LCC — Life Cycle Cost Analysis

Life cycle cost analysis improves 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. This sometimes 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 the useful life. These occur irregularly more than one year apart.

By summarizing the total cost over its lifetime, an 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 truck 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 since 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 rate of interest to such public funds.

First, 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.

Second, 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 is collected.

Third, if a taxpayer did not have to pay taxes he or she could invest that money and earn a return on investment of 5% to 15% or more, depending on 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, however, because you have lost the opportunity to invest your money and earn interest on it.

What interest rate should you use?

When the State of Wisconsin Department of Transportation uses LCC cost techniques to evaluate transportation projects, it uses an interest rate of 6%. Currently municipal bond rates are about 10%. Federal borrowing rates vary from 7% to 12% depending on risk and length of time. An individual investing in certificates of deposit or money market funds can get 9% to 10%. What rate should you use? Perhaps the most logical rate to use is what the taxpayer has lost. Certainly your figure should not be less than the bonding or federal rate. In this fact sheet we use 10%.

A sample LCC analysis

The following example shows how to develop an LCC analysis for a diesel engine truck. We provide you with the costs for a gas engine truck so you can try an LCC analysis on your own and compare the cost of the two trucks. As you can see, you need reasonably accurate annual operating and maintenance cost figures to make such an analysis. For your own LCC analyses these may come from your records or from estimates and calculations provided by the state or the vendor.

Diesel Truck

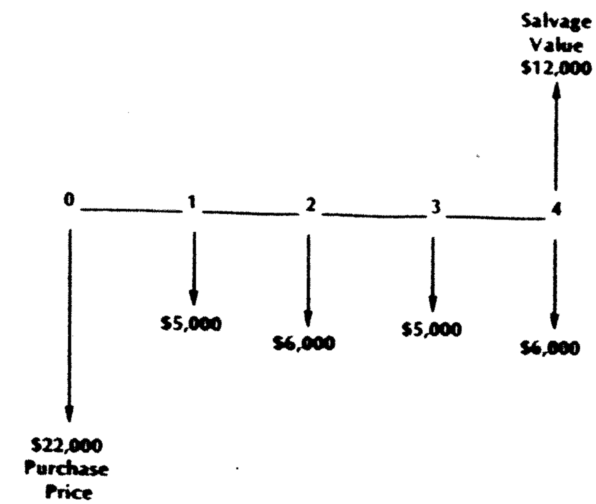
First Cost	**$22,000**
Service Life	**4 years**
Annual Operating Costs	**$5,000 ($.20/mi × 25,000 mi/yr)**
Maintenance/Repair Costs	**$1,000 after 2 yrs; $1,000 after 4 yrs**
Salvage Value	**$12,000**

Gas Truck

First Cost	**$20,000**
Service Life	**4 years**
Annual Operating Costs	**$6,250 ($.25/mi × 25,000 mi/yr)**
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, occured at the end of the year. In this example that means that the $5,000 for operating costs (gas, oil, routine maintenance, etc.) are assumed to occur on the year-end date. After two years the expense is $6,000

Figure 1: Cash flow diagram for diesel truck



The horizontal line represents the four-year life of the truck, from date of purchase to time of trade-in. The vertical lines represent expenses and income.

($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.

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 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 which could be redeemed for $25 at maturity. Published tables (similar to Table 1) supply factors to calculate the present worth of a future amount.

Table 1, Compound Interest Factors, shows the appropriate factor to multiply against the future amount (F) to find P (present worth). For the first year find 1 under n (the number of periods in which interest is compounded) and read the factor from the present worth factor column for the interest rate you are using. For this example interest compounds once a year at 10%. Multiply $5,000 by the factor.

$$P_{1\ (\text{year 1})} = \$5{,}000\,(.9091) = \$4{,}546$$

Table 1: Compound Interest Factors

	Present Worth Factor Find P given F			
n[1]	6%	8%	10%	12%
1	.9434	.9259	.9091	.8929
2	.8900	.8573	.8264	.7972
3	.8396	.7938	.7513	.7118
4	.7921	.7350	.6830	.6355
5	.7473	.6806	.6209	.5674
6	.7050	.6302	.5645	.5066
7	.6651	.5835	.5132	.4523
8	.6274	.5403	.4665	.4039
9	.5919	.5002	.4241	.3606
10	.5584	.4632	.3855	.3220
11	.5268	.4289	.3505	.2875
12	.4970	.3971	.3186	.2567
13	.4688	.3677	.2897	.2292
14	.4423	.3405	.2633	.2046
15	.4173	.3152	.2394	.1827
16	.3936	.2919	.2176	.1631
17	.3714	.2703	.1978	.1456
18	.3503	.2502	.1799	.1300
19	.3305	.2317	.1635	.1161
20	.3118	.2145	.1486	.1037

[1] n = number of periods compounding (1 per year if compounding interest annually; 4 per year if interest compounds quarterly; 12 per year if compounding monthly, etc.)

The same calculations can be made for years 2, 3 and 4 using factor values from the table:

P_2 (year 2) = \$6,000(.8264) = \$4,958
P_3 (year 3) = \$5,000(.7513) = \$3,756
P_4 (year 4) = −\$6,000(.6830) = −\$4,098

Note 1: P_0 (year 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_4 = \$5,000 (operating cost) + \$1,000 (repair) − \$12,000 (trade-in) = −\$6,000.

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

NPW = $P_0 + P_1 + P_2 + P_3 + P_4$
= \$22,000 + \$4,546 + \$4,958 + \$3,756 − \$4,098
NPW = \$31,162

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.

Now you calculate the Net Present Worth (NPW) of the gas truck. Fill in the following cash flow diagram and calculations:

Problem 1: Gas truck

0 ________ 1 ________ 2 ________ 3 ________ 4

P_0 (year 0) = ____________________ = __________
P_1 (year 1) = ____________________ = __________
P_2 (year 2) = ____________________ = __________
P_3 (year 3) = ____________________ = __________
P_4 (year 4) = ____________________ = __________

NPW = $P_0 + P_1 + P_2 + P_3 + P_4$
= _____ + _____ + _____ + _____ + _____

NPW = __________

Check your calculations against the answers provided at the end of the factsheet.

You should get \$35,857 as a NPW for the gas truck. 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 analyses to make such comparisons for your own major expenditures.

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.

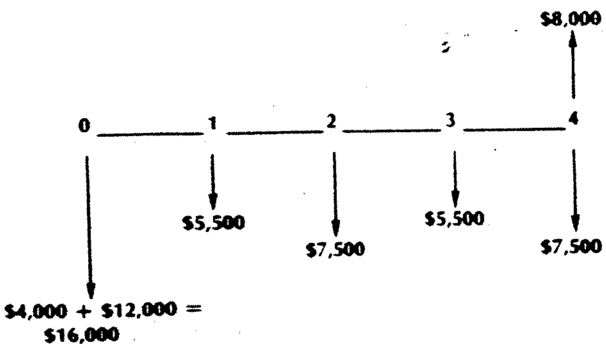
Existing Truck

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

New Truck

First Cost	**$22,000**
Annual Operating Costs	**$5,000/year**
Maintenance/Repair Costs	**$1,000 every 2 years**
Salvage Value	**$12,000**

The cost and operating expenses of a new truck will be the same as the previous example, NPW = $31,162. Here are the calculations for the NPW of repairing the existing truck:



P_0 = $4,000 + $12,000 = $16,000
P_1 = $5,500 (.9091) = $5,000
P_2 = $7,500 (.8264) = $6,198
P_3 = $5,500 (.7513) = $4,132
P_4 = − $500 (.6830) = − $342

NPW = $P_0 + P_1 + P_2 + P_3 + P_4$
= $16,000 + $5,000 + $6,198 + $4,132 − $342
NPW = $30,988

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.

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

LCC techniques can help you make economic decisions for better use of transportation funds. These techniques can be used for buildings, equipment and roads. Here is another sample problem for you to work.

Problem 2: 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 $37,000. The total life will be 15 years.

(2) Overlay now at a cost of $37,000. Expected life, 15 years.

Calculate the present worth of each alternative using 10% interest. Which is the less expensive alternative?

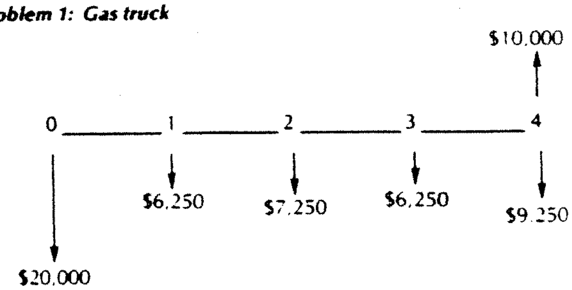
(1) PW = ______________________

(2) PW = ______________________

Check your calculations against the answers provided at the end of the factsheet.

Problem Solutions

Problem 1: Gas truck



P_0 = $20,000
P_1 = $6,250 (.9091) = $5,682
P_2 = $7,250 (.8264) = $5,991
P_3 = $6,250 (.7513) = $4,696
P_4 = ($10,000 − $9,250) (.6830) = $512

NPW = $P_0 + P_1 + P_2 + P_3 + P_4$
= $20,000 + $5,682 + $5,991 + $4,696 + $512
NPW = $35,857

Problem 2: Seal coating vs. bituminous overlay

(1) PW = $5,000 + $37,000 (.6209)
= $5,000 + $22,973
= $27,973

(2) PW = $37,000

Because the overlay is delayed five years, (1) is the least costly alternative even though the total cost is greater.

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