#3355

Energy Efficient Design buildings: financial appraisals

Introduction

Financial appraisals are of the essence in the choice of heating system and building insulation standards to be employed on a particular project. They enable options which employ different resources to be compared on the basis which directly affects the profitability of the company, and this can help to focus the attention of the financial decision makers on areas such as energy management which they are otherwise unused to appraising.

The type of financial appraisal needed when comparing building and heating system options will depend on who is making the decision; logically the appraisal should embrace capital and operating costs in a total cost in use. However, such an appraisal will only be of use to somebody such as an owner-occupier who is concerned with the building throughout its funding, construction and operation phases. The building financier and landlord will be more concerned with the capital costs and the building as an investment, while the tenant will be concerned primarily with the operating costs.

Consequently the appraisal must be broken down into its component parts so that only the relevant parts need be presented to the appropriate decision maker.

Components of financial appraisal

A financial appraisal should reconcile both capital and operating costs and savings, using a technique such as Net Present Value (NPV). It is important to carry out such an appraisal even when the customer is concerned only with either capital or operating costs, to ensure that, in the national interest, the project is energy cost effective.

A financial appraisal of any project comprises:

a) Calculation of capital cost for each option.
b) Calculation of operating cost of each option, including any other benefits which can be costed.
c) Comparing the options to see which best satisfies the criteria of the decision maker using a suitable appraisal technique.

It is important to be clear, before starting such an appraisal, just what options are to be compared. The combination of building fabric standards and heating system which makes up each option must be defined clearly and given a name for recognition purposes at the end of the appraisal.

Calculation of capital cost

Often there will be a limit to the affordable capital cost for a project, determined by the achievable rent or borrowing limits, beyond which it is not worthwhile to go. Subjecting a project to this test initially will determine whether it is worthwhile performing the rest of the analysis.

The capital cost of an option can be calculated in a variety of ways to a range of levels of complexity and accuracy. The depth to which the project may be studied will depend on:

a) How firm are the proposals.
b) The quality of information available on which to base the cost calculation.
c) The time which the appraiser can afford to spend on the project.

An indication of how far the appraiser can go realistically is given by the quality of the drawings available.

Drawings available	Appraisal possible
i) None – only area and height known	Global cost/m² of each part of structure
ii) Sketch design	More accurate cost/m² of each component type and cost of specific plant items
iii) Construction drawings	Bill of quantities

Calculation of construction cost

This booklet aims to give advice on carrying out an appraisal of construction related costs at sketch design stage when there is sufficient information available for a realistic energy consumption and cost comparison to be made. It does not attempt to go into fine detail as this is the job of the Quantity Surveyor in the Bill of Quantities.

At stage (i), prior to the sketch design, the capital cost calculation can be built up from data on the cost/m² of each component of the structure and its services. This cost information can be obtained from guides published by Quantity Surveying practices or advice can be sought from Electricity Boards. The areas of each floor and the external envelope will have to be deduced from the lettable area and height submitted for planning permission.

Later, at stage (ii), the capital cost appraisal can be adjusted to match the actual building at sketch design stage either by hand, knowing the adjusted cost for each component, or using a computerised capital cost appraisal.

At both stages it is important to ensure that the capital costs are up to date; it is best to use an updated costs service. A full project appraisal including outline capital costs will shortly be available through the Electricity Boards or through the Environmental Engineering Section of the Electricity Council.

Initial cost estimates (Nov 1986 prices) based on Davis Belfield & Everest information for provincial office buildings.	Standard where appropriate	£/m²	Area used in calculation
Structure:			
Poor ground – short bored piles	–	115	Ground floor
Poor ground – short bored piles (75mm perimeter insulation)	U = 0.3	117	Ground floor
Upper floors and supporting frame:			
In situ RC frame, slabs and stairs – up to 6 storeys	–	75	Upper floors
Frame to roof:			
In situ reinforced concrete columns and beams	–	42	Roof
Roof:			
Asphalt, insulation and paving on RC flat or waffle slab	U = 0.6	85	Roof
+ further insulation	U = 0.25	86	Roof
+ further insulation	U = 0.2	87	Roof
Stairs:			
RC stairs with stainless steel balustrades and handrails	–	10	Floor
External walls:			
Machine made facing brick, insulation, block, plaster and emulsion	U = 0.6	70	Wall
+ further insulation	U = 0.45	71.50	Wall
+ further insulation	U = 0.3	73.50	Wall
Windows and external doors:			
Hardwood, single glazed, purpose made; stained	U = 4.3	200	Windows and doors
Hardwood, double glazed, purpose made, stained	U = 2.5	225	Windows and doors
Hardwood, kappafloat-argon, purpose made; stained	U = 2.0	245	Windows and doors
Internal walls and doors:			
Blockwork or stud, plaster and vinyl, softwood doors	–	50	Internal partitions
Floor finishes:			
Screed and good quality carpet with underlay; skirtings	–	30	Floor
Ceiling finishes:			
Economical exposed grid suspended ceilings	–	17	Floor
Fittings and furnishings:			
Medium quality reception desk, shelves, cupboards etc	–	7	Floor
Sanitary, water and disposal installation:			
Speculative standard – low rise building	–	14	Floor
Heating installation including controls:			
LPHW radiator system to speculative offices	–	28	Floor
Electric fan storage heaters	–	24.50	Floor
Electric panel heaters	–	11.50	Floor
Electric panel heaters with Energy management system	–	18.50	Floor
Hot water installation:			
Central plant heated by LPHW	–	3	Floor
Electric local storage	–	1.50	Floor
Ventilation:			
Ventilation to internal WC's only	–	4	Floor
Electrical installation:			
Lighting and power – high quality speculative standard	–	65	Floor
Lift installations:			
Passenger lift 13 person 3-6 levels (1.0 m/sec)	£35,000		–
Special services:			
Firefighting installation – hosereels and dry risers	–	5	Floor
Builders work in connection with services:			
Electrical and lift – including allowance for plant rooms	–	18	Floor
External works:			
Restricted urban site, mainly paving, some landscaping	–	16	External site

In addition to construction costs the developer will incur professional design fees based on the construction cost, costs related to the purchase of the site, and the cost of marketing the completed building to potential tenants or purchasers. The sum of all these will be the development cost.

Development cost
Calculations on the financial viability of a project are carried out at different stages depending on how the project is being developed. The development process can take two forms:

a Where a developer constructs the building and then sells it to an owning institution which acts as the landlord.

b Where a property company undertakes the development and landlord phases.

In the case of (a) the developer will be concerned with his profit when selling the project on, and the owning institution will be concerned with the return (in the form of rental) on their investment in the project (the development cost). In (b) a single calculation of financial viability would be carried out on the total development cost including marketing.

The cost of finance is variable depending on the credit rating of the borrower and the period of the loan; it will generally be a few points above base rate except for certain institutional funding, which may be below the base rate.

Calculation of operating costs

The costs of operating a building are many; recurring costs include rent and rates, taxation, insurance, cleaning and staff salaries and other overheads. Some of these can be reduced by improving productivity if the staff are more comfortable. This booklet does not attempt to quantify such benefits, but if such a cost benefit can be attributed to changes in the building fabric or heating system, then that benefit can be included as an offset to other operating costs.

Other operating costs are more directly dependent on the choice of building insulation standard and heating system. These are the cost of fuel or energy required to drive the heating (and/or cooling) system, the cost of maintaining the heating system, and the cost of the space taken up by the heating and ventilation system. The latter is of relevance where the financial appraisal is being carried out for an owner-occupier who could otherwise make use of any new space without having to pay more for the building envelope.

Fuel/energy costs
In order to calculate fuel and energy costs it is necessary to derive the heat energy requirements of the building, to know the conversion efficiency of the heating system between the point of fuel/energy delivery and/or metering and the delivery of heat to the point where it is required (ie the room) and to know the current cost per unit of metered fuel/energy.

To derive the metered energy requirements of the building, the calculation method must allow for variation of the following parameters:

1) Building size, shape and orientation
2) Fabric insulation standards and thermal mass
3) Infiltration control and ventilation
4) Temperatures to be maintained in the building
5) Heating season length
6) External temperatures and other weather conditions at the building location
7) Internal gains and solar gains
8) Control efficiency and its impact on the usefulness of internal gains
9) Scope for control of preheat to minimise energy cost
10) Heat generation efficiency
11) Heat distribution efficiency

The Electricity Supply Industry ESIBEEP computer program allows for these parameters to be varied in its calculation.

The cost of the fuel/energy delivered to the building depends on tariffs which are applied at the project location. Since these may depend on conditions imposed by the supplier of the fuel/energy, it is important to check with the supplier what tariff applies for the project concerned.

Maintenance costs
Proper allowance should be made for maintenance to a heating system to ensure that it continues to provide the service required of it, that is to keep the occupants comfortable.

Ideally, such a cost should be calculated on the basis of experience with previous buildings operated by the decision maker, encompassing the cost of consumables such as air filters and lubricants, in-house or outside staff time for plant cleaning, servicing and maintenance, and replacement components when exessive wear has taken place. Where such experience is not available, the following data can be applied:

Heating system	£/m²gross (Nov 1986)
LPHW, gas boiler,	0.5
LPHW, oil boiler	0.5
LPHW, coal boiler	0.5
Electric panel heaters with EED controls	0.4
Electric panel heaters alone	0.1
Electric storage	0.1
Electric fan storage	0.1
Electric water storage	0.5

Space costs
The use of decentralised space and water heating allows the plantroom space needed for central systems to be saved. This can be costed on the basis of typical rents for the area of the building, either as a direct benefit for the landlord or as a notional benefit for the owner-occupier who might otherwise need to rent space elsewhere for his operation.

Ideally the known area of the plantroom should be used to calculate this benefit. A rough estimate of the extra central plantroom area required for fossil fuel fired central plant in naturally ventilated, heated buildings is as follows:

Building area m²	Central plant area m²
500	14
5000	27

Financial appraisal techniques

The technique to be adopted will depend on who is the decision maker.

i) Developers, their financial supporters and landlords will be concerned primarily with the capital cost of the project and its relationship with the potential rent which can be charged.

ii) The tenant organisation will be interested only in the operating cost of the building.

iii) Owner-occupiers will be concerned with the cost effectiveness of the project over the period of their ownership.

iv) Other onlookers should be concerned that the best use of national resources will be made; this can be demonstrated by the most cost effective solution.

Developer's budget

In refurbishment projects advice should be sought on the impact of VAT.

The developer's budget is built up as follows. The calculation approach given is not unique but indicates the factors which should be included:

			£
Site costs:			£
Site purchase			R
Introduction fee, acquisition fees and expenses = R × g%		=	G
Cost of finance for site purchase = (R+G) × q%		=	Q
Total site cost			S
Construction costs:			£
Demolition	Z		
Advance works	W		
Building structure and services	B		
External works	E		= (Z+W+B+E)
Professional fees (Z+W+B+E) × f%		=	F
Developer's contingency (Z+W+B+E+F) × t%		=	T
Cost of finance for construction (Z+W+B+E+F+T) × k%		=	K
Total construction cost			C
Site and construction cost=			S + C

In a case (a), if the building is sold by the developer to an institution, the following costs will be incurred:

Developer's selling costs = (S + C) × j% = J

A minimum selling price will be set by the developer to cover his costs and make a profit:
Profit = S + C + J) × p% = P

Hence the minimum selling price =(S + C + J + P) = U

The owning institution will meanwhile seek an independent valuation to determine a realistic price for the project; this will be based on the facilities the building offers, its location, etc.
Capital Value = V

If U is greater than V, the developer will have to take a cut in profit.

If V is greater than U, there is scope for negotiation between developer and owning institution on the actual purchase price. The developer may wish to reduce the selling price in order to make the building more attractive to the owning institution; this would enable the institution to offer the building at a lower rental as a tenant inducement while maintaining the same percentage return on its smaller investment.

Letting the building more quickly (reducing the 'letting void') and getting a faster return on the capital invested in site purchase and construction would be profitable to both owning institution and developer.

The actual profit to the developer will be given by subtracting his costs from the eventual purchase price; if the purchase price is V:
Developer's profit = V – (S + C + J) = P

The owning institution would also incur further costs (eg introduction and solicitors' fees) related to the purchase price;
if the purchase price is V: V
Institution's purchasing costs = V × h% H

So in case (a) the owning institution's investment in the building and site will be V + H = M

In case (b) where the building has been handed on from the development to the landlord side of a property company, the corresponding investment is S + C = M

In both cases (a) and (b) the building now has to be let in order to give a return on that investment. Marketing costs are incurred:

Marketing costs:
Promotion and advertising = First year rental N × a% = A
Fees to letting agent = N × l% = L

So the total development cost = M + A + L = D

This will be set against the potential revenue in the form of rent.

Typical values for fees etc used in the initial budget are:

Introduction fee, site acquisition fees and expenses	g = 10%
Professional fees	f = 12%
Developer's contingency	t = 2.5%
Developer's selling costs	j = 2.5%
Institution's purchasing costs	h = 2.5%
Advertising/promotion	a = 5%
Letting fees (say for two agents)	l = 15%

Capital cost appraisal

For organisations with no direct responsibility for the cost of operating the building, the lowest capital cost is sought. However, this must be related to the potential revenue which will be affected by the quality of the building which results.

The revenue which can be obtained by letting a building is not directly related to the capital cost; it is subject to negotiation between the landlord and tenant. The potential rent from a building is governed by its location, the facilities it offers, the quality of finishes, the availability of alternative buildings in the neighbourhood and perhaps to a small extent the operating cost savings it can offer. It is likely that the landlord and the letting agent can judge what this rent could be, and will calculate back from the expected yield what capital cost can be afforded, using the formula:

$$\text{Yield Y\%} = \frac{\text{Expected revenue (eg 1st year rental) N}}{\text{Development cost D}} \times 100$$

The affordable building capital cost can then be derived from the development cost by subtracting developer's profit, site and marketing costs, and professional fees.

The expected yield will vary depending on the risk perceived by the financial decision maker, which will in turn depend on the ease with which the buiding can be let. At a prime City of London site a yield of 5% or less might be thought sufficient because an office building can easily be let and relet should the tenant decide to move on, while outside London in the South East the expected yield for offices might be 5-6% or 7-9% in say Edinburgh or Glasgow. Expected yields in the retail sector, since it is more buoyant, range from 4-6%. In a depressed area, if a developer has sufficient confidence to build an office at all, the calculation of maximum allowable capital cost might be based on a yield of 12% because of the risk that the building would take a long time to let or relet. Since potential rents are low in such areas anyway, the allowable capital cost is reduced still further, so it is important to minimise that cost in locations unfavoured by potential tenants. The adoption of a low capital cost heating system may be the key to getting the building constructed at all.

In all projects the financial decision maker will be anxious to reduce capital costs in order to reduce the extent to which the interest to be paid on that capital (or which could be obtained by investing it elsewhere) will offset the revenue obtained by letting the building.

Where the energy saving measures incur a higher capital cost, the extra rent which can be charged has to be judged carefully; it cannot be greater than the anticipated running cost saving or there will be no incentive for the tenant to take the building.

Public sector projects are sometimes constrained by borrowing limits and once again a minimised capital cost may be the only way to get the building under way at all.

Where appropriate, grants from local or central government sources should be subtracted from the capital costs.

Operating cost appraisal

Tenants are normally concerned only with the costs of operating their building. Comparisons can be carried out simply by calculating the total operating cost saving of one option compared with another.

Where the landlord seeks to charge a higher rent for an energy efficient building, it will be necessary for the tenant to calculate whether the total operating cost, including the enhanced rent is lower than for a rival building which costs more in fuel. Too high a rent enhancement would obviously be self-defeating for the landlord.

It would be useful to the tenant to appreciate how important are the operating costs related to the heating system, compared to the other costs of operating the business. These costs include rent, rates, taxation, cleaning, security, insurance, decorating and, not least, staff salaries. It may be relevant to the financial decision maker to consider the effect of an incremental change in heating system operating cost which gives improved environmental conditions which in turn improve staff productivity. This is difficult to quantify but the disbenefit of uncomfortable conditions may be recognisable.

Cost effectiveness appraisal

Where the decision maker is concerned with both the initial cost of the building and its subsequent operating costs, it is important to carry out an overall cost effectiveness appraisal of all options in order to determine the best one. This will also apply to selecting the option which makes the best use of scarce resources on a national scale.

Often the simple payback technique has been used, where the number of years taken for a constant saving to pay back the capital cost is calculated simply by dividing the latter by the former. This technique fails to deal with:

i) Interest rates on the capital borrowed.

ii) Phased capital expenditure.

iii) Future anticipated costs.

A method which takes account of these factors and indicates the best investment is Net Present Value.

Net Present Value (NPV)

The value of an initial sum of money in successive years can be expressed by

$$S = A(1+r)^n$$

where A = Initial sum invested
S = Sum accumulated
r = Interest rate as a factor eg 0.11 (≡ 11%)
n = Number of years

Conversely, the equivalent present value of money received in n years' time can be expressed by rearranging this formula:

$$A = \frac{S}{(1+r)^n} = S \times \frac{1}{(1+r)^n}$$

Such that S = Forecast saving in the year n
r = Interest rate
A = Present value of money received in year n

The NPV technique takes the capital cost at the start of the project, and for each year adds the present value of savings anticipated in years to come.

The number of years over which the project is to be appraised will depend on the time horizon of the decision maker; for companies in an unstable business the project might be deemed to have a life of 3 to 5 years while if the calculation is concerned with the long term impact on national resources then the actual life of the plant should be used eg 30 years.

The interest rate chosen should be equivalent to that obtained from other investments open to the organisation. In many cases the "Test Discount Rate" would be adopted (typically 11% at present).

The forecast savings should include for anticipated inflation of energy, maintenance and other prices.

Where the NPV of savings less the initial capital cost is positive, the project is financially justifiable. Where it is negative, it would be more worthwhile investing the capital elsewhere for a higher return.

The calculation is best done in a tabular form, to allow the staged savings to be set against the initial capital cost, which is put in as negative saving.

a) Time years	b) Initial cost £ (extra = −ve saving = +ve)	c) Operating cost saving including inflation	d) Present value factor (Table 1)	e) Present value of saving (c x d)	f) Cumulative present value of project
0	$-b_0$				$-b_0$
1		c_1	d_1	d_1c_1	$-b_0+d_1c_1$
2		c_2	d_2	d_2c_2	$-b_0+d_1c_1+d_2c_2$
3	$-b_3$	c_3	d_3	d_3c_3	$-b_0-b_3+d_1c_1+d_2c_2+d_3c_3$
etc	etc	etc	etc	etc	etc

If additional capital expenditure is required in future years, it can be inserted in the tabular calculation, shown above as item b_3.

Where appropriate, grants can be entered with positive values in column b, and differences in taxation used to adjust the figures in column c.

The calculation procedure can also be used where there is a capital cost saving but an increased operating cost, by adhering to the convention of savings being entered +ve, costs as −ve.

Table 1: *Present value factors*

	Annual interest rate %														
Year	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	0.907	0.890	0.873	0.857	0.842	0.826	0.812	0.797	0.783	0.769	0.756	0.743	0.731	0.718	0.706	0.694
3	0.864	0.840	0.816	0.794	0.772	0.751	0.731	0.712	0.693	0.675	0.658	0.641	0.624	0.609	0.593	0.579
4	0.823	0.792	0.763	0.735	0.708	0.683	0.659	0.636	0.613	0.592	0.572	0.552	0.534	0.516	0.499	0.482
5	0.784	0.747	0.713	0.681	0.650	0.621	0.593	0.567	0.543	0.519	0.497	0.476	0.456	0.437	0.419	0.402
6	0.746	0.705	0.666	0.630	0.596	0.564	0.535	0.507	0.480	0.456	0.432	0.410	0.390	0.370	0.352	0.335
7	0.711	0.665	0.623	0.583	0.547	0.513	0.482	0.452	0.425	0.400	0.376	0.354	0.333	0.314	0.296	0.279
8	0.677	0.627	0.582	0.540	0.502	0.467	0.434	0.404	0.376	0.351	0.327	0.305	0.285	0.266	0.249	0.233
9	0.645	0.592	0.544	0.500	0.460	0.424	0.391	0.361	0.333	0.308	0.284	0.263	0.243	0.225	0.209	0.194
10	0.614	0.558	0.508	0.463	0.422	0.386	0.352	0.322	0.295	0.270	0.247	0.227	0.208	0.191	0.176	0.162
11	0.585	0.527	0.475	0.429	0.388	0.350	0.317	0.287	0.261	0.237	0.215	0.195	0.178	0.162	0.148	0.135
12	0.557	0.497	0.444	0.397	0.356	0.319	0.286	0.257	0.231	0.208	0.187	0.168	0.152	0.137	0.124	0.112
13	0.530	0.469	0.415	0.368	0.326	0.290	0.258	0.229	0.204	0.182	0.163	0.145	0.130	0.116	0.104	0.093
14	0.505	0.442	0.388	0.340	0.299	0.263	0.232	0.205	0.181	0.160	0.141	0.125	0.111	0.099	0.088	0.078
15	0.481	0.417	0.362	0.315	0.275	0.239	0.209	0.183	0.160	0.140	0.123	0.108	0.095	0.084	0.074	0.065
16	0.458	0.394	0.339	0.292	0.252	0.218	0.188	0.163	0.141	0.123	0.107	0.093	0.081	0.071	0.062	0.054
17	0.436	0.371	0.317	0.270	0.231	0.198	0.170	0.146	0.125	0.108	0.093	0.080	0.069	0.060	0.052	0.045
18	0.416	0.350	0.296	0.250	0.212	0.180	0.153	0.130	0.111	0.095	0.081	0.069	0.059	0.051	0.044	0.038
19	0.396	0.331	0.277	0.232	0.194	0.164	0.138	0.116	0.098	0.083	0.070	0.060	0.051	0.043	0.037	0.031
20	0.377	0.312	0.258	0.215	0.178	0.149	0.124	0.104	0.087	0.073	0.061	0.051	0.043	0.037	0.031	0.026
21	0.359	0.294	0.242	0.199	0.164	0.135	0.112	0.093	0.077	0.064	0.053	0.044	0.037	0.031	0.026	0.022
22	0.342	0.278	0.226	0.184	0.150	0.123	0.101	0.083	0.068	0.056	0.046	0.038	0.032	0.026	0.022	0.018
23	0.326	0.262	0.211	0.170	0.138	0.112	0.091	0.074	0.060	0.049	0.040	0.033	0.027	0.022	0.018	0.015
24	0.310	0.247	0.197	0.158	0.126	0.102	0.082	0.066	0.053	0.043	0.035	0.028	0.023	0.019	0.015	0.013
25	0.295	0.233	0.184	0.146	0.116	0.092	0.074	0.059	0.047	0.038	0.030	0.024	0.020	0.016	0.013	0.010
26	0.281	0.220	0.172	0.135	0.106	0.084	0.066	0.053	0.042	0.033	0.026	0.021	0.017	0.014	0.011	0.009
27	0.268	0.207	0.161	0.125	0.098	0.076	0.060	0.047	0.037	0.029	0.023	0.018	0.014	0.011	0.009	0.007
28	0.255	0.196	0.150	0.116	0.090	0.069	0.054	0.042	0.033	0.026	0.020	0.016	0.012	0.010	0.008	0.006
29	0.243	0.185	0.141	0.107	0.082	0.063	0.048	0.037	0.029	0.022	0.017	0.014	0.011	0.008	0.006	0.005
30	0.231	0.174	0.131	0.099	0.075	0.057	0.044	0.033	0.026	0.020	0.015	0.012	0.009	0.007	0.005	0.004
35	0.181	0.130	0.094	0.068	0.049	0.036	0.026	0.019	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002
40	0.142	0.097	0.067	0.046	0.032	0.022	0.015	0.011	0.008	0.005	0.004	0.003	0.002	0.001	0.001	0.001
45	0.111	0.073	0.048	0.031	0.021	0.014	0.009	0.006	0.004	0.003	0.002	0.001	0.001	0.001	0.000	0.000
50	0.087	0.054	0.034	0.021	0.013	0.009	0.005	0.003	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000
55	0.068	0.041	0.024	0.015	0.009	0.005	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
60	0.054	0.030	0.017	0.010	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Worked examples

Example A *Operating cost saving, higher capital cost*

Consider two options for a three storey office building: Assuming a capital interest rate of 11% and an operating cost inflation rate of 6%, which option is the best financial proposition if appraised over a 5 year period.

	Capital cost £	First year operating cost £
Option I	1,005,685	4,790
Option II	1,012,194	2,948
Extra cost	6,509	
Annual saving		1,842

Table 2

a) Time years	b) Initial cost (−ve) £	c) Operating cost saving including inflation £/year	d) Present value factor from Table 1	e) Present value of saving £	f) Cumulative present value of project £
0	−6,509				−6,509
1		1,842	0.901	1,660	−4,849
2		1,953	0.812	1,586	−3,264
3		2,070	0.731	1,513	−1,750
4		2,194	0.659	1,446	− 305
5		2,325	0.593	1,379	1,074

The net present value in the fifth year is positive, so option II is a viable investment over that period.

Example B *Capital cost saving, higher operating cost*

Consider two options for an owner-occupied building which will be occupied for at least 30 years.

During the building's life, certain items of plant will be replaced at the following replacement costs in the years indicated. These costs have been inflated at 5% per annum to indicate what would have to be paid in those years.

	Capital cost £	First year operating cost £
Option A	1,215,976	5,162
Option B	1,200,782	5,711
Capital cost saving	15,194	
Extra annual cost		549

Year	Option A Replacement plant	Replacement capital cost £	Option B Replacement plant	Replacement capital cost £	Option B saving (−ve means extra cost) £
10	Controls	6,312	Controls	6,312	
			Heat emitters	9,488	
			Total	15,800	−9,488
15	Heat emitters	9,927			+9,927
20	Boilers	14,062	Heat emitters	15,455	
	Controls	10,282	Controls	10,282	
	Total	24,344	Total	25,737	−1,393
31	Heat emitters	21,669	Heat emitters	26,434	
	Distribution	148,000	Distribution	45,493	
	Controls	17,585	Controls	17,584	
	Total	187,254	Total	89,511	+97,743

The building owner is concerned that with inflation the extra operating cost of option B will wipe out the capital cost saving over the life of the building. Assuming therefore an inflation rate of 9% for energy and other operating costs, with a capital interest rate of 11%, calculate whether his fears are justified over a 30 year period.

Table 3

Note that savings are positive, extra costs are negative.

(a) Time Year	(b) Capital cost saving £	(c) Operating extra cost including inflation each year £/year	(d) Net cash flow each year £	(e) Present value factor from table 1	(f) Present value of cash flow £	(g) Cumulative present value of project £
0	+15,194		+15,194			15,194
1		−549	−549	0.901	−495	14,699
2		−598	−598	0.812	−486	14,213
3		−652	−652	0.731	−477	13,736
4		−711	−711	0.659	−469	13,267
5		−775	−775	0.593	−460	12,807
6		−845	−845	0.535	−452	12,355
7		−921	−921	0.482	−444	11,911
8		−1,004	−1,004	0.434	−436	11,475
9		−1,094	−1,094	0.391	−428	11,047
10	−9,488	−1,192	−10,680	0.352	−3,759	7,288
11		−1,300	−1,300	0.317	−412	6,876
12		−1,417	−1,417	0.286	−405	6,471
13		−1,544	−1,544	0.258	−398	6,073
14		−1,683	−1,683	0.232	−390	5,683
15	+9,927	−1,835	+8,092	0.209	+1,691	7,374
16		−2,000	−2,000	0.188	−376	6,998
17		−2,180	−2,180	0.170	−371	6,627
18		−2,376	−2,376	0.153	−364	6,263
19		−2,590	−2,590	0.138	−357	5,906
20	−1,393	−2,823	−4,216	0.124	−523	5,383
21		−3,077	−3,077	0.112	−345	5,038
22		−3,354	−3,354	0.101	−339	4,699
23		−3,656	−3,656	0.091	−333	4,366
24		−3,985	−3,985	0.082	−327	4,039
25		−4,343	−4,343	0.074	−321	3,718
26		−4,734	−4,734	0.066	−312	3,406
27		−5,160	−5,160	0.060	−310	3,096
28		−5,625	−5,625	0.054	−304	2,792
29		−6,131	−6,131	0.048	−294	2,498
30		−6,683	−6,683	0.044	−294	2,204

The net present value at the end of the evaluation period is still positive, so the building owner's fears are ill-founded.

In table 3, periodic expenditure (or savings) on replacement plant is indicated at intervals during the building's life. On approaching the end of the 30 year period under investigation, the building owner has two options:

a to replace the major items of plant and continue in occupation

b to move, knowing that there is little residual value in the plant.

In case (a) the net present value calculations should be continued for an extended appraisal period. The next two lines of the calculation would be:

Table 4

(a) Time Year	(b) Capital cost saving £	(c) Operating extra cost including inflation each year £/year	(d) Net cash flow each year £	(e) Present value factor from table 1 (interpolated)	(f) Present value of cash flow £	(g) Cumulative present value of project £
31	+97,743	−7,284	+90,459	0.040	+3,618	5,822
32		−7,940	−7,940	0.037	−294	5,528
33	etc	etc	etc	etc	etc	etc

This calculation could continue, including further expenditure or savings on replacement plant in future years, for as long as the building owner expects to remain in occupation.

Example C *Developer's budget costs*

An office project in the Home Counties to Energy Efficient Design standards is being discussed with an insurance company. The building would be constructed by a developer, then sold to the insurance company who will act as landlord. Before committing themselves to forward funding of the project, the insurance company wish to know what the development yield would be.

The site is clear, ready for construction to start. Other details are as follows:

Gross area including circulation, tank rooms etc:		2520 m²
Net lettable area		2016 m²
Construction costs:	Building structure and services	£1,031,476
	External works	£ 100,000
Site cost		£ 500,000

Expected rent at the location=£8/ft²=	£86.08/m²
Expected yield	6%

Finance: Assume 10% per annum interest rate

Duration of loans: Construction 15 months; Site 18 months

Assume fees and other costs:

Introduction fee, site acquisition fees and expenses	10%
Professional fees	12%
Developer's contingency	2.5%
Developer's selling costs	2.5%
Institution's purchasing costs	2.5%
Advertising/promotion	5%
Letting fees (for two agents)	15%

An independent valuation of the proposed building is £2.6 million. The insurance company have agreed to purchase at this price.

Table 5 *Development costs calculation*

	£	£
Site costs:		
Site purchase	500,000	
Acquisition fees and expenses @ 10%	50,000	
	550,000	
Cost of finance for site purchase @ 10% for 18 months compounded	85,250	
Total site cost	635,250	635,250
Construction costs:		
Demolition	0	
Advance works	0	
Building structure and services	1,031,476	
External works	100,000	
	1,131,476	
Professional fees @ 12%	135,777	
	1,267,253	
Developer's contingency @ 2.5%	31,681	
	1,298,934	
Cost of finance for construction @ 10% for 15 months compounded	165,614	
Total construction cost	1,464,548	1,464,548
Total site and construction cost		2,099,798
Developer sells to insurance company:		
Developer's selling costs @ 2.5%	52,495	52,495
Total cost to developer=		2,152,293
Developer's expected profit @ 20%	430,459	430,459
Developer's minimum selling price		2,582,752

Independent valuation=£2.6 million

So developer's actual profit=£2,600,000 - 2,152,293
=£447,707
=20.8% of developer's total cost

	£	£
Owning institution's budget:		
Purchase price	2,600,000	
Owning institution's purchasing costs @ 2.5%	65,000	
	2,665,000	2,665,000
Marketing costs:		
Promotion and advertising @ 5% first year rental =£86.08 × 2016 × 5% =	8,677	
Fees to 2 letting agents @ 15% first year rental =£86.08 × 2016 × 15% =	26,031	
	34,708	34,708
Total development cost:		2,699,708

Calculation of yield

$$\text{Development yield \%} = \frac{\text{First year rental}}{\text{Total development cost}}$$

$$= \frac{£86.08 \times 2016 \times 100}{£2,699,708}$$

$$= 6.43\%$$

This is greater than the expected yield of 6%, so the project is worthwhile to the insurance company. They can take the increased yield as extra profit, or could make the building more lettable by charging a lower rent.
For instance, a yield of 6% would be achieved by a rent of £7.46ft².

Conclusion

A financial appraisal helps to compare options which use disparate resources, such as construction costs and energy in the completed building. The net present value technique is recognised as a suitable one to compare present costs alongside future savings and should be applied whenever the decision maker is concerned with both these aspects of the project over a number of years.

Further information

The following publications describe Energy Efficient Design buildings:

EC 4930 *Energy Efficient Design buildings* – A brochure pointing out the benefits to Developers.

EC 4931 *Technical Information Offices* – Provides an outline specification for the Energy Efficient Design approach in office buildings.

Further Technical Information is under preparation for other building types.