

LIFE CYCLE COST CALCULATIONS

Fundamental Concepts

Time Value of Money

The value of money today and money that will be spent in the future are not equal. This concept is referred to as the “time value of money”. The time value of money results from two factors: (1) inflation, which is erosion in the value of money over time, and (2) opportunity cost. For cash or existing capital, opportunity cost is equivalent to the benefit the cash could have achieved had it been spent differently or invested. For borrowed money, opportunity cost is the cost of borrowing that money (e.g., the loan rate).

Inflation

Inflation reduces the value or purchasing power of money over time. It is the result of the gradual increase in the cost of goods and services due to economic activity. By eliminating inflation from all escalation and discount rates, estimates of future costs can be made in current dollars and then returned to present value with the proper formulas. An estimate of the future behavior of inflation rates can be avoided.

The following formula factors inflation out of any nominal rate:

$$REAL = \frac{1+NOMINAL}{1+INFLATION} - 1$$

Where:

REAL is the real rate

NOMINAL is the nominal rate

INFLATION is the inflation rate

Discount

Project costs that occur at different points in the life of a building cannot be compared directly due to the varying time value of money. They must be discounted back to their present value through the appropriate equations. The discount rate is defined in terms of opportunity cost.

The basic discount equation is as follows:

$$PV = \frac{F_Y}{(1 + DISC)^Y}$$

Where:

PV is the present value (in year 0 dollars)

FY is the value in the future (in Year Y dollars)

DISC is the discount rate

Y is the number of years in the future

Escalation

Most goods and services do not have prices that change at exactly the same rate as inflation. On average over time, however, the rate of change for established commodities is close to the rate of inflation.

Like discount rates, escalation rates are adjusted to remove the effects of inflation. The Escalation Rates table under Life Cycle Cost Parameters below lists the “real” escalation rates of various types of goods and services. Where the real escalation rate is close to zero or zero, the escalation rate for the category is essentially the same as the inflation rate.

The formula for calculating the future cost of an item with a known cost today and a known escalation rate is:

$$COST_{YEAR-Y} = COST_{YEAR-0}(1 + ESC)^Y$$

Where:

$COST_{YEAR-Y}$ is the cost at Y years in the future

$COST_{YEAR-0}$ is today's cost (at Year 0)

ESC is the escalation rate

Y is the number of years into the future

Study Life

The study life in LCCA is the period over which the costs of a project will be examined and will influence LCCA decisions. The study life may not be the same as the building life but may be the same as that of the longest-lived subsystem option under review. To make LCCA comparisons valid, the study life must be the same for all alternatives.

LCCA Calculation Method

LCCA properly weighs money spent today versus money spent in the future. All costs should be converted to common, current dollars and then summed to develop a total cost in present dollars for each alternative. This quantity is sometimes referred to as the net present value or the total cost in today's dollars.

With the net present value calculated for each alternative, comparisons are simple because units are consistent. The best option is simply the alternative with the lowest life cycle cost or net present value.

The basic formula is as follows:

$$LCC = C + PV_{RECURRING} - PV_{RESIDUAL-VALUE}$$

Where:

LCC is the life cycle cost

C is the Year 0 construction cost (hard and soft costs)

$PV_{RECURRING}$ is the present value of all recurring costs (utilities, maintenance, replacements, services, etc.)

$PV_{RESIDUAL-VALUE}$ is the present value of the residual value at the end of the study life (note: these guidelines recommend this to be \$0)

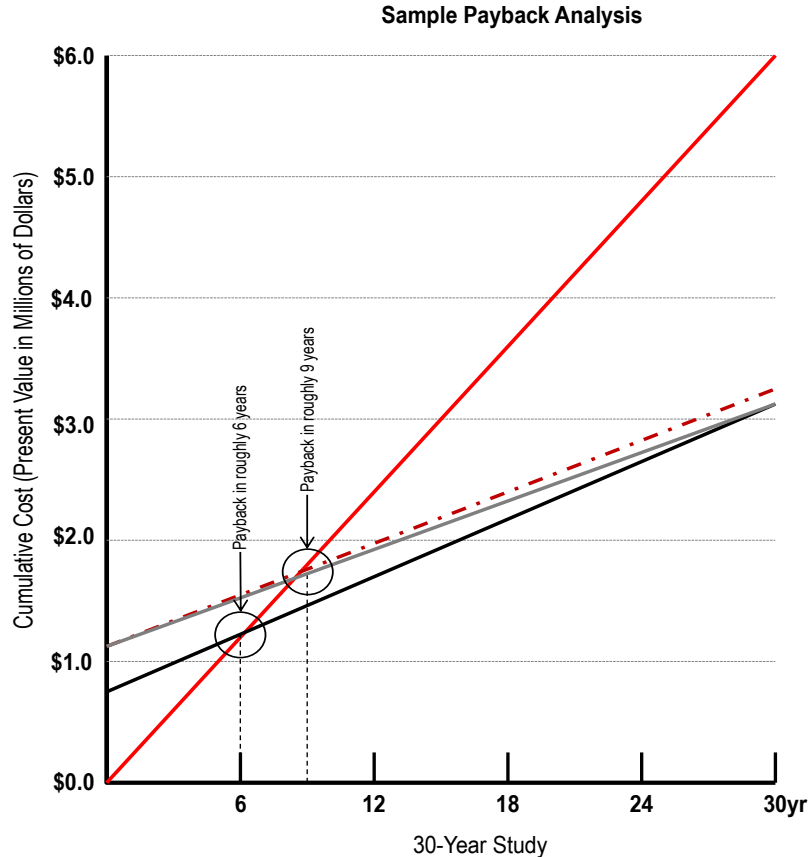
Payback Calculation

One way to evaluate the cost-effectiveness of LCCA alternatives is to look at their “payback” against the base case. The payback term is the time it takes an option to have the same life cycle cost as the base case. For example, the chart below shows the cumulative cost of three LCCA alternatives compared to a base case. The point at which each alternative line crosses the base-case line is the payback point, where the options have the same cumulative cost.

In this example, the red solid line shows the cumulative cost of doing nothing in a retrofit project scenario. This option requires zero initial cost. The LCCA alternatives under study each require some initial project cost, represented by their y-axis intercept points. The option represented by the black solid line has a lower initial cost than the options represented by the red dash and the gray solid lines.

The option represented by the solid black line crosses the solid red base-case line at about the six-year mark, resulting in a six-year payback. The red dash and gray solid lines intersect the red solid base-case line at roughly the nine-year mark, showing that they have nine-year paybacks.

“Payback” here is not exactly the same as “simple payback”. Simple payback typically does not consider time-value-of-money terms such as discount and escalation, or impacts such as maintenance. Payback analysis can easily include these more complex factors.



Uncertainty in LCCA Calculations

Uncertainty can be explicitly addressed in LCCA calculations, but it makes them much more complex. Each parameter used can be assigned a degree of uncertainty; these uncertainties can then be aggregated in statistically justifiable ways to measure the overall uncertainty of the result.

To make LCCA calculations as simple and straightforward as possible, this LCCA approach makes uncertainty an external qualitative consideration rather than a quantitative analytical one. Users should consider uncertainty throughout their LCCA studies and weigh the results *qualitatively*. For example, if an LCCA comparison of a variety of options shows a small difference in overall life cycle costs (e.g., 1%) then these costs should be considered equal. In other words, a small cost differential should not determine the best approach. In this case, the alternative with short-term benefits such as lower first cost, favorable environmental impact, or increased comfort for building occupants should be selected in accordance with project goals and budget.

Assumptions in LCCA Calculations

Many assumptions need to be made over the course of an LCCA study in order to generate enough data to produce results. These assumptions will strongly affect the results. All assumptions used in

LCCA must be clearly stated and documented so that appropriate members of the Project Team can validate them through the design process as costs, goal and budgets change.

Life Cycle Cost Parameters

To provide a reference for users and allow for periodic updates all of the values for parameters in the LCCA procedure are presented below. For each parameter, a responsible office is indicated so that users can obtain updated information or determination appropriate values for a specific project.

Study Life

Description	Value Range	Authority
New Construction Projects	30 Years	Project Manager
Retrofit or Renovation Projects	15 Years	Project Manager
Labs or High-Tech Buildings	10 Years	Project Manager

Campus Time-Value-of-Money Rates

The following rates were appropriate at the time these guidelines were published. See the website (<http://XXXXXX>) for a listing of latest values to be used in the future. All values must be verified by the assigned Project Manager.

Description	Near-Term Value (Years 0-5)	Long-Term Value (Years 6+)	Authority
“Nominal” U of C Discount Rate	6%	7%	TBD
Inflation	1.5%	3.0%	TBD
“Real” U of C Discount Rate (Adjusted to take out inflation)	4.4%	3.9%	calculated

Escalation Rates

The following rates were appropriate at the time these guidelines were published. See the website (<http://XXXXXX>) for a listing of latest values to be used in the future. All values must be verified by the assigned Project Manager.

Description	Near-Term Value (Years 0-5)	Long-Term Value (Years 6+)	Authority
Maintenance, Labor and Materials	0%	1%	Facility Services
Energy and Water Utilities	0.5%	1%	Utilities

Utility Rates

See the FS website for a listing of current rates for the following utilities. See the proceeding table for energy and water utilities escalation rates.

Utilities

- Steam (per 1,000 lb)
- Chilled Water (per ton-hour)
- Electricity (per kWh)
- Natural Gas (per therm)
- Domestic Water (per 1,000 gal)
- Sewer (per 1,000 gal)