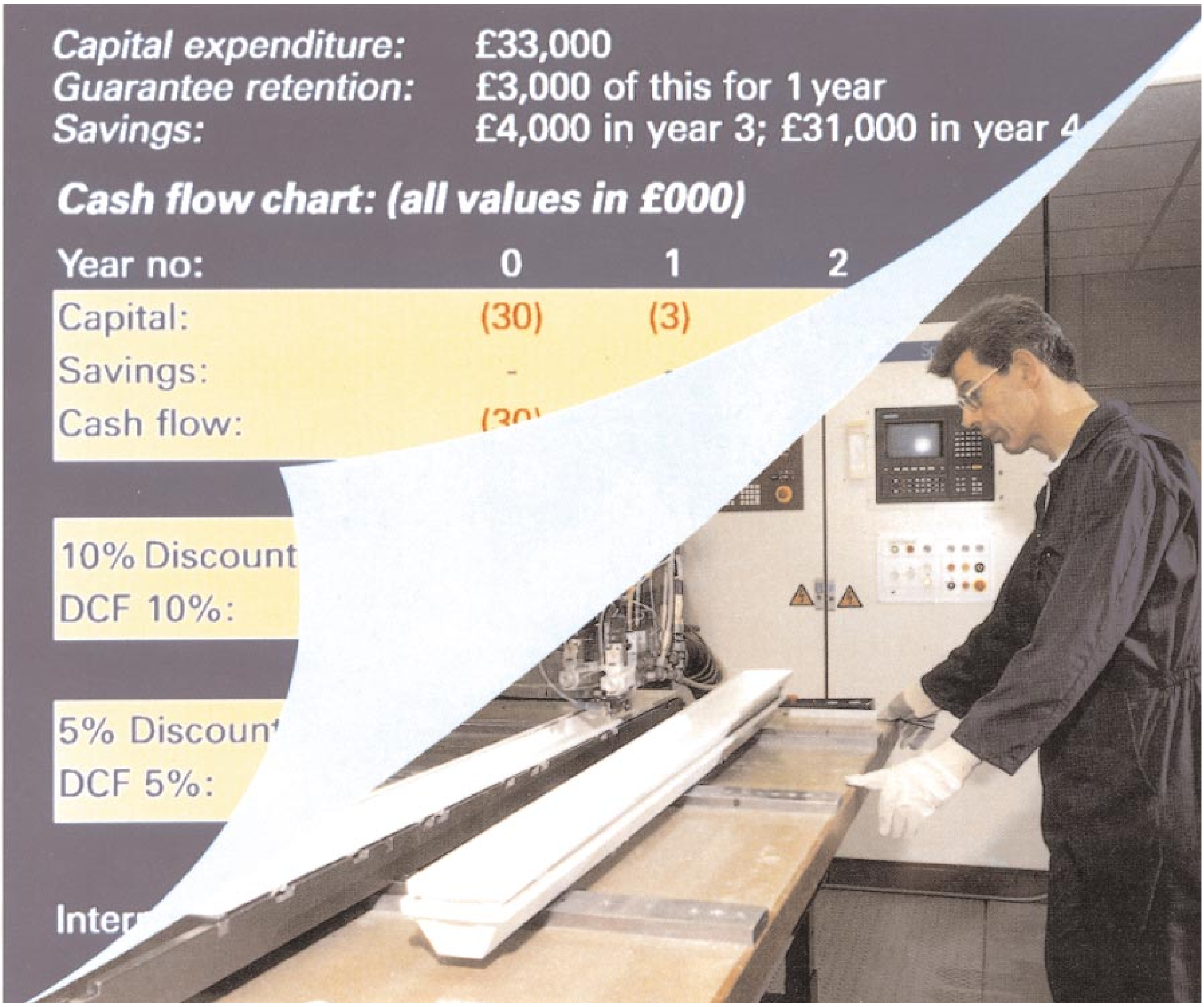
GOOD PRACTICE GUIDE 69

Investment Appraisal for Industrial Energy Efficiency



GOOD PRACTICE GUIDE 69

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE
PROGRAMME

INVESTMENT APPRAISAL FOR INDUSTRIAL ENERGY EFFICIENCY

This booklet is No. 69 in the Good Practice Guide Series and it reviews appraisal techniques used to make decisions related to investment in energy efficiency measures. It examines the concept of financial appraisal, and discusses each stage within the appraisal. Examples are given within the text to clarify the ideas. A detailed worked example from industry is contained in Appendix B, bringing together the points covered in the Guide.

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68. ELECTRIC HOLDING OF HOT METAL IN IRON FOUNDRIES
69. INVESTMENT APPRAISAL FOR INDUSTRIAL ENERGY EFFICIENCY
70. ENERGY CONSERVATION IN THE DRY-CLEANING INDUSTRY
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85. ENERGY MANAGEMENT TRAINING
86. RUBBER MOULDING & CURING IN THE RUBBER PROCESSING INDUSTRY
87. THE PHARMACEUTICAL INDUSTRY
88. ENERGY EFFICIENT USE OF BOILERS USING CHAIN GRATE STOKERS
89. GUIDE TO COMPACT HEAT EXCHANGERS
90. ENERGY EFFICIENCY IN THE PROVISION AND USE OF INDUSTRIAL GASES
91. MONITORING AND TARGETING IN LARGE MANUFACTURING COMPANIES
92. REDUCING ELECTRICITY USE IN EXTRUSION-BLOW MOULDING OF THERMOPLASTICS
114. ENERGY EFFICIENT REFINING OF PAPERMAKING STOCK
115. AN ENVIRONMENTAL GUIDE TO SMALL-SCALE COMBINED HEAT AND POWER
116. ENVIRONMENTAL ASPECTS OF LARGE-SCALE COMBINED HEAT AND POWER
126. COMPRESSING AIR COSTS
127. ENERGY EFFICIENT ENVIRONMENTAL CONTROLS IN THE GLASS INDUSTRY
140. THE ORGANIC DYE AND PIGMENT MANUFACTURING INDUSTRY
142. IMPROVING METAL UTILISATION IN ALUMINIUM FOUNDRIES
163. ENERGY EFFICIENT PULPING/SLUSHING IN PAPER MANUFACTURE
164. ENERGY EFFICIENT OPERATION OF KILNS IN THE CERAMIC INDUSTRIES
166. ENERGY SAVINGS IN FOUNDRY SERVICES
169. TOTAL QUALITY MANAGEMENT
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FOREWORD

This Guide is part of a series produced by the Government under the Energy Efficiency Best Practice Programme. The aim of the programme is to advance and spread good practice in energy efficiency by providing independent, authoritative advice and information on good energy efficiency practices. Best Practice is a collaborative programme targeted towards energy users and decision makers in industry, the commercial and public sectors, and building sectors including housing. It comprises four inter-related elements identified by colour-coded strips for easy reference:

— *Energy Consumption Guides:* (blue) energy consumption data to enable users to establish their relative energy efficiency performance;

— *Good Practice Guides:* (red) and *Case Studies:* (mustard) independent information on proven energy-saving measures and techniques and what they are achieving;

— *New Practice projects:* (light green) independent monitoring of new energy efficiency measures which do not yet enjoy a wide market;

— *Future Practice R&D support:* (purple) help to develop tomorrow's energy efficiency good practice measures.

If you would like any further information on this document, or on the Energy Efficiency Best Practice Programme, please contact the Environment and Energy Helpline on 0800 585794. Alternatively, you may contact your local service deliverer – see contact details below.

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CONTENTS

Appendices

1

INTRODUCTION

The primary objective of a manufacturing enterprise is to make profits for its shareholders. It does so by buying in raw materials and converting them into products which it sells to its customers. To ensure its long term survival, a company must also re-invest at least part of the proceeds; to allow for expansion, to become more competitive and to provide for the development of new products that will be its source of income in future years.

Energy, a cost element which is present in the manufacture of every industrial product, is both measurable and controllable.

Energy is an essential commodity for every manufacturing enterprise and one of the few cost elements present in the manufacture of every industrial product. Energy is also one of the five largest measurable and controllable cost elements in at least 80% of all industrial production.

The technology already exists to reduce UK energy consumption by 25%, and the capital equipment is commercially available. If industry and the other energy-consuming sectors of the economy were to invest only in energy saving capital projects, which offer a better financial return than most other forms of investment, this would be more than enough to meet current targets for reducing the emissions of greenhouse gases such as carbon dioxide.

Investment in energy efficiency has been far lower than makes sound business sense.

However, the level of investment in energy efficiency before and after the oil crisis of 1973/74 has been far lower than was commercially viable or made sound business sense. A review of the response to the industrial energy surveys supported by the former Energy Efficiency Office between 1984 and 1989 shows that, although the take-up of recommendations which involve no capital cost is good, the take-up of recommendations which involve even a low cost investment is poor.

It would be natural to assume that if an organisation has a worthwhile investment project with a good return, it would find the capital resources and give the project the appropriate priority. In practice, industry is very hesitant about investing in energy efficiency. It is only recently that the reasons for this have become clearly understood.

There are three main barriers to be overcome:

- the low priority given to energy efficiency in most organisations;
- ensuring that the standards of investment appraisal used are appropriate to the company's needs;
- ensuring the decision to invest or not is taken at the right level in the company.

These are the main issues addressed in this Good Practice Guide.

2

THE PURPOSE OF FINANCIAL APPRAISAL

Investment appraisal is merely a rational method of making choices. Any healthy commercial enterprise ought to be able to identify more viable investment opportunities open to it than it has money available for. It therefore has to choose which projects to invest in.

Financial appraisal is the process by which these choices are, or should be, made, i.e. the process which evaluates projects using measures of financial return as the yardstick of value.

Financial appraisal has four objectives:

- to determine which investments make the best use of the organisation’s money;
- to ensure optimum benefits from each of these investments;
- to minimise risk to the enterprise;
- to provide a basis for the subsequent analysis of the performance of each investment.

This process produces measurements of the financial contribution each project would make to the business, identifies the risks and uncertainties in each project, and defines the expected costs and benefits. The decision taker then uses the results of the appraisal to choose between projects. Other factors taken into account are the cost structure of the business and how each project relates to the dynamics and objectives of the business in terms of capacity, quality, flexibility, product mix, etc.

The concept that financial appraisal is to make choices is an important one. Although it is often perceived to be a process by which a decision is made as whether to proceed or not with an individual project, this is not the case. When a project is being appraised, what is being determined is its ranking in the whole range of possibilities open to the company.

Financial appraisal is about ranking projects; about choosing between investment projects, rather than deciding whether or not to commit to a particular project.

3

ENERGY EFFICIENCY AND INVESTMENT

Most organisations are receptive to ideas which will reduce costs and are readily prepared to implement measures which involve no cost and no re-organisation. However, once an energy saving measure involves capital expenditure or a change in management practices, other business objectives have to be considered. As far as capital expenditure is concerned, the project has to be considered along with other demands on the organisation's money. This is the function of financial appraisal - to determine the relative priorities of projects proposed by all parts of the business. This decision will be influenced by the capital resources the organisation feels it has available. It has to decide where the money will come from and how money is allocated between capital and revenue budgets. Deciding how to allocate financial resources is, in fact, what the financial appraisal of capital projects is all about.

There is no universally-employed procedure for financial appraisal: methods vary from organisation to organisation.

There are several common misconceptions about financial appraisal. One of the most important is that financial appraisal is a well-established procedure, that is fully described in textbooks and based on theories which financial managers are familiar with and universally employ.

It might reasonably be assumed that the application of financial appraisal to energy efficiency is merely an extension of its use in other aspects of the business, for example investment in new production capacity. This is not however the case. Energy managers, many of whom have engineering and scientific backgrounds, are often surprised about how small the theoretical basis of financial appraisal is and how much financial appraisal practices vary between organisations.

Industry's acceptance of the principles of financial appraisal is a cultural undertaking. Organisations are often selective in the credence they give to financial appraisal, to the way in which investment criteria are based on it, and the standard of application required. Experience shows that this tends to work against energy managers competing for scarce investment funds.

Most companies are currently unable to handle the financial appraisal of large numbers of projects simultaneously, and so they set simple rules to filter out unlikely projects, such as payback criterion. How companies do this varies. They sometimes, for example, set different payback criteria for investments in different parts of the business, however much this disregards what they know of the theory of financial appraisal. Companies also tend to limit individual projects to one submission to the board of directors. This may be appropriate for investments that are clearly influenced by changing market factors, but it is not usually the case for energy efficiency measures. Energy managers should be careful not to allow good projects to wither away like this.

Energy managers who understand the purpose and principles of financial appraisal are better placed to ensure that energy efficiency is given an appropriate investment priority.

Reducing energy costs is an investment area for which financial appraisal is ideally suited. Energy managers who make time to understand the purpose and principles of financial appraisal may appreciate the strengths and weaknesses of their organisation's financial management more. They can then use this knowledge to ensure that energy efficiency obtains the appropriate investment priority within the organisation.

The inadequacies of energy efficiency investment cannot be blamed solely on organisational defects. Energy efficiency often fares badly for the simple reason that the financial appraisal is done badly. The responsibility for this must rest with energy managers. There are four principal ways in which the financial appraisal of energy efficiency projects can go wrong:

- the project’s benefits are underestimated, with the result that the project looks less attractive than it really is and is not proceeded with;
- the engineering options are not fully explored, so the costs and benefits are not optimised;
- the costs are underestimated so that the project appears more attractive than it really is. When it goes ahead the actual costs come to light and create a prejudice against similar projects in the future;
- the decision is taken at the wrong level; for example, senior management sets financial criteria in terms of payback which are taken too literally and are not related to the funds which are available, or to the potential return on investment.

The last point, which is supposed to be a simple filter to assist senior management, usually fails because junior managers misinterpret its meaning. It ought to mean that projects with a longer payback are not likely to be funded, not that they should not be considered at all. Investment is like an iceberg: if management only sees what lies above the water, it will not realise the value of appropriate investment. Projects which fall outside payback criteria should still go forward for senior management to turn down. Many senior company executives have never realised the potential for energy savings, because they have never seen a submission which sets it out.

Energy managers should not manipulate costs or savings to get under the criterion either.

These considerations are important because, almost 20 years after the oil price changes which first brought energy management onto the corporate agenda, many organisations have not significantly altered the payback criterion on which they base investment decisions. Much of the potential for energy saving lies only marginally beyond standard payback criterion. Better financial appraisal, which would examine the relative movements in capital and energy costs, could demonstrate that energy efficiency is an attractive and worthwhile area of investment for many companies.

Some energy efficiency projects never get as far as consideration by senior management, even though they fall only marginally outside the standard payback criterion.

This is how it is intended to work in theory, and for most forms of investment it works moderately well. However, it is now well established that investment in energy efficiency fares less well than it would if this process worked uniformly for all investment types, and it is worthwhile considering why.

4

INVESTMENT IN THE CONTEXT OF THE STRATEGIC OBJECTIVES OF A MANUFACTURING ENTERPRISE

It is essential that the energy manager understands why energy saving investments tend to be afforded a low priority. Until the 1980s this was poorly understood, but a key study[1] commissioned by the Department of Energy from the consultants Armitage Norton revealed some of the reasons. The conclusions of the Armitage Norton report are now broadly accepted as the reasons not just for lack of investment in energy saving, but in many other areas of cost reduction as well.

Types of Business Expenditure

The Armitage Norton study found that expenditure in most businesses tends to be classified in the manner shown in Fig 1 (implicitly even if there is no actual accounting of expenditures in these terms). The detail varies from company to company, but most organisations operate a form of management accounting which incorporates most of these features.

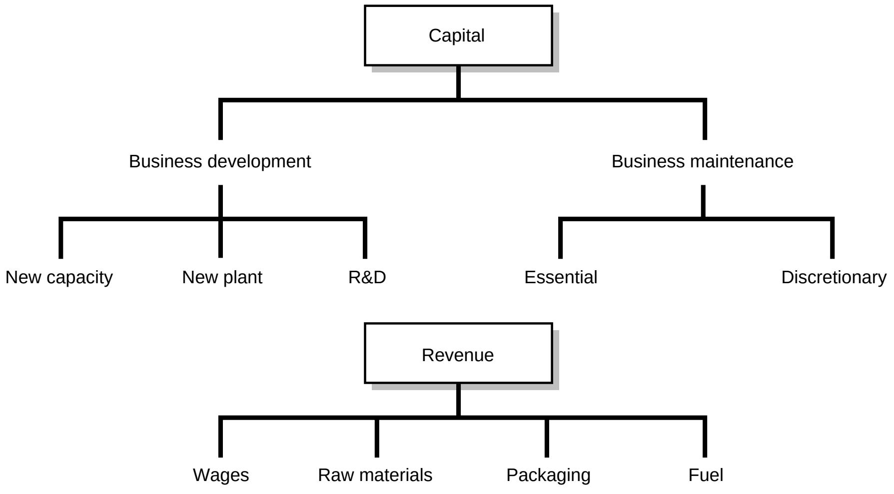

Fig 1 Classes of expenditure in a business

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[1] Energy Paper 50 (1983), *Energy Conservation in Industry: an appraisal of the opportunities and barriers.*

The first broad division is into Revenue Expenditure and Capital Expenditure.

Revenue Expenditure

Revenue expenditure comprises the 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, raw materials, fuel, packaging, advertising and so on.

Capital Expenditure

Capital expenditure comprises goods, plant and machinery, which while bought and paid for in one year, reside in the business in subsequent years and could make a contribution for several years to come. This distinction is formally recognised in all UK businesses because it is important in evaluating the worth of a business for the conventional system of annual reporting.

In most companies, there is then a less formal but implicit further division of capital expenditure into:

- business development or profit-increasing expenditure;
- business maintenance or profit-maintaining expenditure.

Business development capital expenditure is associated with projects that increase production to meet growing markets for existing products, or develop new products for existing or future markets. Investments like new plant capacity to supply new customers, research and development, and investment for new products fall into the business development category.

Business maintenance capital expenditure is capital invested to enable the business to serve existing markets with existing products from existing plant capacity. Business maintenance expenditure falls into two types:

- ***Essential expenditure*** which must be made in order to maintain existing business, declared or implied internal objectives, and other obligations emanating from outside the organisation such as legal, safety and environmental aspects.
- ***Discretionary expenditure*** is money which the organisation can choose whether to spend or not. Discretionary business maintenance expenditure has a low priority, because curtailing it increases short term retention of money in the business as liquidity, i.e. money that is readily available.

The key observation made by Armitage Norton was that in many organisations expenditure on efficiency improving projects is implicitly, if not explicitly, identified as discretionary business maintenance expenditure in order to save on a revenue expenditure. Discretionary expenditure normally represents the lowest level of priority. While such projects should result in an increased medium-term profit on existing business, industry usually perceives this as less important than investment in large-scale profit-generating new business. This may be industry's view, but it is worthwhile considering whether it is necessarily a good one.

Expenditure on efficiency improving projects is often seen as discretionary business maintenance expenditure, which normally represents the lowest priority level.

Sources of Business Revenue

A business obtains its income from the customers that buy its products. Most businesses operate with a range of products and have several or many different customers. They have to compete with other firms providing similar products. Businesses prosper by ensuring that they provide the products that customers want to buy and that they have sufficient customers for their manufacturing capacity. A business does not, however, work in a static world. Customers are lost through natural wastage or because they lose interest in a particular product or become interested in something else. While there is always a natural diminution of existing customers, potential new ones are being generated and customer bases can change. Potential customers, however, are available to both the business and its competitors. Few businesses, furthermore, are happy to stand still but have a desire, or perhaps even a need, to grow. It is necessary for these enterprises to find and develop new business.

The most basic survival strategy for any business depends on maintaining existing business by retaining existing customers for the existing product range. There are two ways an enterprise can achieve this:

- by improving the product to keep it more attractive than the competition;
- by making it cheaper.

The second priority, which is more difficult to accomplish, is to replace any lost business by:

- seeking new customers for existing products;
- finding new products for existing or new customers.

This can continue until a capacity constraint is reached. This is an important stage; up to this point increasing output improves profitability. Beyond this, however, increasing capacity might require investment in fixed assets such as buildings, machinery, etc., which increases fixed costs.

These priorities all require a consensus from the enterprise on its investment needs and its longer term development. The right balance can only be achieved by looking at the product mix, the position of these products in their existing markets (including costs and margins), and the investment requirements created by market conditions.

The Strategic Significance of Products

The Boston Matrix

The most significant contribution to this aspect of business strategy was made by the Boston Consulting Group when it combined market growth and market share in a simple diagram, now called the Boston Matrix (see Fig 2). The inputs to the matrix are the relative share of the firms products in a given market, which can be rated high or low, and the rate of growth of that market, which can also be rated high or low. The matrix segments are therefore:

- high growth, high share;
- high growth, low share;
- low growth, high share;
- low growth, low share.

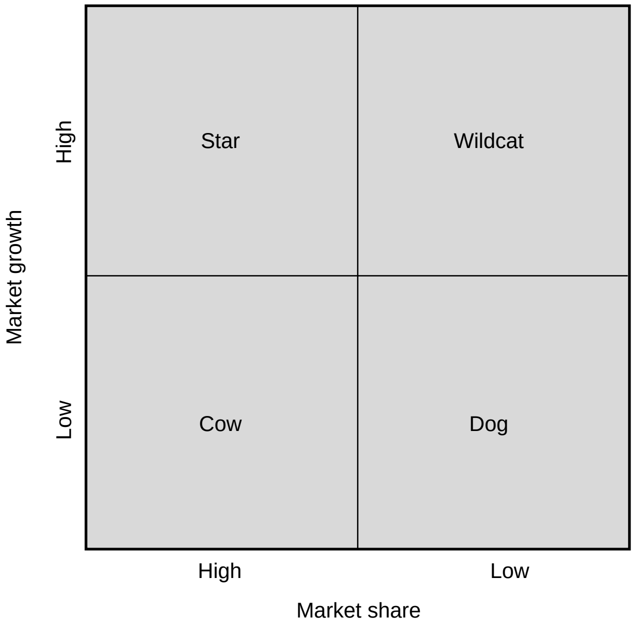

Fig 2 The Boston market matrix

The Boston Consulting Group gave names to these segments:

- a ***star*** has achieved a high market share and generates a large amount of revenue. However, the market is growing rapidly and the enterprise needs to increase production to maintain its dominant position. It probably finds it is obliged to invest in this area;
- a ***wildcat*** or ***problem child*** does not have a dominant market position, but the market is growing rapidly. A star which has received insufficient investment could become a problem child. If the firm wants to gain or restore its market share it will either have to invest heavily or reduce production costs significantly;
- a ***cow*** is a market leader in a static market. Often called 'cash cows', they require little product improvement or investment and often provide a high volume of profitable income. They also constitute a rich source of funds on which the enterprise needs to make little supporting expenditure;
- a ***dog*** is a product with little prospect of generating funds. It is often a drain on resources.

Products have a natural life cycle. A successful product progresses from the problem child, through the star to the cash cow, and finally to the dog.

The Boston Matrix is valuable because, apart from its use in comparing company strengths, it reveals how different products of the same business relate in terms of investment needs and the contributions made by different products to the business. Most companies will have products in more than one segment. Ideally, the cash generated by the cows and dogs is used to develop the stars and wildcats. To continue this supply of funds for business development, it is important to maintain the existing products that are cash generators.

Above all, the Boston Matrix emphasises that:

- it is the business maintenance activities of an enterprise which create the resources for further investment. These should therefore be a priority for investment funds, whether essential or discretionary;
- priority for investment does not equate with the amount of the investment. This is an important divergence from the view of investment taken by many conventionally managed businesses;
- a priority for business maintenance capital investment is cost reduction to maintain competitiveness in markets, especially by supporting 'cash cow' products, and possibly even 'dogs', which are the source of most of the internally generated investment funds.

Business maintenance activities create the resources needed for further investment, and should be given priority for investment funds.

There are in fact two Boston matrices: the one relating to markets which is described here, and one relating to turnover and profitability but with the same correspondence of product types.

Surprisingly, many senior managers are unaware of this interpretation of their business. It is, however, a simple device which energy managers can use to decide how their company earns its revenues and profits and thus determine how energy management can best serve the company's wider business objectives.

Overcoming the Low Priority Given to Investment to Reduce Costs

To understand why businesses mistakenly give low priority to cost reduction, it is necessary to examine how most businesses monitor their financial performance.

Income from sales, expenditure in terms of goods bought and the volume of production are recorded during routine accounting, and are readily available in the accounts department as part of standard accounting procedures. The income and expenditure figures relate directly to quantities of money recorded on invoices, records of goods dispatched, bank debits, cash and cheques received and paid out, and other direct financial transactions. In the context of management accountability and responsibility, they are commonly regarded as the evidence by which the performance of the business can be judged.

When assessing performance in a given area, most businesses simply examine all the expenditures and revenues related to that part of the business under review. For revenue-increasing projects this is relatively easy because the invoices, and other records relating to costs and sales, are readily available in the accounts department. All that is required is to collate the costs and revenues and compare them.

This approach, however, is not possible when the capital expenditure is specifically to reduce a revenue cost, such as improving energy efficiency. The only records routinely assembled by the accounts department are records of continued outgoings, i.e. the costs of the various measures taken, the salaries of the people involved and invoices relating to the fuel and electricity still being used. There are no records of income because energy efficiency, or any other form of cost reduction, does not create income and the costs that would have been incurred in the absence of the investment are not recorded.

Energy efficiency does not create an 'income' which will appear on management reports; similarly, the costs that would have been incurred without energy efficiency measures are not recorded. As a result, senior management may not realise the benefits of energy efficiency for their business.

This is a key reason why energy managers have previously had difficulty in maintaining the interest and commitment of senior management in energy efficiency. Conventional financial management information flows do not show what benefit the business derives from sound energy management.

The solution is very simple, and that is to maintain a capital return budget. This is discussed in Section 5.

Relating Costs to Production

In any business there are two kinds of revenue expenditure or costs: fixed costs and variable costs. Fixed costs are costs that continue irrespective of how much is produced, such as rent, rates, space heating, offices and administration, interest on capital invested and so on. Variable costs are those that increase in line with production such as raw materials, process energy, packaging, and labour costs.

This distinction is important because it affects the average costs for different levels of production and, by the same token, affects the profit margin for different levels of production at the same selling price.

Where it is possible to classify costs as fixed or variable, for example rent is clearly a fixed cost and a key raw material would clearly be a variable cost, this is familiar territory to financial managers. They can work out total costs by first adding up the fixed cost items, which can be obtained from the financial records, and then adding the costs of variable items for any level of production.

Total Costs = Fixed costs + Variable costs

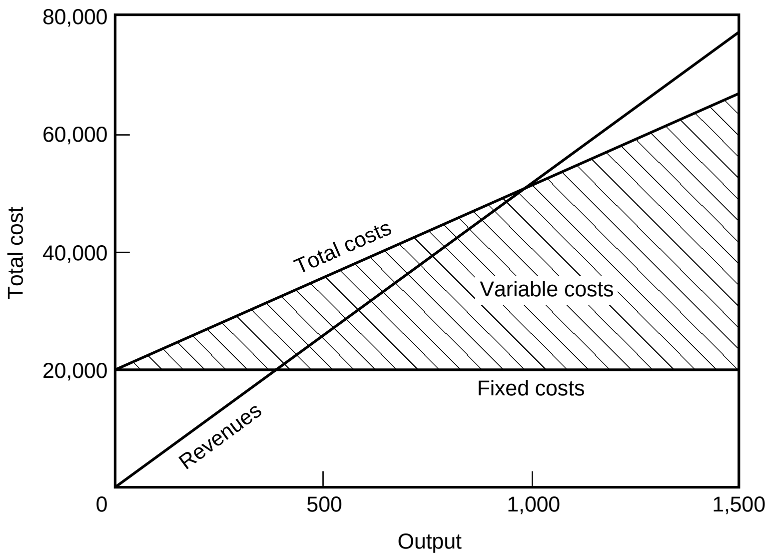

Fig 3 Comparison of costs and revenues

Example

Fig 3 compares the costs and revenues for a process at various levels of output.

Fixed costs are £20,000/year, variable costs are £30/unit and the product sells for £50/unit.

At 1,000 units/year, costs are £20,000 + (1,000 x £30) = £50,000 and revenues are 1,000 x £50 = £50,000; and the product 'breaks even'.

At less than 1,000 units/year, costs exceed revenues and the process runs at a loss. At 300 units/year, costs are £44,000 and revenues £40,000, a loss of £4,000.

At 1,500 units/year, revenues exceed costs and the margin is £10,000/year. Increasing output by only 10% to 1,650 units/year increases the margin to £13,000, i.e. by 30%.

Calculating Energy Costs

There are important consequences when an individual cost item has both fixed and variable components. Energy is a common and important example. In many processes, energy is consumed even at zero output through, for example, the standing losses of the furnace or boiler. The variable energy consumed for each additional unit of output must then be added to this figure.

The same basic diagram as shown in Fig 3 applies to energy costs, except that the diagram is drawn in physical quantities rather than financial ones. Energy (therms of gas, litres of fuel oil, kilograms of steam, etc.) occupies the y-axis and output the x-axis; however, the procedure for determining the split between fixed and variable costs is different.

This is well-known by energy managers, but not necessarily by finance managers. The total costs are all that are known. The fixed costs are obtained by drawing a graph of the energy required in any given period against the output in the same period, and then extrapolating the graph to zero production (see Fig 4). The variable cost component at any level of production is the total cost less this fixed quantity.

Variable costs = Total costs - Fixed costs

Fig 4 shows the most commonly encountered form of graph, although in practice there may be variations. These variations are important when energy monitoring and target setting is applied. The possible relationships are limited by the physical laws that govern energy transformations; these are different from the common variants which are found in textbooks on financial costing. Businesses should know the form of this line, measured in energy units, for any of their processes that use significant amounts of energy. Businesses seldom in fact do so; they may assume forms of this line, but in practice not many verify it.

The effect on the relationship between energy and production is of paramount importance whenever energy saving measures are applied to an existing process. Few energy saving measures affect the fixed and variable energy costs in equal proportions. For example, insulation applied to a furnace affects the fixed consumption while heat recovery affects the variable cost but not the fixed cost. It should be noted that when a measure does not affect the fixed and variable costs in equal proportions, it is not possible to express savings for any process in percentage terms, unless the production rate is also stated.

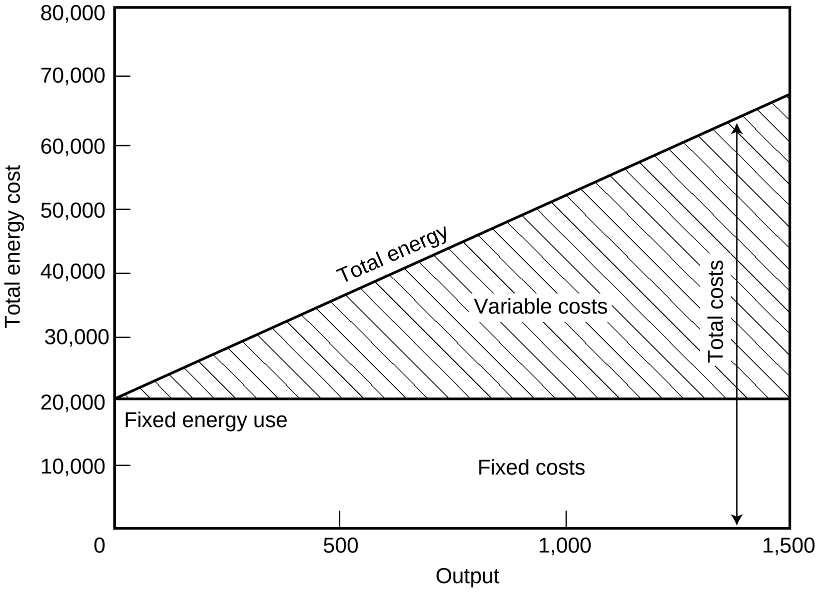

Fig 4 Fixed and variable energy consumption

5

BUDGETING FOR INVESTMENT

It is implicit in the entire concept of financial appraisal of capital projects that there is a choice to be made.

Financial appraisal presumes that the available funds are exceeded by the number of projects that an enterprise could invest in. Financial appraisal is based on the idea that there will always be a surfeit of investment opportunities, rather than a shortage of funds. Energy managers should be constantly aware of this fact; the money is there, but there are other things which the organisation could spend it on. The purpose of financial appraisal is to make the best use of the organisation's money in a global sense, irrespective of which aspect of the business this may be in. Energy efficiency investment opportunities should therefore be part of the trawl of opportunities the organisation should constantly be making.

If all these rules are working properly, energy managers should expect that some of their proposals may get turned down (and in rare cases possibly all of them). However, they should not be discouraged. Financial appraisal is only working when an organisation is turning down proposals (albeit appropriately) - it is a sign that the organisation is making choices.

Energy managers must expect some of their investment proposals to be turned down: financial appraisal is only working properly when an organisation is turning down proposals (hopefully appropriately!).

The energy manager should continue to submit a steady stream of well-prepared proposals that offer a worthwhile investment opportunity for the company. The energy manager's job is to locate the opportunities in his or her area of the business. It is the role of senior management to make the final decision; if senior management turn down proposals inappropriately, it is their fault and it should not reflect badly on the energy manager.

This is not a familiar argument to financial managers in industry and it is possible to employ another strategy - the creation of virtual funds through the capital return budget.

The Capital Return Budget

The objective of a business is to achieve a margin of revenue over costs, i.e. when all the costs are deducted from the selling price of a product, there should be some money left over. If the energy manager can reduce the manufacturing cost while the selling price remains the same, then more money is retained by the business. As is discussed later, the possibility of achieving a higher throughput for the same overheads also exists.

Virtual Funds

The vast majority of businesses, however, are not able to state exactly what any extra retained income is being used for. The energy manager can therefore argue that since it is probably not being used for anything in particular and, if he/she can identify how much money is involved, that he should have first call on it. If the energy manager can create savings by whatever means, for example tariff savings, housekeeping, maintenance, etc, then this is sufficient to start this process. Measuring these savings uses techniques which the energy manager is in a good position to apply, and should provide enough information to set up a capital return budget, which is the source of these so-called virtual funds.

The capital return budget is a simple statement of the capital expenditure and the revenue savings achieved in each year, and the difference between them. An example is shown in Table 1. The essential feature of a capital return budget is that it takes into account the fact that revenue and capital cash flows are being compared and therefore looks at more than a single year.

Table 1 Capital return budget

	1989/90 actual	**1990/91 actual**	**1991/92 actual**	**1992/93 actual**	**1993/94 actual**	**1994/95 actual**	**1995/96 estimated**
EXPENDITURE							
Survey recommendations							
No cost	0	0	0	0	0	0	0
Low cost	2,089	4,215	3,180	952	0	0	0
Insulation of oil tanks	8,950						
Burner replacement		16,219					
Steam trap replacement			11,596				
Condensate recovery				15,793			
Rapid roller doors					16,250		
Air knife					4,550		
Cooker controls						12,250	
Scheduling of compressor						8,724	
Recover washing water							6,280
Cooker heat recovery							25,800
SAVINGS							
Survey recommendations							
No cost	0	0	0	0	0	0	0
Low cost	6,700	13,000	15,400	17,200	17,200	17,200	17,200
Insulation of oil tanks	6,700	6,000	6,000	6,000	6,000	6,000	6,000
Burner replacement		11,000	11,000	11,000	11,000	11,000	11,000
Steam trap replacement			9,600	9,600	9,600	9,600	9,600
Condensate recovery				6,000	6,000	6,000	6,000
Rapid roller doors					24,000	24,000	24,000
Air knife					8,000	8,000	8,000
Cooker controls						4,800	4,800
Scheduling of compressor						6,000	6,000
Recover washing water							2,000
Cooker heat recovery							8,000
TOTALS							
Expenditure	11,039	20,434	14,766	16,745	20,800	20,974	32,080
Savings	13,400	30,000	42,000	49,800	81,800	92,600	102,600
Savings – Expenditure	2,361	9,566	27,244	33,055	61,000	71,626	70,520
Savings – Expenditure (cumulative)	2,361	11,927	39,151	72,206	133,206	204,832	275,352

A capital return budget highlights the fact that capital expenditure on single measures can give rise to savings in any one year, which not only accrue over several years but extend beyond the year in which payback is achieved.

When this feature is examined in a programme of several investments, the capital return budget demonstrates that:

- the main body of savings are from measures which have involved some capital investment;
- only a small number of measures have involved no capital outlay and the savings from these are usually small;

- since the items tackled first tend to be those with the shortest payback period, the entire programme could be in surplus from the beginning and will continue to be in surplus even though measures still to be taken up have much longer paybacks;
- most importantly, the organisation can afford to invest in these longer payback measures because a surplus of funds has already been generated. These funds are called virtual funds because although they cannot be located in the financial accounting system, they must exist. Virtual funds can be quantified and managed through the capital return budget.

Evaluating Savings using CUSUM

The expenditure element of the capital return budget is obtained from the company's financial records. Evaluating savings is more complicated and requires the use of statistical techniques, of which CUSUM is one of the most sensitive and revealing.

CUSUM is a technique which measures bias in equal interval sequential data. Since about 1984, it has been increasingly used by energy managers as a monitoring and target setting tool. It is the basis of quality and production monitoring techniques more generally known as Statistical Process Control (SPC), which is being increasingly used in manufacturing industry.

The advantages of CUSUM are:

- it is easy to calculate;
- it is very sensitive (it can identify process changes at levels of 1-2%);
- it is already used as a monitoring technique by many energy users and therefore provides a link between monitoring and target setting and investment.

An example of a CUSUM graph is shown in Fig 5.

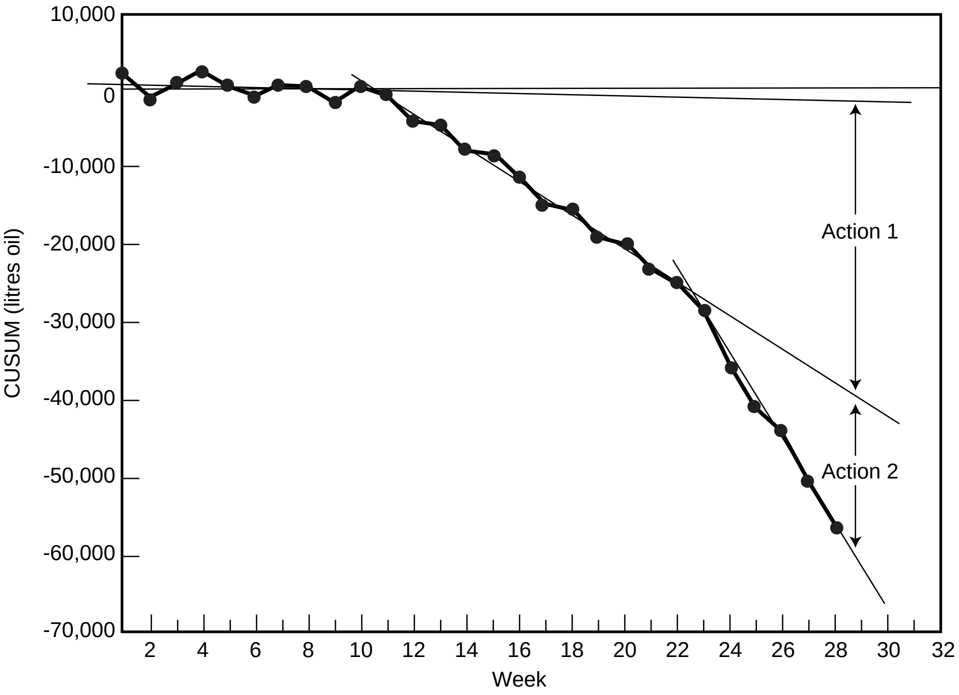

Fig 5 Evaluating savings using CUSUM

The graph consists of a series of straight segments separated by kinks. Each kink represents an event which changes the relationship between energy use and production. It could be an energy saving measure or it could be a fault or a change in the operation of the process which has affected energy use. However, because the change in the pattern can be located in time, it can be attributed to particular events. Thus energy saving actions can be distinguished from other types of event. If each segment in the CUSUM chart is extended to the present time, then the separation of the extended lines at each year end indicates the savings due to each change.

The use of CUSUM is described in more detail in *Energy Monitoring and Target Setting* (Harris) and also in Fuel Efficiency Booklets (FEB) 7 *Degree Days* and 13 *Waste Avoidance Methods.* The FEB series is among the many publications available free of charge from ETSU and BRECSU. Contact ETSU or BRECSU for further details.

A Note on Depreciation

Most financial accounts make an annual allowance for the reduced value of assets (such as buildings and machines) as they become worn out. This exercise is called depreciation and involves the original capital cost (and hence the value) being steadily reduced over a number of years.

Depreciation does not need to be included in the costs of a project.

Many engineers feel that depreciation should be included when identifying the costs of a project. This is not, however, necessary because the actual value of an asset at the end of a project is included as capital income, while the effect of time on the financial values in a project is calculated by discounting. (For further information, refer to Section 4.4 of *Economic Evaluation of Energy Efficiency Projects,* available from ETSU, and *Discounting* in Section 6 of this Guide.)

The Effect of Grants and Taxation

Economic evaluation is concerned with establishing the value of the future returns from a project. The source of the funding for the initial investment should not influence the evaluation, except when choosing the discount rate (refer to *Discounting* in Section 6). The only exception will be some projects which can include tax benefits or grants.

Grants for energy projects may be available offering low interest rates or delayed repayment conditions. As it is important to know when costs and savings will occur during the project lifetime, the timing of capital costs such as grant repayments should be shown in the proposal. Similarly, tax concessions for investment can be included as savings for the appropriate year.

Grants and tax savings are not enough to justify funding a poor project.

In all cases, grants or tax savings information should only be included when the benefits will result from the project going ahead, and not when the benefits would happen anyway; for example, grants available specifically for energy projects should be included. Grants and tax benefits will not be enough to make a poor project justifiable for funding; the project proposal itself still needs to be good enough wherever the funds are coming from. A well-prepared project evaluation will also help any application for grant aid.

6

KEY STAGES IN FINANCIAL APPRAISAL

Financial appraisal should produce both qualitative and quantitative measures to determine the wealth generating potential of each of the possible investments that the enterprise could make in order to decide which of these should be funded and their priority. Financial appraisal should not be considered as a technique for creating absolute yardsticks. It compares the merits of investing in various projects, rather than deciding in isolation whether any one idea is worth taking up.

Quantitative financial appraisal seeks measures of the benefits of projects in relation to their capital costs which will enable some kind of ranking to be achieved. Unfortunately, it is often difficult to find any single parameter which measures this. The different measures produced by quantitative financial appraisal highlight different aspects of a project. No one measure is necessarily better than any other, and each has their strengths and weaknesses. What is important is that the measures which the financial community has largely agreed on, and is trained to understand the significance of, are those which are used.

Whose Job?

A common problem in financial appraisal is a failure to resolve the question of whose job it is.

Many of the initial ideas for reducing production costs for individual projects are produced by engineers or production managers, who consider the various technical approaches and produce feasible costed technical designs. However, before the projects go to senior management for approval, an investment appraisal has to be undertaken.

While it is usually appreciated that engineers may not have a detailed knowledge of financial matters and may not see it as their job, it is often not realised that accountants do not necessarily see it as their job either. In fact, what is commonly regarded as the key issue of financial appraisal, i.e. the discounting of cash flows, is only a very minor procedural aspect. Most of financial appraisal is concerned with the quantification of costs and benefits, i.e. identifying what needs to be bought, what will be saved, what the alternatives are and so on. Much of this is determined by the engineering design; then there is the application of sensitivity tests and decisions regarding the project’s lifetime. Of these, only the lifetime is not an engineering decision - it is a marketing one.

Financial appraisal mainly consists of identifying what needs to be bought, what will be saved, what the alternatives are, and so on; the discounting of cash flows is a minor part of the process.

These decisions are mainly non-financial and rely on the input of engineers, purchasing managers and commercial managers. In most organisations, the last person to be involved in financial appraisal is probably the financial manager who will typically only be comparing the results of appraisals of different projects. This is important. Ultimately, it is the accountant or financial director who will examine the cash flow for the whole enterprise to determine whether and when the projects can be accommodated, having taken into account stock levels, budget commitments, etc. If an accountant is presented with the various cost elements and a statement of benefits, the most he is likely to do is to calculate a discounted cash flow and an Internal Rate of Return from the figures supplied, taking these on trust. This is a far cry from that part of financial appraisal which optimises the project in terms of both cost and benefit, and ensures a full evaluation of the sensitivities of the financial parameters compared to the engineering assumptions in the project.

Cash Flow

The first step in any financial appraisal is to assemble the information on the project costs and benefits and calculate the cash flow. This is simply a statement of how much money will be spent or will accrue in each year of the project.

Example

Taking a simple example of a project costing £50,000 which produces an annual saving of £30,000 for five years. The cash flow is:

Year	0	Capital cost	(£50,000)
	1		£30,000
	2		£30,000
	3		£30,000
	4		£30,000
	5		£30,000

All the key financial criteria are calculated from these figures. Two sets of criteria are normally used - those based on undiscounted cash flow and those based on discounted cash flow.

This example cash flow is hypothetical and is vastly simplified. There is no reason to expect the savings to be the same each year, although there are some common financial parameters, such as the accounting rate of return and annual equivalent cost, which have to assume this. Also, the project ends after five years.

The benefit of a cost saving project is the difference in cost between achieving a particular endpoint by the new means compared with the current.

Another important fact about the cash flow of a cost saving project is that it should now cost less to achieve a particular endpoint. The baseline is the route by which the product or intermediate is currently made.

Payback

The easiest financial parameter to calculate is simple payback. This is defined as the capital cost divided by the average annual savings.

$$\text{Payback} = \frac{\text{Capital cost}}{\text{Average annual savings}}$$

In the above example:

$$\text{Payback} = \frac{50{,}000}{30{,}000} = 1.66 \text{ years}$$

As stated earlier, the savings from a project may not be the same every year. For example, the purchase and installation of a major piece of energy saving equipment, such as a new boiler, can take a year or more. As a result, only part, if any, of the potential savings will occur in the first year. So a more useful definition of payback is:

> The payback period is the time it takes for the cumulative savings to equal the project cost (i.e. when do we get our money back?)

Payback has some obvious attractions as a financial parameter:

- it is easy to calculate;
- it is interpreted in tangible terms, i.e. years;
- it does not require any assumptions about the project in terms of timing, lifetime or interest rates.

However, there are some very severe disadvantages to payback:

- it takes no account of any savings after the payback period;
- it takes no account of the residual value in the capital asset;
- it takes no account of the time value of money.

Some people make a decision to invest based on payback calculations, borrow the money and then find that the actual payback period is much longer. Payback can be misleading unless the cost of borrowing the money is included in the project costs.

It is important to include the cost of borrowing when calculating the payback period.

Payback is however a useful screening method. For example, a project with a payback of a few months clearly warrants a closer look, while a payback of ten years for a project with known costs and benefits clearly stands little chance of receiving funding.

Properly calculated payback, with precisely and accurately determined costs and benefits, does provide two important measures:

- it measures liquidity - the time it takes before the net cash flow for the project is in surplus and therefore not a drain on the company's funds;
- it helps the decision maker to assess financial risk.

Risk in this sense is very different from the engineer's idea of risk. The financial manager ordinarily has no concept of physical risk, other than in the context of insurance.

Financial risk usually means the exposure of the project to factors outside the immediate control of the organisation, such as interest rates, the demand for its products and changes in the market place. If a project has a short payback, then it will cover its costs within a time scale over which these factors can probably be forecast with some confidence. If the project has a long payback, it could be exposed to the threat of change in these factors over the longer term.

Factors outside the control of the organisation, such as interest rates, may be forecast more accurately over a short period than over a long one: therefore, projects with a long payback period are more exposed to financial risk.

Undiscounted Financial Analysis

There are four other commonly used financial parameters which are based on undiscounted cash flow:

- gross return on capital;
- net return on capital;
- gross annual average rate of return;
- net annual average rate of return.

The easiest way for engineers and non-financial managers to understand these terms is to remember that 'return on' means divide by, 'gross' means that capital costs have not been deducted while 'net' means that they have, and 'average annual rate of' means division by the lifetime of the project. These values are usually expressed as a percentage. Thus:

- the ***gross return on capital*** is the total benefit derived from the project over its lifetime divided by the capital costs, and expressed as a percentage;
- the ***net return on capital*** is the total benefit from the project over its lifetime less the capital cost, divided by the capital cost, and expressed as a percentage;
- the ***gross annual average rate of return*** is the gross return on capital divided by the project lifetime;
- the ***net annual average rate of return*** is the net return on capital divided by the project lifetime.

All these parameters are useful because they take into account the earnings after the project has paid back its capital cost, which payback does not.

When the project life has not been agreed, a qualifying statement might be made in the annual rate of return, such as ‘over five years’.

The decision to invest in a project then depends on the organisation’s current objectives. If the organisation needs to earn money in the short term (e.g. within three years), it will look at the contribution from each project over a lifetime of three years.

Example

		£
Year	0	(50,000)
	1	30,000
	2	30,000
	3	30,000
	4	30,000
	5	30,000
Total gross revenue		150,000
less captial		(50,000)
Total net revenue		100,000

Gross return on captial $\frac{150,000}{50,000} \times 100 = 300\%$

Net return on captial $\frac{100,000}{50,000} \times 100 = 200\%$

Average gross annual rate of return $= \frac{300\%}{5} = 60\%$

Average net annual rate of return $= \frac{200\%}{5} = 40\%$

Shareholders may expect a certain return (say 20%) on their investment in the company. If senior management invest capital in projects offering lower return than 20%, shareholders may take their money elsewhere.

Static financial measures, which do not take account of the effect of time on the value of money, are best applied to projects with short lifetimes. Since most energy projects have long lifetimes, discounting should be used to take this into account.

Financial analysis of the cash flow helps senior management decide which project is a good investment to make. All the financial measures described so far are static, i.e. they do not account for the effect of time on the value of money by assuming that any income in the future is worth the same as the equivalent income today. Static measures, as described above, are best applied to projects with short lifetimes, because the results of the evaluation of such projects will not be significantly affected by time.

Discounting

Most energy projects will have long lifetimes and may require large investments, so it is important for the time value of money to be taken into account during the project evaluations. This is done by discounting.

(This is not the same as allowing for inflation; economic evaluation need not be affected by inflation, as explained under *Inflation*, later in this Section.)

Discounting allows the time value of money to be taken into account. Given the choice between £1 next year or £1 today, most people, including shareholders, would choose to take it now, because people know that money loses value with time.

In financial appraisal, the time value of money is allowed for by applying a discount factor to costs and earnings in future years to reflect their diminished value in the year of the transaction relative to today.

Discounted cash flow

Discounting can be applied to all of the parameters described so far, i.e. payback and the four measures of return on investment. This is done by discounting the cash flow before calculating any of the parameters. To calculate a discounted cash flow, the net cash inflow or outflow in each year of the project is multiplied by a discount factor for that year, to give the Present Value of the revenue in that year.

The process of discounting therefore overcomes one of the main disadvantages of these ‘static’ measures, i.e. that they take no account of the effect of time on the value of money.

Discounting is, however, most often applied to a modified net return on investment to produce a parameter called the ***Net Present Value (NPV).***

Net Present Value

To calculate a discounted cash flow, the net cash inflow or outflow in each year into the project is multiplied by a discount factor for that year. This is often given by the formula:

$$\text{Discount factor} = \frac{1}{(1 + r)^n}$$

where r is the discount rate and n the number of years.

Most people, however, look the value up in a table. A selection of values is given in Table 2. A full list is given in Appendix A, Table 3.

When using discount factor tables it is important to use the correct value. Usually these tables are headed ‘Net Present Value of $1’ or ‘Net Present Value of £1’. In fact, the values are pure numbers and it is of no consequence whether the table is presented in dollars or sterling. However, there is another table which is often given in textbooks entitled the ‘Present Value of £1 or $1 Received Annually for *n* Years’ (see Appendix A, Table 4). This is quite different and is used for a different purpose (see *Annual Equivalent Net Benefit* in this section) and should not be confused with NPV.

The discounted cash flow is obtained by multiplying the revenue by the appropriate discount factor, looked up in a table. This gives what is called the ***Present Value*** of the revenue in that year.

Table 2 Net Present Value (NPV) of $1 or £1

Years into project	**Discount rate %**			
	5	**10**	**15**	**20**
1	0.952	0.909	0.870	0.833
2	0.907	0.826	0.756	0.694
3	0.864	0.751	0.658	0.579
4	0.823	0.683	0.572	0.482
5	0.784	0.621	0.497	0.402
6	0.746	0.564	0.432	0.335
7	0.711	0.513	0.376	0.279
8	0.677	0.467	0.327	0.233
9	0.645	0.424	0.284	0.194
10	0.614	0.386	0.247	0.162

Adding up the Present Value over the duration of the project gives a number which would be called the ***Gross Present Value*** of the project. In fact, this term is not normally used, because it is usual to go directly to the next step and deduct the capital cost to obtain the ***Net Present Value*** (NPV).

Example calculation of NPV

		Revenue (£)	Discount factor (10%)	£
Year	0	(50,000)		
	1	30,000	0.909	27,270
	2	30,000	0.826	24,780
	3	30,000	0.751	22,530
	4	30,000	0.683	20,490
	5	30,000	0.621	18,630
	Gross present value			113,700
	Less capital cost			50,000
∴	**NPV**			**63,700**

The NPV indicates the amount of income the project will earn for the business over its expected lifetime, in today's money.

The Net Present Value is a financial parameter of particular interest to the financial manager, because it indicates the amount that the project will earn for the business over its expected lifetime in today's money.

It is should be noted that the precise figure will depend on the number of significant figures used in the discount present value multipliers. Either three or four significant figures are commonly used, though this depends on what is acceptable to a particular organisation. Energy managers are advised to obtain a copy of the appropriate tables from their finance manager.

NPV/Capital Ratio

Another useful parameter is the ratio of NPV to required capital, which takes into account the size of project; the higher the ratio the better the project is as an investment. Organisations usually rank investments according to this ratio, adjusting the order at the appropriate point to make up the capital budget.

Example

A business has identified six possible projects with capital costs and NPVs as given below.

	Capital cost (£)	NPV (£)	NPV/Capital
A	130,000	54,600	0.42
B	30,000	17,100	0.57
C	210,000	109,200	0.52
D	28,000	9,240	0.33
E	34,000	12,580	0.37
F	82,000	31,980	0.39

In order these are:

	NPV/Capital	Capital Cost (£)	Cumulative Cost (£)
B	0.57	30,000	30,000
C	0.52	210,000	240,000
A	0.42	130,000	370,000
F	0.39	82,000	452,000
E	0.37	34,000	486,000
D	0.33	28,000	514,000

Suppose the available capital were £400,000. Then projects B,C and A would be accepted and F would not be funded as the total investment would exceed the capital available. D would receive a new higher priority because it could just be accommodated in the available capital budget remaining after B, C and A were funded.

This is important in the context of the usual practice of providing a cut-off for payback. In this procedure, there is a place for small projects which do not meet the payback criterion that would guarantee funding. Even if the company uses payback as the main selection criterion, this procedure can justify putting small proposals (in the context of the organisation as a whole) forward, including those that do not meet the maximum payback.

Selecting Discount Rates

The selection of the discount rate should also be considered. It is commonly agreed that financial appraisal is incomplete unless the changes in the value of money with time are taken into account. Discounting is designed to take account of the time value of money in what amounts to a forecast. Conventionally, a uniform discount rate is applied in financial appraisal.

The fact still remains that £30,000 is worth more today than £30,000 received in several years time, not least because this money could be invested. From the investor's perspective, the sum invested grows with time; from the point of view of the borrower, the change in value of this capital sum is determined by the interest rate or ***cost of capital.*** In recent years, textbook discussions of discounting have gradually changed from using the term discount rate to using 'cost of capital', as though they are interchangeable. Strictly speaking they are not, but they produce the same number.

There still remains the question of which rate to use for the cost of capital. There is no one interest rate, and interest rates are subject to very wide variations with time. The choice of discount rate tends to vary according to the nature of the organisation and the commercial environment in which it exists; for instance, whether it relates the choice of discount rate to the cost of borrowing money, or the value of bank deposits, or the need to generate capital. It is often a composite figure which represents the average cost of capital weighted according to the sources, e.g. equity, loans, debentures 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. Large organisations often simply do the same and issue a similar figure of their own. While discounting is considered an important procedure, it is very arbitrary in many organisations.

No single discount rate can be applied in all cases; the rate chosen tends to vary according to the commercial environment of the organisation.

The energy manager simply has to accept the organisation's judgement on the costs of obtaining capital. While this is a minor consideration for energy saving projects, energy managers can signal their serious intentions about investment in energy efficiency by asking the organisation's finance manager what 'costs of capital' they should assume.

Internal Rate of Return

Some organisations have no particular policy on discount rates. In this case it is not possible to calculate a straight NPV. However, there is an alternative called the ***Internal Rate of Return*** (IRR) for the project. This represents the rate of interest that money would have to earn outside or elsewhere in the organisation to be a better investment. The higher the IRR, the better the project.

IRR is defined as the discount rate at which the Net Present Value of the project reduces to zero. There is no direct way of calculating IRR. The NPV is calculated for different interest rates and the interest rate at which the NPV becomes zero is determined by successive approximations.

The IRR of a project represents the rate of interest that money would have to earn outside or elsewhere in the organisation to be a better investment.

As with NPV, the IRR can help assess ways of financing the project. 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 and still provide profit.

Example

Discount Rate (%)	10	15	20	25	30	35
Gross Present Value	110,567	94,570	80,678	68,642	58,235	49,250
Less Capital Cost	50,000	50,000	50,000	50,000	50,000	50,000
NPV	60,567	44,570	30,678	18,642	8,235	-750

The interest rate is found by interpolating to the point at which the NPV goes from positive to negative. In this example, this point is reached between 30% and 35%, and at approximately one tenth of this interval from 35%. The IRR would therefore be quoted as 34.5% (approximately). Alternatively, it can be presented graphically as in Fig 6.

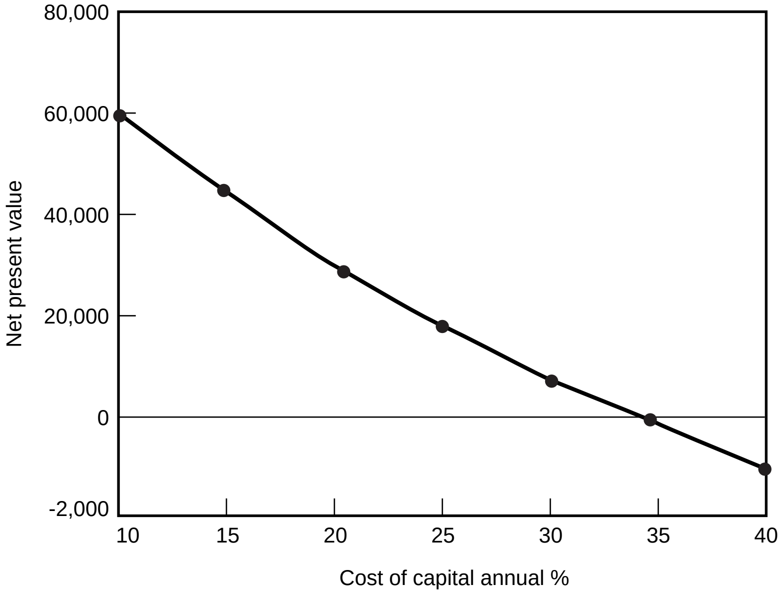

Fig 6 Graphical interpolation of IRR

Annual Equivalent Net Benefit

The Annual Equivalent Net Benefit is a device used by finance managers to transform the Net Present Value (NPV) into a form of annual net benefit over the lifetime of the project. The NPV is the amount by which the benefits at present value exceed the costs of the project. The Annual Equivalent Net Benefit is the average amount by which the project exceeds this in each year of the project's lifetime. It is particularly useful for looking at projects with greatly differing lifetimes.

The Annual Equivalent Net Benefit is calculated by dividing the Net Present Value by the present value of £1 received annually over the lifetime of the project. This value is usually obtained from a table (see Appendix A, Table 4). If the Annual Equivalent Net Benefit is negative it becomes the Annual Equivalent Cost.

Using the example NPV (Page 22), at 10% over 5 years:

$$\text{Annual Equivalent Net Benefit} = \frac{£63{,}700}{3.79} = £16{,}807$$

(3.79 is the cumulative value of £1/year, discounted over 5 years)

Inflation

Up to now, the methods of economic evaluation have been described with prices assumed to be constant. In reality, prices tend to rise over time: this effect is inflation. The inflation rate measures the rate at which the price of a representative selection of products is rising. It is also the rate at which money loses its spending power.

General inflation affects the price of all products in a similar way, and so in an economic evaluation the future costs and the value of the savings are similarly increased. The following example shows that these effects of inflation will cancel one another out.

The financial markets will include the expected rate of inflation within the market interest rate. The precise formula is:

$$^{i}\mathrm{MKT} = (1 + {}^{i}\mathrm{REAL}) \text{ x } (1 + {}^{i}\mathrm{INF})$$

where:

- $^{i}\mathrm{MKT}$ is the market interest rate;
- $^{i}\mathrm{REAL}$ is the actual cost of capital;
- $^{i}\mathrm{INF}$ is the expected rate of inflation.

Example

With no inflation: ***£***

Costs = (3,000)
Savings = 5,000
Cash flow = 2,000

Discount factor for the capital cost of 10% = $\frac{1}{(1 + 0.1)}$

Present value = $2{,}000 \text{ x } \frac{1}{(1 + 0.1)} = \frac{2{,}000}{1.1}$

With 5% inflation:

Costs = (3,000) x 1.05 = (3,150)

Savings = 5,000 x 1.05 = 5,250

Cash flow = 2,100

= 2,000 x 1.05

Cost of capital of 10% with 5% inflation:

Market interest rate = (1.10 x 1.05) - 1
= 0.155
= 15.5%

Discount factor (15.5%) = $\frac{1}{(1 = 0.155)}$

= $\frac{1}{(1.1 \text{ x } 1.05)}$

Present Value = $(2{,}000 \text{ x } 1.05) \text{ x } \frac{1}{(1.1 \text{ x } 1.05)}$

= $\frac{2{,}000}{1.1}$

It can also be assumed that inflation will affect all competing project proposals equally, so a lot of work can be saved if all cash flows are calculated in real terms, i.e. excluding inflation. This avoids having to predict future inflation rates and adding more uncertainty to what are already estimated cash flow figures.

Energy Prices

Economic evaluation should be done in real terms if inflation is expected to affect all prices equally. There may, however, be times when some prices are likely to change relative to others, particularly when dealing with the price of energy. In these cases, the evaluation should take account of the price differential; all other prices can be kept constant.

If energy prices are expected to rise by more than general inflation (as shown in the example), this will increase the value of the project's energy savings. The 'bad news' of large energy price increases being announced will therefore make your energy project a more attractive investment. This point is important when analysing the potential risk in the project: the 'worst case' of likely energy price increases (e.g. 25%) will contribute to the 'optimistic' scenario because the value of the savings will be even higher.

Example of the effect of inflation on energy savings:

Inflation is expected to be 5% per year for the next three years. Gas prices are to be increased by 15% for the next three years.

The energy savings from the project will be worth at today's prices (£):

	Electricity	Gas
Year 1	20,000	50,000
Year 2	40,000	55,000
Year 3	40,000	70,000

Economic evaluation needs to take into the effect of energy prices increasing at a rate greater than inflation. The price differential between gas, and other costs and savings in the project, is 10% per year. This means that the values of the gas savings need to be increased by 10%, compounded from year to year:

Year 1 50,000 x (1.10) = 55,000

Year 2 55,000 x $(1.10)^2$ = 67,000

Year 3 70,000 x $(1.10)^3$ = 93,000

The cash flow can be then be calculated

Project Lifetime

A key element that has not yet been considered is the project lifetime. 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. Project lifetime plays a pivotal role in financial appraisal; decisions about lifetime are likely to be at least as important as discount rate considerations. Project lifetime will be discussed in more detail in Section 9.

The more years included in the cash flow projection, the higher the NPV or IRR.

The Relative Merits of Different Financial Parameters

The relative merits of NPV, IRR and Annual Equivalent Cost are often discussed, as they occasionally rank projects differently. There is a technical reason for preferring NPV, known as the ***re-investment assumption;*** i.e. funds generated by a project are re-investable at the interest rate used for borrowing the capital and would be so invested (which is what the capital return budget is designed to ensure).

In recent years, two other approaches to financial appraisal have been introduced, specifically in the context of the investment appraisal of technology:

- ***Total Lifetime Costing,*** which was introduced in the mid-1970s, was intended to highlight the benefits of lower equipment running costs over the total life. This idea never really gained acceptance because the lifetime of equipment is not appropriate to its economic appraisal;
- The ***Capital Back Method*** was first advocated for the appraisal of robots in order to take account of their particular flexibility. After a robot, or possibly an energy saving device, has outlived its usefulness in its original application, it is still an asset which could be transferred to another application in the future.

The use of capital back overcomes the disadvantage that payback does not take account of the residual value of assets in applications where this is a premium. The result is a period in years which is generally somewhat shorter than payback. It has not yet become universally accepted by financial managers.

Sensitivity Analysis

During the evaluation of a project, values will have to be assumed for some of the project's unknown aspects. These include factors outside management control, such as the cost of fuel or materials, and factors partially within management control, including current production costs, timing and production rate. Sensitivity analysis involves testing the assumptions used in deriving the cash flow to determine the impact of an assumption that proves to be erroneous.

For each area of assumption, there will be a range of plausible values for the parameter concerned. The financial evaluation of the project is not complete until financial parameters have also been calculated using the limits of these assumptions. This allows the assumptions which most critically affect the viability of the project to be determined. A view can then be taken on how likely it is that these extreme values will occur. The consequent risk to the outcome of the project can be assessed, and the possibility of designing out the worst of these critical assumptions can be considered (see Section 8).

Sensitivity analysis allows you to test the assumptions used in deriving the cash flow to find out what the impact of an incorrect assumption would be.

7

EVALUATING COSTS AND BENEFITS

Differences between projects brought out by different financial parameters only reflect the weight each gives to different features of the cash flow - the costs and benefits in each year and the project lifetime. Indeed, the magnitude and time profile of the cash flow are critical factors, and the result of the financial appraisal of a capital project hinges far more on the proper quantification of the components of the cash flow statement than on any of subsequent treatments such as discounting.

A common fault in the financial appraisal of energy saving projects is the omission of secondary benefits and costs.

A common deficiency in the appraisal of energy saving projects is that not all the benefits and/or not all of the costs are taken into account. Projects are often only evaluated in terms of the costs of the main items of plant, with little attention being given to installation costs or benefits other than straight energy cost reductions, such as improvements in the product quality, changes in production rate and so on.

It is essential that all the main areas of cost and benefit are included. It may be that full evaluation is difficult because of inadequate information, but the unknown should not simply be ignored. Some kind of estimate, however crude, should be made for all areas of possible benefit or cost. The importance of any error introduced by such estimates will become clear when the sensitivities are considered.

Evaluating Costs

Levels of Estimate

Financial appraisal is usually introduced when the project costs are only estimated. Depending on how far the project has progressed, the estimate will have different measures of accuracy. The *Guide to Capital Cost Estimating* produced by the Institution of Chemical Engineers (IChemE) identifies five levels of estimate:

- ***Order of Magnitude*** (‘ballpark’ or ‘guesstimate’). As its name suggests, this is a very crude estimate derived from an inspired guess. The inspiration often comes from a similar project which someone else has undertaken and which has known costs, perhaps published in a Best Practice Case Study, PEP or GEM Award Scheme case study, or reported in the trade press;

- ***Study Estimate*** (‘evaluation’ or ‘predesign’ estimate). This will approximately quantify the costs of the major components, perhaps by telephone calls to possible suppliers, ‘rule of thumb’ calculations, and using blanket figures for installation and civil engineering works;

- ***Authorisation Estimate*** (‘sanction’ or ‘funding’ estimate). At this stage most of the items of cost are known to a sufficient level of accuracy for the project to be submitted for approval by the financial management. The technical feasibility of the project will have been established, the components identified and costed, and the scale of assembly and installation work established;

- ***Definitive Estimate*** (‘control’ estimate). All outgoings on the project and the timing of those costs will have been established to an extent that the progress of the project could be measured from the costs incurred at any time. The price at which suppliers will deliver components or carry out work will have been agreed, and any major designs or other alterations since the preliminary estimate will have been incorporated. The only margins allowed are those for costs that cannot be established until an appropriate point in the physical installation of the project is reached;

- ***Detailed Estimate*** ('tender'). This sets an exact amount for the authorisation of payment of invoices on the project. It is in most cases the final cost. So far as possible, all the causes of cost outside those defined in the estimate have been reduced to zero.

The effort required to arrive at the estimated cost figure for each of these five levels differs enormously. One way of judging this is by looking at what proportion of the total cost of the project might be incurred in producing these estimates. This varies from project to project.

Example

The time taken for a £100,000 project might be:

Level of Estimate	Time Taken
Order of magnitude	a couple of hours
Study estimate	a couple of days
Authorisation estimate	two or three more days
Definitive estimate	a week more
Detailed estimate	more than a week more

The Authorisation Estimate is the most critical, because it is at this stage that the decision to proceed with the project is taken. Any benefits that have not been identified by this stage are unlikely to be discovered, because the next stage will not happen. The converse is not true; capital costs not identified by this stage will favour the project. As a consequence it might be approved, but these unidentified costs will subsequently come to light.

Any benefits that have not been discovered at the Authorisation Estimates stage are unlikely to be discovered, because the next stage will not happen.

Most smaller industrial projects tend not to undergo the final two stages of estimating unless tenders are involved or management of the project itself demands it. This can mean that projects are not optimised in terms of cost and benefit, and some viable projects are overlooked or other projects are given a false priority. Project costs often rise once sanction is given and work commences, though the extent of this varies from project to project. Where this is foreseeable, it can also affect project priorities.

Typical areas of cost which are often overlooked or greatly underestimated include:

- site preparation;
- structural alterations to building;
- small fittings, e.g. instrument flanges, valves, brackets, traps, orifice plates, etc;
- plant hire;
- instrumentation;
- wiring and cable laying;
- insulation;
- making good.

Evaluating Benefits

The benefits that can accrue from a project are many and varied. It is important to recognise those which can be directly quantified in money terms, such as savings in raw materials, fuel savings, reduced labour, etc, and those which may be only indirectly quantifiable, including improved product quality or marketability, and which might produce a benefit in terms of increased sales. There may also be other benefits which are not quantifiable at all in money terms, but may have a bearing on the project. These include aspects such as improved working conditions and environmental benefits.

The benefits likely to arise from energy efficiency investments include:

- lower energy consumption;
- lower fuel costs;
- lower water costs;
- lower labour requirements;
- reduced overtime;
- reduced maintenance;
- fewer rejects;
- reduced product finishing;
- improved throughput rate;
- savings in floorspace;
- improved scheduling;
- improved quality;
- improved product specification;
- improved product range.

Improved Energy Efficiency

There are three basic classes of energy saving measure that are applied to processes:

- modification of existing plant by:
  - load rationalisation;
  - part replacement;
  - add-on parts.
- replacement of existing plant;
- new processes.

Load rationalisation can be applied to plant such as boilers, compressors, kilns, furnaces, i.e. anything where the energy per unit of output varies with output (obtained by dividing the energy use at a given output by that output). This will apply to any plant with a fixed consumption at zero output, as shown in Fig 4 (Page 12). The investment is usually made in fitting new control systems.

Part replacement can produce significant savings where the plant has been in place for some time and technical advances in the design or operation of particular components can improve performance, for example. burners, furnace linings, fans, compressors and heat transfer surfaces.

Add-on parts comprise the numerous new devices developed in recent years specifically to reduce energy use such as controls, zirconia/air cell combustion controls, heat recovery devices and so on.

Replacement of existing plant implies the replacement of an established plant/process by one of a similar kind which is simply more efficient or uses a more economic fuel, e.g. 6-effect for 2-, 3- or 4-effect evaporation, mechanical vapour recompression evaporation and continuous rather than batch processing.

New processes are those where drying, joining, melting, heating and so on is achieved by different means. This includes di-electric heating, direct resistance heating, radio-frequency heating, dehumidifier drying and ultraviolet curing.

Energy savings resulting from part replacement, adding on parts or other modifications have to be estimated by reference to the existing consumption pattern and throughput. Many process changes affect both the fixed and variable components of energy use, and can only be quantified reliably by examining the impact of the measure on the relationship between energy and production, shown in Fig 4.

The energy consumption of the existing process can be characterised from the historical consumption records and refined using CUSUM. The use of CUSUM is described in more detail in *Energy Monitoring and Target Setting* (Harris). This should resolve production related and unrelated components of consumption. The claims made for the energy savings achievable by the proposed measure should be consistent with these. The amount of scatter of the available data may indicate that the energy use pattern is somewhat uncertain; this is significant. If the present pattern of energy consumption cannot be characterised accurately from the records, then this has to be regarded as an uncertainty which will be present in the estimate of savings as the difference between this value and the estimates of energy use after the modification.

Survey reports which present very precise figures for energy saving may give a false sense of confidence in the savings that can be made; there are substantial uncertainties associated with some measurements. If this is the case, compare the figures with historical data about the existing plant, to confirm their relevance.

In many cases, the figures for energy savings for measures identified in consultants' or engineers' survey reports are presented so precisely that a false sense of confidence in the savings which will accrue is instilled. For example, the measurements of gas flows in flues which form the basis of estimates of recoverable heat often have very substantial uncertainties associated with them. These could introduce errors which cause a project to proceed when it should not or alternatively, prevent a project from going ahead when it should. In such circumstances, it is advisable to examine the pattern established from the history of the plant. Only when new processes or new plant are involved can the energy changes be so dramatic that such an analysis is no longer relevant.

In cases where processes are currently designed to use heat, the same result can often be achieved far more efficiently using work instead. One example is evaporation using mechanical vapour recompression, instead of heat. Another is drying where it is much more energy efficient to use a dehumidifier to remove water from the product, rather than conventional dryers which evaporate the water from the product without recovering it.

Most heat-based processes seek to put heat into the product, to raise its temperature or to transform it physically, for example to partially or fully melt it, dissolve part of it, etc. The rate of heat transfer is then important. Energy savings can often result when the rate of heat transfer results in less material being heated or when fixed losses are reduced.

Electricity can transfer energy by mechanisms not available to other fuels, i.e. direct resistance, microwaves, inductance and di-electric heating. The advantages of these mechanisms compared with traditional fuel-based heating mechanisms include:

- heat can be deposited at very high rates;
- parts of the body can be heated selectively (this is often linked to the reason given above).

Improved Throughput

Improved throughput can occur as a result of reducing process times or increasing the volume which can be processed in a given time. It only has an economic benefit when all the following circumstances apply:

- where the process stage in which improved throughput is achieved was previously the stage which limited the total throughput, i.e. removing a ‘bottleneck’;
- the additional throughput can be accommodated in subsequent manufacturing stages;
- there is a market outlet for the increased throughput.

The financial benefit of improved throughput is that the fixed costs as a proportion of the unit costs are spread over a greater number of units.

Improved Quality

Many of the newer technologies that obviate the need for extensive heating of products, including ultraviolet curing, infrared heating, dehumidification, direct resistance heating and di-electric or microwave heating, can also reduce the requirement for fixed plant to operate for extended periods at high temperatures. As well as avoiding the problems this creates for the plant’s integrity, it can produce benefits in terms of product quality by, for example, a lower tendency for spoilage through dust created in the furnace, quality impairment because of breakdown and so on.

Improved quality provides benefits in one or more of the following ways:

- fewer rejects;
- reduction in downstream operations;
- increased sales;
- improved selling price.

A quality improvement to an established product is a useful vehicle for introducing a price increase - a proportion of any price increase resulting from a project should be counted as a financial benefit.

Reducing the number of rejects saves variable costs equivalent to all the stages of production up to the point of rejection (less the cost of raw materials if rejected material is normally recycled) proportional to the fraction of rejects.

Examples of downstream processing that are affected include the deburring of castings, annealing of metal and ceramic parts, and drying. The costs of these processes from the modified stage onwards are saved.

Examples of the quality improvements which can have an impact in the market are improvements to the texture of textile fabrics dried by dehumidification or di-electric heating rather than direct heating, improved dimensional stability and tolerances of many products, and improved specification of alloys.

Increased sales as a result of quality improvements are difficult to quantify, and are impossible to estimate in advance because it is difficult to directly attribute sales volume to quality. Increased sales through quality improvements are best treated as a non-financial benefit. However, a quality improvement to an established product is a useful vehicle for introducing a price increase, and a proportion of any price increase resulting from a project should be counted as a financial benefit.

Improved Scheduling

Improved production scheduling does not produce a direct financially quantifiable benefit, but it produces secondary benefits. These include:

- reduced electricity costs through tariff advantages or as an enabling mechanism toward Pool related contracts;
- reduced labour costs through a reduction in unsocial hours payments or reduced staffing levels;
- increased production capacity, subject to the previously mentioned ability to utilise it;
- improved delivery times which can lead to increased sales or retained business;
- improved stock/inventory control.

The first two benefits are directly quantifiable, while the third has already been considered. The last two are difficult to quantify, although techniques to ascribe a financial value to them are likely to be developed as they are becoming increasingly important in the financial justification of improved maintenance systems, and 'Just In Time' and 'Activity Based Costing' production systems.

Lower Materials Costs

Some specific processes can achieve lower materials costs, for example reducing the use of additives in non-ferrous metal casting when certain kinds of melting processes are utilised. Other ways in which materials costs can be reduced include:

- allowing cheaper materials to be used in the process;
- reducing the amount of material required for a given output (this may also reduce waste and offcuts).

Given the costs of the materials, all these are financially quantifiable provided the reductions in physical quantities are known, and can be estimated or determined in trials.

Reduced Maintenance

A recent study of maintenance costs in industry found 30% of non-material costs are maintenance-related. This means that capacity limitations, lost material and rejects add up to approximately one-third of the costs of production.

Improving maintenance produces both direct and indirect benefits. Direct benefits, which can be readily evaluated, include reduced manpower costs, materials and spares for maintenance. Indirect benefits from maintenance are usually reflected in increased output, improved quality, improved production scheduling and reduced waste.

Other manufacturing costs that may be reduced by an energy saving project include:

- water;
- compressed air;
- chilling;
- waste disposal.

Reduced Service Costs

Apart from electricity, other important manufacturing service costs are water, compressed air, chilling and waste disposal.

Water is an important cost. At a cost of 40 p/m^3 to buy and dispose of, water at 41°C or less is possibly more valuable as water than as heat (based on fuel at 1 p/kWh). An important benefit of improved energy efficiency is often a reduction in the requirement for water cooling. Water costs can usually be determined directly from the costs prevailing at the site.

In most factories, the full costs of supplying compressed air are difficult to determine, mainly because air compressors are rarely metered. Measurement is only easy if a large proportion of the compressed air load is affected by the project.

Product Improvements

Product improvements can be classified in four main categories:

- updating the product;
- improved product specification;
- enhancements to the product range;
- improved product performance.

Updating a product may be necessary to maintain its market position. As industry demands increasingly high specifications for components, the ability to meet higher specifications commands a premium in the selling price. This is important in both retaining and extending markets. There are various ways in which this can be achieved including the use of radio frequency welding of plastics instead of machine-sewn seams and higher specifications for castings.

Savings in Floorspace

Occasionally savings in floorspace can provide financially quantifiable benefits, although these are rarely important because floorspace does not constitute a large part of manufacturing costs. Savings in floorspace are normally only quantifiable when they result either from the disposal of space through renting or selling, or present opportunities for business expansion on the released space. In the latter circumstances, the savings in floorspace are assessed in terms of the rent received, and the costs of heating and maintaining the released space.

Inventory Savings

Projects which give rise to savings on inventories that constitute a significant proportion of the benefits are not very common. One example is the savings in starch trays in the sugar confectionery industry when dehumidifiers are used for drying. Others include oven tins in the baking industry and slip casting moulds in the pottery industry. Inventory replacement is taken as a benefit equivalent to its annual replacement cost.

8

TESTING SENSITIVITIES

Assumptions are always likely to be made when a project is evaluated. Sensitivity analysis is the process that tests how the various assumptions affect the cash flow, and determines the impact on the project if the assumptions turn out to be erroneous.

For each assumption, there will be a range of plausible values for the parameter concerned. Assumptions are not only about magnitude, but often contain an implicit reference to timing. Capital costs usually assume that all the cost is incurred at the beginning of the project. Benefits, on the other hand, may not all accrue at once, but take time to work through.

Sensitivity analysis allows you to test how the assumptions you make about a project will affect the cash flow.

Sensitivity Testing of Costs

The first step in sensitivity analysis is to identify those components of the capital costs for which there could be a margin of error and to identify the likely impacts. This is best explained by use of the example on page 36.

Errors in capital costs are usually fairly small and estimable. By the time a project reaches the approval stage, the residual error should have been reduced to an acceptable level. There is one significant exception - when a substantial project appears to be marginal in terms of payback but there is a possibility of significant cost reduction becoming apparent at the detailed design stage. Such cases are fairly common in the energy efficiency field, for example heat recovery (especially where it involves heat pumps), the addition of sophisticated controls, and boiler house decentralisation. It is then important to alert senior management to the opportunities presented by such a project and to gain high level approval for the necessary commitment in additional time and resources needed to examine the project more closely. This has certain other advantages. When the project returns for a final decision, more will be known about it; such projects are often received with greater interest.

Adding an element to allow for ‘contingencies’ is usually prejudicial to a project, because it only adds to the costs and not to the benefits.

Sensitivity Testing of Benefits

Errors in the estimates of benefits can arise from two main sources:

- errors in the estimation of current production costs;
- errors in the estimate of production costs after the project is implemented.

Since the benefits of a project are often obtained by subtracting total production costs arising during the project from the costs of production by some existing means, the net benefit often turns out to be the difference between two large numbers. Errors in estimating the costs by either route are then magnified compared to the errors in the two sets of costs. Large uncertainties should only be disregarded if they affect both sets of costs equally.

Example

The earlier example had capital costs of £50,000 and benefits of £30,000 in each subsequent year. Suppose that the project involves a waste-heat recovery system on a kiln.

The approval estimate for the capital costs comprises:

Item	Description	Capital Costs
1.	Heat exchanger (manufacturer's quote)	£14,000
2.	Ductwork (supplier's estimate based on specification supplied)	£22,100
3.	Modifications to building (estimate)	£5,500
4.	Site clearance (estimate)	£2,000
5.	Controls (quotation)	£3,600
6.	Motors, pumps, traps, etc. (budget estimate)	£2,800
	TOTAL	**£50,000**

Item	Comments	Price Variation min	Price Variation max
1.	A fixed price quote with no error.	–	
2.	Could vary by ±15%.	-£3,315	+£3,315
3.	Must be greater than zero. Assume a bottom figure of £3,000, and a possible need to remove an extra wall and support a floor giving a top figure of £7,000.	-£2,500	+£1,500
4.	A fixed price quote from a demolition company.	–	
5.	Will vary according to the degree of sophistication; but $^{3}/_{4}$ of the quote is essential, and the remainder (£900) is an estimate which might double in cost.	-£900	+£1,800
6.	A budget estimate for which detailed designs are awaited. This could be subject to an error of ±25%.	-£700	+£700
	Total Potential Error	**-£7,415**	**+£7,315**

The total potential error is thus +14.6% or -14.8%, with two items comprising 70 - 80% of the total error. This is normally acceptable in an Authorisation Estimate.

The accounting procedures adopted by most companies often do not allow the true costs of the existing process to be known with certainty. This is particularly true for energy costs because most factory metering systems tend to be unable to apportion energy costs. It is also common for energy to be included with a number of other costs and considered as an overhead. Any errors are likely to underestimate variable costs and enhance fixed costs. This leads, in particular, to errors when different production capacities are concerned.

Very careful analysis of all estimates of benefit is therefore needed in order to establish likely errors.

Energy Prices

Energy Prices are often subject to quite large variations over the payback period, which affects the quantification of energy savings. In projects where the main benefit derives from a fuel change, this is likely to create a major uncertainty. (See Section 6)

Energy prices should not simply be allowed to inflate. In the long term, oil prices will increase in real terms, but over the past two decades most energy prices have fluctuated erratically. The intervals between the highs and lows have been as little as a year, and this is less than the lifetime of most capital projects.

Production Rate Changes

Changes in the rate of production affect a project in different ways, depending on whether all the assumptions are contained within the project itself or whether other factors should be taken into account.

The impact of a change in production rate will not necessarily be uniform throughout the production system, but may only affect the stage being modified.

The immediate impact of a change in production rate is normally to spread the fixed costs over a larger volume of production and therefore reduce the average unit cost.

However, the impact is not necessarily uniform throughout the production system as it may only affect the stage being modified. Firstly, it must be considered whether the additional throughput from the modified stage can be accommodated in subsequent manufacturing stages. While it is fairly easy to identify the process stage that governs overall production rate, in practice it is often not very easy to identify the next bottleneck (once the primary one is removed), whether it will constrain output from the process being modified, and/or the costs of removing this bottleneck.

Apart from these considerations, it is commonly assumed that an investment will not affect the production rate and that the same level of market will exist for the product. However, this might not be the case. While this situation is usually covered to some extent by the payback requirement (as a measure of financial risk), it is a wise precaution to determine how robust the investment is by looking at the production costs at normal and lower production levels.

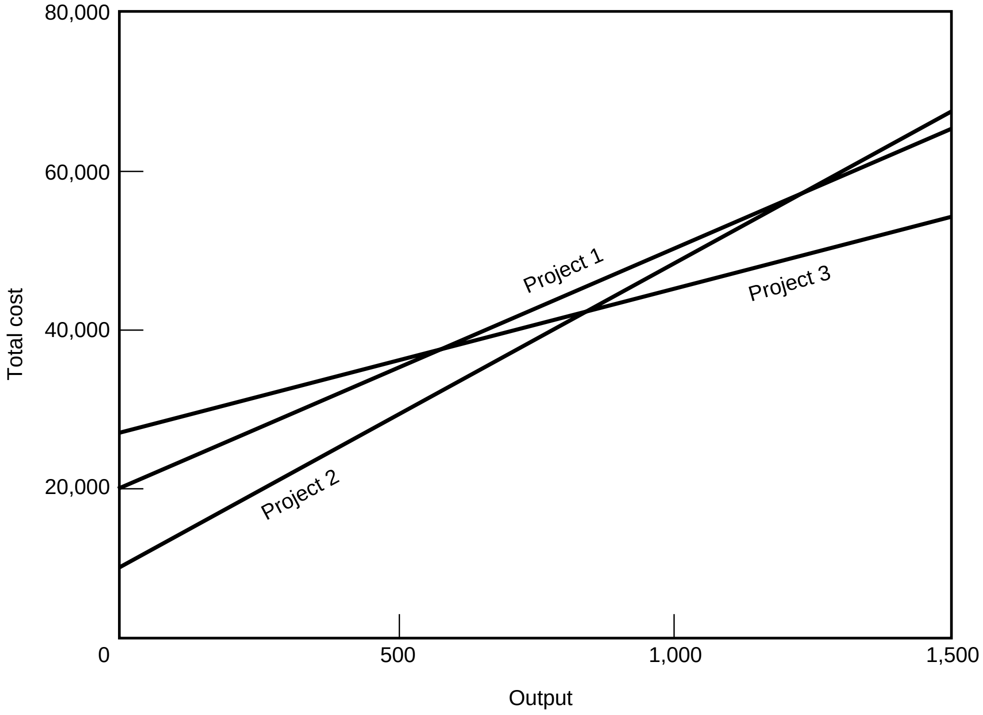

Fig 7 Sensitivity to changes in cost structure

Example

Fig 7 shows an example involving three projects.

Project 1 is the existing process, and projects 2 and 3 are two new processes, both of which impart a lower total cost at the current annual throughput of 1,000 units.

Total Annual Cost = Fixed Cost + (Annual Throughput x Variable Cost per unit)

Project	Fixed Costs	Variable Cost per unit	Total Cost	Total Cost per unit
1	£20,000	£30	£50,000	£50
2	£10,000	£38	£48,000	£48
3	£27,000	£18	£45,000	£45

Fig 7 shows that the benefits from Project 3 diminish with reduced output and improve with increased output, while the benefits from Project 2 fall with increasing production. Which project is selected would therefore depend on sales forecasts.

The consequences of individual design decisions are rarely tested in detail at the design stage. As a result, savings may be reduced because of unforeseen problems during the operation of the project.

It is also possible for investment in a project to radically change the relationship between fixed and variable costs.

Assumptions about the benefits from an improved production rate often translate into sales assumptions. It then becomes a question of when this will happen rather than whether it will. This means that allowances for errors need to be built into the time profile of the trading cash flow when evaluating sensitivities.

Design Related Sensitivities

Engineers or plant designers rarely test the consequences of individual design decisions in detail principally because it creates extra work at the design stage and the project may not be approved. The result is that projects which go ahead are often not based on optimised designs where the risks have been evaluated. The two main consequences are that savings are reduced because of unforeseen problems during the operation of the project and that greater capital costs are incurred in achieving the same end. This can result in lost opportunities because the organisation does not go ahead with projects it erroneously believes are too expensive.

Example

The design of a heat recovery system is based on the measurements of a hot gas stream obtained by sampling temperature and flow across a large duct. This gives an average temperature of 250°C. This hot gas stream is intended to be used as a heat source for a heat exchanger designed to cool the gas stream to 80°C and to heat a fresh water stream from 8°C to 75°C. This is then boosted to 100°C using heat from a boiler. The temperature efficiency of the heat exchanger required (n), a design parameter characteristic, is:

$$n = \frac{75 - 8}{250 - 80} = 0.4$$

Suppose that the source temperature of the stream from which the heat exchanger takes its heat is in fact only 235°C. As the heat exchanger characteristic remains the same, the temperature (T) achieved in the heated water will be:

$$T = [0.4 \times (235 - 80)] + 8 = 70$$

The duty required in the boiler is actually 30°C, not 25°C; and is 20% higher. The relatively small error in the measurement of the temperature of the gas stream has quite high knock-on effects.

Several aspects of the design of a project can be important in this context.

When selecting the components of a system, the designer has to choose from the range of sizes available. It is rarely possible to obtain exactly the size required, and a larger or smaller one may have to be chosen. Design compromises may also be required in order to fit equipment into the space available or to install equipment within a given time window. While such compromises are unavoidable, their consequences should be evaluated and the optimum design selected.

Designers often make sacrifices in efficiency, capacity, controllability and other factors in an effort to reduce costs. These aspects of a project are not always investigated at the approval estimate stage. Once it has been decided that a project is financially promising, the technical options should therefore be more fully investigated to ensure that the best value for money design has been approved.

9

PROJECT LIFETIME AS A VARIABLE

The one variable in the cash flow statement which has not been discussed so far is project lifetime.

Deciding the Project Lifetime

The ***economic life*** of a project is the time period over which it can be expected to yield the benefits taken into consideration in the investment proposal. It is important to understand the distinction between this and a project's physical life or its technological life.

A project's lifetime can be measured in terms of its:

- economic life;
- physical life;
- technological life.

The ***physical life*** of a project is how long the capital equipment will be usable before it becomes physically inoperative, perhaps because of a breakdown that could not be repaired at a justifiable cost. In some instances, this period is extremely long. For example, there are many factories in the UK still using plant and equipment installed in the 1930s. Physical lifetimes are long by financial standards, and it is not common practice to carry out financial appraisal over the whole physical life of an asset.

Technological life is the time over which a particular way of doing something is regarded as technologically up to date, capable of producing a profit and being competitive. This depends on the rate of technological change, competition in the product market and the company's position in that market.

Some technologies, such as those involving computers and microprocessor controls move extremely rapidly, and in some fields technological progress can make a plant obsolete in two years. This should not however prevent a business investing in plant, even though it may be obsolete within the period of the simple payback. It merely means that, by the end of the payback period, the company will be making goods with, perhaps, a smaller profit margin than a competitor using state-of-the-art technology. The company will still have the advantage of an established market share and the physical means of production written-down. It does not mean that the plant will be of no use, nor does it mean that the plant has no residual value as an asset.

The idea of market lifetime should also be considered. A dedicated plant making nuts and bolts will probably not outlast the market, whereas a machine dedicated to making a commodity that is temporarily in fashion will probably outlive its product market.

The choice of project lifetime should be thought about carefully; it should be based on a consideration of physical, technological and market factors. This normally is the most difficult and subjective part of the decision-making process.

Companies typically set prescribed periods for the lifetimes of assets, such as 20 years for buildings, ten years for services and five years for production machinery. As well as being inadequate, these assumptions may make some investments appear over-attractive and others less attractive than they really are.

Lifetime as a Financial Variable

Regardless of the effort that is put into refining a project's costs and benefits, there will always be a residual uncertainty. One suggested point at which to stop is when the residue of uncertainty has been reduced to less than the effect of one year added to the lifetime.

Example

The following are examples of how project lifetime can be decided:

Factory A The investment is in equipment to produce a new product for a growing market. The new product is one of a range of products, but the new equipment is dedicated to this one product. The company is fairly young and still establishing itself. It therefore needs to invest in projects which provide good short-term profits. An appraisal lifetime of four years is considered appropriate.

Factory B The investment is in the core area of the business with flexibility in terms of the final product, but with all production dependent on it. The process technology is now established and not moving fast. The equipment has a physical life of at least ten years. An appraisal lifetime of six years is considered appropriate.

Factory C The investment is in dehumidifiers to dry one of a large range of products. However, it is key process stage for this product. The ability to produce a full range of products is important in the market in which the factory operates. The main drier enclosure has a long physical life, but the dehumidifiers are a replaceable part. A long life is appropriate; eight or perhaps even ten years.

Factory D The investment is to replace a previous investment made only six years before. Caution reigns. The company's aim is to break into new product markets. The equipment is flexible in terms of product, has a long physical life and is fully developed technologically. Caution alone limits the appropriate lifetime to five years.

Total Lifetime Costing

Total Lifetime Costing is often advocated for the appraisal of, in particular, technologically advanced projects. It essentially involves evaluating all costs and benefits over the entire physical life of the asset. Total Lifetime Costing carries the risk of overestimating benefits and exposing the project to a greater level of risk from market effects than is necessary. It is not therefore recommended. In particular, it should never be used to try to enhance a project with a poor payback. Financial appraisal by the accepted methods should bring out any merits in such projects.

10

PRESENTING THE PROPOSAL TO MANAGEMENT

The final stage of financial appraisal is the preparation of a written report and the presentation of the proposal to management. All too often this is another hurdle at which projects fail; not because the project lacks merit, but simply because the case itself is badly presented.

A good project may still be rejected if the proposal document is badly presented.

In all organisations, the repertoire of knowledge and skill required of a manager becomes broader and the time pressure greater as his/her level becomes higher. A senior manager in an organisation has less interest in detail and even less time to examine it. Communications should therefore be kept simple. Engineers on the factory floor often find it difficult to accept that a project that they have spent a long time examining and writing up could be decided in a matter of minutes by a senior manager who does not fully understand how it works or what it does.

The key issue is that senior management need to be reassured that the staff that are commending the project to them understand it, have done their homework and are convinced about it for the right reasons. One of those reasons should be that it makes good use of the organisation’s money.

The Structure of the Proposal

There are some general points which it is worthwhile to bear in mind when presenting a proposal. A useful structure for a written proposal is:

- summary;
- background;
- options;
- capital costs (undiscounted);
- other costs (undiscounted);
- savings (undiscounted);
- financial parameters (return on capital, NPV, IRR, etc);
- uncertainties and sensitivities;
- non-financial factors;
- best option;
- request.

Some of these points are discussed in more detail overleaf.

Background

This is important. The engineer must bear in mind that the people making the final decision about a project may not appreciate its importance from a straight description of the proposed installation; the project should be put into the context of the business as they see it. Senior management might not be engineers and the engineering concepts may need to be set out in reasonably simple terminology. In particular, senior management, even where they are engineers, are often unfamiliar with energy saving techniques.

A background section outlining the problem the project is intended to solve is therefore essential. It should also explain the reasoning behind the solutions being considered and be written in language that the decision-taker will understand.

It should also be remembered that the decision-takers may have only a short time to examine the project before making their decision and, in fact, may not read much of the proposal. A badly presented and/or incomprehensible proposal stands the risk of being turned down without being fully examined.

Your proposal should:

- put the project into context;
- discuss other options that have been explored;
- list additional, non-financial benefits;
- set out the best option clearly and concisely;
- request funding for the project and say when it is needed.

Options

Scientists and engineers usually see the relative merits of different approaches to an engineering problem very quickly. Sometimes this makes it appear to others in an organisation that the engineer has settled on an option and ignored other approaches completely. General managers need to be assured that other, possibly cheaper, options have been explored. Senior management expects the engineer to explore all the options and depends on his professionalism to produce the right design and to make the correct assumptions.

Non-Financial Factors

The calculation of financial parameters, uncertainties and sensitivities has been considered in earlier chapters. Non-financial factors may also be important. These could include:

- ways in which the project improves the way the business meets health and safety or environmental protection regulations;
- quality improvements which are not directly quantifiable in money terms;
- effects on the workforce, such as skill requirements, better working conditions, etc;
- better communications;
- improved response to breakdown.

This section of the final report could also mention other benefits which need to be quantified in some other part of the organisation: for example, the project's effect on the flexibility of production or improved quality, both of which will depend in turn on sales forecasts.

Best Option

The best option should be set out clearly and concisely. The form of installation agreed with the equipment supplier should be described in one or two pages, in a manner that senior management can readily understand.

Request

Finally, there is the request. Once all the details of the project have been decided, the costs and benefits calculated and the risks assessed, all that remains is to request the money and to say when it is needed. It should also be made clear exactly what is being asked for.

Sometimes it looks as though a project could be attractive, but it is not clear how it will fare in competition with other calls on the organisation's finances and it will require a lot of effort to get to the authorisation estimate stage. In these cases it is often appropriate to put forward an outline proposal, with a request for authority to continue working on the project, and to bring it back for final consideration at a later date. This approach has two main advantages. Firstly, it avoids putting a lot of effort into a project that would not succeed anyway. Secondly, it means that the project's existence is known about if resources suddenly become available, perhaps from an underspent capital budget in another part of the organisation.

11

FINANCIAL APPRAISAL AND THE EQUIPMENT SUPPLIER

Barriers to Investment in Energy Efficiency

If equipment suppliers understand the internal barriers to investment in energy efficiency, they can assist the decision-making process in a way that benefits both themselves and their customers.

The energy saving potential in UK manufacturing is about 20% of current energy costs, or about £1.4 billion a year at currently viable rates of return. This figure represents a very substantial business for equipment suppliers. Since the 1974 oil crisis, however, this figure has not changed much as a proportion of the whole, and a persistent lack of investment in energy efficiency has been a contributing factor to the difficulties of the energy efficiency equipment supply industry over this period. These difficulties have been attributed at various times to a multitude of reasons, including lack of awareness of the technical possibilities, the small fragmented energy efficiency equipment industry, lack of money for investment, industry's tendency to adopt a short-term view, lack of incentives and so on.

Various measures have been implemented by successive UK governments in attempts to lower or remove many of these barriers. On closer examination, however, many of these problems are not nearly as evident as is often supposed. Industry is not, in fact, short of capital, it just prefers to spend it on other things. The sustained campaign promoting energy efficiency by the Department of the Environment, the electricity and the gas industry, the trade press and trade associations has largely eroded the possibility that industry is unaware of what measures can be taken to improve energy efficiency. This situation is not unique to energy efficiency. Other ways of improving manufacturing efficiency are experiencing the same difficulties. This Guide offers suggestions as to how one key management function, the financial appraisal of projects, can be improved to overcome the problem. There is, however, a role for the equipment supplier. If equipment suppliers understand the internal barriers to investment in energy efficiency in the companies they deal with, then they can assist the decision-making process in a way that benefits both themselves and their customer.

The main problems are:

- only 4,000 industrial sites in the UK have an energy bill which exceeds £100,000. Only a few energy managers in industry are full-time appointments, and their other duties often command a premium on their time. Energy managers have a limited time to give to investment appraisal;
- much energy efficiency equipment depends on multi-disciplinary engineering principles. Engineers tend to be trained in one branch of engineering and many have only a background knowledge of some of the aspects of engineering involved in energy management. Senior management is largely unaware of this. An equipment supplier who knows his product and its application has a complementary role in supplying essential knowledge and experience;
- most energy managers are engineers with little training in financial management and most senior managers are accountants with no training in engineering. Many engineers in industry are simply not used to making a case for expenditure in discretionary areas of investment;

- senior managers tend to be more cautious than radical and to look on anything new or technical as being fraught with risk;
- the dedicated commitment of financial managers to the needs of annual financial statements can mean that few businesses have a clear idea of their real cost structure. Most companies consider energy as an overhead rather than a production input, and budget for it as such.

These problems manifest themselves in various ways:

- slow penetration of new technologies and techniques;
- a tendency for management to live with technical problems rather than trying to solve them;
- poor techniques applied to the financial appraisal of capital projects;
- over-severe criteria for investment in energy efficiency projects;
- a lack of quantification of the efficiency and costs of production.

These in turn produce specific difficulties for the equipment supply industry trying to encourage take up of energy saving techniques. Despite the often obvious potential in an investment proposal based on energy efficiency, a customer may not believe that the proposal is applicable to his/her company. It may also be difficult to quantify the major benefits of the proposal because the business does not have a clear idea of the costs which could be reduced and the customer may not appreciate the implications of the project in other areas, such as a stronger business and revenue growth.

From the specific point of view of the industrial sales engineer, these problems make it difficult to distinguish between those projects which are likely to lead to an investment and those that are not. This can make it difficult to focus sales effort and to estimate the time scale on which a project might proceed.

The Role of the Equipment Supplier

The sales engineer should try and identify the specific barriers that prevent a customer from making the commitment to invest and then try and remove these barriers.

Energy efficiency equipment suppliers have observed that some projects remain on their books as prospects for several years, while others move quickly from prospect to sale, possibly within a year. This implies that timing is critical. This is perhaps to be expected because of the opportunity funding influences known to occur in industry. A key piece of information for an equipment supplier to find out is when a potential customer’s financial year ends and whether this will have any effect on the project.

When a project is not proceeding actively, it is likely to have been held up at some level in the company. There is usually a reason for this. Such a blockage is often due to poor communication between the engineer and the financial decision-taker and/or a failure to present a worthwhile case. The equipment supplier should ensure that the customer is familiar with the key features of the equipment and understands their significance in the context of the financial appraisal processes set out in this Guide.

Equipment suppliers should note that a particular customer may only evaluate their kind of equipment once. Experiences with other customers should tell the supplier what it is about their product which brings acceptance or rejection. This will enable them to provide the information that will encourage the customer to choose their equipment.

Suppliers of energy efficiency equipment can gain useful information and support from the Department of the Environment’s Energy Efficiency Best Practice programme. Equipment suppliers should maintain familiarity with any Case Studies, Guides or other similar material which could help to smooth a project’s path.

Suppliers of energy saving equipment can get information and support from the Department of the Environment’s Energy Efficiency Best Practice programme.

A

COST OF CAPITAL TABLES

The tables in this Appendix list the present value of £1 according to the discount and the number of years. Table 4 is used when calculating the Annual Equivalent Cost (see Section 6).

Table 3 Present value of £1

	Discount Rate %																		
Years	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**25**	**30**	**35**	**40**
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	0.800	0.769	0.741	0.714
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	0.640	0.592	0.549	0.510
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	0.512	0.455	0.406	0.364
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	0.410	0.350	0.301	0.260
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	0.328	0.269	0.223	0.186
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	0.262	0.207	0.165	0.133
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	0.210	0.159	0.122	0.095
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	0.168	0.123	0.091	0.068
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	0.134	0.094	0.067	0.048
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	0.107	0.073	0.050	0.035
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	0.086	0.056	0.037	0.025
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	0.069	0.043	0.027	0.018
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	0.055	0.033	0.020	0.013
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	0.044	0.025	0.015	0.009
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	0.035	0.020	0.011	0.006
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	0.028	0.015	0.008	0.005
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	0.023	0.012	0.006	0.003
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	0.018	0.009	0.005	0.002
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	0.014	0.007	0.003	0.002
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	0.012	0.005	0.002	0.001

Table 4 Present value of £1 received for n years

	Discount Rate %																			
Years	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**25**	**30**	**35**	**40**
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	0.800	0.769	0.741	0.714
2	1.86	1.83	1.81	1.78	1.76	1.74	1.71	1.69	1.67	1.65	1.63	1.61	1.59	1.57	1.55	1.53	1.44	1.36	1.29	1.22
3	2.72	2.67	2.62	2.58	2.53	2.49	2.44	2.40	2.36	2.32	2.28	2.25	2.21	2.17	2.14	2.11	1.95	1.82	1.70	1.59
4	3.55	3.47	3.39	3.31	3.24	3.17	3.10	3.04	2.97	2.91	2.85	2.80	2.74	2.69	2.64	2.59	2.36	2.17	2.00	1.85
5	4.33	4.21	4.10	3.99	3.89	3.79	3.70	3.60	3.52	3.43	3.35	3.27	3.20	3.13	3.06	2.99	2.69	2.44	2.22	2.04
6	5.08	4.92	4.77	4.62	4.49	4.36	4.23	4.11	4.00	3.89	3.78	3.68	3.59	3.50	3.41	3.33	2.95	2.64	2.39	2.17
7	5.79	5.58	5.39	5.21	5.03	4.87	4.71	4.56	4.42	4.29	4.16	4.04	3.92	3.81	3.71	3.60	3.16	2.80	2.51	2.26
8	6.46	6.21	5.97	5.75	5.53	5.33	5.15	4.97	4.80	4.64	4.49	4.34	4.21	4.08	3.95	3.84	3.33	2.92	2.60	2.33
9	7.11	6.80	6.52	6.25	6.00	5.76	5.54	5.33	5.13	4.95	4.77	4.61	4.45	4.30	4.16	4.03	3.46	3.02	2.67	2.38
10	7.72	7.36	7.02	6.71	6.42	6.14	5.89	5.65	5.43	5.22	5.02	4.83	4.66	4.49	4.34	4.19	3.57	3.09	2.72	2.41
11	8.31	7.89	7.50	7.14	6.81	6.50	6.21	5.94	5.69	5.45	5.23	5.03	4.84	4.66	4.49	4.33	3.66	3.15	2.75	2.44
12	8.86	8.38	7.94	7.54	7.16	6.81	6.49	6.19	5.92	5.66	5.42	5.20	4.99	4.79	4.61	4.44	3.73	3.19	2.78	2.46
13	9.39	8.85	8.36	7.90	7.49	7.10	6.75	6.42	6.12	5.84	5.58	5.34	5.12	4.91	4.71	4.53	3.78	3.22	2.80	2.47
14	9.90	9.29	8.75	8.24	7.79	7.37	6.98	6.63	6.30	6.00	5.72	5.47	5.23	5.01	4.80	4.61	3.82	3.25	2.81	2.48
15	10.38	9.71	9.11	8.56	8.06	7.61	7.19	6.81	6.46	6.14	5.85	5.58	5.32	5.09	4.88	4.68	3.86	3.27	2.83	2.48
16	10.84	10.11	9.45	8.85	8.31	7.82	7.38	6.97	6.60	6.27	5.95	5.67	5.41	5.16	4.94	4.73	3.89	3.28	2.83	2.49
17	11.27	10.48	9.76	9.12	8.54	8.02	7.55	7.12	6.73	6.37	6.05	5.75	5.47	5.22	4.99	4.77	3.91	3.29	2.84	2.49
18	11.69	10.83	10.06	9.37	8.76	8.20	7.70	7.25	6.84	6.47	6.13	5.82	5.53	5.27	5.03	4.81	3.93	3.30	2.84	2.49
19	12.09	11.16	10.34	9.60	8.95	8.36	7.84	7.37	6.94	6.55	6.20	5.88	5.58	5.32	5.07	4.84	3.94	3.31	2.85	2.50
20	12.46	11.47	10.59	9.82	9.13	8.51	7.96	7.47	7.02	6.62	6.26	5.93	5.63	5.35	5.10	4.87	3.95	3.32	2.85	2.50

B

WORKED EXAMPLE: FINANCIAL APPRAISAL OF ENERGY SAVING MEASURES IN A FOOD FACTORY

Initiation

A factory in the food industry makes a range of baked snack products. The snacks industry is very competitive; it is a growing market with new products continuously emerging. Many of these new products only survive in the market for one or two years, but occasionally one succeeds and lasts, often for a very long time. In terms of the processes used, most new products in the snacks industry are merely variants of older more established ones.

The most common feature of the products in this factory is the baking stage. However, the main product, which is a long established product with a substantial share of the market, also involves a steam-heated drying process. It is only produced at this site and accounts for half of the output.

The space heating for the factory is also provided by steam. There are three boilers, but one is primarily a back-up; all three boilers are only used together in the most severe weather.

An energy survey has identified a range of energy saving measures, including a change in the drying process, heat recovery for the baking ovens, new burners on the baking ovens, rapid roller doors in the packing and dispatch area, savings in the steam distribution system, controls in the boiler house, a building management system (BMS), and possible conversion to gas.

The possible capital costs and paybacks indicated in the report, presented in order of capital costs, are:

Project	**Capital Cost**	**Payback (years)**
Switch to radiant heating in workshop	£2,400	0.5*
Modifications to steam distribution	£6,500	1.0*
Change burners on ovens	£6,000	1.5*
Heat recovery for ovens	£11,000	2.75
Rapid roller doors in dispatch area	£12,000	1.25*
Building energy management system	£15,000	1.9*
Switch to gas	£30,000	1.0*
Change drying process to a dehumidifier	£60,000	3.0
TOTAL CAPITAL COST	**£142,900**	

These projects, which have a total cost of £142,900, would produce annual savings of £86,500, giving an overall payback of 1.65 years. This therefore appears to be an attractive package of measures.

The costs and benefits, however, are only the consultant's estimates. Before committing capital to any of the projects, it is necessary to establish which of these projects will make the best use of the available capital and to determine their order of priority. This is the main function of financial appraisal.

Before committing capital to any of a list of possible energy saving measures, you must establish which of the measures will make the best use of the available capital.

First Steps

The energy committee has discussed the report. The company has a limit of two years payback on all discretionary capital projects and has only allowed £30,000/year for energy saving projects. The projects which meet these criteria are indicated by * and cost £71,900 altogether. Neither heat recovery on the ovens nor the dehumidifier dryer are included.

There is also an already agreed capital request of £50,000 for a replacement boiler. The oldest boiler is near the end of its useful life and the replacement is intended to ensure an adequate reserve capacity and meet the site’s needs in the coldest weather. The capital for the boiler is regarded by the Finance Director as part of the total available for energy saving projects in any one year. The improved efficiency of the boiler gives it a payback of ten years. The decision to replace the boiler is, however, seen as essential business maintenance expenditure and is not based on payback.

The total available capital for three to four years would therefore be required to implement just those projects meeting the payback criterion. There are also physical constraints on the order in which the projects can be carried out. As the switch to gas would affect the choice of equipment used for the radiant heaters, the oven burners and the new boiler, the fuel change would have to be carried out before these projects.

The optimum programme judged only on payback and available capital would appear to be to make the fuel switch first, and then fund the change of heating in the workshops, the steam system modification, the burners on the ovens and the roller doors; and then fund the boiler replacement.

More Detailed Appraisal

Once the initial list of possible measures has been narrowed down, the next step is to get more detailed information.

The qualifying criteria have reduced the initial list of projects to a more manageable number. There are now five projects, plus the boiler, for which it is considered worthwhile to take the estimates of costs from the consultant’s ‘ballpark’ to the level of authorisation estimates.

Examination of the previous year’s bills establishes that the total fuel consumption was 1,094,250 litres gas oil (12,518,220 kWh) at a cost of £175,080. This represents an average of 16 pence/litre (1.398p/kWh). The scheduled price for this quantity of business gas is 1.117p/kWh. On the basis of last year’s consumption, annual fuel costs (including fixed costs) would be £139,829. Assuming a 3% increase in the amount of gas required to take account of the differences in net and gross calorific value of the two fuels, the fuel cost savings by conversion to gas would be £175,080 - £144,023 = £31,056.

Whether the price difference between fuels is likely to be maintained over the entire project life is a key uncertainty because the difference is small compared to the historic variation of these prices.

Discussions with the supplier establish that it would cost £26,000 to lay on the gas supply and £8,300 to adapt the burners on three boilers (this is necessary to ensure the margin of capacity is maintained throughout). The total of £34,300 is more than expected and takes it outside the annual capital allowed, although the payback is good.

A telephone enquiry has produced an updated figure for the cost of replacing the boiler of £51,000. The call also established that the cost reduction obtained with a smaller boiler means that it not worth considering anything smaller. A structural engineer has provided an estimate of £6,000 for work associated with installing the new boiler. A new gas burner is also required costing £4,600.

The efficiency of the boiler as stated by the manufacturer is 78%. The energy survey report indicated that the efficiency of the main part of the steam raised in the existing system was 73%. Therefore, changing the boiler would save about 5% on half the boiler fuel. On the assumption that this would be gas, the fuel saving would be worth £5,157 a year; the comparable figure for oil would be £4,341.

A quotation from a manufacturing company provides a firm cost for the roller doors of £14,250. It is very difficult to calculate the savings. The supplier reckons that these doors always give a payback better than two years, and sometimes as little as 6 months. It is assumed that the two year payback will apply here.

The modifications to the steam system have been worked out in detail and the cost comes to £6,800. From estimates of pipe heat losses and lost condensate, the savings have been upgraded to £7,736.

A firm quotation for the BMS system comes to £16,850. The savings are mainly based on the use of optimum start and are confirmed at not less than £5,440.

The lifetime for financial appraisal has to be considered. The type of product and its place in the market makes it appropriate to consider a long period for the lifetime for most of the measures. To calculate the NPV, a project lifetime of ten years has been decided. For the BMS and roller doors, a choice has to be made between considering a shorter life or further capital outlay later in the project. In the case of the roller doors there is likely to be high wear and tear, and in the case of the BMS, the equipment could become obsolete before the end of the ten years.

To achieve a uniform lifetime, extra capital costs of 50% are assumed for the roller door. In financial appraisal, the capital costs are not discounted, only the benefits.

The capital costs, NPV and capital cost/NPV ratio for each project are therefore:

	Capital Cost (£)	**NPV**	**NPV/ Capital Cost**
Switch to radiant heating in workshop	2,400	31,013	12.9*
Modifications to steam distribution	6,800	40,735	5.99
Switch to gas	34,300	135,926	3.96
Change burners on ovens	6,000	15,236	2.54*
Heat recovery for ovens	1,000	13,578	1.23*
Rapid roller doors in dispatch area	14,250	12,759	0.89
Change dryer to dehumidifier	63,200	56,142	0.88*
Building energy management system	16,850	3,754	0.22
Boiler replacement	57,000	(25,310)	(0.44)

The list shows from top to bottom the natural order of funding priority for projects which do not overlap. The * indicates that the costs and savings are still only ‘ballpark’ estimates.

The most appropriate project for the first year, provided that the £30,000 rule can be relaxed slightly, is the switch to gas. The best options for the second year are switching to radiant heating in the workshops, changing burners on the ovens, modifying the steam distribution system and recovering heat from the ovens. In the third year, the capital would have to be spent on the boiler replacement.

Exploring the Wider Options

A key consideration throughout this study has been the need to set aside funds for the replacement boiler. What has not been discussed is whether this is necessary.

The dryer is a major user of steam in the factory. The main reason for the need to set aside capital for the replacement boiler is to meet the steam load when the dryers are running. Five of the measures identified in the energy survey are measures which reduce steam demand. It is important to consider whether the reduced steam demand would be enough to leave the margin of capacity required (in this case a spare boiler for most of the year) if the old boiler is taken out of service and not replaced. This is assessed by examining the site’s energy usage in more detail. A graph of the energy use against degree days establishes that the energy use follows closely the pattern given by the following formula:

Look out for the options which may seem to be outside the scope of the project, but which may have a significant effect on it.

litres oil/month = 55,563 + (180 x degree days in month)

The graph also shows that 39% of the energy use is weather-related.

A simple test was carried out during the pre-weekend factory shutdown to ascertain the changing boiler load and oil consumption as each part of the factory was isolated. This test established that the ovens use approximately 30,000 litres of oil/month (29% of the total annual consumption) and the dryer uses 10,500 litres/month (11.5%), in terms of fuel into the boiler. The remaining fuel consumption, that is unrelated to the weather, consists of minor uses such as the preparation of ingredients and steam system losses.

The main problem with the boiler at present is of ensuring that the peak steam load can be met. This is because demand peaks during the morning as the dryer, the other steam users and the raising of the factory air temperature occur together. An outline calculation indicates that by removing the load on the boiler from the dryer, lowering the space heating needs by means of the roller doors and using the BMS to reschedule the load on the boilers, the rest of the demand can be met by a small margin. Removing the workshops from the steam load would widen this margin.

Tests show that the raw material can be dried using the proposed dehumidifier. In fact, the product quality is slightly improved because of better dimensional stability and changes in the cooking characteristics of the dried intermediate. This makes the dehumidifier dryer a particularly attractive option because, although it costs £63,000, it obviates the need to spend £57,000 on a boiler. It is, however, contingent on making other expenditures.

Costs and Benefits of the Dryer Replacement

The detailed costs are:

Work	**Cost**	**Possible variation**
Drying chamber	£48,000	firm
Building work	£6,250	±£1,000
Services	£1,800	±£300
Heat pump	£3,200	firm
Internal fittings	£4,200	firm
Removal of old drying kiln	£3,500	±£500
TOTAL	**£66,950**	**±£1,800**

The requirement for the BMS, the roller doors and some of the steam system modifications are essential to this project and must be included in it. It could be that it is not necessary to use radiant heating in the workshops; this would be explored in the sensitivity tests. The change to gas to facilitate this heating should also be examined.

The other costs are therefore:

Work	**Cost**	**Possible variation**	
Building energy management system	£16,850	firm	
Rapid roller doors	£14,250	firm	
Modifications to the steam system	£3,000	±£850	
Change to gas			
- laying on a supply	£26,000	-£26,000	
- radiant heating	£2,850	-£2,850	
TOTAL	**£62,950**	**+£850**	**-£29,700**
OVERALL TOTAL (both sets of work)	**£129,900**	**+£2,650**	**-£31,500**

The minimum cost is £98,400 if the radiant heating and change to gas is not necessary; the maximum cost is if the fuel change is necessary. The savings therefore depend on whether the change of fuel is necessary.

	Oil	**Gas**
Present fuel costs (£):	175,080	–
composed of		
Present dryer steam costs	20,358	–
Present space heating costs	36,252	
Other fuel costs not otherwise specified	118,470	–
Fuel costs after project (£):		
Fuel costs not otherwise specified	118,470	106,724
(which have not changed)		
Space heating costs	23,789	21,025
Dryer steam	0	0
Dryer electricity	936	936
Sub total	143,195	128,685
ENERGY SAVINGS	**£31,885**	**£46,395**

Other Savings

The proposed new dryer cabinet has a greater capacity than the current steam dryer and it would be possible to run it over the weekend without any deleterious effect on the product. This means the output of the dried intermediate could be increased. The new dryer would also allow different products to be dried simultaneously.

When this issue is discussed with the Production Department, it is revealed that at present there are occasions when, because of a combined effect of a limited drying capacity and poor control of the drying process, there is some product wastage or the ovens are running without product going through. Additional saving in reduced rejects and reduced oven heating, which were not included in the estimates from the survey, have been found.

	Oil	**Gas**
Reduced oven heating	£3,630	£3,053
Increased throughput	0	0
Reduced rejects in the dryer	£6,500	£6,500
Reduced maintenance of old boiler	£2,500	£2,500
Total additional savings	£12,630	£12,053
Energy savings	£31,885	£46,395
∴ TOTAL SAVINGS	**£44,515**	**£58,448**

These savings arise because advantage is taken of the increased capacity. The impact of increased throughput at this stage is very difficult to estimate. It is certainly not going to be zero, but setting it at zero provides a safe lowest estimate. A number could be added later if required.

These costs and benefits are adequate as Authorisation Estimates.

Appraising the Options

Initially there appeared to be nine options - the eight projects identified in the energy survey, plus ‘doing nothing’. This last option was replaced by the project to change the boiler. There is now a new option, which is to not replace the boiler; however, this is contingent on other projects being implemented. In order to make a worthwhile comparison, it is necessary to consider comparable packages.

The next step is to make a detailed appraisal of the options.

The options are:

- replace the dryer and undertake the other projects necessary to reduce the boiler load, but do not replace the boiler;
- replace the boiler and carry out the best of the projects as prioritised by NPV/capital cost, within the capital available (i.e. best of the rest).

For both these options it is necessary to work out the cash flows on the basis of whether a change of fuel is involved, because this produces the greatest uncertainty.

The content of each package is slightly different. In the case of the boiler, it is based on the best projects available within the available capital. In the case of the dryer, it includes the minimum required to ensure feasibility and excludes, for example, the change of burner on the ovens, which has a good return on present fuel price differences.

In the case of the roller doors, it has been assumed that some equipment replacement will be required during the evaluation period. Although the BMS may become obsolete, it could be regarded as functioning over the entire period. The need for a replacement has not been costed in (there are no hard and fast rules here, these would be judgements made by the engineer).

Option		**1**	**2**	**3**	**4**
		Dehumidifier dryer		Boiler & best of rest	
		No change of fuel	Change to gas	No change of fuel	Change to gas
Captial cost		(£108,165)	(£134,815)	(£93,575)	(£127,875)
	Discount factor*	Savings at present value (£)			
Year 1	0.909	40,464	52,902	26,281	51,464
Year 2	0.826	36,769	48,072	23,882	46,765
Year 3	0.751	33,431	43,707	21,713	42,518
Year 4	0.683	30,404	39,749	19,747	38,669
Year 5	0.621	27,644	36,141	17,955	35,158
Year 6	0.564	25,106	32,824	16,307	31,931
Year 7	0.513	22,836	29,856	14,832	29,044
Year 8	0.467	20,789	27,178	13,502	26,440
Year 9	0.424	18,874	24,676	12,259	24,005
Year 10	0.386	17,183	22,464	11,160	21,854
	*10% cost of capital				
NPV after 10 years (£)		165,335	222,754	84,063	219,973
NPV/Capital		1.53	1.65	0.90	1.72
Average payback (years)		2.43	2.32	3.24	2.26
Gross return on captial		411%	431%	309%	442%
Net return on captial		311%	331%	209%	342%
Gross average rate of return		41%	43%	31%	44%
Net average rate of return		31%	33%	21%	34%

The discounted assessment has been made on the conventional basis that all the capital has been provided at once. (It is argued thereby that, until it is required, the capital exists but is working elsewhere in the organisation.)

The result of the appraisal at this stage is:

- the lowest capital requirement is given by the boiler replacement and the projects which can be fitted into the existing rules on availability of capital, Option 3, with no change of fuel. This turns out to give the poorest return;
- a better return is offered by Option 1, the dryer, but this has a slightly higher capital cost.

The uncertainties in Option 3 are not very large. The main uncertainty in Option 1 is whether the change of fuel would be necessary in order to implement it. Although this would add to the capital cost, it improves the return on the capital invested. If a change of fuel was deemed necessary and the capital was available, then it would be appropriate to proceed with the boiler replacement.

There are, however, uncertainties about how long the price differential between the two fuels would remain. Unlike the other factors, an unfavourable change in this differential could take back savings in later years. This would need to be considered carefully, and would probably result in a decision to retain a dual fuel capability.

The Proposal

At this stage, a written report would be prepared and submitted to senior management as a proposal. In this case, it would not come down firmly in favour of any particular option because the decision is not primarily an engineering one. It would, however, highlight the difference in qualitative features, such as the effect on quality and production capacity, which are higher for the dryer project.

Senior management would examine the proposal against the background of other issues affecting the factory and the company that the engineer may be unaware of, e.g. whether there are plans to increase production or change the product mix.

Features in the Example

1. This example has been used to illustrate the variety of opportunities that can be met in financial appraisal rather than how any one step is carried out. Although the example is fictitious, the features in it are based on real cases.

2. It should be noted that it is difficult at times to distinguish between what is an engineering appraisal and what is a financial appraisal. When the process is carried out well, this distinction can appear even less distinct.

3. The way the financial appraisal developed was largely dictated by the particular features of the site; it did not follow any particular procedure, apart from the evaluation of financial parameters. This is to be expected. Financial appraisal is far less concerned with the formal step of discounting and the calculation of the financial indicators, than with finding out what the options are and their respective costs and benefits. In this case, the decision to examine the proportion of the steam load accounted for by space heating turned out to be important. In another case, a different feature may be significant.

4. This appraisal began with the projects identified from an energy survey which identified up to eight measures. This is not unusual. It is also common for the investment opportunities identified from a survey to greatly exceed the capital available. This is a major reason why survey recommendations often appear to take a long time to be implemented.

5. The most attractive proposition does not fit the original guidelines on payback or capital availability. Such guidelines are invariably posted by companies as a guide, in the absence of a full appreciation of all the possibilities, and they should not be allowed to constrain the financial appraisal process. It is the job of senior management to make decisions if the best opportunities for the enterprise are not matched by the capital available.

6. The need for a replacement boiler or major repair/refurbishment of the existing boiler is a key feature of the example. Given that a boiler typically has a service life 20 to 25 years, boiler replacement or repair is a common feature of investment strategies which look at a period of more than two or three years. The circumstances of this example are by no means rare.

The Government's Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry, transport 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.

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