The Discount Rate

The analysis of most energy conservation and end-use efficiency programmes requires the comparison of present investment with future savings. The result of such comparisons depends on the discount rate, which measures the time value of money. The discount rate is essentially the interest rate or rate of return which one would demand in order to forego a unit of consumption today in turn for a greater amount one year later. Higher the discount rate reflects the greater value placed on current consumption compared to future consumption.

The discount rate can be expressed in nominal terms that reflect the current value of the currency, including inflation, or it can be expressed in real terms that reflect a constant value of the currency, exclusive of inflation. One can use either nominal or real values with equal accuracy; the important thing is simply to be consistent.

So what do discount rates really indicate? The time-value of money can depend on factors other than a strict time-preference. In finance theory, the time-value of money is thought to change (to increase) with greater risk and uncertainty. For two investments with the same average expected return, a
higher present value is given to one with less uncertainty (less risk of loss). In some cases, energy efficiency investments may appear risky to the consumer, due to lack of information and resulting uncertainty, and indeed consumers often appear to apply a high discount rate to such investments. For society, however, energy efficiency is a low-risk investment that normally deserves a low discount rate.

**Net Present Worth**

Net present worth (NPW), also known as net present value (NPV), is the value today of future cash flows. This is the cash value today that is of equivalent value to a stream of cash flows, which occurs in the future.

For a single future flow $F$, the present worth $P$ is defined by:

$$P = F \times \text{PWF}$$

Where:

- $P$ = present worth in base year,
- $F$ = future value in year of occurrence,
- \[ \text{PWF} = \frac{1}{(1+r)^t} \]

Where: $r$ = discount rate, $t$ = time between $P$ (today) and $F$

The net present worth of a series of future cash flows is simply the sum of the discounted present worth of each individual cash flow, including both positive (income) and negative (cost) flows.

For multiple futures flows $F_n$:

$$P = \sum (F_n \times \text{PWF}_n)$$
In future flows if $F_n$ occur in equal amounts $F_n = A$ (where $A$ is a constant annual value for all $n$), then:

$$P = A \left[ \frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \frac{1}{(1+r)^3} + \frac{1}{(1+r)^4} + \ldots + \frac{1}{(1+r)^t} \right] = A \frac{1}{\frac{1}{1+r} - \frac{1}{(1+r)^t}}$$

**Capital Recovery Factor**

The Capital Recovery Factor (CRF) (the factor that converts an investment into an equivalent annual payment) is defined as the ratio between a uniform annual (annuity) value and the present value of the annual stream. This is a very useful quantity for evaluating the performance of energy - efficiency investments that lead to annual -cost savings.

$$\text{CRF} = \frac{r}{A/P} = \frac{r}{\frac{1}{1-(1+r)^{-t}}}$$

**Life Cycle Cost**

The life cycle cost (LCC) is the total discounted (present worth) cash flow for an investment with future costs during its economic life.

$$\text{LCC} = C_c + \sum_{n=1}^{t} \frac{C_n}{(1+r)^n} - \frac{SV}{(1+r)^t}$$

Where:

- $C_c =$ initial Capital Cost (Capital, labour, administrative cost),
- $C_n =$ Operating Cost (operation + maintenance, fuel, tax and interest) in year $n$,
- $SV =$ Salvage Value (in year $t$).
For uniform annual costs: If \( C_n = A \) for all \( n \):

\[
LCC = C_c + \frac{A}{(SV \cdot PWF_{t,r})} - (SV \cdot PWF_{t,r}) CRF_{t,r}
\]

### Annualized Life Cycle Cost

The annualized life cycle Cost (ALCC) is the annual uniform cash flow series (annuity) with a net present worth equal to that of the life cycle cost.

\[
ALCC = LCC \cdot (A/P)_{t,r} = LCC \cdot CRF_{t,r}
\]

### Cost of Saved Energy

Another very useful simple measure of economic performance for energy-efficiency measures is the cost of saved energy (CSE), which measures the cost of an efficiency measure in the same unit as one typically compares energy supply resources, i.e., cost per kwh. The cost of saved energy is the sum of net annualized capital costs of an efficiency measure and its net increase (or decrease) in operating costs, divided by the annual energy savings.

\[
ALCC^* = \frac{CSE}{D}
\]

Where:
- \( CSE \) = Cost of saved energy (e.g., Rs/ M\text{kw}h),
- \( ALCC^* \) = Modified annualized life cycle cost (e.g., Rs/ yr) of the efficiency measure: this cost should not include savings from reduced energy consumption,
- \( D \) = Annual energy savings (e.g., M\text{kw}h/yr).
A key point with regard to the CSE is that if the efficiency improvement is a retrofit to still usable existing equipment, one should use the total cost of the energy-efficiency measure to calculate the CSE (because there would have been zero additional cost without the measure).

But if the efficiency measure replaces other "base-case" new equipment, which was to be installed, then one should use only the net additional (incremental) cost of the energy measure, because the cost of the "base-case" equipment without the efficiency measure would have been spent regardless. In this case, CSE would be defined as follows:

$$\text{CSE} = \frac{\text{ALCC}^*_A - \text{ALCC}^*_B}{D}$$

Where:

- $\text{ALCC}^*_A = \text{ALCC}^*$ using an energy-efficiency measure,
- $\text{ALCC}^*_B = \text{ALCC}^*$ with non-energy-efficient measure (i.e., "base-case"),
- $D =$ Energy savings from replacing measure B by measure A.

The estimation of the CSE can usually be simplified by assuming that the energy savings are a uniform annual series, in which case:

$$\text{CSE} = \frac{(\text{CRF} \times C_c) + C_{op}}{D}$$

Where:

- $\text{CRF} =$ Capital recovery factor
- $C_c =$ Capital cost of measure (Rs)
- $C_{op} =$ Operating cost of the measure only (Rs/ year) (do not include any energy saving),
- $D =$ Annual energy savings (Mkwh/ year).