Learning Objective

1. Definition, objectives and benefits of Life Cycle Costing (LCC)
2. The factors affecting the investment life of a project
3. The applicability of LCC to maintenance
4. The costs and values included in a Life Cycle Costing Exercise
5. The process of implementing a Life Cycle Costing Exercise
6. Data sources used throughout a Life Cycle Costing Exercise

Use of Life Cycle Costing (LCC)

LCC concerns all cost regarding the investment decision, can be used to evaluate:

- Complete building
- Element parts
- Systems
- Components and material
Definition of Life Cycle Costing

“ The present value of the total cost of that asset over its operating life, including

- Capital cost
- Occupation costs
- Operating costs and
- Cost or benefit of the eventual disposal of the asset at the end of its life”

Essentially, it means the total cost that the project will impose throughout its whole life

All future cost are reduced to present value by the use of discounting techniques, and therefore, the economic worth of a project can be assessed.

From Lecture 1 – Life cycle phases of an investment project
Objectives of LCC

LCC is required as decisions made at design stage will impact on the performance (maintenance cost) in the later stage (e.g. air cooled chiller is cheaper for building but expensive to maintain and higher energy cost)

LCC helps to evaluate decisions at design stage, by looking at its economic implications

The specific objectives of LCC includes

1. Evaluate the investment options and opportunities effectively
2. Evaluate the project in term of total (life cycle cost), instead of total initial cost
3. Ensure effective management of asset over its whole life

Such method is getting more popular and is widely accepted
LCC Applications

Applying LCC to decision making process: -

a. As an evaluation technique to choose between options (buildings, components, materials, finishes etc)

b. As a basis for predicting future running costs

c. As a mgt tool – to ensure facility is being used effectively and value for money is being maximized

d. As a basis for budgeting for future expenditure

e. As a mean for considering total cost rather than just capital cost (to guide project decision)

LCC Benefits

The many benefits of LCC includes: -

i. Help to loosen the traditional decision-making process that is based on capital cost. (must recognize that decision today affect tomorrow’s running cost)

ii. LCC promotes strong association with continuous learning and monitoring

iii. Help to build up historical data that serve as the base to identify potential cost reduction zones
**Investment Life**

The outcome of LCC will depend on the following: -

- The life of the project
- The residual value of the asset(s) – base on depreciation
- When there is no longer any use of the asset(s)
- Degree of flexibility (economically and technically) to cope with possible future changes

Building life is influenced by obsolescence. Factor of obsolescence include: -

1. Physical Factors
2. Economic Factors
3. Functional Factors
4. Technological Factors
5. Social and Legal Factors
1. Physical Factors
Concern with:
- Structural integrity of building
- Durability of its component and materials

2. Economic Factors
» Concern with Rate of Return (RR) of the building
» Current use vs future better use (determine by value generated)
» Economically obsolete if unable to generate good revenue based on current use

3. Functional Factors
Consideration of the original intend (purpose) of the bldg
If the use is changed, then some of the facilities may not be useful anymore
For example, factory convert to warehouse, then the big visitors car park may not be required

4. Technological Factors
For example, modern age office needs high speed internet capability. If building cannot accommodate Broadband requirement, then will be consider obsolete

5. Social and Legal Factors
Consideration on appropriateness of bldg in term of indoor environment created, and the associated working condition
For example, having an office in Geylang area (red light district) will have difficulties in getting good ladies worker
Hotel in ill-maintained old pre-war shop house will have difficulties in getting customers
Life Cycle Priorities

The corporate objective of owning an asset varies:

- **Public Sector Client** – concern with customer satisfaction and satisfy social needs
- **Private Sector Client** – concern with overall project profitability (bottom line driven)

Hence the reasons and perception of LCC is also different

### Classification of Clients:

<table>
<thead>
<tr>
<th>Private Sector owner-occupiers</th>
<th>Ones who commission buildings for their own occupation. E.g. factory, NKF building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Sector owner-occupiers</td>
<td>Ones who commission buildings for their own occupation (Central and Local Govt, Nationalized industries) E.g. CPF Bldg, Treasury Bldg etc</td>
</tr>
<tr>
<td>Public Sector Clients</td>
<td>Who build for sale, lease and rental (Devpt Corporations, Local authority Housing Dept) E.g HDB, JTC</td>
</tr>
</tbody>
</table>
### Classification of Clients:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developers</td>
<td>Who prime function is to develop and finance bldgs for sales or rent. The returns on investment may be in terms of occupational rents, or a fixed fee based on performance. E.g. Far East Organization, CDL.</td>
</tr>
<tr>
<td>Financial institutions</td>
<td>Include pensions fund (CPF in Singapore context), insurance companies, property unit trusts, charities, banks. Typically low risk investment.</td>
</tr>
<tr>
<td>Lessee-occupiers</td>
<td>Ones who rent space in a bldg through a landlord-tenant agreement. Each party is permitted to own a separate legal interest. E.g. HDB dwellers, shopping centre tenants etc.</td>
</tr>
</tbody>
</table>
LCC priorities differ from clients, who have different strategic objectives:

| Building Objectives | Short term profit (capital gain)  
|                     | Long term return (investment asset)  
|                     | Satisfy Public Demand (social goods, hospital etc) |

| Building Timescales | Length of ownership depends on:  
|                     | Strategic vision of organization  
|                     | Length of productivity of the project |

| Capital Sources | Investment is affected by the source of finance:  
|                 | Loan  
|                 | Retain profits  
|                 | Government funds or grant |

| Revenue sources | Revenue budget can come from  
|                 | Letting  
|                 | Production turnovers  
|                 | Government sources |

| Tax Position | Depends on tax payable by the company  
|             | Tax rebate etc |
Life Cycle Costing approach is therefore the **Total Cost Approach**

If mgt team for **capital budgeting** not in direct communication with mgt team responsible for **revenue budget**

OR

Both team are not same party

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**Opportunity Cost**

Loss of benefits associated when treating these as 1 budgetary reqts

Higher capital investment usually leads to reduced running costs / lower level of maintenances

This reduction is recurring, and will result in a lower overall cost over the whole life cycle of the asset.

Life Cycle Costing ensure optimization of cost reduction and is widely adopted by long term investors.
Importance of inter-relating budget costs

Best value / Least cost / Highest return option which strengthens the organization’s strategic position

LCC is usually used as a **cost only concept**

It can also measure value effect generated by building expenditure (both public and private sector)

LCC can be used to assess tangible and intangible costs and benefits, with respect to the investment options.
**Costs and Value**

The costs to be considered for Life Cycle Costing should be all cost expenditure throughout the life of a project.

These include:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Costs</strong></td>
<td>Include land, building, professional fees, furniture and equipment</td>
</tr>
<tr>
<td><strong>Financing Costs</strong></td>
<td>Consider flexible funds in terms of amts and sources, effect of alternative funding source, tax implications</td>
</tr>
<tr>
<td><strong>Operating Costs</strong></td>
<td>Estimate of rent, rates, levies, energy costs, building related staffing cost</td>
</tr>
<tr>
<td><strong>Annual and Intermittent Maintenance Costs</strong></td>
<td>Yearly or intermittent estimate can be done once details of building design is done. Can be done in association with equipment manufacturers</td>
</tr>
<tr>
<td><strong>Replacement and Alteration Costs</strong></td>
<td>Estimate is derives from normal quantity surveying techniques</td>
</tr>
</tbody>
</table>
# Costs and Value

| Occupancy Costs | Cost of performing the function (which the asset / bldg is brought for)  
May change throughout the life of the asset  
Cost that are not directly related to the building |
|-----------------|------------------------------------------------------------------------|
| Residual Values and Disposal Costs | The resale value of the bldg, asset or land, and cost of disposing the bldg / plants / other assets  
after the expiry of their lifecycle  
May have major impact on the life cycle costing calculations  
May need to estimate some of these costs, and all assumptions made must be clearly stated. |
Capital and running costs of a building investment
Life Cycle Costing Implementation

7 Steps approach to Life Cycle Costing Implementation

1. Establish the Objectives
2. Choose a Method
3. Formulate Assumptions
4. Identify the Costs and Rank the Alternatives
5. Compare Costs and Rank the Alternatives
6. Perform a Sensitivity Analysis
7. Investigate Capital Cost Constraints
Step 1 – Establish the Objectives

♦ Most important step is to define what the project intend to achieve (its objective)

♦ Can be any objective, range from material selection, commission of new system etc

♦ Objective must be clear, unambiguous and unbiased

♦ Should not make prior judgment within the objective

Step 2 – Choose a Method

♥ Next is to determine the range of feasible alternatives to achieve the objective

♥ All realistic alternative should be considered to assist decision making
Step 3 – Formulate Assumptions

LCC deals with future costs and expenditure, hence there is uncertainty

♣ Assumptions will have to be made to proceed with the analysis

♣ Hence all assumptions made must be clearly and explicitly stated.

♣ Estimate should not be used, if factual data is available. Always use factual data

♣ Assumption maybe, consideration for price escalation in labor / energy / material costs
Step 4 – Identify the Costs and the Life Cycle

♦ Within every alternative, the life cycle of the project, individual component etc must be considered

♦ All costs must be considered for every stage throughout the entire project period

♦ This is not easy to achieve, and may need many assumptions

Step 5 – Compare Costs and Rank the Alternatives

Various techniques are available to rank the alternative

Such as

- Net Present Value
- Savings-Investment Rations
- Internal Rate of Return
- Annual Equivalent Value
Step 6 – Sensitive Analysis

- After ascertaining the most suitable Alternative via Step 5, test the sensitivity of the analysis to certain dominant cost factors and assumptions
- This will provide a clearer picture to the decision maker

Step 7 – Investigate Capital Cost Constraints

» The initial costs of all alternatives should be aggregated to ensure they do not exceed the total funding available

» If exceed, then certain trade off should be explored so that the lowest life cycle cost is achieved within the funding limits set
The Life Cycle Costing process

3.1 Overview

As shown in the attached diagram, Life Cycle Costing is a six-staged process. The first four stages comprise the Life Cost Planning phase with the last two stages incorporating the Life Cost Analysis phase. The six stages are:

- **Stage 1:** Plan LCC Analysis
- **Stage 2:** Select/Develop LCC Model
- **Stage 3:** Apply LCC Model
- **Stage 4:** Document and Review LCC Results
- **Stage 5:** Prepare Life Cost Analysis
- **Stage 6:** Implement and Monitor Life Cost Analysis
A Life Cycle Cost Summary


Figure 1: Life Cycle Costing Process
The Time Value of Money

Throughout the life of a project, many different costs will arise at different time periods.

Need to express all these cashflow in a common manner.

Many available techniques to convert future cash outlays to their current equivalent.

Not appropriate to use Payback Period to ascertain the feasibility of the project, as it did not take into account, the project life span.

Payback Period also did not take into account the time value of money.

Discounting refers to the method of converting future money into its current equivalent.

The rate which future money is discounted, is known as the time value of money.

\[ PV \text{ of } x = \frac{x}{(1+r)^2} \]

\( x \) is received in \( t \) years time, with an interest of \( r \) worth of present value.
Different discount rate will have significant effect on the present value calculation.

\[
\text{interest rate} \quad = \quad \text{present value of the future cost}\]

the present value of future one-time costs the following formula is used:

\[ PV = A_t \times \frac{1}{(1 + d)^t} \]

Where:
- \( PV \) = Present Value
- \( A_t \) = Amount of one-time cost at a time \( t \)
- \( d \) = Real Discount Rate
- \( t \) = Time (expressed as number of years)

To determine the present value of future recurring costs the following formula is used:

\[ PV = A_0 \times \frac{(1 + d)^t - 1}{d \times (1 + d)^t} \]

Where:
- \( PV \) = Present Value
- \( A_0 \) = Amount of recurring cost
- \( d \) = Real Discount Rate
- \( t \) = Time (expressed as number of years)
## Data Sources for Life Cycle Costing

The 3 fundamental requirements in implementation of LCC

- A system
- Data
- Professional skill and judgment

<table>
<thead>
<tr>
<th><strong>System</strong></th>
<th>Provides a set of rules and procedures for techniques to follow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
<td>Required for analysis and decision making</td>
</tr>
<tr>
<td></td>
<td>Impose reasonable limits on uncertainty of data received</td>
</tr>
<tr>
<td></td>
<td>Sometimes need to forecast and analyse the data for decision making</td>
</tr>
<tr>
<td><strong>Professional skill and judgement</strong></td>
<td>Skills set required to exercise a good judgement call on the source and reliability of data, which alternative to select</td>
</tr>
</tbody>
</table>
Source of Data
Can exist in several form: -
  • Physical
  • Performance
  • Qualitative
  • Cost Centre etc

Source of Cost Data
LCC is concerned with cost data analysis
Form of Cost Data includes: -
  1. Data from specialist manufacturers, suppliers and contractors
  2. Data from model building
  3. Historical Data
1. Data from specialist manufacturers, suppliers and contractors

For specialized building components, the specialist manufacturer will have the
detailed knowledge of the performance characteristics of their materials and
components

This is a valuable source for LCC info

- Data obtainable include
- Expected operating life span
- Maintenance requirements
- Energy Use
- Cleaning requirements etc

Specialist Contractor can also provide advice at design stage on the cost
implications of various choices and design decisions.

A lot of info given is base on “best guess”, but it is still better than no info at
all

Check data gathered against performance characteristic, to ensure greater
accuracy and reliability
2. Data from modeling

- The objective of modeling is to reduce a complex system, to its component parts.
- This will capture the fundamental properties of a complex system
- Model can only give the approximate reality, but cannot be 100% accurate
- Modeling data is useful when there is no historical data. It is important at design stage to provide some basic info for design brief
- Modeling can be used to provide design parameters such as:
  - Heating requirements
  - Lighting requirements
  - Ventilation requirements
  - Window area
  - Choice of materials
  - Emergency evacuation
  - Energy requirement
  - Cleaning costs

**Modeling** usually is used with cost estimate

1. To check on data output is of the right order of magnitude
2. To ensure it is in line with estimate from specialist practitioners
3. Historical Data

* Historical data will produce profiles of initial costs and running costs.
* After breaking down into initial cost and running costs of any building to analyze, an indication will emerge as to which areas of the LCC approach is more effective in reducing the total building costs.
* E.g. building foundation is very costly to build (high initial cost), but may have
* very low subsequent running cost. This info gain through LCC for this component is not very useful.
* For component that need recurring maintenance cost, by varies the design, it will affect the LCC significantly.
* Hence usefulness of historical data is very subjective.
**Life Cycle Costing in Practice**  
**Advantages of LCC**

| Encourages Long-Term Strategic Planning | LCC encourages forward planning and consideration of future costs  
This will assist in forming a fully accurate cost for the entire project, instead of one particular aspect of it |
|---|---|
| Supports downstream strategic budgeting | LCC will produce high quality early estimate, that can be used to prepare budget  
This is known as strategic budgeting  
This is difficult to implement but very useful if it is done properly |
| Influences the overall cost viability of the project | Construction no longer become a cost window.  
It is part of the many windows. Hence, decision on high cost can be made, taking into account the subsequent low running cost  
LCC allows various phases to be put into perspective, and highlight area where input is required |
| Influences early stage decision making | LCC will affect early stage decision  
For 2 identical investments of similar costs, its running cost may be totally difference. It is wrong to consider just their capital cost alone.  
By using LCC, early stage decision will also take into consideration subsequent running cost |
## Life Cycle Costing in Practice

### Disadvantages of LCC

| The assumption of a known and deterministic life cycle | Some projects may not have a known life cycle Hence not possible to predict accurately on many aspects of the project life cycle The unknown factors may have significant effect on the overall project cost |
| High cost of performance | High cost due to planning and analysis works, if LCC model is to be accurate. As it involves complex cost model that is costly to set up and operate |
| High sensitivity to changing requirements | Because the model is very complex, it is highly sensitive to change input data Small changes in the current situation or conditions may have a considerable impact on the future cost |
Applicability of LCC to maintenance

In UK, the LCC approach is becoming more popular in the construction industry

This increase popular in strategic LCC planning is due to the following:

- Increase in legislation standards
- Increase in disposal cost
- Increase in de-commissioning costs
- Increase in maintenance costs

3 examples in application of LCC to maintenance

Example 1 - Selection of components
Example 2 – Inspection and Testing
Example 3 – Integrated Logistics Support (ILS)
Example 1 - Selection of Components

At the outline proposal stage, the choice of material for various building element are determined

The architect normally don’t take LCC as basis of their decision criteria. Their selection criteria is usually based on: -

- Aesthetic appeal
- Capital cost
- Availability and delivery dates
- Past experience

1. Programmed maintenance costs
2. Responsive maintenance costs
3. Cyclic maintenance costs
4. Disposal cost
5. Running costs / costs in use
6. Modification of use costs
7. Expansion costs

The architect normally will neglect long term cost implications on the choice of material
1. Programmed maintenance cost

This include all future replacement cost. Regardless of any elements, it has to be replaced at some point, be it in phases or all at one go. Choice should have take this into account.

Also, need to give consideration that:

- Whether to replace all related element at same time (i.e. Replace the heat insulation while doing re-roofing) or
- Design element with proper access to allow part by part replacement, without affecting each other

Hence, estimated life span of all components must be compatible.

2. Responsive maintenance cost

- All elements or its part, will fail at some point of time, regardless how well it is being designed, as such, responsive maintenance are required.
- The responsive maintenance costs are based on responses to random failures.
- At design stage, can only prevent high responsive maintenance costs by choosing items that will not break easily or not going to fail regularly.
- Next, is to ensure proper access are proper to facilitate replacement works and cut down the cost implication of ad-hoc replacement works.

The criteria that will affect the long term cost include:

-
3. Cyclic Maintenance Costs

😊 Cyclic maintenance refers to those costs that are known to be required on a set (periodic) basis

😊 E.g. painting of external façade on 5 yearly basis, not doing it will result in external condition deterioration and possibility of external wall seepage

😊 The cyclic period can be determined quite easily, and normally use as a trade off to responsive maintenance

😊 There are some overlapping between cyclic maintenance cost, responsive maintenance cost and programmed maintenance cost.

😊 These 3 costs should be considered as part of the strategic LCC process
4. Disposal cost

- Disposal cost are rarely considered.
- Hence, very thought is given to it at the design stage.
- The disposal cost are increasing expensive, as it is no longer acceptable to just abandon the building or site and leave it to rot.
- This is because the relevant authorities usually exercise Strict regulation on land de-contamination (e.g unused nuclear power station) and Reclamation (e.g. dock land).
- Such measure are usually very costly.

5. Running costs / costs in use

Include all costs in association with the use of the building.

Such cost will include: - heating, lighting, natural light (heat loss problem, green house effect) Vs artificial lighting (energy cost), cooling etc.

Point of debate is usually:-

Higher initial cost will result must savings in operational life span or Lower initial cost with an eventual increase in running cost.

E.g. choice of chillers, air-cool or water-cool??
6. Modification of use costs

- Many buildings experience changes in use over the years
- This is more the case in industrial and commercial buildings
- Good example of such scenarios will be the increase needs to cater more infrastructure due to new IT requirements, broadband networks etc. more energy requirement, new fiber optic cables.
- Building’s current provision, in term electrical loading, or ducting size, may not meet the requirement, hence need to be upgraded

7. Expansion Costs

- Most industries will expand
- Easy to design building based on current use and requirements, without take into consideration of future expansion needs
- This applies easily to standard industrial units such as factories
- Factories are usually designed in standard portal frames, that can beeasily expand through the gables.
Example 2 – Inspection and Testing

» Inspection and testing are essential in ensuring good, quality works are been (don’t inspect, don’t expect)

» One of the common cost reduction measure is to reduce the cost of maintenance and repair, or responsive maintenance repair, by reducing the time allocated to inspect (both before and after the works)

» This can show immediate savings, but this will result in potential unnecessary repairs or defective workmanship, which will chalk up potential recurring repair cost
Sample of Project Evaluation using LCC

<table>
<thead>
<tr>
<th></th>
<th>Alternate #1</th>
<th>Alternate #2</th>
<th>Alternate #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Investment Cost</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Operations Cost</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Maintenance &amp; Repair Cost</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Replacement Cost</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Residual Value</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Total Life Cycle Cost</strong></td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>GSF of Project</td>
<td>1 GSF</td>
<td>1 GSF</td>
<td>1 GSF</td>
</tr>
<tr>
<td>Initial Cost/ GSF</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>LCC/ GSF</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
</tbody>
</table>