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TOTAL ASSET MANAGEMENT

Life Cycle Costing Guideline

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LIFE CYCLE COSTING - GUIDELINE

1 Introduction

1.1 Why use Life Cycle Costing?

The determination of costs is an integral part of the asset management process and is a common element of many of the asset manager's tools, particularly Economic Appraisal, Financial Appraisal, Value Management, Risk Management and Demand Management.

In the past, comparisons of asset alternatives, whether at the concept or detailed design level, have been based mainly on initial capital costs.

Growing pressure to achieve better outcomes from assets means that ongoing operating and maintenance costs must be considered as they consume more resources over the asset's service life.

> For example, the operating costs of a hospital consume an equivalent of the capital cost every two to three years and can continue to do so for forty years or more. The operating costs of a school can consume the equivalent of its capital cost every four to five years and remain in service for a century.

Both the capital and the ongoing operating and maintenance costs must be considered wherever asset management decisions involving costs are made. This is the Life Cycle Cost approach.

Life Cycle Costing is a process to determine the sum of all the costs associated with an asset or part thereof, including acquisition, installation, operation, maintenance, refurbishment and disposal costs. It is pivotal to the asset management process as an input to the evaluation of alternatives via Economic Appraisal, Financial Appraisal, Value Management, Risk Management and Demand Management.

There is an Australian Standard on Life Cycle Costing (AS4536) that includes examples of the application of Life Cycle Costing in its appendices.

1.2 What is Life Cycle Costing?

The Life Cycle Cost (LCC) of an asset is defined as:

*" the **total cost** throughout its life including planning, design, acquisition and support costs and any other costs directly attributable to owning or using the asset".*

Life Cycle Costing adds all the costs of alternatives over their life period and enables an evaluation on a common basis for the period of interest (usually using discounted costs). This enables decisions on acquisition, maintenance, refurbishment or disposal to be made in the light of full cost implications.

Life cost planning

Life Cost Planning concerns the assessment and comparison of options/alternatives during the design/ acquisition phase. It utilises similar techniques as those for Economic Appraisal in that future, nominal costs are discounted to today's dollar Discounted Cost.

The application of Discounted Cost analyses to *Life Cost Planning* differs from that in *Economic Appraisal* in that *Life Cost Planning* generally:

- considers all cost components within asset options over the asset's life

- does not directly consider benefits or revenue streams that are generally assumed to be equal among the options being compared (benefits and revenues are considered in the evaluation of options).

Life cost analysis

Life Cost Analysis enables the creation, operation and disposal costs of a selected alternative to be monitored throughout its life to enable accurate and timely decision-making as to how these costs can be minimised. Where ownership of the asset changes over time, each owner, takes responsibility for decisions required during the period of ownership only.

Life Cost Analysis is used as the basis for monitoring and management of costs over an asset's life. It is essentially a financial management tool costs are generally not expressed as *real or discounted costs* but as *nominal costs* (ie. estimated costs that are to be paid when due) to enable a comparison of the predicted cost and the actual cost. This enables better prediction and adjustment of the Life Cycle Costing model (LCC).

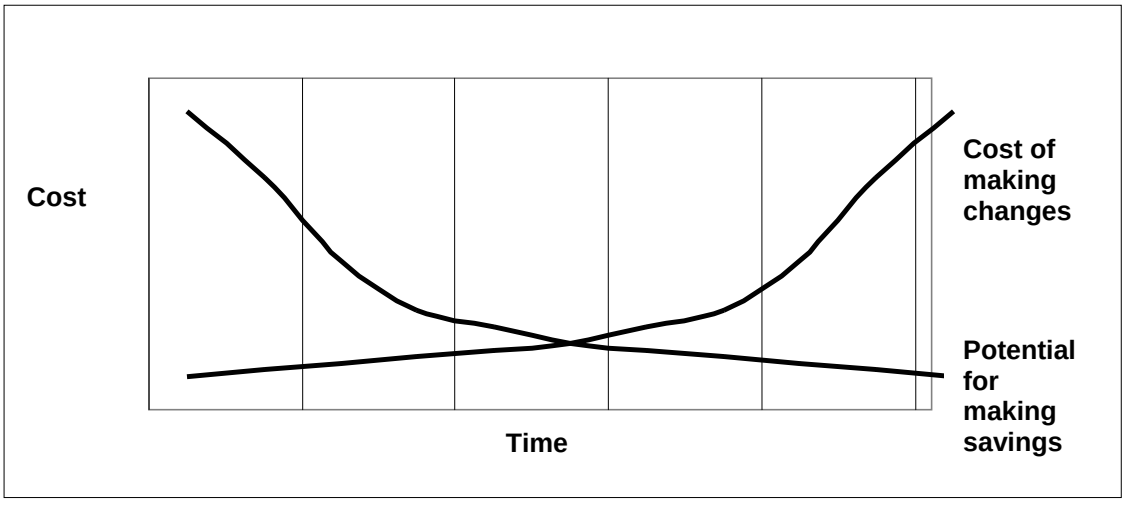
Appendix A provides a summary of the discounting concept along with an explanation of the differences between *real*, *discounted* and *nominal* costs.

1.3 Distribution of costs over the asset life cycle

Life Cycle Costing can be carried out during any or all phases of an asset's life cycle. It can be used to provide input to decisions regarding asset design, manufacture, installation, operation, support and disposal.

By the end of the concept and definition phases of acquisition, more than half of the asset's life costs may be committed by decisions made with respect to asset features, performance, reliability, technology, and support resources. By the end of design and development phases, even more of the asset's life costs may be fixed. The interaction between potential savings and asset costs is shown in *Figure 1 - Potential Savings and Cost Relationship.* Early identification of acquisition and ownership costs enables the decision-maker to balance performance, reliability, maintainability, maintenance support and other goals against life cycle costs. Decisions made early in a asset's life cycle have a much greater influence on Life Cycle Costing than those made late in a asset's life cycle, leading to the development of the concept of discounted costs.

Figure 1 Potential Savings and Cost Relationship



1.4 Linkages with Total Asset Management

TAM reflects priorities for whole-of-life asset management, extended planning requirements for new works, and new relationships between services planning and asset procurement activities.

Costs may change and accumulate as a program or project progresses. Initial provisions made to manage whole-of-life costs should be evaluated and updated before committing to one alternative. A LCC model provides a mechanism to compare these costs.

2 Modelling life cycle costs

2.1 Life Cycle Costing models

LCC model is an accounting structure containing terms and factors which enable estimation of an asset's component costs.

a number of commercially available models can be used for LCC analysis. However, in some cases it may be appropriate to develop a model for a specific application. In either case, the LCC model should:

- represent the characteristics of the asset being analysed including its intended use environment, maintenance concept, operating and maintenance support scenarios and any constraints or limitations
- be comprehensive enough to include and highlight the factors relevant to the asset LCC
- be easily understood to allow timely decision- making, future updates and modification
- provide for the evaluation of specific LCC elements independently of other elements.

Before selecting a model, the purpose of the analysis and the information it requires should be identified. The model should also be reviewed with respect to the applicability of all cost factors, empirical relationships, constants, elements and variables.

2.2 LCC breakdown into asset cost elements

Estimating the total LCC requires breakdown of the asset into its constituent cost elements over time. The level to which it is broken down will depend on the purpose and scope of the LCC study and requires identification of:

- significant cost generating activity components
- the time in the life cycle when the work/activity is to be performed
- relevant resource cost categories such as labour, materials, fuel/energy, overhead, transportation/travel and the like.

Costs associated with LCC elements may be further allocated between recurring and non-recurring costs. LCC elements may also be estimated in terms of fixed and variable costs.

To facilitate control and decision-making and to support the Life Cycle Costing process, the cost information should be collected and reported in a manner consistent with the defined LCC breakdown structure.

2.3 Estimating asset cost elements

The method used to estimate asset cost elements in LCC calculations will depend on the amount of information needed to:

- establish asset use patterns and operational characteristics and hence expected asset life
- understand the technology employed in the asset.

Sources of cost data

By definition, detailed cost data will be limited in the early stages of the asset life, particularly during the design/acquisition phase. Cost data during these early stages will need to be based on the cost performance of similar asset components currently in operation.
Where new technology is being employed, data can only be based on estimated unit cost parameters such as $/construction unit, construction unit/labour hours, specified or suggested by the technology.

More information on asset component costs will become available during use of the asset, enabling more complete and descriptive costs to be defined.

Methods of analyses

One or more of the following methods for analysing cost data should be used.

Engineering cost method

The Engineering Cost Method is used where there is detailed and accurate capital and operational cost data for the asset under study. It involves the direct estimation of a particular cost element by examining the asset component-by-component.

It uses standard established cost factors (eg. firm engineering and/or manufacturing estimates) to develop the cost of each element and its relationship to other elements (known as Cost Element Relationships - CER).

Analogous cost method

This method provides the same level of detail as the Engineering Cost Method but draws on historical data from components of other assets having analogous size, technology, use patterns and operational characteristics.

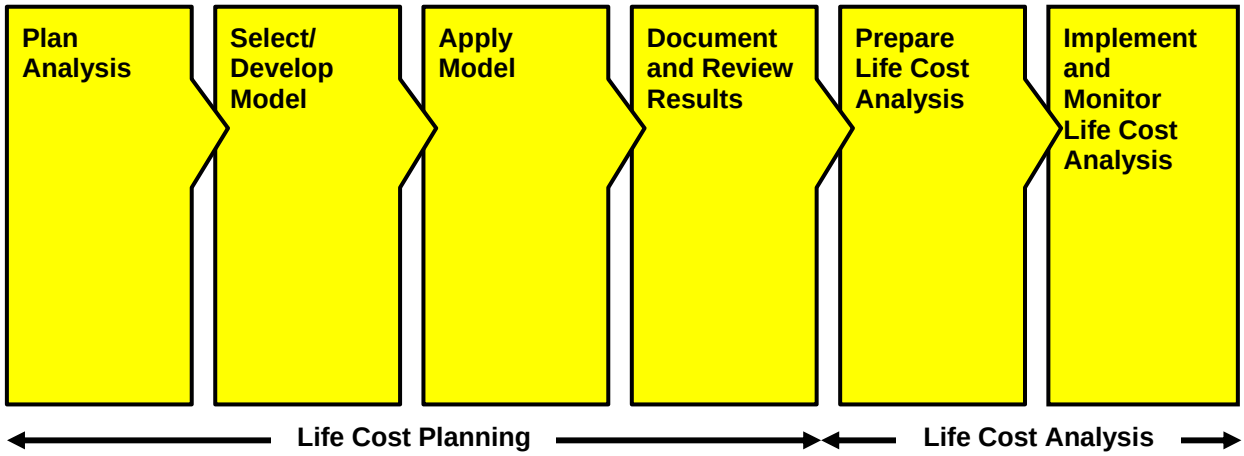
Parametric cost method

The Parametric Cost Method is employed where actual or historical detailed asset component data is limited to known parameters.

This available data from existing cost analyses is used to develop a mathematical regression or progression formula that can be solved for the cost estimate required.

> AS 4536 contains an example of regression analyses to find the cost per vehicle to undertake new delivery routes based on known delivery costs and known route distances. A formula of the form $y=a+bx$ is then solved for the required route.
> (y is vehicle costs, a is a transport constant, b is the slope of the regression line and x is the route distance)

3 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:

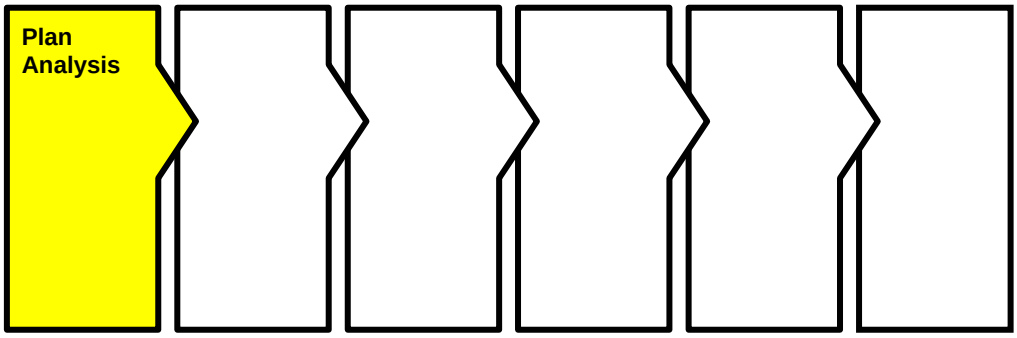
- Stage 1: Plan LCC Analysis
- Stage 2: Select/Develop LCC Model
- Stage 3: Apply LCC Model
- Stage 4: Document and Review LCC Results
- Stage 5: Prepare Life Cost Analysis
- Stage 6: Implement and Monitor Life Cost Analysis

All stages may be performed iteratively as needed. Assumptions made at each stage should be rigorously documented to facilitate such iterations and to aid in interpretation of the results of the analysis.

LCC analysis is a multi-disciplinary activity. An analyst should be familiar with the philosophy, which underlies Life Cycle Costing (including typical cost elements, sources of cost data and financial principles), and should have a clear understanding of the methods of assessing the uncertainties associated with cost estimation.

Depending upon the scope of the analysis, it will be important to obtain cost inputs from individuals who are familiar with each of the phases of the asset life cycle. This may include representatives of both the supplier(s) and the user(s).

Stage 1 Plan LCC analysis



The Life Cycle Costing process begins with development of a plan, which addresses the purpose, and scope of the analysis. The plan should:

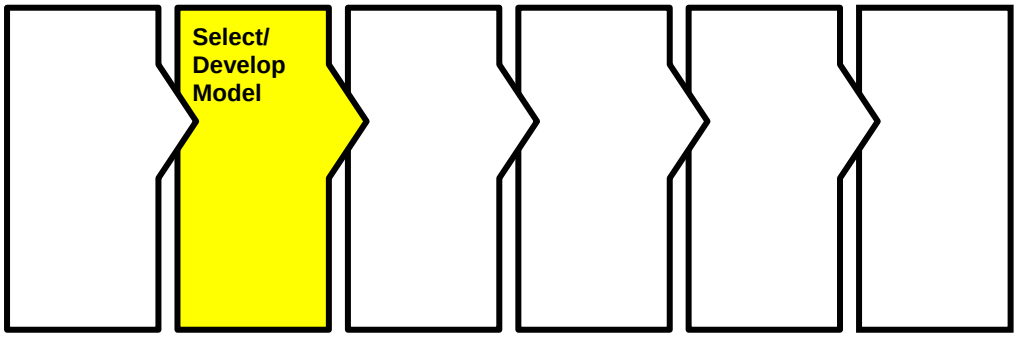
- define the analysis objectives in terms of outputs required to assist management decisions. Typical objectives are:

  - determination of the LCC for an asset in order to assist planning, contracting, budgeting or similar needs
  - evaluation of the impact of alternative courses of action on the LCC of an asset (such as design approaches, asset acquisition, support policies or alternative technologies)
  - identification of cost elements which act as cost drivers for the LCC of an asset in order to focus design, development, acquisition or asset support efforts.

- delineate the scope of the analysis in terms of the asset(s) under study, the time period (life cycle phases) to be considered, the use environment and the operating and maintenance support scenario to be employed.
- Identify any underlying conditions, assumptions, limitations and constraints (such as minimum asset performance, availability requirements or maximum capital cost limitations) that might restrict the range of acceptable options to be evaluated.
- Identify alternative courses of action to be evaluated. The list of proposed alternatives may be refined as new options are identified or as existing options are found to violate the problem constraints.
- Provide an estimate of resources required and a reporting schedule for the analysis to ensure that the LCC results will be available to support the decision-making processes for which they are required.

The plan should be documented at the beginning of the Life Cycle Costing process to provide a focus for the rest of the work. Intended users of the analysis results should review the plan to ensure their needs have been correctly interpreted and clearly addressed.

Stage 2 Select/develop LCC model

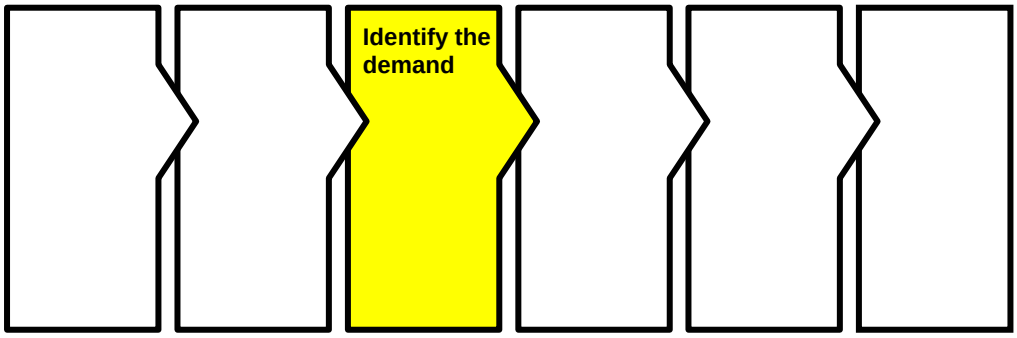


Stage 2 is the selection or development of an LCC model that will satisfy the objectives of the analysis.

The model should:

- create or adopt a cost breakdown structure (CBS) that identifies all relevant cost categories in all appropriate life cycle phases. Cost categories should continue to be broken down until a cost can be readily estimated for each individual cost element. Where available, an existing cost breakdown structure may provide a useful starting point for development of the LCC breakdown structure (see Section 2.2).
- identify those cost elements that will not have a significant impact on the overall LCC of the asset(s) under consideration or those that will not vary between alternatives. These elements may be eliminated from further consideration
- select a method (or methods) for estimating the cost associated with each cost element to be included in the model (see Section 2.3).
- determine the data required to develop these estimates, and identify sources for the data.
- identify any uncertainties that are likely to be associated with the estimation of each cost element.
- integrate the individual cost elements into a unified LCC model, which will provide the LCC outputs required to meet the analysis objectives.
- review the LCC model to ensure that it is adequate to address the objectives of the analysis.
- the LCC model including all assumptions should be documented to guide and support the subsequent phases of the analysis process.

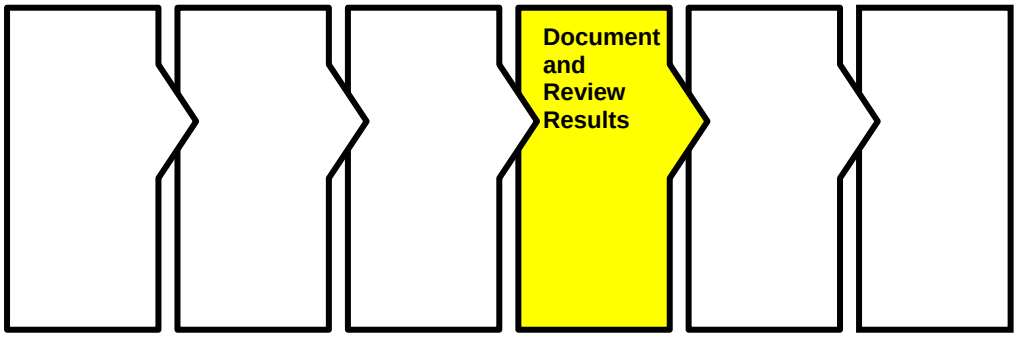
Stage 3 Apply LCC model



Application of the LCC Model involves the following steps:

- obtain data and develop cost estimates and their timing for all the basic cost elements in the LCC model.
- validate the LCC model with available historical data if possible.
- obtain the LCC model results from each relevant combination of operating and support scenarios defined in the analysis plan.
- identify cost drivers by examining LCC model inputs and outputs to determine the cost elements that have the most significant impact on the LCC of the asset(s).
- quantify any differences (in performance, availability or other relevant constraints) among alternatives being studied, unless these differences are directly reflected in the LCC model outputs.
- categorise and summarise LCC model outputs according to any logical groupings, which may be relevant to users of the analysis results (eg. fixed or variable costs, recurring or non-recurring costs, acquisition or ownership costs, direct or indirect costs).
- conduct sensitivity analyses to examine the impact of variations to assumptions and cost element uncertainties on LCC model results. Particular attention should be focused on cost drivers, assumptions related to asset usage and different discount rates.
- review LCC outputs against the objectives defined in the analysis plan to ensure that all goals have been fulfilled and that sufficient information has been provided to support the required decision. If the objectives are not met, additional evaluations and modifications to the LCC model may be required.
- the LCC analysis (including all assumptions) should be documented to ensure that the results can be verified and readily replicated by another analyst if necessary.

Stage 4 Document and review LCC results



The results of the LCC analysis should be documented to allow users to clearly understand both the outcomes and the implications of the analysis along with the limitations and uncertainties associated with the results. The report should contain the following.

Executive Summary: a brief synopsis of the objectives, results, conclusions and recommendations of the analysis.

Purpose and Scope*:* a statement of the analysis objective, asset description including a definition of intended asset use environment, operating and support scenarios, assumptions, constraints and alternative courses of action considered.

LCC Model Description: a summary of the LCC model, including relevant assumptions, the LCC breakdown structure and cost elements along with the methods of estimation and integration.

LCC Model Application: a presentation of the LCC model results including the identification of cost drivers, the results of sensitivity analyses and the output from any other related analyses.

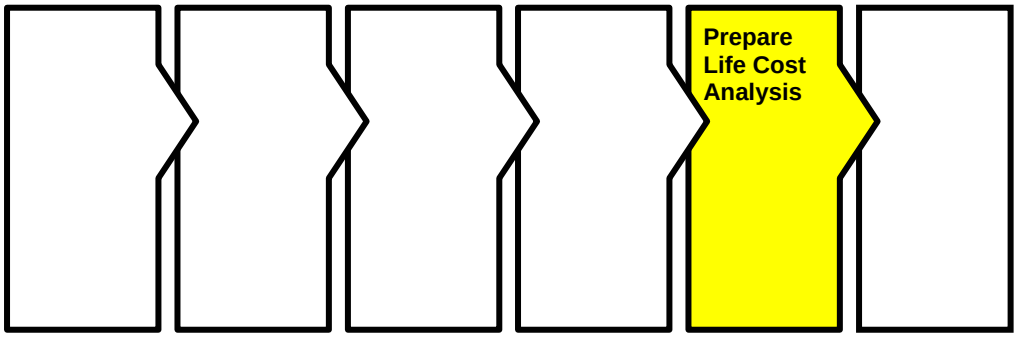
Discussion: discussion and interpretation of the results including identification of uncertainties or other issues which will guide decision makers and users in understanding and using the results.

Conclusions and Recommendations: a presentation of conclusions related to the objectives of the analysis and a list of recommendations along with identification of any need for further work or revision of the analysis.

A formal review of the analysis process may be required to confirm the correctness and integrity of the results, conclusions and recommendations presented in the report. If such a requirement exists someone other than the original analysts should conduct the review (to ensure objectivity).
The following elements should be addressed in the review:

- the objectives and scope of the analysis to ensure that they have been appropriately stated and interpreted
- the model (including cost element definitions and assumptions) to ensure that it is adequate for the purpose of the analysis
- the model evaluation to ensure that the inputs have been accurately established, the model has been used correctly, the results (including those of sensitivity analysis) have been adequately evaluated and discussed and that the objectives of the analysis have been achieved
- all assumptions made during the analysis process to ensure that they are reasonable and that they have been adequately documented.

Stage 5 Prepare life cost analysis

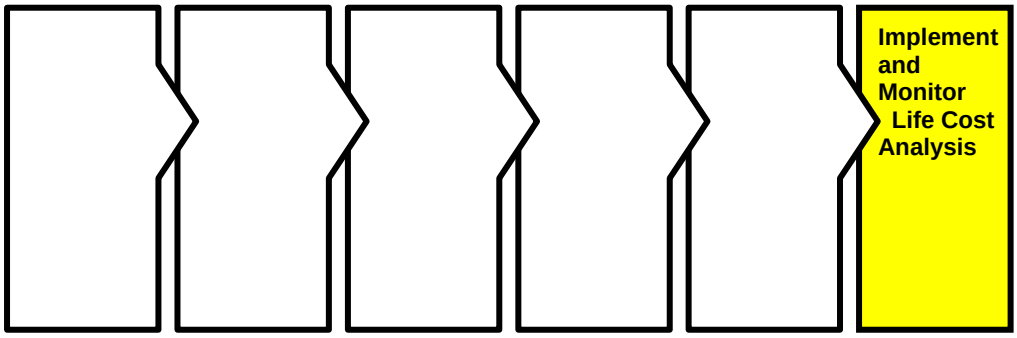


The Life Cost Analysis is essentially a tool, which can be used to control and manage the ongoing costs of an asset or part thereof. It is based on the LCC Model developed and applied during the Life Cost Planning phase with one important difference: it uses data on nominal costs.

The preparation of the Life Cost Analysis involves review and development of the LCC Model as a "real-time" cost control mechanism. This will require changing the costing basis from discounted to nominal costs. Estimates of capital costs will be replaced by the actual prices paid. Changes may also be required to the cost breakdown structure and cost elements to reflect the asset components to be monitored and the level of detail required.

Targets are set for the operating costs and their frequency of occurrence based initially on the estimates used in the Life Cost Planning phase. These targets may change with time as more accurate data is obtained, either from the actual asset operating costs or from benchmarking with other similar assets.

Stage 6 Implement and monitor life cost analysis



Implementation of the Life Cost Analysis involves the continuous monitoring of the actual performance of an asset during its operation and maintenance to identify areas in which cost savings may be made and to provide feedback for future life cost planning activities.

For example, it may be better to replace an expensive building component with a more efficient solution prior to the end of its useful life than to continue with a poor initial decision.

Appendix A The Concept of discounting and its application

A1 The discount rate and its components

Since asset component costs for differing options occur at varying times throughout the asset life cycle, they can only be compared by reducing them to costs at a common base date.
This is achieved through the well-known process of discounting that reflects the net changes in the real *value* of an asset component as a result of:

- decreases in value due to inflation
- increases in value due to the (potential) interest earned if the money expended on the asset component was otherwise invested.

The discounting of costs takes account of three elements:

- the interest rate available from long term investment in bank or government bonds
- the interest rate that business would expect as a return for risk
- the inflation rate that would affect the purchasing power of the currency.

The real discount rate makes allowance for A and B.

The nominal discount rate makes allowance for A, B and C.

Discounting does not incorporate changes due to price movements as a result of changes in efficiency, technology, etc. since these are in essence real changes in value.

The discount rate reflects the net changes in real value due to the compounding effect of interest (potentially) earned on money and the discounting effects of inflation as expressed in the following formula.

The Discount Rate reflects the real rate of interest at which money is borrowed or lent ie. the absolute (or nominal) interest rate at which money is borrowed or lent discounted for the effects of inflation. Consequently, the terms *discount rate* and *real interest rate* are synonymous.

A2 Nominal, real and discounted costs

For the purposes of discounting, there are three relevant expressions of asset component costs. These are:

Nominal Cost, C_N

The expected price that will be paid when a cost is due to be paid (ie. including inflation and price movements due to changes in efficiency, technology, etc.)

Real Cost, CR

The cost expressed in values of the base date excluding inflation but including price movements due to changes in efficiency, technology, etc.

Discounted Cost, CD

The Real Cost discounted by the Real Discount Rate which is equivalent to the Nominal Cost discounted by the Nominal Interest (or Discount) Rate.

The Discounted Cost is thus often referred to as *the Net (or Discounted) Present Value*.

Therefore, for an asset component having a Nominal Cost, C_N in Year *n*, then the Real Cost (or Present Value), C_R at the base date (Year 0) is given by:

$$C_R = C_N(1+f)^{-n}$$

and the Discounted Cost (or Net Present Value), C_D at the base date (Year 0) is thus:

$$\begin{aligned} C_D &= C_R(1+d)^{-n} \\ &= C_N(1+f)^{-n}(1+d)^{-n} \\ &= C_N(1+f)^{-n}\frac{(1+i)^{-n}}{(1+f)^{-n}} \\ &= C_N(1+i)^{-n} \end{aligned}$$

$$(1+\mathrm{d}) = \frac{(1+\mathrm{i})}{(1+\mathrm{f})}$$

$$\mathrm{d} = \frac{(1+\mathrm{i})}{(1+\mathrm{f})} - 1$$

where d = (Real) Discount Rate

i = Nominal Interest (or Discount) Rate

f = Inflation Rate

For this reason, *i* is often referred to as *the Nominal Discount Rate* since it is the rate applied when discounting Nominal Costs.