Illinois Technology Transfer Center

Facts, Tips & Bits

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Life Cycle Cost Analysis

How does life cycle analysis improve money management?

Most medium and large expenditures are for equipment, facilities, and roads, which have useful lives greater than one year.

Therefore, it's reasonable to spread the initial cost over the whole useful life. Sometimes this happens automatically when construction money comes from bonding or loans, which are repaid over several years. Of course you pay interest on the borrowed money.

In addition to the initial cost, most equipment and roads also incur operating expenses. These may be **regular annual expenses** like fuel, oil, routine maintenance, shoulder grading, and snow and ice removal. There are also **periodic expenses** such as engine rebuilding, brake replacement, painting, seal coating, and repaving during useful life. These occur irregularly more than one year apart.

By summarizing the total cost over its lifetime, a Life Cycle Cost (LCC) analysis can help you decide between alternatives such as choosing which new piece of equipment to buy, deciding whether to repair or replace a machine, or choosing between maintenance techniques such as seal coating or repaving a road. For example, the initial cost of a diesel is more than the cost for the same truck with a gas engine, but operating and maintenance costs for the diesel may be lower. LCC techniques allow you to combine all the different types of costs and compare alternatives.

One way to make this comparison is to use the present worth (PW) of each alternative. Present Worth is the total value, considering interest, of all expenditures and receipts during the life of the item. This value is calculated as though all present and future costs and receipts were made today, hence the term *present worth*. Thus alternatives that have different costs in different years can be compared fairly.

Why include interest costs?

Although lenders have operated for centuries on the idea that it costs money to use money, tax money is not always treated this way. Some people maintain that because public funds collected through taxation and user fees are spent each year, interest need not be considered. There are three strong arguments for imputing some rates of interest to such public funds.

1. For larger expenditures, funds are borrowed from a bank or by selling bonds, and interest is actually paid from tax revenues. In the case of bonds the repayment may be spread over 10 or 20 years.
2. Many local transportation expenditures are supported by funds from larger units of government: county, state, and federal. These units frequently borrow to support local projects. This is especially apparent at the federal level where much more money is spent each year than collected.

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3. If a taxpayer did not have to pay taxes he or she could invest that money and earn a return on investment of 5% or 15% or more, depending on the risk. Taxing takes away that opportunity.

When interest rates are taken into account in analyzing a project's cost, the results vary dramatically. A familiar example is purchasing a family car. If you could afford to pay cash for a car, its cost would appear to be the amount on the invoice, say $10,000. However, if you had to borrow at 10% interest to buy the car, you would repay the loan in 36 installments of $322.53 each. The total cost of buying the car would then be $11, 611.08, more than $1,600 greater. Paying cash for the car is not necessarily cheaper because you have lost the opportunity to invest your money and earn interest on it.

What interest rate should you use?

As you know interest rates change with the state of the economy. The Federal Reserve Bank sets the rates periodically. This affects interest rates whether you are borrowing or lending money. Institutions, however, can set up their own rates, but most will stick to the suggested rates published by the government.

Inflation is another issue that must be addressed in Life Cycle Cost Analysis. A 3% to 5% inflation rate reflects a common figure used in economic studies.

To simplify the process of calculations presented in this article, the difference between interest rates and inflation rates (net interest rates) will be used. The calculations shown in the following example assumes a net interest rate of 10%.

A Sample LCC Analysis:

The following example shows how to develop an LCC analysis for a diesel engine truck. As you can see, you need reasonably accurate annual operating and maintenance cost figures to make such an analysis. For your own LCC analysis these may come from your records or from estimates and calculations provided by the state or the vender.

DIESEL TRUCK

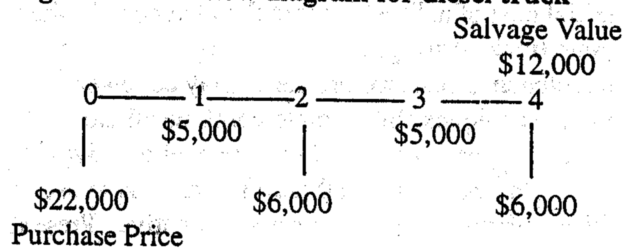
First Cost	$22,000
Service Life	4 years
Annual Operating Costs ($.20/mi x 25,000 mi./yr.)	$5,000
Maintenance/Repair Costs	$1,000 after 2 yrs. $1,000 after 4 yrs.
Salvage Value	$12,000

GAS TRUCK

First Cost	$20,000
Service Life	4 years
Annual Operating Costs ($.25/mi x 25,000 mi./yr.)	$6,250
Maintenance/Repair Costs	$1,000 after 2 yrs. $3,000 after 4 yrs.
Salvage Value	$10,000

The cash flow diagram is helpful in understanding Present Worth. To simplify calculation, we assume that expenses and receipts, except for the first cost at 0, occurred at the end of the year. In this example that means that the $5,000 for operating costs (fuel, oil, routine maintenance, etc.) are assumed to occur on the year end date. After two years the expense is $6,000 ($5,000 operating costs plus $1,000 periodic repairs). At the end of the fourth year the truck is sold for $12,000 after incurring $6,000 of operating and repair costs.

Figure 1: Cash flow diagram for diesel truck



The first step is to calculate the Present Worth of the costs minus the Present Worth of receipts (salvage value) for each year. Although you might simply add up all the expenses and subtract all the receipts, this would not account for interest, a significant factor as our earlier car example shows. Interest makes a given amount of money worth more a year from now than it is today. Therefore, to calculate the Present Worth of next year's expenditures for the diesel truck in today's dollars we must subtract interest from the $5,000 first year maintenance cost figure. This procedure is similar to one you might be familiar with: buying a $25 U.S. Government savings bond. You paid $18.25 for a bond that could be redeemed for $25 at maturity. Published tables supply factors to calculate the present worth of a future amount.

The Net Present Worth (NPW) of all costs is the sum of the year's adjusted costs.

$$
\begin{aligned}
\mathbf{NPW} &= \mathbf{P_0 + P_1 + P_2 + P_3 + P_4} \\
&= \mathbf{P^0 + 1/(1+i)^1 + 1/(1+i)^2 + 1/(1+i)^3 + 1/(1+i)^4} \\
&= \mathbf{22{,}000 + 5000/(1+0.1)^1 + 6000/(1+0.1)^2 +} \\
&\quad \mathbf{5000/(1+0.1)^3 + (-12{,}000+6{,}000)/(1+0.1)^4} \\
&= \mathbf{22{,}000 + 4{,}548 + 4{,}958 + 3{,}756 - 4{,}098} \\
\mathbf{NPW} &= \mathbf{31{,}162}
\end{aligned}
$$

Note 1: P_0 is $22,000, the Present Worth of the cost of the truck at purchase.
Note 2: Since these are costs (debits) the income from selling the truck ($12,000 revenue) at year 4 shrinks these debits and therefore is subtracted from the total. P = $5,000 (operating costs) + $1,000 (repair) - $12,000 (trade in) = -$6,000.

The Net Present Worth of the diesel truck is $31,162. To put it differently, if you had $31,162 today, theoretically you could pay $22,000 for the truck, invest the rest at 10% and pay all costs of the truck for four years.

The Net Present Worth (NPW) of the gas truck is $35,857. From the figures in this example (which may not represent actual experience), the LCC analysis shows that the diesel truck is a more economical purchase even though its initial cost is 10% greater. You can use LCC present worth analysis to make such comparisons for your own major expenditures.

LCC techniques can help you make economic decisions for better use of transportation funds. These techniques can be used for buildings, equipment, and roads.

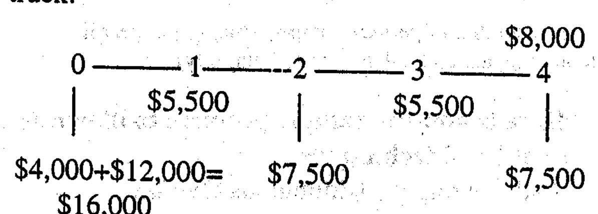
Repair Decisions

Another decision LCC can help is whether to repair or replace equipment. For example, instead of selling the diesel truck, you might spend $4,000 for a major engine overhaul. The truck will last four more years but operating costs and periodic maintenance will be slightly higher. Again, to make such calculations you will need to know or estimate what the operating and maintenance costs will be.

EXISTING TRUCK	
Major Repair	**$4,000**
Annual Operating Costs	**$5,500**
	($.22/mi. x 25,000 mi./yr.)
Service Life	**4 years**
Maintenance/Repair Costs	**$2,000**
	(every 2 yrs.)
Salvage Value	**$8,000**

NEW TRUCK	
First Cost	**$22,000**
Annual Operating Costs	**$5,000/yr**
Maintenance/Repair Costs	**$1,000**
	(every 2 yrs.)
Salvage Value	**$12,000**

The cost and operating expenses of a new truck will be the same as the previous example, NPW = 431,162. Here is cash flow diagram (Figure 2) and the calculations for the NPW of repairing the existinr truck:



Note: The truck has a trade-in or salvage value at time 0 of $12,000 plus the $4,000 repair cost or $16,000 total.

$P_0 = \$16,000 \quad = \$16,000$
$P_1 = \$5{,}500/(1+0.1)^1 \quad = \$5{,}000$
$P_2 = \$7{,}500/(1+0.1)^2 \quad = \$6{,}198$
$P_3 = \$5{,}500/(1+0.1)^3 \quad = \$4{,}132$
$P_4 = \$500/(1+0.1)^4 = -\$342$

$NPW = P_0 + P_1 + P_2 + P_3 + P_4$
$NPW = \$30{,}988$

In this case it would be only slightly less costly to repair the existing truck.

Life Cycle Cost analysis calculations can be made simpler by using published tables that supply present worth factors. Table 1 "Compound Interest Factors" shows the appropriate factor to multiply against the future amount to find the present worth.

Table 1 – Compound Interest Factors

n[1]	6%	8%	10%	12%
1	0.9434	0.9259	0.9091	0.8929
2	0.8900	0.8573	0.8264	0.7972
3	0.8396	0.7938	0.7513	0.6355
4	0.7921	0.7350	0.6830	0.6355
5	0.7473	0.6806	0.6209	0.5674
6	0.7050	0.6302	0.5645	0.5066
7	0.6651	0.5835	0.5132	0.4523
8	0.6274	0.5403	0.4665	0.4039
9	0.5919	0.5002	0.4241	0.3606
10	0.5584	0.4632	0.3855	0.3220
12	0.4970	0.3971	0.3186	0.2567
14	0.4423	0.3405	0.2633	0.2046
16	0.3936	0.2919	0.2176	0.1631
18	0.3503	0.2502	0.1799	0.1300
20	0.3118	0.2145	0.1486	0.1037

n[1]= number of periods compounding (1 per year if compounding annually; 4 per year if quarterly)

Here is another sample problem to illustrate the use of LCC techniques.

Seal Coating vs. Bituminous Overlay

One mile of road needs to be repaired. You are considering two alternatives:

1) Seal coat now and apply a two-inch overlay in five years. The seal coat will cost $5,000 and the overlay $59,600 (the future value of $37,000 in 5 years adjusted for inflation & interest). The total life will be 20 years.
2) Overlay now at a cost of $37,000. Expected life will be 15 years.

Calculate the present worth of each alternative using the compound interest factors for 10% interest shown in Table 1. Which is the less expensive alternative?

<u>Alternative 1</u>

$P_0 = \$5{,}000$
$P_5 = \$59{,}600 \times 0.6209$
$NPW = P_0 + P_5$
$NPW = \$5{,}000 + \$37{,}000 = \$42{,}000$

<u>Alternative 2</u>

$P_0 = \$37{,}000 \quad NPW = \$37{,}000$

Because the overlay is delayed five years, (1) is the least costly alternative even though the total cost is higher. In addition, the life of the pavement is extended 5 more years.

Another method to compare alternatives providing different lengths of service life is to compute the **Average Cost per Year**. Using the example above and comparing the costs of the two alternatives by averaging their costs on a per year basis:

<u>Alternative 1</u>

NPW = $27,973
ACY = $42,000x 0.1216 = $5,107/ year for 20 years

<u>Alternative 2</u>

NPW = $37,000
ACY = $37,000x 0.1354 = $5010/ year for 15 years

This method also shows Alternative 2 to be the least costly.

(Note: the factors 0.1216 and 0.1354 are capital recovery factors computed at 10% interest for the 20 and 15 years stated in the example.)

Whether using the formula or the present worth factors from a table, Life Cycle Cost analysis and Average Cost per Year analysis can be valuable decision making tools.

Source: This bulletin was adapted from the Pennsylvania Local Roads Program Information Sheet # 40, July 1989