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Assessment of Financial and Economic Basics of Energy Saving

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ABSTRACT — Economic growth needs access to more energy resources in the countries heading to development. Expansion of urbanization and industries has enhanced energy need. People in cities require transport means (for passengers and commodities) and other energy-using services. Substructure, Infrastructure, economic, and industrial activities need energy, particularly electrical energy. Heightening of life standard requirements energy-consuming services, including personal automobiles and electrical home instruments, and providing electrical energy for villages in several countries has significantly transformed life levels and is the major preference. There are distinct economic ways for comparing different investments; e.g. ALCC and LCC, but these both quantities rely on investment level, not their relative economy status. Other comparing method is Internal Return Rate that is equal to discount rate. For IRR, the present values of Future Financial Flows are zero.
KEY WORDS: *Integrated planning, evaluation, frugality, economic, financial, energy.*

Introduction

Significant increase of oil rate and increase of interest rate during 1970s ended in low-price energy periods for developing countries. Therefore, energy became a barrier for advancement of third-world countries, that has limited their development in their economic and environment dimensions. Mega economic projects need foreign exchange for oil importing (even with low prices) and investment in new energy units. While consumers in industrial countries were only unsatisfied for oil shocks, high oil prices marginalized several developing countries from the market and they had problems for supplying fuel for their infrastructure, including their food industries. Though world market of oil is relatively stable, this may be a temporary situation. Expectation of oil price increase has kept energy situation in an unstable and ambiguous situation. However, in developing countries, energy is one of the key investment sectors. Many developing countries spend more than 30% of their internal development budget in energy domain. The World Bank also allocated circa 25% of its loans to energy related projects that are often used for electrical energy. Such loans are changed to levers for larger economic loans. The significant segments of these capitals have not been employed for economy of such countries, but were used for buying of foreign services and equipment. The quantity of energy loans in advancing countries indicates that development of energy sector was a significant factor in loan crises of these countries. In addition, each dollar in energy centers has been deducted from training, health educational and agricultural sectors.

Economic fundamentals of energy saving

Discount rate

Present investments should be compared with future frugalities for analysis of energy saving projects and final consumption optimization plans. Such results depend upon discount rate that shows time value of money. Fundamentally, discount rate is similar to interest rate or return rate.

For instance, assume you have $20 and two strategies:

a) You can spend all your money today;

b) You can save your money in a bank for one year, and you will have $22 at the end.

Suppose if both methods equally attract you, this means that today'2 $20 and future $22 ($20×1.1) are of equal values for you, therefore the discount rate is 0.1 or 10%. On the other hand, if you spend your money today in place of waiting for one year, your discount rate is more than 10%; and higher discount rate means higher present value compared with the future. . Usually, it is simpler to use discount rate with fixed dollars. The discount rate can be explained so that it indicates present value of a capital including inflation; or it may indicate fixed capital value without considering inflation. For example, we used the following formula to convert the nominal dollar of 1996 to fixed dollar of 1990:

$$\$(1990) = \frac{\$(1996)}{(1+f)^6}$$

in which, f is annual inflation rate between 1990-1996. Real modified discount rate for inflation r_r is obtained by nominal discount rate r_n as follows:

$$(1+r_r).(1+f) = 1+r_n$$

$$r_r + r_f + f = r_n$$

$$r_r = \frac{r_{n-f}}{1+f}$$

in which,
r_r = Real discount rate
r_n = Nominal discount rate
f = Inflation rate
For example, if nominal discount rate is 12% and inflation rate is 8%, then real discount rate is $\frac{0.12-0.08}{1+0.08} = 3.7\%$ [1]

Although real discount rate is more common, bank interest rate is usually expressed by nominal discount rate. In fact, both can be applied with equal precision. Nevertheless, what do these discount rates mean? Time value of money many change by a larger risk or distrust. Among two investments with equal average return rates, PV of that investment with lower distrust (damage risk) is higher. Sometimes, it is possible a consumer assume investment risk in energy optimization equipment higher since he has not enough information, so he supposes a high discount rate for this investment. For a society, energy optimization is a low-risk investment with a low discount rate.

Net Present Value (NPV)
Net Present worth (NPW) or NPV is the present value of future financial flows. As Fig. 1 shows, future financial flows (dark rectangles) are discounted to determine present value (bright rectangles). The further these financial flows in future, the more discount they will have (at the present time).

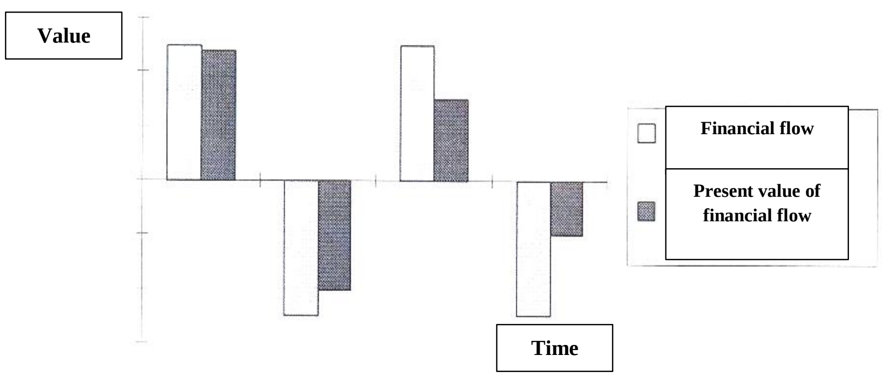

Fig. 1: Relation between discounted present and future financial flows

The present value P for future financial flows F is:
P = F.PWF
In which,
P = Present value at base year
F = Future value at incidence year
PWF = Present value factor = $\frac{1}{(1+r)^t}$
r = Discount rate
t = Interval between P and F
For example, if you pay $500 on December 31, 2000 and annual discount rate is 5%, then present value of this payment on January 1, 1997 (four years before) is:

[1] If time is expressed in terms of "year", unit of r is "1/yr". However, we can use yearly intervals optionally. r can be monthly too, so we have $(1+r_{monthly})^{12} = 1 + r_{annual}$ or $r_{monthly} = (1+r_{annual})^{\frac{1}{12}} - 1$

$$500\$.\frac{1}{(1+0.05)^4} = 411.35\$$$

NPV of a set of future financial flows is equal to the total discounted PV of individual flow, including positive (income) and negative (cost) flows. Therefore, in Fig. 1, PV of this set of capitals is equal to sum of bright rectangles. For a set of future financial flows we have:

$$P = \sum (F_n.PWF_n)$$

If future financial flows have equal values of F_n=A, then we have:

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

Capital Return Factor (CRF) is the ratio between an equal annual value (annuity) and PV of annual flow. This quantity is suitable for evaluation of investments in energy optimization that produce annual savings.

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

For example, if we want to investigate in a productive ventilation system with excess value of $1000, what is minimum energy annual saving for this investment be economic, with life of 12 years and discount rate of 9%?

CRF = A/P = 0/13965

P = 1000; t = 12; r = 90%

Min. energy saving = A = R.CRF = 139.65 $/yr

Life Cycle Cost (LCC)

LCC is total (discounted) future cost due to present investment in a project during its economic life:

$$LCC = Cc + \sum_{n=1}^{n=t} [\frac{C_n}{(1+r)^n}] - \frac{SV}{(1+r)^t}$$

in which,

Cc = Initial investment costs (labor force, administrative costs)

C_n = Current costs (labor, repair and maintenance, fuel, tax, interest) in year n

SV = Salvage value (at year t)

For equal annual costs, if we have A=C_n for all n, then,

$$LCC = Cc + \frac{A}{CRF_{t,r}} - (SV.PWF_{t,r})$$

For example, if purchase cost of a device is $1000 and its present annual cost is 100 $/yr, and the device is sold at the end of 8th year for $300, then we have (assuming a discount rate of 7%):

$$CRF_{8yr,7\%} = 0.16746, PWF_{8yr,7\%} = 0.5820$$

Therefore, LCC of this device is:

$$LCC = 1000\$ + (100\$/0.1646) - (300\$.0.5820) = 1423\$$$ [2]

Annual LCC (ALCC)

ALCC is the annuity with NPV equal to PV of LCC:

$$ALCC = LCC.(A/P)_{t,r} = LCC.CRF_{t,r}$$

In the above example, with LCC=$1423, life cycle=8 years, and discount rate=7%, we have:

$$ALCC = 1423\$.0.16746 = 238\frac{\$}{yr}$$

Prioritization economic measures: IRR

There are different economic methods for comparing investments. LCC and ALCC can be used, but these two quantities severely depend on investment value, not merely to its economy. Another prioritization measures is IRR, which is equal to discount rate. IRR is a value for which present value of future financial flows (FFF) is zero.[2]

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[2] Time interval between financial flows can be other than "year". If K_L payments take place in L≠1 time intervals rather than annual A payments, then $\frac{A}{CRF_{t.r}}$ in A3-9 can be replaced with $\frac{K_L}{CRF_{t*R*}}$, in which $t *= \frac{t}{L}$ and $r *= (1+r)^L - 1$. In the mentioned example, if time interval is one month, we have: $L = 1\, month = \frac{1}{12}\, years, t = 8 years, r = 7\%$

$$K_L = 100\frac{\$}{yr} \div 12 month/yr = 8.33\$/month$$

$$t^* = t/l = 8/(1/12) = 96$$

$$r^* = (1+r)^L - 1 = (1+0.07)^{(1/12)} - 1 = 0.005654$$

$$CRF_{96,0.005654} = \frac{r^*}{[1-(1+r^*)^{-t^*}]} = \frac{00.005654}{[1-(1+0.005654)^{-96}]} = 0.01353$$

Thus, LCC is $\$1000 = (\$8.33/0.01353) - (\$300 \times 0.528) = \$1441$

A project with higher IRR is more economical. By setting eq. (A3-5) equal to zero, we have:

$$P = \sum (F_n.PWF_n) = \sum [\frac{F_n}{(1+r)^n}] = 0$$

If all F_n values are known, we can obtain eq. (A3-11) by iteration for r, which indicates IRR is at the point in which P=0. For annual uniform saving of D during n years due to present investment Cc, we have:

$$CRF_{n,irr} = \frac{D}{Cc}$$

or

$$P = 0 = Cc - \frac{D}{CRF_{n,irr}}$$

This can be assumed a special type of eq. (A3-9). Knowing D and Cc, eq. (A3-12) can be solved for CRF and can be compared with IRR in the interest rate table; or eq. (A3-7) can be solved for IRR. On the other hand, many spread sheet and calculators have IRR functions. For example, if excess cost of a productive device is $500 and it saves $80 during its 12-year life, by eq. (A3-12) we have:

$$CRF = 80\frac{\$}{yr} \div 50\$ = 0.16/yr$$

Which yields:

IRR = 11.81%

Prioritization economic measures: Simple return

Another simple but useful measure for determination of advantage and priority of projects is Simple Return Method (SPB), which is defined as required time for equalization of total annual saving with initial costs (without discount):

$$SPC = \frac{Cc}{D} =$$

For example, for $100 investment with saving equal to $1\frac{MWh}{yr}$, we have:

$$SPB = 100\$ \div 50\frac{\$}{yr} = 2\,years$$

Despite SPB does not consider discount rate and monetary flow after return time, however it is a simpler method than IRR for prioritization with a uniform annual financial flow. Relation between SPB and IRR can be expressed by the following example:

Prioritization economic measures: Saved energy cost (SEC)

Another simple and useful measure for determination of advantage and priority of projects is SEC, in which, the optimum cost is expressed with the same common energy units of supply sources (KWh or GJ). SEC is equal to sum of net annual costs for investment of an optimum strategy plus its net increment (decrement) in current costs, divided by annual saving:

$$CSE = \frac{ALCC^*}{D}$$

in which,

SEC = Saved energy cost ($/MWh)

ALCC* = Modified ALCC ($/yr) for optimization strategy. This cost should not include saving for reduced energy consumption.

D = Annual energy saving (MWh/yr)

A key point for SEC is that if optimization is for modification of the existing equipment, total optimization strategy should be considered for calculation of SEC (since excess costs are zero without strategy). But if optimization strategy is substituted by a new strategy, then merely the added cost for optimization strategy should be considered, since the cost of base strategy was paid without optimization strategy. In this case, SEC is defined as:

$$CSE = \frac{ALCC_A^* - ALCC_B^*}{D}$$

in which,

$ALCC_A^*$ = ALCC* by an optimized strategy

$ALCC_B^*$ = ALCC* by a non-optimized strategy

D = Energy saving due to replacement of strategy B with strategy A

For simplicity, SEC usually is calculated by assuming uniform annual energy saving. Thus we have:

Notice to the differences of LCCs. If we assume current cost is paid once a year, LCC=$1423; if it is once a month, LCC=$1441, which this is because of different payment times of current costs.

$$CSE = \frac{(CRF.Cc) + Cop}{D}$$

in which,
CRF= Capital Return Factor ($\rightarrow$ eq. A3-7)
Cc = Investment cost for strategy ($)
Cop = Current cost of strategy ($/yr) (without any energy saving)
D = Annual energy saving (MWh/yr)

Prioritization economic measures: Saved capacity cost (SCC)

Another useful measure for prioritization is SCC, which is specially used in the load management programs to lower demand peak and retard capacity expansion requirement:

$$CSC = \frac{LCC^{*}.(8760\frac{hr}{yr}).LF}{D}$$

in which,
SCC = Saved capacity cost ($/MW)
LCC* = Modified LCC ($) for optimization strategy. This cost should not include saving for repairing and maintenance due to reduced energy consumption.
D = Annual energy saving (MWh/yr)

Note that the confidence interval of demand peak and the confidence interval of capacity decrement must be modified by used load fraction in demand peak hours.

Summation and conclusion

Significant increment of oil price and increment of interest rate in 1970s ended up low-price energy periods for developing countries. Thus, energy became an obstacle for development of third-world countries, which has limited their development in their economic and environment aspects. Major economic projects require foreign exchange for importing oil (even with low prices) and investment in new energy units. In the developing countries, economic growth requires access to more energy resources. Expansion of urbanization and industries has increased energy demand. People in cities require transportation (for commodities and passengers) and other energy-consuming services. Infrastructure, economic, and industrial activities need energy, especially electrical energy. Improvement of life level demands energy-consuming services, including personal vehicles and electrical home appliances, and supplying electrical energy for villages in many countries has significantly changes life levels and is the main priority. There are different economic methods for comparing different investments; e.g. LCC and ALCC, but these two quantities depend on investment level, not their relative economy states. Another comparing method is Internal Return Rate (IRR), which is equal to discount rate. For IRR, the present values of Future Financial Flows (FFF) are zero.

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