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Investing in energy efficiency: 2 Existing housing

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This Information Paper uses the appraisal technique described in Information Paper IP 17/86[1] to assess the economic value of several energy efficiency measures applied to existing housing. Examples are given for loft insulation, wall insulation, double glazing and reflective foil behind radiators. The basic procedure is explained and sources of further information given.

The paper is addressed to all those concerned with improving energy efficiency in buildings. This includes architects, builders, suppliers, housing authorities, their managers and technical staff, and also home-owners.

INTRODUCTION

Information Paper No IP 17/86[1] described how recognised investment appraisal techniques could be used to assess the economic benefits likely to be achieved by implementing energy efficiency measures in housing. It selected as a yardstick for ranking different measures the ratio of the Net Present Value *(NPV)* of the financial savings over the life of the project to the capital cost *(K)*. If the value of *NPV/K* is positive then the measure will be economically worthwhile and if negative not.

This paper gives some examples of how the procedure can be applied in practice to assess some energy efficiency measures in existing housing, viz:

1 Improved loft insulation
2 Wall insulation
3 Double glazing
4 Reflecting foil behind radiators on external walls.

The assessments are taken from a BRE Report by John Pezzey entitled 'An economic assessment of some energy conservation methods in housing and other buildings'[2]. Many of the costs, including the fuel prices, used in the Report were those for 1982. The results quoted in this paper nevertheless give some broad indications of the relative merits of the measures in question. However, readers who wish to assess their own projects should employ the latest available data using the examples only for guidance.

THE THERMAL MODEL

Pezzey based his calculations upon a number of assumptions concerning the type of house, its U-values and space heating parameters.

(a) **The standard house**

This is a three bedroom, two storey, semi-detached house with the following main dimensions and U-values:

Table 1 — Main dimensions of the standard house

Width	5.4 m
Depth	8.1 m
Height to eaves	5.2 m
External wall area	98.3 m²
Upstairs	
Window area (including frames)	9.8 m²
Opaque wall area	32.6 m²
Loft area	43.7 m²
Volume of air	113.5 m³
Downstairs	
Window area	9.8 m²
Opaque wall area	32.6 m²
External doors area	6.6 m²
Ground floor area	43.7 m²
Volume of air	113.7 m³

(b) U-values

Table 2 — U-values of standard house

Element	U-value (W/m² °C)	
	Solid wall	Cavity wall
Single glazed window	4.3	4.3
Opaque wall	2.1	1.5
Loft: well heated house	0.84	0.84
poorly heated house	1.51	1.51
External doors	2.8	2.8
Ground floor	0.76	0.76

Other factors involved in the assessments are:

(c) **Heating levels**

	Downstairs °C	Upstairs °C
Well heated house	19	16.5
Poorly heated house	16	Uncontrolled

(d) **Fuels and tariffs (1982)**

	£/GJ
Gas	3.18
Electricity:	
Economy 7 night rate	5.28
Economy 7 day rate	14.94

(e) **Fuel price rise assumptions**

0% and 3% in real terms relative to general price trends

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(f) **Remaining life of house**

Solid wall : 35 years
Cavity wall : 80 years

ASSESSMENT PROCEDURE

The selected assessment criterion for a conservation measure is the Net Present Value *(NPV)* of the financial savings achieved over the life of the project per unit of capital cost *(K)*, ie *NPV/K*. As mentioned, if *NPV/K* is positive then the measure is considered economically worthwhile and if negative then the reverse. Projects can be ranked in order of *NPV/K* since the larger its value the better value for money it represents.

NPV/K can be written as equal to $\frac{B-K}{K}$ where:

B = The present value of the net savings *(S)* and

K = The initial capital cost of the measure (or the present value of the capital cost if the expenditure is spread over a number of years).

S = The financial value of the net annual savings achieved by the measure (assuming these occur at a constant rate) ie the actual saving less normal costs of maintenance and replacements or minor energy costs such as the energy needed to run an energy saving pump.

Once S has been estimated (see below) then the present value of net savings can be obtained from the discount equation

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

N (years) = The lifetime of the measure

r = The selected discount rate expressed as a decimal fraction, ie 5% = 0.05.

Energy savings can be estimated from experimental evidence or by calculation. The annual space heating output or 'useful energy' required to maintain target room temperatures can be calculated with the aid of the BRE Domestic Energy Model, BREDEM[3]. Useful energy divided by the percentage efficiency of the appliance gives the 'delivered energy' requirement, ie fuel consumption.

The energy saved by an efficiency measure is estimated from before and after estimates of delivered energy. The net saving *(S)* is the difference converted to money less any regular maintenance or other costs.

Calculation of S values can be less onerous if one employs a microcomputer implementation of the BREDEM model [4,5]. Advice can also be obtained from BRE for particular applications. (Please make contact through the Building Research Advisory Service; Tel 0923 676612).

MEASURE 1: LOFT INSULATION

This example compares the economic benefits achieved in terms of *NPV/K* values from installing loft insulation in the standard house. Two situations are considered, first for the poorly heated house and second for the well heated house.

Calculations are made for various combinations of the following factors:

(a) Either adding 100 mm insulation to an uninsulated loft or topping up an existing 25 mm to 125 mm.

(b) Fuel: gas or electricity

(c) Increase in fuel price either 0% or 3% in real terms.

(d) Installed by DIY or by a builder.

The following sample calculation assumes:

- Installation of 100 mm insulation in an uninsulated loft of a poorly heated house
- Installed by DIY at capital cost *(K)* = £70
- Gas heating
- 0% annual increase in fuel price
- Remaining life *(N)* of house = 35 years
- Discount rate *(r)* = 5%

The annual energy saving estimated with the aid of the BREDEM model was:

Useful energy saved = 3.39 GJ/yr
Money saved *(S)* = £18.55/yr

The value of the *NPV/K* assessment figure is then calculated as follows:

$$NPV/K = \frac{B-K}{K}$$

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

$$= \frac{18.55[1-(1.05^{-35})]}{0.05}$$

$$= 18.55 \times 16.37^{*} = 303.7$$

$$\text{therefore } NPV/K = \frac{303.7 - 70}{70} = 3.3$$

* Obtained from present value tables[6]

This value of *NPV/K* together with those for other combinations of factors for insulation of the poorly heated 'standard' house are illustrated in Figure 1.

All combinations save one have positive values of *NPV/K* and therefore represent worthwhile returns on the cost of the installation. However, some combinations represent bet-

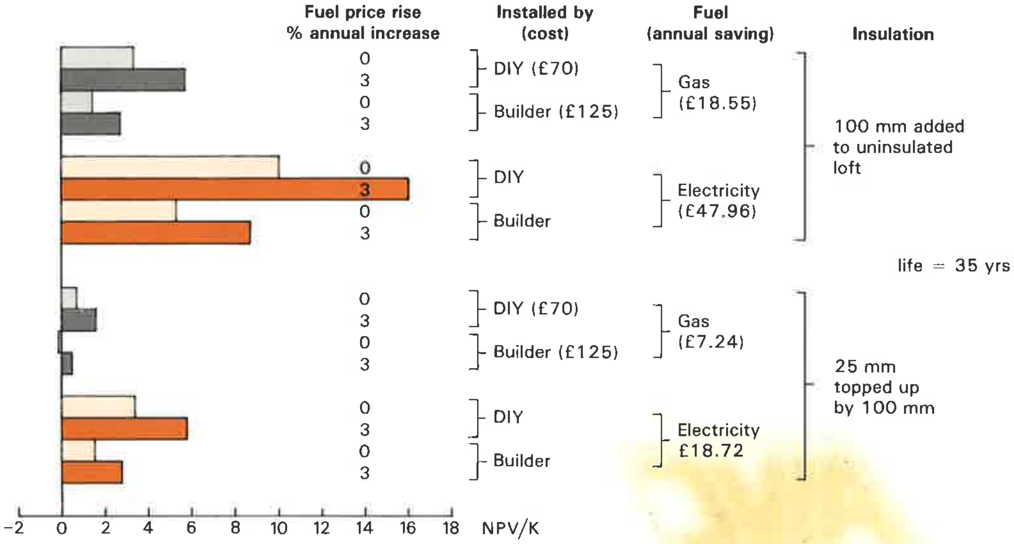

Figure 1 *NPV/K* values for loft insulation in a poorly-heated house

ter value for money than others. In general, insulation of the uninsulated loft gives a substantially better return than addition of the same amount of insulation to the partially insulated one. Also, the assessment was more favourable for electric than gas heating, ie for the more expensive fuel.

Figure 2 shows the effects of the same factors in a well heated house. The general picture is broadly similar but the economic advantages are accentuated.

MEASURE 2: WALL INSULATION

The insulation of external walls of existing houses may be improved in different ways depending upon whether they are solid, cavity or framed. Choice of technique will be influenced by considerations such as the presence of cold bridges, possibly shown as signs of mould. There may also be risk of rain penetration through imperfections in cavity fill at exposed sites or of impact damage to external insulation. Some treatments are only suitable when a dwelling is being improved.

Figures 3, 4 and 5 compare *NPV/K* values for three examples of wall insulation improvements:

(a) Filling a cavity with mineral wool with a reduction in U-value from 1.5 to 0.55 W/m² °C,

(b) Insulating a solid wall with 50 mm insulation applied internally; U-value reduction from 2.1 to 0.55 W/m² °C.

(c) Insulating a solid wall with 25 mm of external insulation and a protective finish; U-value reduction from 2.1 to 0.85 W/m² °C.

To make them plain *NPV/K* values for these and subsequent measures have been illustrated at twice the scale of the loft insulation values It is noticable that, for the most part, roof insulation in these examples represents better value for money than wall insulation.

However, both cavity fill and application of internal insulation to solid walls show positive assessment values and therefore would represent worthwhile investments. Again, some combinations rate better than others.

On the other hand, the return on the cost of applying 25 mm of insulation externally is either negative or just borderline. The measure might have proved more cost effective if a thicker layer of insulation had been used or if the wall had to be re-rendered externally anyway, for example to prevent rain penetration or as part of a programme of general refurbishment.

MEASURE 3: DOUBLE GLAZING

The Pezzey Report examines a number of options, some only for installation by a builder. Double glazing can be installed downstairs or throughout the house, as a secondary system, or associated with window replacements during a housing improvement. The value of double glazing as an investment also hinges on a number of factors; for instance, whether the house is well or poorly heated, its form of wall construction, window sizes etc. Double glazing has a number of other benefits such as improved appearance or comfort which cannot be quantified.

Figure 6 illustrates assessments for replacement of single by double glazing during rehabilitation in a well-heated house with solid walls. The assessment is positive in all cases. However, the economic benefit is marginal for gas heating and is also generally quite small when compared with most of those for roof and wall insulation.

MEASURE 4: REFLECTING FOIL BEHIND RADIATORS ON EXTERNAL WALLS

Placing a sheet of reflecting foil behind radiators on external walls is cheap and saves energy. It is especially useful where electric storage heaters are in use.

The examples compared in Figure 7 are for a solid wall, an unfilled cavity wall and a filled cavity wall. In all three cases the assessment gives this simple DIY measure a good value for money rating though the annual financial saving is really quite modest.

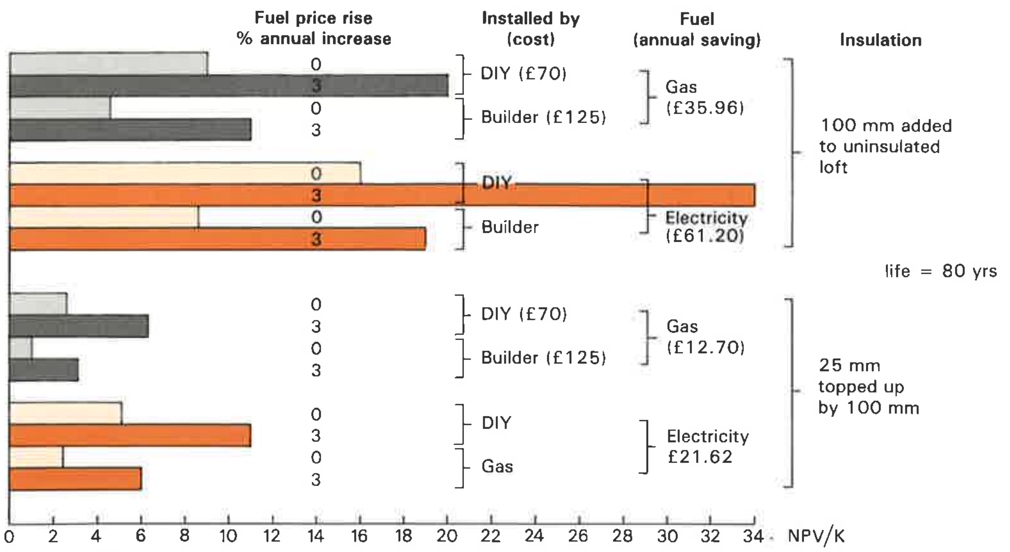

Figure 2 *NPV/K* values for loft insulation in a well-heated house

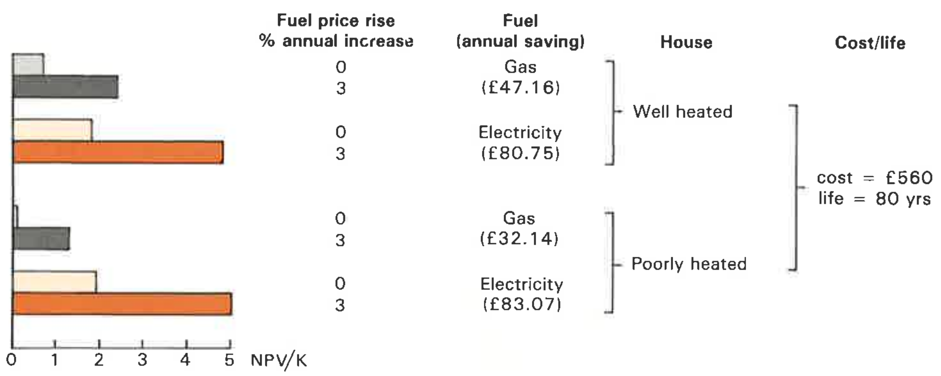

Figure 3 *NPV/K* values for filling cavity with mineral wool

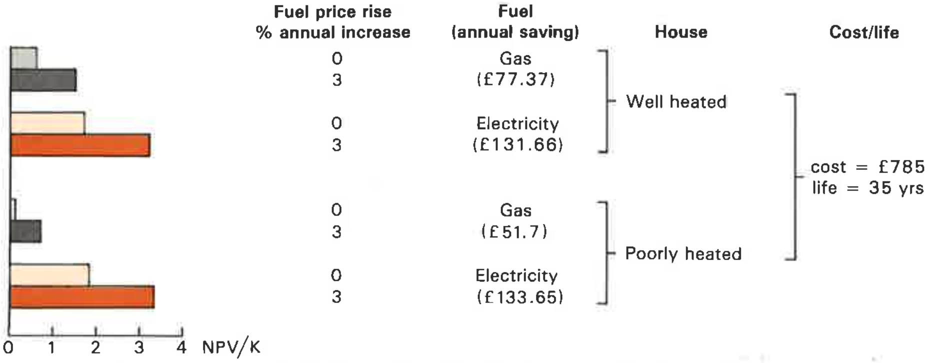

Figure 4 *NPV/K* values for insulating solid wall with 50 mm applied internally

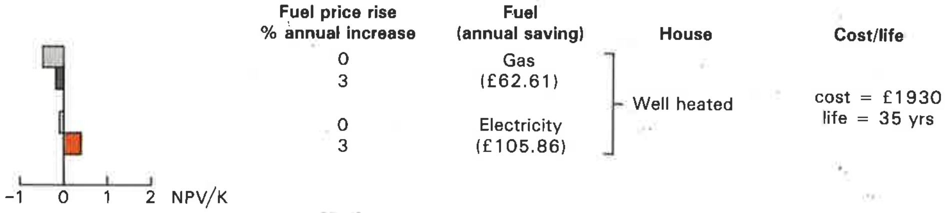

Figure 5 *NPV/K* values for insulating solid wall with 25 mm insulation plus a protective finish

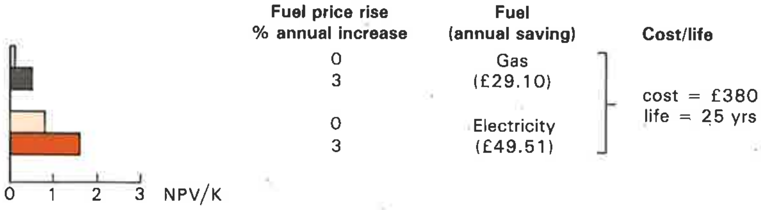

Figure 6 *NPV/K* values for replacement of single by double glazing during rehabilitation. Well heated house with solid walls

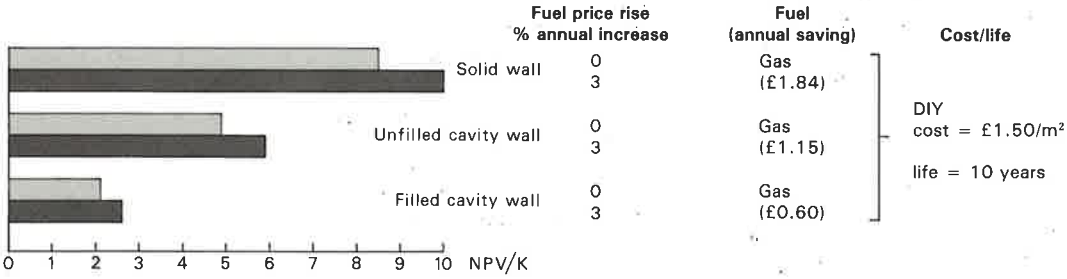

Figure 7 *NPV/K* values for fixing foil behind radiators on external walls. Well heated house

CONCLUSIONS

1 The paper shows how the assessment criterion *NPV/K* can be used to rate the economic value of several energy conservation measures applied to existing housing.

2 Using 1982 costs, the various measures applied to a 'standard' semi-detached house mostly showed a positive return on capital cost measured over the estimated life of the project.

3 Whilst the results varied with precise circumstances, in general, addition of loft insulation to a previously uninsulated loft showed the best return on investment.

4 Topping up loft insulation, insulating walls internally or by cavity fill, double glazing and applying reflective foil behind radiators all gave varying but positive results.

5 However, the economic value of applying 25 mm of insulation to the external surface of a wall was either negative or borderline.

6 It is recommended that those wishing to assess their own energy efficiency projects by this procedure should use the latest available fuel and other costs.

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