TYPE 582: LIFE CYCLE COST ANALYSIS

General Description

One of the most common measures of engineering economics is the life cycle cost of a system and one method of calculating the life cycle cost is referred to as the P1 P2 method. The idea of the method is that the life cycle cost of a purchase option or alternative is calculated based on two economic indicators. The first (P1) is the ratio of the life cycle fuel cost to the first year fuel cost. A low value of P1 indicates that immediate fuel costs are high and that consequently, potential immediate fuel savings are important. The second indicator (P2) is the ratio of life cycle expenditures incurred as a result of the investment to the investment amount. A high value of P2 indicates that the investment has a low first cost but higher costs over the life of the equipment. This component operates in one of two modes. It can either calculate P1 and P2 based on a set of simple economic indicators, or it can accept values of P1 and P2 directly. In both modes, the component calculates the life cycle cost for up to ten system alternatives. More alternatives may be added by modifying a single parameter in the Fortran code and recompiling. The model then compares each alternative to a user designated comparison system.

Nomenclature

LCC	[currency]	Life cycle cost
P1	[-]	The ratio of life cycle fuel costs to first year fuel cost
P2	[-]	The ratio of the life cycle cost of an investment to the initial investment
FuelCost	[currency]	The annual fuel cost to power the equipment
EquipmentCost	[currency]	The purchase price of the equipment
c	[-]	A flag set to 1 if fuel costs are tax deductible and 0 otherwise
t	[0..1]	Income tax rate
n	[years]	Period of the economic analysis
f	[0..1]	Rate at which fuel costs are expected to inflate
i	[0..1]	Investment interest rate
D	[0..1]	The down payment expressed as a fraction of the purchase price
n_{loan}	[years]	The period of the loan taken to finance the purchase of the equipment
m	[0..1]	The loan or mortgage rate used to finance the purchase of the equipment
p	[0..1]	The rate at which property is taxed
M	[0..1]	The annual maintenance cost for the equipment expressed as a percentage of the purchase price
j	[0..1]	The general inflation rate. In other words, the rate at which general costs are expected to rise
$n_{depreciation}$	[years]	The depreciation life span of the equipment
R	[0..1]	The rebate or refund offered on the purchase of the equipment, expressed as a fraction of the purchase price
S	[0..1]	The salvage cost of the equipment at the end of its useful life, expressed as a percentage of the purchase price
LCS	[currency]	Life cycle savings
Payback	[years]	The payback period of a system alternative. In other words, the amount of time required for an alternative's fuel savings to equal its additional cost

		an alternative's fuel savings to equal its additional cost.
ROI	[0..1]	Return on investment (the inverse of the payback period)
AllowableCost	[currency]	The maximum amount that a system alternative can cost and still be economically viable.

Detailed Description

The Life Cycle Cost of a fuel consuming equipment investment alternative is given by (Eq. 582.1).

$$LCC = P1 * AnnualFuelCost + P2 * EquipmentCost \quad \text{(Eq. 582.1)}$$

One feature of Type582 is that if the simulation length is not a full year, the component will calculate the annual fuel cost based on the amount of time that was run. Both integrated and annualized fuel costs are reported by the model. If a non year simulation is run, the Type notifies the user by printing a message in the simulation log and in the list file.

The P1 factor is calculated based on (Eq. 582.2)

$$P1 = (1 - c * t)PWF(n, f, i) \quad \text{(Eq. 582.2)}$$

Where c is a flag (1 or 0) to tell whether or not the equipment is part of an income producing installation. More generally, setting c to 1 indicates that the cost of fuel is tax deductible as it often is for businesses. The value t is the income tax rate and PWF(n,f,i) is the present worth of an ongoing annual investment over n years, at an inflation rate of f and whose alternative investment could make interest at a rate of i.

The present worth factor is computed according to (Eq. 582.3)

$$PWF(n, f, i) = \frac{1}{(1 - f)}\left[1 - \left(\frac{1 + f}{1 + i}\right)^{n}\right] \quad \text{(Eq. 582.3)}$$

The P2 term is quite a lot more complex as it must assess the cost of the equipment over the course of its life including maintenance, financing, salvagability, tax savings, etc. The equation for P2 follows:

$$\begin{aligned} P2 = {} & D + (1 - D)\frac{PWF(n,0,i)}{PWF(n_{loan},0,m)} \\ & - t(1 - D)\left[PWF(n,m,i)\left(m - \frac{1}{PWF(n_{loan},0,i)}\right) + \frac{PWF(n,0,i)}{PWF(n_{loan},0,m)}\right] \\ & + I + \left[p(1 - t) + M(1 - c * t)\right]PWF(n,j,i) \\ & - \frac{c * t}{n_{depreciation}}PWF(n_{depreciation},0,i) - R - S * PWF(n,i) \end{aligned} \quad \text{(Eq. 582.4)}$$

The variables in the above equation are defined in the nomenclature section. In the above, the first three additive terms concern the effect of the down payment. The fourth term (I) concerns the cost of

installing the equipment. The fifth term relates to the property taxes and miscellaneous annual expenses related to the equipment, both of which inflate at the general inflation rate. The sixth term accounts for depreciation, the seventh term (R) to any rebate or refund offered for the purchase of the equipment and the final term to the salvage value of the equipment once its usefulness to the installer is expired. There can be more or less terms included in the calculation of P2 as necessary. The terms included in (Eq. 582.4) are those recommended for energy systems by Duffie and Beckman [1] and by Mitchell [2].

It may be noticed that the final PWF function in the above equation has two arguments instead of three as is true in the case of discounting a single future payment into today's currency. (Eq. 582.5) shows the equation for computing such a PWF factor.

$$LCS_A = LCC_A - LCC_B \qquad \text{(Eq. 582.5)}$$

Once the life cycle cost of each option is computed, various economic figures of merit can be calculated. All of the following rely on some comparison between systems. For each system alternative described in Type582, the user is asked to provide a system number for comparison. The user may choose to compare up to nine system alternatives against one base case or may perform more complex comparisons. The idea is that changing the comparison basis should be simple. If a system is compared against itself (as would be the case if only a single system is analyzed), all but its life cycle cost output will be set automatically to –999.

The life cycle savings of alternative A as compared to alternative B is:

$$LCS_A = LCC_A - LCC_B \qquad \text{(Eq. 582.6)}$$

The simple payback period is defined as the time necessary for the undiscounted annual fuel savings to equal the difference in purchase prices between the two equipment alternatives. A negative payback period can be obtained if the more efficient equipment (requiring less fuel) also costs less.

$$PayBack_A = \frac{EquipmentCost_A - EquipmentCost_B}{FuelCost_B - FuelCost_A} \qquad \text{(Eq. 582.7)}$$

The return on the investment is calculated as the reciprocal of the payback period, as shown in (Eq. 582.8)

$$ROI_A = \frac{FuelCost_B - FuelCost_A}{EquipmentCost_A - EquipmentCost_B} \qquad \text{(Eq. 582.8)}$$

Lastly, the allowable equipment cost is calculated. This is the maximum allowable amount that could be paid for a piece of equipment in order for its life cycle savings (as compared to another system alternative) to be equal to zero. The allowable equipment cost is shown in (Eq. 582.9)

$$AllowableCost_A = \frac{1}{P2_A}\left(P1\left(FuelCost_A - FuelCost_B\right) + P2_B\, EquipmentCost_B\right) \qquad \text{(Eq. 582.9)}$$

References

[1] Duffie, J.A., and W.A. Beckman, Solar Engineering of Thermal Processes, 2nd edition, New York: Wiley and Sons, Inc. (1991)

[2] Mitchell, J.W., and J.E. Braun, Design, Analysis and Control of Space Conditioning Equipment and Systems, unpublished edition (1997)