Engineering Economics - Project Analysis

An Online Continuing Education Course for Engineers

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Engineering Economics – Project Analysis

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There are a variety of economic measures that analysts use to evaluate a project. In general, the most cost-effective alternative will have the lowest Total Life Cycle Cost (TLCC) and shortest Payback Period, and the highest Net Present Value (NPV), Internal Rate of Return (IRR), Benefit to Cost Ratio (B/C) and Savings to Investment Ratio (SIR). Each of these tools are described and used in examples below.

1.0 Total Life Cycle Cost Analysis

Total Life Cycle Costs (TLCC) is the cost incurred through the ownership of an asset over the asset's life span or the period of interest to the investor. Too often, engineers only consider the cost to design and build a project and ignore the often-considerable expense required to keep the structures and machinery in good repair over its useful life. Examples of TLCC are maintenance & repairs, fuel, electricity, insurance, security, and permits & taxes in addition to the obvious design and construction costs. It's not unusual for an alternative that's slightly more expensive to build to have lower operating and maintenance costs. A thorough and complete analysis of the TLCC will reveal if it's also the most cost-efficient in the long run.

Example 1: The owner of a small commercial building is evaluating the purchase of a new heating and cooling system. The purchase and installation cost for the equipment, the annual fuel and maintenance costs over the next 15 years, and the salvage value for the three alternatives under consideration are described in the following table.

Alternative	**1**	**2**	**3**
Description	**Standard Gas Furnace with Add-on A/C**	**High Efficiency Gas Furnace with Add-on A/C**	**Heat Pump with Auxiliary Gas Back-up**
Equipment Cost	$ 10,000	$ 10,500	$ 9,400
Installation	$ 700	$ 700	$ 600
Annual Energy Cost	$ 1,200	$ 900	$ 1,400
Annual Maint. Cost	$ 65	$ 65	$ 175
Salvage Value	$ (100)	$ (100)	$ (200)

Find the Total Life Cycle Cost (TLCC) for each of the three cases using a 5% discount rate and identify the least-cost alternative.

Solution:

To determine the Total Life Cycle Cost, we find the Present Value (PV) for each expenditure.

Here's the calculation for the first alternative.

The PV of the $100 salvage cost is

$$\mathbf{PV = FV / (1+i)^n}$$

Where PV = Present Value
FV = Future Value
i = interest rate
n = term of the investment in years

$$\mathbf{PV = FV / (1+i)^n =} \ \$100 / (1+0.05)^{15} \ \mathbf{= \$48.10}$$

We can use the Present Value of a Series of Uniform Payments formula to determine the PV for the fuel and maintenance costs.

Present Value is usually expressed as a factor for a series of uniform payments of $1.

$$\mathbf{PV = ((1+i)^n - 1) / (i(1+i)^n)}$$

Where PV = Present Value for a $1 annual payment
i = interest rate
n = term of the investment in years

$$\mathbf{PV = ((1+i)^n - 1) / (i(1+i)^n)} = ((1+0.05)^{15} - 1) / (0.05(1+0.05)^{15}) \ \mathbf{= 10.3797}$$

The PV for the 15 years of energy costs is $1,200 x 10.3797 = $12,456

The PV for the 15 years of maintenance costs is $65 x 10.3797 = $675

The TLCC for Alternative 1 is

TLCC = $10,000 equip + $700 installation + $12,456 energy +

$675 maint. - $48 salvage = **$23,783**

The following table details the present values for all three alternatives.

---------------- TLCC Present Value Costs @ 5% discount rate------------------						
Alternative		**1**		**2**		**3**
Description		**Standard Gas Furnace with Add-on A/C**		**High Efficiency Gas Furnace with Add-on A/C**		**Heat Pump with Auxiliary Gas Back-up**
Equipment Cost	$	10,000	$	10,500	$	9,400
Installation	$	700	$	700	$	600
Annual Energy Cost	$	12,456	$	9,342	$	14,532
Annual Maint. Cost	$	675	$	675	$	1,816
Salvage Value	$	(48)	$	(48)	$	(96)
TLCC	$	23,783	$	21,168	$	26,252

Alternative 2, the High Efficiency Gas Furnace has the lowest Total Life Cycle Cost.

2.0 Net Present Value

Net Present Value (NPV) is used to discount a series of present and future net cash flows. **Net cash flow** is simply the arithmetic sum of the annual revenues and expenses associated with the project for the year. It is often necessary to use NPV to compare two investments with varying patterns of cash flow or differences in the term of the investment.

$$NPV = CF_O + \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \frac{CF_n}{(1+i)^n}$$

Where NPV = Net Present Value
- CF_o = initial investment
- CF_n = cash flow in subsequent years
- i = interest rate (i.e., discount rate)
- n = term of the investment in years

Example 2: Company A plans to purchase a new machine with a 5-year useful life for $100,000 by taking out a 5-year loan at 8% interest, compounded daily. Annual operating costs are estimated at $2,000 per year for labor & materials, escalating at 3% per annum. Fuel costs are estimated at $1,000 the first year, increasing at 5% per annum in years 2 through 5. The salvage or resale value for the machine at the end of 5 years is expected to be $20,000. Straight-line depreciation is assumed.

Prepare a tabulation of the project net cash flows and determine the Net Present Value for the series of net cash flows using an 8% discount rate.

Solution:

First, we need to calculate the annual payment on the $100,000 loan. Since the interest is compounded daily, we need to find the effective interest rate.

$$\mathbf{i = (1+ ((i^{(t)})/t))^{t})-1} = (1+ ((0.08)/365))^{365})-1 = 0.0832776 = \mathbf{8.33\%}$$

Where i = effective interest rate
$i^{(t)}$ = nominal interest rate
t = number of times interest is compounded during year

Then input the result in the Present Value for a Uniform Series of Payments formula.

$\mathbf{PV = ((1+i)^{n} - 1) / (i(1+i)^{n})} = ((1+0.0832776)^{5} - 1) / (0.0832776(1+0.0832776)^{5})$ **= 3.9584553**

Annual loan payment = Loan amount/PV factor = $100,000/3.9584553 = **$25,262.38**

You can also use Payment function in Microsoft Excel for this calculation:

PMT(rate,nper,pv) = PMT(0.0832776,5,100000) = **$25,262.38**

Next calculate the annual depreciation using the Straight-line method.

$$\mathbf{D_{SL} = (A - S)/n}$$

Where D_{SL} = Annual Depreciation (Straight-line)
A = Acquisition Cost
S = Salvage Value
n = useful life in years

$$\mathbf{D_{SL} = (A - S)/n =} (\$100,000-\$20,000)/5 = \mathbf{\$16,000/year}$$

Third, we calculate the inflated values for labor & materials and fuel costs.

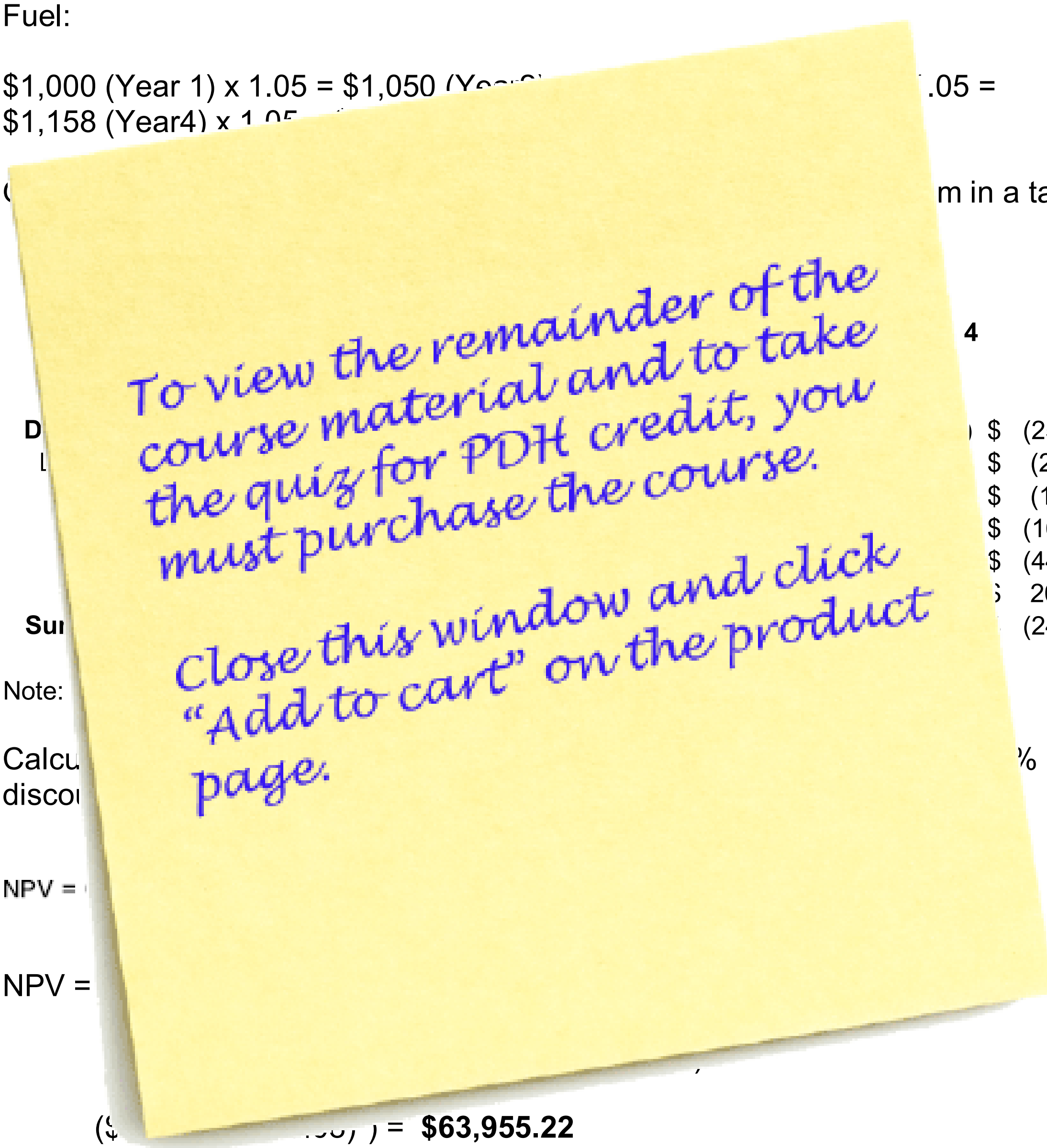
Labor & Materials:

$2,000 (Year 1) x 1.03 = $2,060 (Year2) x 1.03 = $2,122 (Year3) x 1.03 = $2,185 (Year4) x 1.03 = $2,251 (Year5)

Fuel:

$1,000 (Year 1) x 1.05 = $1,050 (Yea ... .05 =
$1,158 (Year4) x 1.05 ...

... m in a table.



	4	5
D	$	(25,262)
L	$	(2,251)
	$	(1,216)
	$	(16,000)
	$	(44,728)
	$	20,000
Su		(24,728)

Note:

Calcu ... %
disco

NPV =

NPV =

($ ...) = **$63,955.22**

(Note: You can also use the NPV function in Microsoft Excel to calculate Net Present Value. (NPV(rate, CF_1 , CF_2 , CF_3 ... CF_n)) However, the NPV function in Microsoft Excel ignores the **CF_o** term in the NPV equation. Make sure you add **CF_o** to the result you get from Excel.)

3.0 Pay Back Period