CHAPTER 8

Project Investment Appraisal

It is important to justify any capital investment project by carrying out a financial appraisal. The financial issues associated with capital investment in energy-saving projects are investigated in this chapter. In particular, the discounted cash flow techniques of net present value and internal rate of return are presented and discussed.

8.1 Introduction

When planning an energy-efficiency or energy-management project, the costs involved should always be considered. Therefore, as with any other type of investment, energy-management proposals should show the likely return on any capital that is invested. Consider the case of an energy consultant who advises the senior management of an organization that capital should be invested in new boiler plant. Inevitably, the management of the organization would enquire:

- How much will the proposal cost?
- How much money will be saved by the proposal?

These are, of course, not unreasonable questions, since within any organization there are many 'worthy causes', each of which requires funding and it is the job of senior management to invest capital where it is going to obtain the greatest return. In order to make a decision about any course of action, management needs to be able to appraise all the costs involved in a project and determine the potential returns. However, this is not quite as straightforward as it might first appear. The capital value of plant or equipment usually decreases with time and it often requires more maintenance as it gets older. If money is borrowed from a bank to finance a project, then interest will have to be paid on the loan. Inflation too will influence the value of any future energy savings that might be achieved. It is therefore important that the cost-appraisal process allows for all these factors, with the aim of determining which investments should be undertaken and of optimizing the benefits achieved. To this end a number of accounting and financial appraisal techniques have been developed which help managers make correct and objective decisions. It is these financial appraisal techniques which are introduced and discussed in this chapter.

8.2 Fixed and Variable Costs

When appraising the potential costs involved in a project it is important to understand the difference between fixed and variable costs. Variable costs are those which vary directly with the output of a particular plant or production process, such as fuel costs. Fixed costs are those costs, which are not dependent on plant or process output, such as site-rent and insurance. The total cost of any project is therefore the sum of the fixed and variable costs. Example 8.1 illustrates how both fixed and variable costs combine to make the total operating cost.

Example 8.1

Determine the total cost of a diesel generator operating over a 5-year period. Assume that the capital cost of the generator is £15,000, the annual output is 219 MWh and the maintenance costs are £500 per annum. The cost of producing each unit of electricity is 3.5p/kWh.

Solution

Item	Type of cost	Calculation	Cost (£)
Capital cost of generator	Fixed	n.a.	15,000.00
Annual maintenance	Fixed	£500 × 5	2500.00
Fuel cost	Variable	219,000 × 0.035	7665.00
			Total cost = 25,165.00

From Example 8.1 it can be seen that the fixed costs represent 69.5% of the total cost. In fact, the annual electricity output of 219 MWh assumes that the plant is operating with an average output of 50 kW. If this output were increased to an average of 70 kW, then the fuel cost would become £10,731, with the result that the fixed costs would drop to 62% of the total. Clearly, the average unit cost of production decreases as output increases.

The concept of fixed and variable costs can be used to determine the break-even point for a proposed project. The break-even point can be determined by using eqn (8.1):

$$\mathrm{UC_{util}} \times W_{\mathrm{av}} \times n = \mathrm{FC} + \left(\mathrm{UC_{prod}} \times W_{\mathrm{av}} \times n\right) \tag{8.1}$$

where $\mathrm{UC_{util}}$ is the unit cost per kWh of bought-in energy (£/kWh), $\mathrm{UC_{prod}}$ is the unit cost per kWh of produced energy (£/kWh), FC is the fixed costs (£), W_{av} is the average power output (or consumption) (kW) and n is the number of hours of operation (h).

Example 8.2

Assuming that electricity bought from a local utility company costs an average of 8.1p/kWh, determine the break-even point for the generator described in Example 8.1, when:

(i) the average output is 50 kW and
(ii) the average output is 70 kW.

Solution

(i) Assuming that the average output of the generator is 50 kW:

$$0.061 \times 50 \times n = (15{,}000 + 2500) + (0.035 \times 50 \times n)$$
$$\therefore\ n = 13{,}461.5 \text{ hours}$$

(ii) Assuming that the average output of the generator is 70 kW:

$$0.061 \times 70 \times n = (15{,}000 + 2500) + (0.035 \times 70 \times n)$$
$$\therefore\ n = 9615.4 \text{ hours}$$

Clearly, increasing the average output of the generator significantly reduces the break-even time for the project. This is because the capital investment (i.e. the generator) is being better utilized.

8.3 Interest Charges

In order to finance projects, organizations often borrow money from banks or other lending organizations. Projects financed in this way cost more than similar projects financed from an organization's own funds, because interest charges must be paid on the loan. It is therefore important to understand how interest charges are calculated. Interest charges can be calculated by lending organizations in two different ways: simple interest and compound interest:

(i) *Simple interest*: If simple interest is applied, then charges are calculated as a fixed percentage of the capital that is borrowed. A fixed interest percentage is applied to each year of the loan and repayments are calculated using eqn (8.2).

$$\mathrm{TRV} = \mathrm{LV} + \left(\frac{\mathrm{IR}}{100} \times \mathrm{LV} \times \mathrm{P}\right) \tag{8.2}$$

where TRV is the total repayment value (£), LV is the value of initial loan (£), IR is the interest rate (%) and P is the repayment period (years).

(ii) *Compound interest*: Compound interest is usually calculated annually (although this is not necessarily the case). The interest charged is calculated as a percentage of the outstanding loan at the end of each time period. It is termed 'compound' because the outstanding loan is the sum of the unpaid capital and the interest charges up to that point. The value of the total repayment can be calculated using eqn (8.3):

$$\mathrm{TRV} = \mathrm{LV} \times \left(1 + \frac{\mathrm{IR}}{100}\right)^{\mathrm{p}} \tag{8.3}$$

The techniques involved in calculating simple and compound interests are illustrated in Example 8.3.

Example 8.3

A company borrows £50,000 to finance a new boiler installation. If the interest rate is 9.5% per annum and the repayment period is 5 years, determine the value of the total repayment and the monthly repayment value, assuming that:

(i) simple interest is applied and
(ii) compound interest is applied.

Solution

(i) *Assuming simple interest*:

$$\text{Total repayment} = 50,000 + \left(\frac{9.5}{100} \times 50,000 \times 5\right) = £73,750.00$$

$$\text{Monthly repayment} = \frac{73,750.00}{(5 \times 12)} = £1229.17$$

(ii) *Assuming compound interest*:

$$\text{Repayment at end of year 1} = 50,000 + \left(\frac{9.5}{100} \times 50,000\right) = £54,750.00$$

and

$$\text{Repayment at end of year 2} = 54,750 + \left(\frac{9.5}{100} \times 54,750\right) = £59,951.25$$

Similarly, the repayments at the end of years 3, 4 and 5 can be calculated:

Repayment at end of year 3 is £65,646.62
Repayment at end of year 4 is £71,883.05
Repayment at end of year 5 is £78,711.94.

Alternatively, eqn (8.3) can be used to determine the compound interest repayment value:

$$\text{Total repayment value} = 50{,}000 \times \left(1 + \frac{9.5}{100}\right)^5 = £78{,}711.94$$

$$\text{Monthly repayment} = \frac{78{,}711.94}{(5 \times 12)} = £1311.87$$

It can be seen that by using compound interest, the lender recoups an additional £4962. Not surprisingly lenders usually charge compound interest on loans.

8.4 Payback Period

Probably the simplest technique which can be used to appraise a proposal is payback analysis. The payback period can be defined as 'the length of time required for the running total of net savings before depreciation to equal the capital cost of the project' [1]. In theory, once the payback period has ended, all the project capital costs will have been recouped and any additional cost savings achieved can be seen as clear 'profit'. Obviously, the shorter the payback period, the more attractive the project becomes. The length of the maximum permissible payback period generally varies with the business culture concerned. In some countries, payback periods in excess of 5 years are considered acceptable, whereas in other countries, such as in the UK, organizations generally impose payback periods of less than 3 years. The payback period can be calculated using eqn (8.4):

$$PB = \frac{CC}{AS} \tag{8.4}$$

where PB is the payback period (years), CC is the capital cost of the project (£) and AS is the annual net cost saving achieved (£).

The annual net cost saving (AS) is the cost saving achieved after all the operational costs have been met.

Example 8.4

A new combined heat and power (CHP) installation is expected to reduce a company's annual energy bill by £8100. If the capital cost of the new boiler installation is £37,000, and the annual maintenance and operating costs are £700, what will be the expected payback period for the project?

Solution

$$PB = \frac{37{,}000}{8100 - 700} = 5.0 \text{ years}$$

8.5 Discounted Cash Flow Methods

The payback method is a simple technique which can easily be used to provide a quick evaluation of a proposal. However, it has a number of major weaknesses:

- The payback method does not consider savings that are accrued after the payback period has finished.
- The payback method does not consider the fact that money, which is invested, should accrue interest as time passes. In simple terms there is a 'time value' component to cash flows. Thus a £100 today is more valuable than £100 in 10 years' time.

In order to overcome these weaknesses a number of discounted cash flow techniques have been developed, which are based on the fact that money invested in a bank will accrue annual interest. The two most commonly used techniques are the 'net present value' and the 'internal rate of return' methods.

8.5.1 Net Present Value Method

The net present value (NPV) method considers the fact that a cash saving (often referred to as a 'cash flow') of £1000 in year 10 of a project will be worth less than a cash flow of £1000 in year 2. The NPV method achieves this by quantifying the impact of time on any particular future cash flow. This is done by equating each future cash flow to its current value today, in other words determining the present value of any future cash flow. The present value (PV) is determined by using an assumed interest rate, usually referred to as a discount rate. Discounting is the opposite process to compounding. Compounding determines the future value of present cash flows, whereas discounting determines the present value of future cash flows.

In order to understand the concept of present value, consider the case described in Example 8.4. If instead of installing a new CHP system, the company invested £37,000 in a bank at an annual interest rate of 8%, then:

$$\text{The value of the end of year } 1 = 37{,}000 + \left(0.08 \times 37{,}000\right) = £39{,}960.00$$

and

$$\text{The value of the end of year } 2 = 39{,}960 + \left(0.08 \times 39{,}960\right) = £43{,}156.80$$

The value of the investment would grow as compound interest is added, until after n years the value of the sum would be:

$$FV = D \times \left(1 + \frac{IR}{100}\right)^{n} \tag{8.5}$$

where FV is the future value of investment (£) and D is the value of initial deposit (or investment) (£).

So after 5 years the future value of the investment would be:

$$FV = 37,000 \times \left(1 + \frac{8}{100}\right)^n = £54,365.14$$

So in 5 years the initial investment of £37,000 will accrue £17,365.14 in interest and will be worth £54,365.14. Alternatively, it could equally be said that £54,365.14 in 5 years' time is worth £37,000 now (assuming an annual interest rate of 8%). In other words the present value of £54,365.14 in 5 years' time is £37,000 now. The present value of an amount of money at any specified time in the future can be determined by eqn (8.6):

$$PV = S \times \left(1 + \frac{IR}{100}\right)^{-n} \tag{8.6}$$

where PV is the present value of S in *n* years time (£), and S is the value of cash flow in *n* years time (£).

The NPV method calculates the *present value* of all the yearly cash flows (i.e. capital costs and net savings) incurred or accrued throughout the life of a project and summates them. Costs are represented as a negative value and savings as a positive value. The sum of all the present values is known as the NPV. The higher the NPV, the more attractive the proposed project.

The *present value* of a future cash flow can be determined using eqn (8.6). However, it is common practice to use a *discount factor* (DF) when calculating present value. The DF is based on an assumed discount rate (i.e. interest rate) and can be determined by using eqn (8.7):

$$DF = \left(1 + \frac{IR}{100}\right)^{-n} \tag{8.7}$$

The product of a particular cash flow and the *DF is the present value*:

$$PV = S \times DF \tag{8.8}$$

The value of various DFs computed for a range of discount rates (i.e. interest rates) is shown in Table 8.1. Example 8.5 illustrates the process involved in an NPV analysis.

Example 8.5

Using the NPV analysis technique, evaluate the financial merits of the two proposed projects shown in the following table. Assume an annual discount rate of 8% for each project.

Capital cost (£) **Year**	**Project 1** **30,000.00** **Net annual saving (£)**	**Project 2** **30,000.00** **Net annual saving (£)**
1	+6000.00	+6600.00
2	+6000.00	+6600.00
3	+6000.00	+6300.00

Continued

Capital cost (£) **Year**	**Project 1** **30,000.00** **Net annual saving (£)**	**Project 2** **30,000.00** **Net annual saving (£)**
4	+6000.00	+6300.00
5	+6000.00	+6000.00
6	+6000.00	+6000.00
7	+6000.00	+5700.00
8	+6000.00	+5700.00
9	+6000.00	+5400.00
10	+6000.00	+5400.00
Total net savings at end of year 10	**+60,000.00**	**+60,000.00**

TABLE 8.1 Computed discount factors

Year	**Discount rate % (or interest rate %)**							
	2	**4**	**6**	**8**	**10**	**12**	**14**	**16**
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1	0.980	0.962	0.943	0.926	0.909	0.893	0.877	0.862
2	0.961	0.925	0.890	0.857	0.826	0.797	0.769	0.743
3	0.942	0.889	0.840	0.794	0.751	0.712	0.675	0.641
4	0.924	0.855	0.792	0.735	0.683	0.636	0.592	0.552
5	0.906	0.822	0.747	0.681	0.621	0.567	0.519	0.476
6	0.888	0.790	0.705	0.630	0.564	0.507	0.456	0.410
7	0.871	0.760	0.665	0.583	0.513	0.452	0.400	0.354
8	0.853	0.731	0.627	0.540	0.467	0.404	0.351	0.305
9	0.837	0.703	0.592	0.500	0.424	0.361	0.308	0.263
10	0.820	0.676	0.558	0.463	0.386	0.322	0.270	0.227
11	0.804	0.650	0.527	0.429	0.350	0.287	0.237	0.195
12	0.788	0.625	0.497	0.397	0.319	0.257	0.208	0.168
13	0.773	0.601	0.469	0.368	0.290	0.229	0.182	0.145
14	0.758	0.577	0.442	0.340	0.263	0.205	0.160	0.125
15	0.743	0.555	0.417	0.315	0.239	0.183	0.140	0.108
16	0.728	0.534	0.394	0.292	0.218	0.163	0.123	0.093
17	0.714	0.513	0.371	0.270	0.198	0.146	0.108	0.080
18	0.700	0.494	0.350	0.250	0.180	0.130	0.095	0.069
19	0.686	0.475	0.331	0.232	0.164	0.116	0.083	0.060
20	0.673	0.456	0.312	0.215	0.149	0.104	0.073	0.051

Solution

The annual cash flows should be multiplied by the annual DFs for a rate of 8% to determine the annual present values, as shown in the following table.

Year	Discount factor for 8%	Project 1		Project 2	
		Net savings (£)	Present value (£)	Net savings (£)	Present value (£)
	(a)	(b)	(a × b)	(c)	(a × c)
0	1.000	−30000.00	−30,000.00	−30000.00	−30,000.00
1	0.926	+6000.00	+5556.00	+6600.00	+6111.60
2	0.857	+6000.00	+5142.00	+6600.00	+5656.20
3	0.794	+6000.00	+4764.00	+6300.00	+5002.20
4	0.735	+6000.00	+4410.00	+6300.00	+4630.50
5	0.681	+6000.00	+4086.00	+6000.00	+4086.00
6	0.630	+6000.00	+3780.00	+6000.00	+3780.00
7	0.583	+6000.00	+3498.00	+5700.00	+3323.10
8	0.540	+6000.00	+3240.00	+5700.00	+3078.00
9	0.500	+6000.00	+3000.00	+5400.00	+2700.00
10	0.463	+6000.00	+2778.00	+5400.00	+2500.20
			NPV = +10,254.00		NPV = +10,867.80

It can be seen that over a 10-year lifespan the NPV for Project 1 is £10,254.00, while for Project 2 it is £10,867.80. Therefore Project 2 is the preferential proposal.

The whole credibility of the NPV method depends on a realistic prediction of future interest rates, which can often be unpredictable. It is prudent therefore to set the discount rate slightly above the interest rate at which the capital for the project is borrowed. This will ensure that the overall analysis is slightly pessimistic, thus acting against the inherent uncertainties in predicting future savings.

8.5.2 Internal Rate of Return Method

It can be seen from Example 8.5 that both projects returned a positive NPV over 10 years, at a discount rate of 8%. However, if the discount rate were reduced there would come a point when the NPV would become zero. It is clear that the discount rate which must be applied, in order to achieve a NPV of zero, will be higher for Project 2 than for Project 1. This means that the average rate of return for Project 2 is higher than for Project 1, with the result that Project 2 is the better proposition. The discount rate which achieves an NPV of zero is known as the internal rate of return (IRR). The higher the IRR, the more attractive the project.

Example 8.6 illustrates how an IRR analysis is performed.

Example 8.6

A proposed project requires an initial capital investment of £20,000. The cash flows generated by the project are shown in the following table.

Year	Cash flow (£)
0	−20,000.00
1	+6000.00
2	+5500.00
3	+5000.00
4	+4500.00
5	+4000.00
6	+4000.00

Given the above cash flow data determine the IRR for the project.

Solution

The NPV should be calculated for a range of discount rates, as shown below.

Year	Cash flow (£)	8% discount rate		12% discount rate		16% discount rate	
		Discount factor	Present value (£)	Discount factor	Present value (£)	Discount factor	Present value (£)
0	−20,000	1.000	−20,000	1.000	−20,000	1.000	−20,000
1	6000	0.926	5556	0.893	5358	0.862	5172
2	5500	0.857	4713.5	0.797	4383.5	0.743	4086.5
3	5000	0.794	3970	0.712	3560	0.641	3205
4	4500	0.735	3307.5	0.636	2862	0.552	2484
5	4000	0.681	2724	0.567	2268	0.476	1904
6	4000	0.630	2520	0.507	2028	0.410	1640
			NPV = 2791		**NPV = 459.5**		**NPV = −1508.5**

It can be clearly seen that the discount rate which results in the NPV being zero lies somewhere between 12% and 16%. The exact IRR can be found by plotting the NPVs on a graph, as shown in Figure 8.1.

Figure 8.1 shows that the IRR for the project is 12.93%. At first sight, both the NPV and the IRR methods look very similar, and in some respects they are. Yet there is an important difference between the two. The NPV method is essentially a comparison tool, which enables a number of projects to be compared, while the IRR method is designed to assess whether or not a single project will achieve a target rate of return.

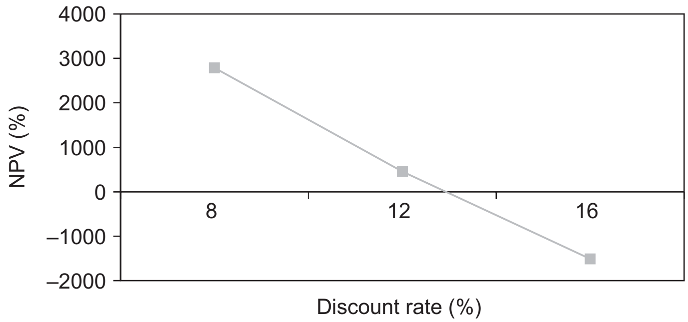

FIG 8.1 NPV versus discount rate.

8.5.3 Profitability Index

Another technique which can be used to evaluate the financial viability of projects is the profitability index. The profitability index can be defined as:

$$\text{Profitability index} = \frac{\text{Sum of the discounted net savings}}{\text{Capital costs}} \tag{8.9}$$

The higher the *profitability index*, the more attractive the project. The application of the *profitability index* is illustrated in Example 8.7.

Example 8.7

Determine the *profitability index* for the projects outlined in Example 8.5.

Solution

$$\text{Project 1: Profitability index} = \frac{40,254.00}{30,000.00} = 1.342$$

$$\text{Project 2: Profitability index} = \frac{40,867.80}{30,000.00} = 1.362$$

Project 2 is therefore a better proposal than Project 1.

8.6 Factors Affecting Analysis

Although Examples 8.5 and 8.6 illustrate the basic principles associated with the financial analysis of projects, they do not allow for the following important considerations:

- The capital value of plant and equipment generally depreciates over time.
- General inflation reduces the value of savings as time progresses. For example, £100 saved in 1 year's time will be worth more than £100 saved in 10 years' time.

The capital depreciation of an item of equipment can be considered in terms of its salvage value at the end of the analysis period. Example 8.8 illustrates this point.

Example 8.8

It is proposed to install a heat recovery device in a factory building. The capital cost of installing the device is £20,000 and after 5 years its salvage value is £1500. If the savings accrued by the heat recovery device are as shown below, determine the NPV after 5 years. Assume a discount rate of 8%.

Data:

Year	1	2	3	4	5
Savings (£)	7000	6000	6000	5000	5000

Solution

Year	**Discount factor for 8% (a)**	**Capital investment (£) (b)**	**Net savings (£) (c)**	**Present value (£) (a) × (b + c)**
0	1.000	−20,000.00		−20,000.00
1	0.926		+7000.00	+6482.00
2	0.857		+6000.00	+5142.00
3	0.794		+6000.00	+4764.00
4	0.735		+5000.00	+3675.00
5	0.681	+1500.00	+5000.00	+4426.50
				NPV = +4489.50

It is evident that over a 5-year lifespan the NPV of the project is £4489.50. Had the salvage value of the equipment not been considered, the NPV of the project would have been only £3468.00.

8.6.1 Real Value

Inflation can be defined as the 'rate of increase in the average price of goods and services' [1]. In the UK, inflation is expressed in terms of the retail price index (RPI), which is determined centrally and reflects average inflation over a range of commodities. Because of inflation, the real value of cash flows decreases with time. The real value of a sum of money (S) realized in n years time can be determined by using eqn (8.10):

$$RV = S \times \left(1 + \frac{R}{100}\right)^{-n} \tag{8.10}$$

where RV is the real value of S realized in n years time (£), S is the value of cash flow in n years time (£), and R is the inflation rate (%). As with the 'discount factor' it is common practice to use an 'inflation factor' when assessing the impact of inflation on a project. The inflation factor can be determined by using eqn (8.11):

$$\mathrm{IF} = \left(1 + \frac{R}{100}\right)^{-n} \tag{8.11}$$

The product of a particular cash flow and the inflation factor is the real value of the cash flow:

$$\mathrm{RV} = \mathrm{S} \times \mathrm{IF} \tag{8.12}$$

The application of inflation factors is considered in Example 8.9.

Example 8.9

Recalculate the NPV of the energy recovery scheme in Example 8.8, assuming that the discount rate remains at 8% and that the rate of inflation is 5%.

Solution

Because of inflation:

Real interest rate = Discount rate − Rate of inflation

∴ Real interest rate = 8 − 5 = 3%

Example 8.9 shows that when inflation is assumed to be 5%, the NPV of the project reduces from £4489.50 to £4397.88. This is to be expected, because general inflation will always erode the value of future 'profits' accrued by a project.

Year	Capital investment (£)	Net real savings (£)	Inflation factor for 5%	Net real savings (£)	Real discount factor for 3%	Present value (£)
0	−20,000.00		1.000	−20,000.00	1.000	−20,000.00
1		+7000.00	0.952	+6664.00	0.971	+6470.74
2		+6000.00	0.907	+5442.00	0.943	+5131.81
3		+6000.00	0.864	+5184.00	0.915	+4743.36
4		+5000.00	0.823	+4115.00	0.888	+3654.12
5	+1500.00	+5000.00	0.784	+5096.00	0.863	+4397.85
						NPV = +4397.88

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