Building Energy Manager's Resource Guide

Written by NIFES Consulting Group on behalf of Sustainable Energy Ireland.

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This Guide is divided into five main sections:

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Section 5 | People Aspects - Reaching the Goals

Energy Managers

The Guide has been written primarily for the person responsible for energy management in a single building or an estate. In large organisations this person may have the title of "Energy Manager" but is likely to have other responsibilities and may be managing energy as a part time responsibility. In smaller organisations the person responsible for energy will have multiple responsibilities and energy management will be a minor role. If you are responsible for energy management the whole of this Guide is for you. Some topics are covered in more detail in the Appendices.

Senior/Middle Managers

For senior or middle managers with an indirect responsibility for energy management then Section 2 "Management Actions - Setting the Goals" is for you. Also Section 3 "Data - Information is Power" is a useful guide to key data sources and analysis methods.

Technical Managers/Engineers

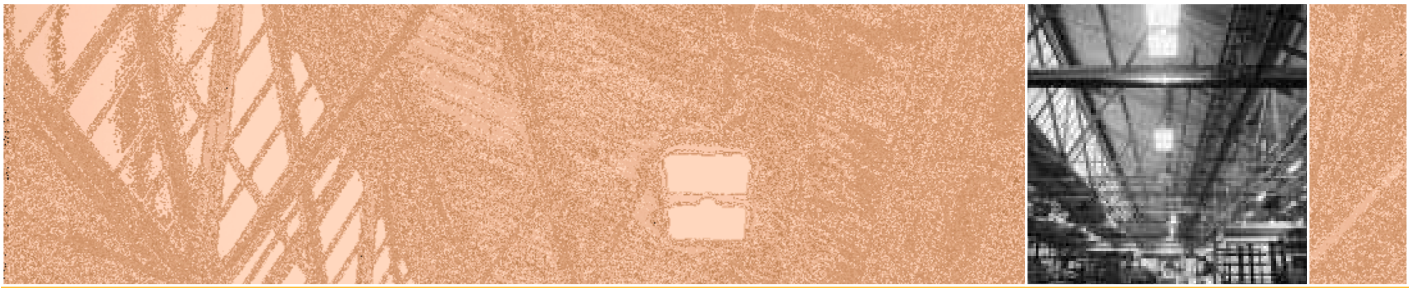
For managers/engineers/technicians seeking to apply energy saving technology, Section 4 "Technical Solutions - Smarter Technology Choices" is the most applicable section.

Human Resources

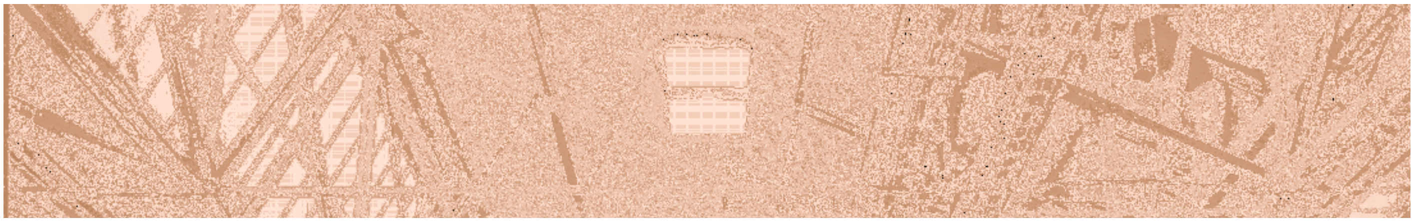
Section 5 on "People Aspects - Reaching the Goals" is relevant to anyone interested in saving energy by influencing the attitudes and behaviour of employees to be more environmentally responsible.

The Guide cannot go into detail on every aspect of energy management and additional information is available and this is mainly free of charge, particularly from Sustainable Energy Ireland and The Carbon Trust in the UK. These sources are signposted.

Section 1 | Energy in Buildings - Why it Matters



1 | Energy in Buildings - Why it Matters



1.1 Introduction

The Kyoto Protocol imposes challenging targets for Ireland in terms of reducing greenhouse gas (GHG) emissions. Ireland has been set a target to limit the increase in GHG emissions by 13% between 1990 and 2010. The Kyoto Protocol entered into force on February 16th 2005 following the ratification of the Protocol by Russia in November 2004. Failure to reach the targets may result in significant financial implications.

Greenhouse gases contribute to climate change and oxides of sulphur and nitrogen, emitted during the combustion process, cause acid rain which damages our health, corrodes buildings and increases the acidity levels of lakes, rivers and the sea.

Ireland currently imports over 85% of its energy requirements and this makes us vulnerable to supply issues and volatile energy prices on the world market. With rising fuel costs, opening of electricity and gas markets to alternate suppliers and climate change, the requirement to monitor and reduce energy consumption is receiving greater attention than ever before in Irish business.

Buildings consume 40% of Ireland's total energy use and fall into three main categories:

- Commercial/Public Sector Buildings
- Industrial Buildings
- Residential Dwellings

This Guide focuses on the first two categories and provides useful information on managing energy, reducing costs and our environmental impact. Energy consumption by sector is shown in Figure 1.1.

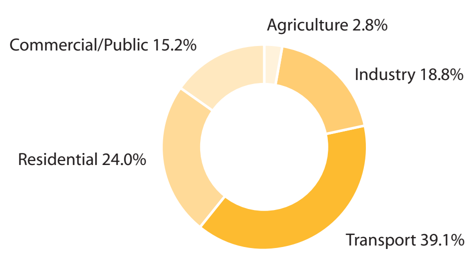
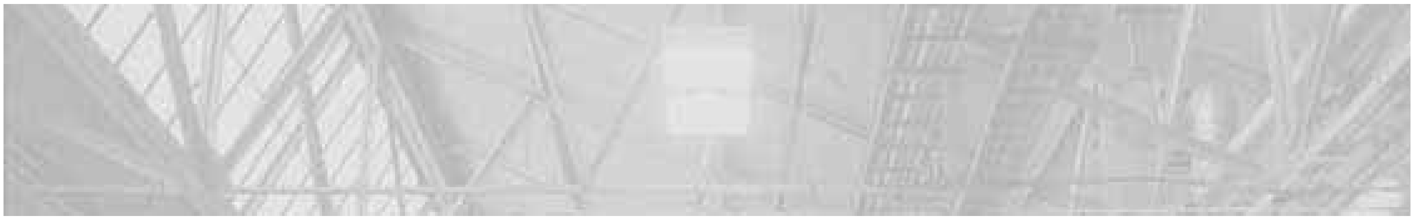


Figure 1.1 Total delivered energy use by sector in 2003



1.2 Energy Consumption in Buildings

The services sector includes both commercial service activities (banking, cinemas, hotels, retail outlets and swimming pools) and public services (universities, hospitals, local authorities and government departments). Buildings are the predominant point of energy consumption (for space heating, lighting and water heating) within the services sector, the balance being mainly represented by certain municipal and civic facilities. Buildings consume 40% of total energy delivered in Ireland.

Figure 1.2 shows the energy expenditure profile for 1999, across eleven sub-sectors of the services sector, segmented between natural gas, heating oil (also known as gasoil) and electricity consumption. The total expenditure on energy for 1999 for the eleven commercial services sub-sectors, which represents 40% of the entire commercial and public service, was €337 million (current prices) of which 82% was spent on electricity, 7.1% on natural gas and 11% on heating oil.

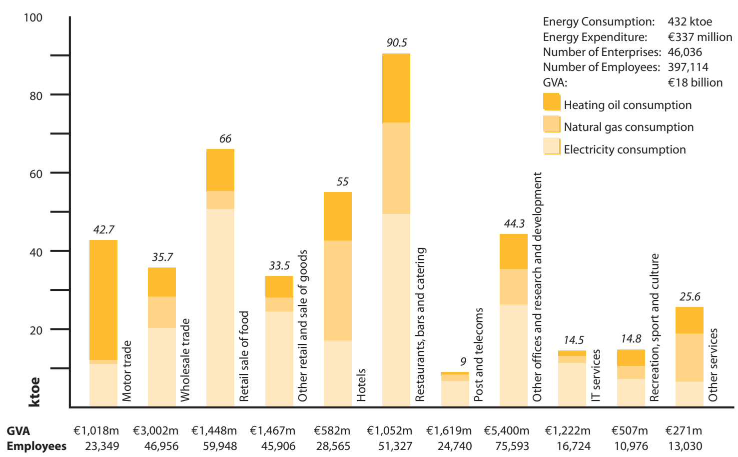


Figure 1.2 Delivered energy consumption by services sector

Source SEI - Profiling Energy and CO_2 Emissions in the Services Sector

1.3 Energy End Use in Buildings

Energy end use in buildings varies greatly with the type, function and occupancy of building. For example, the energy use associated with two typical office blocks is contrasted in Figures 1.3 and 1.4. One building is naturally ventilated open plan and the other is air conditioned. Electricity consumption in an air conditioned office is up to 2.5 times greater than in a naturally ventilated office. The larger area of pie chart in Figure 1.4 shows the overall increase in energy use for an equivalent floor space for both buildings.

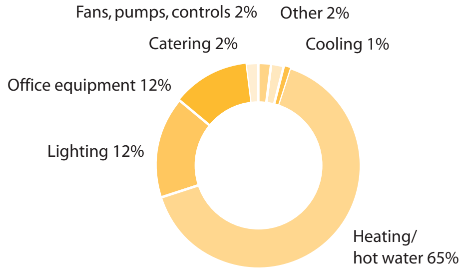


Figure 1.3 Typical energy end use in a naturally ventilated open plan office

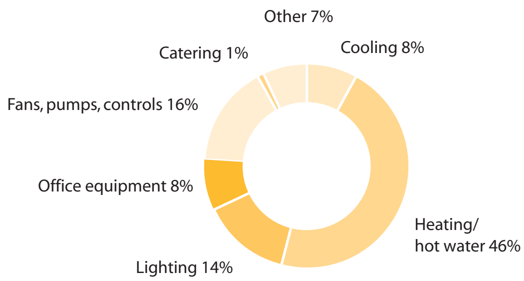


Figure 1.4 Typical energy end use in an air conditioned office

1.4 Environmental Impact of Energy Use in Buildings

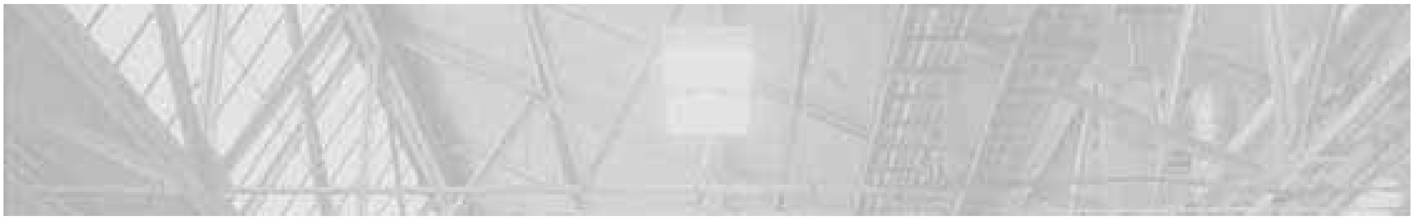
Energy consumption in buildings, which involves the use of fossil fuels, contributes to air pollution with downstream impacts on public health and damage to the environment. Carbon dioxide emissions from fossil fuels cause global warming and ultimately climate change. Other harmful emissions include oxides of sulphur and nitrogen which cause acid rain.

Much of Ireland's electricity is generated from fossil fuels and because of the inefficiencies and losses in generation and distribution, carbon dioxide (CO_2) emissions from electricity are relatively high compared to other energy sources. See Figure 1.5.

Energy Source	CO_2 emissions (kg CO_2/kWh)
Electricity	0.6510
Coal	0.3406
Gas Oil	0.2639
Natural Gas	0.1978

Figure 1.5 Carbon dioxide emissions for different energy sources

The emissions from electricity change on a yearly basis as a result of the fuel mix of electricity generation. In 2003 it was 0.651 kg per kWh. Carbon dioxide emissions for electricity are 3.9 times greater than those for gas per kWh. Unlike electricity, not all the energy in gas burned can be usefully used. But even taking this into account CO_2 emissions are still 2.5 to 3.0 times greater for electricity. For more detailed data on carbon emissions see Section 3.4 "Energy Units, Conversion and Emissions Factors".



CO_2 emissions from energy use in the Ireland services sector are shown by fuel type in Figure 1.6 and by end use in Figure 1.7.

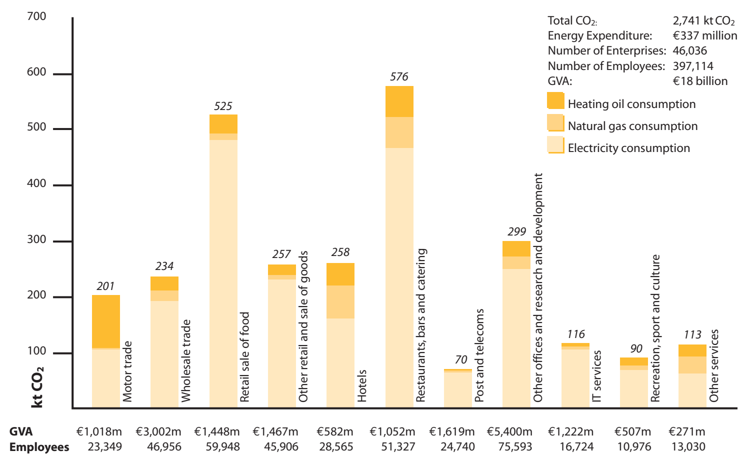


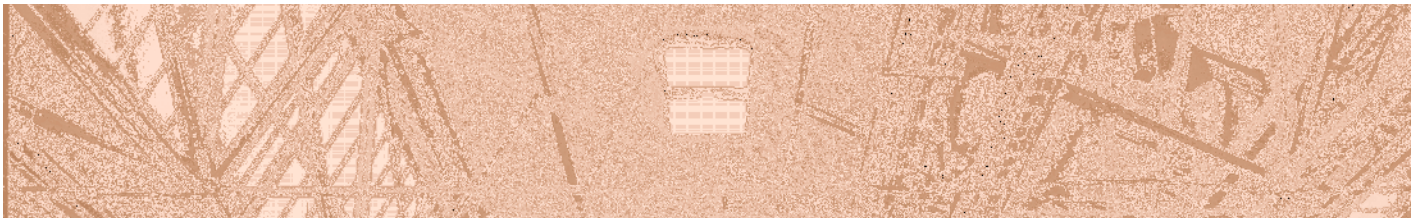
Figure 1.6 CO_2 emissions from energy use in the service sector

Source SEI - Profiling Energy and CO_2 Emissions in the Services Sector

1.5 Energy Costs in Buildings

The annual energy costs in the services sector by end use are shown in Figure 1.7 (Source SEI - Profiling Energy and CO_2 Emissions in the Services Sector).

These energy costs represent 0.6% of total direct costs for the organisations studied. It is important to consider however that energy costs are a growing cost and controllable through energy management. Finally, cost savings from energy saving add directly to profits. They require no additional turnover, service provision or increase in customer numbers.



Service Sector	Annual Energy Costs € million/annum
Motor Trade	26
Wholesale Trade	29
Retail Sale of Food	58.7
Other Retail and Repair of Goods	34.8
Hotels	29.3
Restaurants, Bars and Catering	75.3
Post and Telecomms	6.4
Other Offices and Research and Development	39
IT Services	11.6
Recreation, Sports and Culture	11.9
Other Services	14.9
	Total 337

Figure 1.7 Service sector energy costs

1.6 Design Opportunities in Buildings

Opportunities in New Buildings

The best time to introduce energy and carbon dioxide saving measures is when specifying, designing and or constructing a new building. This provides the well-briefed designer with the opportunity to:

- optimise the location and orientation within a site;
- make use of the layout, form and fabric to moderate energy needs;
- reduce heat demand by using insulation and air tight construction;
- meet the remaining heat demand with efficient plant and controls;
- minimise cooling needs through the use of fabric;
- maximise the use of natural ventilation;
- consider the use of renewable energy sources;
- meet residual cooling needs with innovative plant and controls and;
- satisfy the requirements of building occupants.

Many of these points are specifically addressed in the Building Regulations Part L.

As a rule, a well-designed energy efficient building, using the form and fabric of the construction to allow plenty of daylight and natural ventilation, provides a more productive workplace than a heavily serviced conventional alternative. This is enhanced by providing staff with the right combination of automatic systems and individual control over their local environment.

For further details on opportunities in new buildings see Appendix 1 'Checklist for Design Teams of New Buildings'.

Opportunities in Existing Buildings

In existing buildings the scope for improvements in efficiency is more limited, but there are many opportunities for cost-effective investment, either as stand-alone measures or as part of other replacement or refurbishment plans. Lighting systems can be upgraded with more efficient lamps, luminaires and controls. Domestic hot water can often be provided in more efficient ways. Boiler plant at the end of its life can be replaced with more efficient alternatives. Properly designed controls for building services should form part of all new and upgrade building projects. IT and office equipment can be chosen for its energy performance along with other criteria. Pumps and fans can be powered by efficient motors - some with the use of variable-speed drives. More innovative approaches such as heat pumps and combined heat and power (CHP) systems can be justified under certain conditions.

The rest of this Guide goes into these opportunities in more detail.

1.7 Legislation

The two key elements of legislation affecting energy management in buildings are:

- EU Directive on the Energy Performance of Buildings
- Building Regulations

Summaries of each element are as follows:

EU Directive on Energy Performance of Buildings

Context of the Directive

Arising from the Kyoto protocol, the EU has set the reduction of greenhouse gas emissions as an important objective. The most significant greenhouse gas is CO_2 almost half of which derives from energy use in buildings. EU research has indicated that CO_2 emissions from buildings could be reduced by 22% through improving energy efficiency. In 2000, the European Commission's Action Plan on Energy Efficiency indicated the need for specific measures in the building sector.

In response, the Commission published the proposed Directive on The Energy Performance of Buildings in May 2001. The European Parliament and Council signed the agreed text of the directive at Energy Council on 25 November 2002. Upon its publication in the EU Official Journal on 4 January 2003, the directive is now European Law.

The directive's main objectives are to promote:

- improved energy performance of buildings within the EU through cost effective measures;
- the convergence of building energy standards towards those of member states which already have ambitious levels.

Scope of the Directive

The directive will apply to almost all buildings, residential and non-residential, both new and existing. Member states are allowed to exempt certain categories of buildings, such as buildings of historical or architectural importance, religious buildings, and buildings of low occupancy or size.

Requirements of the Directive

The Directive sets a common methodology for calculating the energy performance of buildings and gives minimum energy performance standards (both for new build and major refurbishment).

For building owners and operators the main provisions and requirements of the Directive are as follows:

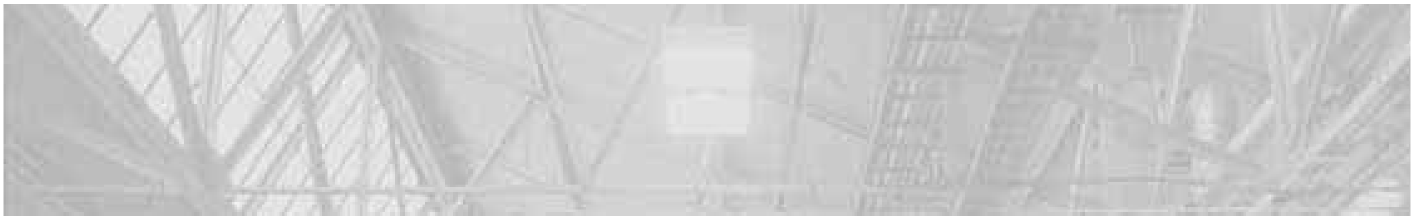
- For new buildings over 1000m^2, alternative energy measures need to be considered;
- For buildings over 1000m^2 undergoing renovation, energy performance is to be upgraded as far as is technically, functionally and economically feasible;
- For almost all buildings, an energy performance certificate (or energy rating) is to be supplied by the owner to a prospective buyer or tenant when sold or rented. The Certificate is to be accompanied by recommendations for cost-effective improvements to energy performance.
- For buildings of over 1000m^2 and "used by the public" an energy certificate is to be posted in a prominent place;
- Regular inspection requirements and provision of advice on best practice in use and replacement apply for particular classes of boiler and air-conditioning systems;
- Measures are to be taken to provide information on heating systems and best use of energy in buildings.

Probably the best known requirement is the mandatory provision of energy certificates to prospective buyers or tenants. Such a concept of "energy rating" in the housing sector was already scheduled in the work programme of Sustainable Energy Ireland and in the government's National Climate Change Strategy. However, it will be seen that the scope of the directive is considerably wider.

Implementation and Timescale

The directive must be implemented by member states no later than 4th January 2006. However, member states have the option of an additional 3 year period to apply the provisions on energy performance certificates (for both residential and non-residential sectors), inspection of boilers and inspection of air conditioning systems. This is to allow time to develop suitable energy rating systems and certification schemes for buildings within the scope of the directive, as well as accreditation and training of sufficient personnel to undertake the energy performance assessments and equipment and systems inspections.

The Department of the Environment & Local Government will take the lead for legislatively implementing the measures contained within the Directive, in conjunction with the Department for Communications, Marine & Natural Resources, supported by Sustainable Energy Ireland.



The Building Regulations 1997 - 2002

The primary purpose of the Building Regulations is to provide for the health, safety and welfare of people in and around buildings. In general, the Building Regulations 1997 - 2002 apply to the construction of new buildings and to extensions and material alterations to existing buildings and to certain changes of use of existing buildings. These Regulations apply to all types of construction.

The Building Regulations are couched in broad functional requirements, or general statements of intent of the relevant regulation. For instance, the Regulations governing Access and Use of a building in Part M is stated as: "Adequate provision shall be made to enable people with disabilities to safely and independently access and use a building". Technical Guidance Documents A to M give guidance on how to comply with the Regulations. Part L relates to the conservation of fuel and energy.

The 1991 Regulations first came into force on 1st July 1992 and were superseded by the 1997 Regulations with effect from 1st July, 1998. They apply to new buildings, extensions and material alterations to buildings. Certain parts of the regulations (listed A to L) apply to material change of use of a building. The second schedule lists the various parts (A to M) and the regulations within each part. The third schedule lists the types of buildings that are exempted from the Building Regulations.

For further information on the building standards please visit:
www.environ.ie
and click on "Building Standards".

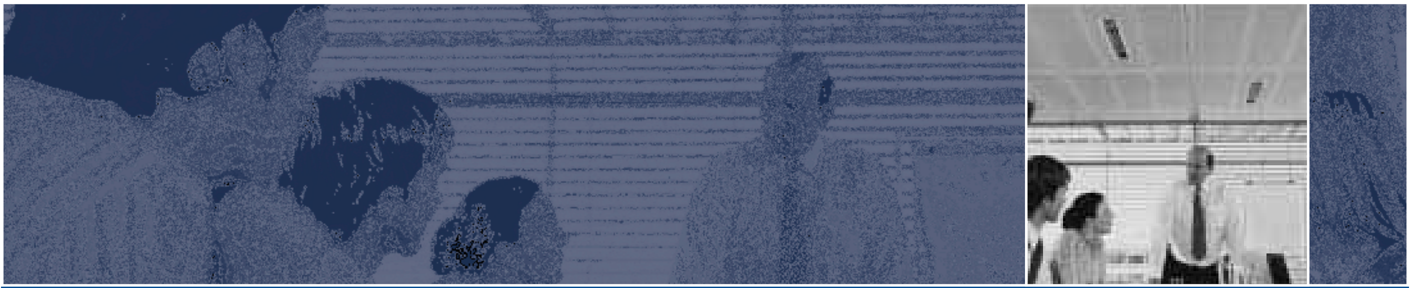
1.8 Further Information

For further details on the EU Directive on Energy Performance of Buildings (EPBD) see:

- www.epbd.ie

For further details on energy use in the services sector please refer to:
Profiling Energy and $C0_2$ Emissions in the Services Sector, April 2005, SEI.

Section 2 | Management Actions - Setting the Goals



2.1 Overview of Energy Management

Introduction

When developing an energy management policy and strategy it is important to consider all the key factors. In most organisations there is a surplus of opportunities to reduce energy costs but the savings are limited to the human and financial resources an organisation is willing to make to achieve results. This means that organisations need to make choices and set priorities. This section provides an overview of the main options available.

Aim of Energy Management

The aim of energy management is to achieve organisational objectives at minimum energy cost. This can be achieved by two methods as shown in Figure 2.1:

- Pay less per unit of energy consumed
- Reduce energy consumed without compromising organisational objectives.

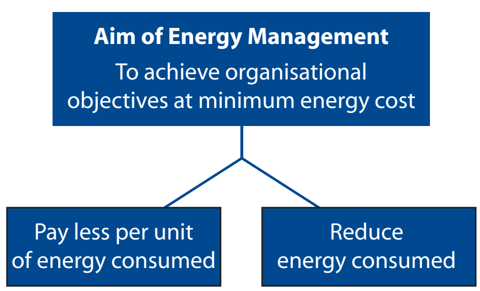


Figure 2.1 Aim of energy management

Pay Less per Unit of Energy

It is possible to pay less per unit of energy without reducing the amount consumed. See Figure 2.2. Options include:

- Negotiate Lowest Price - In the deregulated energy market getting competitive bids can reduce costs. Also combining a number of sites on a single contract might attract lower prices.
- Select Best Tariff - For smaller users of electricity it is important to consider how much electricity is used and patterns of consumption so that load profiles determine the most appropriate tariff.
- Cost Avoidance Measures - These include load shedding to avoid peak prices, improving power factor, improving load factor and reducing maximum demand and supply capacity charges.
- Fuel Change/Selection - For boilers with dual-firing on gas or oil there is the possibility of switching

to the cheaper fuel. Oil and gas prices tend to mirror each other therefore savings may be marginal but purchasing oil at low season prices can provide more options. Also it is worth considering fuel choice when equipment is purchased. For example, electricity is usually at least four times more expensive than gas in cents/kWh, so when catering equipment is being purchased it always makes sense to purchase gas-fired equipment if the choice is available.

- On-site Power Generation - Combined heat and power (CHP) can be attractive to sites with all year heat loads, e.g. hospitals, leisure centres, hotels. CHP provides cheaper electricity and offsets heating costs. Also when testing standby generators it is worth doing so at periods when electricity costs are high.

Other options include use of on-site generated power from renewable sources, e.g. photovoltaic cladding on buildings or the use of wind turbines.

Reduce Energy Consumed

The options for reducing energy consumption are shown in Figure 2.2. The three main options are:

Energy Efficient Buildings by Design
A new building and/or services provides the best of all opportunities for a step improvement by incorporating energy efficiency into every aspect of design. It is always less expensive to include energy efficiency at the design of a new building than to apply retrofit measures once the facility is built. For design options see Appendix 1.

Capital Investment (Retrofit)
Energy surveys and audits can reveal energy saving opportunities in existing buildings. These can be retrofit measures or those included in a refurbishment programme. These will be high or low cost measures. For higher cost measures a detailed financial appraisal will be necessary. See Appendix 2.
Sometimes non energy factors should be included in the decision. For example, health and safety reasons, regulatory compliance or improved comfort conditions.

Reducing Waste Using Existing Plant and Equipment

In this category there are two main options:

Energy Waste Avoidance
This is a proactive approach to preventing energy waste before it occurs by applying good operational management to:

- Energy conversion (e.g. boilers, chillers)
- Energy distribution (e.g. insulation of pipework)
- Efficient operation of plant and equipment
- Effective maintenance
- Good housekeeping (e.g. only switching on lights and equipment when needed)

Energy Waste Detection
This is a reactive approach to energy waste as it is detected by an energy monitoring system. No matter how well a building is run, faults, technical problems and actions by occupants or maintenance contractors can lead to significant energy waste. A good monitoring system will detect waste as it occurs and pinpoint where remedial action should be taken to stop future waste.

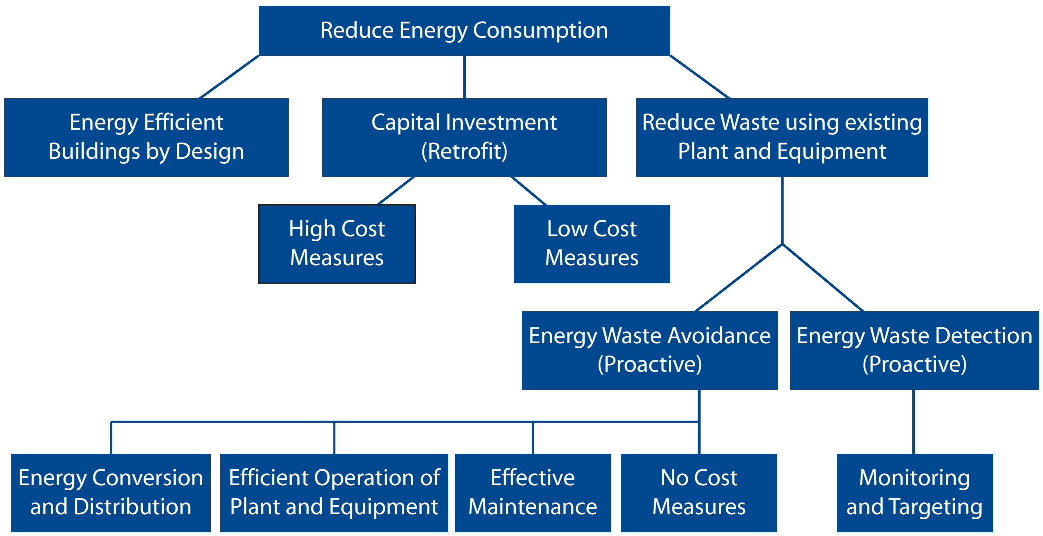


Figure 2.2 Reduce energy consumption

2.2 Organisation/Technical/People Opportunities

Effective energy management requires a balanced approach in three key areas as shown in Figure 2.3:

Organisation/Information involves senior management commitment, a clear energy policy, strategy and objectives, human and financial resources to implement initiatives, proper systems for energy purchase, data collection, analysis, reporting and a capital investment programme.

People solutions involves raising energy awareness and motivation of all employees, the professional development of staff who manage energy and the use of energy teams for implementing no cost measures. It also involves providing energy training for maintenance/operational staff, caterers, cleaning and security staff.

Technical solutions include, but are not limited to, space heating, ventilation, air conditioning, lighting, hot water, office equipment, computer suites, lifts, escalators, catering, building fabric, doors, windows, insulation, power factor correction, controls and Building Energy Management Systems (BEMS).

All three areas are vital to success and are interdependent.

For example, a BEMS system can only be effective if it is run by a competent person. So a balanced energy strategy has to address technical and people issues simultaneously.

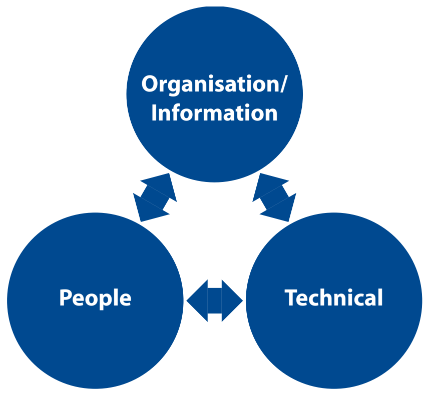


Figure 2.3 A balanced approach to energy management

2.3 Benefits of Energy Management

Managing energy is simply good management of an organisation's resources. The main benefits of saving energy are:

- **Saves Money**
  Saving energy saves money. Cost reduction is important for private companies as this saving contributes directly to increased profit. A useful question for a company is to ask: "How much extra turnover would we require to produce profits equivalent to a saving of 20% of our energy bill " For public sector organisations a saving on energy means finances can be used more usefully elsewhere.
- **Saves Fossil Fuel**
  Fossil fuels are a finite commodity and will not last forever. The less fossil fuel we use in this generation, the more will be available for future generations. It also buys time to develop new renewable forms of energy so that we move to a low carbon economy.
- **Reduces Pollution**
  Saving energy, particularly electricity, reduces the amount of carbon dioxide (CO_2) and other harmful gases we put into the atmosphere. Carbon dioxide is a greenhouse gas and is a major contributor to global warming and climate change.
- **Improved Working Environment**
  Buildings which are too hot or cold can have a negative impact on occupants' comfort, morale and productivity. Also poor control of energy can lead to damage of building fabric or equipment/goods within a building. There can also be implications for health, safety and risk management.
- **Legal Compliance**
  Buildings must comply with legislation. For example, Building Regulations and the EU Directive on Energy Performance of Buildings. Lack of compliance by poor energy management can lead to legal action, fines and poor publicity for an organisation.

- **Improved Environmental Performance**
  Organisations which are proactive in energy management have something positive to report to stakeholders. Greening an organisation can help to secure compliance to internationally recognised environmental standards, e.g. ISO 14000. This in turn can lead to more business opportunities because the organisation is proven to be acting responsibly.
- **Reduction in Replacement and Maintenance Costs**
  Plant and equipment within buildings usually have to be replaced or maintained more regularly if they are misused or left to run unnecessarily. Saving energy can extend equipment life and reduce replacement and maintenance costs.

2.4 Strategic Energy Management

The process of managing energy is not new or complicated. Energy should be treated as a controllable cost and the resources allocated to a strategic approach should be appropriate to the size of energy expenditure and the likely savings based on the current levels of efficiency. If an organisation is just starting out in energy management it is likely that savings from good housekeeping (no cost measures) will be in the region of 15% to 20% or even more.

Although energy management requires a strategic approach it does not necessarily require a formal system and any organisation can improve their energy performance by following a few simple techniques. Strategic energy management incorporates a few fundamentals steps as shown in Figure 2.4.

Organisations that are already utilising quality and/or environmental management systems such as ISO 9000/14001 or EMAS will undoubtedly find the implementation of a formal energy system familiar as the method and management of the system should follow the structured 'plan-do-check-act' approach ideally to provide an integrated approach to business sustainability. It makes sense that energy management is incorporated into any existing systems.

Energy strategy spans a number of key functions within an organisation and therefore requires cooperation and commitment from all. Senior management provide the leadership and set direction, finance are invoiced to ensure the most appropriate purchasing decisions are made; technical staff ensure that plant is operated and maintained efficiently and HR are involved to facilitate training and help generate a culture of energy awareness.

The most successful energy management strategies typically involve the setting up of an energy management team with participants from each of the functions mentioned above. This team would support an energy manager with responsibility for the coordination of energy management activities. Depending on the size of the business, this may or may not be a full-time, dedicated post. The team, in association with senior management would establish an energy management policy, which should include general aims and specific targets, timetables and budgetary limits, the methods to be employed and the organisation of management resources. The energy manager should set up a system to collect, analyse and report on energy consumption and costs. This can consist of reading meters on a regular basis and the analysis of utility bills.

The next step is to assess how, when and why energy is used in the organisation through an energy review or audit. An energy audit establishes energy use patterns, the potential for energy and cost savings, and usually includes recommendations for actions for improving energy efficiency. The typical energy survey examines the use of the main utilities including electricity, gas, oil and water. This survey may be carried out internally if sufficient expertise is available in-house, but very often is carried out by independent energy consultants. A typical, comprehensive energy survey may cost in the region of 1% of the total site energy bill but would, in many cases, identify costs savings opportunities worth up to 20 times the cost of the survey. Based on the findings and recommendations of the energy survey, a prioritised action plan should be drawn up. Energy and cost savings and the required investment should be listed for all items in the plan. The projects should be implemented in order of priority as set out in the action plan. The energy team should report results and progress to management and staff on a regular basis. An energy management plan or strategy will be more effective if its results are reviewed annually and the action plan revised. The review should at least detail actions undertaken during the year and projects and implementation plans for the next 12 months. Adjustments can be made to targets in light of business or operational requirements.

The best run organisations in Ireland are also the most energy efficient. They recognise that energy is a controllable cost and apply sound business principles to energy management - just as they would to any other issue.

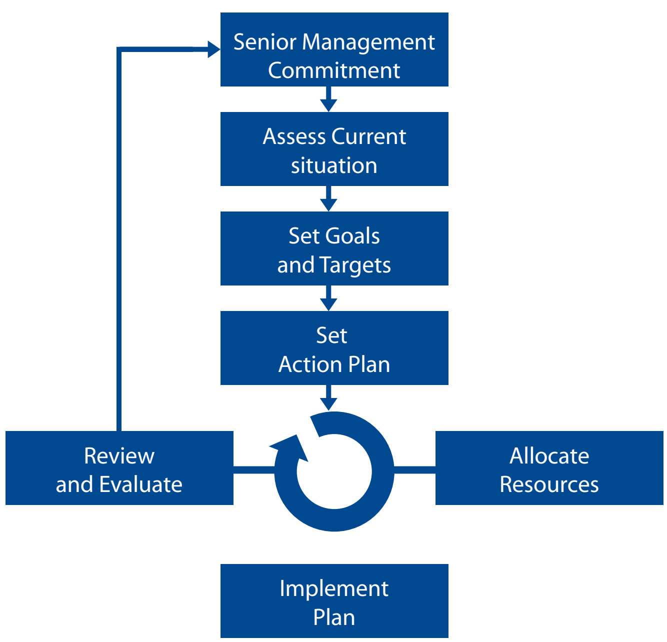


Figure 2.4 Energy management process

2.5 Purchasing Energy

Purchasing Oil

Purchasing oil is similar to purchasing any other commodity and the following points are important:

- Be aware of current market prices, trends and supplier stock levels
- Deliveries of small quantities can be costly
- Contract prices can be improved by consolidating supply without giving all the business to one supplier
- Fill oil tanks when prices are low, e.g. at the beginning the summer
- Obtain the latest lowest price in a falling market even if this means switching supplier
- Only attempt forward or spot buying if you are a large consumer and knowledgeable about the market
- Consider joining an oil purchasing consortium. Buying larger quantities enables better discounts to be negotiated.

Purchasing Natural Gas

While legislation is in place to allow the development of gas markets in Ireland the competition in gas supply has been limited. As competition grows it is worth looking for competitive prices. However, standards of service are also important, e.g. regularity of meter reading and invoicing.

Each meter has a number that is, in effect, a postcode that determines the transportation element of the cost. If a site has more than one gas meter it might make sense to aggregate them into a single account to reduce standing and unit charges. If boilers are dual fuelled there is the option to fuel switch but this requires keeping a regular watch on market prices.

Purchasing Liquefied Petroleum Gas (LPG)

For sites not connected to the natural gas distribution system it is possible to use liquefied petroleum gas (LPG) as a clean fuel option. This is usually in the form of propane (C_3H_8) or butane (C_4H_{10}) and is delivered in bottles or by bulk delivery to a liquefied storage tank. LPG is considerably more expensive than natural gas. There are two main suppliers and a number of smaller suppliers in Ireland. It is always worth seeking competitive prices. Some suppliers will provide storage tanks, gauges and valves either on a rental basis or by adding a charge to the unit cost of energy.

Purchasing Electricity - Smaller Users

Even for the most modest users there are opportunities to reduce costs in the electricity market through competitive purchasing and load management. It is important to have accurate data on consumption and load factor as this helps to select the most appropriate tariff to minimise costs. Tariffs applicable to smaller users include:

General Purpose Tariffs
Billed bi-monthly a fixed price in c/kWh is charged anytime of day or night. Alternatively cheaper units can be obtained at nights (11.00 to 08.00). The initial 8,000 units in any two-month period are charged at a higher rate. There is always a standing charge. There is a low power factor surcharge with wattless units (kVArh) being metered and charged for if their number exceeds a threshold value and is greater than half the number of metered kWh.

Maximum Demand

Again a bi-monthly tariff although users may be billed monthly on the basis of estimates. Meters record the highest fifteen minutes of electricity use between 08.00 and 21.00 UTC* Monday to Friday in the billing period and calculate the Maximum Demand value. This is measured in kW and charged separately with charges being slightly higher in the winter months (November to February inclusive) than the summer. A service capacity charge is also made based on the agreed Maximum Import Capacity (MIC). Note that this figure will be above the measured maximum demand value. If the MD can be controlled and reduced through load management then savings can be made by reducing the MIC. If a site has reduced its activities or operations the MIC may be well above the level required and can be reduced which saves on cost. Standing charges, unit charges (day and night) and the low power factor surcharge also apply.

The Winter Demand Reduction Incentive (WDRI) is an arrangement whereby the maximum demand is only measured at certain specified peak hours. This allows the user cost savings through load management and the supplier flexibility in dealing with high winter demands.

For further details on energy invoices see Section 3.3.

Purchasing Electricity - Other Users

All electricity users can continue to purchase electricity on the basis of published Maximum Demand tariffs with the option of receiving supplies at higher voltages. Alternatively all users can change supplier in the deregulated market.

Before purchasing electricity in the developing competitive market there are some important preparatory steps required:

- **Site details**
  The Meter Point Registration Number (MPRN) is required which contains specific data related to the site. The supply voltage and Maximum Import Capacity (MIC) are also required.
- **Connection**
  A Connection Agreement must be signed with the network operator (ESB).
- **Metering**
  All sites require half hourly profile data collected electronically and transmitted on-line.
- **Data**
  Potential suppliers will need half hour profile data for 12 months in order to submit a price. This is available from the meter operator (ESB).

Once these things are in place it is possible to approach suppliers. A list of suppliers is available from the Commission for Energy Regulation (CER).

* Universal Time Co-ordinated

Typically the information required by the suppliers to submit a tender are:

- Site half hour data for one year
- Proposed contract start/finish dates
- Meter Point Registration Number (MPRN)
- Supply voltage
- Maximum Import Capacity (MIC)
- Quantity of electricity (kWh)
- Maximum Demand (kW or kVA)
- Specific payment or invoicing requirements

For further details on energy invoices see Section 3.3

Purchasing Green Electricity

Currently a small number of generators are licensed to supply "green electricity" obtained from renewable energy sources directly to consumers. These are concentrated in the domestic and smaller non-domestic areas of supply. Potential customers should approach the suppliers directly.

Details can be obtained from the Commission for Energy Regulation (www.cer.ie) or a list is available from ESB, www.esb.ie

Energy Services Companies (ESCOs)

To improve energy efficiency an organisation needs to identify opportunities, recommend cost effective measures, implement the measures and be vigilant in maintaining the improved standards. This requires technical expertise and financial resources. If either of these factors are constrained there will be real barriers to progress in achieving savings. In such cases Contract Energy Management (CEM) is a possible method of securing the required resources to realise the potential energy savings. CEM is a generic name for a range of services offered by a number of companies. The broader term of Energy Services Company (ESCO) is now more common.

ESCOs usually cover three main areas:

- Determine if energy savings can be achieved and if there is a need for new and secure supplies of energy. The contractor will carry out a detailed survey and identify opportunities for energy improvements.
- The contractor then negotiates, designs, supplies and installs all the necessary energy plant and equipment.
- Finally the contractor often takes full responsibility for the ongoing operation and maintenance of the plant for the duration of the agreement. It ensures that all energy plant and equipment is running effectively at optimum efficiency and complies with all current regulations.

Contractors offer a wide range of services, which can be tailored to suit individual sites needs and do not necessarily include all of the above areas. One such example is the ESCO set up by SEI to monitor the energy consumption of Dublin's four main universities, see www.e3.ie.

The different services can be categorised according to the type of contract used by the ESCO to recover its investment:

- **Heat Service Contract**
  in which variable charges are levied according to the energy supplied to the site
- **Shared Savings Contract**
  in which charges are based on energy savings achieved
- **Fixed Fee Contract**
  in which charges are based on the level of services provided

In general, contracts tend to be long term (typically 5-20 years), particularly where the contractor is investing capital; contracts are often complex to ensure that benefits and risks are clearly defined and involve a high degree of mutual trust and cooperation between the site owner and the contractor. Successful contracts will require a considerable amount of preparation to make sure everything is right especially considering the length of some contracts. Key points to consider are;

- Carry out a comprehensive energy audit to establish the starting position.
- Prepare a well considered specification of requirements (preferably as an output specification). Independent assistance in drawing this up may be advisable.
- Make sure bidders have all the information they require and sufficient time to prepare a good proposal.
- Consider the proposals carefully, including vetting the bidders track record and resources.
- Check the final contract terms clause by clause to ensure it covers all requirements and costs, not just the service specified but also all the management and contract functions that will be required for smooth operation.
- Carry out regular audits to compare against the original audit to monitor progress, this will aid contract reviews.
- Perform any duties affecting the contractor's costs conscientiously.

Most large buildings are suitable for ESCOs. The appropriateness will depend on in-house availability of expertise, funding and manpower. For smaller buildings with an energy expenditure of less than €70,000 per annum, it would not normally be appropriate.

Equipment Supplier Finance (ESF)

In ESF the capital is provided by the equipment supplier, which makes ESF attractive to those organisations that do not have access to capital or wish to use available capital for other projects. It is a method commonly used to finance Combined Heat and Power (CHP) projects.

ESF is a specialised form of leasing in which the equipment supplier provides and installs the equipment at no cost to the site and retains ownership of the plant and provides maintenance. The site pays for the fuel to the CHP plant and contracts to buy the electricity generated at an agreed price. This price might be based on an agreed supply tariff, a fixed discount on the normal electricity supply price, an initial price linked to the RPI or some similar type of arrangement. Essentially the site buys the electricity at a lower price than from an external supply and gets the heat 'free'. The supplier uses the income to finance and maintain the equipment and produce profit.

2.6 Renewable Energy

Renewable energy sources are those which occur naturally and repeatedly in the environment. These sources include the sun, wind, oceans, plant life, and falling water. It can also include energy from waste and new technologies such as fuel cells. Some renewable technology is well developed and other areas need more research and development. Therefore the technical and commercial viability of each source varies considerably. Renewable sources include:

Solar	Biomass
passive solar design	energy crops
active solar heating	biogas
photovoltaics	landfill gas
Hydro	anaerobic digestion
hydroelectric (large scale)	municipal waste
hydroelectric (small scale)	agricultural/forestry waste
tidal	**Geothermal energy**
wave	
Wind	**Heat Pumps**
on shore	
off shore	

Ireland has a large potential for developing renewable energy sources. Currently Ireland imports over 85% of its energy needs. Therefore the development of an indigenous renewable industry is important. The benefits are;

- reduced CO_2 emissions
- cleaner, less polluting energy sources
- secure and stable long-term supplies
- reduced reliance on fuel imports
- less exposure to volatile global energy prices
- investment and employment opportunities
- economic development in rural and under developed areas

Currently renewable energy meets about 2% of Ireland's total energy needs. See Figure 2.7.

The majority of renewable energy electricity generation comes from hydro and wind power. See Figure 2.8.

There are substantial renewable energy sources still to be harnessed in Ireland. Hydro power is well established technology with five large scale and 40 small scale systems in use. Studies show that 75% of Ireland's hydro sources have been exploited and the remaining potential will be realised using small scale systems.

Wind power has been developing at a rapid rate in recent years as Ireland has some of the best wind energy sources in Europe. Wind farms currently generate 230 MW and more sites are coming in stream. Studies indicate that only 10% of the realistic potential has been exploited so far. There is also a largely untapped resource in biomass, biogas and agricultural and forestry waste.

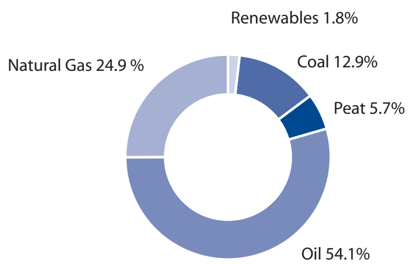


Figure 2.7 Total primary energy requirement 2003

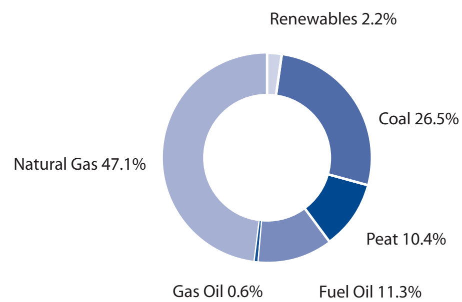


Figure 2.8 Share of electricity fuel mix 2003

Renewable Energy Information Office (REIO)

The Renewable Energy Information Office, a national service of Sustainable Energy Ireland, promotes the use of renewable sources and provides independent information and advice on the financial, social and technical issues relating the renewable energy development.

Contact details:
Sustainable Energy Ireland
Renewable Energy Information Office
Shinagh House
Bandon
Co. Cork

t +353 23 42193
f +353 23 29154
e renewables@reio.ie
w www.sei.ie/reio.htm

2.7 Investment In Energy Efficiency

Reviewing Opportunities

An energy survey of any organisation will usually reveal a number of opportunities to save energy, money and reduce carbon dioxide emissions. These will include simple good housekeeping measures, low and medium cost investments through to major capital projects.

In any long term energy management strategy there will come a point when most low cost and no cost measures have been implemented or are being maintained. To progress further capital investment will be required. Often the best opportunities come with a new build or the refurbishment of existing buildings.

Purpose of Financial Appraisal

Most organisations have more investment opportunities than funds available. Therefore a choice must be made between projects. Financial appraisal is the tool by which these choices are made. It is a process in which costs and benefits of projects are combined to produce a measure of financial return. Financial appraisal has four objectives;

- **Identify best investments**
  Financial appraisal helps to identify which investments make the best use of the available capital.
- **Optimise benefits from each investment**
  Detailed appraisal examines all the relevant factors and enables optimisation to derive maximum benefit.
- **Risk minimisation**
  Rigorous investigation highlights how financially sensitive a project is if key assumptions change during the project. This enables an assessment of risk to be made and, if possible, minimised.
- **Performance analysis**
  Detailed appraisal provides a yardstick for assessing project performance once the investment is made.

Key Steps in Financial Appraisal

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

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

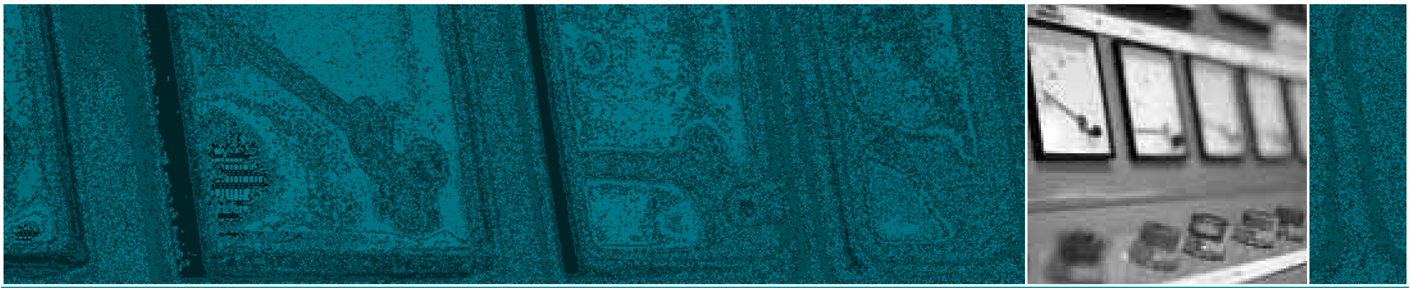
Taking short cuts in any step prejudices the outcome of the subsequent steps and could lead to a poor financial decision. Among the most common reasons for failure of the financial appraisal exercises are insufficient systematic searches for energy saving opportunities, inadequate information systems and overestimation of potential benefits.

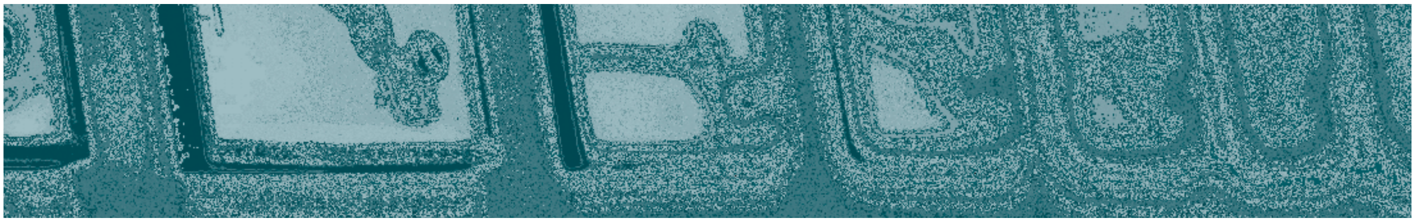
2.8 Further Information

For further information on investing in energy efficiency, see:

- Investing in Energy - A Practical Guide to Preparing and Presenting Energy Investment Proposals, 2004, SEI

Section 3 | Data - Information is Power





3.1 Introduction

The provision of accurate data is of paramount importance for energy managers. Without regular and reliable data, energy cannot be managed.

The following steps will enable this data to be gathered and analysed to indicate where energy savings may be identified and achieved. **Meter readings** can be used to check energy **invoices** and assist in the correct choice of supply tariff or most appropriate contract. **Benchmarking** will reveal which buildings should be targeted for further investigation while **energy audits and surveys** will pinpoint particular utilities usage and where waste is occurring. Local **degree days** can be used to monitor building energy use and examine the degree of control. Continuous **monitoring and targeting** can then be carried out to ensure that improvements in energy use continue by detecting waste when it occurs and ensuring that performance is maintained.

There are two main sources of energy data – utility meters and fuel bills, but other sources of data exist which should not be overlooked, such as degree day information, building log books and building energy certificates.

3.2 Utility Meters

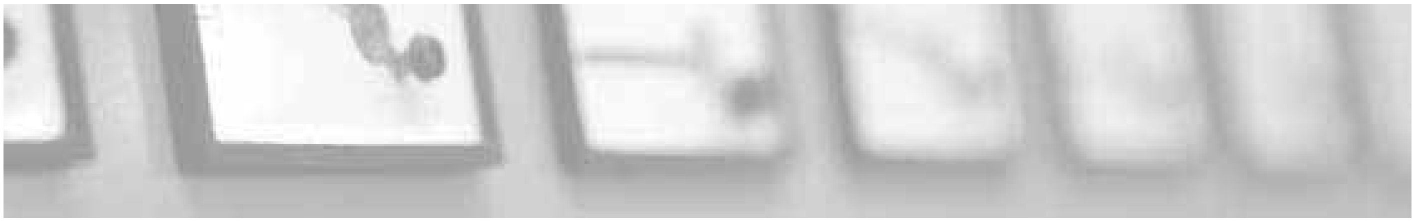
Metering is at the heart of good energy management. If a commodity cannot be measured it cannot be managed. In addition to site meters that provide billing information, sub-meters may be installed for energy management purposes. Some new equipment may even be installed with integral metering (for example new gas-fired boilers). This trend is set to increase in the future.

While there are a very large number of methods of electricity and fluid flow measurement, the common types of meters used to measure flows relating to energy management are considered below.

Electricity

Traditional electricity meters are electromechanical in operation, with a spinning disc indicating that power is being consumed. The number of rotations is a measure of the energy used. Usually a mechanically operated digital display indicates the kWh reading. Similar meters may be encountered measuring reactive units, kVArh also known as wattless units.

If the meter has two ranges, indicating day and night rates then there may be a clock or time switch situated near to the meter that changes the ranges. Another type of electromechanical meter that may be present is a maximum demand meter. In appearance these meters resemble a car speedometer and measure the actual current being drawn over fifteen minute intervals. This may be measured in kW or kVA.



Modern electronic meters are gradually replacing the electromechanical type and offer a range of extra services to the user, such as indication of kWh consumption in different time ranges (depending on programming), maximum demand measurement in kW or kVA and reactive units, kVArh. They will also often provide a pulsed output for use by a data logger, building management system (BMS) or automatic meter reading system (AMS).

For an explanation of reactive units and power factor see Appendix 5.

Gases

All gas meters measure volume flow. This must be converted to an amount of energy by multiplying it by the calorific value of the gas. The declared calorific factor will be stated on invoices and may vary slightly from time to time (See next section).

If the gas is supplied at high pressure then allowance must also be made for density changes by allowing for pressure and temperature correction. These may be continuously measured at the meter or a constant figure may be assumed. If the latter, the "correction factor" will also be shown on the invoice. It is important that meter readings are corrected and converted before being used for energy monitoring purposes.

There are three types of gas meter in common use: the steel case diaphragm meter, rotary displacement meters and turbine meters. Meters are sized on the basis of a nominal flow (Qnom) at a given supply pressure and pressure drop. There will also be a recommended maximum flow (Qmax).

Each type of meter has its applications depending on flow rates, range and turndown accuracy. Meter manufacturers will advise on the type required for a particular application.

Liquids

Liquid flows can be measured by a variety of positive displacement meters and turbine meters, the flow converted to kWh using a conversion factor.

In addition to mechanical and electronic flow measurement devices, flows can also be measured by observing the pressure drop caused by an orifice, or other restriction, placed in the flow. With a suitably calibrated device a range of flows can be inferred from this pressure differential. This system is frequently used for steam measurement. The most basic such device is a simple orifice plate. Cheap and robust they are simple to fit and use but can be subject to wear which can lead to errors. Further developments include the use of nozzles and venturi tubes that may be more resistant to erosion and produce less overall pressure drop.

Various alternative flow-measuring methods may be encountered with two of the commonest including:

- **Vortex Meters** - where eddies are shed from a "bluff body" situated in the flow stream at a rate proportional to the flow rate.
- **Ultrasonic Meters** - measure the time-of-flight of an ultrasonic signal across the flow. Alternatively they may measure the Doppler shift of the signal interacting with bubbles or entrained particles within the flow.

Other Types of Metering

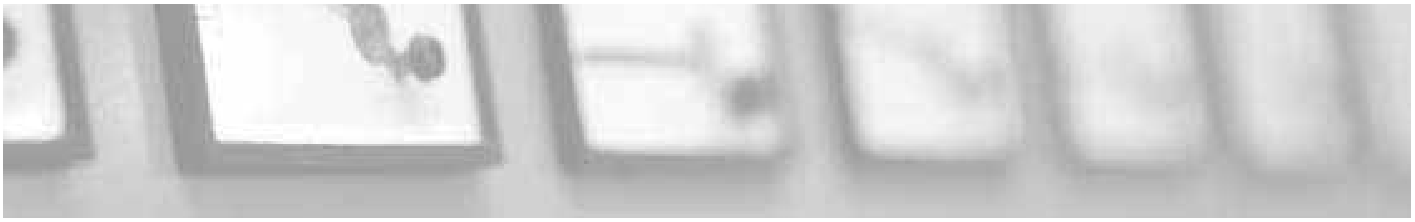
Where recording the flow of fuel is more difficult for instance in the case of coal or wood it may be possible to infer consumption by using another measure such as operating hours or perhaps rotations of a screw feeder for a coal fired boiler.

Delivered quantities of fuel may also be used in which case it is essential to also record the stock level ether by a sight glass in oil tanks or by estimating the size of a stock pile.

Errors in Meter Reading

Energy management relies on accurate meter readings whatever the metering method chosen. Some of the errors that may be encountered include the following:

- **Meter 'round the clock'**
  Here the meter rotates past its maximum reading of (say) 9999 to 0000. This situation manifests itself as the latest meter reading being less than the previous one implying a negative consumption. The solution is to add back the missing volume, 10,000 units in the case of a four-digit meter.
- **Exchanged Meters**
  When meters are exchanged (whether it is the utility supplier's or sub-meter) it is essential to record the final reading on the old meter and the initial reading on the new. There is no real need to know the date of the change since the evidence of the two meter readings at the time of the swap will only be used to make an adjustment to the next scheduled reading. If the new meter uses a different measurement to the old one (e.g. hundreds of ft3 to m3) check the next invoice to ensure this has been taken into account.
- **Mistakes by Meter Readers**
  Even the modern digital meters can be misread, especially if the people reading them have not been trained.
- **Steam Metering Errors**
  Steam metering by orifice-plates depends on the measurement of a differential pressure across the orifice. Often the pressure sensor is mounted well below the steam meter body and condensate may collect in the connecting pipes and lead to errors. This connecting pipework must therefore be drained or equalised regularly, especially after start-up from cold.
- **Paying for Another's Energy Use**
  It is not uncommon where properties are in close proximity for one organisation to unknowingly be paying for the energy use of another. Also double billing can occur. One way to identify if this is an issue is to benchmark building performance; another is to cut off power, gas or water to a building and see if neighbouring buildings are affected.



3.3 Energy Invoices

Invoices are an important source of information about energy use and associated charges. Knowledge of the terms used will also assist in analysing bills, choosing tariffs, contracts and supplier.

Electricity

Depending on the size of the supply, customers will purchase their electricity either based on published tariffs or on a specific contract. Regardless of the size many similar terms are used to describe the different elements of the invoice. The important data that can be obtained from these bills is summarised below (see www.esb.ie for a full description):

- **Account Number**
  Essential if it is necessary to contact the utility company.
- **Supply Address**
  Address the electricity is supplied to, check to make sure it is yours, as it is not unheard of for large companies with many electricity supplies to be paying invoices for properties other than their own. Supply address may be different to the billing address.
- **Meter Point Reference Number**
  The MPRN is a unique number identifying the electricity supply, essential if you wish to change Supply Company.
- **Tariff**
  Type of supply.
- **Billing Period**
  Dates the invoice covers. Note: this may correspond to the meter reading dates, but not necessarily.
- **Meter Readings**
  Day units at the top, followed by night units and then wattless (reactive) units. Readings may be followed by a C or E indicating a customer or estimated reading respectively. If an estimated reading has been used check it to see if it corresponds to the actual reading; if not contact the supplier with the actual reading.
- **Day Units**
  To determine the number of day units the previous reading is subtracted from the present reading and then multiplied by the multiplier factor to get the consumption in kWh. The multiplier factor is available from your electricity supplier.

The day units are charged at two rates. The first block of units is based on the Chargeable Maximum Demand x 350 and then pro-rated based on the actual number of days the invoice covers divided by 61.

The remaining day units, if there are any, are charged at a reduced rate.
Note: the day rate charges may also change depending on the time of year, often higher charges are levied at times of peak demand such as Nov – Feb.

- **Night Units**
  Units used between 23:00 and 08:00 are charged at an even lower rate. It is therefore advantageous, if possible, to delay large electrical demands until this period. Note the multiplier still applies.

Check the ratio of day units to night units. If night unit consumption is less than 10% of day unit consumption, it may be worthwhile converting to a single rate tariff, which will have slightly lower charges for day rate units than a two rate tariff.

- **Wattless (Reactive) Units**
  Reactive power measured in kVArh is a measure of the induction current generated in circuits by coils of windings in motors transformers etc. The reactive current serves no useful purpose and reduces the capacity of transformers, cables and switch gear; it is therefore discouraged by electricity suppliers. If the wattless units exceed 1/3 of the total kWh, the excess is charged at a fixed rate.

If your invoice regularly includes charges for reactive units it may well be worth investing in power factor correction equipment to reduce reactive loads.

For an explanation of reactive units see Appendix 5.

- **Standing Charge**
  A fixed charge often quoted as € per year and then pro-rated to cover the billing period.

- **Capacity Charge**
  A fixed charge based on the Maximum Import Capacity (MIC) measured in kVA. The charge is pro-rated to cover the billing period.

- **Demand Charge**
  A fixed charge based on the actual maximum demand during the billing period.

Compare the maximum demand to the MIC, if it is higher the MIC you may be charged extra for exceeding your authorised import capacity, equally if it is substantially less, over a period of a year, it may be possible to get the MIC reduced and save money.

- **PSO Levy**
  Public Service Obligation Levy is a charge made to cover the extra cost of producing/purchasing electricity from indigenous and environmentally friendly forms of fuel. Either a fixed charge per month or based on MIC.

- **Total Amount Owing**
  Check to make sure the elements add up to the invoiced amount.

Natural Gas

All gaseous fuels are metered by volume, which then needs to be converted into energy supplied. The steps involved will usually be itemised on invoices, but in general the process involves:

The metered volume in cubic metres (or possibly hundreds of cubic feet, which will need converting to cubic metres) first needs to be corrected to standard temperature and pressure conditions. This is particularly important if the gas is metered at high pressure. For low pressure supplies this correction is often achieved by means of a "fixed factor" applied to the meter reading. This will be stated on the invoice and usually has a value of approximately 1.022. It represents the fact the even low-pressure supplies are compressed slightly. This corrected volume is multiplied by the calorific value to give the delivered energy in mega joules, MJ. This is then converted to kWh for billing. The calorific value will vary slightly from time-to-time and will be stated on the invoice in units of megajoules per cubic metre, MJ/m^3. This will be the gross calorific value and is commonly about 38.6 MJ/m^3.

Oil

As with gases oils are measured in terms of volume and converted to energy using a declared calorific value. Invoices will normally show delivery date, volume delivered in litres and the cost per litre.

3.4 Degree Day Records for Heating and Cooling

It is apparent that the amount of heat lost from any building depends on the difference between the inside and the outside temperatures. The quantity of fuel used to heat the building will be a function of this temperature difference. The outside temperature will obviously vary throughout the time of day and time of year and so the concept of degree days is introduced to account for this.

Degree days are a measure of "heating requirement", that is they answer the question "how cold has it been and for how long?" It follows that there should be a simple relationship between the fuel used for heating and the number of local degree days in any particular time period. This can reveal the effectiveness of your heating (and cooling) controls and the value of improvement measures.

Details of how to obtain and use degree day information is included in Appendix 6 and Section 3.9 "Monitoring and Targeting".

3.5 Other Sources of Data

Building Log Books

The completion of building log books which describe the controls and services of any building and, importantly, changes and modifications to them will become a requirement of the European Union's Energy Performance Directive (EPD) or EPBD (Energy Performance in Buildings Directive).

The Chartered Institute of Building Services Engineers (CIBSE) has published Building Log Books – A guide and standard template for preparing log books for non-domestic buildings as a key tool to enable design teams and contractors to meet this requirement. Details can be found at www.cibse.org.

There are many obvious benefits of keeping an up-to-date building log book, for example:

- There is one single source of reference.
- It should always present an up-to-date picture of the building.
- Here will be one record of alterations to controls.
- Staff and Managers new to the building will be able to learn immediately how the building should be operated.

Building Energy Certificates

The production of energy certificates will soon become a requirement as part of the European Union's Energy Performance Directive (EPD) or EPBD (Energy Performance in Buildings Directive). The certificate will show the buildings design and actual energy consumption together with recommendations for improvements.

Walk Around Survey

To make sense of all the utility data being collected it is important to also understand what is happening within the building. Conducting a regular walk around survey can fill in the gaps in information by chatting to people to find out what is happening. This can often have the added benefit of also highlighting simple opportunities for energy saving, such as lights left on after hours or thermostats set too high.

3.6 Energy Units, Conversion Factors and Emission Factors

As previously shown energy data is measured by a number of methods, in order to be able to compare consumptions they have to be converted into the same units. The standard energy unit is usually taken as the kilowatt hour, kWh. Electricity meters will measure this directly. Fuel usage will need to be converted from measured volumes by means of the declared calorific value.

Calorific values will be stated in megajoules per cubic metre, MJ/m^3, for gases and megajoules per litre, MJ/litre, for oils.

Typical figures are shown in Figure 3.1. Gross calorific value relates to the maximum amount of heat that can be extracted from a fuel by burning it and returning the combustion products to a temperature of 25°C thus causing the water vapour to condense to liquid water. Net calorific value assumes that this does not occur and the water vapour remains as a gas.

Fuel	Gross CV MJ/m^3	Net CV MJ/m^3
Natural Gas	38.62	34.82
LPG (Propane)	93.87	86.43
LPG (Butane)	117.75	108.69
Gas Oil	45.6	42.8
Heavy Fuel Oil (HFO)	42.9	40.5

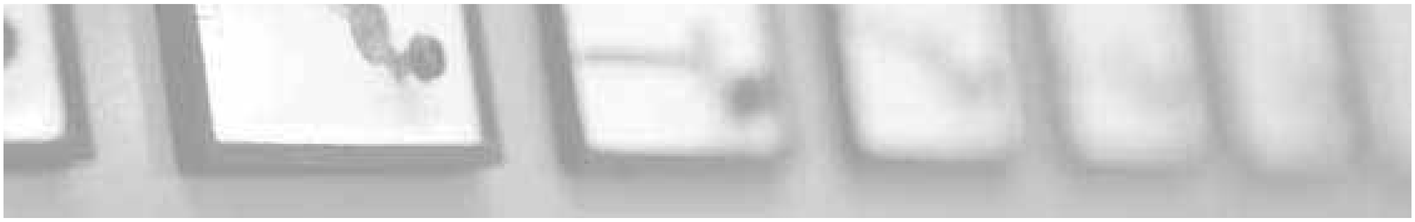
Figure 3.1 Calorific values of fuels

To convert MJ to kWh multiply by 0.2778 or divide by 3.6. To convert kWh to MJ multiply by 3.6

Carbon Dioxide Emissions

Burning hydrocarbon fuels of any type produces carbon dioxide emissions. 1 kilogram of carbon burns with 2.7 kilograms of oxygen to form 3.7 kilograms of carbon dioxide.

Carbon dioxide emissions are usually quoted in terms of the delivered energy, for example kg CO_2/kWh. The figures are often described as "Carbon Factors". For all primary fuels this is a simple matter of chemistry and emissions can be calculated from the measured energy usage. In the case of electricity the emission figure depends on the method of generation, for example if wind generation is considered the carbon dioxide emissions are often taken as zero. Looking at a national figure the mix of different generating methods must be considered. This enables an average figure to be stated which will be subject to revision from time-to-



time as the generation mix changes. Increasing use of renewable energy sources will tend to force this figure downwards.

A table of Carbon Factors is shown in Figure 3.2. To calculate the CO_2 emissions simply multiply energy consumption (kWh) by the appropriate factor.

Liquid Fuels	**kg CO_2/kWh**
Motor Spirit (Gasoline)	0.2495
Kerosene	0.2570
Gas Oil	0.2639
Residual Oil	0.2736
LPG	0.2293
Solid Fuels	
Coal	0.3406
Milled Peat	0.4140
Peat Briquette	0.3559
Gas	
Natural Gas	0.1978
Electricity (2003*)	0.6510

Figure 3.2 Carbon factors

* the carbon factor for electricity depending on the energy sources used for power generation. The figure shown here is the average for 2003. For latest figure see www.sei.ie.

3.7 Energy Performance Indicators and Benchmarks

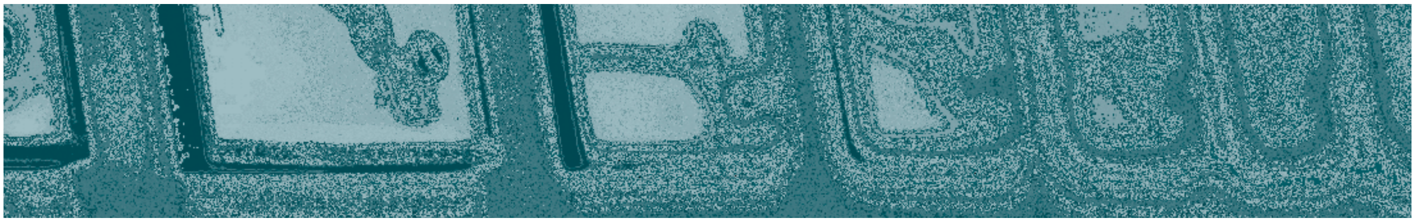
Introduction

A building's energy Performance Indicator or PI essentially refers to a specific quantity of energy use per unit of floor area. A benefit is that if building energy use can be reduced to a single value in terms of kWh per square meter per year, then different buildings can be compared with each other and external standards or benchmarks applied.

In the simplest terms a PI is calculated by taking the annual building energy consumption and dividing it by the floor area. This might be done in two parts, firstly in terms of electricity and secondly for fossil fuels (coal, oil or gas).

For example, for a building of floor area 1200 m^2:

Annual electricity consumption of 324,860 kWh
Annual natural gas consumption of 1,863,728 kWh
Then the electricity benchmark is 324,860 kWh / 1200 m^2 = 270.7 kWh/m^2
And the fossil fuel benchmark is 186,372 kWh / 1200 m^2 = 155 kWh/m^2



These figures can then be compared with other buildings in the estate and a "league table" drawn up. The worst performing buildings could then be addressed first, thus avoiding effort being spent on well performing buildings.

Published Benchmarks

A further use of these figures is to compare them with published benchmarks. Studies of different categories of real buildings have allowed data to be assembled. These benchmarks are available for a range of buildings are classified in three categories;

Good	achieved by 25% of buildings studies
Fair	achieved by the middle 50% of buildings studied
Poor	achieved by 25% of buildings studied

Benchmarks are usually expressed in energy units (usually kWh), per m^2 of treated floor area per annum. For example, published benchmarks for a single shift office with standard air conditioning are;

	Energy kWh/m²/annum		
	Good	**Fair**	**Poor**
Thermal	<97	97-178	>178
Electrical	<128	128-226	>226
Total	<225	225-404	>404

Figure 3.3 Annual energy use benchmarks for a singe shift air conditioned office

Published benchmarks usually qualify the basis of calculation so that a like-for-like comparison can be made. For example, a standard number of degree days in a year are usually specified (say 2462 degree days). It is important, therefore, to adjust the space heating element of the fossil fuel to standard degree days so that a fair comparison is made against published benchmarks. For an explanation of degree days see Sections 3.4 and 3.9.

Offices are divided into four categories;

- Naturally ventilated cellular
- Naturally ventilated open-plan
- Air conditioning standard
- Air conditioned prestige

It is a limitation of benchmarks that every office considered must be put into these categories leading to a certain imprecision. This need not be a problem as long as it is understood. If a building is well into the "poor" category it is likely that improvements in performance are possible. In practice offices often have mixed spaces - some areas naturally ventilated and others air conditioned. In this situation different benchmarks can be applied to different areas to produce a composite benchmark. A worked example is shown in Appendix 3.

It is useful to have separate benchmarks for electricity and thermal energy use because a benchmarking exercise may reveal that thermal energy performance is good but electrical performance is poor. This helps to set priorities in terms of knowing where to focus efforts in identifying savings.

Further refinement of figures is possible with allowances for treated floor area (excluding stairs, ducts, plant rooms, etc.) location, exposure, occupation and other factors. However, a simple comparison of actual consumption against benchmark will give a rapid indication of overall performance.

Benchmarking is a mandatory requirement of the EU Directive on Energy Performance of Buildings. Further details can be found at www. epbd.ie
For further details of published benchmarks see the SEI website (www.sei.ie) and The Carbon Trust (www.thecarbontrust.co.uk). Another useful source is the chapter on benchmarks in Energy Efficiency in Buildings, Guide F, CIBSE, London, 2004 - see www.cibse.org.

3.8 Energy Audits and Surveys

When commencing an energy management study it is important to determine the current position. When this has been established future action can be planned.
To achieve this, the following questions must be asked:

- What types of energy are used?
- How much is being used?
- How much does it cost?
- Where is the energy being used?
- How efficiently is energy being converted, distributed and used?
- What are the potential savings?
- How can they be achieved?
- How much will it cost to achieve the savings?
- What are the priority areas?

All the questions posed are important and can be answered by conducting an energy audit and energy survey.

Energy Audits

An energy audit consists of a study to determine the quantity and cost of each form of energy used in a particular situation. This may refer to a single building, a particular area, a whole site or combinations of the above. The audit will use data over a given period of time, usually a year.

An energy audit for a public building (over one year) is shown in Figure 3.4. The fuel consumption information can be gathered from invoices or meter readings.

Energy Consumption				Cost		CO_2	
Fuel type	Purchased Units	Equivalent kWh	%	€	%	tonnes	%
Electricity	2,192,043 kWh	2,192,043	32	207,163	71	1,700	60
Natural Gas	1,542,211 kWh	1,542,211	22	27,661	9	305	11
Gas Oil	295,429 litres	3,131,543	46	56,963	20	826	29
Total		6,865,800	100	291,787	100	2,831	100

Figure 3.4 Energy audit of a public building

Such an audit allows the major energy using areas to be identified and action taken to further analyse the situation. Fuels are converted to a common energy unit, usually taken as the kWh although in some organisations mega joules, MJ, are used.

The audit shows clearly that while fuel oil represents the major energy use with 3,131,546 kWh this only accounts for 20% of the cost. The lesser consumption of electricity at 2,192,043 kWh accounts for a much larger 71% of the cost.

These figures are often presented as pie charts to allow an easy display of the data. Typically there will be one of energy consumption and one of energy cost.

Energy Surveys

An energy survey is a technical investigation of the control, flow and uses of energy in a particular area. This area could be a building, process, a whole site or a particular piece of equipment such as an air conditioning plant. The aim of the survey is to identify cost effective energy saving measures.

A survey will usually commence with an energy audit. It will then progress to include an examination of energy conversion (such as boiler plant), distribution and end uses. Investigations can then be made by direct examination of the building and questioning the owners and occupants. Some of the areas to be considered will include;

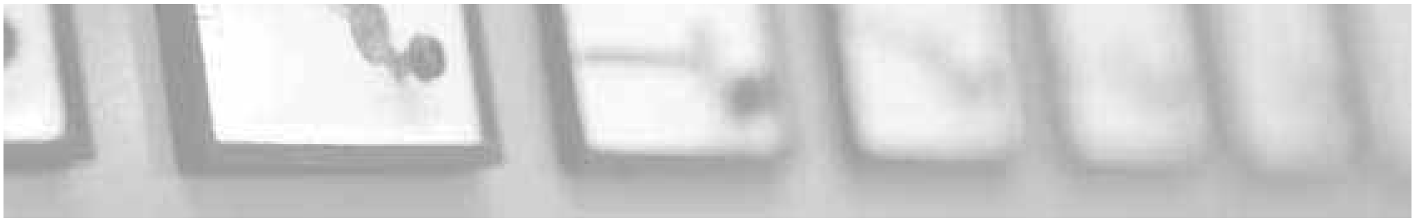
Boiler Plant

- What is the age and condition of the plant?
- Is the combustion efficiency of the boiler(s) known?
- Is the boiler sized correctly (are there complaints about heating levels)?
- Are there separate heating and hot water boilers?
- Is the boiler and pipework insulation present and in good condition?
- Is the performance of the boilers monitored?
- Are they regularly serviced?
- If there is more than one boiler are sequencing controls fitted?
- Are extra boilers turned off in mild weather and the summer?

In answering the above questions recommendations might be made for improvements and savings.

Heating/Cooling System

- Is there a relationship between building energy use and local degree days?
- Are buildings (or particular areas) over-heated (above 19°C for offices) or under-heated?
- Check the location of thermostats
- Are thermostatic radiator valves fitted and properly set?
- Are time switches (or BMS time controls) set correctly?
- Is the building heated out of occupancy hours?
- Are frost thermostats set correctly?
- Are radiators, fan convectors etc. unobstructed?
- In areas with both heating and cooling units, can they be operated together?
- Are there unwanted sources of heat in air conditioned areas?
- Do staff use portable heaters?
- Can staff reduce their heating levels rather than open windows and doors?



- If radiant heating is used does a black-bulb thermostat control it?
- Are gas and oil fired heaters serviced regularly?
- Is heating pipework properly insulated?
- Is the heating system zoned?
- Are building controls such as weather compensation and optimum start present?

Lighting

- Is the lighting performing its task?
  That is, are the clients lighting what they want staff/customers to see?
- Are there local light switches and can staff identify them?
- Are staff encouraged to turn off lights when leaving a room?
- Are lights turned off at the end of occupancy?
- Is the best use made of daylight?
- Are fittings cleaned regularly?
- Are areas over-lit?
- Are slimline T8 fluorescent tubes used?
- Is exterior lighting turned off in the daytime?
- Are tungsten filament lamps replaced with compact fluorescent lamps?
- Is high frequency control used on fluorescent lighting?

Electricity Use

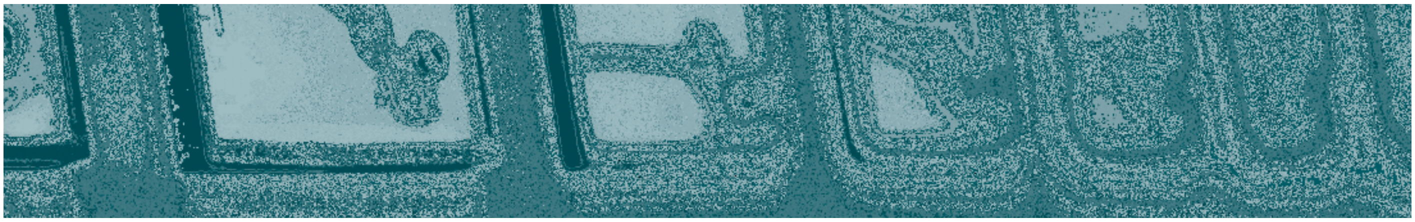
- Is all electrical equipment turned off when not in use?
  This includes offices, kitchens and (perhaps) workshops, warehouses etc.
- Is equipment such as photocopiers switched to stand-by mode when not in use?
- Are electric motors properly sized. Are drive improvements such as installing variable speed systems applicable?

Management Systems

- How is energy related information obtained, analysed and used? (if at all)
- What is the opinion of building users about comfort and lighting levels?
- Are there technicians or other staff members who regularly work with the boilers, air conditioning or other plant and might know of control or equipment failures?

The surveyor will analyse the information gathered and give recommendations that are traditionally divided into three useful categories, namely:

- No Cost Measures (Good Housekeeping)
- Low Cost Measures
- High Cost Measures



Considering each category in turn:

No Cost

Obviously this area is of great interest to many building users, particularly if control failures have been identified that are simple to correct and then yield considerable energy savings. For example an optimised start control could fail in such a way as to cause a heating system to run continuously.
It must be borne in mind however that considerable time might need to be spent achieving no-cost savings, particularly for activities such as raising staff awareness.

Low Cost

Here changes such as the purchase of new controls might be made such as the recommendation to change a 24-hour timer to a 7-day one on a building heating system. Low cost measures would be typically below €3,000.

High Cost

This is looking towards major investment such as replacing a complete lighting system. A recommendation might be more usefully made to consider improvements at the next refurbishment opportunity for example. It is important therefore before beginning a survey to determine its scope; obviously there is no point examining high cost measures unless there are sufficient funds to implement them. High cost measures would be typically above €3,000.

Finally, when stating costs it is worth considering benefits other than simple cost savings, for example savings on maintenance and labour or improved working conditions which can help improve staff morale and efficiency.

Energy Survey Reports

An energy audit/survey report is not an end in itself but a means to an end, i.e. to achieve savings. Therefore the report has to be written with the decision-maker in mind. The report should contain a one or two page summary of findings with a table of measures showing each recommendation with the estimated annual savings in kWh and €, estimated cost of implementation and simple payback in years. The recommendations can be divided into no-cost, low-cost and high-cost categories. An example is shown in Figure 3.5.

Description of Recommendations	Estimated annual saving (kWh)	(€)	Estimated cost (€)	Simple payback years
No Cost Measures				
Review compensator settings on BEMS	85,000	1,190		
Optimise restaurant heating and ventilating times	38,860	630		
Reduce print hall air-conditioning plant operation	551,600	21,700	-	-
Adjust time and temperature settings on Block 'A' computer room air-conditioning	215,400	7,070	-	-
Good housekeeping - lighting	80,000	4,620	-	-
Sub-totals	970,860	35,210	-	-
Low Cost Measures				
Reduce water meter size	-	3,780	860	0.2
Boost MTHW temperature at occupancy optimum start	844,000	13,328	715	0.1
Provide separate heating circuit - East Block showers	17,500	266	1,140	4.2
Time control for CWS booster pump	18,000	1,624	360	0.2
Flow restrictors for taps	(1500m^3)	3,640	2,860	0.8
Sub-totals	879,500	22,638	5,935	0.3
High Cost Measures				
Automatic flow isolation for North Block convector circuits	125,000	1,890	5,720	3.0
Review of print hall air-conditioning plant operation	1,157,000	31,640	71,400	2.2
Modify new computer suite air-conditioning	227,000	13,174	17,140	1.3
Additional lighting controls - print hall	52,300	3,024	3,160	1.0
L Ground lighting control	32,800	1,904	3,570	1.8
Sub-totals	1,594,100	51,632	100,990	1.9
Total	3,444,460	101,374	106,925	1.05

Figure 3.5 Energy survey summary of measures, savings and costs

The remainder of the report can detail the investigations and data on which the recommendations are made. The main sections of a typical survey could include:

- Management summary
- Table of measures with savings, costs and payback
- Energy, Cost, CO_2 Audit
- Boiler plant
- Space heating
- Air-conditioning
- Hot and cold water services
- Electrical services
- Controls and BEMS
- Building fabric
- Appendices

3.9 Monitoring and Targeting

Introduction

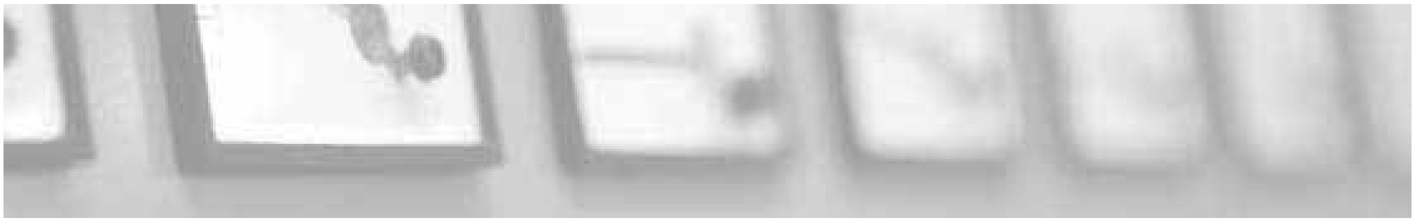
Monitoring and Targeting or "M&T" as it is generally known, is a generic term meaning the systematic collection of plant or building operating data and energy consumption, with a view to detecting and resolving anomalies in consumption or expenditure. This is its primary purpose, but M&T also yields valuable secondary information that can be used for budget forecasting, benchmarking and, importantly for the energy manager, verifying energy and water savings. It can also form the basis of competitive energy procurement. As a result, M&T underpins every aspect of energy management.

It can be applied to buildings, processes or vehicles and although principally concerned with the consumption of energy and water, it can be used for almost any consumable commodity or service. It is especially useful where the rate of consumption is driven by the weather or other such driving factor.

The level of commitment in terms of time and money for setting up and running a system should be in proportion to the size of energy expenditure and likely savings. Often savings of 4% - 12% can be achieved. Sometimes it can be substantially more.
Monitoring and targeting is a highly interactive process of continual measurement, comparison and improvement - see Figure 3.6. The four main elements are;

- **Data collection**
  Energy consumption data is best taken from actual meter readings, but for a large number of small properties, such as a retail chain, invoice data might have to be used.
- **Data analysis**
  Data analysis is usually done by computer and involves a comparison of energy performance against an expected performance based on one or more variables, such as weather and occupancy. Normally, data handling systems also provide a mechanism to check the data input for likely errors and quality. Comparisons can be made against historical data and benchmarks.
- **Reporting**
  The output reports need to be concise, easy to understand and tailored to those who are accountable for energy use.
- **Action**
  It is essential that everyone involved supports the initiative with action on the basis of the information. This local action delivers the savings. The system is only worthwhile if actions result in savings.

Figure 3.6 Key elements of a monitoring and targeting system



Data Collection

There are two categories of M&T, focused on financial and physical performance respectively. The type of system required will determine the data to be collected.

- Physical performance focus - is most common in large, complex sites (such as commercial buildings) where there may be only one supply point per utility, but numerous opportunities for excess consumption to occur undetected. Performance orientated M&T needs to be complemented by the availability of knowledgeable and skilled personnel able to resolve the technical and human causes of excessive consumption when it is detected. Monthly or weekly analysis of returns from utility sub-meters is commonplace in performance M&T although daily or even real-time schemes are operated by some very large energy users.
- Financial performance focus - is mainly concerned with the correctness of billing and the appropriateness of supply tariffs. It is prevalent in organisations that have a significant number of energy supply accounts, where perhaps the majority of end-user sites are too small to warrant monitoring of their individual physical performance. The main risks perceived are billing errors and uncompetitive prices and where it is essential to maintain a historical cost and consumption database. Monthly analysis based on invoice data is the norm for financial M&T systems.

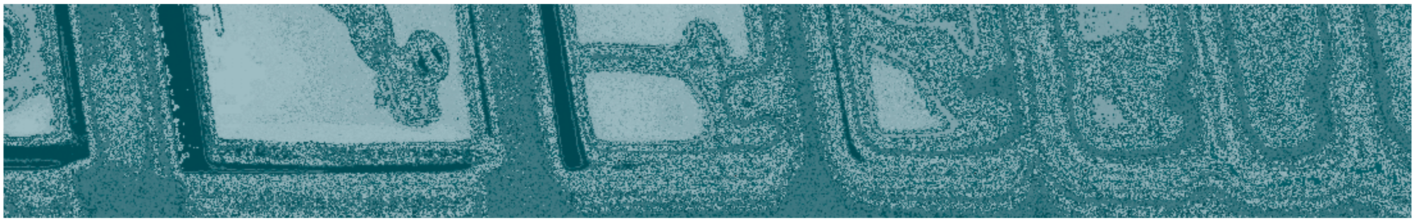
Degree Days

In buildings, the factor that drives energy consumption is, quite often, simply how cold it has been expressed in terms of degree days. Cooling degree days might be used when air-conditioning is fitted, as might the number of hours of darkness, if there were significant daylight-linked lighting. In each case, the 'determining factor' is analogous to the distance driven by a car, which determines the amount of fuel required.

Data Analysis

M&T uses historical information to build a picture of energy (water etc.) consumption as a function of weather (or other driving factor) and then compares continuing consumption with this relationship to allow changes to be identified. For example, energy use may increase due to waste occurring or it may decrease due to energy saving activities (note that M&T will allow the actual energy and cost savings to be identified). Given that the changes in energy consumption may be subtle it is not surprising that they can go unnoticed by those using traditional methods of management. M&T makes visible the unexpected changes that inevitably accompany the onset of waste.

The process of analysing a buildings performance is a simple but powerful technique. The following example will demonstrate the steps required.



Date	Gas consumption (kWh)	Dublin Deg Days
01/01/03		
01/02/03	148586	313
01/03/03	134792	291
01/04/03	123792	260
01/05/03	122228	191
01/06/03	90126	144
01/07/03	77947	63
01/08/03	70639	30
01/09/03	63332	41
01/10/03	68203	77
01/11/03	117177	194
01/12/03	131535	211
01/01/04	153893	298
01/02/04	147520	312
01/03/04	138191	289
01/04/04	131200	271
01/05/04	125180	197
01/06/04	87453	150
01/07/04	75320	61
01/08/04	72640	60
01/09/04	68548	35
01/10/04	73723	61
01/11/04	122851	184
01/12/04	144145	219
01/01/05	156542	282

Figure 3.6 Gas Consumption and degree days

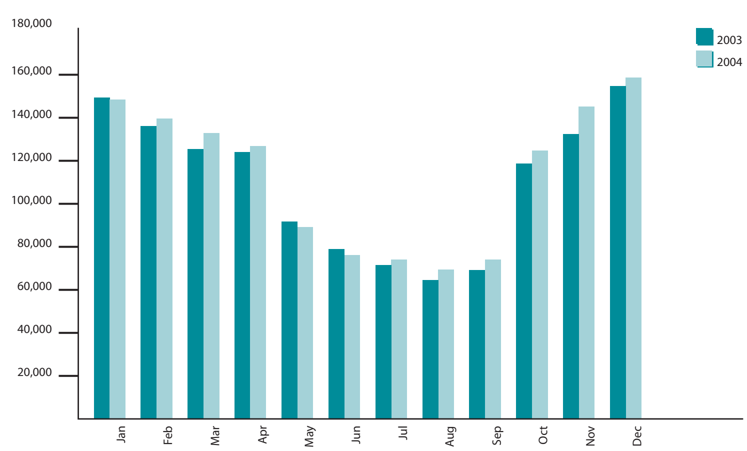


Figure 3.7 Gas consumption graph

Step 1 – Tabulate Data

Using a spreadsheet programme create a table showing energy consumption and the corresponding degree day data. An example is shown in Figure 3.6.

A typical energy management graph is shown in Figure 3.7 shows fairly typical consumption reducing over the summertime and increasing in the wintertime. Comparison of 2003 and 2004 shows similar consumptions.

Step 2 – Plot Energy Consumption against Degree Days

Using the spreadsheet plot a graph of energy consumption against degree days. The scatter of points will vary from site to site, but the chart will usually show a similar pattern to that shown in Figure 38.

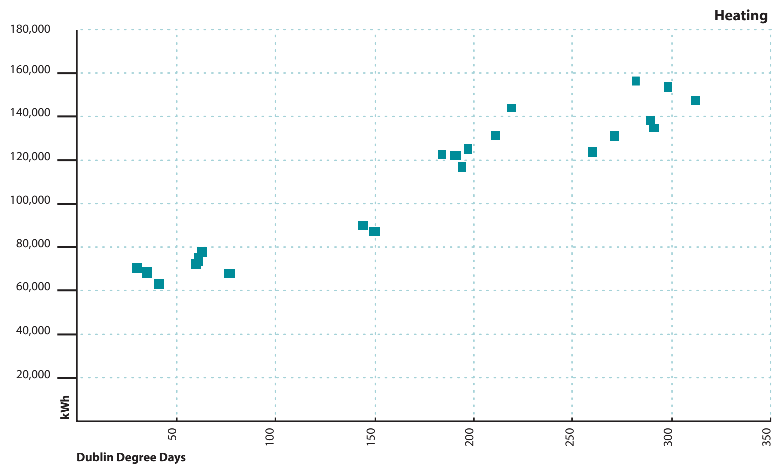


Figure 3.8 Gas consumption versus degree days

It is clear from this that there is a linear relationship between energy use and degree days, which is exactly what you would expect – the colder it is the more heat a building needs to stay comfortable.

Add a straight line to the chart, in this case it is a best fit line, but as this is only the starting position it does not really matter what line is used. See Figure 3.9.

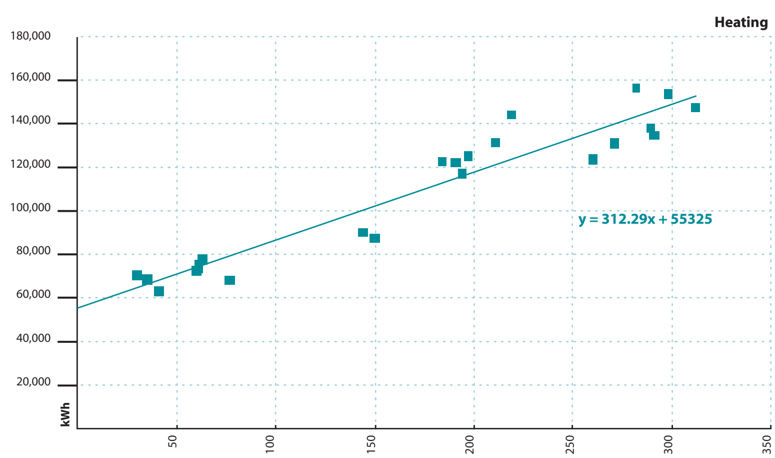


Figure 3.9 Line of best fit

This line is characteristic of the building and, if nothing changes, you would expect all following points to be situated on it. All new points should be on the same line although a warm year would see them grouped at the lower end of the line and a cold year them grouped at the higher end.

Whenever a consumption volume is recorded lying significantly above the target line, you will have detected energy wastage. Energy saving measures will result in consumption lying below the target line.
The line can be extrapolated to show the energy used at a zero value of the determining factor. This is the weather independent energy use that may include, building heat loss, plant standing losses, catering or domestic hot water etc. Note that care must be taken extrapolating beyond the range of points, particularly if there are few points at the lower end of the graph.

Although the straight line shown in Figure 3.11 is the most common type of relationship, there are others that represent more complex associations.

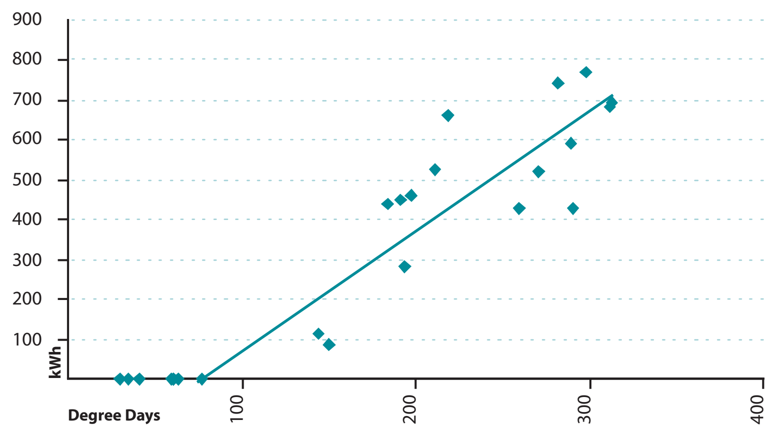
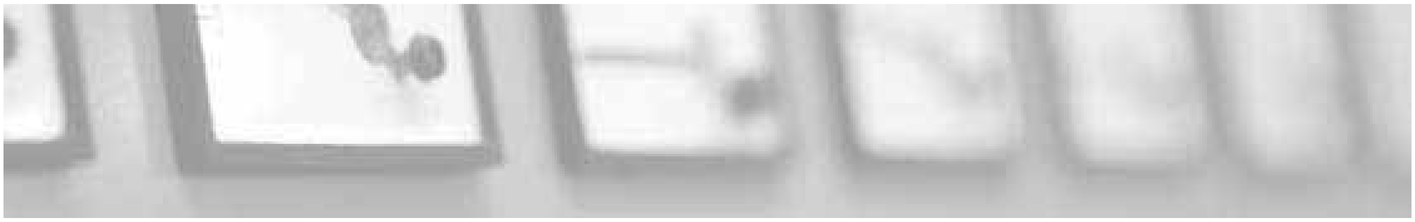


Figure 3.10 Abnormal line of best fit (example 1)

Example 1 (See Figure 3.10)
The line is initially horizontal along the degree day axis and then slopes upwards. As previously shown degree days are calculated using a base temperature of 15.5°C. This type of line shows that the outside temperature needs to get colder than 15.5°C before heating is required. This could be because the building is super insulated or heat gains from equipment are higher than normal or the internal temperature is lower than normal.

Example 2 (See Figure 3.11)
The line is initially horizontal, but above the degree day axis and then starts to slope upwards. This indicates a fixed load that is occurring regardless of the weather. Often this will be hot water production or catering, but it could equally represent a problem with control of the boilers.

Example 3 (See Figure 3.12)
The line appears to reduce in gradient almost becoming horizontal at high degree days. This type of line often indicates that the heating system has reached its capacity and can not cope on particularly cold days or possibly there is poor temperature control.



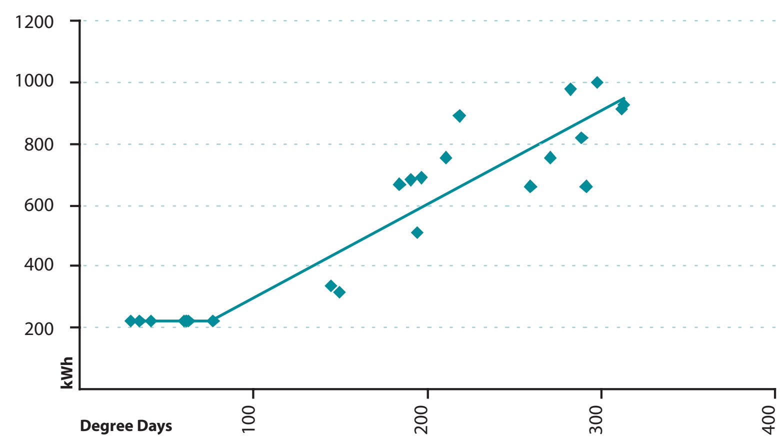


Figure 3.11 Abnormal line of best fit (example 2)

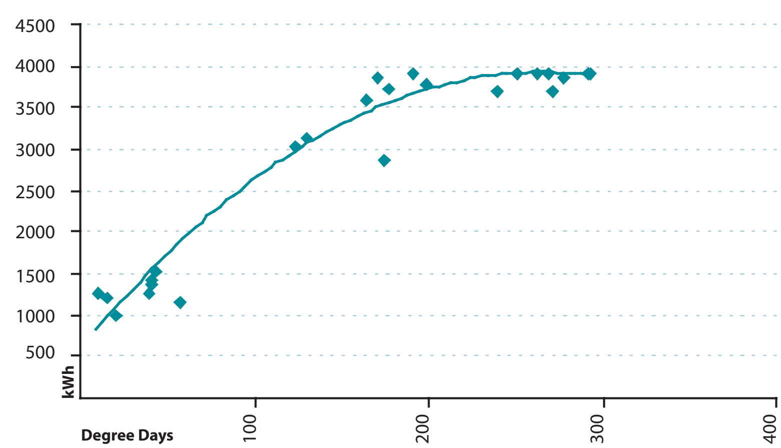
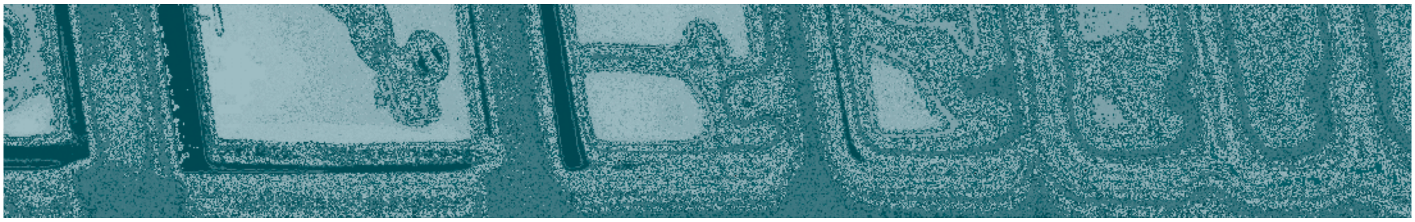


Figure 3.12 Abnormal line of best fit (example 3)

Step 3 Calculate Predicted Values

Using the formula of the straight line calculated above add three new columns to the spreadsheet.

- Predicted – The expected energy consumption based on the straight line relationship calculated in Step 2. In this case the formula of the line was y = 302 x Deg Day + 55921.
- Difference – The actual consumption minus the predicted. Thus a figure less than zero shows performance better than predicted.
- CUSUM – The running total of the difference column, i.e. the CUmulative SUM.



Date	Heating (kWh)	Dublin Deg Days	Predicted (kWh)	Difference (kWh)	CUSUM (kWh)
01/01/03					
01/02/03	148586	313	153075	-4489	-4489
01/03/03	134792	291	146205	-11413	-15902
01/04/03	123792	260	136523	-12731	-28633
01/05/03	122228	191	114975	7253	-21380
01/06/03	90126	144	100297	-10171	-31550
01/07/03	77947	63	75000	2947	-28603
01/08/03	70639	30	64694	5945	-22659
01/09/03	63332	41	68130	-4798	-27456
01/10/03	68203	77	79372	-11169	-38626
01/11/03	117177	194	115912	1266	-37360
01/12/03	131535	211	121221	10314	-27046
01/01/04	153893	298	148391	5502	-21544
01/02/04	147520	312	152763	-5243	-26786
01/03/04	138191	289	145580	-7389	-34175
01/04/04	131200	271	139959	-8759	-42934
01/05/04	125180	197	116848	8332	-34602
01/06/04	87453	150	102170	-14717	-49320
01/07/04	75320	61	74376	944	-48375
01/08/04	72640	60	74063	-1423	-49799
01/09/04	68548	35	66256	2292	-47506
01/10/04	73723	61	74376	-653	-48159
01/11/04	122851	184	112789	10063	-38097
01/12/04	144145	219	123719	20426	-17671
01/01/05	156542	282	143394	13148	-4522

Figure 3.13 Cusum data chart

Step 4 - Plot a Cusum Chart

Plot a chart showing the Cusum values against the date.

Figure 3.14 shows actual performance against predicted or target values and allows the underlying trends to be identified.

- When its trend is horizontal, it signifies that the deviances are equally balanced around zero: in other words, the monitored building is operating near the current target.
- An upward trend signifies over-consumption relative to the current established relationship
- A downward trend signifies the use of less than expected

- It follows that a change in direction signifies a change in the way the monitored building or plant is behaving.

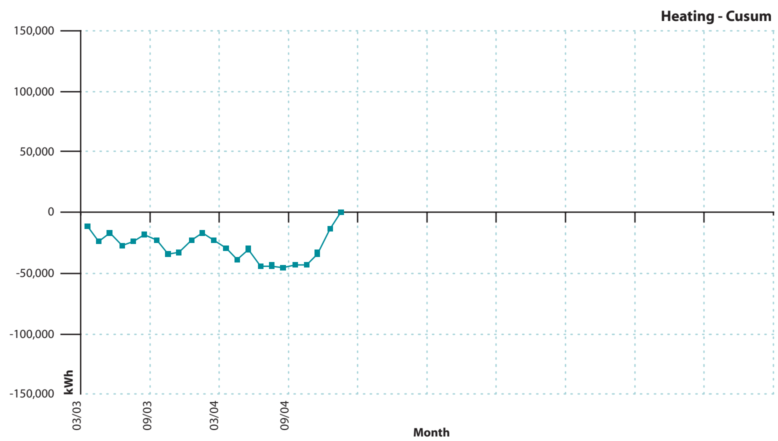


Figure 3.14 Cusum graph

The absolute value of the CUSUM is not significant. However, the change in value over any period of time represents a cumulative loss or saving.

The above chart shows that usage remained generally steady until the last three weeks when consumption rose rapidly. Already the benefit can be seen from this technique, wastage that wasn't apparent in step 1 has been identified. Furthermore this can be taken into account to set a more realistic target.

The best fit line was again recalculated, but this time excluding the last three points. Figure 3.15 shows the difference between the original line (green) and the new line (black). It can be seen that the base load has remained about the same at 55582. but the slope has reduced to 297.2. The points excluded from the calculation are shown with a red circle around them.

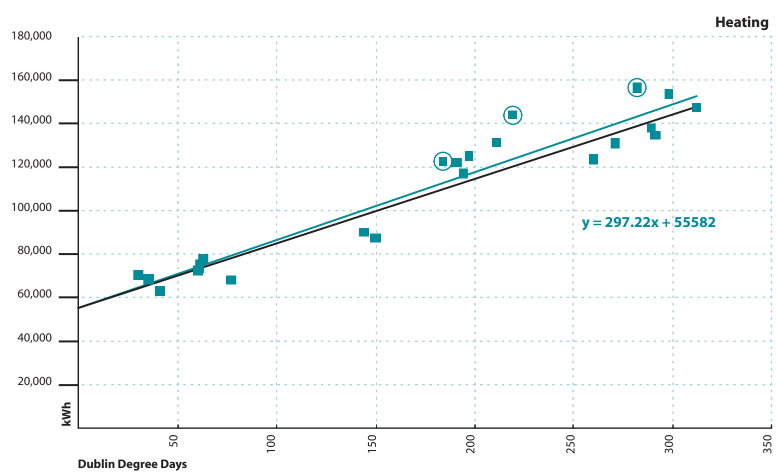


Figure 3.15 Revised line of best fit

By using this new equation the predicted, difference and Cusum values can also be recalculated and the chart re-plotted.

Date	Heating (kWh)	Dublin Deg Days	Predicted (kWh)	Difference (kWh)	CUSUM (kWh)
01/01/03					
01/02/03	148586	313	148588	-2	-2
01/03/03	134792	291	142049	-7257	-7259
01/04/03	123792	260	132835	-9043	-16303
01/05/03	122228	191	112327	9901	-6402
01/06/03	90126	144	98358	-8232	-14634
01/07/03	77947	63	74283	3664	-10970
01/08/03	70639	30	64475	6164	-4806
01/09/03	63332	41	67744	-4412	-9218
01/10/03	68203	77	78444	-10241	-19459
01/11/03	117177	194	113219	3958	-15501
01/12/03	131535	211	118272	13263	-2238
01/01/04	153893	298	144130	9763	7526
01/02/04	147520	312	148291	-771	6755
01/03/04	138191	289	141455	-3264	3491
01/04/04	131200	271	136105	-4905	-1414
01/05/04	125180	197	114111	11069	9656
01/06/04	87453	150	100141	-12688	-3032
01/07/04	75320	61	73689	1631	-1401
01/08/04	72640	60	73391	-751	-2152
01/09/04	68548	35	65961	2587	435
01/10/04	73723	61	73689	34	469
01/11/04	122851	184	110247	12604	13073
01/12/04	144145	219	120649	23496	36569
01/01/05	156542	282	139374	17168	53737

Figure 3.16 Cusum recalculated

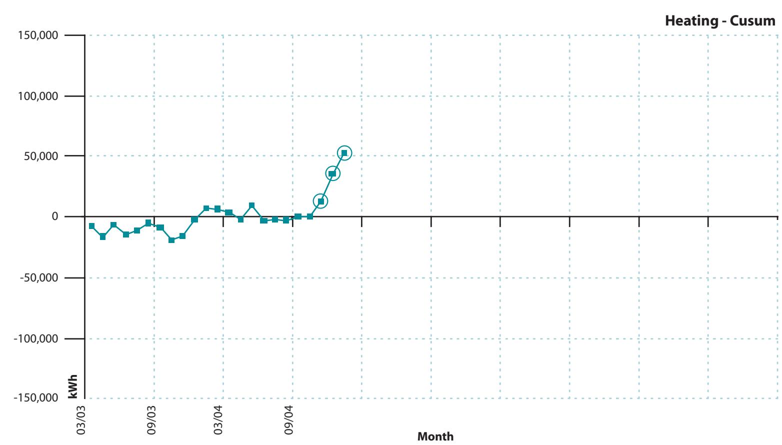
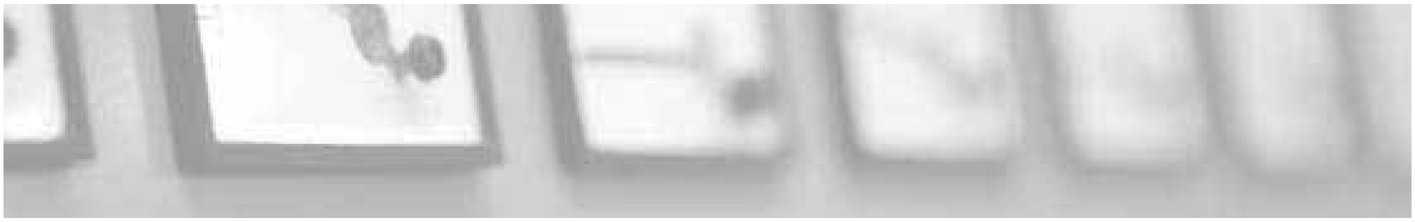


Figure 3.17 Cusum replotted

Remember that although a point's position above or below the x axis will indicate overall if the year-to-date performance is above or below target. The slope of the line is also important. Thus Figure 3.17 now shows performance on target (horizontal) points 1-7, a slight improvement in performance as the slope goes downwards (point 8) followed by performance slightly worse than target (points 9-11). Then a period of



performance on target (points 12-20), then the last three points were the gradient is much steeper indicating poor performance compared to target.

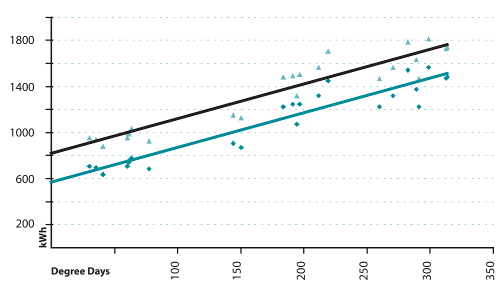
Step 5 – Set Baseline, Targets and Budget

It is now possible to use these lines to set baseline, target and budgets.

- Baseline – A historical marker of the starting performance, useful for demonstrating savings against. In this case use the red line.
- Target – Realistic, but aggressive goal for consumption based on the best of recent consumption. In this case use the black line.
- Budget – A prediction of next years consumption based on the target and average degree days.

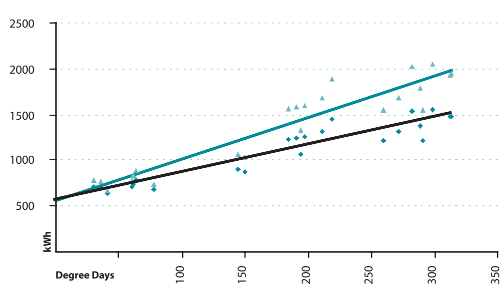
Step 6 – Monitor Performance

As previously indicated M&T is an iterative process



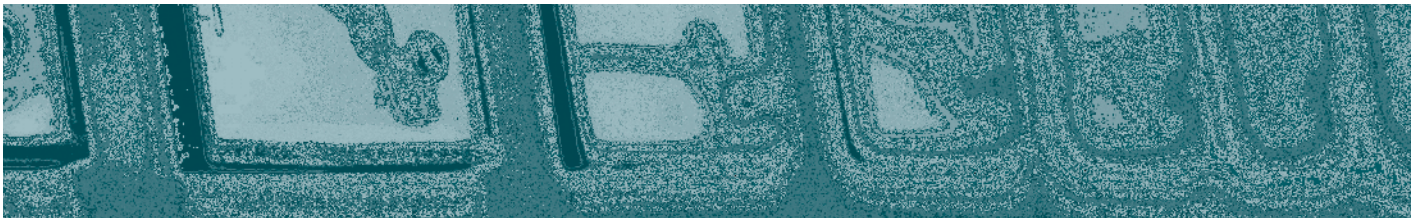
Here the slope of the line (black) has remained the same but the base load has increased, compared to the target (green). This is indicative of greater standing losses, such as a poorly maintained boiler. Conversely if the new line is below the baseline, it shows a saving made, perhaps from increased insulation.

Figure 3.18 Shift in base load consumption



Here the slope of the line (black) has increased compared to the target (green), but the base load has remained the same. This is indicative of a failure in control or an increase in the heating systems set-point. Obviously often both situations will occur.

Figure 3.19 Shift in weather-related consumption



Step 7 – Report Performance

The M&T process characterises a building based on the slope of the target line and the intercept with the y axis. Points occurring above this line indicate waste and points below it energy saved, but this or the even the Cusum chart do not lend themselves readily to interpretation by non-technical staff. It is therefore useful to use two reporting methods to monitor performance – Deviance chart and performance league table.

- **Deviance chart**, shown below, is plotted by using the difference column from Figure 3.16 against date. Two further lines are added to indicate the limits of confidence, if a point occurs between these two lines it is not considered to be significantly out of the ordinary. However, if a point does occur outside the two lines, either above or below, something significant has occurred and it should be investigated. As can be seen from Figure 3.20, the last two points are above the upper confidence line and indicate poor performance, which needs to be understood.

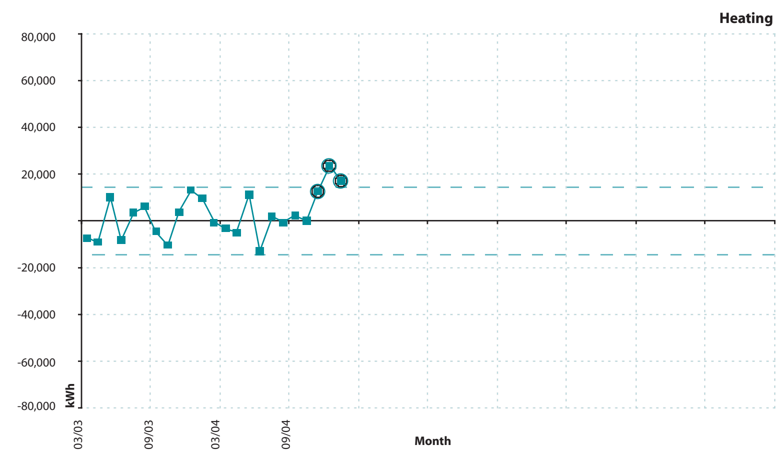


Figure 3.20 Deviance chart

The control limits can be assigned by using a number of methods, but one of the simplest is to look at Figure 3.18 and identify the largest negative value in the difference column, in this case -12688. Round the number to the nearest 100 and use this to set the control limit, in this case a significant change is indicated by a value +/- 12700 of the target value.

- **League table** – A deviation chart shows details of a particular meter well, but if it is necessary to present a number of meters a highlight priorities for action an overspend league table summarises this information quickly and easily. Simply multiply the difference column in Figure 3.16 by the utility cost to get the over or under spend and then sort the meters by overspend to present the data for a concise monthly report.

An example from another site is shown in Figure 3.21

Overspend analysis for week ending 11/12/2004					
Description	Actual units	Expected units	Units difference	%	Excess cost
Building 6b elec (kWh)	207,525	138,190	69,335	50%	€ 1,971
Building 7 gas (kWh)	93,829	21,348	72,481	340%	€ 1,036
Building 7 elec (kWh)	206,944	181,354	25,590	14%	€ 727
Building 6 gas (kWh)	54,702	44,621	10,081	101%	€ 453
Building 5 LV elec (kWh)	54,702	44,621	10,081	23%	€ 287
Building 5 HV elec (kWh)	100,135	94,862	5,273	6%	€ 150
Building 6a Elec (kWh)	451,900	455,304	-3,405	-1%	-€ 97

Figure 3.21 Energy cost report league table

Step 8 - Action

The most critical phase of the M&T process is to make sure action is taken once energy wastage has been highlighted. This may be as simple as a quick phone call or require a full energy survey, but without this stage no energy savings are made at all.

Occasionally there may be spontaneous evidence that performance is consistently better than the current target. When this happens the target should be revised downwards to reflect it. Targets should be revised as and when such revisions are warranted.

Benefits of Monitoring & Targeting

Using the 'waste avoidance' approach described here generally points to quick, cheap solutions. It is inherent in the kind of a fault which it is used to detect – tampering, breakdowns and lapses of good operating practice – that little time and money will be needed to put things right, while a lot can be lost if they remain undetected, as they often do. As a secondary benefit, the method will often reduce maintenance load and breakdowns because it tends to point out idle and out-of-hours running, allowing these practices to be eliminated.

The method gives a high degree of vigilance with less need for routine inspections. Moreover, you get this degree of vigilance much more cheaply than you could by monitoring your bills (if you manage by monitoring expenditure, you have to waste the money before you can see the problem). Furthermore, the method gives fair targets with the minimum of prior research. You do not necessarily need to survey the building or process and calculate a theoretical target; nor apply benchmarks. Every consumption process can have a target set on the basis of its own best past performance, even if that process has no counterpart elsewhere.

Financial Monitoring & Targeting

Having outlined the benefits of performance M&T, financial M&T should not be ignored as there is also considerable potential for money saving by checking invoices, changing tariffs or supplier.

Mistakes can and do occur during the purchase of utilities. It is worthwhile therefore to be equipped to challenge errors and to reclaim payments based on invoicing errors.

Evidence from large multi-site companies with very large energy spend suggests that refunds of between 2-4% can be expected from rigorous attention to invoice validation. Errors also occur with smaller users and while less common their individual impact can be quite disproportionate.

The invoice-checking process can be considered under the four general headings of Authenticity, Continuity, Integrity and Deviation (ACID).

Authenticity

Under the heading of 'authenticity' the issues are these: Are the data and prices correct? Is the correct person is being billed? For the small user this is not such an issue, because the accounts clerks will probably know enough about the business to detect mistakes. But for the large multi-site utility buyer, it is essential to operate a tight site-by-site budget coding scheme which clearly identifies individual points of supply (a key concept) and forces expenditure to be allocated accordingly.
Tariff prices are another aspect of bill authenticity that can go wrong spontaneously. Prices should be checked against the original contract or current price schedule always remembering the rule that it pays to be vigilant when contract tariffs change. Validating against a previous bill is somewhat less secure.

Continuity

Continuity of billing is easy to check when meter readings are given, because the previous meter reading can be checked against the previous bill. Where no meter readings are shown, the bill may indicate the start and end dates of the period to which if refers and these offer some small measure of protection.

Integrity

Arithmetic errors in bills are now becoming a rarity, but they can occur, more usually when a manual bill or a corrected or amended bill is rendered.

Deviation

Lastly, one should apply checks for deviant billing values. This is a safety net that will flag up any errors that have not been detected in the earlier stages.

Various validation strategies can be used depending upon the circumstances. In some cases where billing is not expected to vary greatly from one period to the next, it may be sufficient to compare the current bill's parameters such a consumption volume with the previous. In others, there may be a clear seasonal pattern to billing and here a comparison with the same period a year before may be useful, although one has to bear in mind that the reference period may itself have been unrepresentative, making this a slightly unsafe method.

With complex electricity contract tariffs where it may not be clear which of many billed items to use for comparison purposes, it may be useful to derive a parameter (such as price per unit) that can be used as an overall yardstick for comparison purposes.

These are the so-called 'internal' consistency checks. It should not be forgotten that it is possible to apply external yardsticks as well, including weather-related variable targets where appropriate. These are usually more reliable and accurate than year-on-year comparisons and, if suitably applied, will yield information about deviations in underlying patterns of consumption. In other words, they give the user an indication of whether an excessive quantity was purchased in the first place.

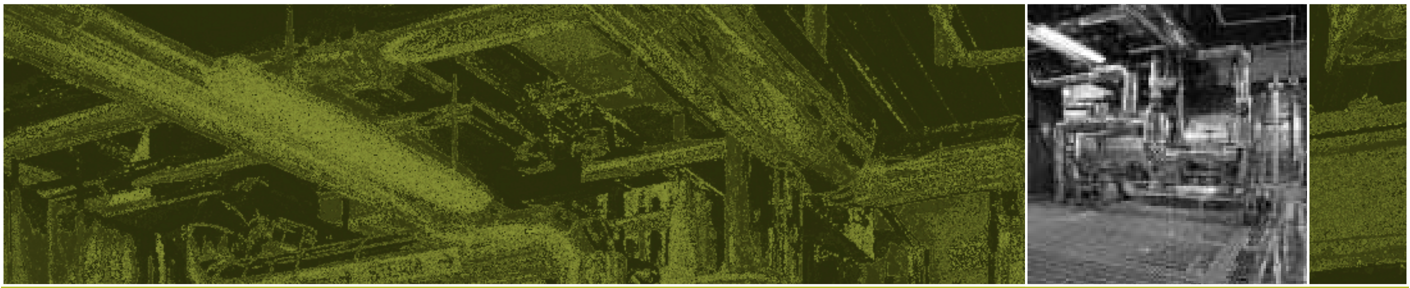
Software Support

Spreadsheets can provide an aid to monitoring and checking invoices, and for the small to medium user this is one of the most cost effective methods. There are also a number of off-the-shelf software products for this purpose that are of considerable benefit to the large energy user with multiple sites.

3.10 Further Information

- Case Studies
- Irish Met Office
- CIBSE Logbooks
- www.vesma.com
- Carbon Trust Website degree days
- Carbon Trust Logbooks

Section 4 | Technical Solutions - Smarter Technology Choices



4.1 Introduction

Technical solutions are an essential part of any energy management strategy and they fall into three categories:

- **High Cost Measures** involve substantial investment and are usually justified by the energy and cost savings they produce. However, there are times when investment may be for other reasons (e.g. fabric renewal, staff comfort) when energy saving is a by-product rather than the main reasons for the investment. Retrofit measures in existing buildings are usually always more expensive than designing energy efficiency in at new build stage.
- **Low Cost Measures** can produce substantial energy savings for relatively small investment. These measures may include fitting new or improved controls for heating, cooling or lighting. Such measures can be identified from an energy survey but it is also useful to conduct energy walkabouts and gather ideas from building occupants.
- **No Cost Measures** are technical solutions that involve some form of human intervention. For example, someone resetting controls or making better use of a Building Energy Management System. In essence it involves saving energy using existing equipment without any capital investment. Maintenance is also an essential factor. While there is a cost element to any maintenance it is essential for the efficient running of plant, equipment and controls.

4.2 Building Fabric

Introduction

For new buildings it is vital to include a high level of energy efficiency in the fabric at the design stage. It is always worth going beyond the minimum standards set in Building Regulations. For new builds there is a range of opportunities not available in existing buildings. For example, examining the best orientation of the building, designing in or out passive solar gain, positioning of internal use of space such as IT suites located on north side of buildings and varying the size of glazing to suit solar direction. These opportunities are discussed more fully in Appendix 1 "Checklist for Design Team of New Buildings".

In retrofit situations it is often difficult to justify expenditure on major fabric measures as stand-alone projects, mainly because the energy savings are usually small in comparison to the capital costs. However, the best opportunities for building fabric measures usually occur when a building is being refurbished. In this situation energy saving projects go ahead because the extra marginal costs are more attractive and possibly because the building fabric has deteriorated and work is required for reasons of health, safety and occupancy comfort.

Roofs

It is important to check the thickness of insulation above ceilings in pitched roof spaces. Some areas may have old ineffective insulation or it could be missing completely. Older compact insulation will need replacing or upgraded.

It is also possible to fit suspended ceilings beneath flat and pitched roofs. This will save energy by reducing the treated volume. An important factor in improving roof insulation is to consider additional ventilation, vapour barriers or other measures to prevent condensation in roof spaces. Insulation should not be allowed to obstruct ventilation particularly at the eaves. Any services including water tanks and pipework above an insulated ceiling will require insulation to protect against freezing.

Walls

Cavity wall insulation is cost effective with paybacks of between 3 and 5 years with minimum disruption to occupants. It is only applicable where there is a suitable cavity with no danger of interstitial condensation and no risk of damp penetration due to rain. Suitable insulation materials should be selected and installed to professional recognised standards.

Where there are no cavities it is possible to install external or internal wall insulation. Internal wall insulation is usually more expensive than external wall insulation. Internal wall insulation has the disadvantages of reducing room volume and can be disruptive to building occupants during installation. There is also the danger of thermal bridging. External wall insulation has low risk of thermal bridging, but it can be expensive to install in high rise buildings and can have a negative effect on building appearance.

Exterior joints need to be properly sealed as do openings for piping and cables. External covers and flaps can be fitted to outside air connections of wall fans and air conditioning units to reduce ingress of air when not in use.

Doors

Doors can be the source of the ingress of large volumes of unwanted air. Opportunities for savings include:

- Install draught stripping materials
- Use of automatic door closers on external doors
- Maintaining doors in terms of proper closure, door handles operating correctly, automatic door closers working, loose hinges corrected and correction of distorted frames
- Use of door lobbies, revolving doors or fast acting automatic doors for busy entrances
- Consider the thermal properties of the door materials

Floors

Floors are often ignored but can provide opportunities for energy saving by looking for air infiltration through suspended floors. Under floor insulation is effective in suspended floors and above floor insulation beneath carpets and floor coverings is effective in both suspended and solid floors. However, for suspended floors it is important to check the impact of restricted ventilation.

Windows

Where windows can be opened by occupants it is important to check for maintenance issues, e.g. catches/handles in need of repair, broken draught stripping, broken or cracked panes of glass and distorted frames.

When specifying new windows for a new design or refurbishment it is essential to specify double or triple glazing and consider using low emissivity glass. Other opportunities include:

- Fitting films to existing windows to minimise glare and solar gain thus reducing cooling loads and reduce radiative heat loss.
- Fit daylight blinds which reflect direct sunlight but allows in daylight and enable occupants to still see through the blinds.
- Reduce excessive glazed areas, but only if it can be achieved without compromising daylighting levels.
- Fit and maintain draught stripping.
- Seal gaps between window frames and walls.
- Make building occupants aware that windows do not need opening if the building is being heated or cooled.
- Consider the choice of the inert gas used in double glazing.
- Use lifecycle costing methods on the embedded energy in window materials, e.g. PVC, hardwood and aluminium. Consider the recycle potential of materials at the end of the life of the building.

Further Information

Sustainable Energy Ireland

- www.sei.ie
- SEI Glasnevin Building - Energy Efficient Office Building

The Carbon Trust

- www.thecarbontrust.co.uk
- Industrial Buildings - Essentials (FL123)
- Industrial Buildings Fact Sheet (GIL125)
- Building Regulations Fact Sheet (GIL131)
- Economic Use of Electricity in Buildings (FEB009B)

4.3 Heating/Hot Water/Controls

Introduction

In most buildings the largest amount of delivered energy is used for space heating and hot water. Controlling these elements can result in substantial savings of energy, cost and CO_2 emissions.

For systems to be energy efficient it is important to address the following:

- Heating Sources. The most efficient plant should be chosen for the application to generate the required amounts of heat and hot water.
- Distribution. Once generated the heat must be distributed efficiently and effectively using an appropriate heat transfer medium (usually air or water).
- Controls should ensure that heat and hot water are only delivered to the required areas at the correct time and temperature. The controls should also respond quickly to other factors such as solar gains, changes in the weather and internal heat gains from equipment and occupants.

Choosing Appropriate Heating Systems

For new buildings careful design of heating systems is required. Needs vary greatly from office developments to leisure centres to industrial buildings. Issues to be considered include:

Centralised or Decentralised
The selection process can be complex depending on the application. For example, in a multi-tenanted building with diverse periods of occupancy, the use of decentralised services would match the operation rather than a centralised system. Key factors affecting the decision include the price and availability of fuels, space available for plant and distribution pipework, losses in a centralised system and the size of loads involved.

Combined Heat and Power (CHP)
This involves simultaneous on-site generation of both electricity and heat often using a turbine or reciprocating engine. The heating source issues associated with CHP are discussed in Section 4.4 and Appendix 4.

Heat Pumps
This technology is making rapid improvements and should be considered as a heat source in the design of all new buildings. Heat pumps operate as the reverse of the refrigeration cycle. Heat from a cooler source can be upgraded to a hotter source by use of refrigerants and work done by a compressor. Under the right conditions a heat pump can transfer more heat from a cooler source to a hotter output, than the energy required to run the compressor. The heat can be obtained from a variety of sources including rivers, lakes, the earth or even lumps of concrete.

The ratio of the energy obtained from the condenser to the energy put in as work to the compressor is used as quantitative measure of performance. This ratio is called the Co-efficient of Performance (COP). The COP is the governing factor for all refrigeration vapour compression cycles and affects the economics of the system. The COP can be varied by the design of the system but can be as high as 10 for theoretical calculations but up to 4 or 5 for practical cycles. If a heat pump has a COP of 4, then every one unit of energy put into the compressor results in four units of heat coming from the condenser.

The most popular system is the closed loop ground-coupled heat pump. This consists of a reversible vapour compression cycle linked to a heat exchanger buried in the ground. In secondary loop systems brine (to prevent freezing) is circulated through a liquid-to-refrigerant coil and a buried thermoplastic pipe network.

Active Solar Heating
This is generally used to describe systems which collect the sun's radiation and transfer it in the form of heat to air, water or some other fluid. As the technology does not require direct sunlight for it to be effective, there are opportunities in all parts of Ireland to exploit solar radiation for this purpose.

Applications of active solar technology include:

- hot water supply
- swimming pool systems
- space heating

The most common application for active solar power is for domestic hot water (DHW) systems. These consist of solar collectors, a preheat tank (optional), a pump, a control unit, connecting pipes, the normal hot water tank and a conventional heat source (a standard solar system in Ireland cannot provide enough heat to supply hot water at the desired temperature throughout the year).

Biomass Boilers: are growing in popularity and can use a variety of fuel sources including forestry waste, woodchip, coppice, crop derived fuels, agricultural waste, straw and poultry litter. Key issues to consider are: correct boiler specification, consistency of fuel supply (e.g. moisture content), security of supply and the correct infrastructure to allow delivering and handling of fuels.

Type of conventional heating system: There are so many types of heater available that generalised guidance is difficult without considering a specific application. Factors to consider include: the system previously installed, available fuels, heating requirements, level of insulation and draught stripping, building design and structure, purpose of the building and tasks to be performed.

Figure 4.1 gives some, but not all, of the advantages of each system. The choice of heating system requires careful thought. Some systems will cope with occasional extremes in external conditions better than others. For example, hot water system designed to operate at 70°C can be boosted to 85°C without any risk. A direct fired air heater has no such overload capacity, but the response time of a direct fired air heater or radiant heater is much quicker than a hot water system.

Wet Heating Systems

Many small to medium sized buildings have wet systems using hot water as the heat transfer medium. Water is preferable to air because it has a higher heat carrying capacity which reduces infrastructure costs. The heat carrying capacity of a wet system is determined by the flowrate and the supply and return temperatures.

The greater the difference between supply and return temperatures means the flowrate can be reduced for the same amount of heat carried. However, the return water temperature is often determined by the type of boiler in use and for engineering reasons this temperature often cannot be reduced. The problem can be overcome because the flow temperature can be increased by increasing the pressure of the system.

Traditionally, the pressure and temperature ranges for hot water systems have been categorised into three ranges as shown in Figure 4.2. It is not always the case that pressures and temperatures are linked; for example, a block of flats may need medium pressure water operating at low temperature.

Systems	Heating Requirements			Insulation		Draught Proofing		Ceiling Height		*Building Structure		Fuel
	Continuous	Intermitent	Localised	High	Low	High	Low	Less than 6m	More than 6m	Heavy	Light	
Hot Water												
Radiator	✔	✔	✖	✔	✖	✔	✖	✔	✖	✔	✖	Any
Convector	✔	✔	✖	✔	✔	✔	✔	✔	✖	✔	✔	Any
Underfloor	✔	✔	✖	✔	✖	✔	✖	✔	✖	✔	✖	Any
Air Heaters												
Direct	✔	✔	✔	✔	✔	✖	✔	✔	✔	✔	✔	Natural Gas LPG
Indirect	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	Natural Gas LPG Liquid Fuel
Radiant												
Electric	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	Electricity
Gas	✔	✔	✔	✔	✔	✔	✔	✖	✔	✔	✔	Natural Gas LPG
Steam	✔	✔	✖	✔	✔	✔	✔	✖	✔	✔	✔	Any
Electric Storage Heaters												
Plain	✔	✖	✖	✔	✖	✔	✖	✔	✖	✔	✔	Electricity
With fans	✔	✔	✔	✔	✖	✔	✖	✔	✖	✔	✔	Electricity

* Heavy building structure: solid internal walls and partitions, solid floors, and solid ceiling.
Light building structure: lightweight demountable partitions with suspended ceilings.
Floors either solid with carpet or wood block finish or suspended type.

Figure 4.1 Advantages and disadvantages of conventional heating systems
(Source: NIFES Consulting Group)

Category Pressure/Temperature	Pressure Range Bar Gauge	Temperature Range (°C)	Temperature Drop Across System (°C)
Low	less than 0.4	40 - 90	8 - 12
Medium	1 – 2	120 - 133	25 - 30
High	4 – 9	150 - 180	45 - 65

Figure 4.2 Typical pumped hot water pressure categories

At the higher pressures there is a higher flow temperature with the option to reduce the return temperature and hence the flow rate and pipe size. Heat emitters are therefore smaller with the higher temperature drop. These benefits are balanced by increased maintenance costs associated with the need for boiler and ancillary plant to withstand higher pressures.

In general High Pressure Hot Water (HPHW) is only an economic choice for large systems with extensive pipe runs and a heat load typically of over 3MW, often using high temperature radiant heating. For many medium sized buildings, Medium Pressure Hot Water (MPHW) gives the most economic balance between the capital savings on smaller pipework and more expensive boilers, pressurisation sets and ancillary equipment. Low Pressure Hot Water (LPHW) systems are the commonest systems to be found in small to medium sized buildings.

Boilers

Boilers are usually designed to meet peak loads but this design condition is only required for a few cold days in a year. This means boilers generally operate below design conditions and therefore the efficiency of a boiler only at the design condition is not that relevant. A better measure is the 'seasonal' efficiency based on the useful heat output compared to heat input over a set period.

Typical seasonal efficiencies are:

• Condensing Boilers	85 to 90%
• High Efficiency Boilers	70 to 82%
• Older Boilers	50 to 70%

Condensing Boilers have extra efficiency because of a secondary heat exchanger, which condenses water vapour out of the combustion products which would otherwise be lost in the flue. The latent heat of condensation is recovered and put into the heating system. Even when not in condensing mode the minimum efficiency is about 85%. Condensing boilers are also unusual in that the efficiency can increase at part load.

Boilers spend a considerable time idling, so standing losses can be significant. Retrofit dampers, either on the burner inlet or flue outlet, yield significant reductions in heat losses caused by air purging through the boiler. For sites of variable loads it can be beneficial to install several small boilers with sequence control as opposed to one large boiler operating at low efficiency at low loads. With a multiple boiler arrangement one smaller boiler can operate at high load and high efficiency when the overall demand is low. Sequencing control valves on multiple boiler installations isolate boilers when they are not required, which again reduces standing losses.

Effective combustion within boiler plants is dependent on the condition of the burner and appropriate adjustment of the air to fuel ratio. However, the correct fuel to air ratio can be lost over time. The fitting of oxygen trim controls enables efficient combustion by continuous monitoring of combustion products and adjustment of the air to fuel ratio. These systems are usually cost effective only on larger installations.

Other points to consider include:

- Replace an old boiler installation with one that provides a minimum seasonal efficiency of at least 80%, preferably including at least one condensing boiler acting as the lead boiler. Specify multiple boilers with a sequence controller rather than one large boiler in installations over 100 kW, with the most efficient boiler leading the firing sequence.
- Ensure that boilers can only run when there is a heat demand. Unnecessary firing is known as dry cycling and is often remedied by correctly wiring the boiler thermostat into the control system. In multi-boiler installations, wide-band thermostats often overcome dry cycling.
- Install a heater other than the main boiler to produce domestic hot water and turn off the main boiler during the summer.

- Where small volumes of domestic hot water are required some distance from the main heating plant, consider installing local instantaneous water heaters.
- Consider the use of direct solar heating integrated into an existing installation or stand-alone systems for small volumes required at some distance from the main system.

Boiler Efficiency

The instantaneous efficiency of a boiler can be calculated by measuring the losses from the flue. The boiler (or any piece of combustion equipment such as ovens or furnaces) will be set-up to have the correct fuel-firing rate to give the correct heat input and equivalent quantity of air to burn it completely. The theoretically correct quantity of air is referred to as the "stoichiometric" amount although usually a little more than this will be required to ensure that all the fuel burns. This extra is referred to as "excess air".

This excess air should be controlled since too much will cause heat to be lost up the flue and too little will affect combustion leading to soot formation with oil-firing and carbon monoxide formation with natural gas firing. Both of these situations lead to fuel wastage.

A probe inserted through a hole in the flue can be used to measure excess air levels and temperature and thus compute the heat being lost – the so-called "flue loss". This is conveniently done using an electronic flue-gas analyser.

The analyser will then calculate the boiler efficiency allowing a small percentage for case losses.

Regular use will enable a log to be kept that will reveal trends in changes of efficiency. Any decrease can be acted upon. Rises in flue gas temperature must be taken seriously as it markedly reduce the efficiency of the boiler and might indicate fouling of the heat exchanger surfaces or more urgently, precipitates from the water onto the boiler tubes.

Distribution of Heat

Heat is lost from boiler casings and from the heating system through ductwork, valves, pipe work and hot water storage tanks. Pipe runs should be short with minimal elbows to reduce flow resistance and therefore pump power. All parts of the system should be well insulated including valves and flanges which can be insulated using 'wraparound' products which are easy to remove and replace for maintenance of the pipework.

Heat should only be supplied to a space or to produce hot water where and when it is needed. Wherever possible, large boilers should not be operated to meet small loads as the operating efficiency will be very low.

Heating Controls

Heat may be generated and distributed efficiently, but it can still be wasted unless there are effective controls. Types of control include:

- **Time control**
  A time switch that turns heating on and off at a fixed time each day. Seven day time switches allow for variable occupancy during the week.
- **Optimum start control**
  This automatically switches the heating system on so that the building reaches the desired temperature just in time for occupation. Optimisers are self learning devices which read and memorise the thermal characteristics of the building so that the temperature is correct at occupancy without overheating or underheating in terms of time and temperature.
- **Weather compensation**
  This automatically varies the system temperature in relation to weather conditions. This provides useful energy savings in spring and autumn and avoids overheating a building.
- **Room thermostats**
  These keep the temperature in a room to the required level. Modern electronic thermostats can control to within 0.5°C and can be purchased cheaply. These should replace the old-style thermostats (bimetallic sensor) which can achieve an accuracy of + 3°C.
- **Black bulb thermostats**
  These measure radiant heat instead of air temperature. These are used to control gas-fired radiant heaters which are often used in high-bay areas, such as warehouses and production areas. This type does not rely on heating the air so standard thermostats would be inappropriate and inefficient.
- **Zone controls**
  These are useful when some areas of a building require more or less heat than others (e.g. north facing areas with no solar gain would require more than south facing highly glazed areas). They are also useful for heating only those parts of a building that are occupied, e.g. at weekends heating a small space rather than heating the whole building. An alternative is to use two-stage electronic thermostats linked to occupancy sensors.
- **Thermostatic radiator valves (TRVs)**
  These regulate the flow of hot water through radiators in a room in order to maintain a local temperature. These provide local control in rooms that are prone to overheating, for example from solar gain.
- **Building energy management systems (BEMS)**
  These are computer based systems which automatically monitor and control a range of building services such as heating, ventilation, air-conditioning and lighting. They can incorporate fire alarm and security systems and they can log energy performance for analysis and maintenance purposes. They are most cost effective in large buildings with complex building services. The operator running the BEMS needs to be fully trained and competent. For further details of BEMS see Section 4.10.

For a useful overview of heating controls see Good Practice guide 132 "Heating controls for wet central heating systems in small, commercial and multi-residential buildings". Available on www.thecarbontrust.co.uk

Further Information

The Carbon Trust

- www.thecarbontrust.co.uk
- Heating systems and their control (GIR040)
- Boilers Fact Sheet (GIL121)
- Steam Boilerhouse Efficiency Improvements (GPCS444)
- The Essentials : Industrial Boilers & Heat Distribution Systems – Money to Burn? (FL117)
- Economic Use of Oil-Fired Boiler Plant (FEB014)
- Everyone's Guide to Saving Energy With Boilers (FL0069C)
- Heating Fact Sheet (GIL124)
- Energy efficient boilers and heat distribution systems, choosing the best for your site (GPG381)
- Economic Use of Fired Space Heaters for Industry and Commerce (FEB003)

4.4 Combined Heat and Power (CHP)

What is CHP?

In conventional power stations most or even all of the heat produced is wasted giving typical overall efficiencies of 40%. In older power stations efficiencies are generally lower and in more modern stations generally higher.

Some of this waste can be overcome by generating power locally at the point of use and putting the heat produced to good use. This simultaneous generation of heat and power is called co-generation or combined heat and power (CHP). Typically CHP systems can achieve efficiencies of 85% or greater.

CHP Options

There are three main categories of CHP:

- **Large Scale CHP**
  This category is usually of output greater than 1MWe (1MW electrical output) and typically might be a gas turbine or a spark ignition gas engine with heat recovery systems fitted to generate steam or hot water. Large scale CHP is often used in industrial processes where there is a large demand for heat, e.g. paper mills, breweries and food processing. It is also used in large institutions such as hospitals and universities.

- **Small Scale CHP**
  This category is mainly in the range from 50 kWe up to 1 MWe and is usually a packaged unit with generator, gas reciprocating engine and heat recovery. They are often used in leisure centres, hospitals, hotels and multi-residential dwellings.

- **Micro CHP**
  Micro-CHP are small units designed for domestic dwellings or small businesses. The sizes vary in electrical output up to about 10kWe. This technology is still developing and the market will undoubtedly grow in the future.

The best sites for CHP are those where there is an all year round heat demand. Examples include industrial processes, airports, hospitals, leisure centres with swimming pools, hotels, universities and multi-accommodation sites.

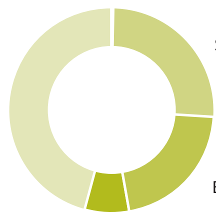


Figure 4.3 Percentage of installed capacity 2002 by prime mover

(Source: SEI)

Criteria

CHP is a revenue earning device and represents a significant financial investment. It therefore has to run to be economically viable. Normally a minimum of some 4000 hours per year are regarded as essential. The CHP unit is usually treated as the lead boiler, to maximise running hours, and is normally sized to the base heat load, otherwise heat may have to be dumped in the summer months. However, in buildings where heat demand during the summer is too low for CHP to be viable in a conventional arrangement, it may be worth considering using the waste heat to drive an absorption chilling unit.

Benefits

There are four good reasons for installing CHP if the above criteria can be met:

- **Cost savings**. A CHP system designed and configured to run for the maximum number of hours per year will achieve significant energy and cost savings.
- **Environmental savings**. CHP reduces greenhouse gas emissions as shown in Figure 4.4.
- **Supply reinforcement**. If a site electrical demand is nearing its maximum import capacity, CHP provides additional generation capacity to meet site requirements.
- **Supply reliability**. In cases where a site is susceptible to interruption in power supply, CHP can reduce risk and provide a more reliable supply.

Greenhouse Gas Emission	Estimated net reduction in emissions per kWh of electricity produced by CHP (g/kWh)
CO_2	1,000
SO_2	17
NOx	4.6
CO	(3)
CH_4	3.9

Figure 4.4 CHP emissions

(Source: SEI report An Examination of the Future Potential of CHP in Ireland)

Practicalities

As stated, CHP is a significant financial investment. It can be purchased outright or financed through contract energy management or equipment supplier finance schemes (see Section 2.4 "Purchasing Energy").

Small scale CHP units are often delivered to site as skid-mounted packages which can be quickly connected to the fuel, electricity and heating infrastructure. The units have an acoustic casing and an onboard computer so that performance and maintenance requirements can be remotely monitored. Success in CHP can deliver significant cost and emissions reductions but any investment requirements careful design, appropriate equipment selection and proper maintenance.

For further details on assessing CHP and a worked example see Appendix 4 "Simple CHP Appraisal Method".

Further Information

The Irish Combined Heat and Power Association

- www.ichpa.com

Sustainable Energy Ireland

- www.sei.ie
- Case Study 7 - CHP at Jurys Hotel and Towers
- Case Study 3 - CHP at Dairygold Cooperative
- Case Study 17 - St. Dympna's Hospital, Microturbine CHP
- Combined Heat and Power in Ireland
- Assessment of the Barriers and Opportunities Facing the Deployment of District Heating In Ireland
- An Examination of the Future potential of CHP in Ireland

The Carbon Trust

- www.thecarbontrust.co.uk
- The Manager's Guide to Custom Built Combined Heat and Power Systems (GIR082)
- Combined Heat and Power for Buildings (GPG388)

4.5 Ventilation and Air Conditioning

Introduction

Ventilation is an important aspect in any building and there are energy implications for how this is achieved. As insulation and U values improve under Building Regulations, less heat is lost by conduction and therefore convective heat losses comprise a larger proportion of overall losses. Many older buildings have large convection losses because of poor levels of design, construction and maintenance. It is important to address these leaks if building performance is to be improved. See "Building Fabric" Section 4.2.

Ventilation is required for:

- **Health** removal of odours and pollutants including CO_2 exhaled by occupants.
- **Comfort** air movement to increase perceived cooling.
- **Cooling** removal of heat produced by occupants, equipment and solar gains.

There are two types of ventilation: natural and mechanical. In some buildings a combination of the two types is used to achieve health, comfort and cooling requirements. In selecting the ventilation rate there is an optimum level: if too high it will significantly increase energy consumption and rates which are too low will not meet the occupants' requirements. The minimum ventilation rate required is 5 litres per second per person and the recommended rate is 8 litres per second per person.
A correctly designed ventilation system and a tight building envelope with minimum leakage and a good degree of local control is the key to effective building performance.

Natural Ventilation

Where possible it is preferable to design-in natural rather than mechanical ventilation as capital and running costs are usually less. The driving forces for natural ventilation are the pressure and temperature differences between the inside/outside of a building and within the building itself. Often naturally ventilated buildings rely on the stack effect by drawing air in from different controlled locations.

Advantages of Natural Ventilation

- Lower capital costs
- Reduced energy consumption
- Lower maintenance costs
- Less equipment noise
- Less plant room space
- More direct control by occupants

In some circumstances local environmental conditions exclude the use of natural ventilation. For example, in a location where there are high levels of noise and pollution from traffic, plant or machinery. If natural ventilation is an option, it is important at the design stage to maximise its scope by reducing heat gains. These gains can come from the sun, lighting, equipment (office/process), distribution pipework and occupants. Sometimes it is useful to group energy-intensive equipment into a mechanically ventilated zone and allow the remainder of the building to be naturally ventilated.

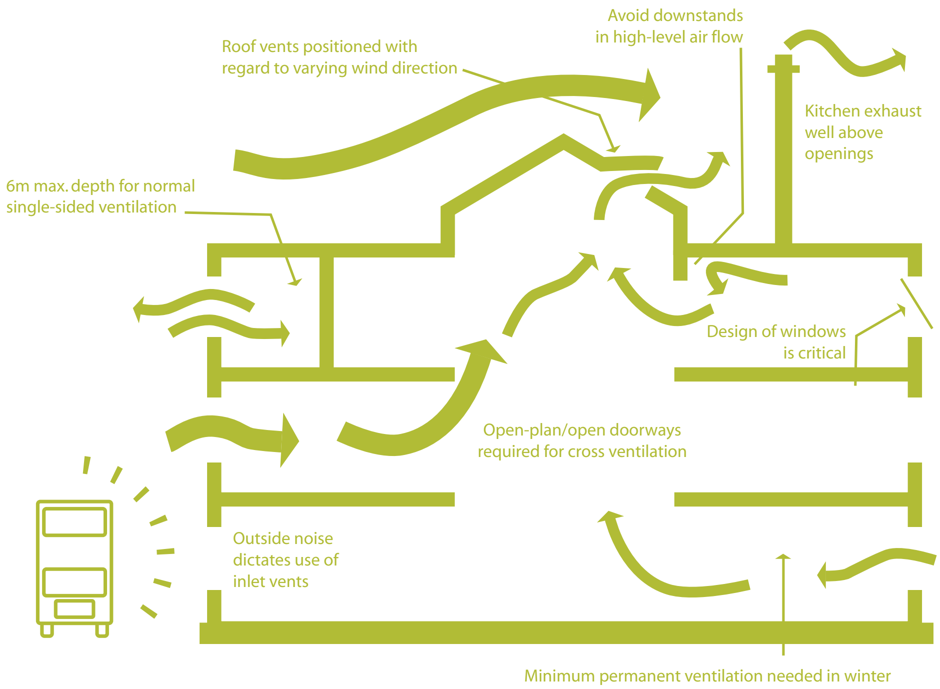


Figure 4.5 Typical layout of a naturally ventilated building
(Source GPG237)

To reduce energy consumption the building must be designed to be as airtight as possible and then provide natural ventilation by controllable means. Basic natural ventilation designs addressing heat gains of up to 20 W/m² will usually cost less than designs relying on mechanical ventilation. More complex natural ventilation solutions coping with gains up to 40 W/m² may be more costly in capital but often can be justified in reduced energy and maintenance costs.

Simple no cost measures to save energy in naturally ventilated buildings include:

- checking window ventilation systems operate correctly and are user friendly
- educating occupants on how the building works and choices available to them
- removing barriers to free air movement, e.g. partitions
- ensuring relief vents are closed in winter
- using destratification fans to redistribute high level heat when heating the building
- using external night air for cooling

Types of Natural Ventilation	Description
Trickle Ventilation	Provides the required fresh air rate, particularly in winter, without increasing energy loss by opening windows.
Single-Side Ventilation	Occurs when large, natural ventilation openings are situated on only one external wall. Exchange of air is the result of wind turbulence, by outward openings interacting with local external air streams and by stack effects driven by temperature difference.
Cross Ventilation	Occurs when inflow and outflow openings in external walls have a clear internal flow path between them. Flow characteristics are determined by the combined effect of wind and temperature difference.
Stack Induced Ventilation	Ducts, shafts and solar chimneys can be used to create a column of air at higher temperature thus generating pressure differences that result in the stack effect.
Night Cooling	Increased ventilation at night can help remove heat stored in the building structure during the daytime to avoid high summer temperatures.

Figure 4.6 Types of natural ventilation
(Adapted from Energy Efficiency in Buildings, Guide F, CIBSE, London, 2004)

Displacement Ventilation

If natural ventilation strategies are not sufficient, it is worth considering displacement ventilation before opting for full mechanical ventilation. Displacement ventilation allows air to be introduced at low velocity at a low level and just below the general ambient temperature. This provides cooling where it is needed and avoids the need to regulate the entire volume of the space and therefore saves energy.

Air flow is created by the buoyancy of the air created by the heat sources in lower areas which aid upward movement by convection. The air collects at high level where it is extracted. The higher air temperature at the ceiling provides a differential between the supply temperature and extract temperature thus improving the cooling capacity.

Mechanical Ventilation

Where mechanical ventilation is chosen the system needs to be well designed to minimise energy consumption. A major issue is to decide where to locate air handling units. The length of ductwork and costs can be reduced by locating plant as close as possible to the ventilated areas. Ductwork should have cross-sectional areas to produce low velocities which produce low pressure drops and minimise fan power. The three main categories of mechanical ventilation are low, medium and high velocity.

Velocity	Typical AHU face velocity	Typical main duct velocity	Advantages	Disadvantages
Low	<2 m/s	3 m/s	Low fan power Low noise	Higher capital cost More space
Medium	2 to 3 m/s	5 m/s Requires less space	Lower capital cost Increased noise	More fan power
High	> 3 m/s	> 8 m/s	Least capital cost Least space	High fan power High noise

Figure 4.7 Categories of mechanical ventilation

It is important that ductwork design achieves steady laminar flow because turbulent flow increases pressure drop and fan power. For example, the use of turning vanes and radius bends are preferable to right-angled bends. Energy efficient air filters also reduce pressure drop.

Efficiency can be improved by varying the volume of air supplied to suit demand. This type of control is termed variable air volume (VAV). The air volume can be varied in response to CO_2 levels, temperature, humidity and pressure.

The air supplied by fans can be controlled by;

Variable Speed Drives (VSDs)
These vary air flow and fan power by varying the motor speed. For variable loads VSDs can yield large energy savings because power consumption is proportional to speed. Thus a 20% reduction in speed can reduce energy consumption by 50%. See Section 4.5 "Motive Power, Pumps and Fans".

Two Speed Motor Control
This is where the motor runs at one of two speeds. This is cheaper than VSDs but provides less flexibility and less energy saving.

Inlet Guide Vanes
This method is often used in the absence of VSDs or two speed motors. Air flow is varied by adjustable vanes in the air stream entering the fan. This is the least efficient option.

Time Control
Ventilation systems generally only need to run when a building is occupied. Supply and exhaust fans should be controlled by 7 day time switches or under BMS control. Time clocks need to be set correctly and if not self adjusting will need adjusting between Summer Time and Universal Time Co-ordinated (UTC).

Damper Controls
Most mechanical ventilation systems have a facility to re-circulate warm extract air and mix it with fresh inlet air. This requires different settings in summer - when 100% fresh air may be required for cooling compared to winter when fresh air intake is minimised to get the balance between human health and comfort conditions and minimising energy use. This regulation of air is usually made by damper control in the ductwork.

If this facility is not properly used it can result in excessive ventilation and wasted energy. It is therefore important with such systems to make adjustments during the year and should form an explicit part of the maintenance and servicing programme. In more sophisticated systems dampers can be automatically controlled by a BMS.

Filters

When filters get dirty they should be replaced or cleaned. The quality of the air supply will determine how often this needs to happen. If there is only one set of filters this may be every 3 to 6 months. If there is a second set behind the first set, they may only need changing every 6 to 12 months. An increased pressure drop across the filters, measured using a manometer, gives an indication of filter blinding. There are a variety of low energy filters available but they may be more expensive.

Mixed - Mode Systems

These are systems which can operate in a variety of modes to meet user demand. This may include heating only, natural ventilation, assisted natural ventilation, mechanical ventilation and air conditioning. Mixed mode systems can also be zoned so that an area of high heat gain, such as a computer suite, may require 24 hour operation whereas in the rest of the building mechanical ventilation is sufficient during occupancy hours but also making use of night cooling.

Air Conditioning

Full air conditioning substantially increases capital and running costs of buildings and should be avoided by careful design and reducing heat gains. Where air conditioning is fitted many systems provide heating and cooling only. This is commonly referred to as "comfort cooling". Full air conditioning means humidity control is added. This further increases energy consumption and should only be specified if there is no alternative.

There are three main types of air conditioning systems, with many variations within each:

- **Centralised air systems** in which all the heating and cooling is carried to a central plant room and conveyed to rooms by ductwork.
- **Partially centralised air/water systems**, in which centrally cooled or heated air is further heated or cooled at entry to rooms depending on demand.
- **Local systems** in which all operations are performed locally.

Common components are the same as for mechanical ventilation systems plus some of the following depending on complexity: cooling coils, chillers, humidifiers, condensers, evaporative cooling towers or fin fan coolers.

Most air conditioning systems use refrigerants called HFCs which are damaging global warming gases. Therefore alternatives should be explored such as hydrocarbons and ammonia except where there are good technical, safety and cost reasons not to do so.

If it is necessary to install air conditioning, it is important to explore technologies that use existing resources to generate cooling. For example, if waste heat is available then absorption cooling may be an option; likewise, groundwater cooling is often possible where space permits. These technologies generate reliable cooling usually at an overall lower cost than that of standard electrically driven air conditioning systems.

Typical Energy Saving Measures

- Set the temperature required for cooling as high as possible (24°C or higher) to reduce the cooling demand.
- Ensure that air conditioning systems make use of 'free cooling', i.e. using ambient conditions to generate chilled water or the use of cold fresh air to cool a building. If there are no cooling loads in winter the cooling plant can be completely shut down.
- Ensure that controls are set to avoid simultaneous heating and cooling.
- When heating or mechanical cooling is required, ensure that the proportion of air re-circulated within the building is as high as possible within the requirements for minimum fresh air rates.
- Review motor sizing and consider using variable speed drives on larger fans and pumps where loads vary significantly.
- Minimise air leakage from ductwork to prevent wasting fan power and the heating or cooling content of treated air as well as preventing unwanted heat gains and losses to other areas.
- Ensure heating is shut down whenever there are no heating loads, especially where internal heat gains are such that heating plant operation is unnecessary.
- If humidifiers are being specified or replaced use ultrasonic humidification but ensure that precautions are taken to avoid Legionella. Consider switching off humidifiers when minimum humidity is not critical.
- Consider heat recovery opportunities from any source of warm exhaust air but balance gains against the requirement for additional power for pumps and fans.
- Consider the use of cooling plant which uses local resources, such as absorption and ground water cooling.
- Use low global warming refrigerants, such as hydrocarbons and ammonia wherever possible.

Summary

Energy efficiency in building designs aims to meet the service conditions of equipment and occupancy comfort at minimum energy consumption. Natural ventilation should be the first consideration. The next step is mechanical ventilation but this increases energy consumption, capital and running costs. The other options are shown in Figure 4.8 until the final option of full air conditioning. The further down the hierarchy there is increasing complexity of plant resulting in increasing capital, energy consumption and maintenance costs.

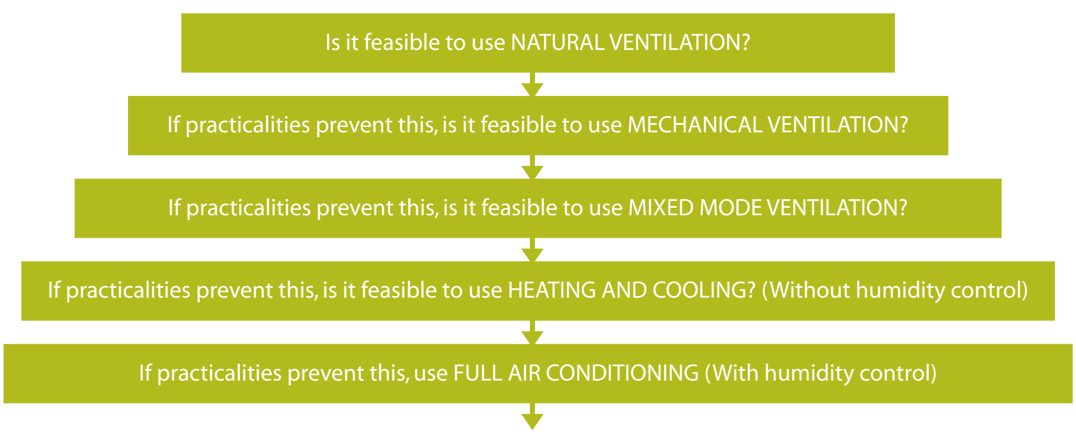


Figure 4.8 Ventilation design hierarchy

(Source: Energy Efficiency in Buildings, CIBSE Guide F, London 2004)

Further Information

Sustainable Energy Ireland

- www.sei.ie
- Case Study 18 - UCD Lecture Theatre, Ventilation & Control Systems Upgrade
- Case Study 14 - Waterford Institute of Technology Library Building, Passive Environmental Control

The Carbon Trust

- www.thecarbontrust.co.uk
- Air Conditioning Fact Sheet (GIL120)
- Avoiding or minimising the use of air-conditioning – A research report from the EnREI (GIR031)
- Energy-efficient mechanical ventilation systems (GPG257)
- Energy savings in fans and fan systems (GPG383)

4.6 Motive Power, Pumps and Fans

Introduction

Electric motors and drives can use significant amounts of energy in buildings. An 11kW induction motor costing €450 can cost over €11,500 to run in an intermittently occupied building, with seasonable operation, over ten years.

With continuous operation over the same period, the running cost would be €43,000.

Savings can be achieved when designing new systems with motors, replacing motors and in the way motors are operated and maintained.

Motor Sizing and Selection

Motors are often over-sized at the design stage. For example a duty may require delivered power of 7.5 kW, but designers add 10% margin and a project engineer may add another 10% for contingency, resulting in a 9.1 kW specification. The next motor size available is 11 kW with the result that the motor installed operates at 60% or less of its rated output.

Modern motors are designed for maximum efficiency at 75% or more of full load, so over-sizing increases the capital cost (motor, switch gear, wiring, power factor correction) and running costs due to lower efficiencies.

High Efficiency Motors

These motors use more copper, iron and steel in their construction to reduce inherent losses of energy and save typically 3% to 4%, on average, compared to standard motors. Many motor manufacturers offer these more efficient motors at no extra capital cost.

Rewinding Motors

It is possible to rewind motors but the cost of doing so can be high compared to purchasing a new motor. Unless the motor is rewound to a high standard the efficiency can be reduced by up to 2%. Therefore a careful economic analysis is recommended. A recent study shows that it is uneconomic to rewind motors under 55 kW.

Belt Drives

In the past belt drives have usually been used to enable the matching of fan and pump speeds to duty. However, direct driven fans and pumps avoid the need for belt drives with their associated losses and maintenance requirements. The variation in power to demand can now be easily met by variable speed drives (VSDs).

Variable Speed Drives

Fans, pumps and compressors are designed to meet a maximum load, which often does not occur, due to excessive margins being allowed for peak loads, or even if it does occur the duration may be small. The normal, lower, flow requirements are usually met by throttling. Fans can have inlet or outlet dampers and pumps a throttle valve, usually on delivery line, and compressors may operate on stop/start, or "unloading" by controlling valve gear.

While the squirrel cage motor is usually used as a robust, cheap and reliable power source, efficiency falls at low loads. Also, as shown in Figure 4.9, the power consumption of a fan or pump does not fall off proportionally if output is reduced by throttling - a pump being particularly bad, requiring almost full load power until throttled below about 40% load.

Modern variable frequency inverter controllers use solid state circuitry to give smooth speed control of an ordinary motor from zero to above normal speed, and can even give a reverse rotation. For motors running continuously at low loads, such controllers can recover their costs in less than two years, if fitted retrospectively - and can be very attractive if installed with new plant. They will vary speed automatically given a suitable control signal.

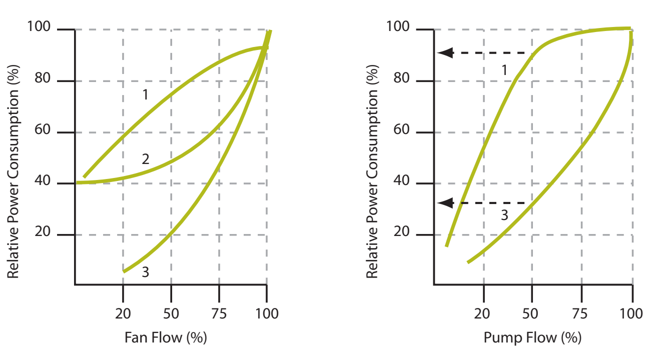


Figure 4.9 Power Requirements of Pumps and Fans at Varying Loads

Line 1 on both diagrams shows change in power consumption when flow is throttled by outlet damper or valve.

Line 2 (on fan diagram) shows that inlet vane damper control gives some savings in power consumption compared to outlet damper control.

Line 3 on both diagrams shows the effect of a variable speed controller and the power consumption savings produced compared to lines 1 or 2. For example on a pump running at 50% rating such a controller would save 60% (from 90% to 30%) of power requirement.

Many existing motors can be converted to VSDs using variable frequency inverters. Most pumps and fans are driven by AC squirrel cage motors which are single speed motors. The speed is determined by the number of poles and the frequency of supply voltage. An inverter converts a fixed frequency of 50 Hertz to a 3 phase supply which is variable and controllable in frequency between zero and 65 Hertz. The speed is usually monitored and controlled automatically to maintain an optimum condition of temperature, flow, humidity, pressure or any other variable. An inverter also incorporates 'soft start' so that the speed is increased gradually thus reducing the start current and torque surges. This is particularly useful in pumping applications and reduces wear and tear on seals, joints and pipework. Power factor correction equipment is usually included as part of the system and gives a power factor of around 0.96. In many applications payback on energy savings alone are usually less than two years.

Two Speed Motors

Two speed or multiple speed motors can be a lower cost alternative to a VSD where a drive has two to four distinct operating conditions. For example, a local authority swimming pool previously used a fixed speed fan in their air handling units. The management realised that the much lower ventilation requirement at night meant there was the potential to saving energy by reducing the fan speed during this period.

A two speed 4/8 pole (6.5/1.5 kW) motor was fitted as a low cost way of reducing the fan speed at night. The energy saving of €1,715 per year gave a payback of 21 months on the €2,970 cost of a replacement two-speed motor. However, if this motor had specified from new, the price would have been €645 giving a payback of around 4 months.

Further Information

Sustainable Energy Ireland

- www.sei.ie
- Case Study 5 - Variable Speed Drives at Ascend International
- Case Study 4 - Variable Speed Drives at Premier Periclase

The Carbon Trust
www.thecarbontrust.co.uk

- Energy savings from motor management policies (GIL056)
- Purchasing Policy for Higher Efficiency Motors (GPCS222)
- Guidance notes for Reducing Energy Consumption of Electric Motors and Drives (GPG002)
- Variable Speed Driven Pumps Best Practice Guide (GPG344)

4.7 Lighting/Controls

Lighting in Buildings

Lighting accounts for 20% of national electricity use. A significant percentage of electrical energy consumption of most buildings is used in lighting as shown in Figure 4.9. In this shows the proportion of electricity use by lighting for four office categories. Although the percentage of power going into lighting decreases in more heavily serviced offices, the actual amounts in kWh/m^2/annum increases substantially.

Office Category	Typical energy consumed in lighting kWh/m^2/annum	Lighting expressed as % of overall power consumption
1. Naturally ventilated cellular	23	43%
2. Naturally ventilated open-plan	38	45%
3. Air-conditioned standard	54	24%
4. Air-conditioned prestige	60	17%

Figure 4.10 Electricity consumption in lighting in offices

Lighting technology is developing at a rapid pace and modern energy efficient lamps, luminaries and controls can often reduce energy consumption by up to 40% while actually improving the quality and quantity of light delivered.

The best opportunities occur when designing new buildings by, for example, maximising the use of natural daylight and designing in cost effective controls. However, there are substantial savings to be made by retrofitting existing systems.

Benefits of Energy Effective Lighting

- Saves energy and running costs
- Reduces loads on air conditioning systems
- Improves productivity
- Reduces errors
- Reduces maintenance costs
- Improves security and safety
- Enhances visual environment
- Provides end users with local control

Energy Effective Lighting by Design

Lighting in any building needs to be both effective and efficient. It is vital that the designer takes into account the needs of people and the tasks to be performed.

Many lighting schemes deliver much higher lighting levels than are actually required. This may also lead to glare and visual discomfort as well as high capital and running costs. Designers sometimes design to those levels because they anticipate poor maintenance and cleaning or simply install fittings to coincide with existing ceiling patterns to minimise disruption.

Good lighting design provides the appropriate level of illumination levels for the activity or work performed and the building orientation and plan. It is important to maximise the use of natural daylight, but also avoid overheating and glare from both natural and artificial sources.

To make a space look appreciably brighter it is important to light the vertical surfaces, i.e. light what people see. There is much waste in systems which deliver light where it is not needed.

Good Lighting Design Criteria

- Optimise the use of natural light
- Provide appropriate illuminance levels for the activity or work performed
- Provide effective controls to illuminate areas when and where light is needed
- Be easy to maintain and clean
- Be energy efficient and effective

Factors to Consider in Lamp Selection

The choice of lamp is significant and the key factors to consider are:

Luminous Efficacy

This is a measure of efficiency and is measured in lumens per watt; it is a measure of how much light is emitted per unit of energy consumed. A tungsten lamp would produce approximately 12 lumens per watts because of most of the energy is emitted as heat not light. Low pressure sodium lamps might achieve efficacies up to 140 lumens per watt.

Colour Appearance

This is a term used to describe the colour of light falling on a white surface, e.g. 'warm white' colour temperature is defined by temperature measured in degrees Kelvin and different bands are described in Figure 4.11.

Correlated Colour Temperature (CCT) °Kelvin	CCT Class
CCT < 3300 K	Warm
3300K < CCT < 5300 K	Intermediate
5300 K < CCT	Cold

Figure 4.11 Colour temperature bands

Colour Rendering

Colour rendering is a measure of how much light discolours an object relative to a reference illuminant. In some situations, such as security lighting, colour rendering may not be important but in other situations, such as in art galleries or aircraft maintenance factories good colour rendering is essential. This will have a direct influence on lamp selection. Figure 4.12 shows typical colour rendering groups and their application.

Colour rendering groups	CIE general colour rendering index (Ra)	Typical application
1A	Ra > 90	Where accurate colour matching is required, e.g. printing inspections.
1B	80 < Ra < 90	Where accurate colour judgements are necessary or good colour rendering is required for reasons of appearance, e.g. shops and other commercial premises.
2A	70 < Ra < 80	Where moderate colour rendering is required.
2B	60 < Ra < 70	
3	40 < Ra < 60	Where colour rendering is of little significance but marked distortion of colour is unacceptable.
4	20 < Ra < 40	Where colour rendering is of no importance and marked distortion of colour is acceptable.

Figure 4.12 Colour rendering ranges and applications

Lamp Life

Lamp life is an important consideration when accessibility and maintenance costs are important issues. Lamp life is not a measure of mortality (i.e. when the lamp fails). Lamp life is usually defined as the time taken for the light output to decrease to 80% of the initial lumens.

Other Factors

Other factors may also be important in the lamp selection including re-strike time, ability to link to controls, the need for particular control gear and aesthetics. Figure 4.13 gives typical characteristics of various lamp types.

Lamp Types

Compact Fluorescent Lamps (CFL)

A wide range of CFLs are available which yield significant savings (up to 75%) over tungsten equivalents. They are produced in a variety of forms and can be installed as direct replacement for most types of tungsten lamps. CFLs have a lower power rating than tungsten - an 18W CFL compares with a 100W tungsten and this not only saves energy but reduces heat gains and maintenance costs as CFLs last between 8 and 12 times longer.

CFLs should be considered for both new and retrofit installations, some have ballasts that can be detached from the lamp on failure so that only the lamp needs replacing. Also dimmable ballasts are now available. Due to the higher initial costs of CFLs, replacement is usually most cost effective in areas where lamps are required to be on for long periods.

Spot and Display Lighting

For display lighting low voltage tungsten halogen lamps can be a good alternative to mains voltage equivalents. However, there are energy savings to be made by the type specified. The orientation of the filament can make a considerable difference: an axial filament of a 35W delivers the same light as a transverse filament of a 50W yielding 30% savings. Also voltage regulation and soft start additions to circuits can greatly extend lamp life and reduce maintenance costs.

Fluorescent Lighting

On average savings of 8% can be achieved by replacing older T12 (38mm dia.) fluorescent tubes with T8 (26mm dia.) slimline equivalents see Figure 4.13. The light output is the same and in most cases this can be a direct replacement. T8s are also less expensive than the equivalent T12. However, in older fittings the starting gear is not compatible, and direct replacement is not possible.

Triphosphor Fluorescent Lamps T5 and T8

These provide approximately 10% more lumens and are therefore more efficient than the older halophosphate coatings; they also provide excellent colour rendering properties. Lumen depreciation is less with triphosphor and the number of luminaries can be reduced significantly for the same maintained illuminance. So savings are made on both capital and running costs.

T5 lamps (16mm dia.) have been available for some years. These are shorter in length than T8 lamps and can be used in smaller luminaries. They are more efficient because of their reduced size but this increases light intensity therefore glare may be an issue; their application requires careful consideration.

High Frequency Ballasts and Control

Fluorescent lamps require a ballast to start the lamp and regulate the discharge while it is in operation. In the past these were electromagnetic wire-wound ballasts, running at mains frequency of 50 Hz. These ballasts themselves consume energy and low loss versions have been developed.

The use of high frequency control gear brings many advantages. High frequency gear is given this name because the electronic gear operates above 20,000 Hz compared to 50Hz normal mains frequency. HF ballasts reduce energy consumption, are lighter in weight, eliminate strobe and flicker and shut the lamps down at the end of their life avoiding the annoying flicker. They provide flicker free start, are stable at lower temperatures, have extended lamp life, good power factor and can be dimmed with links to lighting controls. Energy savings of 30% reduce direct costs. Heat loads on air conditioning systems are also reduced and a single ballast can drive two, three or four lamps instead of many separate ballasts on conventional systems.

Type	Luminous Efficacy (Lumens/Watt)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Tungsten	12	2600	100	1000
Tungsten (long life)	8.75	2500	100	6000
Tungsten (extra long life)	5.25	2500	100	16000
Tungsten Halogen	18	3000	100	2000 – 8000
Compact Fluorescent	70	2700-4000	85	8000+
38mm T12 White F/Tube	67	3500	59	7000+
25mm T8 White F/Tube (S/G*)	77	3500	58	8000+
25mm T8 White F/Tube (HF**)	88	3500	58	8000+
25mm T8 Full Spectrum Multiphosphor	64	5000	95	17500
25mm T8 H/F Triphosphor	100	2700-6000	80+	12000 – 18000
25mm T8 H/F Triphosphor	65	2700-6000	90+	12000+
16mm T5 H/F Triphosphor	90-106	2700-6500	80+	16000+
7mm H/F Triphosphor	55	3500-6000	85	8000-12000
Metal Halide	60-80	3000-6000	65-85	8000 – 12000
Mercury	45	3900-4300	40-49	12000+
Mercury D/Luxe	50	3300	60	12000+
Mercury Plug-in	45	3300-3600	50-70	8000 – 10000
Low Pressure Sodium/E	138	1800	0	6000
High Pressure Sodium	108	2000	25	12000 – 30000
High Pressure Sodium D/L	82	2200	60	12000
HPS Plug-in	85	2000	23	12000+
White Sodium	40	2500	80	8000+
Induction	70	3/4000	85	10000 – 60000
Light Emitting Diodes (LEDs)	50/100	Saturated/6000		50/100000

Figure 4.13 Lamp type characteristics

*S/G - standard electromagnetic control gear. **HF - high frequency electronic control gear. (Source: Lighting Enterprises Consultancy)

Metal Halide and High Pressure Sodium Discharge Lamps

These are high wattage lamps with high light outputs with applications for large spaces such as factories, industrial buildings and larger retail premises. They are also useful for exterior lighting, car parks and flood lighting. Generally these lamps have high efficacy but are not designed for frequent switching. Other versions in lower wattages with improved colour properties, such as white sodium find applications in offices, shopping malls and retail premises.

Induction Lamps

The most vulnerable parts of any discharge lamp such as fluorescent, metal halide, sodium, are the electrodes. The induction lamp dispenses with the need for electrodes to bring about ionisation of the gas. Instead it uses an internal attenae powered from an external high frequency generator to create an electromagnetic field within the discharge vessel which induces the electric current in the gas to cause ionisation (See Figure 4.14).

The main advantage of this technology is the large increase in lamp life. With a life of 60,000 hours, the induction lamp can burn eight hours a day for 20 years. Smaller versions are available with integrated control gear but they have a shorter life of 10,000 hours. Induction lamps have indoor and outdoor applications requiring increased reliability where relamping is difficult and maintenance expensive such as over stairwells. Induction lamps start instantly and provide good colour rendering. Their relatively high cost needs to be balanced against reduced energy and maintenance costs.

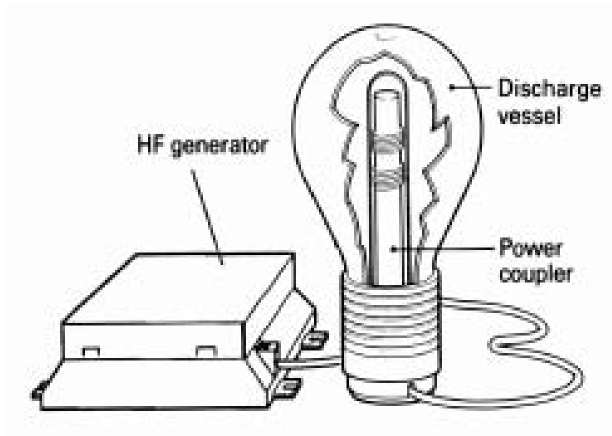


Figure 4.14 An induction lamp

(Source: Philips)

Luminaires

'Luminaire' is the correct term for a light fitting. Its main purpose is to distribute, diffuse and direct light. It includes all components for fitting, protecting the lamps and connecting them to the supply.

A Luminaire must:

- control and distribute light from the lamp(s)
- be efficient
- be appropriate for the application
- be robust for normal conditions of use
- be aesthetically pleasing

The efficiency of a luminaire is measured by the Light Output Ratio (LOR) which is the ratio of light emitted by a luminaire to the light output of the lamps in it. In practice the LORs of different ranges of luminaries can vary considerably, even for similar looking luminaries. The LOR depends on the quality of materials used as well as the basic design of the reflector/luminaire.

Refurbishment of older installations using modern equipment can often result in substantial energy savings in addition to improved visual conditions. Many modern luminaires contain carefully designed reflector systems to direct the light from lamps in the required direction. These allow for fewer lamps and luminaries to be used to produce a given illuminance.

It may be possible to improve older, less efficient, luminaries by replacing diffusers or prismatic panels with reflector systems. Alternatively, reflectors may be added to the luminaire - retaining the existing light control components. In some cases this can be accompanied by a reduction in the number of lamps to produce the same illuminance with consequential savings. It is also important to regularly clean diffusers to maximise light output. (See Figure 4.15)

A key issue to consider in luminaire specification relates to areas of heavy computer usage. It is important that lighting is designed so that users do not get glare on computer screens. These higher category

luminaires cost more and therefore should only be used in areas of computer use.
Where people are reading text as well as using computers the optimum lux level is 380 lux. Often in offices lux levels are between 500 and 700 lux. This wastes energy, increases capital costs of lighting systems and results in more errors by the occupants.

Lighting Controls

Substantial savings can be made by using lighting controls to ensure the correct level of lighting is provided at the right time and in the right place, without compromising health and safety standards and without alienating end users. There is usually a product to meet every situation.

Improvements by lighting control arise from using available daylight to reduce artificial light and from switching off lights when a space is unoccupied. Also localised controls can increase user satisfaction by allowing occupants to have more control over their working environment. The four main types of lighting systems are;

Time Control Systems
For greatest benefit, time control systems will switch off lights according to a specified schedule, with occupants using an override control to switch lights on. When people enter buildings in the morning they switch on lights but rarely switch them off when the space is unoccupied or if there is sufficient daylight. In some situations lighting is timed to go out five minutes after the start of the lunch break. Occupants have the facility to switch the lighting back on but rarely do so if there is sufficient daylight. It is important to minimise the number of switch offs programmed into the system and they should reflect work patterns.

Occupancy-Linked Control Systems
These systems use some form of presence detection, usually ultrasonic, infra-red, microwave or acoustic to control one or more luminaries. They usually switch on lighting when occupancy is detected and off once they have failed to detect an occupant for a set time. The most favoured systems are microwave and dynamic infra-red.

Occupancy-linked controls are appropriate for spaces where people are usually only present for short periods, such as stores, corridors and toilets. They can be used in conjunction with time-based and daylight-linked controls. Further benefits can be obtained by linking occupancy detectors to other equipment, such as fans or urinal flushing in toilets. In this case, the lights and fans would turn off and the urinals flush a set time after the space has been vacated.

Daylight-Linked Controls
Daylight-linked controls can be used with both timed and occupancy controls as an override dependent on available natural light. This type of control is based on photocell controls and can also be used to switch off or dim lights when daylight is adequate.

Photocell control is particularly appropriate for 'unowned' or common areas such as stairwells, corridors, reception areas where daylight is available. They are also effective in open plan areas where rows of lights parallel to windows can be controlled as daylight increases.

Dimming daylight-linked controls are useful for providing a constant illumination level at the working plane. The photocell controls a dimmable high frequency ballast to maintain a preset lux level throughout the day. Dimming controllers can vary the light output of fittings over the full range of 0 to 100%. The preset lux level can be varied to say 300, 400 or 500 lux or figures in between to suit the occupants and the task.

Photocells are relatively cheap and robust for controlling lights outside buildings and are often used in conjunction with time controls, for example in car park lighting. It is essential that the photocells are maintained with time controls correctly set.

Localised Switching

In small cellular offices or work spaces ordinary manual switches are usually adequate. The switches should be placed in obvious places and easily accessible. In larger open plan areas banks of switches can cause high levels of energy waste unless they are well labelled and occupants use them appropriately. In these spaces people are usually reluctant to switch off any lighting until everyone has left the area. Even then lights are left on because the last person out thinks someone might still be present. To overcome these problems localised switching can help. Local control can take the following forms:

- pull cords to control lighting;
- portable infra-red controllers on desks or wall mounted; and
- dialling up a code via the telephone to a Building Energy Management system.

Systems can also operate using dimmable ballasts via infra-red control. So lights dim to a pre-set level when no-one is present in an area. This helps to avoid 'dark spots' in a space which can be intimidating to some occupants.

It is worth considering the existing switching arrangements to see if rows of lights parallel to windows can be switched off manually or automatically to maximise use of natural light.

Staff Consultation

It is important that the permanent occupants of a space are aware of the existence of an automatic lighting control system, how it works and how they can interact with it. This is particularly important in retrofit installations, where considerable resistance to the introduction of controls can occur if occupants are not consulted and fully informed about the system. Occupants need to know that their needs have been taken into account.

Lighting Maintenance

The efficiency of a lighting system will be drastically reduced if there is no maintenance or cleaning programme. If a typical fluorescent installation is not cleaned over a three year period, the illumination will drop to less than 50% of the original level, as illustrated by the broken line in Figure 4.17. There is a natural decline in light output but this is accelerated if no cleaning takes place.

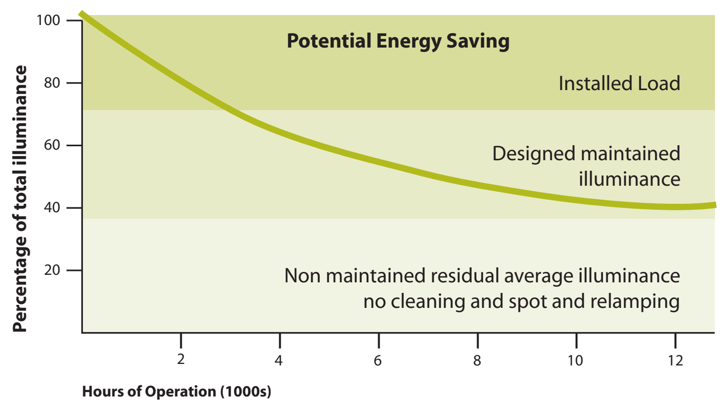


Figure 4.15 Maintenance can increase light output

To be really effective, all large properties should have a lighting maintenance programme involving regular cleaning of luminaries and replacement of lamps. Relamping cycles will vary but usually an economic relamping cycle for fluorescents is when 10% of the lamps have failed. If lamps are replaced on an ad hoc basis after this the cost becomes prohibitive. Replacement costs in a typical commercial environment are around €1.50 per lamp if they are all replaced at the same time. If replaced on an ad hoc basis the cost could range from €15 to €30 per lamp, primarily due to the additional labour costs.

Further Information

Sustainable Energy Ireland

- www.sei.ie

The Carbon Trust

- www.thecarbontrust.co.uk
- Daylighting Design in Architecture (ADH011)
- Lighting Fact Sheet (GIL126)
- Energy Efficient Lighting in Warehouses (GPCS169)
- Energy Efficient Lighting in Factories (GPCS159)
- Energy Efficient Lighting in Industrial Buildings (GPCS309)
- The Installer's Guide to Lighting Design (GPG300)
- The Chartered Institute of Building Services Engineers: www.cibse.org
- The European Greenlight Programme: www.eu-greenlight.org

4.8 Office Equipment

Overview

Energy use in office equipment is growing annually. Equipment includes computers, printers, photocopiers, fax machines, desk fans, vending machines and kettles. Office equipment is a major electricity user in most office environments. The amount of office equipment is doubling every few years. Office equipment typically uses more than 20% of the total energy consumption of some offices, and in some cases can be as high as 70%.

Energy costs for computers, fax machines, copiers, printers, vending machines and other office equipment could be reduced by more than one third by adopting energy efficiency measures. The savings increase to 50% if reduced air-conditioning loads are included.

Figure 4.16 shows the proportion of energy used by different types of office equipment.

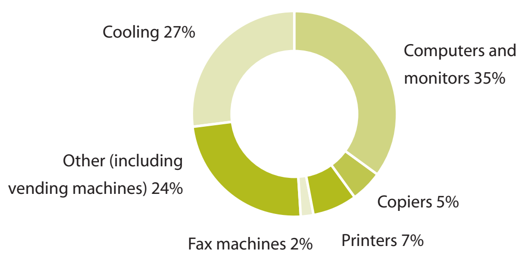


Figure 4.16 Typical office equipment energy use

Cooling to reduce waste heat produced by equipment is a significant factor. Inefficient equipment not only uses more energy, it requires more energy to cool the working environment. Building designers are aware of this but they sometimes compound the problem by overestimating the heat emitted. The result is over-specified air conditioning equipment running on low loads and at low efficiencies.

Use of Equipment

Factors affecting consumption: The energy used in office equipment depends not only on the efficiency of equipment but on the number of staff working in the office, how often they are there, how much they use the equipment and how the equipment is being operated.

Office Myths

- Start-up uses lots of energy - insignificant relative to switch off saving.
- Turning off monitors is bad for them - did you leave your TV on this morning?
- Screen savers save energy - most don't, some increase energy use!

Switching off

End users should be encouraged to switch off equipment not in use providing it is cost effective to do so - it might take to long to bring equipment back into operation for it to be cost effective. **All equipment should be switched off at night and weekends unless there is a specific reason not to do so.**

Energy Saving Features

Most modern PCs and some other equipment such as copiers have energy saving software built into them. A recent Government survey of PCs in the UK discovered that of all PCs with energy saving devices built-in, only 25% were actually activated. Assistance can be obtained from instruction manuals or manufacturers on:

- which equipment has such features
- the effectiveness of the level of stand-by reached
- how delays can usually be set at approximately levels; and
- time taken to return to use from stand-by

Most PC energy saving features apply to monitors, which use more energy than the processors. If the computer registers no activity for a pre-set time the circuits in the screen begin to power down, one by one, until the screen is in full sleep mode. The time delay can usually be set between three and 120 minutes. Energy use typically falls from 80W to less than 10W per monitor. The image of the screen is reactivated at the touch of the mouse or a key. Recovery time varies but usually is about one second. See Figure 4.17:

Item	Average power consumption (Watts)	Stand-by energy consumption obtainable (Watts)	Target recovery times (seconds)
PCs	40	20-30	Almost immediate
Monitors	80	10-15	Almost immediate
Laser printers	90-130	20-30	30
Photocopiers	120-1000	30-150	30
Fax machines	30-40	10	Almost immediate
Vending machines	350-700	300	Can be almost immediate

Figure 4.17 Examples of average power loads and energy savings achievable

Screen Savers

Screen savers are not a low-power mode. Some reduce energy consumption by 10W at best - often not at all - and sometimes actually increase consumption. Some users mistake dark screen savers for low power modes.

Health, Safety and Security

Some computer monitors have been known to auto-ignite when left on. Therefore all equipment should be switched off for health and safety reasons. It is worth checking insurance cover to see if it is valid in the event of a building burning down because an office user left their equipment running. Also from a security point of view computers should be switched off otherwise out of hours staff or contractors could view confidential or sensitive data.

Processors and Monitors - Running Costs

A typical processor with monitor left on for 24 hours each day can use €90 or more of electricity each year. Turning off at night and weekends will reduce the bill to €20 a year. This amount can be reduced by a further €14 or more by adopting simple energy management techniques.

In an office of 100 computers, annual energy cost savings could be around €7200 from the equipment alone, €10,700 to €14,300 if they are sited in an air-conditioned office.

Flat screens using LCD technology use 50 to 70% less energy than older cathode ray monitors.

Purchasing Policy

An important first step in reducing energy consumption in office equipment is to review the purchasing policy and specifications of machines.

Any organisation which regularly purchases or leases office equipment should have a clear policy which;

- sets objectives and targets for office equipment
- makes clear the responsibilities of those using the equipment
- describes the responsibilities of those who purchase office equipment to ensure cost effective and energy efficient equipment is procured

Key Questions

- Do we know which items of office equipment have energy saving devices built in?
- Are the devices activated?
- Does everyone know who is responsible for switching off equipment at the end of the working day?

Energy Star

A simple way to identify environmentally preferable equipment is by choosing equipment with one of the recognised labels for energy and environmental performance. These labels consider the environmental impact during all stages of a product's life-cycle.

For more information visit www.eu-energystar.org

Other Opportunities

Combined Equipment

Combined printers, fax machines and copiers are now widely available. These can make a significant impact on energy consumption as only one machine is required instead of three, cutting energy consuming stand-by time. However, average consumption and stand-by levels for the whole machine need to be checked to ensure savings.

Thin Film Technology (TFT)

In recent years a number of manufacturers have moved from cathode ray monitors to supply all-in-one PCs which incorporate monitors using Thin Film Technology or "flat" screens using Liquid Crystal Display (LCD).

Benefits include:

- Reduced energy consumption, typically 50 to 70% less energy. For further details see Energy Star website.
- Zero emissions of electro-magnetic radiation.
- Less space required at desk level as they are smaller.
- Less screen flicker.

The machines cost more than conventional versions but savings are made in space, energy and air-conditioning costs.

Further Information

Sustainable Energy Ireland

- www.sei.ie
- SEI Glasnevin Building - Energy Efficient Office Building

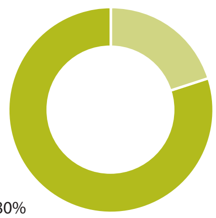
The Carbon Trust

- www.thecarbontrust.co.uk
- Energy Efficiency in Offices (GPCS020)
- Procuring smart, energy efficient office buildings (GPG362)

4.9 Catering

Energy Consumption and Use

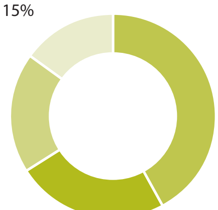
The potential for energy saving in catering are high - usually in the range of 20% to 40%. For a typical catering function in school, factory, office, hospital or university the total energy consumed per meal is approximately 5 kWh. If the catering function is run on gas and electricity, the gas accounts for 80% of energy use and electricity accounts for 20%. See Figure 4.18.



	Energy kWh/meal	%
Gas	4.0	80
Electricity	1.0	20
Total	5.0	100

Figure 4.18 Energy consumption per meal

The energy used in catering covers not just cooking, dishwashing and ventilation but also the heating and lighting of both the kitchen and dining areas. The breakdown in energy use is shown in Figure 4.19.



Typical energy consumption per meal		
	kWh/meal	%
Food storage, preparation and cooking	1.22	24%
Hot water and dishwashing	0.96	19%
Heating and ventilation	2.09	42%
Lighting	0.73	15%
Total	5.00	100%

Figure 4.19 Breakdown of energy use in catering

Catering Equipment Rating

Catering equipment falls into three main categories - small, medium and large. Figure 4.20 shows typical power ratings (kW). The amount of energy used will depend on how long the equipment is switched on.

Small	Medium	Large	
Fryers	10.0	20.0	32.5
Steaming Ovens	3.0	6.0	13.0
Pressure Cooker	-	12.0	25.0
Microwave Ovens	0.6	1.3	2.0
Convection Cookers	7.5	12.0	17.5
Range Burners with Ovens	-	-	28.0 (6 burner)
Boiling Table	-	-	28.0 (6 burner)
Induction Tops	3.5	5.5	13.0
Brat Pan	-	12.0	15.0
Grill	-	10.0	-
Boiling Pans	4.0	12.0	23.5
Water Boilers	3.0	10.5	22.0
Display Boilers	3.0	6.0	-

Figure 4.20 Catering equipment power ratings (kW)

Kitchen Operation

Cooking

The way in which a kitchen is organised and operated, the menu variation, types of food cooked and the timing of the various preparation and cooking tasks all contribute to the efficiency with which energy is used.

Studies have shown that different chefs operating in the same kitchen, with identical menus, can use up to 50% more energy.

Utilisation of kitchen equipment plays a significant part in determining energy use. Switching appliances on too soon and leaving them at cooking temperature when not in use is the prime cause of energy wastage.

The principal energy-saving messages in terms of kitchen operation are:

- **Do not switch equipment 'on' until it is required for cooking**
- **Switch equipment 'off' immediately after use**

Other operational and energy-saving good housekeeping measures that should be adopted are as follows:

- Do not switch on equipment too soon - the warm-up times for cooking equipment are often overestimated and consequently appliances are turned on too far in advance of use (see Figure 4.21). Switch off when not in use.
- Do not use 'standby' settings - switch off equipment.
- The minimum number of heated and refrigerated servery units should be provided to meet operational requirements. Units chosen should have a high level of insulation.
- Do not cook food too early - it will have to be kept warm for a prolonged period. This is detrimental to the nutritional value, texture and appearance of the food, as well as being wasteful of energy.
- Automatic controls and timers should be fully utilised and not overridden.
- Saucepan lids should always be used - these reduce energy loss by 7%.
- Use pans of the appropriate size for the hob.
- Moving pans to allow only partial contact with the hob, rather than adjusting the heat source, is wasteful. A pan positioned 25% off centre reduces energy efficiency by 15%.
- Do not use large items of equipment to cook a small food portion - use equipment appropriate for the task.
- If the appliance has a part setting, for example a half-fill setting, then use it for cooking small amounts.
- A microwave oven is ideal for heating or reheating small portions.
- 'Domestic' requirements, for example provision of food for the catering staff, should be met by use of appropriate 'domestic' cooking equipment. For example, use a toaster rather than the salamander grill, or an electric kettle rather than the water boiler.
- Do not use cooking equipment as a substitute for a space-heating system. It is inefficient.
- Always consider energy use when planning menus.

	Minutes
Large oven	10-15
Deep-fat fryer	5-10
Chargrill	10
Salamander grill	10
Griddle	15
Combi-oven	nil

Figure 4.21 Typical preheat times

Dishwashers

- Use gas in preference to electricity for water heating in dishwashers (i.e. hot fill).
- Do not use dishwashers on part load - run them only when full.
- Use a water softener to prevent scale formation and minimise energy use.
- Consider use of low-temperature sanitising liquids.

Lighting

- Light fittings and diffusers should be cleaned regularly.
- When a lamp fails, replace it with a more energy-efficient alternative if possible.

Refrigerators and Freezers

- Check that the correct temperatures are being maintained. Set points may need adjusting for summer/winter.
- Keep refrigerators and freezers as full as possible.
- Minimise the frequency of opening refrigerators and freezers, and ensure that doors are properly closed, not left wedged open.
- Do not put hot food directly into a refrigerator.
- Ensure the condenser coils are not fouled and have an adequate supply of cooling air.

Extraction

- Only switch on when needed.
- Switch off as early as possible.
- Consider two speed or variable speed drives on fan motors of larger installations.
- Ventilation should be interlinked to gas supply to ensure sufficient air for safe gas combustion appliances.
- Ensure filters are cleaned or changed regularly.
- Consider heat recovery from exhaust.

Area	Energy Saving Measures
Food Storage	Locate refrigerators and freezers away from heat sources. Minimise frequency of opening refrigerators and freezers. Avoid putting hot food in refrigerators. Adopt a planned defrosting programme. Check door/lid seals and replace as necessary. Replace old equipment with new efficient models.
Food Cooking and Serving	Minimise preheating times for ovens, fryers and other equipment. Switch off ovens before the end of cooking time. Minimise storage of cooked food. Keep hot plates and gas burners clean. Introduce regular servicing of cooking appliances including thermostats and automatic timers. Install energy efficiency and effectively controlled cooking appliances. Select induction hobs. Select equipment sizes appropriate to task. Consider batch cooking to optimise use of appliances. Install microwave ovens to cook and reheat meals.
Air Extraction Equipment	Install energy efficient ventilation hoods, Locate hoods directly over ovens, fryers, grills which need air extraction. Co-ordinate layout of kitchen hoods and ductwork with cooking equipment layout and cooking process. Switch on extract systems only when required and switch off as soon as possible. Clean filters, grilles, and fan blades regularly to prevent grease build up. Close external doors when operating extract fans.
Dishwashing and Hot Water	Maximise dishwasher loads with full loading and correct stacking. Clean and maintain machines regularly. Consider using sanitising liquids and water softeners to reduce boost temperatures. Install efficient dishwasher units incorporating economy wash cycles and/or heat recovery. Consider direct fired gas heaters for water supply. Undertake regular cleaning and maintenance. Insulate hot water tanks and pipework. Check hot water thermostats and reduce where possible (Note. 55°C is minimum recommended temperature to avoid Legionnaire's disease). Install spray taps for handwashing facilities. Mend leaking taps.
Heating	Ensure kitchen extract ventilation does not draw excessive air from dining areas. Consider heat recovery system for mechanical ventilation. Improve insulation in walls and roofs. Consider double glazing. Install draught-proof doors and windows. Fit automatic door closers. Operate kitchen extract systems only when required for cooking periods. Install kitchens with local thermostatic controls, e.g. radiators with tamper-proof Thermostatic Radiator Valves. Do not use cooking appliances to heat kitchen areas.
Lighting	Install more efficient lighting sources. Keep lamps and luminaires clean. Switch off when not required. Fit automatic lighting controls for intermittently used areas, e.g. cloakrooms, stores.

Figure 4.22 Energy saving measures in catering

4.10 Building Energy Management Systems (BEMS)

Introduction

Over the last 25 years the use of microprocessor based technology has become increasingly prevalent in the control of energy consuming plant. These systems are called **Energy Management Systems (EMS)** which control energy using plant by digital controllers which have the capacity to report to and receive instructions from a personal computer. The greatest growth area for EMS has been in the control of building services such as heating, air conditioning, boiler plant and lighting. These systems are referred to Building Energy Management Systems (BEMS).

BEMS should be differentiated from 'stand-alone' controls which are packaged units designed to operate a limited amount of plant (e.g. a heating circuit or one air handling unit) without any form of intelligent interaction with a secondary control unit.

BEMS are computer-based systems which automatically monitor and control a range of building services including air-condition, ventilation, heating, boilers and lighting. Other facilities can also be integrated in the system including security, fire alarms maintenance and monitoring and targeting.

Definitions of BEMS

BEMS are computer-based systems which automatically monitor and control a range of building services including heating, ventilation, air conditioning and lighting. Other facilities can be integrated into systems including ID security, fire alarms, CCTV, maintenance schedules and monitoring and targeting.

What can a BEMS do?

- **Automatic switching of plant on and off**
  (e.g. on the basis of time, type of day or environmental conditions). For example, the BEMS can control lighting to avoid unnecessary consumption outside normal working hours or when ambient daylight levels are adequate.
- **Optimisation of plant operation and services**
  A typical application is the optimum start/stop routine for space heating where the start and stop times can be automatically adjusted by the system to compensate for external temperature changes and the thermal inertia of the building. Other examples include the control of fuel/air ratios on boilers and to maximise free cooling in air conditioned buildings.
- **Monitoring of plant status and environmental conditions**
  A building manager can be alerted to alarm conditions in time to take remedial action. Energy management systems can therefore improve standards of operation and maintenance.
- **Provision of energy management information**
  Data on energy flows, consumption, trends and overall building performance are easily accessible.

Managers can make quick assessments of energy efficiency improvement measures and also use the information for forward planning and costing.

- Remote monitoring and control capabilities for plant and services. In a large building or site, a BEMS produces a more effective use of manpower. It is even more apparent when plant and services are addressed over the telephone networks, permitting geographically remote buildings to be remotely monitored and controlled.
- **Remote management by bureau services**
  With the use of telephone networks, supervision and monitoring of buildings can be undertaken remotely by an independent energy management company as a service to building owners or operators. An example can be seen at www.3e.ie.
- **Building or premises management**
  BEMS can be readily extended to incorporate features such as fire and security monitoring with local or remote alarm and indication.
- **Planned Preventative Maintenance**
  Many BEMS can be furnished with software for managing routine maintenance of plant within the building, irrespective of whether the plant is controlled by the BEMS. This will reduce labour costs, improve reliability and reduce energy costs.

Main Components of a BEMS

A complete BEMS system consists of:

- **Hardware**
  e.g. outstations, valves, controllers.
- **Software**
  which dictates procedures for the BEMS to follow.
- **The network**
  including network cable and communications hardware and software to allow BEMS components to communicate with each other.
- **Interfaces**
  with other systems such as fire alarms, CCTV, security and occupant ID systems.

As a minimum the hardware components are:

- **Sensors**
  which send input signals to the BEMS indicating physical condition such as temperature.
- **Actuators**
  which perform some action under the command of a BEMS.
- **Outstations**
  which are devices with a microprocessor, time device, and input/output sections which, through software, can independently control plant.

The following hardware components are also often found in BEMS:

- **Terminal unit controllers**
  which control a small item of plant such as an air conditioning terminal unit.
- **Central terminal**
  which provides an enhanced interface to the outstations, terminal unit controllers, sensors and actuators.
- **Local plant panel**
  provided by a manufacturer specially designed control equipment/plant they supply.
- **Network**
  which allows communication between outstations, terminal unit controllers and central terminal. A network is required if there is more than one outstation, or if the system also has terminal unit controllers or a central terminal.

How can BEMS save energy?

- Optimising the efficiency of plant
- Minimising unnecessary energy use
- Improving maintenance
- Improving ease of plant operation
- Increasing energy awareness
- Data logging for monitoring and targeting
- Providing data on building energy performance to help identify potential energy saving measures.

Specification

It is important that a proper specification is developed early on in a BEMS project to ensure the level of control and the facilities provided are appropriate to the application. An under-specified system will cause much frustration and an over-specified system will cost more to provide unnecessary capabilities and functions.

Commissioning

The purpose of commissioning is to check and adjust all sensors and actuators to ensure they are accurate to within defined limits. All cable runs must be checked for point to point continuity and insulation. Earthing is particularly important as poor earthing is often a source of interference with electronic data transfer. The cost of proper commissioning should be built into the contract price and all tests should be carefully logged. Where BEMS systems are not commissioned correctly faults can cause problems over its entire life.

Operator Training

It is important that there are a minimum of two operators who are fully trained and competent to use the BEMS. The training should be in two parts: a general course on the principles of BEMS and site specific training on the system they will operate. The long term success of a BEMS is the combination of both the user and the system. The user must able to interpret data and be able to make sensible judgements on adjustments.

Further Information

Sustainable Energy Ireland

- www.sei.ie
- Case Study 1 - BEMS at Stratus Computers
- Case Study 2 - BEMS at UCD, Belfield

The Carbon Trust

- www.thecarbontrust.co.uk

Building management system in multi-site commercial and industrial buildings - Shell UK Exploration and production, Aberdeen (GPCS390)

4.11 Summary Table of Measures

Electrical Plant

- Better use of tariffs – day/night rates etc.
- Power factor correction
- Plant scheduling and maximum demand control
- Motor size reduction
- High efficiency electric motors
- Variable speed drives for motors
- Application of flat belts for electric drives
- Transformer selection and sizing
- Efficient utilisation of lift equipment and operational controls

Lighting Systems

- Replace tungsten with compact fluorescent
- Replace T12 fluorescents with T8s
- Use T5 fluorescents where possible but avoid glare in low ceilings
- Use soft start on existing non high frequency control gear especially when fitting lighting controls
- Use high frequency control gear
- Specify luminaires with high Light Output Ratios (LOR)
- Use correct luminaires in spaces using computers
- Use task lighting to reduce ambient lighting
- Use induction lamps in difficult access areas
- Minimise use of décor lighting
- Light vertical surfaces to make a space look brighter
- Maintain existing light controls
- For intermittent use areas use presence controls (microwave or dynamic infra red)
- Use photocell control on outdoor lighting
- Use photocell/dimming control indoors where appropriate
- Avoid overlighting areas
- Keep luminaires clean

Boiler Plant

- Improvements to combustion efficiencies
- Use of high efficiency boilers
- Use of condensing boilers
- Installation of economisers, waste heat recovery units, blowdown recovery, etc.
- Improvement to boiler plant management and operating procedures
- Decentralisation of boilers
- Possible reduction in boiler operating pressure
- Reduction in standing heat losses from boilers
- Installation of new and improved controls, i.e. optimised start and stop, compensated circuits, etc.
- Installation of sequence boiler firing controls
- Fuel Storage and Handling Systems
- Oil tank insulation
- Oil temperature controls improvements

On Site Power Generation

- Combined heat and power
- Peak demand reductions ('lopping') using stand-by power generation

Distribution Systems

- Insulation of distribution pipework and of pipework fittings and valves, etc.
- Rationalisation of distribution (e.g. removal or isolation of redundant pipework)
- Steam trap operation
- Improvements to condensate recovery
- Flush radiators, pipework systems and clean fins and filters of convectors
- Reduction in energy losses by repairing leaking distribution pipework
- Destratification systems
- Effective air venting

Domestic Hot Water Systems (DHW)

- Improvements to existing DHW controls
- Changing centralised DHW generation to local electric/gas heating systems
- Use of showers rather than baths
- Check storage tank insulation and recommissioning of controls
- Check storage temperatures

Air Conditioning and Mechanical Ventilation

- Heat recovery for space heating, pre-heating of DHW
- Improvements to existing Heating, Ventilation and Air Conditioning (HVAC) controls
- Introduction of new HVAC controls
- Better use of speed control for ventilation plant
- Investigation of speed control for ventilation plant
- Free cooling (fresh air/recirculating air mixing ratios)
- Sequence control of cooling tower fans and condenser pumps
- Night time purge
- Air quality control – to vary air ventilation rates
- Recommissioning of controls
- Run-around coils

Space Heating Systems

- Improvements to existing space heating controls
- Removal of 'day time' supplementary electric heating
- Improvements to zoning of space heating
- Replacement of existing space heating systems with more efficient alternatives, e.g. radiant heating systems
- Introduction of improved space heating controls
- Use of an energy management system
- Installation of thermostatic radiator valves
- Fitting of reflective foil behind radiators
- Recommissioning of controls
- Optimisers and compensators for temperature control

Building Fabric

- Reduction in air infiltration rates
- Improvements to building insulation
- Installation of secondary glazing
- Improvement to draught-stripping
- Better utilisation of space
- Installation of fast acting doors
- Installation of air curtains
- Door closers
- Draught lobbies

Catering

- Replacement of existing equipment
- Improvements to operation techniques (use by staff) –
  avoiding excessive pre-heating of catering equipment, operation of freezers/fridges etc.
- Use gas in preference to electricity

Swimming Pools

- Use of a pool cover
- Investigation of use of combined heat and power
- Investigation of use of heat pumps
- Investigation of use of condensing boilers
- Effective space and pool water temperature control
- Run-around coils/plate heat exchangers
- Pump speed modulation (reduction in quiet/out of hours)
- Reduced ventilation at quiet/out of hours periods especially with pool cover

Water Systems

- Reduction in leakage rates
- Recycling of water
- Installation of water conservation devices
- Meter sizing

Chiller/Cold Store Plant

- Space utilisation
- Heat recovery
- Sequence and load control
- Temperature control
- Insulation
- Evaporation/condensing pressures

Utility Management

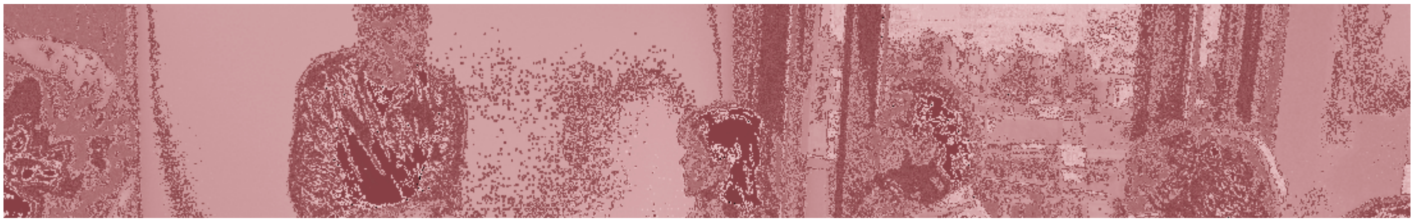
- Installation of Building Energy Management Systems
- Initiation of formal Monitoring and Targeting programme
- Energy awareness programme and good housekeeping programmes
- Energy-conscious design incorporated into new build and refurbishment projects
- Energy efficiency improvement tasks included in planned maintenance contracts
- Electricity purchasing review
- Natural gas purchasing review
- Bureau Services

4.12 Further Information

Publications are available free of charge from the following web sites:

- Sustainable Energy Ireland - www.sei.ie
- The Carbon Trust - www.thecarbontrust.co.uk

Section 5 | People Aspects - Reaching the Goals



5.1 Introduction

The importance of a balanced approach to energy management was outlined in Section 2.2 and involves:

- Organisation/information
- People solutions
- Technical solutions

All three areas are interdependent and need to work simultaneously for energy management to be effective. However, in many organisations people solutions are often neglected and this can lead to difficulties in achieving energy and cost reduction goals.

Sometimes organisations shy away from people solutions in the belief that technology can solve all energy waste problems. Clearly it cannot because people themselves are often unwittingly the source of waste. Others feel they are technically trained and don't have the people and change management skills to address issues like employee awareness and motivation. Others feel that they cannot hope to change employees' behaviour and habits in energy use unless there is senior level commitment. These concerns are valid. However, a number of organisations have faced them and addressed people issues in an appropriate way as an integrated element of their energy management strategy. As a result they have achieved large savings often between 10 and 20%. The purpose of this section is to highlight some key principles and describe effective approaches to saving energy through people.

5.2 Determining Reality and Potential

Introduction

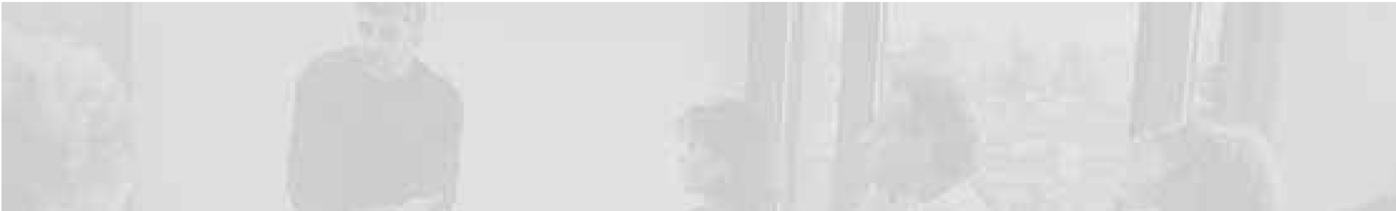
Max du Pré in his book, Leadership is an Art, wrote that "...the first responsibility of a leader is to define reality." Leaders not only need to set direction and goals but also need to have a clear grasp of the current situation. Defining reality, or the current situation, in people solutions is not a simple task. It must be carried out rationally and objectively.

Therefore in this section two tools are described to help define the current situation. They are the:

- Energy/People Matrix
- Awareness/Motivation Grid

Energy/People Matrix

This matrix helps an organisation to determine its progress in people solutions by scoring its performance against six key criteria. This helps to define strengths and weaknesses and the potential areas to address. (See Figure 5.1.)



The six key factors are at the top of each column. The rows in the matrix represent increasing levels of sophistication. At Row 1 nothing is being achieved but moving up the matrix signifies increasing maturity and progress in the people aspects of energy management.

You can locate your own organisation in the matrix by:

1. Consider each column in turn. Mark the place on each column which best describes your organisation. Place your mark anywhere between 1 and 5 on the scale.
2. Join up your marks across the columns to produce a line.

This is your organisational profile. It gives you an immediate visual indication of how balanced and mature people solutions are in your organisation.

If your profile is low around 1 and 2, do not be despondent. This is the case with many organisations and, in fact, shows there are potential savings by people solutions.

The peaks are where you are most advanced and the low points are areas for attention. How flat the profile is matters. Ideally the profile should be horizontal and progress up the matrix should be on all fronts so that the profile remains horizontal. If the profile is jagged or uneven it presents a threat as weaknesses can easily undermine strengths as all six areas are inter-dependent.

Energy/People Matrix

Level	Commitment	Awareness	Motivation	Promotion	Training	Momemtum
5	Active commitment from senior management supporting a comprehensive strategy to save energy through people	High awareness levels throughout the organisation	All users at every level self-motivated to save energy	All users at every level self-motivated to save energy	Ongoing comprehensive internal training initiatives tailored to identified needs with evaluation	People solutions fully integrated into all management systems which sustain momentum and continuous improvement
4	Formal policy and strategy but lacking senior level commitment	Most major users aware of potential and opportunities to save energy	Most major users motivated to save energy	One off energy campaign tailored to the organisation	Internal training targeted at major users following a training needs analysis	People solutions partially integrated into existing effective management systems
3	Outline strategy drafted but lacking commitment from key people and lacking integration into mainstream management	Some awareness of energy saving potential and how to achieve it	Some motivation by a few major users	Some use made of organisation's information channels to promote energy savings	Occasional internal training for selected people as required	People solutions have a temporary impact and loose momentum
2	Commitment by a few people to some unwritten ideas	Awareness in places but patchy	Motivation restricted to enthusiasts	Energy savings promoted by informal contacts and published awareness literature	Occasional use of external specialist courses for some technical people usually at their request	Energy saving initiatives regarded as a 'passing phase' by most end users
1	No interest, initiative or commitment to saving energy through people	No awareness of how to save energy	No motivation to save energy	No motivation to save energy	No energy training	No initiatives therefore no momentum

Figure 5.1 Energy/people matrix

Awareness/Motivation Grid

Two key elements in the Energy/People Matrix are 'awareness' and 'motivation'. Awareness defines what people know and motivation defines why they take action. These two elements are related. For example, some people may be highly motivated to save energy but do not have the knowledge (i.e. awareness) to make any savings. Conversely others might have the awareness but take no action because they are demotivated. Figure 5.2 describes four main categories in the Awareness/Motivation Grid.

Before embarking on any programme it is helpful to identify where in the awareness/motivation grid employees are located. Wherever they are, everyone needs to be moved to the high awareness/high motivation quadrant if significant savings are to be achieved.

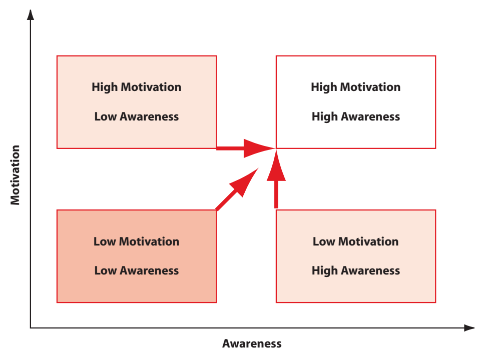


Figure 5.2 Awareness/motivation grid

(Source: NIFES Consulting Group)

Different individuals in an organisation will be at different parts of this grid. Also different groups of people within an organisation may fall into a particular quadrant. It is important to determine where people are in their levels of awareness and motivation before developing a strategy. One method of determining where people are is to devise a simple questionnaire which focuses on knowledge (awareness) and attitude (motivation) levels. The questionnaire should be tailored to the specific organisation/section/department in which the staff are located.

Each individual can be given two scores out of 100 (one for awareness and one for motivation). These scores can be plotted on the grid. This provides helpful information on the starting point and will give guidance on developing an appropriate strategy.

It is relatively easy to move from high motivation/low awareness to high motivation/high awareness. The motivation is already there: it is simply the awareness that is missing. Typically these people will say "Yes, we want to help in a campaign but tell us what practical things we can do to save energy?"

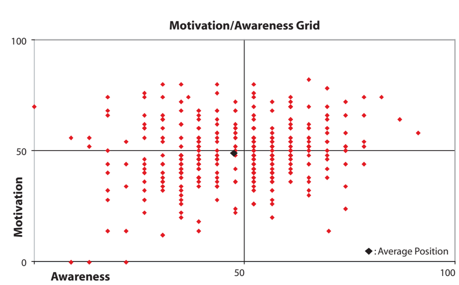


Figure 5.3 Results of a staff survey showing scores for awareness and motivation

(Source: NIFES Consulting Group)

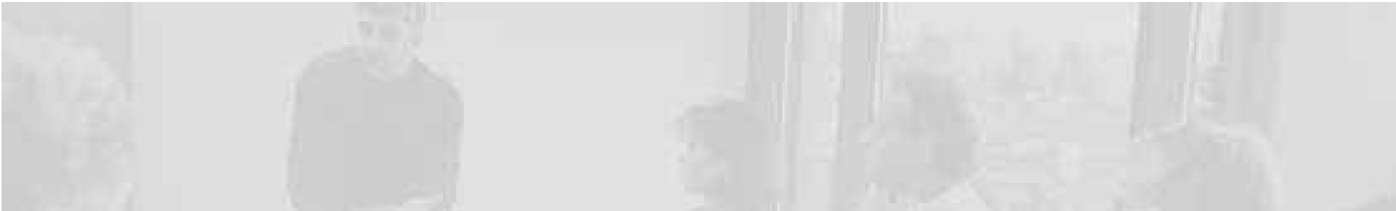


Figure 5.3 shows the results from a survey in the healthcare sector. There is quite a spread of scores. To achieve savings it is important to devise strategies to get people into the top right quadrant - high motivation/high awareness.

This analysis can be used to identify individuals who are already in the top right quadrant and they can be recruited to help play a key role in a campaign, e.g. acting as an Energy Co-ordinator. The analysis can also be used to determine the savings potential of a campaign before it is launched. For example, a shift in the average score from 50/50 to 60/60 usually represents an 8% savings in energy in the healthcare sector.

5.3 Ten Steps to an Effective Energy Awareness Campaign

Introduction

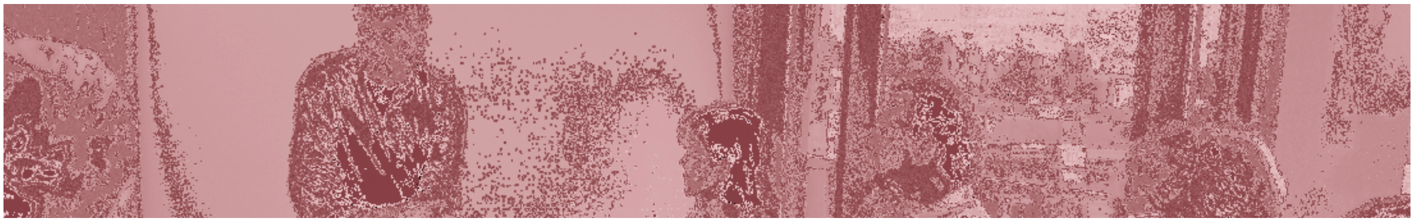
Every organisation is different and has its own unique culture which is determined by its history, vision, ethos and values. Therefore any programme of behavioural change to save energy has to be tailored and be specific to the organisation. However, there are some common principles which should be employed to have an effective campaign. These are now described.

1 Management Commitment

Senior and middle managers need to give their full support to the campaign. One of the three most common reasons for failure of energy campaigns is the lack of management support. The backing for a campaign must be at both senior and middle management levels. It is easy to assume that if senior management are committed then middle managers will be also. However, this rarely occurs. Therefore middle managers need to be actively recruited and convinced after senior level commitment has been secured. This commitment does not mean managers have to devote a lot of time to the issue but it is important their commitment is visible, practical and effective.

Practical Ways Senior Management can Demonstrate Commitment

- Develop an energy policy
- Energy management on boardroom agenda
- Appointment of a Board Energy Champion
- Appointment of a Campaign Team
- Ensure energy management is adequately resourced
- Release funds for campaign
- Support at energy campaign launch
- Personally brief middle managers
- Release staff for training
- Personally conduct energy walkabouts
- Hold Campaign Team accountable for achieving agreed targets



- Write articles for staff newsletters or intranet
- Review progress reports

2 Funding

Energy campaigns which fail usually always have one thing in common: they are attempted with inadequate funding. Usually no strategic long-term plan has been developed and no activities or materials have been properly costed. To run an effective campaign the investment level needs to be between 1% and 2% of the total annual utility expenditure. So for an annual utility expenditure of €1 million a budget of between €10,000 and €20,000 should be set. Often people in organisations of this size budget for figures as low as €500 to €2000. But to reach a critical momentum these sums are simply not enough. In fact such investment is often wasted. It would be wiser to do nothing if less than 1% of the annual energy budget is available.

An investment of 1% to 2% of the annual utility expenditure can often result in savings of between 5% and 15% in 12 months. They also have rapid paybacks which means that the cost of energy awareness campaigns can be funded from the annual utility budget without having to seek special capital funding for a campaign.

Technical people find it much easier to invest in hardware solutions such as new boiler controls or upgraded lighting systems rather than in 'soft' solutions such as people who are less predictable. However, the hard facts show in numerous cases that there is enormous potential to save energy through people if the strategy is right and properly funded. One example is a large retailer who designed their own campaign. For an investment of €30,000 they saved €300,000 of electricity in 12 months. This sort of return is typical and compares very favourably with any hardware investment.

3 Campaign Team

For a campaign to be effective there needs to be a team of people dedicated to the campaign, driving it forward and making things happen. This team should be mainly 'insiders' not external specialists. They also need to have sufficient authority to be taken seriously. It is suggested this team has a clear remit, meets regularly, take personal responsibility to achieve agreed goals and hold each other accountable. For a large organisation the team could consist of:

- Campaign Manager
- Board Energy Champion
- Energy Manager
- Estates or Production Manager
- HR/Communications Manager
- External Energy/Training Consultant

For smaller organisations teams smaller than this would be appropriate. Campaign team meetings should be short, at regular intervals, with clear goals and points for action by the next meeting. The Campaign Manager should set the agenda and lead meetings. This regular focus will ensure the campaign stays on track and acts as stimulus for feedback and new initiatives.

4 Strategy

It is important to design a campaign appropriate to the organisation's culture. Every culture is different so "off the shelf" campaigns are rarely effective. Each campaign must be carefully crafted and tailored for maximum impact.

In developing an appropriate strategy it is important to determine the starting point. In addition to using the Matrix and Grid described in Section 5.2, it is useful to ask questions.

The sort of questions to ask are:

- What are the current levels of awareness?
- How motivated are people?
- What are the barriers?
- What are the opportunities?
- What would get people interested and committed?
- Can some people make much larger savings than others because of their job function?
- What are the best ways of communicating with people?
- What are the best ways of giving feedback?
- Which sites are likely to yield the largest savings?

An appropriate and realistic strategy helps to define where to put the most effort. For example, in some built environments the Pareto (80/20) rule might apply. This is where 20% of the employees actively control 80% of the energy use. This may occur in a leisure centre or a department store where the majority of staff have limited control over energy use. But a few key technical staff can exercise much control. See Figure 5.4.

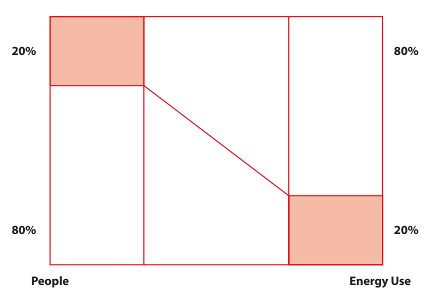


Figure 5.4 Pareto principle

If this is the case then much training and resources need to be given to the 20% who can make the biggest contribution. In other organisations it may be 70/30 or some other ratio.

5 Response Mechanisms

It is one thing to raise staff expectations and awareness but it is another to respond to the number of ideas, issues and questions generated by the campaign. It is important to allocate staff time to deal with the response which the campaign might generate. If people do not get a response they may get the feeling their views are not valued and lose interest.

A manned helpline might be the answer particularly if there is already an estates or maintenance helpline in use. An online discussion board on a dedicated energy campaign website has been used effectively by some organisations.

6 Monitoring

Once a campaign has been launched most people will make an effort. However, their next question will be "How are we doing?" To answer this question it is important to have an adequate energy monitoring system in place. This system needs to be able to look back historically at past energy use trends and take account of changes in estates size (e.g. new buildings). For organisations with a largely built environment then variables such as occupancy levels, occupancy times and weather (degree days) need to be assessed. The reason for this level of sophistication is to be able to differentiate the savings achieved by people from savings achieved by other means, e.g. installation of energy saving technology or a warmer than expected autumn.

"Success breeds success" - but if success cannot be measured then everyone is in the dark. Not only will staff know how much is being saved by the efforts but it will be impossible to relay back to those funding the campaign any progress towards achieving the agreed targets.

7 Appropriate Timing

An energy campaign is a change programme: motivating people to become energy savers and not energy wasters. But energy campaigns do not happen in isolation. Staff may have a number of other initiatives on their agenda e.g. organisational restructuring, health and safety training, fire safety, customer care, etc. If staff are hit with everything at once they may respond negatively. Much of it depends on their capacity and attitude. It is important to co-ordinate the timing of an energy campaign so that it gets the recognition it deserves.

There is never an ideal time to run a campaign but there may be a good 'window of opportunity' which minimises the risk of staff being overwhelmed.

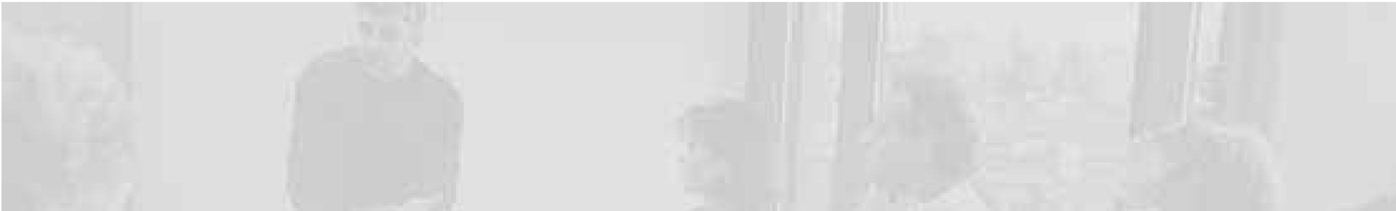
8 Sensitivity about Morale

Another factor affecting campaigns is staff morale. For example, it is not a good idea to launch an energy saving campaign the same week that redundancies are announced. Saving energy requires staff co-operation. If staff feel grieved about a corporate issue they usually hit back at easy targets such as energy campaigns.

Critical reactions to energy campaigns are usually symptomatic of ill feeling by employees towards the organisation. Saving energy is a win-win situation for everyone. So if people oppose energy saving it is usually for a reason unrelated to energy use.

9 Investment and Maintenance

In any energy management strategy it is important to invest in energy efficient plant, controls and buildings. It is also important to avoid waste in existing equipment. Some people invest to the point where they can go no further with technical solutions. They then turn to people solutions, partly because there is nowhere else to go and partly because any potential savings from investment can easily be wasted by end-users of energy if they are not sufficiently aware and motivated.



Sometimes people solutions are approached from another direction: there is not much capital available and because people solutions are low risk and relatively low cost, energy awareness is logical focus. However, one of the problems with this approach is that end-users can have the attitude: "It's all very well you telling us to switch off lights and equipment - but what about all those draughts in our office and leaking taps that never get fixed when we report them? And what about some investment in a decent heating system?"

Energy is there to serve staff and enable them to reach their goals. The aim of energy management is to achieve this at minimum cost. But if the energy provided is not delivering the required comfort conditions, then how realistic is it to expect staff to be positive about reducing consumption?

So energy campaigns must not be an excuse to dodge the maintenance or investment elements of sound energy management strategy.

The ideal situation is to run an energy campaign in parallel with an on-going capital programme. This communicates with end-users that it is not a one-way street. Also in parallel it is important to have an effective maintenance function which responds rapidly to users' needs.

10 Motivation

Senior managers and budget holders will rightly judge the success of an energy campaign by how much money it saves. Their prime motivator is cost reduction. But if the truth is known the end-users of energy in most organisations are not particularly interested in saving energy to save their organisation money - particularly if they see money wasted elsewhere.

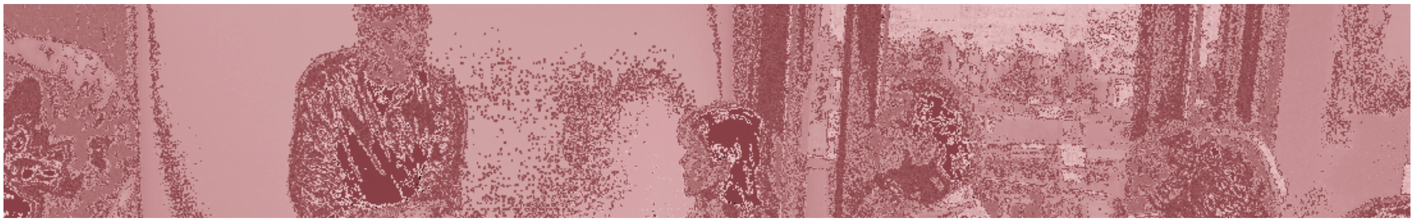
Therefore it is vital to give clear positive messages to employees why it is important to save energy. These reasons have got to go beyond cost savings, e.g. energy use in their own homes, improved working conditions, improved productivity and the environmental impact of energy use. The key to getting people on board is to relate energy efficiency to their own personal value systems.

5.4 Methods

The methods of communicating the message to your organisation will vary according to:

- type and size or organisation
- culture of your organisation
- campaign budget
- phase of the campaign
- target audience

You should select methods relevant to your own situation - you don't have to use all of them. Some methods are more appropriate to certain groups within your organisation (e.g. e-mail for those with access to computers).



Most methods can be divided into the following categories:

- Personal/Face-to-Face
- Literature
- Point-of-Use
- Participative schemes
- Current standard methods
- Exhibitions etc.
- Video
- External initiatives

Personal/Face-to-Face

- **Presentations**
  These might be used to brief managers before a campaign and to launch the campaign itself. An outline of the campaign aim, benefits and strategy can be described and the role of the audience. Other short presentations can be made once the campaign is launched. These could highlight the impact of saving energy and give advice on how to save energy.
- **Workshops**
  Possibly one to three hour sessions explaining in more detail to smaller groups, possibly by job function, about the benefits of saving energy and what they can do. Ideas generation sessions might be appropriate.
- **Use of existing meetings**
  Face to face contact can be made at staff focus groups, regular department or section meetings, team briefings or information gatherings.
- **Internal training**
  For people with direct involvement and responsibility in the campaign. (e.g. energy co-ordinators) to equip them for their role and to help them pass on information on energy saving actions to people in their area.
- **Energy walkabouts**
  Short visits to a building or area with the energy co-ordinator; Energy Manager, Energy Champion to affirm good practice and encourage people to take the campaign seriously.
- **Word of mouth**
  This is often one of the most powerful methods of communication within an organisation, and probably the one that is more difficult to control. It can be both negative and positive. The most important aspect is to try to generate messages which stimulates interest and gets people talking about the campaign, i.e. high in conversational value. It is also important to nip in the bud any negative comments or mis-information that may be circulating.

Literature

- **Special energy booklet**
  Tailor-made with company and campaign logo, colours and style. Specific advice to the people in your organisation possibly with content on energy in the home and environmental impact. These can be designed and printed professionally or produced in-house. Can be distributed with wages or salary slips. It is usually worth including information in the booklet on the cost of producing the booklet expressed as a ratio of the annual utility cost. Details of the recycled paper used for the booklet should also be included.
- **Energy newsletters**
  These can be produced at regular intervals using campaign letterhead and logo.
- **Energy leaflets**
  A new leaflet, every four weeks, could be distributed to employees e.g. on their desks. Each new leaflet would have a theme (e.g. lighting, office equipment, water use etc.)

Point-of-Use

Energy Posters

There are three types:

- professionally produced and tailor-made using campaign logo, colours and style. Or produced in-house
- ready-made energy posters free from the SEI and other voluntary or commercial organisations
- posters generated as part of a competition by employees and/or their children. Twelve winning entries could be made into an energy calendar.

Energy Stickers

Same comments can be applied as energy posters above.

Promotional 'Merchandise'

Such as coffee mugs, mouse mats, pens, diaries, screen savers etc. carrying an energy-saving message.

Pop-up Messages on intranet featuring 'energy thought for the day'.

Participative Schemes

- **Suggestion schemes**
  If suggestion schemes work well then energy saving ideas could be incorporated.
- **Competitions**
  Energy based competitions, quizzes with prizes can be useful. Also if a particular cost centre or building has done well a prize or some sort of recognition could be given.
- **Incentives**
  In the form of bonuses, rewards, outings, gifts and most importantly, recognition. Individual rewards should be used with caution because it is often a team effort which results in success. A proportion of savings could go to improving staff amenities or to the organisation's support of a local charity or fund raising project.
- **Recognition**
  Any person or team making a significant contribution should be given appropriate recognition. This does not need to be financial but it could be a meal out with their partner, hot air balloon flight with the story appearing in local press and energy newsletter.

Current Standard Methods

- **Letters/memos**
  These can keep people informed and do have an impact if they are signed personally by the Chief Executive or Energy Champion.
- **E-mail**
  Can be effective for keeping people informed. Also e-mail can be used for people to contact the Energy Manager with questions, ideas, suggestions.
- **Regular cost reports**
  If cost reports are weekly, monthly or quarterly then it is possible to add a section on energy performance. See also 'Feedback' below.
- **Public relations**
  Your organisation's image can be enhanced by communicating environmental achievements including energy savings. It could feature in the annual report and as part of the environmental report. Information could also be incorporated into brochures, direct mailings and other communication with suppliers and customers.
- **In-house/staff magazine**
  Articles on energy can be placed in the magazine at regular intervals.

Displays/Exhibitions

- **Special exhibitions**
  These can be positioned in key locations with energy advice including saving energy at home. They can be moved between buildings and sites.
- **Energy noticeboards**
  Can be located in buildings with energy information specific to that building or cost centre.

External Initiatives

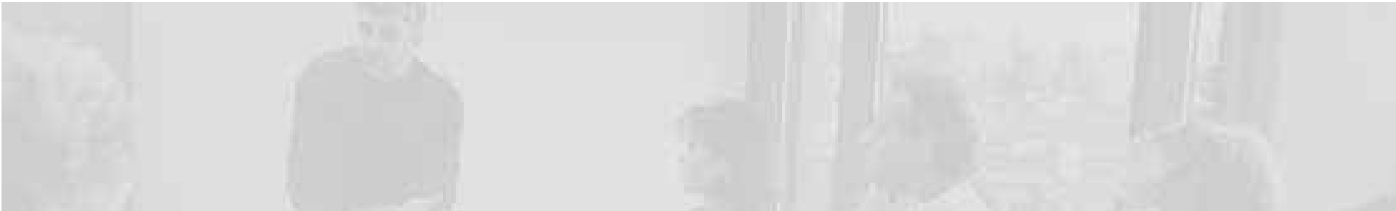
- **Discounts at local DIY stores**
  It might be possible to arrange a discount on a range of energy saving items in the home at a local DIY store for a limited period during the campaign. Employees would be eligible for a discount on the production of their ID card.
- **Sponsorship**
  Local organisations might wish to sponsor prizes in exchange for free publicity.
- **External publicity**
  Can be useful in promoting the organisation's image. Energy efficiency may not make the headlines but if you do something a little more innovative then it can be a newsworthy item. e.g. teaming up with a good cause such as hospice or getting celebrities involved.

5.5 Maintaining the Momentum

The three most common questions asked about energy campaigns are:

1. How much will it cost?
2. How much will it save?
3. How long will it last?

Some people are critical of energy campaigns because they can be short lived and brand them a "flash in the pan". However, it is worth asking "Is a flash in the pan better than no flash at all?" For example, if a company invests 1% of its annual energy bill in a campaign, saves 5% after a year but all momentum is lost in 12 months. Was it worth doing? The answer has to be "yes".



Having said that maintaining the momentum is desirable and should be part of the campaign's objectives. The key to maintaining the momentum is to identify the functions and communications systems of an organisation and integrate awareness into the system so it is a permanent element of organisational culture, practices and procedures.

Practical ways of doing this are:

- **Job descriptions**
  Ensure that energy management is part of their job. It is not an after-thought but they are being paid to take an energy responsibilities.
- **Performance appraisals**
  Once energy management is built into job descriptions performance must be monitored. If people do well they should be rewarded.
- **Induction training**
  Including energy awareness at induction is particularly important in organisations with high levels of staff turnover.
- **Information highways**
  If an existing information highway exists and works well then it makes sense to integrate energy awareness into the system. For example, if an intranet site is well used by employees then a campaign site would be appropriate. In one company there is a weekly newspaper distributed to every employee. Each week the Energy Manager includes a short article on energy and environmental issues at home and at work. Some organisations have existing suggestion schemes for encouraging staff to contribute ideas for saving energy.
- **Environmental management systems**
  All systems including ISO 14001 require that environmental awareness is raised amongst all employees. For many organisations energy use is the largest environmental impact. So the saving energy can easily be strengthened in the general environmental awareness element.
- **Quality systems**
  Most large organisations have quality management systems. Energy efficiency is seldom recognised as a legitimate target for improvement in implementing quality systems. Energy awareness is particularly relevant as it includes 'least cost' and 'workforce involvement'.
- **Purchasing policy**
  It is important to influence purchasing decisions of equipment which consume energy. In one large hospital medical consultants regularly authorised the purchase of comfort cooling systems but the Estates Department did not discover they existed until there was a maintenance fault. Eventually the system was changed so that any energy using piece of equipment on a purchase order has now to be counter signed by the Energy Manager. This also applies to medical equipment, catering and all IT equipment.
- **Contractors**
  It is possible to build energy efficiency responsibilities into maintenance contracts.

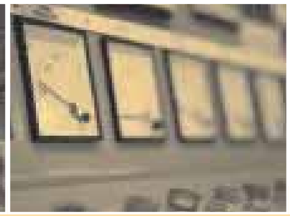
All these examples show how momentum can be maintained but the key is to determine what works in an organisation and to integrate the energy message.

5.6 Training

Awareness and motivation campaigns are usually aimed at everyone in an organisation. However, there is a place for targeted training to specific people in certain job functions. For example:

- **Operations/maintenance** staff can have a large impact on how plant and buildings services run. Irrespective of whether the maintenance staff are in-house or external contractors they need training in energy efficiency. Some organisations make attendance at energy efficiency training a stipulated condition of contract for contractors.
- **Energy management staff** need to attend seminars and workshops on all aspects of energy management whether involving management, information, technical or people issues. At training events staff can often learn from the experiences of others who have similar role and responsibility for managing energy.
- **Catering staff** have a lot of hands-on control of energy using equipment and several studies have shown that training catering staff to do their job in an energy efficient manner can save between 20% and 60% of energy and water usage.
- **Cleaning staff** are usually the first in and/or the last out of a building and can positively help to reduce energy consumption. The three key areas are:
  - Reducing the amount of energy, particularly lighting, as they move from one area to another.
  - Not leaving lighting running between ending cleaning and the arrival of building occupants.
  - Switching off electrical and office equipment not in use - particularly if cleaning takes place in the evening.
- Security staff are a key ally because any lighting or electrical equipment left on unnecessarily on a Friday night will run 65 hours over the weekend. So if security staff can be empowered to switch off equipment large savings can be achieved. In one organisation every computer and electrical item had a coloured sticker. A green sticker meant security staff had the authority to switch off equipment. A red sticker meant they were not allowed to touch the equipment.

Appendix 1 | Checklist for Design Teams of New Buildings

Appendix 1 | Checklist for Design Teams of New Buildings

Introduction

It is more cost effective to give careful thought to the energy and environmental impact of a building at the earliest stages in the design process. If it is left to later then many options will be closed and the running costs of the building will be higher. Therefore it is important to use an integrated approach to achieve the lowest demands on energy consuming building services. The design team should consider all the energy implications at the beginning of the process and review each aspect as the design progresses.

Many energy efficient features can be incorporated at little or no extra cost if considered in the context of the whole building. Other features will have an investment cost but it should be able to be justified by lower running costs and possibly on other grounds, e.g. increased comfort of building occupants. By careful design it may be possible to design out some of the assumed air conditioning requirements and this will reduce both capital and running costs.

An excellent document for any design team is Energy Efficiency in Buildings, CIBSE Guide F, London, 2004.

Site Location

The choice of site is important and the layout of the building, including orientation, has fundamental implications on the energy efficiency and environmental impact of the project. Once made these decisions are irreversible. Consideration should be given to public transport service and car parking requirements. A redevelopment site has a lower overall environmental impact than a green field site. It is also worth considering heat sources close to the site, if available, from other buildings or processes. At an early stage any limitations of gas and electricity supply infrastructure should also be identified.

Site Layout

It is important for designers to consider maximising the benefits of the natural characteristics of the site including slopes, existing trees and earth mounds. Trees and mounds provide protection from wind and noise. South facing slopes allow maximum benefit from solar heat gains.

Building Forms and Features

The careful design of the form of the building, its detailed features and internal planning can reduce artificial lighting, heating, cooling and ventilation loads.

- Design the building structure so that the required internal conditions can be achieved with minimum reliance on services.
- Consider the depth of the building. Deep plans are less easy to light and ventilate naturally than shallow plans with daylit spaces up to 6-7 metres from windows. Courtyards and atria can be used to introduce light and air into the centre of buildings.

- Make use of windows to benefit from daylight and, where possible, solar gains. One way in which glare can be controlled and daylighting levels equalised throughout the space is to incorporate a suitably angled shelf in the window design.
- Daylight blinds can be used to project natural light onto ceilings and at the same time reduces glare and unwanted solar gain.
- Place activities which benefit most from daylight and natural ventilation near the perimeter. Spaces which are infrequently occupied or require mechanical ventilation or air-conditioning for functional reasons can be placed towards the inside, or used to protect other parts of the building from noise, e.g. from an adjacent road.
- Carefully consider the height of the building. Walls enclosing the top storeys of high buildings are more exposed to cold winds than those of low buildings and consequently suffer greater heat loss from air leakage. Sealed windows may be needed on higher floors, placing greater reliance on mechanical ventilation.

Building Fabric

The term building fabric refers to the internal structure and the external elements (roof, walls and floors) of the building. It is the insulation and air tightness of the external elements which determines the rate of heat loss, but the characteristics of the inside of the building can also have an influence on the use of energy.

The life of a building will vary depending on its type and location. In many sectors the average life of a building exceeds 60 years. During this period there may be limited opportunities to improve building fabric, whereas the services may be completely replaced every 15 to 20 years. So it is vital to deal with fabric issues at design.

Air leakage through gaps and cracks causes unnecessary heat loss, as well as discomfort for occupants of the building.

- Insulate the building to the optimum level taking account of the capital cost of the insulation and the value of energy savings.
- Ensure that air leakage is minimised. Attention to detail at both the design and construction stages is essential. Consider providing draught lobbies at busy entrances.
- Specify double glazing for all windows.
- Sealed glazing units, with low emissivity glass, should be considered for the thermal comfort benefits.
- Design the structure to be sufficiently exposed so that its thermal mass will absorb solar gains and delay peak internal temperatures until the occupants have left the building reducing the need for air conditioning or at least its capacity.
- Seek detailed guidance on avoiding thermal bridging, minimising air leakage and the specification of sealed glazing units.

Services

Services should form an integral part of the design concept of the building, not as the means of creating satisfactory internal conditions within a poorly designed building structure. It is important therefore that the Building Services Engineer is involved early in the design process.

Avoid making the performance specification from the internal environment too tight, e.g. by specifying unnecessarily narrow limits for internal temperature. Do not use more complex technology than necessary to solve the problem effectively. This can create unnecessary maintenance or management burdens.

Ventilation and Air Conditioning

Energy use in naturally ventilated buildings is significantly less than in air-conditioned buildings due to a substantial reduction in electricity consumption. Electricity use per m^2 in a naturally ventilated building is often 35 to 45% of that in an air-conditioned building.

- Consider the use of natural ventilation first: most occupants prefer to control their own fresh air supply in summer by opening windows. It is often possible to avoid the need for mechanical ventilation and air-conditioning, although some designs which are essentially naturally ventilated can benefit from fans to assist in air movement when natural conditions are unfavourable.
- For naturally ventilated buildings, specify controllable background ventilation, e.g. by 'trickle' ventilations or fanlights.
- Specify windows that are simple to operate.
- Consider mechanical ventilation systems if natural ventilation is impractical due to external noise levels or pollutants. Options for summer include 'free' cooling when the outside air temperature is below the required internal temperature, 'night-time' ventilation with cool night air and, in winter, heat recovery.
- Consider partial air-conditioning before full air-conditioning. 'Mixed mode' designs allow different parts of the building to be ventilated in different ways at different times. In this way some areas can remain mechanically or naturally ventilated while others are fully air-conditioned. Spaces that are air-conditioned can revert to natural ventilation at other times, for example by opening windows.

Lighting

Artificial lighting is often the largest individual item of energy cost. Savings can be achieved by exploiting daylight to displace artificial lighting. Careful design of the size and location of windows, as well as the choice of colour in internal finishes, can ensure that lighting demands are met from daylight for a substantial part of the year.

- Use light colours internally to help to achieve the required lighting levels.
- Choose the size of windows on each facade carefully, depending on the orientation.
- Choose appropriate standards but do not over light. Special needs for additional lighting should be met locally and not for the entire area.
- Specify efficient lamps and fittings. Most areas can be lit using no more than 2.5 W/m^2 of installed lighting power (including control gear) per 100 lux of illuminance. New technology has made lamps, reflectors and control gear much more efficient. Reductions of 50% and more in installed power are common relative to older systems. Use tungsten or tungsten-halogen lighting sparingly. Where considering high intensity discharge lighting, remember the lamps take several minutes to warm up and restart and so will tend to be left on unless provision is made.
- Lighting should be designed with easy access in mind so that maintenance costs are reduced.
- Consider automatic controls, particularly for lights in open areas. Try to adopt a policy of manual ON/OFF but with automatic OFF providing a remainder/backup. Integrate automatic controls with daylight where possible. Provide local switches so that users can easily control their own lighting.
- Specify that circuits should allow sub-metering of individual zones or floors of the building.

Heating

The heating requirement should be minimised by the overall building design which will include the insulation and airtightness of the building fabric. After the design and construction is completed the key to energy efficient heating is the use of efficient boiler plant and appropriate control systems. Contributions to heat input can also be derived from the recovery of heat from exhaust air or from the use of solar energy.

- Specify efficient boiler plant. Condensing boilers, gas or oil-fired, are the most efficient for space and water heating. They are cost-effective in many applications particularly where they can be used as the lead boiler in a multi-boiler installation.
- Consider combined heat and power (CHP) for buildings which have a reasonably constant requirement for heat and power, e.g. hospitals, hotels and leisure buildings.
- Provide effective central zone and room controls. Consider separate systems to meet small loads, such as independent water heaters for summer use.
- Consider heat recovery. Note that the cost of the additional electricity used will need to be set against the value of the heat saved.
- Consider shading devices to avoid excessive heat gain in summer or glare close to windows. These may be either fixed to the outside of the building, such as fins or using internal daylight blinds.

Renewable Energy

At the design stage it is important to consider the use of renewable energy. Examples include:

- Maximising the use of natural light in building design but also harnessing technology to introduce more natural light, e.g. daylight blinds and light wells where light can be delivered via highly reflected light wells from the roof into corridors.
- Using solar energy to pre-heat ventilation air or hot water.
- Using photovoltaic panels by integrating these into roof tiles or building facades.
- Use of biomass, e.g. wood-chip boilers.

Controls

- Provide effective central, zone and room controls or health and safety, energy efficiency, prolonging plant life and responding to the needs of occupants.
- Ensure that devices requiring regular resetting and programming are readily accessible to the people responsible.
- Provide feedback devices, so that the status of the installation and compliance with design intentions can be readily monitored, for example to warn if heating boilers are operating when average outside temperatures are high, if heat recovery and free cooling are operating effectively, if refrigeration and heating are operating simultaneously in conflict, or if air mechanically supplied for night cooling is significantly warmer than outside.
- Avoid excessive complication, beyond the normal capabilities of site staff and maintenance contractors.
- All default sates should be to low energy.

Building Energy Management Systems

Well-designed building energy management systems (BEMS) can be very powerful in larger buildings or estates, but they should be regarded as an adjunct to good management not a substitute for it. In smaller buildings, BEMS should not be too complicated for the level of management skills available. In rented buildings, the different requirements and responsibilities of landlord, tenant and maintenance contractor must be addressed.

Sub-Metering and Monitoring

It is important to provide electricity, gas, oil and water sub-metering to encourage effective monitoring and management, particularly for:

- individual buildings as a multi-building site
- individual tenancies in a building
- areas of high energy intensity, such as catering and computer rooms
- larger plant items such as chillers, air handling units and humidifiers

Minimum levels of sub-metering are clearly specified in the EU Directive of Energy Performance in Buildings.

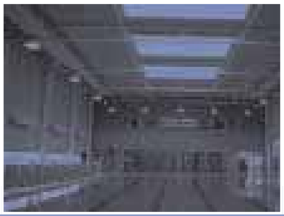
Ideally, sub-metering should be at plant item or motor control/panel level and linked to a BEMS, if installed.

Sustainability

At the design stage it is important to consider both energy efficiency and sustainability of the materials used. Life-cycle costing methods can help to justify costs. There are a number of methods of assessing a building's overall sustainability. One well established method is the Building Research Establishment Energy Assessment Method (BREEAM) which scores a building design against a range of environmental factors to yield an overall score. These scores are then put into category ratings.

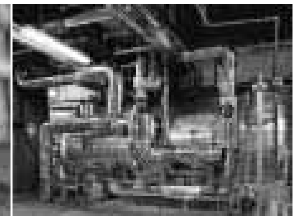
For further details see

- www.breeam.org


Appendix 2 | Investing in Energy Efficiency




Introduction

Section 2.6 of this manual has some introductory material on investment in energy efficiency including the purpose of financial appraisal and key steps in appraisal. This Appendix provides information on key appraisal methods and a tool to evaluate an organisation's current practice in investment - the Financial Energy Management Matrix. For further information on this subject refer to SEI's manual "Investing in Energy: A Practical Guide to Preparing and Presenting Energy Investment Proposals". It was published in 2004 by SEI and is available free of charge and can be downloaded from SEI's website www.sei.ie.

Undiscounted Appraisal Methods

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

Simple Payback is the simplest method of evaluation but also the crudest and it can be misleading.

The following project (Project X) requires a €10,000 investment today (Year 0) with savings of €5,000 per year achieved over 3 years.

Year	Capital Cost (€)	Savings (€)
0	(€10,000)	-
1		€5,000
2		€5,000
3		€5,000

Payback is defined as the capital cost divided by the annual savings.

$$\text{Payback (Years)} = \frac{\text{Capital Cost}}{\text{Annual Savings}}$$

$$\text{Payback} = \frac{€10{,}000}{€5{,}000} = 2.0 \text{ years}$$

Advantages of Payback

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

Disadvantages of Payback

Payback has the disadvantage of not taking into account savings achieved after the payback period. Also the time value of money is ignored (e.g. €5,000 saved in 3 years time is worth less than €5,000 saved today). Finally, at the end of the project life no account is taken of any residual capital asset value.

Payback simply indicates the time when the cashflow becomes positive.

However, in many organisations payback is used as a method of filtering out 'good' from 'poor' projects. This can lead to serious errors. For example if faced with following choice between Project X and Project Y.

	Project X	Project Y
Capital	€10,000	€0,000
Annual savings	€5,000	€4,500
Payback	2 years	2.2 years
Project Life	3 years	10 years

If the investment sum available is limited to €10,000, a choice must be made. On a simple payback basis the choice is Project X. However, if the life of both projects is taken into account: then Project Y will clearly be more attractive than Project X over a 10 year period, because a considerable amount of savings are made after the payback period.

Discounted Appraisal Methods

Discounted evaluation methods take into account the time value of money, life of the project, interest rates and other factors. A key purpose of discounting is to take into account that the value of a sum to be received next year is less than the value of the same sum received today.

For example, if €935 were deposited in a bank at an interest rate of 7%, one year from now the value would be €1,000. This is calculated from a compound interest formula:

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

A = initial sum

S = sum accumulated after 'n' years

r = interest rate

So $S = 935(1+0.07)^1 = €1{,}000$

If we have energy saving project which delivers savings of €1,000 one year from now it is helpful to know what they would be worth in today's money. This can be done by rearranging the above formula to:

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

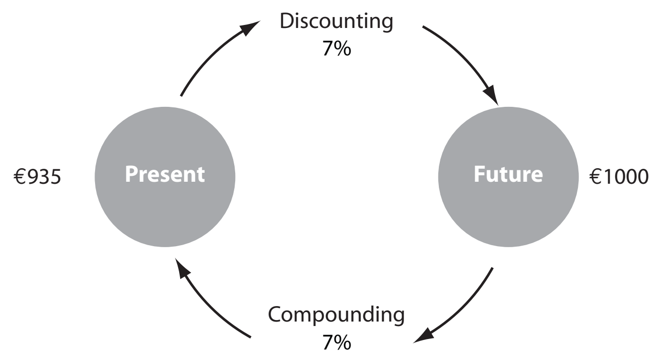
A = today's (present) value of € received in 'n' years time

r = discount rate

S = forecast savings in year 'n'

So if a project delivers €1,000 saving a year from now, then at a discount rate of 7% then it is worth in today's money:

$$A = \frac{1000}{(1+0.07)^{1}} = €935$$



The purpose of discounting future savings in each year in the project life is to get all the savings assembled in a common time currency of today's value or "present value". When added together they represent the gross present value. If the capital cost is deducted we have the net present value or NPV.

If we return to Projects X and Y and using a nominal discount rate of 13% we can calculate the NPV of each project:

Project X

Year	Capital Expenditure	Savings	Discount Factor at 13% Discount Rate	Present Value
0	(€10,000)	-	1.0	(€10,000)
1		€5,000	0.885	€4,425
2		€5,000	0.783	€3,915
3		€5,000	0.693	€3,465
			Net Present Value	€1,805

Project Y

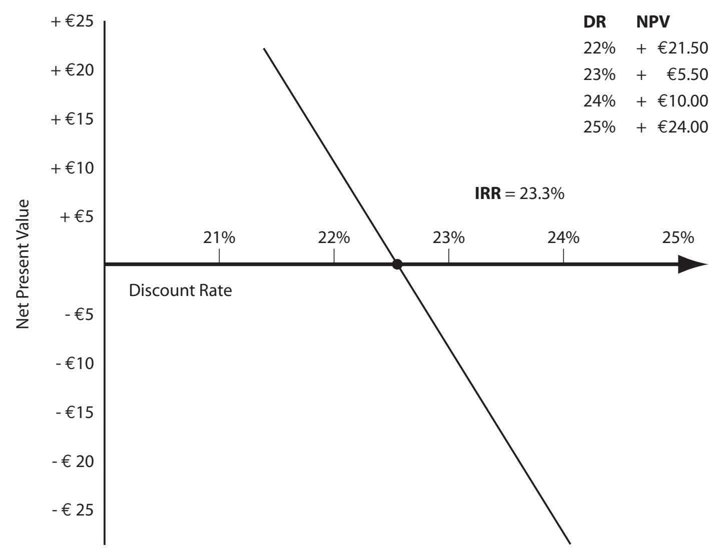
Year	Capital Expenditure	Savings	Discount Factor at 13% Discount Rate	Present Value
0	(€10,000)	-	1.0	(€10,000)
1		€4,500	0.885	€3,982
2		€4,500	0.783	€3,523
3		€4,500	0.693	€3,118
4		€4,500	0.613	€2,758
5		€4,500	0.543	€2,443
6		€4,500	0.480	€2,160
7		€4,500	0.425	€1,912
8		€4,500	0.376	€1,692
9		€4,500	0.333	€1,498
10		€4,500	0.295	€1,327
			Net Present Value	€14,413

The **Net Present Value** is a financial measure of particular interest to financial managers. It tells them what the project will earn over its costs in today's money over its expected lifetime. The NPV of a project should be positive to be a viable option. In comparing Project X with Project Y, then Project Y gives a much greater NPV and therefore is more attractive. A key issue to consider is the risk that the life of Project Y is significantly longer (i.e. 10 years) and the building may be refurbished, sold or demolished during this 10 year period.

Selecting Discount Rates
The appropriate discount rate can be shown, from the application of more advanced financial theory, to be the cost of capital, i.e. interest which has to be paid on acquiring the capital to invest in the project. This idea is comparatively new and over some years use of the phrase "cost of capital" has been displacing the term "discount rate". Public sector bodies often use a fixed discount rate. In the private sector it is worth asking the finance/accounting department what discount rates they use for NPV calculations.

Internal Rate of Return
If we take Project X and keep repeating the calculation using higher discount rates the Net Present Value decreases and passes zero to become a negative number. This occurs between 23% and 24% discount rate.

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



Internal Rate of Return (IRR)
This is defined as the discount rate at which the Net Present Value reduces to zero.

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

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

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

Sensitivity Analysis

In evaluating a project, some of the quantitative aspects of the project may not be known initially and therefore are assumed or estimated. Sensitivity analysis is the process by which these estimates are tested to determine what impact they may have on the value of a project.
For example for Project Y if the project life and discount rate remain fixed but the capital costs and the annual savings varied it is possible to see the impact of the changes in the NPV.

Project Y

Capital €	Annual Savings	Project Life (years)	Discount Rate	NPV
€10,000	€4,500	10	13%	€14,413
€15,000	€4,500	10	13%	€9,410
€10,000	€4,000	10	13%	€1,700
€15,000	€4,000	10	13%	€6,700

By varying key parameters it is possible to test the sensitivity of the project. It is likely that decision makers will ask questions about sensitivity, e.g.

"What happens to the NPV if the price of gas increases by 15%?"

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

Selecting Discount Rates

In the private sector it is important to ask the finance department or accounts what discount rate should be used for NPV calculations. The rate will vary from company to company depending on their financial situation, how cash-rich the company is, the cost of borrowing and assets and liabilities. Typically discount rates are between 6 and 12%. In the public sector a test discount is usually used and this tends to be fixed for long periods typically at 6%

Appendix 3 | Example of Building Benchmark Calculation

Appendix 3 | Example of Building Benchmark Calculation

The following worksheet shows how to calculate the performance indicators and benchmarks for an office building. Source ECON19.

Energy Data

Description	Measure	Notes	Ref
Annual electricity consumption	817,800kWh		A
Annual heating consumption [i]	335,400kWh	Total of gas, oil, LPG and coal usage	B
Average electricity cost	7.0c/kWh	Average including standing charges	C
Average heating cost	2.0c/kWh	Average including standing charges	D

Building Data

Description	Measure	CF [ii]	TFA	Notes	Ref
Floor area measurement type [iii]	GIA	-	-	See Table 1	E
Naturally ventilated cellular [iv]	0m^2	95%	0m^2	Measure x CF	F
Naturally ventilated open plan [v]	0m^2	95%	0m^2	Measure x CF	G
Air conditioned standard [vi]	3100m^2	90%	2790m^2	Measure x CF	H
Air conditioned prestige [vii]	1100m^2	85%	935m^2	Measure x CF	I
Total Floor Area	4200m^2	-	3725m^2	F+G+H+I	J

Building Performance Indicator

Description	Measure	Notes	Ref
Electricity Performance Indicator	219kWh/m^2	A/J	K
Heating Performance Indicator	90kWh/m^2	B/J	L
Overall Performance Indicator	309kWh/m^2	K+L	M

Electricity Benchmarks

Description	Typical	Good Practice	Notes	Ref
Naturally ventilated cellular	54kWh/m^2	33kWh/m^2		N
Naturally ventilated open plan	85kWh/m^2	54kWh/m^2		O
Air conditioned standard	226kWh/m^2	128kWh/m^2		P
Air conditioned prestige	358kWh/m^2	234kWh/m^2		Q
Building Benchmark	259kWh/m^2	155kWh/m^2	(FxN+GxO+HxP+IxQ)/J	R

Heating Benchmarks

Description	Typical	Good Practice	Notes	Ref
Naturally ventilated cellular	151kWh/m^2	79kWh/m^2		S
Naturally ventilated open plan	151kWh/m^2	79kWh/m^2		T
Air conditioned standard	178kWh/m^2	97kWh/m^2		U
Air conditioned prestige	210kWh/m^2	114kWh/m^2		V
Building Benchmark	186kWh/m^2	101kWh/m^2	(FxS+GxT+HxU+IxV)/J	W

Building Benchmark

Description	Typical	Good Practice	Notes	Ref
Overall Benchmark	445 kWh/m²	256 kWh/m²	R+W	X

Potential for Improvement

Description	Performance	Saving	Action	Notes	Ref
Electricity	Better than typical	€16688	Some investigation required	(K-R[viii])*C*J/100	Y
Heating	Better than good practice	€0	No action required	(K-R[ix])*C*J/100	Z
Overall	Better than typical	€16688			

Summary

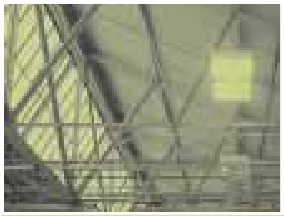
Some potential for improvement, but priority should be given to other buildings with performance worse than typical.

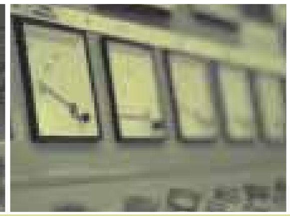
Table 1	Gross internal area (GIA)	Treated floor area (TFA)	Net lettable area (NLA)
Area conversion factors	Total floor area within the walls	GIA less unheated spaces such as plant rooms	GIA less common areas & unheated spaces
	Conversion Factor to TFA	Conversion Factor to TFA	% of GIA
Naturally ventilated cellular	95%	100%	125%
Naturally ventilated open plan	95%	100%	125%
Air conditioned standard	90%	100%	125%
Air conditioned prestige	85%	100%	125%

Key

- i The benchmarks are not suitable for assessing electrical heating performance
- ii See Table 1
- iii Many different measure of floor area are used, see Table 1
- iv A simple old style building with small individual offices
- v Tend to be larger than F with open floors and few individual offices
- vi Similar to G but fully air conditioned
- vii Large head office type building
- viii Good practice figure
- ix Good practice figure

Appendix 4 | Simple CHP Appraisal Method





Introduction

Combined Heat and Power (CHP) offers many organisations scope for saving energy costs and carbon as can be seen from Figure 1.

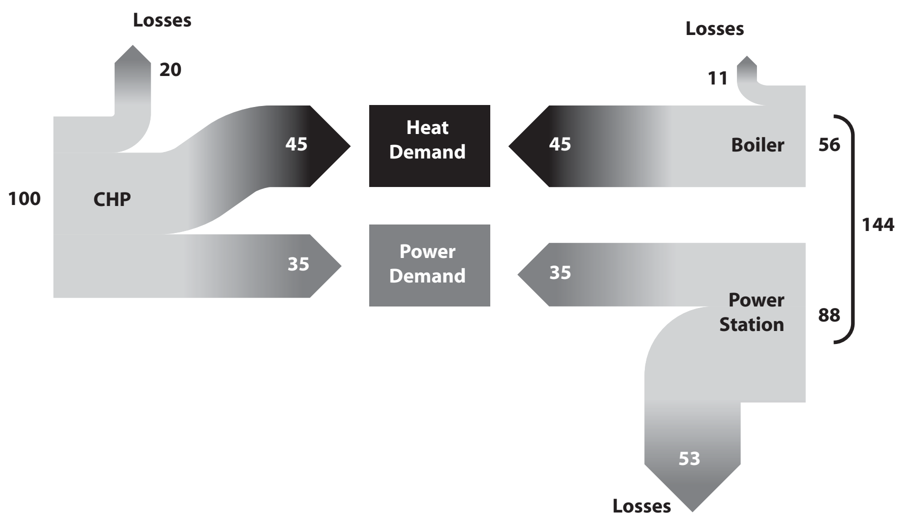


Figure 1 Comparison of CHP with conventional boilers & electricity generation

Figure 1 shows that using conventional methods of heat and electricity generation require 44% more energy than a CHP unit with the same output, but CHP is not suitable for every organisation. To establish if it is worthwhile conducting a detailed feasibility study, the following issues should be considered to appraise suitability.

CHP Applications

A variety of buildings have found CHP cost effective. If other organisations with similar buildings to your own are using CHP it might be appropriate for your organisation. Typical applications include:

- Leisure centres with pools
- Community heating schemes
- Universities & Colleges,
- Hotels
- Hospitals
- Prisons
- Shopping centres
- Multi-residential dwellings

Heat Demand

To obtain the optimum balance of plant efficiency and capital cost it is essential to carefully match plant size with base heat and power demand. As a rule of thumb applications that have a simultaneous demand for heat and electricity of more than 5000 hours per year will be worth investigating. CHP in buildings is usually sized on the base heat load, thus ensuring the plant is always operating flat out and no heat is wasted (see Figure 2).

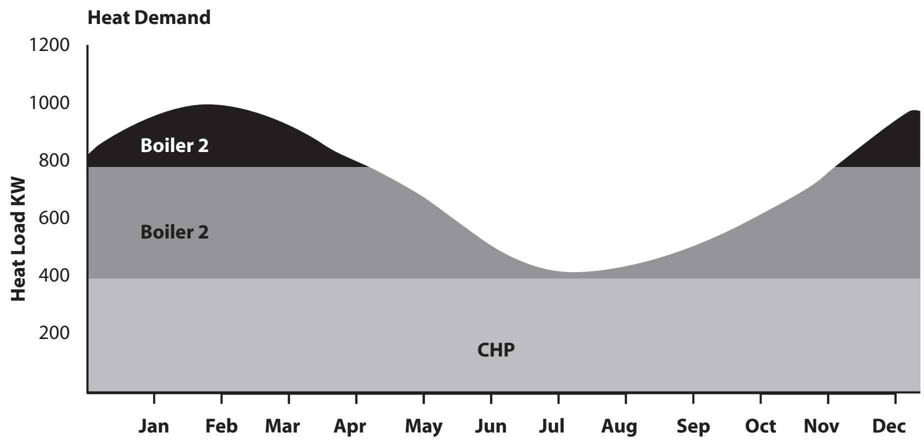


Figure 2 – CHP boiler sizing

However in reality due to available plant sizes and the relative costs of electricity and gas it may be economic to slightly oversize the plant, knowing that some heat will be wasted.

Points to consider:

- Heat and electricity profile data – Information can be gathered from existing meters or possibly from the utility supply company. If no daily profiles are available construct one by reading meters every hour during operating hours. Repeat the process several times throughout the year, especially in the summer when demand is likely to be at its lowest, to get an estimate of base loads.
- Minimise demand – It may sound perverse to try and minimise demand when the scheme depends on a good base load, but by implementing simple no-cost and low-cost energy efficiency measures will not only save money but will also help to avoid installing incorrectly sized plant. Measures that are implemented to reduce running costs may also lead to capital savings if the size of CHP unit required can be reduced.
- Future changes – consider possible future changes in demand and utility costs

Infrastructure

Even if a there is a suitable heat demand problems with the infrastructure may make CHP uneconomic. Consider:

- Fuel – is a suitable large enough fuel supply available (gas preferable), if not what would be the costs of bringing in a new supply or up rating an existing one
- Integration – Connecting to the existing heating system, setting the CHP unit as lead boiler and coordinating operation with other boilers (remember it is most likely that other boilers will still be required to meet peak demand) requires careful design.
- Electrical connections – talk to the local network operator about connection issues, it may be there

are problems that would make connection costs especially high. Also consider where the network connection will be done, excessive cabling from the CHP to the connection point can add substantially to costs.

- Plant space – is there sufficient space for the plant room
- Noise/vibration - could noise/vibration from the proposed location interfere with building occupants or neighbours, if so the plant room may have to be sited further away
- Exhaust location and emissions – careful sitting required to avoid noise and any emissions requirements

Costs

Whilst the capital and installation costs of CHP plant are significantly higher than for conventional boiler plant, CHP can yield very considerable savings in running costs. In the right applications, it can provide attractive economic returns on the additional investments. Figure 3 shows typical capital costs (installed) per electrical unit output for small-scale packaged units.

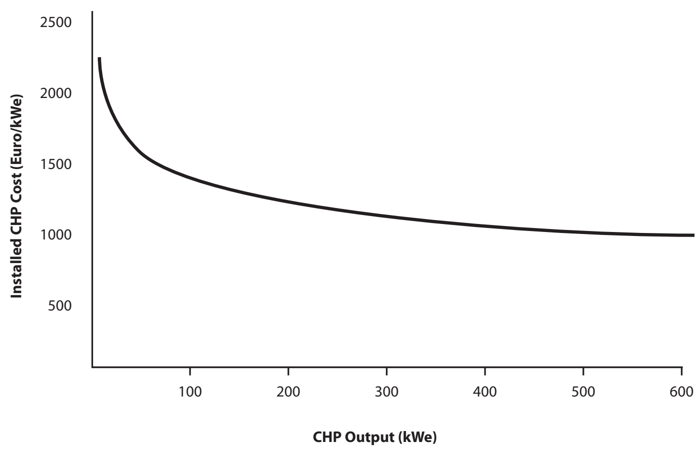


Figure 3 Typical small scale CHP installed costs

Points to consider:

- Financial options – CHP plant can be purchased outright, but there are also many attractive options including ESCO's and leasing.
- Running costs – fuel is the main running. When negotiating a contract consider price, length of contract, security of supply.
- Maintenance - It is important to plan and carry out regular maintenance on CHP installations to ensure they continue to operate correctly. Maintenance is usually contracted out to a specialist company, often the CHP supplier itself. Typically maintenance costs are between 0.9 and 1.5 c/kWhe. Ensure the maintenance contract guarantees availability of at least 90% and emergency cover in the event of a breakdown.

Financial Appraisal

There are a number of well-established techniques for carrying out a financial appraisal. Simple payback may be acceptable at an early stage of the investigation as shown in the example below, but a more rigorous technique is required for the detailed appraisal.

The following example evaluates a gas fired packaged CHP unit rated at 95 kWe and 160 kW thermal output. The unit will operate 17 hours per day and is available 90% of the year. The boiler fuel displaced is gas.

	Electrical output	$95kW_e$
	Heat output	$160\ kW_{th}$
	Fuel input	315 kW
	Unit price of electricity	7 c/kWh
	Gas cost	1.5 c/kWh
	Boiler efficiency	70%
	Maintenance costs	1.2 c/kWh
	Annual hours equivalent full load	5,585 hours
	Capital costs	€125,000
	Savings on boiler replacement	€30,000
	Total system cost	€95,000

Savings

Electricity displaced	95 kWe x 7.0c/kWh = 665 c/hr
Boiler fuel displaced	$\frac{160\ \text{kWhth}}{0.7}$ x 1.5 c/kWh = 168 c/hr
Total savings	**= 833 c/hr**

Costs

Fuel costs	315 kW x 1.5 c/kWh = 473 c/hr
Maintenance costs	95 kWe x 1.2 c/kWh = 114 c/hr
Total costs	**= 587 c/hr**

Net Benefit

Net benefit	833 - 587 = 246 c/hr
Annual hours equivalent of full load operation	= 5585 hours/year
Annual savings	5585 x $\frac{246}{100}$ = €13,739/year
Payback	$\frac{€95,00}{€13,739/\text{year}}$ = 6.9 years

Further Details

- www.ichpa.com

Appendix 5 | Reactive Units and Power Factor





Appendix 5 | Reactive Units and Power Factor

Most loads on an electrical distribution system fall into one of three categories:

Load Type	Voltage/Current	Examples
Resistive	Current in phase with voltage	Tungsten lamps Electric heating elements
Inductive	Current lags voltage	Transformers Some discharge lamps (including fluorescents) AC induction motors
Capacitive	Current leads voltage	Capacitors

All inductive loads require two kinds of power to function properly:

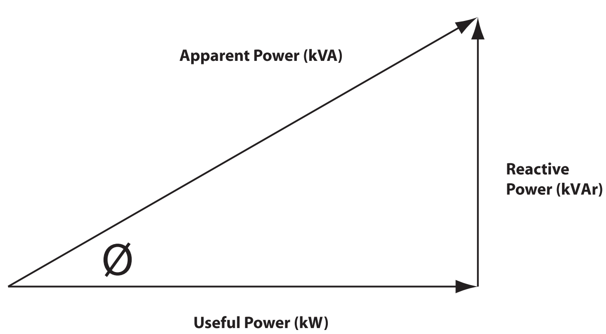
- Active power (kW) - actually performs the work
- Reactive power (kVAr) - sustains the electro-magnetic field

With an unloaded AC motor most people would expect the no-load current to drop to nearly zero. However, in reality the no-load current will generally be between 25% and 30% of full load current. This is caused by the continuous demand for current to sustain a magnetic field and is called the reactive element which is found in all inductive loads.

Inductive loads caused problems for electricity distribution systems which have to cater for both the active and reactive components. The reactive element is in effect a "wattless" part of the supply and is measured as kilovolt amps reactive (kVAr).

In both industry and commerce a large proportion of equipment has an inductive effect. This means electricity companies have to supply far more current than is theoretically required and, in turn, transformers and cables have to be larger than normal to supply the extra wattless magnetising current.

The relationship between active (useful) power and reactive power is shown in the vector diagram below.



The ratio of useful power to apparent power is defined as the power factor.

$$\text{Power Factor} = \frac{\text{Useful power (KW)}}{\text{Apparent power (kVA)}} = \text{Cos Ø}$$

For a purely resistive load the apparent power would equal the useful power and the power factor would be 1.0.

For an inductive load with reactive power the ratio may be 0.85 or lower. The higher the reactive power the lower the power factor.

Poor power factor is normally anything less than 0.95. Electricity supply companies penalise customer with low power factors and this can occur in two ways:

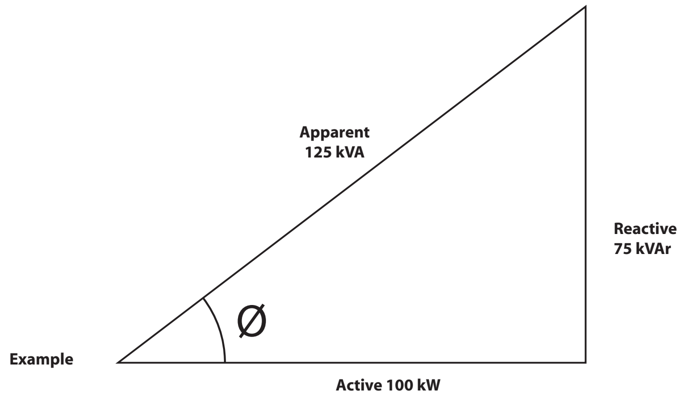
1. Maximum demand can be measured in kW or kVA. If it is measured in kVA the figure is higher than kW for inductive loads as the kVA includes the reactive element. This can also have a knock on effect of increasing the Maximum Import Capacity (MIC).

2. If Maximum Demand is measured in kW it is likely that reactive units (kVArh) are measured and charged separately. In the sample ESB invoice in Section 3.3 it can be seen that if the reactive units exceed one third of the total kWh, the excess is charged at the fixed 7.6 c per kVArh. This means any power factor below 0.95 will attract a charge. In this example the power factor is 0.87 and the resulting reactive charge is €95.61 for the month.

To avoid reactive charges it is possible to improve power factor by purchasing power factor correction equipment. These are a bank of capacitors which can be fitted at the mains switchboard to apply an overall correction. This would ideally be automatically controlled by sets of relays to ensure the capacitors 'step in' to meet the varying demand conditions.

Alternatively, if the load is predominantly made up of individual motors, individual capacitors can easily be connected to each motor. This has the effect of cancelling out the wattless current drawn from the supply. This method also means the capacitor is controlled and only works when the motor is in the circuit.

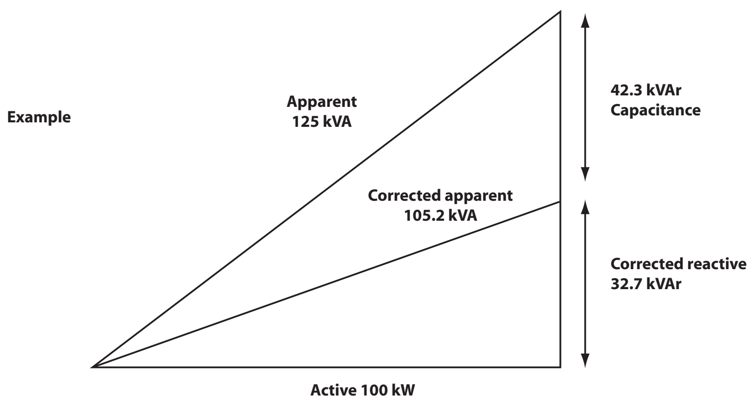
Capacitors are rated in kVAr. Higher ratings result in higher costs. If the power factor is 0.80 and is penalised below 0.95 then capacitors are only required to achieve an improved power factor of 0.95.



Example

In this example the power factor is $\frac{100}{125} = 0.8$

To improve the power factor to 0.95 capacitors of 42.3 kVAr rating would be needed and the maximum demand would reduce from 125 kVA to 105.2 kVA.







Appendix 6 | Degree Days

Introduction

To calculate degree days we start with the assumption (found by experience and widely used) that no heating is required inside a building if the outside temperature is equal to or greater than 15.5°C. Heat gains from occupants, lights, electrical equipment etc. will ensure comfort levels are maintained. This temperature, 15.5°C, is referred to as the base temperature.

If during a day the outside temperature was 14.5°C all day that would represent one degree day of heating requirement. If the temperature was 13.5°C all day, that would be two degree days of heating requirement. Finally if the outside temperature was 14.5°C for ten days, that would represent ten degree days of heating requirement. It can be seen therefore that the number of degree days over a particular time represents by how much and for how long the temperature has been below 15.5°C. Information is usually published monthly, corresponding to utility invoices. A cold month such as January may have 300 degree days, a warm one like July only 40 or 50. Figures are also totalled annually so that, for example, a location may have an annual figure of 2500 degree days.

This explanation is incomplete because in reality the outside temperature varies during the day and night often with a profile similar to a sine wave. Different formulae can be used to calculate how long the outside temperature is below the base temperature and to what extent.

Some buildings really need to employ a higher base temperature than 15.5°C, either because of poor heat retention or because of higher occupation temperatures. Buildings in the health service estate for example, are commonly assessed against a base temperature of 18.5°C because healthcare buildings are heated to higher temperatures.

Other buildings, meanwhile, call for a lower-than-usual base temperature. In this latter category are modern, densely-occupied, well-insulated buildings containing office and electronic equipment. The accepted standards for heating degree day base temperatures are:

18.5°C	for health service properties and similar applications
15.5°C	for general use (and compatibility with historical conventions)
10.0°C	for low balance point applications

Viewed in this light, figures based on 15.5°C may be of limited value. They provide no support for monitoring cooled spaces or for heated buildings with unusually high or low base temperatures. They do not meet the needs of users who wish to do weekly reports. These applications require either local measurement or subscriptions to a commercial service.

Daily measurements are made at meteorological stations and information is available, for instance, from Dublin, Cork, Belmullet and Shannon.

Figures 6.1 and 6.2 below show Dublin degree days for 2004 and annual totals for the four aforementioned stations.

Month	Degree Days
Jan 04	312
Feb 04	289
Mar 04	271
Apr 04	197
May 04	150
Jun 04	61
Jul 04	60
Aug 04	35
Sep 04	61
Oct 04	184
Nov 04	219
Dec 04	282

Figure 6.1 Monthly heating degree days for 2004 measured at Dublin

Year	2001	2002	2003	2004
Belmullet	1935	1827	1749	1766
Cork	1992	1951	2004	2022
Dublin	2134	2059	2113	2121
Shannon	1816	1682	1656	1793

Figure 6.2 Annual degree day totals for 2001 to 2004

Degree day data is available from the Irish Meteorological Office (www. metoffice.com)

Cooling Degree Days

Cooling degree days are used to determine cooling requirement and are calculated in a similar way as heating degree days. The accepted standard for cooling degree day base temperatures is:

15.5°C	for peak season comfort cooling
5.0°C	for year-round air conditioning
20.0°C	for outdoor cold stores

Data Collection (Ground Based Stations)

Location	County
Malin Head	Derry
Finner	Donegal
Belmullet	Mayo
Clones	Monaghan
Knock Airport	Mayo
Claremorris	Mayo
Dublin Airport	Dublin
Mullingar	Westmeath
Casement	Kildare
Birr	Offally
Shannon Airport	Limerick
Kilkenny	Kilkenny
Rosslare	Wexford
Valentia	Kerry
Cork Airport	Cork
Roches Point	Cork

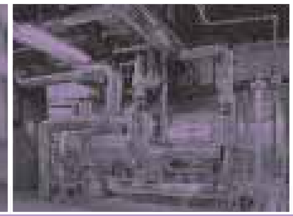
Figure 6.3 Degree Day collection points

Further Details

- www.met.ie

Appendix 7 | Summary of High, Low and No Cost Measures




Appendix 7 | Summary of High, Low and No Cost Measures

Building Fabric

No Cost
- Check for effective window and door closing
- Use daylight where possible
- Consider energy efficiency in the design of new build and refurbishment projects

Low Cost
- Draught proofing
- Use of door closers
- Fit reflective films to windows to reduce solar gain
- Use daylight blinds to restrict direct sunlight

High Cost
- Cavity wall insulation
- Any building fabric improvement
- Loft Insulation
- Installation of double/triple glazing
- Installation of door lobbies

Heating/Hot Water/Controls

No Cost
- Check that existing controls are correctly set and working properly, ie:
  - Time including optimum start controllers
  - Temperature including weather compensation and radiator valves
  - Zones
  - Building Management System (BMS)
  - Boiler sequencing controls
  - Black-bulb thermostats for radiant heating
- Check that internal and external sensors are situated correctly and not obscured or damaged
- Check that boilers are not cycling rapidly at low loads
- Isolate redundant boilers
- Regularly check combustion efficiency and flue gas temperatures

Low Cost
- Insulate bare pipes and valves etc
- Use small local electric water heaters at points remote from central boilers
- Install timers on hot water heaters

High Cost
- Consider more novel heating systems at the design/plant replacement stage (CHP, heat pumps, condensing boilers etc)
- Add more controls to space heating system
- Install solar heating for hot water provision
- Oxygen trim control
- Use of burners incorporating variable speed drive air fans

Ventilation and Air Conditioning

No Cost
- Maximize natural ventilation
- Reduce heat gains from electrical appliances etc
- Ensure that heating and cooling are not operating together
- Remove internal barriers to free air movement
- Check that existing controls are correctly set and working properly (as with heating) and set temperatures as high as possible
- If a recirculation damper is fitted ensure that it is being used correctly
- Clean and check filters at recommended intervals

Low Cost
- Use colder night air to cool the building
- Install timer controls on chilling units

High Cost
- Incorporate natural cooling strategies in building design
- Install speed control on air fans
- Consider the use of alternative cooling plant such as absorption chilling and ground water cooling

Motive Power, Pumps and Fans

No Cost
- Size motors correctly and avoid oversizing
- Develop a motor management policy with respect to rewinding
- Re-configure lightly loaded three-phase motors to star wiring

Low Cost
- On motor failure, replace with high-efficiency motors
- Install simple on/off controls to relate motor use to requirements

- Adjust pulley size on lightly loaded installations to reduce fan speeds
- Possible use of motor controllers on lightly loaded motors but check references

High Cost
- Replace existing motors with high-efficiency alternatives
- Use variable speed drives (or multi-speed motors) wherever appropriate to replace damper fan control and throttling valve pump control

Lighting/Controls

No Cost
- Make the most of available switching
- Mark switches if remote from lights
- Ensure that the lights are lighting the correct subject and light is not delivered to where it is not needed
- Ensure that light fittings chosen have a high light-output-ration (LOR)
- Limit the use of display and feature lighting to the minimum

Low Cost
- Replace any tungsten filament lamps with energy efficient alternatives
- Choose lamps with a longer life as this will reduce maintenance (replacement) costs
- Use the slimmer T8 and T5 fluorescent tubes where possible
- Install time controls and occupancy controls
- Use photocells to control external lighting
- Clean fluorescent lighting to maintain light output

High Cost
- Install high frequency control gear to fluorescent lighting
- Install induction lighting in inaccessible places
- Use daylight-linked lighting controls where natural light is present

Office Equipment

No Cost
- Educate office users and instigate a "turn it off" policy regarding electrical equipment to save energy and reduce heat gains
- Enable energy saving software on computers
- Discourage the use of screen savers to "save energy"
- Don't leave equipment on standby

Low Cost
- Install timers on vending machines and other suitable equipment
- Instigate a purchasing policy to encourage the uptake of energy efficient appliances

High Cost
- Purchase equipment that uses less energy and/or has energy saving features
- Purchase flat-screen PC displays

Catering

No Cost
- Discourage the use of catering equipment for space heating
- Do not turn equipment on until it is needed, and turn it off directly after it has been used
- Always use lids
- Do not cook too soon – keeping food warm uses energy
- 'Domestic' requirements, for example provision of food for the catering staff, should be met by use of appropriate 'domestic' cooking equipment. For example, use a toaster rather than the salamander grill, or an electric kettle rather than the water boiler
- A microwave oven is ideal for heating or reheating small portions
- Do not use dishwashers on part load - run them only when full
- Check that the correct refrigeration temperatures are being maintained. Set points may need adjusting for summer/winter
- Keep refrigerators and freezers as full as possible
- Minimize the frequency of opening refrigerators and freezers, and ensure that doors are properly closed, not left wedged open
- Turn on extraction only when required

High Cost
- Consider two speed or variable speed drives on extract fan motors of larger

Notes

Notes

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