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Investing in energy efficiency: 1 Appraisal techniques and assumptions

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This Information Paper reviews several investment appraisal techniques and discusses how they can be used to assess the economic benefits of different energy efficiency measures in housing. The procedure for using the preferred method is described. Energy savings are estimated with the aid of the BREDEM Domestic Energy Model. This paper is addressed to all persons concerned with energy efficiency in buildings. This includes architects, builders, suppliers, housing authorities, their managers and technical staff and also home-owners.

Subsequent Information Papers will give examples of how the assessment procedure can be used in existing and new housing, for domestic hot water and lighting.

INTRODUCTION

Saving energy can be a good investment. Some measures are better investments than others. A few are of little worth if energy saving is the sole objective.

To evaluate a measure as an investment, energy saved over a period of time must be costed, and the saving compared with implementing and maintaining the measure, taking into account possible replacements needed during that time. Its economic worth can then be compared with that of other investment opportunities, and ranked with them in merit order.

This is the first of several Information Papers based on the BRE Report[1] by John Pezzey which makes an economic assessment of some energy efficiency measures in housing and other buildings. Pezzey employed some recognised investment appraisal techniques for this purpose. This IP examines several of these procedures before selecting one as a general yard-stick for assessing energy efficiency.

Subsequent IP's will contain some sample assessments based on 1982 costs and fuel prices. Whilst these still give some broad indications of the relative merits of the measures in question, readers who wish to assess their own projects should employ the latest available data.

INVESTMENT APPRAISAL TECHNIQUES

Four of the procedures examined by Pezzey are summarised in Table 1.

Table 1 Some investment appraisal techniques

Method	Definition	Comment
P: Simple payback period	Period of time over which net savings *(S)* equal costs of implementation *(K)*; ie $P = K/S$	Simple and easy to calculate and understand: but has little use comparing measures with markedly different lifetimes
NPV: Net present value	Difference between present value of net savings *(S)* and capital costs *(K)* over lifetime *(N)*	Allows measures having different lifetimes to be compared, and uneconomic investments to be identified ie where *NPV* is −ve
NPV/K: Net present value per unit cost	Net present value *(NPV)* divided by costs of implementation *(K)*	Allows different efficiency measures to be ranked in merit order as investments; useful where available finance is limited
IRR: Internal rate of return	Discount rate *(r)* which makes $NPV = 0$	Does not require initial choice of discount rate but may have to be determined graphically or by numerical iteration

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Pezzey selected as the most useful procedure for the long lifetimes characteristic of housing the third method in Table 1, ie *NPV/K* or Net Present Value per unit of capital cost (*K*).

The concept of 'Present Value' hinges on the fact that, regardless of inflation, a sum of money received today is worth more than the same sum received in several years time. This is because a sum invested today would grow at a compound rate of interest. Therefore, to obtain the present value of a future sum this has to be discounted at an appropriate rate over the number of years in question. All sums have to be in real terms, ie adjusted to the value of the £ sterling in year one of the project.

Pezzey employed a discount rate of 5% which is the rate used in public sector investment analyses. However, an individual or firm could use the interest rate currently received on investments or, in the case of a firm, its current return on capital employed.

MEANING OF A *NPV/K* VALUE

NPV/K can be regarded in simple terms as being equal to $(B-K)/K$ where:

B = discounted lifetime savings from the efficiency measure and

K = initial capital cost (unless capital expenditure was spread over several years when it would be the discounted capital cost.)

This means that:

(1) If B is less that K then *NPV/K* is negative, there are no economic benefits and the investment is a loss,

(2) If B equals K then *NPV/K* equals zero and the project breaks even,

(3) If B is greater than K then *NPV/K* is positive and the measure is likely to be a worthwhile investment. Naturally, the larger the value of *NPV/K* the better this investment will be.

CALCULATION OF *NPV/K*

In the above relationship $NPV/K = (B-K)/K$ the value of B, ie the present value of net savings, is given by

$$B = \frac{S[1-(1+r)^{-N}]}{r}$$

This equation assumes that the savings occur at a constant rate.

S(£) = The net annual savings. This is effectively the annual saving less normal costs of maintenance and replacements or minor energy costs such as the electricity needed to run an energy saving pump.

N (years) = The lifetime of the measure

r = The selected discount rate expressed as a decimal fraction, ie 5% = .05.

To save calculation, B can also be obtained from tables of present value for different discount rates[2].

Pezzey (page 24) shows how the calculation can be modified to allow for an assumed future rate of fuel price increase. In his examples he assumes either 0% or 3% annual price rises in real terms. For a 3% rise the value of r used in the above equation if effectively reduced from .05 to .0194.

Also, values of *NPV/K* can be directly read from Figure 1 and Figure 2 showing graphs of simple payback period ($P = K/S$) against lifetime (N).

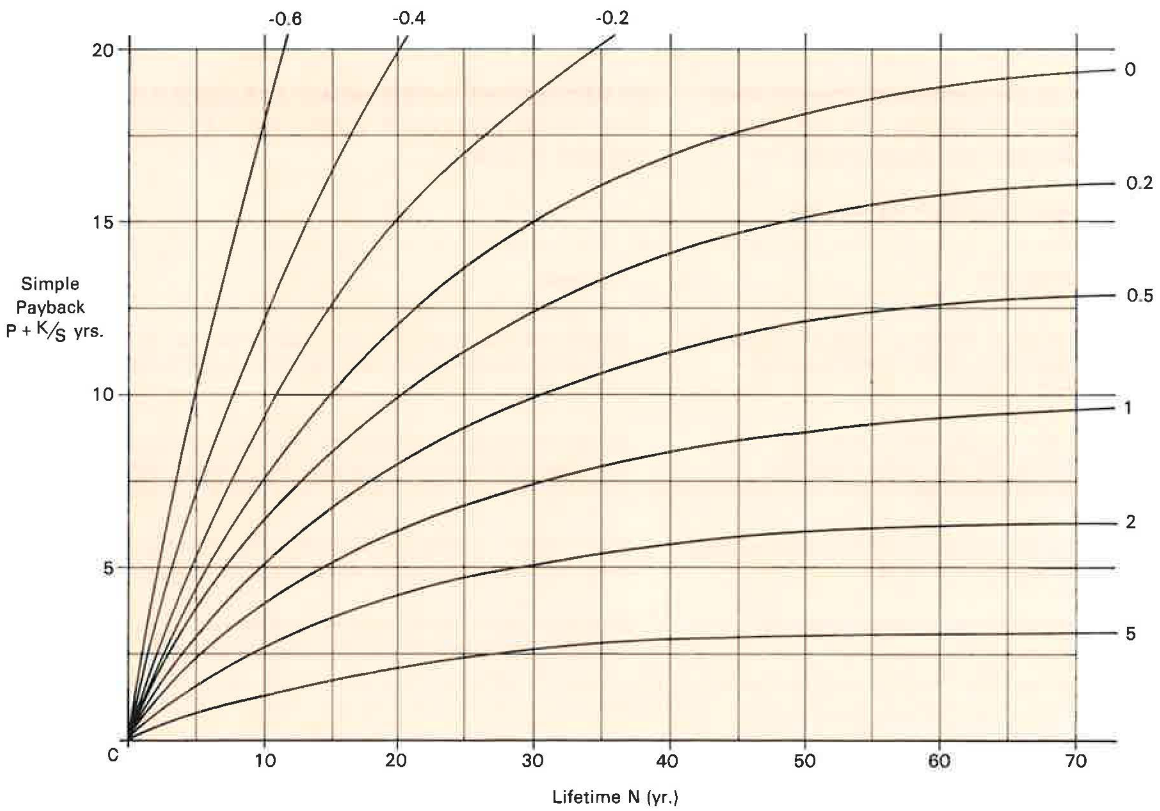


Figure 1 Lines of constant *NPV/K* assuming energy prices rise with general costs. Discount rate 5%

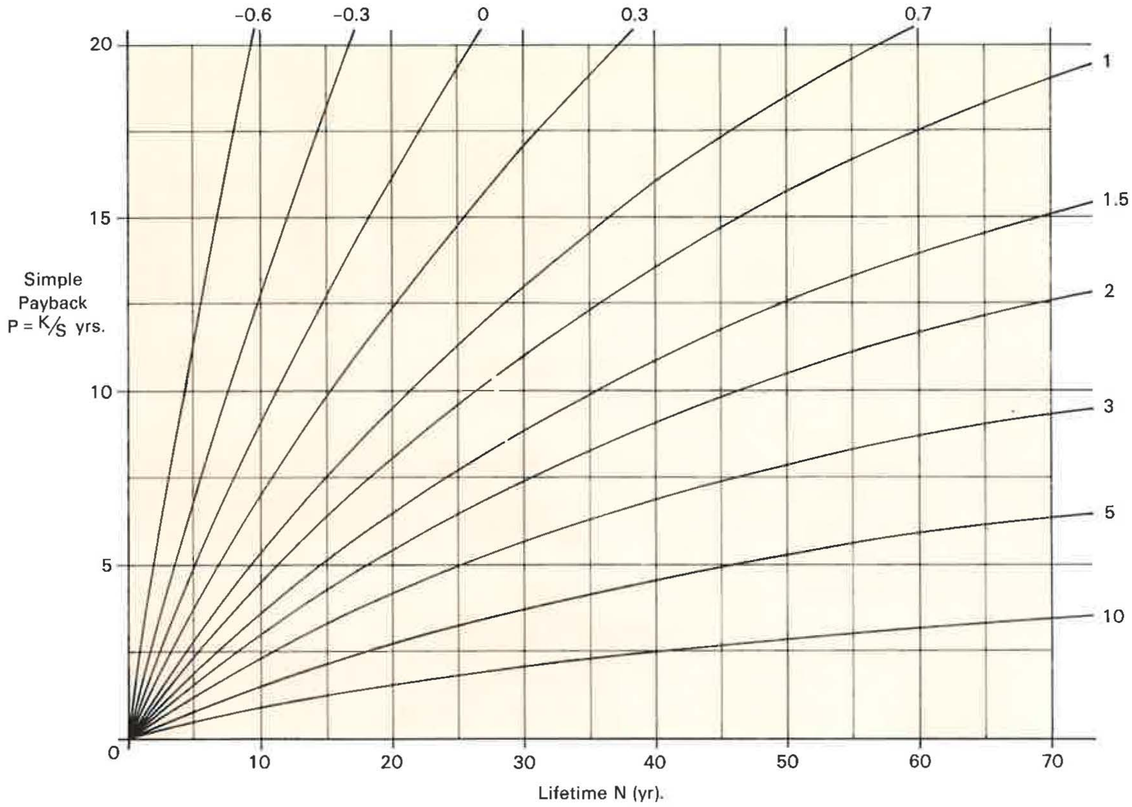


Figure 2 Lines of constant *NPV/K* assuming energy prices rise at 3%/yr in real terms. Discount rate 5%

Figure 1 assumes 0% growth in fuel prices relative to any general increase in prices and Figure 2 a 3% relative growth rate. In both cases the discount rate is 5% per 1 year.

ESTIMATING ENERGY SAVINGS

To obtain a meaningful value for *NPV/K* you first need to make a realistic estimate of the energy saving that could be expected from introduction of an energy efficiency measure for example, by calculation or by using experimental evidence. The BRE Domestic Energy Model or BREDEM[3,4] is designed to facilitate this process for housing projects.

BREDEM is a mathematical procedure based upon practical experience which enables calculation of the annual energy requirements of houses. There are several versions of BREDEM each with its own objectives and assumptions. Pezzey used a two heating zone model allowing for a controlled temperature downstairs. Figure 3 illustrates the temperatures, thermal conductances and heat flows in such a model.

The data required for a calculation fall into three types:

(a) House and heating system — U-values, ventilation rates, appliance efficiences etc will be the best estimated for the particular case under consideration;

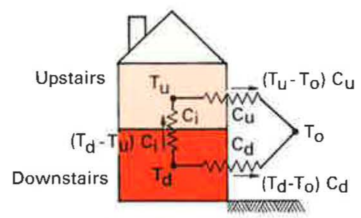
(b) Weather — external temperatures (or degree-days), solar radiation will be those applicable to the locality concerned;

(c) Householder variables — heating patterns, water heating, electrical appliances etc will be

(i) in the case of a calculation relating to a particular household, the best estimates available for that household, or
(ii) in the case of calculations over groups of similar houses, appropriate average values.

The energy saved by an efficiency measure is gauged by performing the BREDEM calculation for the before and after situations. Amongst the factors involved, the calculation has to allow for the respective efficiencies of different heating appliances in converting delivered energy into useful energy or output. For example, some comparative appliance efficiencies are:

Heating appliance	Efficiency %
Gas fired boiler supplying hot water radiators	60 – 75
Gas fired warm air system	70 – 75
Gas fired (radiant or convective or combination)	55 – 60
Electric fire (direct acting)	100



Temperatures: T_u, T_d, T_o as shown (°C)

Conductances: C_u, C_d, C_i as shown (W/°C)

Steady — state heat flows between compartments: (——►) $(T_u - T_o)\ C_u$, $(T_d - T_o)\ C_d$, $(T_d - T_u)\ C_i$ as shown (W)

Subscripts: u upstairs d downstairs i interflow o outside

Figure 3 Thermal model of a two-storey house indicating steady state thermal conductances and heat flows

To convert energy savings to money the following energy and tariff conversions are used:

kWh	$= 3.6 \times 10^6$J
Therm	$= 1.0551 \times 10^8$J
1 p/kWh	= 2.778 £/GJ
1 p/therm	= 0.09478 £/GJ

The S1 unit Joule (J) is used as the common unit of energy and its multiple the Gigajoule (GJ) equals 10^9J.

Some marginal domestic fuel prices that were current in 1982 are compared in Figure 4.

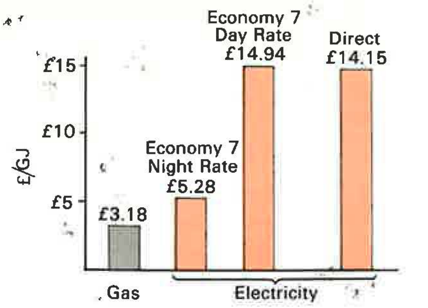


Figure 4
Marginal domestic prices for delivered energy (UK average: 1982 4th quarter)

Computer software for undertaking BREDEM calculations is now available from several sources [5,6]. Advice can also be obtained direct from BRE for particular applications. (Please contact the Building Research Advisory Service in the first instance; Tel: Garston (0923) 676612.)

EXAMPLES

Examples of some assessments of energy efficiency measures in existing and new housing and for domestic hot water and lighting will be described in forthcoming Information Papers.

GENERAL CONCLUSIONS

1. Several approaches based upon investment appraisal procedures are available for assessing the economic benefits likely to be achieved by implementation of energy efficiency measures in housing.

2. Pezzey has chosen as the most useful yard-stick the value of NPV/K_c which relates the Net Present Value of the financial saving to the capital cost of the efficiency measure.

3. The likely energy saving from implementation of such a measure can be predicted with the aid of the published BREDEM Domestic Energy Model.

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6 Educational program 'Domestic Heating'. Longmans Micro Software.

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