Chapter 14
Economics of Energy Projects

Abstract When one asks the question, “why there are no more wind or solar photovoltaic power generation units in the world?” the simple answer is: “because fossil fuels and nuclear energy were cheaper sources to produce electricity in the near past.” When a new coal power plant produces a kWh at 3.5 cents and an old nuclear power plant for less than 1 cent per kWh, it is difficult for an electricity producing corporation to justify purchasing a wind turbine that would produce electricity at 12 cents per kWh or a solar farm that would produce at 16 cents per kWh. When the price of electricity produced from renewable sources of energy becomes less than the price produced from conventional energy sources, the economic considerations will favor the development of more geothermal units, solar plants, wind generators, etc. A combination of rising fossil fuel prices, the probable initiation of carbon credits, and a favorable regulatory environment that provides tax credits and accelerated depreciation may change these economic and financial circumstances for alternative energy. This chapter provides a succinct exposition of the entire decision making process that leads to the construction and operation of a power plant, from the realization of the need for more electric power, to the enumeration of the alternatives, to the choice of the optimum alternative solution that maximizes profitability for a corporation or, equivalently, provides the needed amount of electric energy at minimum cost. Central to the financial considerations are the concept of the time-value of funds and the Net Present Value method for the appraisal of an investment. Because this book is aimed for the engineering student with little or no knowledge of economics and finance, the level of this chapter is rather elementary. There are no highly sophisticated economic concepts and methods to be presented, while simple and comprehensive definitions of all the concepts used are offered in the text.

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14.1 Introduction

The decision-making process on energy projects is similar to the decision-making process of other engineering projects and involves the following steps:

1. The need for a project is identified. For example: the increase of the population of the City of Westerheimer necessitates the addition of 100 MW of electric power within 5 years.
2. Alternative solutions to the problem are formulated as projects, e.g. the increased electricity demand in the City may be met by one of the following: an additional nuclear power plant, an additional gas-fired plant, a new solar-thermal plant, a wind energy farm, etc.
3. The alternative projects are evaluated. This step includes a feasibility analysis and a detailed economic analysis of all the alternatives, which were identified in step (2). In evaluating the projects, all factors must be examined and some of the proposed alternative solutions may be excluded for reasons other than economic considerations. For example, the nuclear power moratorium the citizens of Westerheimer voted upon in 1988 precludes the consideration of a nuclear power plant.
4. A decision is made on the best alternative solution and the engineering project is identified and fully specified. For example, the electric company that supplies the City of Westerheimer will build from June 2012 to May 2015 a wind energy farm with wind turbines of total rated power 180 MW (to account for the lower availability factors of the wind turbines) at the Windstrum site and the project will be completed by the end of July 2015.

It must be noted that the final decision is specific enough to allow the planning and construction of the facility, but also allows sufficient flexibility for the next stages of the project. For example, it does not specify, which wind turbines will be bought and installed, how the wind turbine towers will be built, which towers will be built first, or what will be the spatial arrangement of the towers. These decisions will be made during the planning and construction stages of the project and include several engineering and environmental considerations.

This chapter will focus on steps 2, 3, and 4 of the decision making process, with particular emphasis on the formulation and evaluation of the alternatives.

14.1.1 Fundamental Concepts and Definitions

The definitions of several concepts used in the fields of economics and management, which are helpful in the decision making process for energy projects, are given in this section in alphabetical order:

Average cost: The total of all *fixed* and *variable* costs calculated over a period of time, usually one year, divided by the total number of units produced, e.g. "the average cost of electricity is $0.059/kWh."
Average revenue: The total revenue over a period of time, usually one year, divided by the total number of units produced, e.g. "the average revenue of electricity is $0.072/kWh."
Average profit: The difference between average revenue and average cost. Using the two examples above, the average profit is $0.013/kWh.
Fixed costs: All costs that are not affected by the level of business activity or production level, such as rents, insurance, property taxes, administrative salaries, and interest on borrowed capital.
Life cycle cost: The sum of all costs, fixed and variable, associated with a project from its inception to its conclusion. The life cycle costs include the planning costs as well as any abandonment, disposal, or storage costs.
Marginal or incremental cost: The cost associated with the production of one additional unit of output.
Marginal or incremental revenue: The revenue resulting from the production of one additional unit of output.
Opportunity cost: The opportunity to use scarce resources, such as capital, to achieve monetary/financial advantage. For example, an opportunity cost to building a new power plant for a company is not to build and invest their capital in 7% interest bearing securities.
Salvage value: The price paid by a willing buyer for a plant or business after all operations have ceased.
Sunk costs: All costs associated with past activity that may not be recovered and do not affect any future costs or revenues.
Time horizon: The time from the inception to the end of the project, including any disposal or storage of equipment and products.
Variable costs: Costs associated with the level of business activity or output level, such as fuel cost, materials cost, labor cost, distribution cost, etc. The variable costs increase monotonically with the number of units produced.

14.2 The Decision Making Process

The decision making process for engineering projects follows a well-defined need and is accomplished by multi-step, structured procedures, simulations, and mathematical modeling techniques. An economic analysis is made for a few carefully selected alternative solutions to the problem and the final decision takes into consideration the economic analysis as well as previous experience, environmental and social factors as well as engineering input.

14.2.1 Developing a List of Alternatives

The first stage of this process is the reformulation of the problem or need in several ways, which may stimulate creative thinking and inspire at least one alternative solution. For example, the problem that the City of Westerheimer will need another 100 MW of electric power by 2015 may be phrased in several ways including the following:

1. "By 2015 we need to install another 100 MW of electric capacity." Alternative: Build a 100 MW power plant.
2. "By 2015 we will be short of 100 MW of electric power." Alternative: Start conservation efforts that would save 100 MW.
3. "By 2015 we need to increase the power produced by our plants by 100 MW." Alternative: Build additional reheaters and feed-water heaters in the three existing coal power plants and increase their rated capacity by a total of 100 MW.
4. "We need 100 MW of green power by 2015." Alternative: Build a wind farm or a solar plant that will produce 100 MW.
5. "Unless we have another 100 MW of power by 2015, we will not be able to sustain the City's growth." Alternative: Restrict housing building permits and impede the growth of the City.
6. "Can we buy 100 MW electric capacity by 2015?" Alternative: Buy the additional energy from the nearby City of Oesterheimer, which is expected to have a surplus of electric production capacity between 2015 and 2030.

The second stage is the development of a long list of alternative solutions to the problem/need. Some of these alternatives may be mutually exclusive, while others may be combined to yield another, usually superior, alternative. Two management processes are used for the development of the longer list of alternatives, *brainstorming* and *the nominal group technique.*

A. The **conventional brainstorming process** is based on the principles that "quantity of ideas and possible solutions evolves into quality" and "deferment of judgment and selection." The process involves the following three phases:

   1. Preparation,
   2. The brainstorming session, and
   3. The evaluation session.

During the preparation phase, the participants are selected and a loosely defined statement of the problem or need is circulated. The number of participants is limited to individuals who have the ability and experience to contribute or have demonstrated creative abilities *vis a vis* the problem to be discussed. Typically, five to twelve individuals constitutes a good group for brainstorming. During the brainstorming session, ideas are generated and duly recorded. Participants are encouraged to pose different questions to the problem at hand, which would elicit alternative solutions, as in items 1–6 above. For the unhindered expression of the participating individuals and the smooth flow of ideas it is essential that:

1. All participants perceive they have equal standing during the session. Unconventional seating arrangements (round table or theater seating), casual dressing and use of first names without titles facilitate the smooth exchange of ideas.
2. Quantity of solutions/ideas is encouraged from the beginning. The concept of quality comes at a later stage.
3. Critique or list of disadvantages is ruled out. Evaluation and critique are parts of the process to follow.
4. Improvement of contributed solutions and combination of solutions is actively encouraged.

The evaluation stage will follow at the end of the brainstorming session if all participants are expected to attend. If this is not desirable, the evaluation stage will become a separate session with a smaller number of participants. During this session the outcomes of each solution are evaluated relative to the problem at hand and a smaller list of alternatives is formulated for further evaluation.

B. The **nominal group session** is a more formal meeting with the objective to achieve consensus among the participants. The list of participants and the loosely-defined statement of the problem or need are circulated to all participants before the meeting and solutions are sought. The actual meeting has a more formal setting and includes the following parts:

   1 All individual participants are expected to present and discuss their ideas in an orderly fashion. Questions and criticism of the ideas is allowed at this stage.
   2 Clarification and modification by an individual of the ideas based on the criticisms and suggestions follows and is expected as part of this process.
   3 Group modification and clarification of each idea.
   4 Ranking of all the solutions to the problem by individual voting or other means that are previously specified.
   5 Final discussion, clarification, and, perhaps, a final modification of the short list of solutions to produce group consensus on the final list.

It must be noted that, in both processes, the alternative projects to be established may be *mutually exclusive,* that is only one of the projects may be pursued at the exclusion of all others, or *complementary,* when a group of projects may be pursued simultaneously or in series.

14.3 The Time-Value of Money

After the short list of ideas/alternatives has been selected, a detailed economic evaluation for the projects in the short list is undertaken. This evaluation takes into account only the economic aspects of the chosen alternatives and determines the *profitability* of the projects. Other issues, which may not be quantified and do not affect materially the cash flow and the profitability of the project, are called *intangible items* and are left out at this stage. Such intangible items are "the public good", "a greener planet", or "overall national security." These items must have been discussed and must have been part of the short-list selection process that resulted in the short list of the alternatives. The economic analysis that follows treats the projects strictly as investments and the final decision is based on whether or not a project would be profitable to be developed for the corporation. In a capitalist, market-oriented system of for-profit corporations money-loosing projects are not initiated and are not developed.

The concept of the time-value of money is based on the premise that $1 today is worth more than $1 a year from now, the latter is worth more than $1 two years from now, and so on. The time-value of monetary funds is intricately related to the concepts of:

(a) *return to capital*, which stipulates that an amount of capital invested must yield more capital at the end of the investment period;
(b) *interest rate* or *discount rate*, r, which is the percentage of additional funds that must be earned for the lending of capital; and
(c) current and expected future *inflation*, which increases the cost of goods in the future.

When capital investments, such as energy production or conservation investments, are appraised there is an inherent risk that the investment may not succeed and that all or part of the capital may be lost. This *investment risk* is a justification for the charging of an interest rate and the expectation of higher return on the invested capital. In general, the higher the investment risk the higher would be the expected return on the capital.

Some types of investments are considered *risk free*. The interest rate associated with them, r_{rf}, is the lowest interest charged by the capital markets. Risk-free investments are usually short-term government securities, such as 3 or 6 month governmental obligations (called *treasury paper* in the USA), which typically yield very low interest. Since the government is a very stable debtor, the investors are certain that their capital and interest will be paid in full.

The return on the capital expected for other types of debt may be significantly higher: Investors will lend funds to a corporation at rates 1–10% above the r_{rf} rate and to individuals at higher rates than these. The *premium* over the rate r_{rf} depends on the financial strength of the corporation, the nature of the investment and the duration of the loan. Loans to financially weaker corporations are riskier and carry higher interest. Longer duration loans, e.g. 30 years versus 2 years, are also riskier and in general, command higher interest rates. Certain energy-related activities, such as drilling for oil and gas or building solar photovoltaic energy farms are considered among the riskiest investments. The interest rates charged for these investments and the expected return on the capital are among the highest in the energy production industry.

It is apparent from the above, that there is not only one value for the interest rate but a whole array, ranging from the risk-free, r_{rf}, to significantly higher values. There are two attributes one must consider related to the interest rate: The first is the value and the second the duration: e.g. 6% per year, 1% per month 37% per five years, etc. Typically, interest rates are quoted per year (*per annum)* but other durations may also be contracted.

14.3.1 Simple and Compound Interest

The s*imple interest* is equal to the product of the initial capital invested, which is also called *the principal, P*; the interest rate charged, r; and the number of periods the loan/investment is made, N. The formula for calculating the simple interest, I, at the end of N periods is:

$$I = PNr. \tag{14.1}$$

With simple interest the total to be paid at the end of the N periods for the whole debt is $T = P + I$. Thus, a sum of $10,000, which is lent at a 6% simple interest rate for 5 years will yield $10,000*5*0.06 = $3,000 interest. The total to be paid after five years is $13,000.

While the simple interest is easy to apply, it is not frequently used in contemporary commercial practice. The *compound interest* is used in most commercial transactions. According to the concept of compound interest, accrued interest at the end of each period is added to the original capital, P. Hence, during the subsequent periods, interest is earned not only on the original principal, but on the previously earned interest, which is added to the principal. The formula for calculating the total amount to be paid with compound interest is:

$$T = P(1 + r)^N, \tag{14.2}$$

and the interest is: $I = T - P$. With compound interest, the total interest on $10,000 invested at 6% after 5 years is: $3,382, which is significantly higher than the simple interest.

It is apparent from the above, that the time period of compounding is as important as the value of interest rate, r, in the calculation of the interest paid and a borrower must carefully consider this variable. For example, several credit card lenders charge interest compounded daily. On an average credit card balance of $1,000, a 15% annual rate (compounded annually) results in $150 interest paid at the end of one year. On the same balance, a daily compounded interest rate of 15/365% results in $162 interest.

14.3.2 Cash Flow, Equivalence and Present Value

The objective of the decision making process is the evaluation or appraisal of several alternative solutions to a need, as it was elaborated in Sect. 14.2.1. Every alternative solution involves a complex timetable of investments, expenditures and revenues or other receipts of funds. The concept of *cash flow* or *net cash flow* is a tool that keeps track of the net influx of funds for each year of the duration of the project. The *net cash flow* is defined as the sum of all yearly receipts minus all yearly expenses associated with the development, operation, and closure or abandonment of a project. Such projects may be as simple as the lending of principal in the first year to obtain the principal plus interest in the future, to a complex investment in the construction and operation of a solar energy field that is expected to last over a period of several decades. In the more complex cases, cash flow diagrams are often used to depict graphically the progress of a project and the yearly cash flow from the project. Net expenditures appear as negative values and net receipts as positive values.

Consider the construction of a photovoltaic generation plant where the owner and operator must invest $500,000 in the first year and $1,000,000 in the second year. The plant is completed at the end of the second year and operates continuously for ten more years. The total revenue of the plant's operation is $200,000 during the third year and increases afterwards at a rate of 7% annually. The total expenses associated with the operation of the solar project are $50,000 during the third year and increase at a rate of 5% annually in the subsequent years of operation. At the end of the project, the end of the twelfth year, the operations discontinue. At this point, the salvage value of the solar energy project is $300,000. Table 14.1 shows all the monetary expenditures and receipts from the inception to the end of the project and the net cash flow for every year.

The cash flow diagram for this solar project is depicted in Fig. 14.1. The cash flow diagram is a succinct and convenient depiction of the annual income, from which a more detailed financial analysis may be made.

The monetary amounts comprising the cash flow pertain to funds earned or spent during the corresponding year. For example, if the first year for the solar energy field project is 2010, the cash flow item 250.8 pertains to the tenth year, or the calendar year 2019. The concept of the time value of money complicates the appraisal method by inserting the concept time as an additional variable: Given that when one compares solutions or projects there must be a common basis for the comparison, how does one evaluate several potential projects that involve a multitude of monetary expenses and receipts over the lives of the projects that span several years or decades? It is apparent that for such an evaluation or appraisal of the projects, one must reduce all the monetary expenses and benefits of each

Table 14.1 Yearly expenditures, revenues and cash flow for the small solar photovoltaic power plant. In thousands of $US

Year	Investment	Sum of receipts	Sum of expenses	Salvage value	Cash flow
1	−500	0	0		−500
2	−1,000	0	0		−1,000
3	0	200	−50		150
4	0	214	−52.5		161.5
5	0	229.0	−55.1		173.9
6	0	245.0	−57.9		187.1
7	0	262.2	−60.8		201.4
8	0	280.5	−63.8		216.7
9	0	300.1	−67.0		233.1
10	0	321.2	−70.4		250.8
11	0	343.6	−73.9		269.8
12	0	367.7	−77.6	300	590.1

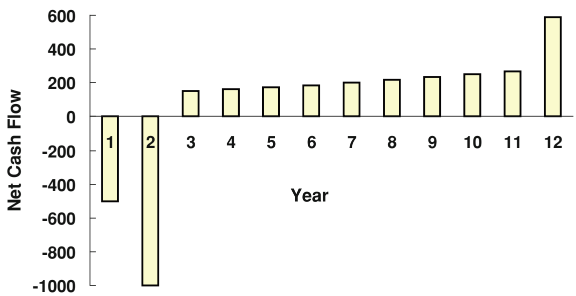

Fig. 14.1 Cash flow diagram for a small solar photovoltaic power plant

project to an *equivalent basis*. Equivalency here implies that an informed investor is indifferent between two sums of funds to be received at two different times in the future. For example, if an investor is indifferent between $100,000 to be paid in 2014 and $120,000 in 2017, then these two sums are *equivalent* to this investor. The *Present Value, PV,* of future funds or future returns offers a way of establishing this equivalent basis for the comparison of several projects. The PV establishes the currently equivalent monetary value of future funds for an investor or a corporation.

The present value, PV, of a principal amount of funds, M, to be obtained after N time periods at a discount rate, r_d, is defined as:

$$PV = \frac{M}{(1 + r_d)^N}, \tag{14.3}$$

that is an amount equal to PV today is accepted to be equivalent to a greater amount M after N periods of time. A glance at Eqs. (14.2) and (14.3) proves that the present value is directly related to the compound interest concept, with the discount rate being equivalent to the interest rate. The PV is equivalent to the principal invested today and the future amount M is equivalent to the total sum, T, which is expected after N periods of the investment. Another way to look at the present value is that an informed investor is indifferent between having a sum equal to PV today or a sum equal to M, N periods of time later. By evaluating the present value of all the cash flows for all the alternative projects, one establishes an equivalent basis for the appraisal of alternative projects that have different durations of cash flow and life cycles. Also one establishes a common basis for a rational economic comparison of the alternative projects. This will aid the final stages of the decision-making process.

Oftentimes in financial calculations there is a constant amount of funds, expenditures or incomes, which is repeated for several years. This is called an *annuity* and, since it is earned or expended over several years, it has a present value. The present value of the constant amount, A, earned or spent in every year, starting in year 1 and ending in year N is:

$$PV_A = \frac{A}{(1+r_d)} + \frac{A}{(1+r_d)^2} + \ldots + \frac{A}{(1+r_d)^N} = A\left[\frac{1/(1+r_d)^{N+1} - 1}{1/(1+r_d) - 1}\right] = \\ = \frac{A}{(1+r_d)^N}\left[\frac{(1+r_d)^{N+1} - 1}{r_d}\right]. \tag{14.4}$$

Associated to the annuity concept is the present borrowing of a principal sum of funds with the promise to repay both the principal and the interest in equal amounts over a fixed number of time periods. This is the concept most of the housing *mortgages* are based on, as well as most bank loans to small companies. In consideration of funds received at present, P, the owner promises to make a number of equal and regular payments in the future. In such cases, the term of the mortgage is counted in months and the agreed upon annual interest rate, i, takes the place of the discount rate. The periodic monetary payment, M, is given by the expression:

$$M = \frac{iP(1+i)^N}{(1+i)^{N+1} - 1}. \tag{14.5}$$

For a typical house mortgage with 30 year duration, the number of monthly periods is N = 30*12 = 360, and the interest rate, i, is the monthly interest. The latter is equal to 1/12th of the quoted annual rate. For example if the quoted annual rate is 6%, i = 0.06/12 = 0.005.

14.3.3 Cash Flow Calculations

The cash flow is a convenient concept in financial accounting that summarizes all the revenues and expenses associated with a project during a period of time, typically one calendar year. The following items are summed to make up the cash flow of a project, with the positive items denoted by (+) and negative items denoted by (−):

Revenues (+): All cash receipts from selling the product or services related to the project.
Interest earned (+): Any interest earned by funds directly associated with the project.
Tax credits (+): Credits on paid and unpaid taxes granted by local, regional, and national governments. These are typically a percentage (10–30%) of the project investment. Because of the worldwide energy challenge and climate change regulations, alternative energy projects are beneficiaries of tax credits in most OECD countries. However, for a corporation to take advantage of tax credits, it must have taxable income during the year at which credits are sought. Certain tax credits may roll in future years.
Rebates (+): All monetary receipts that are directly connected to the investment of the project and are received as a result of the investment.
Salvage value (+): The fair market price of equipment that is not used and may be sold in the market.
Capital expenditures (−): All expenses of capital equipment and construction associated with the project.
Other fixed costs (−): These include: rents of space or equipment, management and administration costs, interest paid, insurance, etc. The fixed costs do not depend on the units of energy produced and must be paid even if the business or project does not produce any units.
Variable costs (−): These are monotonically increasing with the level of production. Among the variable costs are the cost of fuel, labor costs excluding administration, and distribution costs.
Taxes (−): These are usually a percentage of the *taxable income* of a corporation. Detailed tax codes in every country specify what the *tax rate* is and how the taxable income may be calculated. While a full description of the tax code is beyond this short exposition, an item of importance for energy projects is the *depreciation schedule*. The depreciation schedule, which is different in the tax codes of different countries, specifies the way capital expenditures of a project may be *amortized* (or subtracted from the taxable income). In general, high depreciation expenses reduce the taxes paid by corporations.
Closure costs (−): Any cost associated with the termination of the project. For energy projects, this may include land clean-up and rehabilitation, well shutting, disposal of equipment, and, in the case of nuclear power plants, the decontamination of the equipment and the long-term storage of nuclear waste.

14.3.4 A Note on the Discount Rate and Interest Rates

It is apparent that the discount rate, r_d, is a fundamental concept in the calculation of the present value of any future sum, M. The choice of the right value for the appropriate discount rate is of paramount importance in any engineering project.

As with the interest rates, there is not a single discount rate used by corporations, governmental agencies and individuals, but a range of discount rates that depend upon the following parameters:

1. *The type of entity/corporation that performs the project* (*public or private*). In general, public corporations do not aim for profits and may borrow funds at lower rates than private corporations and, since their cost of capital is lower, their discount rates are lower too.
2. *The risk of the project*. The more risky the project (e.g. because of new technology utilization) the higher is the return sought and the higher would be the discount rate.
3. *The overall economy and ease of borrowing capital*. In general, when the overall economy is healthy it is easier to borrow funds. Interest rates are lower and so are the discount rates of corporations.
4. *Inflation*. Inflation or expected future inflation is directly and monotonically correlated with discount rates.
5. *The length of the project*. Longer projects are associated with higher economic uncertainty and risk and the discount rates used may be significantly higher. For that matter, the long term interest rate charged by financial institutions is in general higher than short term interest rate.

The discount rate, r_d, used by corporations and public utilities is significantly higher than the interest rate, r, charged by financial institutions. It is usually tied to an interest rate by a simple formula such as: $r_d = r+\delta r$, where δr is in the range 3–15%. Corporations have a range of discount rates, which depend on the perceived risk and the duration of the project (short, intermediate, or long term). The interest rate, to which the discount rate may be tied, is usually one of the following:

1. The *inter-bank discount rate*, which is the rate banks charge each other for borrowing funds and (in the USA) is set by the Federal Reserve Board.
2. The *short-term interest rate* of government securities. This is typically the interest rate on the 6 month or 12 month Treasury bonds.
3. The *intermediate interest rate,* which is the interest rate of 10 year Treasury bonds.
4. The *long-term interest rate* of government securities. This is typically the interest rate on 20 or 30 year Treasury bonds.
5. The *prime rate* charged by financial institutions. This rate is usually offered to the best and most risk-free customers of the institutions.
6. The *cost of borrowed* capital. This represents the interest rate paid by the corporation when it issues long-term bonds. Because every corporation and public utility has different financial ratings and ability to attract capital by issuing bonds, the cost of borrowed capital varies significantly between the several corporations and public utilities.
7. The *expected return on equity*. This rate is used for internally financed projects and is equal to the return expected by the shareholders of the corporation.

This rate also varies significantly between the different corporations and public utilities.

Typically, large energy projects are financed by a combination of public borrowing and equity. The pertinent discount rate is between the values of the last two rates. If any part of the project is financed by banks, one of the first four rates may come in the formula that determines the discount rate. It must be noted that the interest rates are not constant and vary daily (usually by a small amount). A glance at the financial pages of most newspapers shows the previous-daily values of the first five interest rates, which were mentioned above. The last two pertain to individual corporations and are not publicized.

14.4 Investment Appraisal Methods

When the list of the possible alternative projects has been established and a way has been determined for the equivalency of the future cash flow, one must use a method to evaluate the alternatives and to make a final decision on which project to develop. Every good method of project evaluation must have the following characteristics:

1. It takes into account the time horizon of the project.
2. It takes into account all cash flows pertinent to the project for the entire time horizon.
3. It defines an acceptable way to discount future cash flows and uses an *equivalent basis* of future cash flows.

In the next subsections, several methods that are commonly used for the evaluation of investments in energy projects are presented and compared.

14.4.1 The Net Present Value (NPV)

This method is sometimes called *present worth or net present worth.* The NPV of a project is the sum of the discounted annual cash flows from the inception to the disposal of the project. Consider a project that commences at the present year, which is usually denoted as year 0, and finishes at year n, that is n + 1 years later. The pertinent cash flow streams are: CF_0, CF_1, $CF_2 \ldots$, CF_n and the discount rate is r_d. The equation that defines the NPV of this project is:

$$NPV = CF_0 + \frac{CF_1}{(1 + r_d)} + \frac{CF_2}{(1 + r_d)^2} + \ldots + \frac{CF_n}{(1 + r_d)^n} = \sum_{i=0}^{n} \frac{CF_i}{(1 + r_d)^i}. \quad (14.6)$$

If the NPV of a project is positive, the entity that considers it (a public utility or a for-profit corporation) incurs a net present benefit or profit from its development and execution. If the NPV is negative, there is no advantage to the entity from pursuing the project, because it is equivalent to a present loss. The latter project is not undertaken. It is apparent that the discount rate, r_d, plays a very important role in the calculation of the NPV and this is one of the most difficult parameters to determine precisely. The r_d value for projects is usually established by the management after taking into account the factors listed in the previous section.

During the decision making process, the NPV's of all alternatives are calculated. For a project to be acceptable, its NPV must be positive. Therefore, all alternative projects with negative NPV must be rejected and only the ones with positive NPV are considered. If these alternatives are exclusive, that is only one must be selected, the alternative project with the highest positive NPV is selected to be developed. If the projects are not exclusive, they are ranked in order of decreasing NPV, with the first few projects having the priority for further development. In the latter case, the decision of how many projects to pursue is dictated by resource availability considerations, such as: a) the availability of capital (do we have enough funds available for the investments needed?); and b) the capacity of the entity to pursue simultaneously these projects (can we design all the power plants? Do we have enough supervising engineers for all the projects?).

The NPV is a straightforward way of calculating the present equivalent of all the benefits and costs associated with the energy projects and provides an excellent method to assess the benefits of all energy production and conservation projects. It also helps to prioritize and rank projects. For these reasons, the NPV method is recommended for the appraisal of all energy projects.

14.4.2 Average Return on Book (ARB)

The "Book" in this method refers to the *Book Value* of an investment, which is an accounting concept. The Book Value is defined as the initial monetary value of the investment minus the accumulated depreciation. According to this method, a project is undertaken if the ARB is greater than an acceptable rate, which is usually determined by management.

Let us consider a project that starts in year 0 with a $12,000 investment, straight line depreciation is allowed during the years 1–3. The yearly net income of this project is $2,700. Table 14.2 shows the Book Value of this project during the four years of the life of the project:

The Average Book Value is (12,000 + 8,000 + 4,000 + 0)/4 = 6,000 and the ARB is 2,700/6,000 = 0.45 or 45%. This project would be undertaken if the acceptable ARB rate to the management is less than 45%.

The ARB method suffers from several deficiencies: First, there is no allowance that immediate income is more valuable than future income. Thus, the *equivalent basis* of revenues and costs is not an inherent attribute of this method. Secondly, it

Table 14.2 Calculation of book value

	Year 0	Year 1	Year 2	Year 3
Investment	12,000			
Net income	2,700	2,700	2,700	2,700
Accumulated depreciation	0	4,000	8,000	12,000
Book value	12,000	8,000	4,000	0

does not use the cash flows, which are real and tangible flows, but the accounting income, which is an accounting concept. The accounting net income does not take into account all capital expenses for a project during the year they occur, but only takes into account the allowed depreciation of these costs. Thirdly, the method uses the Average Book Value, another accounting concept, which does not differentiate between recent and distant capital expenditures. And, fourthly, the acceptable ARB is usually based on historical facts and is more difficult to determine based on the current economic environment and the current interest rates. For all these reasons, the ARB is not an investment appraisal method that is recommended to be used with energy projects, which are typically long-term projects.

14.4.3 The Pay-Back Period (PBP)

According to this method, the initial investment on the project must be recovered from net receipts/income within a specified period of time, which ranges from two to six years. This is the *payback period* and is calculated by counting the number of years it takes for the cumulative cash flows to equal the initial investment. Thus, a project that requires an initial investment of $1,000,000 and pays net cash flows of $100,000 in the first two years and $210,000 thereafter would have a payback period of six years: During the first five years the cumulative cash flow is $830,000, which is less than the initial investment, while during the first six years the cumulative cash flow is $1,040,000 which surpasses the initial investment of $1,000,000.

The payback period method makes use of the cash flows, which is the correct parameter for the calculation of the annual costs and benefits of the project. However, it does not differentiate between recent and distant cash flows or between capital expenditures that occur at the beginning or at another time during the life of the project. Therefore, the *equivalence basis* is not inherent in the PBP method. Another disadvantage of the method is that the recovery of the initial capital may be achieved in a fraction of years, while the rule for the acceptance of a project is always expressed in whole years. Table 14.3 shows the cash flows, the payback period and the NPV, calculated at a discount rate of 10%, for three projects, which have the same initial investment of $2,000,000. It is apparent that, although all projects have the same payback period of two years, one of the

Table 14.3 Payback period and net present value for three hypothetical projects. Numbers in $1,000

Project	CF_0	CF_1	CF_2	CF_3	PBP (yrs)	NPV
A	−2,000	1,000	1,000	5,000	2	3,492
B	−2,000	0	2,000	5,000	2	3,409
C	−2,000	1,000	1,000	100,000	2	74,857

projects (C) is superior to the first two by a wide margin, because of the large income that occurs after the initial payback period. Even when one examines only projects A and B, the first project is superior because it provides positive cash flow during the first year. The NPV, which is listed in the last column, is a better way to make a rational choice among the three projects.

The *Discounted Payback Period* (*DPBP*) method has been proposed, where the cash flows are discounted by a rate as in the NPV method. While this modification takes into account the time value of funds, it still does not take into account any funds that are obtained after the cutoff period. In addition, the value of the Payback Period (in years) is arbitrary and does not take into account the current economic environment and the ability of the corporation or utility to borrow and use funds. In the projects of Table 14.3 the large payoff in year 3 of project C does not receive the emphasis it deserves.

14.4.4 Internal Rate of Return (IRR)

The IRR method is connected directly and, in most cases, is equivalent to the NPV method: The IRR of a project is the value of rate of return, r_{ir}, which makes the NPV of the project equal to zero. The expression that defines the rate r_{ir} is:

$$CF_0 + \frac{CF_1}{(1+\ r_{ir})} + \frac{CF_2}{(1+\ r_{ir})^2} + \ldots + \frac{CF_n}{(1+r_{ir})^n} = \sum_{i=0}^{n} \frac{CF_i}{(1+r_{ir})^i} = 0. \qquad (14.7)$$

For the application of the IRR method, the nonlinear Eq. 14.7 is solved to obtain the value of r_{ir}. For the decision making process, if $r_{ir} > r_d$, then the project should be undertaken and if $r_{ir} < r_d$ the project should be abandoned.

It is apparent that calculating the IRR is more cumbersome than calculating the NPV. The IRR is based on the NPV and in most cased the two methods are equivalent and may be used interchangeably. However, there are cases when the IRR method is not equivalent to the NPV. This stems from the non-linearity in the computation of the IRR and applies to mutually exclusive projects and projects that include investments at different timeframes. Table 14.4 below, shows three mutually exclusive projects where the NPV and IRR methods yield different results. While projects A and B have the same initial investment, project A has a higher IRR because the returns occur early in the life of the project. In this case,

Table 14.4 IRR and NPV for three mutually exclusive projects. Numbers are in $1,000

	CF_0	CF_1	CF_2	CF_3	CF_4	CF_5	CF_6 to CF_∞	IRR, %	NPV at 10%
A	−9,000	6,000	5,000	4,000	0	0	0	33	3,592
B	−9,000	1,800	1,800	1,800	1,800	1,800	1,800	20	9,000
C	0	−6,000	1,200	1,200	1,200	1,200	1,200	20	6,000

the NPV and the IRR will yield different rankings for the two projects as long as the value of r_d used in the NPV method is lower than 15.6%. If $r_d > 15.6$ the two methods yield the same rankings. Projects B and C have the same IRR (20%), but the NPV of project B is higher, primarily because of the higher initial investment.

While the NPV and the IRR methods are equivalent in most cases, the NPV is simpler and leads to better decisions, especially when one deals with mutually exclusive projects with complex payoff schedules.

14.4.5 Profitability Index (PI)

The *profitability index* is sometimes referred to as *benefit-cost ratio* and is defined as the sum of all discounted future positive cash flows divided by the initial investment. If all initial investment occurs in year 0 and is denoted by I, and the cash flows in years 1 to n are denoted as CF_1, CF_2, CF_3,…, and CF_n, respectively, the expression for the PI is as follows:

$$PI = \left(\frac{CF_1}{(1 + r_d)} + \frac{CF_2}{(1 + r_d)^2} + \ldots + \frac{CF_n}{(1 + r_d)^n} \right) / I = \frac{1}{I} \sum_{i=1}^{n} \frac{CF_i}{(1 + r_d)^i}. \tag{14.8}$$

For the decision-making process, if $PI > 1$, the project is profitable and should be undertaken.

The PI method has several common features with the NPV method. For example, the time-value of funds is inherent in both methods and the present value of all positive cash flows is used in the PI method. Both methods may also use the same discount rate. However, when the investment occurs over a period of several years and when the investment and revenue streams follow a complex pattern and are mixed during several years, as it often occurs in the early years of an energy project, the PI method becomes more difficult to use and may lead to an erroneous decision between two mutually exclusive projects.

It is apparent, that the NPV method is a relatively simple method to use, especially with long-term and complex projects. This method is recommended to be used for energy generation and improved efficiency projects because it is well defined, it is relatively simpler to use than the other methods, and it is widely accepted by the business and engineering communities.

14.5 Use of the NPV Method for Electricity Generation Projects

Having established the advantages of using the NPV method as a tool for energy project investment appraisal, we may now study how to use this method in a practical situation:

Let us consider the building of a wind farm for the production of electricity in a location in Western Texas. The nominal power rating of this wind farm is 50 MW. The investment for this project is estimated to be $40,000,000 ($40 M) to be spent as follows: $10 M in year 0 for the preparation of the field and the design of the farm; $25 M in year 1 to be spent mostly on the wind turbines/generators; and $5 M in year 2 for the installation of the turbines/generators and connection to the grid. The corporation plans to put $20 M of investment into the project and finance the other $20 M in year 1 of the project by issuing 12 year bonds at an interest rate of 7%. Based on the wind conditions in the area, it is determined that the plant will produce on average 300,000 kWh per day for 365 days per year, or an average of $1.095*10^8$ kWh/yr. No electricity will be produced in years 0 and 1, while the plant is in construction, 50% of the total capacity will be produced in year 2 and 100% thereafter. It is estimated that the useful life of this power plant will be 12 years after the completion of the installation. At that point, the year 14 of the project, the whole wind farm may be sold to another corporation for $8 M. The fixed costs of the plant are estimated to be $100,000 per year, starting in year 0 and increasing at an annual rate of 3%. The operating costs are estimated to be $250,000/yr, starting in year 2 and increasing at 7% annually for the duration of the project. The average price of electricity is currently $0.047/kWh and it is expected to increase at an annual rate of 3.5%. The corporation is taxed at 28% rate and a straight-line, 10 year depreciation schedule is allowed. Given that wind farm technology is still considered risky, the corporate discount rate, r_d, for this type of investment is 15%.

A clarification is needed on the financing of this project: It is common practice for energy producing corporations to issue interest-bearing bonds to finance part of their projects, in this case 50% of the total investment. For simplicity, it will be assumed that the total revenue of the bonds will be collected at the end of year 0, interest will be paid for the bonds during years 1 through 12 and the whole principal of $20 M for the bonds will be repaid to the bondholders at the beginning of year 13. Thus, in year 1 the actual investment by the corporation is $5 M with the other $20 M coming from the issuing of bonds that will be repaid in year 13.

Regarding the cash flow, the revenue of this project comes entirely from the production of electricity, which is: 0 during years 0 and 1; $0.5475*10^8$ kWh during year 2; and $1.095*10^8$ kWh during years 3–14; and from the salvage value at the end of the project. The costs of the project consist of: investment of capital, annual fixed and variable costs; closing costs of $100,000 at the end of the project; interest expense on the bonds; and taxes paid by the corporation. The taxes are 28% of the *taxable income* of the corporation, which is for simplicity defined as the total annual revenue minus annual fixed and variable expenses, minus interest, minus the allowable depreciation. Given the schedule of the investment for this project, the depreciation of all the expenses is allowed over a period of 10 years. Thus, the allowable depreciation is as follows:

- for the year 0 the allowable depreciation is $1 M (= $10 M/10)
- for the year 1 the allowable depreciation is $3.5 M ($10 M/10 + $25 M/10)
- for years 2 through 9 the allowable depreciation is $4.0 M ($10 M/10 + $25 M/10 + $5 M/10)
- for year 10 the allowable depreciation is $3 M ($25 M/10 + $5 M/10)
- for year 11 the allowable depreciation is $0.5 M ($5 M/10).

Thus, at the end of year 11 the entire investment has been depreciated and there is no depreciation allowed in the subsequent years. It will be assumed that the corporation has other profitable activities to take advantage of the accrued depreciation during years 0 and 1, when there is no revenue from the project. In these two years, the project will incur a "negative tax," which is equivalent to a tax benefit for the corporation by offsetting taxes from other operations. Table 14.5 shows the steps for the calculation of the NPV for this project. Under the assumptions stated above, the NPV of the project is a negative $1,011,078, which dictates that the corporation should not undertake the development of this wind farm.

The question arises then, "under what conditions would this *green energy* project be profitable?" And the obvious answer is "if some parameters changed to favor the NPV." For example, if the current price of electricity were $0.05/kWh and everything else remained the same, the NPV would be a positive $148,094 and the project would be worth undertaking. This implies that, if consumers are willing to pay half a cent per kWh more, this renewable energy project would materialize. Similarly, if the project were determined to be less risky by the corporation and the discount rate were 13% instead of 15%, the NPV would be a positive $426,635 and, again, this project would be worth undertaking by the utility. Projects become less risky, when corporations accumulate a great deal of expertise in operating them and when certain financial guarantees are received from local or state governments, which is the subject of the next section.

The formulae used for the computation of the cash flow are given here for reference purposes. It must be pointed out that these formulae and the Tables in this chapter are for illustration purposes only. Accounting and the tax laws differ from country to country and, hence, the *taxable income* is differently defined in different countries.

Total Revenue = (Revenue from Electricity) + (Salvage Value).
Total Costs = (Capital Investment) + (Closing Costs) + (Fixed Costs) + (Variable Costs) + (Interest on Bonds) + (Bond Repayment).
Pre-Tax Income = (Total Revenue)−(Closing Costs)−(Fixed Costs)−(Variable Costs)−(Interest on Bonds)−(Bond Repayment).

Table 14.5 NPV calculation of the wind farm—basic scenario

NPV of a 50 MW wind farm,basic scenario

Years	0	1	2	3	4	5	6	7
Revenue								
Price, per kwh	0.0470	0.0486	0.0503	0.0521	0.0539	0.0558	0.0578	0.0598
kWh produced	0	0	54,750,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363	6,547,785
Salvage value	0	0	0	0	0	0	0	0
Total revenue	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363	6,547,785
Costs								
Capital investment	10,000,000	5,000,000	5,000,000	0	0	0	0	0
Closing costs	0	0	0	0	0	0	0	0
Fixed costs	100,000	103,000	106,090	109,273	112,551	115,927	119,405	122,987
Variable costs	0	0	250,000	267,500	286,225	306,261	327,699	350,638
Interest on bonds	0	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
Bond repayment	0	0	0	0	0	0	0	0
Total costs	10,100,000	6,503,000	6,756,090	1,776,773	1,798,776	1,822,188	1,847,104	1,873,625
Tax calculation								
Pre-tax income	−1,00,000	1,503,000	1,000,440	3,929,244	4,106,951	4,290,239	4,479,258	4,674,160
Depreciation	1,000,000	3,500,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
Tax credit	0	0	0	0	0	0	0	0
Taxable income	−1,100,000	5,003,000	−2,999,560	−70,756	106,951	290,239	479,258	674,160
Tax	−308,000	1,400,840	−839,877	−19,812	29,946	81,267	134,192	188,765
Cash flow	−9,792,000	5,102,160	−3,159,683	3,949,056	4,077,005	4,208,972	4,345,066	4,485,395
Discount factor	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269
Discount cash flow	−8,514,783	3,857,966	−2,077,543	2,257,885	2,026,992	1,819,655	1,633,471	1,466,284
Net present value	−1,011,078							

Table 14.5 (continued)

NPV of a 50 MW wind farm,basic scenario

Years	8	9	10	11	12	13	14
Revenue							
Price, per kwh	0.0619	0.0641	0.0663	0.0686	0.0710	0.0735	0.0761
kWh produced	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	6,776,958	7,014,151	7,259,647	7,513,734	7,776,715	8,048,900	8,330,611
Salvage value	0	0	0	0	0	0	8,000,000
Total revenue	6,776,958	7,014,151	7,259,647	7,513,734	7,776,715	8,048,900	16,330,611
Costs							
Capital investment	0	0	0	0	0	0	0
Closing costs	0	0	0	0	0	0	100,000
Fixed costs	126,677	130,477	134,392	138,423	142,576	146,853	151,259
Variable costs	375,183	401,445	429,547	459,615	491,788	526,213	563,048
Interest on bonds	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	0	0
Bond repayment	0	0	0	0	0	20,000,000	0
Total costs	1,901,860	1,931,923	1,963,938	1,993,038	2,034,364	20,673,066	814,307
Tax calculation							
Pre-tax income	4,875,098	5,082,229	5,295,708	5,515,696	5,742,351	7,375,834	15,516,304
Depreciation	4,000,000	4,000,000	3,000,000	500,000	0	0	0
Tax credit	0	0	0	0	0	0	0
Taxable income	875,098	1,082,229	2,295,708	5,015,696	5,742,351	7,375,834	15,516,304
Tax	245,027	303,024	642,798	1,404,395	1,607,858	2,065,233	4,344,565
Cash flow	4,630,071	4,779,205	4,652,910	4,111,301	4,134,493	−14,689,400	11,171,739
Discount factor	0.2843	0.2472	0.2149	0.1869	0.1625	0.1413	0.1229
Discount cash flow	1,316,155	1,181,346	1,000,111	768,432	671,971	−2,076,033	1,372,945
Net present value							

Production 109,500,000 kWh/yr; Price growth rate = 0.035% annually; Internal Rate of Return = 15%; Fixed cost growth rate = 3%; Variable cost growth rate = 7%; Corporate tax rate = 28%

Taxable Income = (Pre-Tax Income)−(Depreciation).
Tax = (Taxable Income)*(Tax Rate)−(Tax Credit).
Cash Flow = (Total Revenue)−(Total Costs)−(Tax).
Discount factor for year i: $1/(i + r_d)^i$.
Discounted Cash Flow = (Cash Flow)*(Discount factor for year i).
NPV = Sum of all Discounted Cash Flows.

14.5.1 NPV and Governmental Incentives or Disincentives

It is apparent from the calculations of the last section that one may find several combinations of prices, variable and fixed costs, growth rates, etc. that render a given project worth undertaking to a corporation. The use of a spreadsheet helps significantly with the calculations. It must be noted, however, that these parameters are not within the control of a corporation. The determination of the future values of most of these parameters represents mere assumptions that are made by accountants and engineers, using past experiences on similar projects. However, recent experience dictates that many of these parameters (e.g. fuel costs in the decade 2001–2010) may vary widely and unpredictably. This adds to the risk of a project and contributes to corporations using higher discount rates.

There are several parameters that determine the NPV of a project, which are controlled by the local or central governments. Among these parameters are:

(a) The tax rate (28% in the example of Table 14.5).
(b) The allowable schedule of depreciation.
(c) Offering tax credits for certain *green energy* activities and projects.
(d) Guaranteed price for the energy produced or yearly rate increases.

Items b) and c) are offered currently as incentives for the renewable energy projects in several OECD countries. Recently, renewable energy and conservation projects have attracted significant credits from 5 to 30% in most OECD countries. Such incentives play a significant role in reducing the risk of renewable energy projects and, also, in making the NPV or the project positive and the project worth developing. We will consider here two such cases, both of which affect the taxation of the corporation:

1. *Allow the capital costs of the project to be depreciated faster*: Instead of a 10 year depreciation schedule, let us assume that the capital equipment may be depreciated with the straight-line method within 5 years. Thus, the allowable depreciation in year 0 is \$2 M; in year 1 it is \$7 M; in year 2, \$8 M; in year 3, \$8 M; in year 4, \$8 M; in year 5, \$6 M; and in year 6, \$1 M. This is called *accelerated depreciation schedule.* The effect of only this schedule of accelerated depreciation is to make the NPV of the project from a negative \$1,011,078 to a positive \$665,287. The positive NPV will

swing the decision-making process in favor of the construction of the plant. The calculations for this example are shown in Table 14.6. All parameters are the same as in the previous case except for the allowable depreciation. It is apparent that only this, seemingly minor modification, would swing the decision-making process from negative to positive. An accelerated schedule of depreciation allows a corporation to receive certain tax benefits earlier rather than later on the funds it has already spend. Since the early benefits of a project affect the NPV the most, an accelerated depreciation schedule always has a positive effect on the NPV.

2. *Tax credits on the investment*: Tax credits work in a similar way, with the corporation receiving back in the form of reduced taxes a percentage of its investment in equipment and facilities. Let us assume that there is a governmental 10% tax credit on the investment for renewable energy projects, such as the wind farm under consideration. Although tax credits vary from country to country, 10% is on the lower end of the range of rates that have been offered for such projects in the U.S.A., France, Germany, Greece, the United Kingdom, and Italy during the decade 2001–2010. With a 10% tax credit on renewable energy investments, the corporation saves from other taxable activities \$1 M during year 0, \$2.5 M in year 1 and \$0.5 M in year 2. In this case, the tax credits are sufficient to change the negative NPV of the basic scenario to a positive value of \$2,077,605 as shown in Table 14.7, which has been calculated with the same parameters as those for Table 14.5, but with a 10% tax credit on the investment for the wind farm.

It must be emphasized that, for a corporation to receive the tax benefits of accelerated depreciation and the tax credits, it must have other profitable taxable operations, whose taxes would be offset by the depreciation benefit. If a corporation does not have other profitable operations, claiming the depreciation and credits may be delayed for later years in some countries. However, this delay would have a negative impact on the NPV. Individuals, smaller corporations or small start-up companies typically do not benefit from accelerated depreciation schedules. Direct subsidies and rebates may be more effective incentives for smaller corporations and individuals.

3. *A regulatory disincentive:* The regulatory environment, which is largely controlled by central, regional and local governments, may also impose incentives and disincentives to energy projects. An obvious disincentive is the taxation of alternative energy activities or by-products, such as the imposition of a disposal fee on nuclear waste, which may be justified on the grounds that it takes funds to process and store the waste produced by nuclear power plants. Another disincentive that rarely comes to the attention of the public is a prolonged delay of the commencement of the energy project because of a local judicial decision, usually on a perceived environmental or ecological effect of the energy project. Consider, for example, the case of the wind farm with accelerated depreciation. As shown in Table 14.6, the project has a NPV of \$665,287 and the corporation

Table 14.6 NPV calculation of the wind farm—basic scenario with accelerated depreciation

NPV of a 50 MW wind farm, accelerated depreciation

Years	0	1	2	3	4	5	6	7
Revenue								
Price, per kwh	0.0470	0.0486	0.0503	0.0521	0.0539	0.0558	0.0578	0.0598
kWh produced	0	0	54,750,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363	6,547,785
Salvage value	0	0	0	0	0	0	0	0
Total revenue	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363	6,547,785
Costs								
Capital investment	10,000,000	5,000,000	5,000,000	0	0	0	0	0
Closing costs	0	0	0	0	0	0	0	0
Fixed costs	100,000	103,000	106,090	109,273	112,551	115,927	119,405	122,987
Variable costs	0	0	250,000	267,500	286,225	306,261	327,699	350,638
Interest on bonds	0	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
Bond repayment	0	0	0	0	0	0	0	0
Total costs	10,100,000	6,503,000	6,756,090	1,776,773	1,798,776	1,822,188	1,847,104	1,873,625
Tax calculation								
Pre-tax income	−100,000	−1,503,000	1,000,440	3,929,244	4,106,951	4,290,239	4,479,258	4,674,160
Depreciation	2,000,000	7,000,000	8,000,000	8,000,000	8,000,000	6,000,000	1,000,000	0
Tax credit	0	0	0	0	0	0	0	0
Taxable income	−2,100,000	−8,503,000	−6,999,560	−4,070,756	−3,893,049	−1,709,761	3,479,258	4,674,160
Tax	−588,000	−2,380,340	−1,959,877	−1,139,812	−1,090,054	−478,733	974,192	1,308,765
Cash Flow	−9,512,000	−4,122,160	−2,039,683	5,069,056	5,197,005	4,768,972	3,505,066	3,365,395
Discount factor	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269
Discount cash flow	−8,271,304	−3,116,945	−1,341,125	−2,898,249	2,583,830	2,061,758	1,317,684	1,100,154
Net present value	665,287							

Table 14.6 (continued)

NPV of a 50 MW wind farm, accelerated depreciation

Years	8	9	10	11	12	13	14
Revenue							
Price, per kwh	0.0619	0.0641	0.0663	0.0686	0.0710	0.0735	0.0761
kWh produced	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	6,776,958	7,014,151	7,259,647	7,513,734	7,776,715	8,048,900	8,330,611
Salvage value	0	0	0	0	0	0	8,000,000
Total revenue	6,776,958	7,014,151	7,259,647	7,513,734	7,776,715	8,048,900	16,330,611
Costs							
Capital investment	0	0	0	0	0	0	0
Closing costs	0	0	0	0	0	0	100,000
Fixed costs	126,677	130,477	134,392	138,423	142,576	146,853	151,259
Variable costs	375,183	401,445	429,547	459,615	491,788	526,213	563,048
Interest on bonds	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	0	0
Bond repayment	0	0	0	0	0	20,000,000	0
Total costs	1,901,860	1,931,923	1,963,938	1,998,038	2,034,364	20,673,066	814,307
Tax calculation							
Pre-tax income	4,875,098	5,082,229	5,295,708	5,515,696	5,742,351	7,375,834	15,516,304
Depreciation	0	0	0	0	0	0	0
Tax credit	0	0	0	0	0	0	0
Taxable income	4,875,098	5,082,229	5,295,708	5,515,696	5,742,351	7,375,834	15,516,304
Tax	1,365,027	1,423,024	1,432,798	1,544,395	1,607,858	2,065,233	4,344,565
Cash Flow	3,510,071	3,659,205	3,812,910	3,971,301	4,134,493	−14,689,400	11,171,739
Discount factor	0.2843	0.2472	0.2149	0.1869	0.1625	0.1413	0.1229
Discount cash flow	997,781	904,499	819,559	742,265	671,971	−2,076,033	1,372,945
Net present value							

Production 109,500,000 kWh/yr; Price growth rate = 0.035% annually; Internal Rate of Return = 15%; Fixed cost growth rate = 3%; Variable cost growth rate = 7%; Corporate tax rate = 28%

Table 14.7 NPV calculation of the wind farm—basic scenario with 10% tax credit

NPV of a 50 MW wind farm,basic scenario with 10% tax credit

Years	0	1	2	3	4	5	6
Revenue							
Price, per kwh	0.0470	0.0486	0.0503	0.0521	0.0539	0.0558	0.0578
kWh produced	0	0	54,750,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363
Salvage value	0	0	0	0	0	0	0
Total revenue	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363
Costs							
Capital investment	10,000,000	5,000,000	5,000,000	0	0	0	0
Closing costs	0	0	0	0	0	0	0
Fixed costs	100,000	103,000	106,090	109,273	112,551	115,927	119,405
Variable costs	0	0	250,000	267,500	286,225	306,261	327,699
Interest on bonds	0	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
Bond repayment	0	0	0	0	0	0	0
Total costs	10,100,000	6,503,000	6,756,090	1,776,773	1,798,776	1,822,188	1,847,104
Tax calculation							
Pre-tax income	−100,000	−1,503,000	1,000,440	3,929,244	4,106,951	4,290,239	4,479,258
Depreciation	0	1,000,000	3,500,000	4,000,000	4,000,000	4,000,000	4,000,000
Tax credit	1,000,000	2,500,000	500,000	0	0	0	0
Taxable income	−100,000	−2,503,000	−2,499,560	−70,758	106,951	290,239	479,258
Tax	−1,028,000	−3,200,840	−11,998,777	−19,812	29,946	81,267	134,192
Cash flow	−9,072,000	−3,302,160	−2,799,683	3,949,056	4,077,005	4,208,972	4,345,066
Discount factor	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759
Discount cash flow	−7,888,695	−2,496,907	−1,840,837	2,257,885	2,026,992	18,196,555	1,633,471
Net present value	1,212,774						

Table 14.7 (continued)

NPV of a 50 MW wind farm,basic scenario with 10% tax credit

Years	7	8	9	10	11	12	13	14
Revenue								
Price, per kwh	0.0598	0.0619	0.0641	0.0663	0.0686	0.0710	0.0735	0.0761
kWh produced	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	6,547,785	6,776,958	7,014,151	7,259,647	7,513,734	7,776,715	8,048,900	8,330,611
Salvage value	0	0	0	0	0	0	0	8,000,000
Total revenue	6,547,785	6,776,958	7,014,151	7,259,647	7,513,734	7,776,715	8,048,900	16,330,611
Costs								
Capital investment	0	0	0	0	0	0	0	0
Closing costs	0	0	0	0	0	0	0	100,000
Fixed costs	122,987	126,677	130,477	134,392	138,423	142,576	146,853	151,259
Variable costs	350,638	375,183	401,445	429,547	459,615	491,788	526,213	563,048
Interest on bonds	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	0	0
Bond repayment	0	0	0	0	0	0	20,000,000	0
Total costs	1,873,625	1,901,860	1,931,923	1,963,938	1,993,038	2,034,364	20,673,066	814,307
Tax calculation								
Pre-tax income	4,674,160	4,875,098	5,082,229	5,295,708	551,566	5,742,351	7,375,834	15,516,304
Depreciation	4,000,000	4,000,000	4,000,000	3,000,000	500,000	0	0	0
Tax credit	0	0	0	0	0	0	0	0
Taxable income	674,160	875,098	1,082,229	2,295,708	5,015,696	5,742,351	7,375,834	15,516,304
Tax	188,765	245,027	303,024	642,798	1,404,395	1,607,858	2,065,233	4,344,565
Cash flow	4,485,395	4,630,071	4,779,205	4,652,910	4,111,301	4,134,493	−14,689,400	11,171,739
Discount factor	0.3269	0.2843	0.2472	0.2149	0.1869	0.1625	0.1413	0.1229
Discount cash flow	1,466,284	1,316,155	1,181,346	100,111	768,432	671,971	−2,076,033	1,372,945
Net present value								

Production 109,500,000 kWh/yr; Price growth rate = 0.035% annually; Internal Rate of Return = 15%; Fixed cost growth rate = 3%; Variable cost growth rate = 7%; Corporate tax rate = 28%

goes ahead with the construction and operation of the plant. However, a local environmental group determines that the wind turbines will be harmful to a migratory species of Canadian geese that happen to pass near the wind farm site. The environmental group persuades a local judge to issue an injunction for the construction and operation of the wind farm, pending a "…complete and thorough environmental impact of the proposed plant." The corporation appeals this decision to a higher court and, eventually, prevails in the court system of the country. However, the effect of this judicial process has been to delay the operation of the plant for 12 months (a very short time for most judicial systems). This causes revenue to start being generated in year 3 instead of year 2. The results are shown in Table 14.8. It is observed that the effect of this simple twelve-month delay is to reduce the NPV of the project from a positive \$665,287 to a negative \$71,839. This delay and the negative NPV would classify this project as unprofitable for the corporation. Longer delays in the commencement of the power production may become disastrous and even threaten the viability of smaller corporations, thus, adding significantly to the risk of projects. This risk is reflected by an increase in the discount rate used by corporations and has a detrimental effect on the NPV and the commercial viability of such energy projects.

14.5.2 Use of the NPV Method for Improved Efficiency Projects

The NPV method is a general and sound financial accounting method that may be used in all the projects and not in power plant construction projects alone. Because it is a general method, it may be used in energy conservation as well as in improved energy efficiency projects. These projects are very similar to the electricity generation projects, but usually of shorter duration. The main difference between the electricity generation and the conservation/efficiency projects is that the "revenue" is actually generated from energy savings, which need to be quantified. Also, it is very common for conservation and energy efficiency projects to attract tax credits from central or local governments.[1] Oftentimes, these incentives are augmented by electricity production companies, who perceive these projects as a means to avoid or to delay new generation projects that are more costly and more capital intensive. In addition, because these involve small engineering projects that may be completed in a few weeks, the savings or revenues typically start accruing immediately (during year zero).

[1] In the wake of the debate on environmental change and global warming, the governments of several countries offer generous incentives for energy conservation/efficiency projects in the form of tax credits and accelerated depreciation.

Table 14.8 NPV of the wind farm—basic scenario with accelerated depreciation as in Table 14.6, but with a 12 month delay in the production of power

NPV of a 50 MW wind farm, accelerated depreciation, 12 month delay in construction							
years	0	1	2	3	4	5	6
Revenue							
Price, per kwin	0.0,470	0.0,486	0.0,503	0.0521	0.0539	0.0558	0.0578
kWh produced	0	0	0	54,750,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363
Salvage Value	0	0	0	0	0	0	0
Total revenue	0	0	2,756,530	5,706,017	5,905,727	6,112,428	6,326,363
Costs							
Capital investment	10,000,000	5,000,000	5,000,000	0	0	0	0
Closing Cost	0	0	0	0	0	0	0
Fixed costs	100,000	103,000	106,090	109,273	112,551	115,927	119,405
Variable cost	0	0	250,000	267,500	286,225	306,261	327,699
Interest on bonds	0	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
Bond repayment	0	0	0	0	0	0	0
Total costs	10,100,000	6,503,000	6,756,090	1,776,773	1,798,776	1,822,188	1,847,104
Tax calculations							
Pre-tax income	−100,000	−1,503,000	1,000,440	3,929,244	4,106,951	4,290,239	4,479,258
Depreciation	2,000,000	7,000,000	8,000,000	8,000,000	8,000,000	6,000,000	1,000,000
Tax credit	0	0	0	0	0	0	0
Taxable income	−2,100,000	−8,503,000	−6,999,560	−4,070,756	−3,893,049	−1,709,761	3,479,258
Tax	−588,000	−2,380,840	−1,959,877	−1,139,812	−1,090,054	−478,733	974,192
Cash flow	−9,512,000	−4,122,160	−2,039,683	5,069,056	5,197,005	4,768,972	3,505,066
Discount factor	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759
Discount cash flow	−8,271,304	−3,116,945	−1,341,125	2,898,249	2,583,830	2,061,758	1,317,684
Net present value	−71,839						

Table 14.8 (continued)

NPV of a 50 MW wind farm, accelerated depreciation, 12 month delay in construction

years	7	8	9	10	11	12	13	14
Revenue								
Price, per kwin	0.0598	0.0619	0.0641	0.0663	0.0686	0.0710	0.0735	0.0761
kWh produced	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000	109,500,000
Revenue from electricity	6,547,785	6,776,958	7,014,151	7259,647	7,513,734	7,776,715	8,048,900	0
Salvage Value	0	0	0	0	0	0	0	800,0000
Total revenue	6,547,785	6,776,958	7,014,151	7259,647	7,513,734	7,776,715	8,048,900	800,0000
Costs								
Capital investment	0	0	0	0	0	0	0	0
Closing Cost	0	0	0	0	0	0	0	100,000
Fixed costs	122,987	126,677	130,477	13,492	138,423	142,576	146,853	151,259
Variable cost	350,638	375,183	401,445	429,547	459,515	491,788	526,213	563,048
Interest on bonds	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	0	0
Bond repayment	0	0	0	0	0	0	20,000,000	0
Total costs	1,873,625	1,901,860	1,931,923	1,963,938	1,998,038	2,034,364	20,673,066	814,307
Tax calculations								
Pre-tax income	4,674,160	4,875,098	5,082,229	5,295,708	5,515,696	5,742,351	7,375,834	7,185,693
Depreciation	0	0	0	0	0	0	0	0
Tax credit	0	0	0	0	0	0	0	0
Taxable income	4,674,160	4,875,098	5,082,229	5,295,708	5,515,696	5,742,351	7,375,834	7,185,693
Tax	1,308,765	1,365,027	1,423,024	1,482,798	1,544,395	1,607,858	2,065,233	2,011,994
Cash flow	3,365,395	3,510,071	3,659,205	3,812,910	3,971,301	4,134,493	−14,689,400	5,173,699
Discount factor	0.3269	0.2843	0.2472	0.2149	0.1869	0.1625	0.1413	0.1229
Discount cash flow	1,100,154	997,781	904,499	819,559	742,265	671,971	−2,076,033	535,819
Net present value								

Production 109,500,000 kWh/yr; Price growth rate = 0.035% annually; Internal Rate of Return = 15%; Fixed cost growth rate = 3%; Variable cost growth rate = 7%; Corporate tax rate = 28%

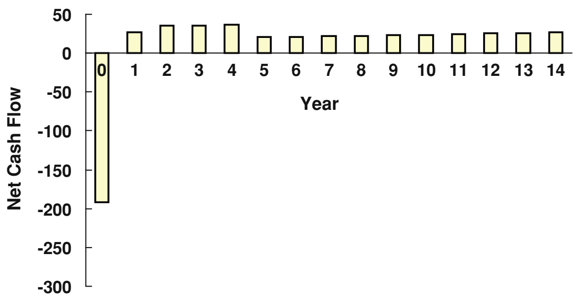

Fig. 14.2 Cash flow diagram for the installation of a GHP system

Let us look at the substitution of a simple, conventional air-conditioning unit in a small commercial building with a Geothermal Heat Pump (GHP). The building is located in Fort Worth, Texas, USA and is occupied and used throughout the year. It is proposed that the old air-conditioning and heating systems of the building be replaced with a GHP. While the mechanical systems will be replaced, the duct-work and air distribution systems in the building will be kept intact to reduce the overall cost and inconvenience of the replacement. The entire replacement of the system will cost \$300,000. It is expected that the more efficient GHP will result in savings of 230,000 kWh per year from the air-conditioning load of the building. At \$0.095 /kWh[2] this amounts to a savings of \$21,850 per year for the owner of the building. It will also save the equivalent of \$4,450 per year from the heating costs during the winter and the hot water supply during the entire year (see Sect. 13.3.3 for a complete analysis). The total savings for the project amount to \$26,300 per year, start accruing in year zero and are expected to increase at a rate of 3%, because of higher energy prices in the future. In addition, the federal U.S.A. tax code allows for a 30% tax credit for the owner of the building and depreciation of the investment in five years. The GHP system is expected to have a life-time of 15 years and does not need significant maintenance. It may be assumed that the discount rate for the investment is 12% and the tax rate for the owner of the building is 28%.

Figure 14.2 shows the cash flow diagram for this project. The cash flows in the first five years, shown as years 0–4, include the tax benefits from the depreciation of the investment. The NPV of the project will be given by the following formula:

$$NPV = CF_0 + \frac{CF_1}{(1.12)} + \frac{CF_2}{(1.12)^2} + \ldots + \frac{CF_{14}}{(1.12)^{14}} = \sum_{i=0}^{14} \frac{CF_i}{(1.12)^i}, \tag{14.9}$$

In this case it is observed that, after the first five years when the tax credits and depreciation are accounted for, the cash flow consists of the energy savings only. At year 4 the energy savings amount to \$29,601 and, for all the subsequent years,

[2] Because air-conditioners use at peak demand periods, the cost of electricity to the owner of the building is more expensive during the hours of their operation.

Table 14.9 NPV calculation for the substitution of an older air-conditioning system by a GHP

Internal rate of return	12%					
Tax rate	28%					
NPV for the replacement of the air-conditioning unit with a GHP						
Years	0	1	2	3	4	5–14
Revenue						
Revenue from energy savings	26,300	27,089	27,902	28,739	29,601	203,875
Costs						
Capital investment	300,000			0	0	0
Total costs	300,000	0	0	0	0	0
Tax calculation						
Pre-tax income	26,300	27,089	27,902	28,739	29,601	203,875
Depreciation	42,000	42,000	42,000	42,000	42,000	0
Tax credit	90,000	0	0	0	0	0
Taxable income	−15,700	−14,911	−14,098	−13,261	−12,399	203,875
Tax	−94,396	−4,175	−3,948	−3,713	−3,472	57,085
Cash flow calculation						
Cash flow	−179,304	31,264	31,849	32,452	33,073	146,790
Discount factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674
Discounted cash flow	−179,304	27,914	25,390	23,099	21,018	83,293
Net present value	1,410					

the savings increase at a constant rate of 3% and are discounted by 12%. One may use this simple feature of this problem and the general property of the series

$$1 + x + x^2 + x^3 + x^4 + \ldots + x^n = \frac{1 - x^n}{1 - x}, \tag{14.10}$$

to calculate the discounted cash flows from year 5 to year 14 as follows:

$$\frac{CF_5}{(1.12)^5} + \frac{CF_6}{(1.12)^6} + \frac{CF_7}{(1.12)^7} + \ldots + \frac{CF_{14}}{(1.12)^{14}} = \frac{CF_5}{(1.12)^5}\left[1 + \frac{1.03}{1.12} + \left(\frac{1.03}{1.12}\right)^2 + \left(\frac{1.03}{1.12}\right)^3 + \ldots + \left(\frac{1.03}{1.12}\right)^9\right] = 6.589\,\frac{CF_5}{(1.12)^5}. \tag{14.11}$$

Equation (14.11) shows that the discounted cash flow from the energy savings between years 5–14 amount to $83,293. These computations and the pretax income for the building owner are shown in Table 14.9. It may be seen in the Table that the NPV of this project is a positive $1,410, which implies that it is worth substituting the old air-conditioning system with the Geothermal Heat Pump.

The positive NPV in this case justifies completely the investment for the energy efficiency project. It is evident, however, that the tax credit of 30% plays a very important role in the positive NPV and the justification of this project. Without the tax credit the NPV of the project would have been strongly negative. This is a common characteristic of most alternative energy and improved efficiency projects: because of the price structure of the fossil fuels, the maturity of fossil fuel technology and the long-term engineering experience in fossil fuel projects, switching to alternative energy sources typically becomes uneconomical without economic and financial externalities, such as regulations or governmental incentives. The latter are justified by the following reasons:

- The potential adverse effects of carbon dioxide build-up.
- The declining supply of fossil fuels and the certainty that they will have to be replaced in the future at considerable expense to the society.
- The creation of new professions and new jobs that may support the economy in the future.
- Energy security for the countries that import fossil fuels.

In addition, it has been observed that several electricity generation companies (utilities) are willing to subsidize energy efficiency projects, such as the one described in this section. This trend is more evident with the publicly owned utilities sector. For example, since 2009, the San Antonio, Texas utility (CPS) offers a $400 rebate per ton of air-conditioning that is substituted by a more efficient GHP. The underlining reason for this rebate is that more efficient air-conditioning units cause lesser peak power demand during the summer months. This has three beneficial effects for the power producing corporations that justify the small investment of the rebates:

1. The lesser peak power demand implies that the most inefficient and expensive power producing units will not need to be operated for the production of power.
2. Any growth in the demand for electricity, e.g. because of population growth, will not need to be met immediately, thus deferring the high capital cost associated with the building of new power plants further in the future. It must be noted here that the average cost of adding 1 MW of electric producing capacity by constructing a new power plant in 2009 was approximately $5,000,000.
3. There are lesser atmospheric emissions of pollutants from the power plants of the corporation. This is often a mandate of the citizens the electricity generating corporation serves.

14.6 Project Financing for Alternative Energy Technology

It is apparent from the examples of the previous sections that the building of new alternative energy power plants and the completion of energy efficiency projects requires significant injection of capital. Energy projects are capital intensive and, especially, new technology for the production of electric power from renewable sources requires significant capital investment. In the beginning of the Twenty First Century the world economy and the international financial markets are very much influenced by the 1985–2000 era when the new inventions in electronics, computers and internet created the "new world economy" with several very successful information, high-tech companies, such as Microsoft, Apple, Google, Yahoo, etc. The creation of these, now gigantic, corporations involved an excellent idea and a relatively very small amount of capital. The capital was typically provided by the teams of investors that in the U.S.A. are called "angels" (a few hundred thousand dollars) and "venture capitalists" (a few million dollars). The financial rewards to these investors from successful projects were momentous, typically 10–1,000 times return on the invested capital. The rewards were also very quick to materialize, typically within 3–5 years, when the original company made its first Initial Public Offering (IPO) of stock.

The timeframe of the "high technology" projects and their financial models are not applicable to energy production investment models for the following reasons:

1. Oftentimes, the technology involved in alternative energy projects is not new. This implies that these projects are not very risky and, as a consequence, they are not as profitable as certain high technology projects.
2. Energy production and conservation projects are easier to be duplicated and patents that may ensure high profitability are more difficult to obtain.
3. All energy projects are long-term projects with payoffs that extend from 20 to 60 years. The original investors that are risking their capital, typically, do not recoup their investment within 2–5 years in an Initial Public Offering of the company's stock.
4. The investment required for even a small alternative energy power plant is very high in comparison to investments in internet-related corporations.

Because of these reasons, it is not rational to expect that the free market will provide the means to finance all the alternative energy projects that have reasonable potential to become successful and profitable. The continuation of regulatory intervention and governmental subsidies may be necessary for the initial financing and the long-term success of alternative energy and energy efficiency projects, at least until the expected or perceived depletion of the fossil fuel resources brings in a more favorable and realistic price regime for alternative energy. An additional reason for the continuation of governmental subsidies and intervention is the reduction of atmospheric pollution, which is a significant public health benefit.

Problems

1. You are considering the construction and operation of a 5 MW solar photovoltaic power plant. Enumerate: three of your expected fixed costs and three of your expected variable costs.
2. List all the costs you will expect to have from the construction and operation of a geothermal power plant, which is to produce energy for 40 years.

3. Because of population growth, it is expected that the city you live in will need an additional 300 MW of electric power. List all the alternatives to satisfy the increased demand.
4. The expected average rate of return in the next decade is 4%. What is the value of $60,000 ten years from now?
5. A financial company uses a 5% rate of return today and expects that this rate of return will increase by one percentage point in each of the next nine years. How much is today's sum of $100,000 worth to this company ten years from now?
6. You borrow $250,000 for a business venture to be repaid three years from now. You have the option to take a simple interest rate of 40 or a 1% rate compounded monthly interest. Which option will you choose?
7. What is the present value of $1,000,000 twenty years from now? The discount rate is 7%.
8. A small geothermal power plant is expected to generate a net income of $300,000 in each of the next thirty years. What is the present value of this monetary stream if the discount rate is 6.5%?
9. From the point of view of an investment company, explain what the difference between the following is:
(a) The inter-bank discount rate.
(b) The prime rate.
(c) The cost of borrowed capital.
(d) The return on equity.
10. For the small photovoltaic power plant of Table 14.1 determine:
    (a) The net present value for a discount rate 7%.
    (b) The payback period.
    (c) The average return on book if the straight-line depreciation is taken.
    (d) The internal rate of return.
    (e) The profitability index.
11. For the small photovoltaic power plant of Table 14.1, what would be the net present value if there were a 25% investment credit in addition to the cash flow shown in the years when the investment is made?
12. [3]The initial investment for a geothermal power plant is $60,000,000 and is to be paid in two years (year 0 and year 1) equally. The electricity generated by the plant is expected to bring revenue of 10,000,000 per year increasing at a rate of 3% annually. The total annual expenses of the plant will be 1,500,000 increasing at a rate 4% annually. The company that owns the plant plans to borrow 50% of the capital expenditure at a rate 6%. The discount rate for this company is 12% and its taxation rate is 35%. A 10 year depreciation period is allowed for this power plant. The plant is expected to generate electricity for

[3] Construct a spreadsheet to facilitate the solution of the next four problems.

30 years after which it will have zero value. What is the present value of this investment? Should the company undertake the investment?

13. What would be the answer to the plant of problem 12 if the company were allowed to borrow 80% of the cost of the geothermal power plant at an annual rate of 5%.
14. In order to promote the development of alternative energy sources the government allows 5 year depreciation for the project of problem 12. What is the net present value of the investment?
15. In order to accelerate the use of geothermal power, the government allows a 20% tax credit for investment in geothermal energy (in the years the investment is made) as well as 5 year depreciation for the project of problem 12. What is the net present value of the investment now?
16. "The government does not need to subsidize energy projects. In a free market economy we should allow the market forces to determine if a project is going to succeed or fail." Comment.