ENERGY DESIGN ECONOMICS

Adapted from
SIMPLIFIED
ENERGY
DESIGN
ECONOMICS

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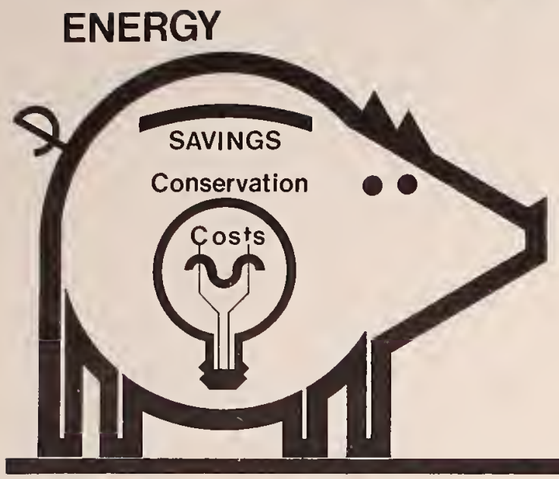

PRINCIPLES OF ECONOMICS APPLIED TO ENERGY CONSERVATION INVESTMENTS IN BUILDINGS

Five Economic Tools

The five economic tools described here are Life-Cycle Costs (LCC), Net Benefits or Savings (B-C), Savings-to-Investment Ratio (SIR), Internal Rate of Return (IRR) and Discounted Payback (DPB).

The first four are comprehensive analytical tools that can be used to evaluate investments in energy conservation. They consider both first costs and future costs and savings. Because they all look at the significant costs and benefits over the life of an investment, they are often referred to collectively as life-cycle techniques. The fifth tool, the discounted payback method (DPB), does not fully use the life-cycle approach. It nevertheless may be quite useful to designers under certain circumstances, as, for example, when the client requires rapid recovery of investment funds or when the durability of investment assets is highly uncertain. Each of the five tools considers the timing of cash flows and associated cost of money.

HOW

CAN SAVINGS BE COMPARED TO COSTS?
LARGE AN INVESTMENT TO MAKE?
TO FIND THE LEVEL OF MAXIMIZED DOLLAR BENEFITS?
MUCH OVERALL COSTS WILL BE LOWERED BY INCREASED CONSERVATION?
CAN PROJECTS DIRECTLY COMPETING FOR THE SAME PURPOSE
(e.g., R-10 INSULATION VERSUS R-19 INSULATION) BE COMPARED?

LIFE-CYCLE COSTS

Life-Cycle Costs = Purchase and Installation Costs − Salvage Value + Maintenance and Repair Costs + Replacement Costs + Energy Costs

$$LCC = P - S + M + R + E,$$

Life-Cycle Costs (LCC): Life-cycle costing sums the energy costs of the building together with the net costs of purchase and installation (less any salvage value), maintenance, repair, replacement, and all other costs attributed to the conservation investment. This includes the cost of money over the life of the investment. The investment that has the lowest total life-cycle cost while meeting the investor's objective and constraints is the preferred investment.

All cash amounts are generally converted to either present value or annual value dollars. Present Value is defined as the equivalent value of past and future dollars corresponding to today's values. Annual Value means that all past, present, and future costs are converted to an equivalent constant amount recurring annually over the evaluation period. The conversion process for both present value and annual value dollars is called discounting.

● All costs are in life-cycle present value or annual value dollars and adjusted for taxes and incentives.

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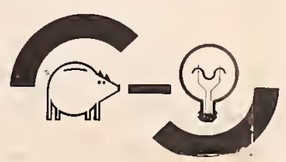
NET BENEFITS or SAVINGS



Net Benefits or Savings = Reduction in Energy Costs − Differential Purchase and Installation Costs + Differential Salvage Value − Differential Maintenance and Repair Costs − Differential Replacement Costs

$$(B\text{-}C) = E^* - (P^* - S^* + M^* + R^*)$$

Net Benefits or Savings (B-C): This tool finds the difference between the life-time dollar energy savings and life-time dollar costs of a conservation investment. Net benefits or savings may be expressed in either present value or annual value dollars. This tool applies to the same types of investments as the life-cycle cost (LCC) tool, but is formulated somewhat differently as is shown.

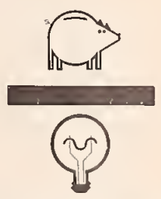
+The values of "E," "P," "S," "M," and "R" in this and subsequent equations, where accompanied by an asterisk (*), represent the difference between the present value or annual value costs for an energy conserving investment and its alternative. While the previous LCC formula must be applied to each of two investments being compared, the (B-C) formula is applied directly to the difference between two alternative investments.

●All costs and benefits are in present value or *annual* value dollars and adjusted for taxes and incentives.

HOW

CAN SAVINGS BE COMPARED TO COSTS?
CAN DIFFERENT PURPOSE PROJECTS COMPETING FOR THE SAME BUDGET
(e.g., INCREASING THE THERMAL MASS OF THE BUILDING WALLS VERSUS THE USE OF EXTERIOR OVERHANGS TO SHADE THE WINDOWS) BE COMPARED?

SAVINGS-TO-INVESTMENT RATIO



Savings-to-Investment Ratio = Reduction in Energy Costs ÷ Differential Maintenance and Repair Costs − Differential Purchase and Installation Costs + Differential Salvage Value − Differential Replacement Costs

$$SIR = (E^* - M^*) \div (P^* - S^* + R^*)$$

Savings-to-Investment Ratio (SIR): Like the two preceding tools, the SIR is based on discounted cash flows. However, savings and investment costs are expressed as a retio rather than a dollar amount. For positive net savings, the ratio must be greater than one. The higher the retio, the more dollar savings realized per dollar of investment.

●All costs are in present value or annual value dollars and adjusted for taxes and incentives.

HOW

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CAN DIFFERENT PURPOSE PROJECTS COMPETING FOR THE SAME BUDGET
(e.g., INCREASING THE THERMAL MASS OF THE BUILDING WALLS VERSUS THE USE OF EXTERIOR OVERHANGS TO SHADE THE WINDOWS) BE COMPARED?
TO FIND THE RATE OF RETURN ON INVESTMENT?

INTERNAL RATE OF RETURN

Find i such that $(\bar{E} \cdot a) - [\bar{P} - (\bar{S} \cdot b) + (\bar{M} \cdot c) + (\bar{R} \cdot b)] = 0$

Internal Rate of Return (IRR = i); Reduction in Energy Costs; Discount Factor for Interest Rate i (UPW*,i,N); Differential Purchase and Installation Costs; Differential Salvage Value; Discount Factor for Interest Rate i (SPW,i,); Differential Maintenance and Repair Costs; Discount Factor for Interest Rate i (UPW,i,N); Differential Replacement Costs; Discount Factor for Interest Rate i (SPW,i,)

Internal Rate of Return (IRR): This tool finds the rate of return on an investment. This is the interest rate, stated as a percent, for which life-time dollar savings are just equal to life-time dollar costs. The calculated IRR is compared to the investor's minimum acceptable rate of return to determine if the investment is desirable.

The IRR is generally calculated by a structured process of trial and error. Selected compound rates of interest are used to discount the cash flows until a rate is found for which the net value of the investment is zero or close to zero.

●Bar over the symbols, e.g., "$\bar{E}$," indicates that the cost differences have not yet been converted to present or annual values. The terms a, b, and c refer to discounting factors.

HOW

CAN SAVINGS BE COMPARED TO COSTS?
SOON WILL ENERGY INVESTMENTS BE PAID OFF BY SAVINGS?

DISCOUNTED PAYBACK

Find Y such that $\sum_{j=1}^{Y} (E^*_j - M^*_j - R^*_j + S^*_j) = P^*$

Summation from years 1 to Y; Reduction in Energy Costs in year j; Differential Maintenance and Repair Costs in year j; Differential Replacement Costs in year j; Differential Salvage Value in year j; Differential Purchase and Installation Costs

Discounted Payback (DPB): This tool measures the elapsed time between the point of initial investment and the point at which accumulated savings, net of other accumulated costs, are sufficient to offset the initial investment cost. Costs and savings are adjusted to account for the changing value of money over time. If a time adjustment is omitted, the tool is termed "simple payback."

For investors who seek a rapid turnover of investment funds, the investment increases in desirability as the payback period decreases. However, a shorter payback time does not necessarily indicate the most economically efficient investment. An investment with a longer payback period may prove more profitable than an investment with a shorter payback period if it continues to yield savings for a longer period of time.

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