ENGINEERING ECONOMY AS THE MAIN DETERMINANT FOR CHOICE OF ALTERNATIVES AND PROFITABILITY IN AN ENTERPRISE

A PAPER PRESENTED

AT THE CONFERENCE ON

ENGINEERING ECONOMY AS THE KEY DRIVER FOR SUSTAINABLE DEVELOPMENT IN NIGERIA

BY

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ABSTRACT

Engineering Economics is simply the application of principles of economics to the evaluation design and engineering alternatives. In the past, the major challenge before engineers was technological. However, a stage has been reached in which engineers seek solutions to problems by considering economic viability alongside with the technical aspects. This implies that it is not enough to base the acceptability of engineering facility by considering only the technical viability without assessing the economic viability aspect of such facility. Therefore, considering the time value of money is critical to most engineering economic analysis. For every engineering problem, there are usually many possible alternatives but there is usually one best way of doing it. In engineering economics, cash flows are discounted using an interest rate over a stipulated period of time and the alternative with the favorable economic criteria is chosen as the best alternative.

1.0 INTRODUCTION

Engineering economics is the application of economic techniques to the evaluation of design and engineering alternatives. The role of engineering economics is to assess the appropriateness of a given project, estimate its value, and justify it from an engineering standpoint. This paper discusses the time value of money and other cash-flow concepts, such as compound and continuous interest. It continues with economic practices and techniques used to evaluate alternatives with a view to taking an appropriate decision. The final section illustrates the principles of engineering economics. The Council has been involved in design, procurement and installation of various engineering facilities such as raw materials process equipment. The techniques used to evaluate alternatives have been useful in facilitating appropriate decisions.

This paper also includes case illustrations showing how to apply the practices and techniques to investment decisions.

2.0 ELEMENTS OF ECONOMIC ANALYSIS

2.1 Cash-Flow Concepts

Cash flow is the stream of monetary (Naira) values—costs (inputs) and benefits (outputs)—resulting from a project investment.

2.2 Time Value of Money

The following are reasons why N3000 today is "worth" more than N3000 one year from today:

1. Inflation
2. Risk
3. Cost of money

Of these, the cost of money is the most predictable and hence, it is the essential component of economic analysis. Cost of money is represented by (1) money paid for the use of borrowed money, or (2) return on investment. Cost of money is determined by an interest rate. Time value of money is defined as the time-dependent value of money stemming both from changes in the purchasing power of money (inflation or deflation) and from the real earning potential of alternative investments over time.

2.3 Cash-Flow Diagrams

It is difficult to solve a problem if you cannot see it. The easiest way to approach problems in economic analysis is to draw a picture. The picture should show three things:

1. A time interval divided into an appropriate number of equal periods
2. All cash outflows (deposits, expenditures, etc.) in each period
3. All cash inflows (withdrawals, income, etc.) for each Period

Unless otherwise indicated, all such cash flows are considered to occur at the end of their respective periods. Figure 1.0 is a cash-flow diagram showing an outflow or disbursement of N1000 at the beginning of year 1

and an inflow or return of N2000 at the end of year 5.

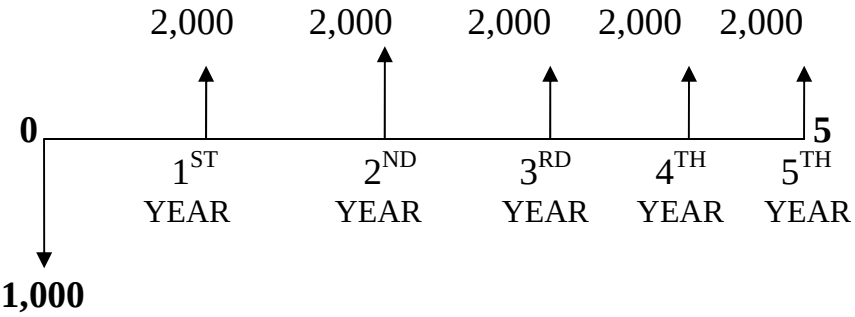


Fig1.0

2.4 Notation

To simplify the subject of economic analysis, symbols are introduced to represent types of cash flows and interest factors. The symbols used in this paper conform to those used in engineering economics, however, not all practitioners follow this standard convention, and care must be taken to avoid confusion when reading the literature. The following symbols will be used here:

P = Present sum of money (N)

F = Future sum of money (N)

N = Number of interest periods

i = Interest rate per period (%)

Aj= Cash flow at end of period j

A= End-of-period cash flows (or equivalent end-of-period values) in a uniform series continuing for a specified number of periods

G =Uniform period-by-period increase or decrease in cash flows (or equivalent values); the arithmetic gradient

S =Salvage (residual) value of capital investment

f= Rate of price level increase or decrease per period; an “inflation” of “escalation” rate

r= Effective interest rate per interest period a (discount rate), expressed as a percent

2.5 Economic Analysis of Alternatives

Various Calculation and formulae applied to arrive at estimates depending on the factors to be determined. These include:

A. Interest Calculations

Interest is the money paid for the use of borrowed money or the return on invested capital. The economic cost of construction, installation, ownership, or operation can be estimated correctly only by including a factor for the economic cost of money. The following factors are usually computed : Simple Interest; Compound Interest; Notional Interest; Effective interest rate; Continuous compounding interest rate;

B. Compound amount factors

i. Future worth

The future worth of a present amount when interest is accumulated at a given interest rate i for a number of period n

$$F = P(1 + i)^n$$

ii. Resent Value factor,

The future worth of present amount when interest is accumulated at a given rate i for a number of period is

$$F = P(1 + i)^n$$

iii. Capital Recovery and Sinking Fund Factor;

If a fund is to accumulate to a given future value as a result of uniform series of payment, this fund is called Sinking Fund.

$$A = \frac{Fi}{(1 + i)^n - 1}$$

iv. Capital recovery;

Suppose a project owes a bank certain amount of money, you may wish to know the amount of each future series, of equal payment require to accumulate to a given present value at a given interest rate and n period. In other words, compute annuity as follows if the present worth is given.

$$A = \frac{Pi}{\{1 - 1/(1 + i)^n\}}$$

v. Capital Recovery factor;

The present worth of annuity is the inverse of the capital recovery factor

$$P = A\{1 - \frac{1}{(1 + i)^n}\} \frac{}{\frac{}{i}}$$

vi. Gradient factor;

Suppose a base annuity increases or decreases by a constant value, the annuity is $A = A^1 + G (A/G, i, N)$. $(A/G, i, n)$ is known as Gradient factor.

vii. Economic analysis of Alternatives

- Net Present Value – NPV

The net present value of an investment is defined as the present value of the net cashflow at a pre-determined discount rate.

$$NPV = \sum_{t=0}^{n} \frac{F_t}{(1+r_i)^t}$$

where $\sum$ = a sum total for the whole life time of project from year zero to n

F_t = Net cashflow in year t

r_I = rate of discount.

- Internal Rate of Return

The internal rate of return (IRR) is the rate of discount that reduces the net present value (NPV), of net cashflows of a project to Zero.

$$NPV = \sum_{t=0}^{n} \frac{F_t}{(1+r_i)^t}$$

- Profitability Index).

It has been observed that when net present value (NPV) and internal rate of return (IRR) are used to evaluate two or more exclusive projects, it is often misleading to

rank and select the most viable choices based on their results. The profitability index (P.I) is used to provide a better picture of the profitability of the chosen project.

$$P.I. = \frac{\text{Discounted cashflow}}{\text{Net investment}}$$

The profitability index is also useful for comparing the viability of project having unequal life and leads to a more desirable decision than net present value and internal rate of return.

As professionals we use the application of these principles to enhance effective engineering decisions.

3.0 CASE STUDIES: SIMULATED CALCULATIONS CONCERNING TYPICAL RMRDC PROJECTS
(Applications in Process equipment acquisition and Installation)

Case Study1

The Council is considering three methods of acquiring gas cyclone for use by field engineers. The alternatives are:

A. Purchase the gas cyclone for N7,200 each and sell after 4 years for an estimated N1,200 each.

B. Lease the gas cyclone for 4 years for N2,250 per year paid in advance at the beginning of each year. The contractor pays all operating and maintenance costs on the gas cyclone and the leasing company retains ownership.

C. Purchase the gas cyclone on special time payments with N750 down now and N2,700 per year at the end of each year for 3 years.

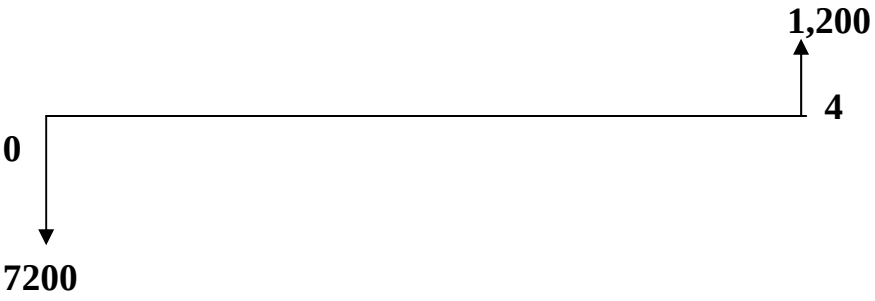
Assume the gas cyclone will be sold after 4 years for N1,200 each.

If the contractor's MARR is 15%, which alternative should he choose?

Note: All alternatives involve equal lives.

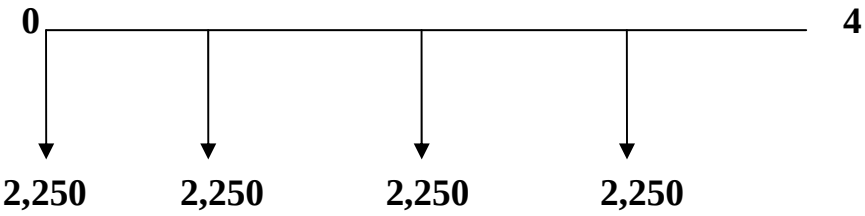
To solve, calculate the net present worth (NPW) of each alternative at 15% and select the least costly alternative:

A



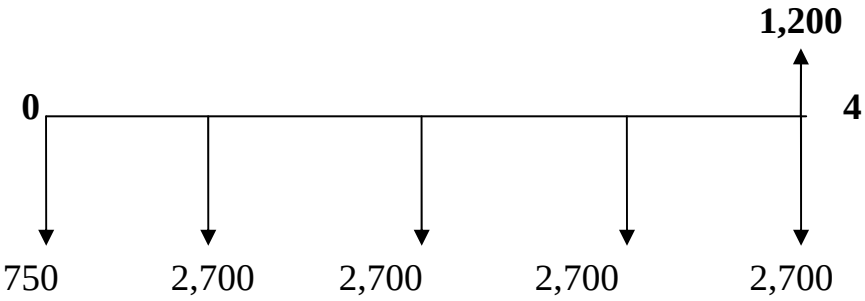
NPWA = -7,200 + 1,200(P/F),15,4) = -N6,514

B



NPWB = -2,250 - 2,250(P/A),15,3) = -N7,387

C



NPWC = -750 - 2,700(P/A),15,4)+1,200(P/A),15,4) = -N7,772
The least costly alternative is A

Case Study 2

The Council established a model factory in Niger state to produce talcum powder, and because of the low capacity of the hammer mill, a critical equipment of the company, the output is very low. The company could increase production by procuring a new hammer mill. The selling price of processed talc per ton is N30,000.00 and remain unchanged even if output and sales will increase. A market survey was conducted and the following estimates based on the annual increased output of 480 tons are:

(a) cost of the new hammer mill having an expected life of 5 years is N500,000.00
(b) cost of installation N30,000.00
(c) Expected scrap value Nil
(d) Annual increase in utility expenses N150,000.00
(e) Annual increase in labour cost N100,000.00
(f) Annual additional cost of raw materials N500,000.00

(Assuming taxation of 40%, Straight line depreciation method and that the policy of the company is not to invest in projects earning less than 25% rate of return.

Should management of the project embark on the procurement of the new hammer mill?

Solution

Cost of equipment	500,000.00
Cost of installation	30,000.00
	530,000.00
Annual sales (N30,000 x 480)	14,400,000.00

Annual production expenses	750,000.00
Annual income	13,650,000.00

Table 1

Year	Income Before tax N'000	Depreciation cost N'000	Taxable Income N'000	Taxes N'000	After tax cash flow N'000
0	530.00				
1	13,650	100	13,550	5,420	8,230
2	13,650	100	13,550	5,420	8,230
3	13,650	100	13,550	5,420	8,230
4	13,650	100	13,550	5,420	8,230
5.	13,650	100	13,550	5,420	8,230

Since the five years cash flow of N8,230,000 is an annuity and discount rate of 25%, the present value is

$$\frac{A[1 - (1 + i)^{-n}}{i}$$

$$= \quad 8{,}230{,}000\left[\frac{1 - (1 + 0.25)^{-5}}{0.25}\right.$$

$$= \quad 8230{,}000 \times 2.689$$

$$= \quad 22{,}132{,}774.00$$

The net present value = -530,000.00 + 22,132,774.00

= N21,602,774

The net present value is positive, hence the management should go ahead with the procurement of the hammer mill.

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