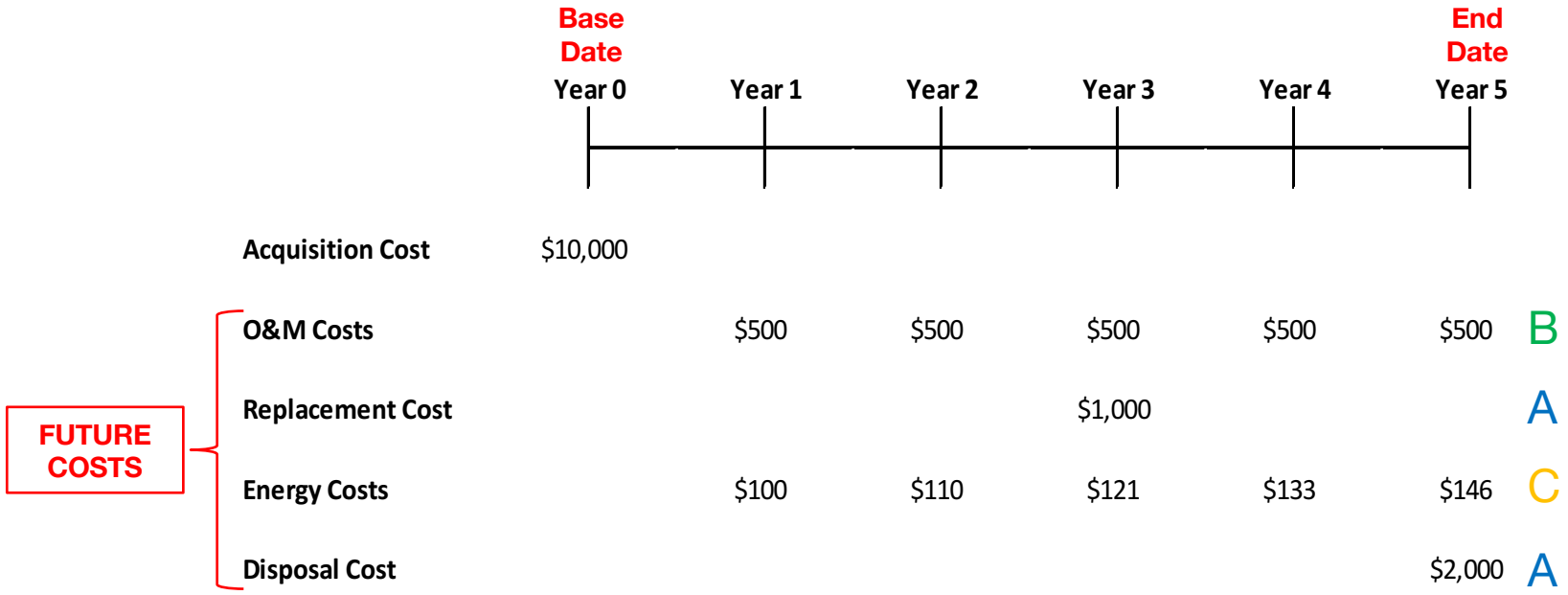
Process Phase	LCCA Goals	Leader
Scoping	• Assign O&M cost benchmark	Capital Planning
Feasibility/ Programming	• Develop O&M cost benchmark in addition to project benchmark (if not done at Scoping) • Hold LCCA work session • Develop LCCA Decision Matrix	Project Manager
Schematic Design (SD)	• Review LCCA Decision Matrix • Determine which LCCA studies to perform • Select cost-effective alternatives based on LCCA studies • Report results of LCCA	Project Manager
Design Development (DD)	• Review LCCA studies to confirm/verify results given project development	Project Manager
Construction Documents (CD)/Permitting	• Confirm value engineering decisions from earlier design phases with LCCA results	Project Manager
Construction	• Outline LCCA elements to contractor • Discuss commissioning and testing requirements	Project Manager
Closeout	• Conduct training program; perform eleventh-month evaluation	Project Manager
Ownership	• Validate LCCA study outcomes and assumptions	Facilities Operation Representative

Life Cycle Costing: Steps

- Steps:

1. Identify Alternatives
   - Consider alternatives which bring value for each project participant and end user
2. Define Constant Parameters
   - Time period and discount rate
3. Identify Costs
   - Operating expenditures (OPEX) and Capital expenditures (CAPEX)
4. Generate LCCs for Each Alternative
   - Evaluate all project alternatives using the same time period and discount rate
5. Performe a LCCA Comparison
   - Compare the net present value of each alternative
   - Compare benefit-to-cost -ratio of best alternatives in order to select the most cost-effective options for the project budget

Example Project A - Cash Flow Diagram



Investor's MARR is 12%

A – Single non-recurring future costs

B – Annually recurring uniform costs

C – Annually recurring non-uniform costs

LCCA

- In Project A, calculating the PW of the various costs:

$PW_{Replacement\ Cost} = F(P/F, 12\%, 3) = \$1{,}000 * (P/F, 12\%, 3)$=\$712

$PW_{Disposal\ Cost} = F(P/F, 12\%, 5) = \$2{,}000 * (P/F, 12\%, 5)$=\$1,135

$PW_{O\&M\ Cost} = A(P/A, 12\%, 3) = \$500 * (P/F, 12\%, 5)$=\$1,802

$PW_{Engery\ \ Cost} = A(P/A, g, i, n) = \$91\left(\frac{P}{A}, 10\%, 12\%, 5\right)$=\$431

Item	Present Value of
Acquisition cost	$10,000
O&M costs	$1,802
Replacement cost	$712
Energy costs	$431
Disposal cost	$1,135
Total Life Cycle Cost	**$14,080**

LCCA

- Supplementary Measures of Economic Performance
- LCCA is the most complete and accurate way to estimate project costs over its lifetime
- Other measures of economic evaluation that supplement LCCA:
  - Net Savings (NS)
  - Savings to Investment Ratio (SIR)
  - Adjusted Internal Rate of Return (AIRR)
- All of these supplementary measures are based on life-cycle costs

Net Savings

- The amount that an alternative project will save over the base case:
- $NS = LCC \quad - \quad LCC$
- NS calculations can be used to determine whether to accept or reject a project (NS > 0)
- A project with the highest NS is equivalent to choosing a project with the lowest LCC

Savings to Investment Ratio

- $SIR = \frac{\text{Operating Savings}}{\text{Investment Costs}}$
- SIR > 1 generally means that a project is cost effective
- Can be used to accept or reject a project
- Useful in ranking and prioritizing independent projects (a higher SIR means higher savings)

Adjusted Internal Rate of Return

- Measures the economic performance of an investment as a % yield
- AIRR is a more accurate measure of return because it adjusts the cash flows using an explicit reinvestment rate
- $AIRR = (1 + i)SIR^{1/n} - 1$
- For projects to be attractive, AIRR > MARR
- Similar to SIR, also useful in ranking and prioritizing independent projects

References:

- Economic and Financial Analysis for Engineering and Project Management, Abol Ardala, Technomic, 2000.
- CIVL 401: Introduction to Capstone Project, Lecture Note, Yitmen, I. East Mediterranean University, 2016.