GOOD PRACTICE GUIDE 312

Invest to save?

Financial appraisal of energy efficiency measures across the government estate

- A standard methodology for financial appraisal
- Prioritising actions to reduce energy waste

GOOD PRACTICE GUIDE 312

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

CONTENTS

1 INTRODUCTION

The aim of this Guide is to provide a standard methodology to allow both technical and non-technical personnel to conduct an in-depth assessment of the economic viability of energy-saving measures across the range of civil and Ministry of Defence (MoD) buildings. This will help to prioritise those actions that should be incorporated in order to reduce unnecessary energy and water usage.

Saving energy reduces costs and releases funds for further investment in energy efficiency measures, or for other purposes. Energy efficiency should be taken seriously, not least because the introduction of the Climate Change Levy in April 2001 has significantly increased energy costs.

Buildings that are too hot or too cold can adversely affect the occupants' comfort levels, morale and productivity. Saving energy also reduces emissions of carbon dioxide (CO_2), the principal contributor to climate change, and other gases causing air pollution and acid rain.

Energy reductions are essential to meet the government's legally binding target, agreed at Kyoto in 1997, to reduce a basket of greenhouse gases by 12.5% on 1990 levels by 2012. Furthermore, the UK has set a voluntary target to reduce CO_2 emissions by 20% by 2010. Improving energy efficiency is the single most effective method of achieving this target.

There are also some valuable spin-offs from introducing energy efficiency measures, such as avoiding capital replacement costs of process equipment, office equipment or building plant, which usually have to be replaced or maintained more frequently if they are left on continuously.

Finally, improving energy efficiency is one of the most effective means of improving an organisation's environmental performance. This will be of particular value if the organisation is aiming to achieve accreditation under a recognised environmental management system, eg ISO 14001.

ABOUT THIS GUIDE

This Guide is one of a series of publications published under the Government's Energy Efficiency Best Practice programme, and should be read alongside Good Practice Guide (GPG) 286 (for the civil estate) and Energy Consumption Guide (ECON) 75 (for MoD establishments).

Before following the guidance in this publication, it is assumed that appropriate target performance benchmarks have been calculated for the buildings under investigation, using the guidance in either GPG 286 or ECON 75, and that you have identified likely energy-saving measures as set out in GPG 311 'Detecting energy waste'. The next step is to follow the procedures outlined in this Guide to assess the energy-saving options that will give the best return on investment.

Figure 1 shows the relationships between the various publications.

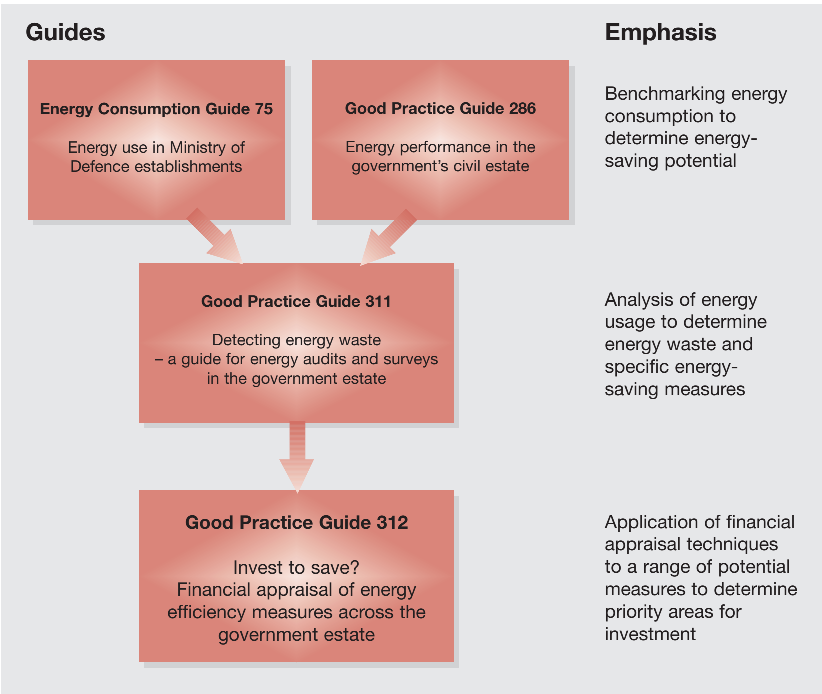


Figure 1 Guidance for MoD and civil buildings

INTRODUCTION

The main part of this Guide centres around the simple payback method of evaluating energy-saving projects. The advantages and disadvantages of this method are described. Other undiscounted methods of evaluation are proposed (eg gross return on capital). Many of the disadvantages of simple payback can be overcome using discounted evaluation methods. These are described in Section 4 together with worked examples. For any major investment in energy efficiency projects it is recommended that these methods are used in addition to undiscounted methods.

Appendix 1 comprises a list of typical energy-saving measures, what they are likely to save and an indication of payback. These data have been gathered from a number of energy surveys conducted in the MoD and the government civil estate over the past 10 years. However, the figures should be used with care. The notes in Section 6 should be read before using the figures in Appendix 1.

The Guide incorporates two example evaluation calculations (Projects X and Y), and these examples are referenced throughout the Guide. The assumptions for these two examples are included on a fold-out sheet from the inside back cover, thus providing a quick and convenient reference while reading through the Guide. The fold-out sheet also includes a glossary of terms and abbreviations.

Various government publications provide general advice and guidance on procurement and investment appraisal.

The Office of Government Commerce (OGC) has published a series of construction procurement Guides. The Guides provide best practice advice at a strategic level and cover the client's role in ensuring that products and services meet needs fully and at the best possible value.

The Guides can be downloaded as PDFs from the OGC website at **www.ogc.gov.uk**

The Treasury provides general advice on investment appraisal via 'The Green Book', which is also downloadable as a PDF file at **www.hm-treasury.gov.uk** (click on 'Economic Data and Tools' then click on 'PDF file of The Green Book: Appraisal and Evaluation in Central Government'. Although the advice is not specific to energy efficiency, the guidance does cover related issues that impact on energy and energy use.

All of the above documents are referenced in the 'further reading' section of this Guide (see back cover).

2 INVESTMENT IN ENERGY EFFICIENCY

The concept of 'spend to save' is well known but investment measures to reduce energy costs are sometimes seen as the only option. In fact several other options are available. For example, energy cost savings can be achieved by:

- purchasing energy from cheaper sources
- servicing and maintenance of energy-using equipment
- checking that existing controls are operating correctly
- energy-related good housekeeping measures
- monitoring and targeting of energy consumption.

When managing energy costs it is important to address all the options rather than treating investment in isolation. Otherwise investment might take place but the expected savings are not achieved because other issues are not being addressed, eg end users might be particularly wasteful by failing to apply good housekeeping measures.

The different options are now outlined and include investment as a key element in an overall energy management strategy.

HOW INVESTMENT FITS INTO AN ENERGY MANAGEMENT STRATEGY

The aim of energy management is to achieve organisational objectives at minimum energy cost.

This can be achieved by two routes:

- pay less per unit of energy
- reduce energy consumed while still achieving service requirements.

PAY LESS PER UNIT OF ENERGY

See Figure 3. Routes to paying less per unit of energy include the following.

Negotiate the lowest price

Through, for example, competitive tendering for electricity and combining a number of sites on a single contract. If electricity is purchased on a tariff basis, it is important to ensure that the tariff is appropriate to the load pattern.

Cost avoidance measures

Through measures such as re-scheduling operations or load shedding to avoid peak prices or to reduce maximum demand and supply capacity charges. Other methods include power factor correction if reactive power is charged on invoices.

Change of fuel

Switching fuel used on boiler/combustion plants to the cheapest option.

On-site power generation

Co-generation of heat and power, possibly utilising standby generators for load shedding during periods of high unit costs for electricity.

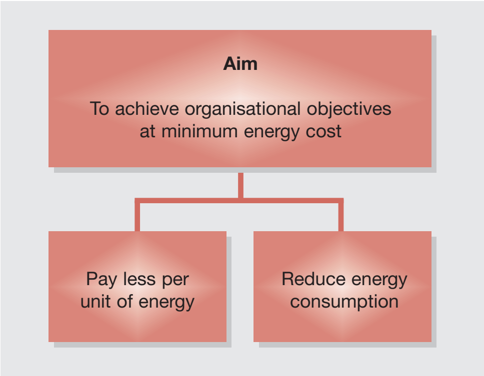


Figure 2 Routes to energy management

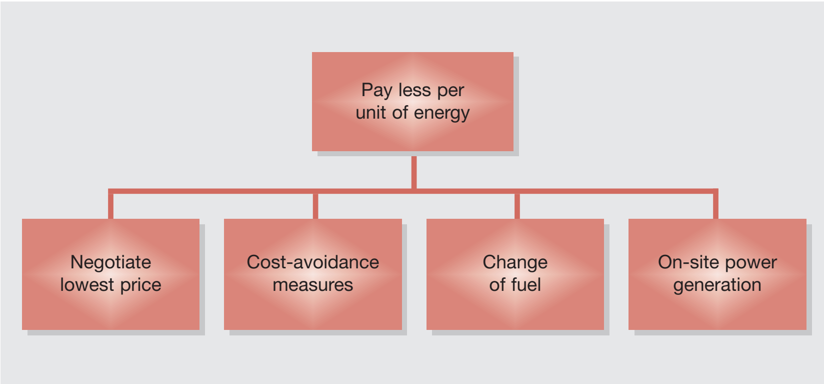


Figure 3 The 'pay less per unit of energy' route

The Treasury 'Green Book' is considered the overarching document and starting point for all investment decisions. See the back cover of this Guide for details of publications.

INVESTMENT IN ENERGY EFFICIENCY

REDUCE ENERGY CONSUMED

See Figure 4. There are three main options.

Energy efficiency by design (new projects)

A new project provides the best of all opportunities for a step improvement in energy efficiency. There may be an opportunity to use a more efficient technology (including measurement control), or better building design using modern materials and standards of construction.

It is also important to remember that whenever purchasing new equipment (eg air compressors, PCs, catering equipment) there is usually an energy-efficient option.

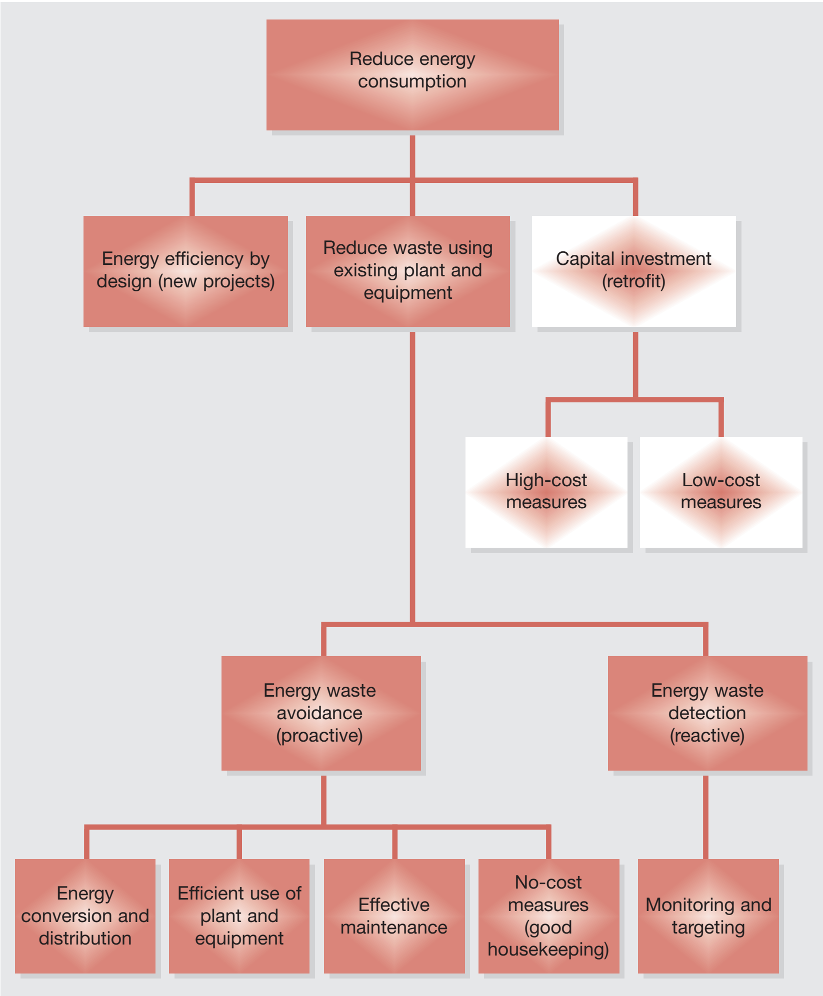


Figure 4 The 'reduce energy consumption' route

Reducing waste using existing plant and equipment

Under this category there are usually two main options.

Energy waste avoidance (proactive)

Energy waste can be avoided by applying good operational management to:

- energy conversion/distribution
- efficient use of plant/equipment
- effective maintenance
- good housekeeping.

This is essentially preventive or proactive waste avoidance.

Energy waste detection (reactive)

Irrespective of how well a building or a plant is run, unexpected energy waste will occur. When this happens it can be detected by a good monitoring and information system pointing to opportunities for corrective action. This is sometimes called monitoring and targeting (M&T).

Improved operating practice and reduced waste can be assisted by employee awareness, motivation and training.

Capital investment (retrofit)

Energy surveys reveal opportunities for investment in energy efficiency initiatives. These may be high-, medium- and low-cost measures for which costs and savings will be calculated to provide justification for investment.

INVESTMENT IN ENERGY EFFICIENCY

PURPOSE OF FINANCIAL APPRAISAL

Most organisations have more investment opportunities than funds available. Therefore a choice must be made between projects.

Financial appraisal is the tool by which these choices are made. It is a process in which costs and benefits of projects are combined to produce a measure of financial return.

Financial appraisal has four objectives.

Identify best investments

An organisation usually has limited access to capital. Financial appraisal helps identify which investments make the best use of the capital available. Energy efficiency projects are likely to be considered alongside all other projects requiring capital.

Optimise benefits from each investment

Detailed appraisal examines all the relevant factors and enables optimisation to derive maximum benefit.

Risk minimisation

Rigorous investigation highlights how financially sensitive a project is if a key parameter changes during the project. This enables an assessment of risk to be made and, if possible, minimised.

Performance analysis

Detailed appraisal gives a yardstick for assessing project performance once the investment is made.

KEY STEPS IN FINANCIAL APPRAISAL

The seven key steps in financial appraisal of energy efficiency investment are:

- identify the buildings with energy-saving potential
- identify the area(s) in each of these buildings where a saving can be made and identify the measures required to realise these savings
- establish the costs and savings for each measure and calculate the key financial indicators, such as payback and net present value
- optimise the financial return measured by these indicators for each project
- establish how much investment capital is available and identify new sources of capital
- decide which projects make the best use of the organisation's available capital
- prioritise projects for optimum return on capital.

Taking short cuts at one step only prejudices the outcome of the subsequent steps and leads to a poorer financial decision. Among the most common reasons for failure of the financial appraisal exercises are insufficient systematic searches for energy-saving opportunities, inadequate information systems and overestimation of potential benefits.

REVIEWING THE CURRENT SITUATION

There is a useful tool for evaluating your position and the approach of your organisation to investment in energy-saving projects. It is called the financial energy management matrix and it can be found in GPG 75 'Financial aspects of energy management in buildings – a summary'. By scoring your organisation's performance, the matrix gives a pictorial representation of strengths and weaknesses against six key aspects:

- identifying opportunities
- exploiting opportunities
- management information
- appraisal methods
- human resources
- project funding.

Copies of this Guide are available from the Energy Efficiency Best Practice programme (see details on the back cover).

The matrix is shown on page 8 together with a typical profile for an organisation that is strong in the areas of identifying opportunities and human resources, but weak in the areas of providing adequate management information and appropriate levels of project funding.

INVESTMENT IN ENERGY EFFICIENCY

Level	Identifying opportunities	Exploiting opportunities	Management information	Appraisal methods	Human resources	Project funding
4	Detailed energy surveys are regularly updated. Lists of high- and low-cost opportunities already costed and ready to proceed immediately.	Formal requirement to identify the most energy-efficient option in all new-build, refurbishment and plant replacement projects. Decisions made on the basis of life cycle costs.	Full management information system enabling identification of past savings and further opportunities for investment meeting organisation's financial parameters.	Full discounting methods using internal rate of return and ranking priority projects as part of an ongoing investment strategy.	Board take a proactive approach to a long-term investment programme as part of a detailed environmental strategy in full support of the energy management team.	Projects compete equally for funding with other core business investment opportunities. Full account taken of benefits that do not have direct cost benefit, eg marketing opportunities, environmental factors.
3	Energy surveys conducted by experienced staff or consultants for buildings likely to yield largest savings.	Energy staff are required to comment on all new-build, refurbishment and plant replacement projects. Energy efficiency options often approved but no account is taken of life-cycle costs.	Promising proposals are presented to decision-makers but insufficient information (eg sensitivity or risk analysis) results in delays or rejections.	Discounting methods using the organisation's specified discount rates.	Energy manager working well with accounts/finance department to present well-argued cases to decision- makers.	Projects compete for capital funding along with other business opportunities, but have to meet more stringent requirements for return on investment.
2	Regular energy monitoring/analysis identifies possible areas for saving.	Energy staff are notified of all project proposals with obvious energy implications. Proposals for energy savings are vulnerable when capital costs are reduced.	Adequate management information available, but not in the correct format or easily accessed in support of energy-saving proposals.	Undiscounted appraisal methods – eg gross return on capital.	Occasional proposals to decision-makers by energy managers with limited success and only marginal interest from decision-makers.	Energy projects not formally considered for funding from capital budget, except when very short-term returns are evident.
1	Informal ad hoc energy walkabouts conducted by staff with checklists to identify energy-saving measures.	Energy staff use informal contacts to identify projects where energy efficiency can be improved at marginal cost.	Insufficient information to demonstrate whether previous investment in energy efficiency has been worthwhile.	Simple payback criteria are applied. No account taken of lifetime of the investment.	Responsibility unclear and those involved lack time, expertise and resources to identify projects and prepare proposals.	Funding only available from revenue on low-risk projects with paybacks of less than one year.
0	No mechanism or resources to identify energy-saving opportunities.	Energy efficiency not considered in new-build, refurbishment or plant replacement decisions.	Little or no information available to develop a case for funding.	No method used irrespective of the attractiveness of a project.	No one in the organisation promoting investment in energy efficiency.	No funding available for energy projects. No funding in the past.

Figure 5 The financial energy management matrix with an example profile

3 UNDISCOUNTED EVALUATION METHODS

INTRODUCTION

Before any method of appraisal can be applied, it is necessary to identify the energy-saving opportunities and gather all the appropriate information. All the costs and benefits must be established, together with the time period over which they will occur. This will yield the cash flow for the project and help build a case for the investment.

SIMPLE PAYBACK

This is the simplest method of evaluation but also the crudest and can be misleading. An example of simple payback is shown below. A summary of the project assumptions and data is included on a fold-out sheet from the back cover of this Guide, together with a glossary of terms and abbreviations used throughout this document.

Project X

Project X has a capital investment of £1000 today (Year 0) with energy cost savings achieved over three years.
Payback is defined as the capital cost divided by the annual savings.

Year	Capital cost (£)	Savings (£)
0	1000	–
1		500
2		500
3		500

$$\textit{Payback (years)} = \frac{\textit{capital cost}}{\textit{annual savings}}$$

$$\textit{Payback} = \frac{\textit{£1000}}{\textit{£500}} = \textit{2 years}$$

Advantages of payback

Payback is simple to calculate, easy to understand, and is expressed in tangible terms (years). Also it does not require any assumptions about the project lifetime or interest rates.

Disadvantages of payback

Payback has the twin disadvantages of not taking into account savings achieved after the payback period, or the 'time value' of money (eg £500 saved in three years' time is worth less than £500 saved today). Also, at the end of the project life, no account is taken of any residual capital asset value.

Payback simply indicates the time when the cashflow becomes positive. Payback time can also be used as a measure of risk.

However, in many organisations payback is used as a method of filtering out 'good' from 'poor' projects. This can lead to serious errors; for example, if faced with following choice between Project X and Project Y, where the annual savings for Project Y are less than for Project X, with a consequent longer payback period (see Table 1).

If the investment sum available is limited to £1000, a choice must be made between the two projects. On a simple payback basis the choice is Project X.

However, if the life of both projects is taken into account, Project Y will clearly be more attractive than Project X over a 10-year period, because a considerable amount of savings are made after the payback period (see Table 2).

	Project X	Project Y
Capital	£1000	£1000
Annual savings	£500	£450
Payback (years)	2	2.2

Table 1 Illustrating simple payback

	Project X	Project Y
Capital	£1000	£1000
Annual savings	£500	£450
Payback (years)	2	2.2
Project life (years)	3	10

Table 2 Effect of project lifetime

NON-LINEAR PAYBACK

As shown in the above examples, the capital is a single payment and the savings are the same each year. This is linear payback. However, often capital expenditure and savings are not uniform and a cumulative cashflow table helps to identify non-linear payback.

For example, take the project shown in Table 3. From the cumulative cash flow column it can be seen that the payback period is just under four years.

UNDISCOUNTED RETURN ON CAPITAL

This method compares the initial capital investment with undiscounted cashflow over the life of the project. At the appraisal stage the project life must be estimated and this can be based on information from both manufacturers and/or existing users. When the project has a life considerably longer than the payback period, this can make the project look quite different to simple payback.

UNDISCOUNTED EVALUATION METHODS

There are four parameters in which undiscounted cashflow is usually expressed.

Gross return on capital (method 1)

The total benefit from the project over its life divided by the capital cost, expressed as a percentage.

For Project X, the gross revenue (assumptions as Table 2) is £1500 and the capital is £1000, so:

gross return on capital = $\frac{\pounds 1500}{\pounds 1000} \times 100 = 150\%$

For Project Y, the gross revenue is £4500 and the capital is £1000, so:

gross return on capital = $\frac{\pounds 4500}{\pounds 1000} \times 100 = 450\%$

Ratio X:Y = 1:3

Net return on capital (method 2)

The total benefit of the project over its life less the capital cost divided by the capital cost, expressed as a percentage.

For Project X:

net return on capital = $\frac{(\pounds 1500 - \pounds 1000)}{\pounds 1000} \times 100 = 50\%$

For Project Y:

net return on capital = $\frac{(\pounds 4500 - \pounds 1000)}{\pounds 1000} \times 100 = 350\%$

Ratio X:Y = 1:7

Gross annual average rate of return (method 3)

The gross return on capital (see method 1) divided by the project life in years.

For Project X:

gross annual average rate of return =

$\frac{\pounds 1500}{\pounds 1000} \times 100 \times \frac{1}{3} = 50\%$

For Project Y:

gross annual average rate of return =

$\frac{\pounds 4500}{\pounds 1000} \times 100 \times \frac{1}{10} = 45\%$

Ratio X:Y = 1:0.9

Net annual average rate of return (method 4)

The gross return on capital (see method 2) divided by the project life in years.

For Project X:

gross annual average rate of return =

$\frac{(\pounds 1500 - \pounds 1000)}{\pounds 1000} \times 100 \times \frac{1}{3} = 16.6\%$

For Project Y:

gross annual average rate of return =

$\frac{(\pounds 4500 - \pounds 1000)}{\pounds 1000} \times 100 \times \frac{1}{10} = 35\%$

Ratio X:Y = 1:2

Summary

It can be seen that the four different ways of stating the return on capital employed give different ratios between the two projects. The first, second and fourth methods emphasise the advantages of Project Y to different degrees but the third method, which considers the average year and disregards depreciation of the equipment, actually finds it hard to distinguish between the two projects and indeed slightly favours Project X.

Because most organisations will feel that the loss of capital when the equipment has to be scrapped or replaced has to be taken into the calculations, the second and fourth methods are more usually used, to give the net return.

Year	Capital expenditure (£)	Savings (£)	Cashflow (£)	Cumulative cashflow (£)
0	(32 000)		(32 000)	(32 000)
1	(4000)	3000	(1000)	(33 000)
2		10 000	10 000	(23 000)
3		12 000	12 000	(11 000)
4		12 000	12 000	1000
5		12 000	12 000	13 000
6		12 000	12 000	25 000

Table 3 Non-linear payback

UNDISCOUNTED EVALUATION METHODS

Number	Method	Project X (%)	Project Y (%)	Ratio X:Y
1	Gross return on capital	150	450	1:3
2	Net return on capital	50	350	1:7
3	Gross annual average rate of return	50	45	1:0.9
4	Net annual average rate of return	16.6	35	1:2

Table 5 Summary of undiscounted method

CASE STUDY – PAYBACK CALCULATION

Building

Computer centre, built in 1979. Entrance lobby and toilets lit from tungsten lamps, offices and corridors lit from 1.5 m twin-tube fluorescent quickstart fittings to give design illuminances of 500 lux. The computer room and print room were lit from triple-tube fluorescent quickstart designed to give 500 lux.

Hours of use

Entrance lobby and toilet lights were found to be on for typically 2000 hours per year. Offices and corridor lights were found to be on for 2500 hours per year. The computer room and print room are used 24 hours a day, all year round (8760 hours per year).

Measures taken

It was decided to replace the tungsten lamps with compact fluorescent lamps. The 1.5 m twin-tube fluorescent quickstart fittings in offices and corridors were left until office refurbishment. The use of high-frequency (HF) fluorescents in the computer room and print room was investigated.

Table 4 shows the basic source data and calculations required in order to arrive at the payback when considering installing HF fluorescents.

Data and calculations	Existing system	Proposed replacement system
Annual hours use (a)	8760	8760
Light/lamp type	1.5 m triple-tube fluorescent quickstart	1.5 m twin tube HF fluorescent
Electrical load per fitting (b)	279 W	132 W
Number of fittings (c)	48	54
Total electrical load (d = b x c/1000)	13.392 kW	7.128 kW
Annual electrical use (e = a x d)	117 314 kWh	62 441 kWh
Cost of electricity (f)	4.56p/kWh	4.56p/kWh
Annual electrical cost (g = e x f/100)	£5350	£2847
Annual electrical cost savings of proposed system (h = g existing system – g proposed system)		£2503
Capital cost of proposed system (i)		£7950
Payback period (i/h)		3.2 years

Table 4 Comparison of lighting systems (source: Inland Revenue)

4 DISCOUNTED EVALUATION METHODS

DISCOUNTED EVALUATION METHODS

To take the next step in evaluation methods it is necessary to adopt discounted evaluation methods that take into account the time value of money, life of the project and other factors. This is covered in the following section.

The purpose of discounting is to take into account the time value of money, ie the present value of a sum to be received next year is less than the value of the same sum received today.

COMPOUNDING

If you invested £935 in a bank that promised an interest rate of 7%, how much would you have one year from now? This can be calculated from the compound interest formula:

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

where:
S = sum accumulated
A = initial sum
r = interest rate (%)
n = number of years

so:

$$S = 935\ (1 + 0.07)^1 = £1000$$

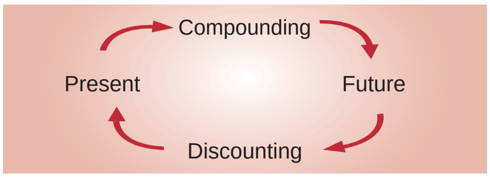
DISCOUNTING

If we rearrange the formula:

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

where:
S = forecast savings in year 'n'
r = interest rate (%)
A = present value of £ received in 'n' years time

So £1000 received one year from now is worth £935 today at a discount rate of 7%.



So just as we can predict future sums from present values (using compounding), by reversing the process we can take future savings and, by discounting, express the savings in present day value (to obtain a return of £1000 in one year's time we need to invest only £935 now).

DISCOUNT FACTORS

The formula can be written:

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

$\frac{1}{(1 + r)^n}$ is defined as the **discount factor**

where:
r = discount rate (%)
n = years into the project

Discount factors can be derived by putting different values of 'r' and 'n' into the formula and tables can be generated to speed up the calculation process. The tables are shown in Appendix 2 on page 26.

NET PRESENT VALUE

If we apply an arbitrary discount rate of 13% to Projects X and Y we can calculate the present value of future savings, as shown in Table 6. When these present value savings are added, with the capital cost deducted, it is possible to calculate the net present value (NPV).

The NPV is a financial parameter of particular interest to financial managers. It tells them what the project will earn over its costs in today's money over its expected lifetime.

The NPV of a project should be positive to be accepted.

In comparing Project X with Project Y, Project Y gives a much greater NPV and therefore is more attractive.

A key issue to consider is the risk that the life of Project Y is significantly longer (ie 10 years) and the building may be refurbished, sold or demolished during this 10-year period.

DISCOUNTED EVALUATION METHODS

SELECTING DISCOUNT RATES

The appropriate discount rate can be shown, from the application of more advanced financial theory, to be the cost of capital, ie interest which has to be paid on acquiring the capital to invest in the project. This idea is comparatively new and over some years use of the phrase 'cost of capital' has been displacing the term 'discount rate'.

There still remains the question of which rate to choose for the cost of capital. There is no single cost of capital – the choice will vary according to the nature of the organisation and the commercial environment in which it works; whether it relates to the cost of borrowing money, the value of bank deposits or the need for the organisation to generate capital internally. The cost of capital is supposed to be a composite figure, an average weighted according to the sources of capital likely to be used by the enterprise. HM Treasury issues a test discount rate to be adopted in the public sector for all investment appraisal. This is usually 5% or 6%. Large organisations often do the same with a similar figure of their own.

For all the importance attached to discounting as a procedure, it can be very arbitrary. The energy manager simply has to accept the organisation's judgement on costs of capital. For energy-saving projects it may be a minor consideration because these projects sometimes have comparatively short lifetimes. Discounting cash flows provides a useful way for energy managers to signal their serious intentions about investment in energy efficiency by asking senior management what cost of capital or test discount rates they are to assume.

INDEX OF PROFITABILITY

In comparing Projects X and Y with the same initial capital investment, the NPV gives a direct comparison of these projects. The higher the positive NPV the better, but if the NPV is negative the project should be rejected.

However, it is common for competing projects to have different capital costs. If two such schemes generate different NPVs, how is it possible to decide on the more attractive option?

An alternative way of comparing projects is to use the Index of Profitability (IOP). It takes the present value of project cashflow and divides it by the initial capital cost:

$$IOP = \frac{\text{present value of cashflows}}{\text{initial capital cost}} = \frac{PV}{C}$$

If the IOP is greater than 1 the project should be seriously considered, as the NPV is positive.

If the IOP is less than 1 the project should be rejected on the grounds that the NPV is negative.

So for Project X at a discount rate of 13%:

$$IOP = \frac{£1180}{£1000} = 1.18$$

Year	Capital expenditure (£)	Savings (£)	Discount factor at 13% discount rate	Present value (£)
Project X				
0	(1000)	–	1.0	(1000)
1		500	0.885	442.50
2		500	0.783	391.50
3		500	0.693	346.50
			Net present value	180.50
Project Y				
0	(1000)	–	1.0	(1000)
1		450	0.885	398.25
2		450	0.783	352.35
3		450	0.693	311.85
4		450	0.613	275.85
5		450	0.543	244.35
6		450	0.480	216.00
7		450	0.425	191.25
8		450	0.376	169.20
9		450	0.333	149.85
10		450	0.295	132.75
			Net present value	1441.70

Table 6 Calculating the present value of future savings

DISCOUNTED EVALUATION METHODS

For Project Y:

$$IOP = \frac{£2441}{£1000} = 2.44$$

However, imagine Project Z to be identical to Project Y except the capital cost is £2000 instead of £1000. This would yield:

$$IOP = \frac{£2441}{£2000} = 1.22$$

Project	IOP	Payback (years)
Y	2.44	2.2
Z	1.22	4.4
X	1.18	2.0

Table 7 Index of profitability for three projects

Project	IOP	Payback (years)
Y	3.475	2.2
Z	2.475	4.4
X	1.361	2.0

Table 8 Use of TDR of 5%

Year	Capital expenditure (£)	Savings (£)	Discount factor	Present value (£)
Project X (23% discount rate)				
0	(1000)	–	1.0	(1000)
1		500	0.813	406.5
2		500	0.661	330.50
3		500	0.537	268.50
			Net present value	+5.50
Project X (24% discount rate)				
0	(1000)	–	1.0	(1000)
1		500	0.806	403
2		500	0.650	325
3		500	0.524	262
			Net present value	-10

Table 9 Relationship between the IRR and the NPV

The IOP of Project Z is significantly lower than Project Y but it is still higher than Project X. The three projects ranked by IOP are shown in Table 7.

Project X has the best payback but the lowest IOP.

In the public sector the Treasury usually issues a test discount rate (TDR) for evaluating and comparing projects using NPV and IOP methods. Often this TDR is in the order of 5% or 6%.

If a TDR of 5% was applied to Projects X, Y and Z, the ranking would be as shown in Table 8.

INTERNAL RATE OF RETURN

If we take Project X and keep repeating the calculation using higher discount rates the NPV decreases and passes zero to become a negative number.

In Table 9 the NPV goes from a positive to a negative value as the discount rate moves from 23% to 24%.

The discount rate which yields an NPV = 0 is significant. It defines the Internal Rate of Return (IRR).

The IRR is defined as the discount rate at which the NPV reduces to zero.

It is often used as a financial yardstick in organisations with no particular policy on discount rates, in which case it is not possible to calculate NPVs.

The IRR is significant in that it roughly represents the rate of return money would have to earn in the organisation or externally to be a better investment. The higher the IRR the better. IRRs allow projects or investments to be compared.

The IRR can be compared with the current interest rate for borrowing the capital required. If the IRR is lower than this interest rate, the project would lose money if it was financed by borrowing. If the IRR is greater than the cost of borrowing the capital, the project will generate enough income to repay the loan with interest and still provide profit.

DISCOUNTED EVALUATION METHODS

Project X gives an IRR of 23.3%. At a time of relatively low interest rates this would represent a good project.

There is no direct way of calculating IRR. NPVs must be calculated for different discount rates and by successive calculations the discount rate can be determined when the NPV reaches zero. Computer software or published tables can speed up the iterative process.

Finally, consider the following two points when using IRR.

- It is worth comparing IRR with simple payback, eg a simple payback of two-and-a-half years on a project may yield an IRR of 18%. So while a project may fail a simple payback hurdle (eg two years) it may qualify on an IRR basis (eg anything over 15% IRR is accepted).
- IRR gives a figure based on a percentage. An IRR figure on its own gives no indication of the size of the project and the capital investment required compared to other competing projects.

To overcome this problem, it is useful to use a ratio of NPV/capital. This is described below.

NPV/CAPITAL RATIO

Earlier in this section, the IOP was used and defined as the ratio of present value to capital. A similar ratio can also be used to rank projects: the NPV/capital ratio that also takes into account the size of the project. The higher the ratio, the greater the margin of benefit over the cost for a given capital outlay and the more financially attractive the project.

The ratio is particularly useful in the context of planning investment with a fixed capital budget. Projects are ranked according to NPV/capital ratio and funded according to rank. Adjusting rank around the capital limit optimises the budget. Imagine an organisation with 120 buildings, a £4 million annual energy expenditure and a capital investment budget for energy efficiency set at £100 000.

Suppose seven possible projects had been identified with capital costs and NPVs as shown in Table 10 overleaf. The final column shows the NPV/capital ratio for each of the seven projects.

The cumulative capital expenditure for the lifetime of the projects is shown in Table 11 overleaf, which shows the projects ranked in order of highest to lowest NPV/capital ratio.

If, for example, there is a capital expenditure limit of £100 000 this year which of the seven projects would you select?

If the capital available is £100 000 then Projects E and F would be accepted. Project A would not be funded as it would exceed the capital available.

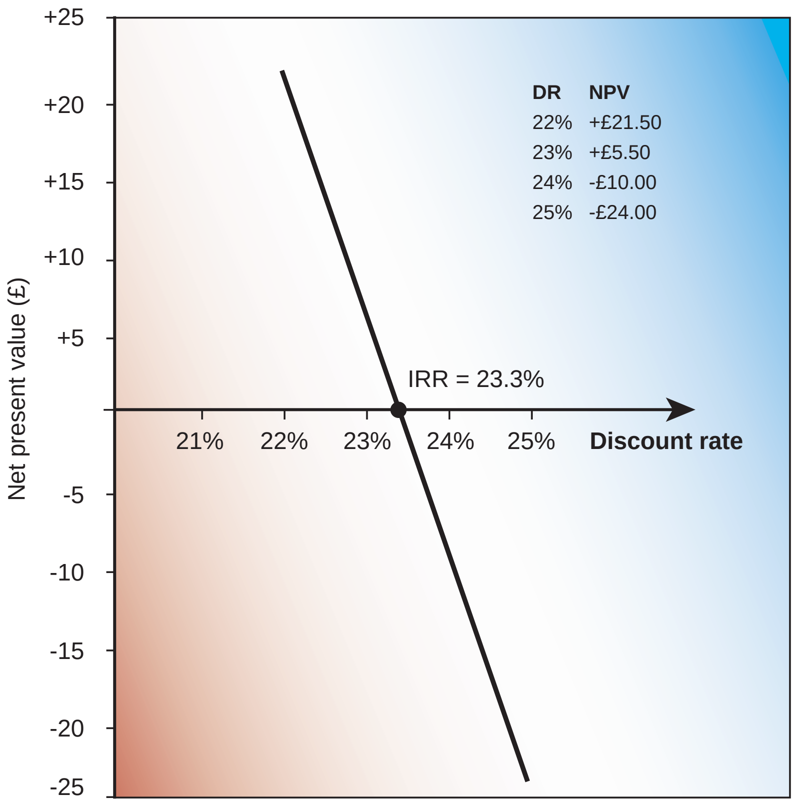


Figure 6 Graph showing the IRR for Project X

DISCOUNTED EVALUATION METHODS

Project name	Capital cost (£)	Payback (years)	Life (years)	NPV (£)	NPV/capital ratio
A	58 000	1.9	6	74 950	1.29
B	41 000	3.2	7	21 377	0.52
C	49 000	4.1	12	32 432	0.66
D	78 000	5.7	11	10 880	0.14
E	22 000	1.9	16	68 590	3.12
F	33 000	2.4	14	68 292	2.07
G	19 000	3.1	8	13 698	0.72

Table 10 Summary of projects

Project	NPV/capital ratio	Capital cost (£)	Cumulative capital cost (£)
E	3.12	22 000	22 000
F	2.07	33 000	55 000
A	1.29	58 000	113 000
G	0.72	19 000	132 000
C	0.66	49 000	181 000
B	0.52	41 000	222 000
D	0.14	78 000	300 000

Table 11 Calculating the cumulative capital expenditure for each example project

Year	Capital expenditure (£)	Energy savings (£)	Cashflow (£)	DF at 13% DR	Present value (£)
0	(800)		(800)	1.0	(800)
1	(200)	500	300	0.885	265.50
2		500	500	0.783	391.50
3		500	500	0.693	346.50
				Net present value	203.50

Table 12 Staged payments

Year	Capital expenditure (£)	Energy savings (£)	Cashflow (£)	DF at 13% DR	Present value (£)
0	(800)		(800)	1.0	(800)
1	(200)	250	50	0.885	44.25
2		500	500	0.783	391.50
3		500	500	0.693	346.50
				Net present value	(17.75)

Table 13 Showing how a negative NPV can accrue

So there is now £45 000 available. Projects C and D would not qualify because each project exceeds this figure. But Projects G or B could be brought higher up the priority list because one could be accommodated within the capital limit. Project C might be squeezed in if there is flexibility in the budget limit. Projects E, F and C together would result in a total capital spend of £104 000. The budget is clearly arbitrary, ie 2.5% of total energy spend. Examining how the budget was established opens up two possibilities – reschedule Project A into a future budget year (if there is one) and move up the other projects or expand the capital budget by 13% to accommodate Project A.

STAGED PAYMENTS FOR CAPITAL INVESTMENT

In the examples shown for Projects X and Y, the capital expenditure is shown as Year 0, ie the capital is spent today. Year ‘1’ means income received one year from today. In practice, capital is often paid in two or more staged payments, eg an initial payment with some capital retained as a guarantee until the plant or equipment has met agreed operating performance criteria. Consider Project X with an initial capital payment of £800 with £200 paid a year later, shown in Table 12.

In this situation the NPV improves from £180.50 to £203.50 because the £200 is retained for a year. The discount factor is applied to both the capital and the savings on the assumption that the £200 during the first year could be used usefully elsewhere, eg gaining interest before payment is due at Year 1.

Another situation that can arise is that most of the capital is paid at Year 0 but the equipment takes time to be installed and commissioned, which means the savings in Year 1 are reduced. In the above Project X, if the savings begin only halfway through the first year, yielding £250 (instead of £500) the situation would be as shown in Table 13.

DISCOUNTED EVALUATION METHODS

The result of the delay in savings is a negative NPV of £17.75 at a discount rate (DR) of 13%. This is a poor result even with staged payments of capital.

So the message is clear: arrange projects so that the savings begin accruing as soon as possible after capital expenditure and, where appropriate, negotiate staged payments linked to plant performance.

INFLATION

Inflation will affect all competing project proposals equally, so much effort can be spared if all cashflows are calculated in real terms, ie excluding inflation. This avoids having to predict future inflation rates and adding further uncertainty to what are already estimated cashflows.

Inflation affects investment appraisal in two ways: it affects the cashflow forecast and the cost of capital. These effects cancel each other out, so that linking to inflation is not an appropriate way to decide the discount rate.

If inflation is taken into account a nominal discount rate is used that has two components: first the real discount rate that takes into account the time value of money, and second inflation. The relationship is expressed as:

(1 + nominal discount rate) = (1 + real discount rate) x (1 + rate of inflation)

So if inflation is 4.6% and the real discount rate is 8% then:

(1 + nominal discount rate) = (1 + 0.08) x (1 + 0.046) = 1.1296

Therefore the nominal discount rate = 0.13 (ie 13%).

It is possible to calculate the NPV using both real figures and nominal figures, as illustrated in Table 14.

SENSITIVITY ANALYSIS

In evaluating a project, some of the quantitative aspects of the project may not be known initially and therefore are assumed or estimated. Sensitivity analysis is the process by which these estimates or key design features are tested to determine what impact they may have on the value of a project.

For example, for Project Y, if the project life and discount rate remain fixed but the capital costs and the annual savings are varied it is possible to see the impact of the changes in the NPV.

Year	Real cashflows (£)	DF factor at 8%	Present value (£)	Nominal cashflows (£)	DF factor at 13%	Present value (£)
0	(20 000)	1.000	(20 000)	(20 000)	1.000	(20 000)
1	4000	0.926	3704	4185	0.885	3704
2	6000	0.857	5142	6568	0.782	5143
3	7000	0.794	5558	8018	0.693	5557
4	7000	0.735	5145	8389	0.613	5144
5	5000	0.681	3405	6270	0.543	3405
Net present value			2954			2953

Table 14 The effect of inflation

Capital (£)	Annual savings (£)	Project life (years)	Discount rate (%)	NPV (£)
1000	450	10	13	1441
1500	450	10	13	941
1000	400	10	13	1170
1500	400	10	13	670

Table 15 Sensitivity analysis

DISCOUNTED EVALUATION METHODS

Project Y

The original £1000 expenditure with annual savings of £450 per year over 10 years at a 13% DR yielded an NPV of £1441 (see Table 15).

If the capital expenditure was underestimated and in reality was £1500, then at the same DR of 13%, the NPV reduces to £941. Alternatively, if savings estimated at £450 per year were overestimated and should have been £400 per year, then for the same DR the NPV becomes £1170.

If the capital underestimate and savings overestimate are combined, then for the same DR the NPV becomes £670 (see Table 15).

Variation in the project life and discount rates can also be evaluated as shown in Table 16.

By varying key parameters it is possible to test the sensitivity of the project. It is likely that decision-makers will ask questions about sensitivity, eg 'What happens to the NPV if the price of gas increases by 15%?'

It is well worth anticipating questions and possibly pre-empting them during a written or oral presentation to show to the decision-makers that you are aware of the impact on the project of variations in key parameters.

Capital (£)	Annual savings (£)	Project life (years)	Discount rate (%)	NPV (£)
1000	450	10	12	1542
1000	450	10	10	1765
1000	450	6	13	768
1000	450	8	13	1158
1000	450	10	13	1441

Table 16 Variation in the project life and discount rates

5 KEY FACTORS TO CONSIDER

SEQUENCING EFFECT

Every energy efficiency measure has its own costs and benefits. In some instances there is minimal or no interaction between projects. An example of this is the installation of improved lighting and the insulation of hot pipes.

There are other situations where a strong relationship exists such that one energy-saving measure impacts on another. An example would be the simultaneous installation of roof insulation and of a more efficient boiler. If the boiler is sized and installed on the existing heat requirements, and then the roof is insulated, which reduces the heat requirement, the boiler will run almost exclusively on part load. The original estimated energy savings for the boiler will not be realised due to the reduced heating requirement and the reduced efficiency of the boiler. If, however, the roof had been insulated first, then the boiler sized and installed, the boiler would run nearer its peak efficiency, and the savings estimated on the reduced heating requirement would be achieved. Furthermore, as a smaller boiler is likely to be installed, there may also be a capital cost saving.

In general, to achieve the best results in energy efficiency measures, the energy requirements or load should be minimised first, then the delivery should be optimised.

PROJECT LIFETIME

A key input to any discounting calculation is the project lifetime. Clearly this has a critical bearing on the outcome of the appraisal because the more years included in the cash flow projection, the higher the NPV or IRR. It is especially important if one project has a longer assumed life than another. Decisions about lifetime are likely to be at least as important as considerations of discount rate.

There are different meanings of project life.

- The **economic life** of a project is the time over which it can be expected to yield the benefits taken into consideration for the investment proposal. For example, a lighting scheme might have a projected life of 10 years but if the building will be demolished in five years the economic life is five years.
- The **physical life** is how long the capital will be useable before it becomes physically inoperative, perhaps because of a breakdown that could not be repaired at a justifiable cost. The physical life can be very long, eg 50 or 60 years, but in these circumstances it is not usual to carry out an economic evaluation over the physical life of an asset.
- The **technological life** is the time over which a particular way of doing something is regarded as technologically up to date, delivering the required standard of service and in keeping with legislation (eg luminaires in modern lighting and VDU requirements).

The choice of project lifetime should be carefully considered as it may be a combination of all these factors.

MAINTENANCE

By installing new plant there are likely to be savings in labour and materials for maintenance purposes. Some of these future savings should be taken into account in cashflow calculations.

OPERATION

There may be labour savings on central boiler plant when decentralising. There will also be a reduction in water treatment chemical costs. Insurance costs should be considered for installation of MPHW, high-temperature hot water (HTHW) and steam boilers and local calorifiers. Additional costs will be incurred, eg labour and consumables for inspection strip-down.

PLANNING

Not all investment opportunities applicable to a building, site or system may be able to be implemented at the same time. Due allowance for capital expenditure and operating costs for the intermediate steps should be considered as part of the overall project. These costs sometimes do not become apparent until the detailed project plan is developed.

The OGC Guide No 7 ‘Whole life costs’ provides useful advice and guidance when considering the whole life of a facility. See the back cover of this Guide for details of publication.

KEY FACTORS TO CONSIDER

NON-FINANCIAL FACTORS

While financial factors, risk and sensitivity analysis are important, it is also necessary to consider non-financial factors. These would include how the project:

- meets health, safety and environmental protection regulations
- helps in economic scheduling of maintenance (eg a variable speed drive can indicate increased energy use when filters are getting blocked)
- reduces staffing requirements (eg use of automatic controls or building management systems), freeing staff to be more effective elsewhere
- improves the working environment for staff
- improves communication
- improves response to equipment or plant breakdowns
- improves environmental performance (eg attaining CO_2 reduction or other greening targets – see 'Life cycle assessment' below).

LIFE CYCLE ASSESSMENT

Life cycle assessment (LCA), sometimes known as life cycle analysis, examines the environmental impact of a product from its birth to disposal: in effect a cradle-to-grave analysis. It allows comparisons to be made between competing products and gives an overall view of environmental costs in a quantitative form.

At each stage of the life of a product the likely effects on the environment are considered. The four major stages are usually:

- production/manufacture – includes extraction and processing of raw materials, production of components and manufacturing the final product
- distribution – including the manufacture of packaging and transportation of products from the assembly site to the end-user
- use – including energy, water and other resource use and its associated pollution during the useful life of the product
- disposal – includes collection and transport of used products, energy for recycling materials and final disposal of wastes.

At each of these four stages it is usual to assess systematically the following environmental impacts:

- raw materials used
- energy consumed
- emissions to air
- emissions to water
- solid waste.

To make comparisons, these environmental impacts must be quantified and the basis of calculation and any assumptions must be clearly identified.

For some products the major environmental impact is at the production stage (eg thermal insulation). For other products, eg a boiler or a dishwasher, the major impacts are associated with the use of the product.

Increasingly, manufacturers of energy-saving products are conducting LCAs of their products – particularly if they have certification under ISO 14001 or a similar environmental management standard. Therefore, in comparing products it is worth considering whole life cycle costs as a factor in the investment decision-making process.

6 ENERGY EFFICIENCY MEASURES AND TYPICAL PAYBACK PERIOD

Payback tables need to be used with caution. There are only two factors that are required to calculate payback periods: capital cost and annual savings. However, calculating these figures may not be as simple as the task initially appears.

If we consider annual energy savings there are a number of issues to consider.

- What is the unit cost of energy? Unit costs will depend not only on the purchase cost but on the efficiency of the system, eg a heating system may have a boiler efficiency plus distribution losses yielding an overall efficiency of 75%.
- Some of the savings for electricity may need to be calculated on day units and some on cheaper night units if electricity is purchased on this basis; similar allowances should be made for seasonal, time of day, and weekend tariffs.
- Could there be additional savings by reducing maximum demand, availability and power factor charges?
- If hot water is saved is the water saving included or excluded?
- A key factor when calculating savings is to consider the running hours, ie necessary longer operating periods equates to shorter paybacks.
- Are all the savings considered? For example, if an optimiser is fitted to a gas-fired boiler there will be both gas and electrical savings, eg in the boiler fan and in the distribution pumps.
- Some buildings use electricity or liquefied petroleum gas (LPG) for space heating/hot water because there is no supply of natural gas. Payback periods on measures in these buildings will be considerably shorter because of the high cost of electricity and LPG relative to natural gas.
- Should other savings be considered? For example, savings in maintenance costs by installing PVC-U windows with double glazing or extra-long-life induction lamps in areas difficult to access.

In considering capital cost, issues to consider include the following.

- Should the installation cost be added to the equipment/material cost to give a total cost?
- Is the installation cost covered by a maintenance or other budget for simple measures such as installing draughtstripping?
- Is it an overcost? (For example, if an existing boiler is old and needs replacing, instead of using a standard boiler a higher-efficiency condensing boiler could be chosen. The extra capital cost would be the overcost and this should be compared with savings achieved by fitting a more efficient boiler.)
- Is the capital cost an estimate, or based on a supplier's quotation or price list?
- Purchasing in bulk can significantly reduce capital costs. (For example, bulk purchase of compact fluorescents might attract 50% discounts, so halving the capital cost will reduce the payback period by 50%.)
- The costs of removing/decommissioning old plant, eg large boilers, oil storage, concrete bunds, asbestos, etc.
- Are consultancy fees included?
- Will a significant reduction in fuel consumption result in an increase in energy unit costs?
- Will fuel costs (oil) for decentralised boilers increase due to the number of extra delivery points?

The purpose of raising these issues is to show that every situation is different and local factors can affect the calculation of both annual savings and capital costs.

With these points in mind, care should be exercised when using the data in the tables in Appendix 1. An energy-saving measure in one situation might have a payback of two years, whereas the identical measure in another situation may have a payback of five or six years. It is also important to remember the impact of 'sequencing', ie the impact of one measure on another when calculating savings (see Section 4).

ENERGY EFFICIENCY MEASURES AND TYPICAL PAYBACK PERIOD

Appendix 1 of this Guide comprises indicative and typical payback periods for a range of energy efficiency measures. They are derived from a number of energy surveys conducted in the past 10 years in the MoD and the government civil estate. There is no substitute for assembling data specific to your own site.

Finally, it must be stressed again that simple payback is a crude measure of evaluating energy-saving projects. Before making major investment decisions it is recommended that the discounted evaluation methods in Section 4 are followed.

APPENDIX 1 – TYPICAL MEASURES WITH PAYBACKS

ELECTRICITY

Lighting

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Replace tungsten GLS lamps with CFLs	40-70	1-3	Payback period dependent on hours of use
Replace tungsten GLS spotlights with low-voltage tungsten halogen	30-60	2-3	Payback period dependent on hours of use
Replace 38 mm diameter fluorescent tubes on failure with 26 mm tubes	8	2-3	Only possible with switch-start ballasts. Also capital savings as 26 mm tubes are less expensive than 38 mm
HF ballasts for fluorescent tubes	15-20	3-12	Reduced number of fittings required
Replace opal diffusers or 'egg crate' louvres with prismatic panels or specular reflectors	20-50	2-6	Payback is on assumption that fewer luminaires will be required
Install automatic lighting controls	20-50	2-10	
Localised instead of general lighting (task lighting)	30-70	4-8	For example, task lighting on desks/workbenches. Also can be part of central lighting control
Replace high-pressure mercury discharge lamps with plug-in SON replacements	15	1.5-2	
Replace high-pressure mercury discharge lamps with complete new lamp/gear SON (DL)	50	2-5	

Other electricity users

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Replace standard motors with high-efficiency motors	3-6	0.5-3	Overcost
Variable speed drives on pumps, fans, compressors	20-70	0.5-5	Only economic on variable loads on larger motors
Voltage controllers for constant speed motors	5-10	2-5	
Power factor correction capacitors	–	2-3	Only applicable to sites charged for power factor, directly or indirectly, on electricity invoices
Time controls on drinks machines, photocopiers and office equipment	20-60	0.5-3	
Time controls on electric HWS cylinders	20-50	1-2	Based on heat losses
Presence detector controls on electrically heated rooms (full time and dual temperature set back)	10-40	0.5-3	Set back under time control

APPENDIX 1 – TYPICAL MEASURES WITH PAYBACKS

BOILER PLANT

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Automatic total dissolved solids (TDS) control of steam boilers	1-3	2-6	Economics vary with size of boiler. Additional water savings
Steam boiler blowdown heat recovery	1-2	2-6	As above
Burner combustion control – oxygen trim	1-3	3-6	Only for larger boilers
Electric trace heating of oil lines instead of steam	2-7	0.5-2	For use when there is no site demand for steam at night/weekends
Boiler sequence controls	3-5	2-5	
Condensing boilers	15-20	3-4	Overcost compared to new standard boiler
High-efficiency boiler	5-7	2-3	Overcost compared to new standard boiler

WATER

Measure	Typical water saving (%)	Typical payback (years)	Comments
Urinal controls	30-80	0.2-1.0	
Volume control in WC cisterns	15	0.2-0.5	
Percussion taps	40-80	2-4	Plus energy savings for hot water
Spray taps	40-80	1.5-3	Plus energy savings for hot water. Not suitable if risk of Legionella
Tap flow restrictors	20-40	1-2	Plus energy savings for hot water

MANAGEMENT SYSTEMS

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Installation of building energy management system	5-10	3-6	Allows reduction in staffing levels and remote identification of prevailing conditions and alarms. Automated data logging as part of an M&T system

SWIMMING POOLS

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Combined heat and power	30-55	3-6	Usually only feasible on pools running all year
Heat recovery systems	15-25	3-5	
Manual pool covers	2-5	2-3	

APPENDIX 1 – TYPICAL MEASURES WITH PAYBACKS

HEATING/HOT WATER

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Zone control valves	5-10	1-5	Suitable for buildings with identifiable heating circuits and different occupancy patterns
Gas radiant heaters	30-50	2-4	Workshops, hangars, stores and other large open areas
Upgrade insulation of main circulation pipework	60-80	1-3	Higher for steam systems
Insulation of valves and flanges on distribution pipework	50-70	1-5	Dependent on service temperature
Point-of-use hot water heaters to avoid long runs of distribution pipework	10-30	2-3	
High-speed shutter doors	12-18	2-3	Minimal electricity usage to save fuel heating
Destratification fans	10-20	1-2	Electricity spent to save on fossil fuel heating
Microswitches fitted to warehouse doors	10	3-5	Heating automatically switches off as doors open
Thermostatic radiator valves	5-10	2	
Upgrading heating control systems (optimisers, compensators, zone controls)	5-25	1-5	Electricity savings in addition to fossil fuel savings
Reflective foil behind radiators on external walls	5-10	0.5-1	
Draughtstripping	10-15	1-3	
Local supplementary heating for small areas with occupancy	10-30	1-5	Package heat pumps on electric resistance heaters for extended out-of-hours only
Decentralised heating services using direct-fired warm air or packaged local boiler plant	10-25	3-8	
Low limit (frost) operation of heating plant based temperature	3-5	1-3	Pumps only run an ambient frost condition to prevent internal pipe freezing. Boilers and fans run on internal low temperature
Loft insulation*	10-20	2-4	
Flat roof insulation*	10-15	20-30	Less if performed as part of roof refurbishment
Cavity wall insulation*	10-20	3-6	
Internal wall insulation*	10-20	5-8	Applied to solid single-skin structures
External insulation*	10-20	25-35	Rendering also improves finish of building
Floor insulation*	3-5	10-20	
Draught lobby*	2-5	16-20	
Double glazing*	5-25	10-20	Savings on extra cost of installing double glazing on replacement windows. Higher savings from improved control of air infiltration
Self-closing devices to external doors*	2-10	0.5-2	
* Based on building total energy for space heating in naturally ventilated buildings.			

AIR-CONDITIONING

Measure	Typical energy saving (%)	Typical payback (years)	Comments
Enthalpy controls or air-handling units, use of free cooling	5-15	1-2	

APPENDIX 2 – DISCOUNTING FACTOR TABLE

Percentage rate of discount	Future years														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585	.557	.530	.505	.481
6	.943	.890	.840	.792	.747	.705	.665	.627	.592	.558	.527	.497	.469	.442	.417
7	.935	.873	.816	.763	.713	.666	.623	.582	.544	.508	.475	.444	.415	.388	.362
8	.926	.857	.794	.735	.681	.630	.583	.540	.500	.463	.429	.397	.368	.340	.315
9	.917	.842	.772	.708	.650	.596	.547	.502	.460	.422	.388	.356	.326	.299	.275
10	.909	.826	.751	.683	.621	.584	.513	.467	.424	.386	.350	.319	.290	.263	.239
11	.901	.812	.731	.659	.593	.535	.482	.434	.391	.352	.317	.286	.258	.232	.209
12	.893	.797	.712	.636	.567	.507	.452	.404	.361	.322	.287	.257	.229	.205	.183
13	.885	.783	.693	.613	.543	.480	.425	.376	.333	.295	.261	.231	.204	.181	.160
14	.877	.769	.675	.592	.519	.456	.400	.351	.308	.270	.237	.208	.182	.160	.140
15	.870	.756	.658	.572	.497	.432	.376	.327	.284	.247	.215	.187	.163	.141	.123
16	.862	.743	.641	.552	.476	.410	.354	.305	.263	.227	.196	.169	.145	.125	.108
17	.855	.731	.624	.534	.456	.390	.333	.285	.243	.208	.178	.152	.130	.111	.095
18	.848	.718	.609	.516	.437	.370	.314	.266	.225	.191	.162	.137	.116	.098	.084
19	.840	.706	.593	.500	.419	.352	.296	.249	.209	.176	.148	.124	.104	.088	.074
20	.833	.694	.579	.482	.402	.335	.279	.233	.194	.162	.135	.112	.093	.078	.065
21	.826	.683	.564	.467	.386	.319	.263	.218	.180	.149	.123	.102	.084	.069	.057
22	.820	.672	.551	.451	.370	.303	.249	.204	.167	.137	.112	.092	.075	.062	.051
23	.813	.661	.537	.437	.355	.289	.235	.191	.155	.126	.103	.083	.068	.055	.045
25	.806	.650	.524	.423	.341	.275	.222	.179	.144	.116	.094	.076	.061	.049	.040
25	.800	.640	.512	.410	.328	.262	.210	.168	.134	.107	.086	.069	.055	.044	.035

EXAMPLE PROJECTS

This Guide incorporates examples of various sites. The assumptions made for the principal projects (Projects X and Y), together with the associated data, are shown below.

Project X: £1000 investment made today (Year 0); annual savings £500 over three years; project life three years.

Project Y: £1000 investment made today (Year 0); annual savings £450 over three years; project life 10 years.

In terms of simple payback, Project X seems more favourable than Project Y. Applying more sophisticated analysis techniques reveals the true picture.

	Project X	Project Y
Simple payback	2.0 years	2.2 years
Gross return on capital	150%	450%
Net return on capital	50%	350%
Gross annual average rate of return	50%	45%
Net annual average rate of return	16.6%	35%
Net present value	£180.50	£1441.70
Index of profitability at a discount rate of 13%	1.18	2.44

GLOSSARY

Payback period
Ratio of capital cost to annual savings at current cost expressed in years.

This is easily calculated if the capital cost is a single payment and the savings are the same each year. This is linear payback. Usually expenditure and savings are not uniform and a cumulative cashflow table helps identify non-linear payback.

Compounding
The prediction of the future worth of today's investment for a selected interest rate.

Discounting
The time value of money is allowed for by applying a discount factor to costs and earnings in a future year, to reflect their reduced value relative to today.

Discount factor (DF)
Defined as:

$$\frac{1}{(1 + r)^n}$$

where:
r = discount rate %
n = years into project

Used to calculate present value of future savings in 'n' years at a selected discount rate 'r' (see Appendix 2).

Present value (PV)
Today's value of savings likely to be made in future years.

Net present value (NPV)
Savings of a project less its costs in today's money over its expected lifetime.

Internal Rate of Return (IRR)
The discount rate for which the total income from the project, once discounted, equals the initial investment.

It approximately represents the rate of return capital would have to earn elsewhere (inside or outside the organisation) to be an equal investment.

NPV/capital ratio
A ratio which takes into account both the earnings and size of a project. Ratios for different projects can be compared for common discount rates. This aids selection if capital is limited.

Capital expenditure
Comprises goods, plant and machinery, bought and paid for in one year, which reside in the organisation in subsequent years and could be making contributions for several years to come.

Revenue expenditure
Comprises money spent on services and consumables that make their major contribution to the enterprise in the same financial year in which the money is spent. Such items include wages, fuel, advertising, maintenance, etc.

Gross return on capital
The total benefit from a project over its life divided by the capital cost, expressed as a percentage.

Net return on capital
The total benefit of the project over its life less the capital cost divided by the capital cost, expressed as a percentage.

Gross annual average rate of return
The gross return on capital divided by the project life in years.

Net annual average rate of return
The net return on capital divided by the project life in years.

Index of Profitability (IOP)
The sum of the present values of a project divided by the capital cost. Attractive projects have an IOP greater than 1 (ie NPV is positive).

FURTHER READING

FURTHER READING

HM Treasury

Investment appraisal policy and guidance
'Green Book', Economic Appraisal in Central Government (downloadable from the Treasury website at **www.hm-treasury.gov.uk**)

Office of Government Commerce (OGC)

Construction Procurement Guides (downloadable from the OGC website at **www.gov.uk**)

Guide No 1	Essential requirements for construction procurement
Guide No 2	Value for money in construction procurement
Guide No 3	Appointment of consultants and contractors
Guide No 4	Teamworking. Partnering and incentives
Guide No 5	Procurement strategies
Guide No 6	Financial aspects of projects
Guide No 7	Whole life costs
Guide No 8	Project evaluation and feedback
Guide No 9	Benchmarking
Guide No 10	Achieving excellence through health and safety

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following related Best Practice programme publications are available. Contact details are given below.

Energy Consumption Guide

75 Energy use in Ministry of Defence establishments

Good Practice Guides

69 Investment appraisal for industrial energy efficiency
75 Financial aspects of energy management in buildings – a summary
165 Financial aspects of energy management in buildings
213 Successful project management for energy efficiency
286 Energy performance in the government's civil estate
311 Detecting energy waste – a guide for energy audits and surveys in the government estate

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The Government's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at **www.energy-efficiency.gov.uk**

Call the Environment and Energy Helpline on **0800 585794**

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy-efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.