Introduction to Energy Efficiency in Offices

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1

INTRODUCTION

1.1 Who this guide is intended for

This guide is aimed at office managers, facilities managers and others who have responsibility for energy use in office buildings. It should also be of interest to energy managers in larger organisations.

It is intended to introduce the steps that anyone responsible for energy needs to take in order to control and reduce energy consumption in office buildings. It shows how to gain an understanding of how energy is used in offices and indicates the methods by which savings are likely to be made.

1.2 Use of the guide

This guide is one of a series for different types of building. A full list of titles is given in section 9.4; make sure that you have the guide most suited to your needs.

If you are unfamiliar with energy management, you should start with section 2, Energy Management, in order to get an overview of the subject.

- The subsequent sections concern creating and following an action plan (section 3) and implementing measures to achieve energy savings (section 4). Sections 5 to 7 describe methods for assessing energy use in offices.
- The case studies (section 8) give examples of office buildings where energy saving measures have been successfully implemented.
- Section 9 lists further sources of help and information, including addresses for obtaining copies of the information referred to throughout the guide.

More experienced energy managers or consultants may use the action plan (section 3), or the suggested measures (section 4) as aide-memoires. They may also use the method for calculating performance indices described in section 6 and appendix 1.

A manager responsible for energy on a number of different sites may wish to distribute the guide to the person responsible for energy management at each site.

1.3 Environmental benefits of energy efficiency

Most of the energy used today originates from fossil fuels (gas, oil and coal). Burning fossil fuels emits pollutants, including gases that cause acid rain, and carbon dioxide. As carbon dioxide and other gases build up in the atmosphere, more of the sun's heat is trapped (the greenhouse effect). This could result in the earth becoming hotter (global warming), which may also increase the risk of storms, coastal flooding and drought. Using energy more efficiently is one of the most cost effective means of reducing emissions of carbon dioxide and also helps to conserve finite reserves of fossil fuels.

1.4 Financial benefits of energy efficiency

Energy is the largest controllable outgoing in running office buildings, and averages 22% of total service costs. Using simple and cost effective measures, fuel bills can often be reduced by an average of about 20%. Further savings are possible in new construction and when buildings are refurbished or their services replaced.

Well designed and efficiently managed services not only result in energy savings, but also in an improved and more comfortable working environment. This can give rise to better productivity and reduced absence due to sickness.

Efficiently run buildings also require less manpower to service complaints, providing savings additional to the reduced costs of energy.

1.5 Acknowledgements

This guide was prepared for the Energy Efficiency Office (EEO) by Target Energy Services Ltd. The EEO gratefully acknowledges the assistance given by the following organisations in providing information:

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ENERGY MANAGEMENT

2.1 Energy efficiency - a management issue

The aim of energy management is to ensure that energy use and energy costs are as low as possible while standards of comfort, service and productivity are maintained or improved. This requires somebody to be directly responsible for energy efficiency, even if this is only a part of their job:

- As a rule of thumb, organisations or sites with an energy bill over £1 million may justify the employment of a full time energy manager. Otherwise, energy management will normally be combined with other responsibilities.
- Each building should have someone responsible for energy management.
- In larger organisations, energy efficiency should also be managed centrally.
- Energy efficiency must be strongly supported at the highest levels with the authority and resources needed for initiatives to be effective.

Encourage your management board to sign up to the EEO's Making a Corporate Commitment campaign if it has not already done so (see section 9.5).

The duties and functions of an energy manager are discussed here. Section 3 includes a suggested action plan which can be used to get things moving.

2.2 Actions and measures to save energy

One of your main activities should be to identify areas of energy waste and implement energy saving measures to reduce them. Some waste is simple to diagnose and to correct, for example lighting left on all night in unoccupied areas. Other waste may be more difficult to identify and take more expertise or resources to correct (see section 4).

2.3 Controlling energy use

To control energy consumption and costs, regular and reliable records of energy use should be maintained. Such records will help to identify changes in energy costs and consumption. This is commonly called monitoring and targeting or M&T. The simplest arrangement is a form which can be filled in regularly for each fuel, recording monthly energy use. Alternatively, systems can be based on a computer spreadsheet, or commercially available systems can be purchased. Computer based systems are essential for effective monitoring of a large estate or site.

An M&T system should:

- Record energy consumption and any other factors that affect energy use (building usage, weather, productivity, etc).
- Compare your energy use to previous years, to other offices, or to yardsticks representing typical or target energy performance.
- Alert you to sudden changes in energy use patterns as soon as possible, so that any increase can be investigated and corrected if appropriate.
- Produce regular summary reports, especially if there are many sites, to confirm performance and show savings achieved overall.

If fuel bills are not available or some are missing, then duplicates can usually be obtained on request from the relevant fuel supply company. Meters should be checked every few months to ensure that billed readings are correct. In shared or multi - meter sites ensure you are being billed for your use; label your meters.

For further information see:

EEO Practical Energy Saving Guide For Smaller Businesses.

Example recording of monthly electricity use

Period: *JAN-DEC 92* Completed by: *NJK* Date: *10.2.93*

Meter Reading Date	kWh Used	Cost £
8.1.92	*39,700*	*2756.29*
5.2.92	*38,700*	*2653.65*
5.3.92	*31,500*	*2200.35*
9.4.92	*25,000*	*1584.02*

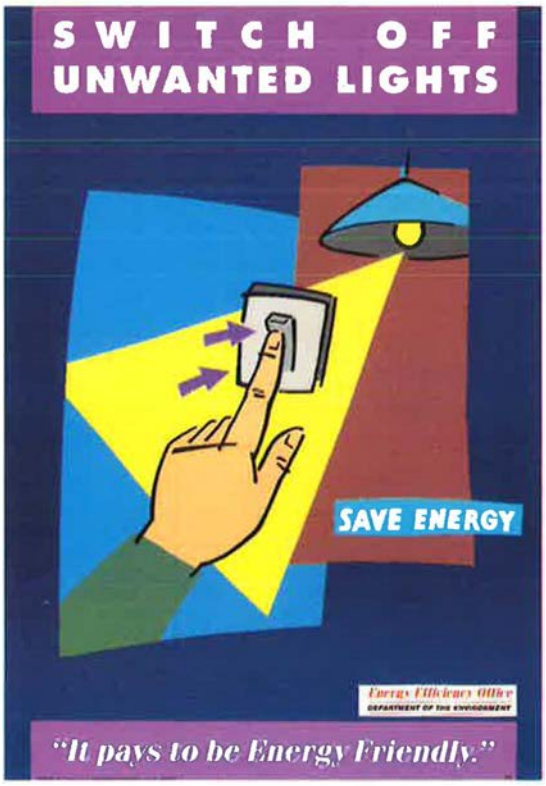
2.4 Getting on the right tariffs

Making sure that fossil fuels and electricity are purchased at the cheapest rates is increasingly important. Considerable cost savings are sometimes possible by changing to more suitable tariffs for electricity, or by making alternative supply arrangements.

Tariff savings usually incur little or no initial cost and may be used to help finance measures to reduce energy costs further. Reviewing tariffs should therefore be one of your first actions:

- Seek alternative electricity tariffs from your existing supplier.
- Consider using other electricity suppliers in the contract market when the supply is for more than 100 kW (representing a bill of around £30,000 a year).
- Consider a different supplier for oil, or for gas supplies over 70,000 kWh a year (representing a bill of around £1,000 a year).
- For large sites with complicated tariffs and load patterns, it may be worth employing a tariff consultant, although be aware of consultants' costs (contact the Energy Systems Trade Association (ESTA) or the Major Energy Users' Council, see section 9.9).

Energy Efficiency Poster



For further information see:

Fuel Efficiency Booklet 9 - Economic use of electricity in buildings.

2.5 Motivating occupants and staff

The greatest possible savings can only be achieved with the cooperation of staff. Foster their support and give them every chance to participate in energy saving initiatives. Feed back information to staff on the results of these initiatives.

Activities could include:

- Providing information about why energy conservation is important, describing practical and environmental benefits
- Setting up an incentive scheme
- Stressing that most energy is used by all occupants - for lighting, equipment and for maintaining comfortable conditions
- Encouraging staff to switch off equipment and lighting when it is not needed, by providing information and training on how to operate systems and controls, through stickers, posters and articles in staff magazines
- Relating energy use at work to energy use at home.

You should monitor the savings achieved and publicise them to help motivate staff and senior management. Obtaining capital investment for future energy efficiency measures may depend on demonstrating the cost effectiveness and the environmental benefits of measures that have already been completed.

For further information see:

EEO Good Practice Guide 84 - Managing and motivating staff to save energy.

2.6 Energy management in larger organisations

In larger organisations with estates of buildings, an energy manager may be responsible for many separate locations. He or she will have a different role from a site energy manager which is not addressed in detail here.

For further information see:

EEO General Information Report 12 - Organisational aspects of energy management

EEO General Information Report 13 - Reviewing energy management

Making a Corporate Commitment - various guides.

2.7 Responsibilities in larger offices

In larger office buildings, a number of groups should be involved in energy management:

- Senior management
- Local or departmental management
- Facilities management
- Plant operators
- Security staff
- Landlord's representatives (if appropriate)
- Maintenance contractors.

You should have regular contact with all of the above and with the individual building occupants. A facilities manager often makes a good energy manager because they already have close contact with staff. You should find out about factors relating to occupants' comfort, including:

- How plant and equipment controls are set and who is responsible for their adjustment
- How comments from occupants are acted on - especially those reflecting dissatisfaction.

2.8 Tenanted office buildings

For offices where the landlord provides central services such as heating and security, energy management can be complicated by conflicting interests:

- The tenants' view may be that the landlord is committed to provide conditioned office space all year round so the air-conditioning plant should be on all the time
- Savings on the use of central plant from the efforts of one tenant will be divided amongst all the tenants, and so reduce the incentive to save
- The landlord's view may be that tenants complain at any reduction in plant operation so it is not worth the trouble.

Here you need to ensure that everybody realises they have something to gain from effective energy management - the tenants want cheaper service charges (without reduction in comfort) and the landlord wants satisfied tenants with lower service charges to help future letting (see section 5.3).

2.9 New and refurbished property

Energy efficiency measures are most cost effective when installed in new or refurbished buildings, or while replacing equipment which is at the end of its normal life. New items of of equipment which are required anyway should be as efficient as possible. Additional items to improve energy efficiency can be installed most cheaply during other building work. These special opportunities to incorporate energy efficient design are relatively rare and should not be missed.

You should be involved in decisions about new or refurbished property and should not just be brought in to correct high energy use following decisions made by others. Your knowledge of how the building is used should be drawn on when specifying appropriate levels of services and controls.

When moving or refurbishing office premises, take the opportunity to select or specify:

- Energy targets
- The type of office accommodation - for example the inclusion of full or partial air conditioning may double overall energy costs
- Systems which are suitably simple and within the capabilities of the occupants to manage
- High efficiency of major plant and equipment such as boilers or main lighting systems
- Good levels of insulation
- Appropriate controls for the anticipated pattern of use
- Suitable metering and monitoring facilities
- Information, advice and training for staff in the use of new systems.

For further information see:

EEO Good Practice Guide 34 - Energy efficient options for new offices - for the design team.

EEO Good Practice Guide 35 - Energy efficient options for refurbished offices - for the design team.

EEO Good Practice Guide 71 - Selecting air conditioning systems.

2.10 Getting help

Sources of further information are described and listed in section 9.

To obtain further information about possible energy saving measures (see section 4), contact relevant manufacturers, installers or service providers who will advise you of the features of their products. Make sure that these features are relevant and appropriate to your requirements.

Refurbishment offers a rare opportunity to incorporate many energy efficiency measures.

Gas and electricity suppliers can also offer advice.

If time is not available or if discussions with a selection of competing suppliers do not provide a consistent picture, it may be worth hiring a professional consultant to provide advice or to conduct an energy survey. For organisations with less than 500 employees the EEO's Energy Management Assistance Scheme (EMAS) may offer financial help towards energy consultants' fees (see section 9.5).

If the availability of finance and management time is a problem for opportunities requiring substantial investment, contract energy management (CEM) organisations may provide a solution - they offer a comprehensive service including finance and management responsibility. ESTA can provide a list of companies (see section 9.9).

For further information see:

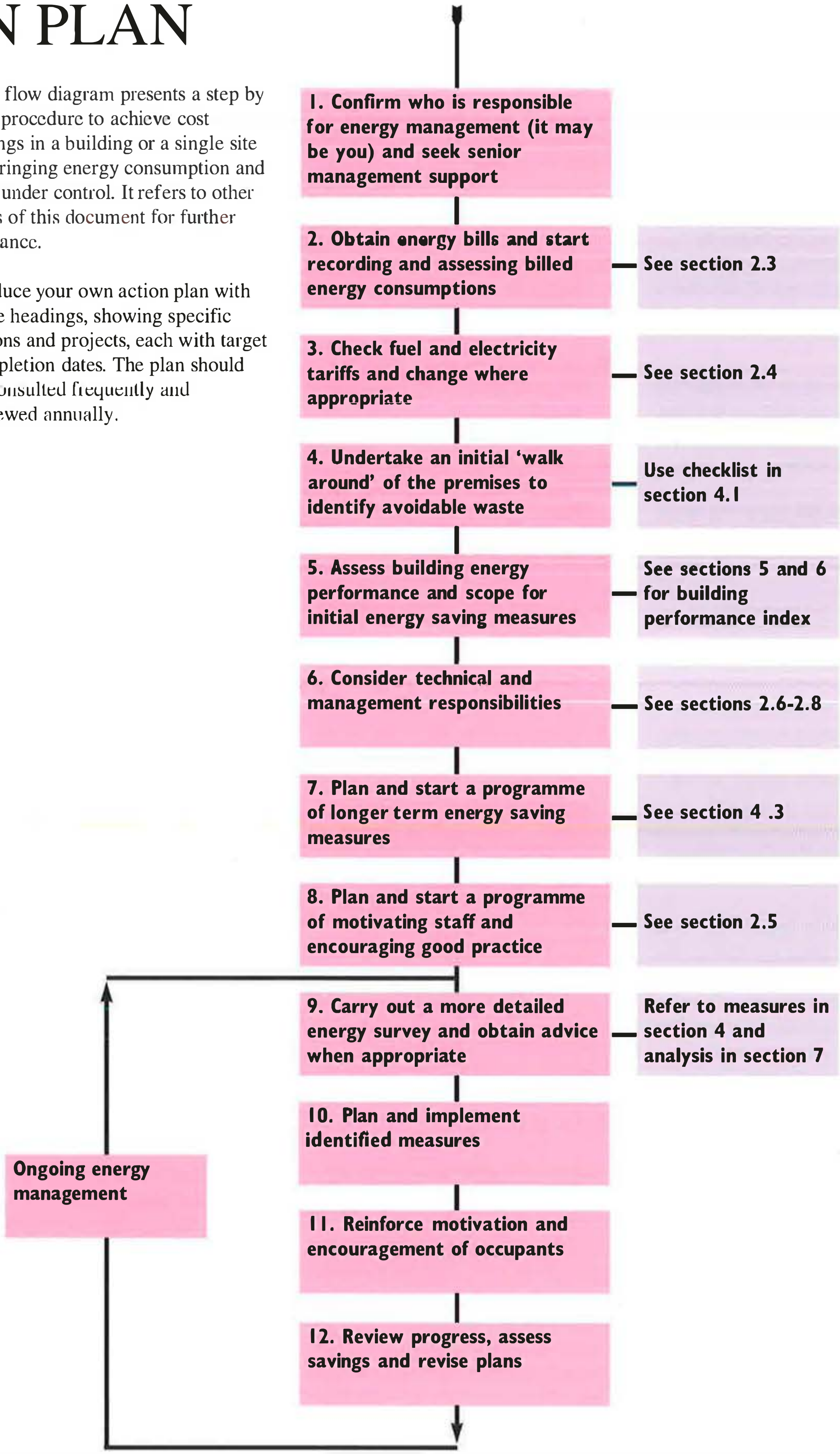
Choosing an Energy Efficiency Consultant (EEO).

3

ACTION PLAN

This flow diagram presents a step by step procedure to achieve cost savings in a building or a single site by bringing energy consumption and cost under control. It refers to other parts of this document for further guidance.

Produce your own action plan with these headings, showing specific actions and projects, each with target completion dates. The plan should be consulted frequently and reviewed annually.



MEASURES TO ACHIEVE ENERGY SAVINGS

4.1 Initial measures

In most offices it is possible to make some savings by using the existing building and equipment as efficiently as possible. No financial investment is needed; instead, a check on how the building is being used may reveal areas where equipment can be turned off when it is not needed, or where the level of service can be reduced without affecting the comfort of staff.

Some opportunities may be easy to identify and implement, such as altering thermostats or timeclocks. Others, such as turning lights off when rooms are not being used, may require the cooperation of staff. Motivating staff to help is therefore important, although a long term task. The list below indicates the type of items to check in an initial assessment of 'good housekeeping' opportunities. An exercise to review energy purchasing tariffs (see section 2.4) should be carried out at the same time.

Checklist of Initial Energy Saving Measures

Space and water heating

- Consider fuel switching (if your boiler can operate using more than one fuel).
- Check that time switches are set to the minimum period and ensure that room thermostats and radiator controls are on minimum settings commensurate with comfort conditions.
- Ensure that only occupied areas are heated, and that heating is off or reduced in non-working hours.
- If you have a building energy management system (BEMS), check that it is operating correctly and ensure that operators are trained to use it effectively.
- Reduce temperature of stored domestic hot water by turning down the thermostat to a minimum of 60°C, but no lower because of the risk of Legionella.
- Make sure that pumps are running only when required.

Lighting

- Ensure that someone is responsible for switching off in each room or area when not in use.
- Make the best use of daylight by keeping windows and roof lights clean and by using working areas near windows where possible; encourage staff to turn off lights when daylight is good.
- Investigate existing lighting controls to see if the hours of use of artificial lighting can be reduced.
- Install 'task' lighting where this means that background artificial lighting levels or hours of use can be reduced.
- Avoid excessive lighting levels and hours of use in corridors. Where fluorescent lighting is used, it may be possible to reduce the number of tubes in luminaires.

Ventilation

- Ensure the main ventilation plant and toilet extractor fans are switched off outside occupancy hours.
- Check that windows are not being opened to avoid overheating during winter.
- Ensure kitchen fans are switched off when no cooking is taking place.

Air conditioning

- Set temperature controls for cooling to 24°C or higher - lower settings require more cooling energy and may be 'fighting' the heating.
- Where the design permits, ensure heating and cooling are not on at the same time in the same part of the building (the advice of a consultant or on site services engineer may be needed).
- Make sure that refrigeration plant such as chilled water systems do not run unnecessarily.
- Ensure that fans and pumps do not run when not required.

Office equipment

- Encourage staff to turn off office equipment when it is not being used, particularly at lunchtime and at the end of the working day.

Controls

- Ensure all controls are labelled to indicate their function and, if appropriate, their new reduced settings.
- Establish responsibilities for control setting, reveiw and adjustment.

Building fabric

- Ensure all insulation is in a state of good repair.

4.2 Maintenance

Regular maintenance is a prerequisite to controlling energy costs and is also essential for maintaining a healthy environment in buildings. A maintenance programme should include:

- Replace filters at the manufacturer's recommended intervals and keep heat exchanger surfaces, grilles and vents clean in order to allow unobstructed flow of air
- Check plant operation and controls regularly
- Ensure that all motorised valves and dampers fully open and close without sticking
- Check that thermostats and humidistats are accurate
- Check calibration of controls
- Service the boiler plant and check combustion efficiency regularly
- Look for water leaks and carry out repairs where necessary
- Clean windows to maximise daylighting
- Replace 38mm diameter fluorescent tubes in switch start fittings with 26mm diameter high efficiency triphosphor tubes as the former expire (see diagram on page 10)
- Clean lamps and luminaires regularly and replace at the manufacturer's recommended intervals.

4.3 Longer term measures

There will almost certainly be items of equipment or insulation which could be replaced with more efficient alternatives. The main areas for savings, starting with the most cost effective, are:

- Control systems
- Lighting and office equipment
- Heating and air conditioning plant
- Building fabric.

Care is required in deciding which measures to implement and the most effective way of carrying them through. In the first instance, measures should be undertaken which have as many of the following features as possible:

- Worthwhile energy and cost savings
- Low capital cost
- Short period to repay initial cost
- Little technical knowledge required
- Little or no extra maintenance
- Little or no disruption to normal operations.

Further information is given in references listed in section 9 - note particularly:

EEO Fuel Efficiency Booklets:
1 Energy audits for buildings
8 The economic thickness of insulation for hot pipes
10 Controls
12 Lighting

EEO Good Practice Guides:
35 Energy efficient options for refurbished offices
46 Heating and hot water systems in offices

Energy Efficient Lighting in Offices. A THERMIE Maxibrochure.

Assessing costs of measures

The cost effectiveness of an energy efficiency investment can be expressed as the initial cost divided by the monthly or annual cost savings - the simple payback period.

More sophisticated appraisal techniques for comparing different investments, such as 'discounted cash flow' methods, are sometimes used in larger organisations and for major investments. If these are needed, advice should be sought from those who use these methods.

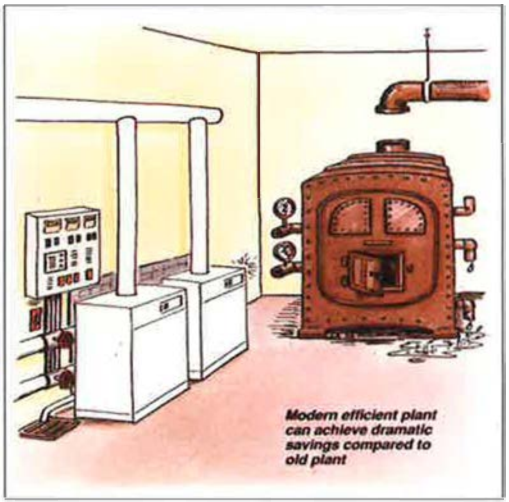
If energy-saving initiatives are taken during refurbishment or when moving office, capital cost is often substantially reduced and interference with normal working practices is kept to a minimum.

For measures included during replacement or refurbishment, the initial cost (for calculating the payback period) is only the over-cost: for example, the extra cost of a high efficiency 'condensing' boiler compared with a conventional boiler. This reduces payback periods and increases cost-effectiveness.

In some cases, energy efficiency measures can reduce overall capital costs, such as providing natural ventilation which avoids the need for air conditioning.

Where shortage of funds and/or lack of expertise is holding up promising measures, it may be worth considering contract energy management as described in section 2.10.

Measures can be split into those which require limited attention such as insulation, and those which require management time to ensure that they continue to be effective, such as building energy management systems. For the latter, manageability is as important as the potential for energy savings, and should be a prime consideration in the design.



Modern efficient plant can achieve dramatic savings compared to old plant

LIGHTING

Lighting is usually the largest or second largest energy cost in an office, and good savings can be achieved by ensuring that lighting equipment and its controls and management are of a high standard.

The energy used for lighting depends upon the energy consumption of the lamps and the hours of use. The most efficient systems are well designed, and have efficient lamps and fittings which provide the required level of illuminance (without over-lighting). They have controls which enable the lights to be switched off when they are not required, whether because a space is not being used or because there is sufficient daylight.

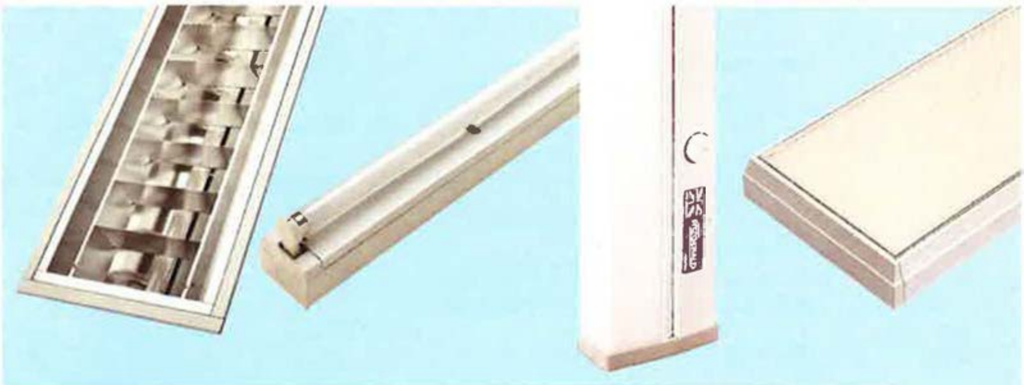
All new lighting in offices must comply with the Health and Safety (Display Screen Equipment) Regulations 1992 which implement the 1990 European Directive 90/270/EEC. Lighting for existing workstations must comply by 31 December 1996. Wherever lighting is upgraded, it offers an opportunity to select the most energy efficient options.

Some types of lamps, in order of increasing efficiency, are:

- 'Domestic' tungsten bulbs - very inefficient; should usually be replaced
- Tungsten spotlights - used for display lighting; even the most efficient lamps are much less efficient than fluorescent lamps
- Compact fluorescent lamps - efficient replacements for tungsten bulbs, although not as efficient as modern tubular fluorescent lamps
- Fluorescent tubes - used in most office areas
- Metal halide and sodium discharge lamps - these vary in efficiency depending on type (most are more efficient than fluorescent tubes). Sometimes used in uplighters; well suited to lighting large areas such as car parks.

Tungsten bulbs typically have a life of about 1,000 hours, while fluorescent and discharge lamps typically last for 8,000 hours or more. Removing tungsten bulbs therefore gives substantial savings in maintenance costs in addition to any energy savings.

Typical levels of energy consumption of different types of lamp, expressed as a percentage relative to tungsten lamps, are given in figure 4.1.



Luminaires, left to right: recessed mirrored reflector with louvres, batten fittings, opal, and prismatic diffusers.

Photographs supplied by Philips and Fitzgerald.

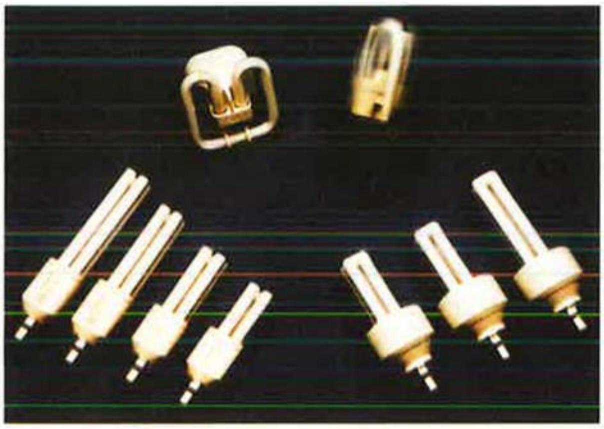
Figure 4.1 Typical relative energy consumption

lamp type	typical energy consumption relative to tungsten bulbs for similar levels of lighting (%)
tungsten filament bulb	100
tungsten halogen spotlight	70
compact fluorescent with electronic ballast	18
metal halide (MBI)	15
high pressure sodium	11
Fluorescent tubes:	
(1) choke & starter control gear with 38mm diameter tubes	18
(2) as 1), but 26mm diameter high efficiency triphosphor tubes	16.5
(3) as 2), but with electronic ballast	13

These figures give an indication of the typical savings which may be made by replacing lamps with more efficient alternatives. For example, replacing an old inefficient tubular fluorescent system (1) with a modern efficient system (3) would reduce energy consumption by a factor of 13/18, a reduction of about 30%.

As well as lamps, light fittings (luminaires) contain a number of other elements, including:

- Diffusers or louvres - these are designed to give a good distribution of light without glare. Luminaires with prismatic and especially opal diffusers are less efficient than those with reflectors.
- Control gear - fluorescent and other discharge lamps need control gear to strike up and maintain light output. Old



Compact fluorescent lamps

fluorescent luminaires have chokes and starters; modern electronic controls (ballasts) are more efficient.

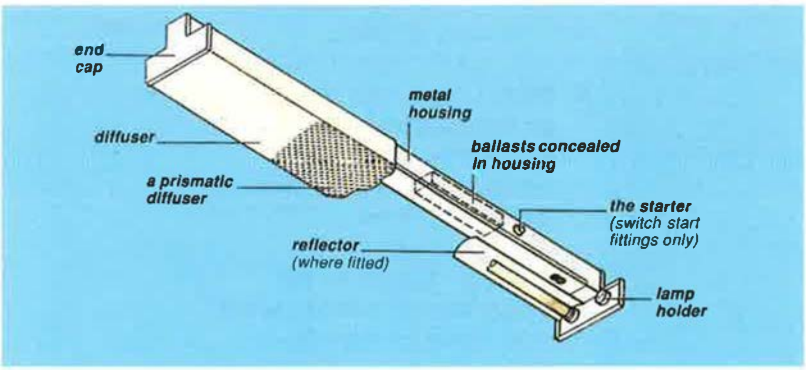
Lighting controls should be used to ensure that, as far as possible, lights are off when they are not needed. It is important that staff should have control over their levels of lighting. If automatic controls are used to turn lights on or off, staff should be able to over-ride them using manual switches. Automatic controls are most effective in open plan areas and corridors, where lights tend to be left on all day if there is no automatic switching off.

Lighting controls include:

- Time controls - allow any group of lights to be switched on or off automatically at set times of the day
- Presence detectors - automatically switch lights on when somebody enters a space, and off again after the space is vacated
- Daylight detectors - allow groups of lights to be switched off or on according to the level of daylight. Some lights can also be dimmed as daylight levels alter.

LIGHTING MEASURES

- Replace tungsten lamps with compact fluorescent lamps or, better, with tubular fluorescent lamps.
- Replace tungsten spotlights with low voltage tungsten halogen lamps.
- Replace existing control gear in fluorescent fittings with electronic, high frequency ballasts.
- Replace diffusers in tubular fluorescent fittings with reflectors and reduce the number of tubes if possible.
- If light fittings are over 15 years old, replace with new efficient fittings and consider installing new lighting controls.
- Use metal halide or sodium discharge lamps for outside areas such as car parks.
- Improve lighting controls, including:
  - local manual switching, such as pull cords on lights, so that all staff have control over their local lighting, particularly in open plan offices
  - time controls for office areas which, for example, switch off at lunch time and the end of the day (ensure they are switched off in stages)
  - time controls or daylight detection controls for external lighting
  - presence detection controls for corridors and stairs (excluding emergency lighting) and for areas which are infrequently used, such as stores
  - daylight detection controls for lighting in offices adjacent to windows.



The parts of a fluorescent light fitting

MECHANICAL VENTILATION AND AIR CONDITIONING

Mechanical ventilation provides air which is filtered and heated. Air conditioning additionally provides cooling and humidity control.

Pumps and fans consume a considerable amount of energy, in air conditioned buildings they typically consume at least half, and often more, of the total energy used for air conditioning.

Cooling is usually provided by an electrically driven refrigeration plant. Cooling systems should be controlled and insulated in the same way as heating systems. The savings will be proportionally higher as cooling is considerably more expensive to produce than heat.

MECHANICAL VENTILATION AND AIR CONDITIONING MEASURES

- Install variable speed controls on fans and pumps; these allow motor speeds to be controlled according to the demand instead of running at full power continuously.
- Set the temperature required for cooling as high as possible (24°C or higher) to reduce the demand for refrigeration.
- Ensure that controls are set or improved to avoid both heating and cooling air at the same time.
- Ensure that air conditioning systems make use of outside air for 'free cooling' whenever possible.
- When heating or mechanical cooling is required, ensure that the proportion of air recirculated within the building is as high as possible within the requirements for minimum fresh air rates.
- If humidifiers are being specified or replaced use ultrasonic humidification (but ensure that precautions are taken to avoid Legionella).
- Explore the opportunities for heat recovery from any source of warm exhaust air but bear in mind the increase in pump and fan power that will be required.

HEATING SYSTEM

The cost of providing heat for space heating or hot water depends on the cost of the fuel used, the efficiency of conversion of fuel to heat, and the extent of the distribution losses in supplying the heat when and where it is needed.

Fossil fuels such as gas, oil or coal are usually burnt in a boiler and the heat is transferred to a heating system. Boilers have varying seasonal efficiencies - old boilers may convert less than 50% of the energy content of the fuel into heat in the heating system, while the most efficient gas condensing boilers may achieve seasonal efficiencies of over 90%. Condensing boilers can be used with most existing heating systems and ought to be considered whenever boilers are replaced.

Heat is lost from the heating system through ductwork, pipework, valves and hot water storage tanks. Pipe runs should therefore be short, and all parts of the system well insulated. Heat should only be supplied to a space or to produce hot water where and when it is needed. Where possible, large boilers should not be operated to meet small loads, as the efficiency will be very low.

Effective heating controls are essential. Types of control include:

- Simple 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: switches the heating on so that the building reaches the desired temperature just in time for occupation
- Weather compensation: varies the heating according to the outside temperature
- Room thermostat: keeps the temperature in a room to a required level
- Thermostatic radiator valves (TRVs): regulate the flow of hot water through the radiators in a room in order to maintain a local temperature
- Boiler sequence control: enables only the number of boilers required to meet the system demand.

The 1990 Building Regulations specify that new non-domestic buildings should have time controls and weather compensation, room thermostats or TRVs, and that large buildings should also have optimum start control.

HEATING MEASURES

- Fit TRVs in rooms which are prone to over-heating, due to solar gain, for example.
- Upgrade heating controls to include a seven day programmable timer, optimum start control and weather compensation as a minimum.
- Where small volumes of domestic hot water are required a long way from the main heating plant, consider installing local instantaneous water heaters.
- Install spray taps where possible.
- Insulate hot water tanks and boilers, and all pipework, valves and flanges which do not provide useful heat to occupied spaces.
- Replace an old boiler installation with one that provides a minimum seasonal efficiency of at least 80%, preferably including at least one condensing boiler. Specify multiple boilers with a sequence controller rather than one large boiler in installations over 100kW, 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.
- Separate the heating system into zones so that areas of the building with different heating requirements can be controlled separately.

BUILDING FABRIC

Simple roof insulation and draught proofing are usually cost effective at any time, but most other building fabric measures are most cost effective when they form part of general maintenance or refurbishment.

Caution: Insulation measures should be checked for condensation and water penetration risks. Double glazing may reduce air infiltration rates to a level where additional ventilation becomes necessary.

BUILDING FABRIC MEASURES

- Insulate roof voids.
- Draught proof around windows and doors.
- Fit secondary glazing.
- Install cavity wall insulation or internal or external insulation.
- Reduce excessive glazing areas by replacing the glass with insulated wall panels.
- If windows are being replaced, fit multiple glazing, preferably with low emissivity glass which reduces heat loss in winter.

Building Energy Management Systems (BEMS)

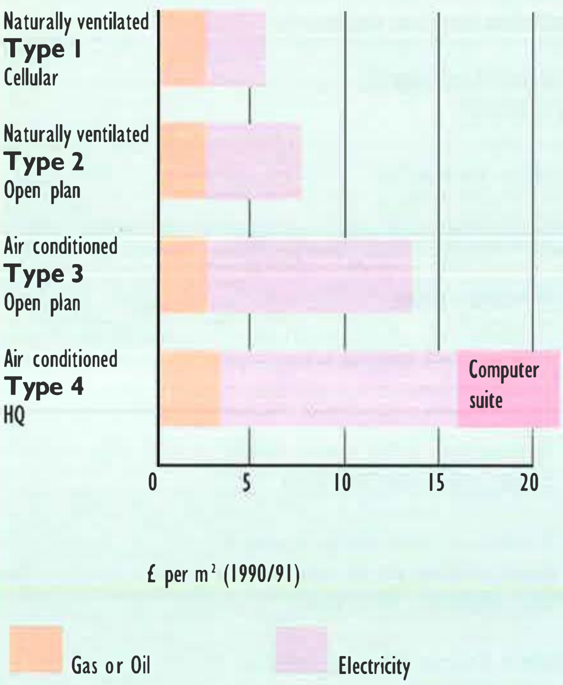
BEMS are computer-based systems which automatically monitor and control a range of building services such as heating, air conditioning, ventilation and sometimes lighting. They may also provide data on energy performance to enable energy savings to be targeted. They are most cost-effective in large buildings with complex building services.

Caution: A BEMS should be considered as an aid to management and not a substitute for it, and it is important that someone manages it to ensure that it operates effectively.

5

ENERGY USE IN OFFICES

Figure 5.1 Typical energy costs of office buildings



Energy costs in a typical headquarters (Type 4) office are around three times those in a typical Type 1 office building with individual offices and no air conditioning. The typical air conditioned open plan office (Type 3) uses 70% more than an open plan office without air conditioning (Type 2). This highlights the need to consider carefully what features are required when new or refurbished premises are being sought.

Note that the Type 4 (Headquarters building) includes a large variable energy consumption for computer rooms and catering, so caution is needed when comparing with this yardstick.

These examples are typical buildings. The good practice equivalents tend to use 30% to 40% less energy, mostly achieved by good management and simple measures. Still lower energy consumption is achievable in new buildings and major refurbishments.

5.1 Why analyse building energy use?

Assessing the energy performance of a building allows you to:

1. Compare performance with standards to suggest the potential for energy saving in the building.
2. Compare with other buildings in an estate or group of buildings to help identify which should be investigated first.
3. Compare with performance in previous years to monitor progress and to assess the effect of any changes or energy saving measures.
4. Consider the energy use in more depth to help understand where energy is used and wasted, and hence where savings are most likely to be made.

A general understanding of what electricity and fuels are used for in different types of office building helps to concentrate attention on priority areas, especially where the use of one of the fuels is particularly high.

5.2 Types of office building and their energy use patterns

Offices come in all shapes and sizes but for clarity we have defined four common types. Typical and good examples of each type of office are used as yardsticks against which a given building can be compared.

Typical energy costs of the four types are given in figure 5.1. Figures 5.2-5.5 show typical breakdowns of the energy costs. Note that the consumptions of energy for different purposes in any one building may be significantly different from the typical breakdowns given here.

5.3 Landlords and tenants energy use

In multi-let offices, tenants generally have a metered electricity supply which serves their lighting, office equipment and any catering or computer rooms. The landlords are responsible for the heating fuel and electricity for any central air handling and cooling plant, and lighting for common areas such as stairways, external lighting and toilets.

As tenants' lighting is the bulk of the total lighting cost, the energy breakdowns which follow can be used to indicate approximate percentages for the landlords and tenants energy costs.

EEO Energy Consumption Guide 19 gives 'typical' and 'good practice' energy consumption values in kWh/m² for different areas of energy use such as lights, heating and hot water, fans, pumps, controls and catering.

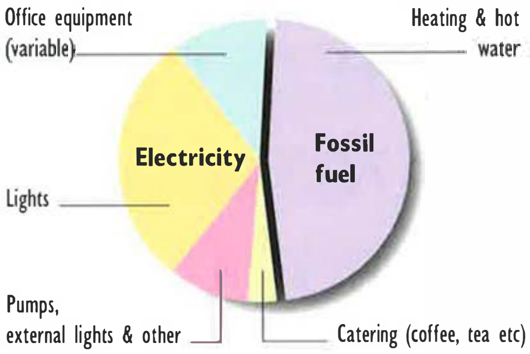
If you are able to determine the energy consumption of any of the different areas, by sub-metering for example, you can compare them with values given in Energy Consumption Guide 19. This will indicate the potential for savings in a specific area.

5.4 The Office Types

Type 1 Non air conditioned office with mostly individual office rooms

A fairly small, simple building with mostly individual offices, and perhaps a few group spaces. Daylight is good while artificial lighting is usually less intense than in the other three office types, and easily controlled by individual switches near the doors.

Figure 5.2 Typical energy cost breakdown - type 1



Type 2 Non air conditioned open plan office

Largely open planned with natural ventilation but with some individual offices and special areas such as conference rooms which may have local ventilation systems. There is often more office equipment, vending machines etc.

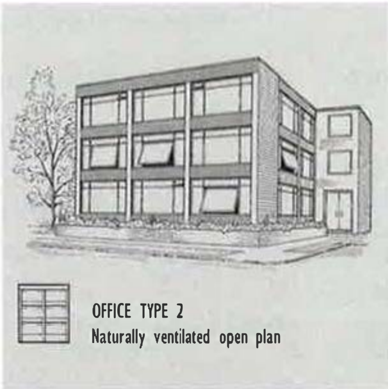
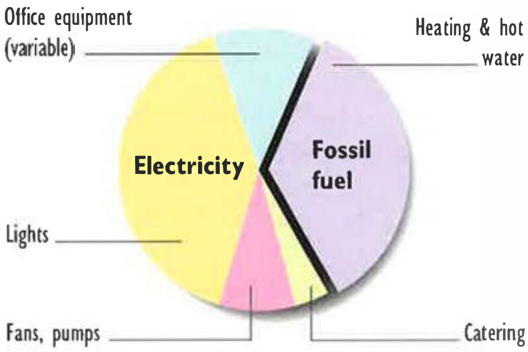


Figure 5.3 Typical energy cost breakdown - type 2



Type 3 Air conditioned open plan office

This type of office is similar in occupancy and planning to Type 2, but usually larger and with a deeper floor plan and tinted or shaded windows which reduce the availability and use of daylight still further. There is often more office equipment.

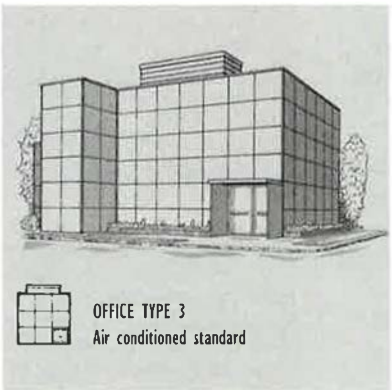
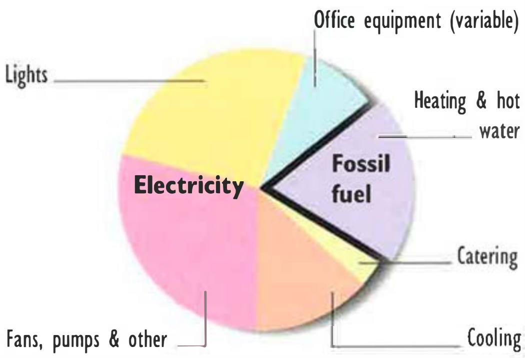


Figure 5.4 Typical energy cost breakdown - type 3

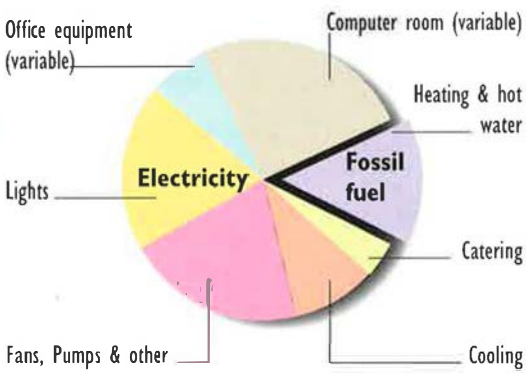


Type 4 Headquarters-type building

Larger still and often a national or regional head office, with a computer suite, a restaurant serving hot lunches for at least half the staff, and a generally higher level of equipment, facilities and information technology.

The electricity use of computer suites varies considerably from building to building, so caution is needed when assessing energy use in headquarters buildings.

Figure 5.5 Typical energy cost breakdown - type 4



6

COMPARING WITH ACCEPTED STANDARDS - PERFORMANCE INDICES

The performance indices are obtained by dividing the annual building energy use by the floor area. Yardstick values for the different office types are given below, with electricity consumption and fossil fuel energy consumption shown separately.

The procedure is:

1. Enter the annual energy use for each fuel into column 1 of figure 6.1.
2. Multiply each fuel by the conversion factor in column 2 to get common units of energy (kWh is used for electricity and now for gas - conversion units are given in Appendix 2).
3. Enter the treated floor area of the building in column 4.
4. Divide the energy use of each fuel by the floor area to get energy use per unit area (kWh/m²) in column 5.
5. Add the fossil fuel figures together to get a fossil fuel index - the electricity figure can be used directly.
6. Compare the indices with yardsticks for the building type in figure 6.2 to give an energy performance assessment.

Note: this does not take account of the effect of weather on heating energy use (see section 6.4).

6.1 Why use performance indices?

Performance indices give a measure of the energy use of a building which can be compared with the yardsticks. They can indicate the potential for improvements and can be used to show progress over time. They can also allow comparisons to be made between buildings in a group or estate.

6.2 Calculating the performance indices of a building and comparing to yardsticks

Two separate indices are calculated for the building, one for electricity and the other for fossil fuels. The separate indices should not be added together, because of the different cost and environmental impact of fossil fuels and electricity.

Floor area information.

The measure of floor area used to standardise energy consumption is treated area, defined as follows in relation to the more commonly available gross and net floor areas:

Gross	Total building area measured inside external walls. These figures are often used by architects and quantity surveyors.
Net	Gross area less common areas and ancillary spaces. As used for Property Agents' lettable floor area.
Treated	Gross area less plant rooms and other areas not heated (e.g. stores, covered car parks and roof spaces).

The best available information on floor area should be entered as either ft² or preferably m² in the form below - the estimates of treated floor area can be obtained using typical ratios as shown in the form. If more than one estimate of treated area is then available, the most reliable should be used.

	ft²	÷ 10.76 = m²				Treated floor area	
Gross floor area			x	0.90	=		m²
Treated floor area			x	1.00	=		m²
Net floor area			x	1.25	=		m²

Annual energy consumption of your building.

This is most conveniently obtained from past bills but take care that the figures collected represent a full year and are not "estimated" by the utility. It may be helpful to look at more than one year's bills providing that there have been no significant changes to the building or its use in that time. The numbers you require are the energy units consumed, not the money value. Include all fuels: solid fuel, bottled fuel, natural gas, oil and electricity.

Figure 6.1 Energy Performance Index Calculation

		Column 1 Annual Billed Units			Column 2 kWh Conversion	Column 3 Annual kWh	Column 4 Treated floor area (m²) divide by	Column 5 Annual kWh/m²
Gas			kWh*	x	1.0			
Oil type			litres	x				
Other Fossil fuel								
Total of fossil fuel								
Electricity			kWh	x	1.0			

Note * for kWh conversion factors see Appendix 2

There may be exceptional reasons to explain a low or high consumption. For example, a building may have a low consumption because it is half empty, or a high consumption because it has a large computer suite which has not been properly allowed for.

Even a building with a low consumption may have opportunities for cost-effective improvement.

The indices show which fuel requires the most attention. The description of typical energy use patterns in section 5 may help to ascertain which use of energy is most likely to offer potential for savings. Section 4 then shows possible energy saving measures for each energy use. The next step is to select and progress suitable measures.

6.3 Overall yardsticks

Overall yardsticks based on carbon dioxide (CO_2) emissions or the cost of energy per m² of floor area can be used to provide a single performance index. These can be used to prepare league tables which compare groups of buildings or to assess buildings which have fuel supply arrangements which do not fit into the yardstick categories. This may occur, for example, in offices with electric heating and buildings which use combined heat and power (CHP).

Appendix 1 shows how to apply simple factors for CO_2 emissions or energy cost for each fuel type to calculate an overall performance index.

6.4 Refining the performance indices

If there is more information available, you may wish to assess your performance indices further in a number of ways as described in Appendix 1.

- If your building has unusual occupancy, or experiences unusual weather or exposure you may want to know their likely effect.
- You can compare your building performance with the 'Normalised Performance Indicator' used in previous editions of these guides.
- You may wish to take account of the effect of weather when comparing buildings in different parts of the country.

Figure 6.2 Energy Consumption Yardsticks

Performance Assessment

	Low consumption Less than	Medium Consumption Between	High consumption Greater than
	Yardsticks in kWh/m²		Yardsticks in kWh/m²
Type 1. Smaller office			
Fossil fuels	95		200
Electricity	36		48
Type 2. Naturally ventilated open plan			
Fossil fuels	95		200
Electricity	61		85
Type 3. Air conditioned open plan			
Fossil fuels	100		222
Electricity	132		202
Type 4. Headquarters type (including computer room and catering)			
Fossil fuels	132		273
Electricity	261		361

7

A CLOSER LOOK AT ENERGY CONSUMPTION

7.1 Introduction

Often a fuller understanding of energy use in a building may be useful, for example after the initial measures have been undertaken, if there is a problem, if the building has poor performance or if it has unexpected energy bills. This section outlines techniques which you may find useful.

7.2 Monthly energy use

You can ask your supplier for monthly fuel data, or take monthly meter readings yourself.

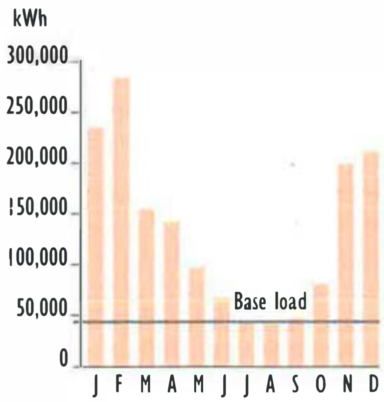
Larger sites have monthly energy bills. By looking at how these vary with the seasons some valuable insights can be obtained. Produce a monthly consumptions bar chart plot for each energy source over a year.

The billing periods should be checked. If they are not regular, some months will appear unrealistically low and others unrealistically high. This is particularly likely in December and January. If this is the case the average daily consumption for each month can be plotted to give more accuracy.

Fossil fuel consumption, used mainly for heating, should reduce greatly in summer - to zero if it is not being used for other services such as hot water or catering.

Electricity consumption should decrease in summer in a building which is not air conditioned, because of lower lighting loads. In an air conditioned building, peaks in spring and autumn may indicate simultaneous heating and cooling.

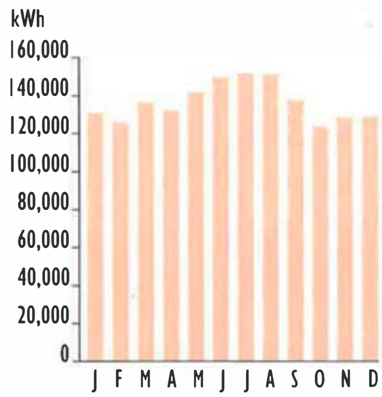
Example monthly fossil fuel use



The figure above shows the monthly fossil energy consumption of a fairly efficient building which has a central boiler system for heating and hot water - the summer usage is much lower than winter usage and is at a fairly steady 'base load' level which suggests that the heating is off, though it is useful to confirm this by checking that heating pumps are off, and that pipework used solely for heating is cold.

This graph shows a base load, which helps to identify the hot water load and system losses, and the heating load which depends on the weather.

Example monthly electricity use

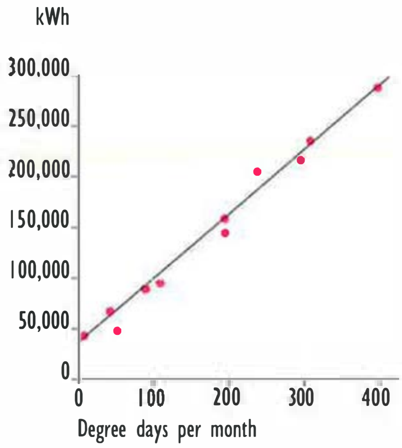


The figure above shows monthly electricity consumption for an air conditioned office building showing a small increase in the summer months as the cooling load increases. A possible small increase in winter may be due to increased lighting or some electric heating.

7.3 Relating heating use to weather

A fuel that is mainly used for heating should be used more in colder weather. The coldness of the weather can be expressed by a measure known as degree days. This shows by how much and for how long the outside temperature is below a control temperature (usually 15.5°C). Drawing a graph of fossil fuel consumption against the degree days for each month in the year shows how energy consuption is related to weather. Monthly figures for degree days for different areas of the country are published in the EEO's free bimonthly magazine 'Energy Management' (section 9.4).

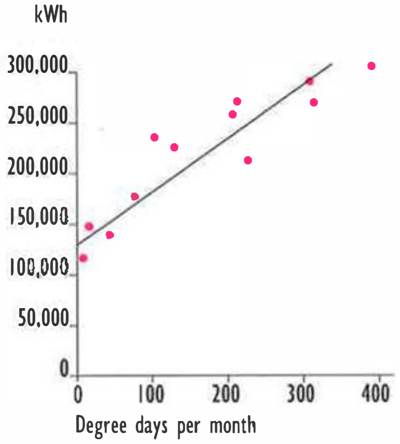
Example monthly heating energy use in a well controlled building



The building represented above has a well controlled heating system shown by the close fit of the points to the straight line. As the weather gets colder the energy used goes up proportionally. For this building the energy consumption falls to a small value in summer when only hot water is being provided.

A building with better insulation would have a less steep slope because energy consumption in winter would be lower.

Example monthly heating energy use in a poorly controlled building



The figure above has a large scatter of points indicating a building with poor control. The energy use in the summer months remains higher than in the previous figure, indicating that either heating is being used unnecessarily in the summer or that the boiler and hot water systems have high losses which lead to excessive waste.

> For further information see:
>
> EEO Fuel Efficiency Booklet 7. Degree Days

7.4 Adjusting energy use for weather

Once you know how weather conditions affect energy use, it is possible to allow for varying conditions. For example, it is possible to take account of the weather when comparing a building energy performance from year to year. Such comparisons show with greater accuracy the effect of any energy saving measures.

In order to adjust for weather it is necessary to know how much of the fossil energy is used for heating and how much is a steady base load. The base load can be estimated by looking at the monthly consumption of fossil energy as shown in section 7.2 or the graphs of fossil fuel against degree days as shown in section 7.3, and the rest is the energy used for space heating which varies with weather conditions.

7.5 Comparing energy use with standards

More detailed information on energy use in office buildings is available from the EEO. It is possible to meter or estimate energy usage for a particular service such as heating or lighting and compare against published levels. This helps to ask more detailed questions, such as

- Is the building intensively used ?
- Are the lights left on longer than necessary ?
- Is the lighting level too high (find typical values) ?
- Is the lighting equipment inefficient ?

> For further information see:
>
> EEO Energy Consumption Guide 19
>
> EEO Good Practice Guide 33 Understanding energy use in your office
>
> CIBSE Applications Manual 5 Energy Audits and Surveys.

8

CASE STUDIES

This section gives examples of buildings where energy saving measures have been implemented.

The usefulness of the Performance Index calculation is also demonstrated, both for assessing how energy efficient a building is, and as a means of evaluating the improvement in energy performance resulting from the implementation of energy saving measures.

These case studies are described more fully elsewhere.

For further information see:

EEO Good Practice Case Study 16 Heslington Hall.

EEO Good Practice Case Study 18 Quadrant House.

EEO Good Practice Case Study 21 One Bridwell Street.

Improvement in energy consumption

Treated floor area = 4,470 m²

	Fossil fuel index (kWh/m²)	Fossil fuel performance assessment	Savings	Electricity index (kWh/m²)	Electricity performance assessment
Before energy audit	452	High consumption			
After low cost measures	316	High consumption	30%		
After other measures	181	Medium consumption	60%	38	Medium consumption

8.1 Heslington Hall, University of York

Heslington Hall is an Elizabethan building reconstructed in Victorian times and converted to offices in the 1960s. The building has individual rooms (cellular), is naturally ventilated and accommodates a staff of 150 people.

An energy audit in 1979-80 revealed that the annual fuel consumption per unit area for central heating and hot water use was very high. Following the audit a number of measures were implemented.

Low cost measures

Low cost measures reduced annual oil consumption by 30%. These included recommissioning the boiler, improving time controls, weather-stripping the windows, re-fitting roof insulation, and relocating weekend uses to other buildings or heating them separately, rather than from the central plant.

Other Measures

Boilers

Prior to the survey, heating and domestic hot water were provided by two oil fired boilers which were 72% efficient when continuously fired but much worse in intermittent operation. It was felt wise to have a heating system that could use either oil or gas and the University decided not to replace the old boilers but to add a highly efficient gas boiler.

The new boiler was a lightweight boiler with an efficiency of around 80% over much of its operating range. The oil boilers were retained as standby and to provide extra capacity for cold weather conditions.

Domestic Hot Water

The original central hot water system served kitchens, showers and the main toilets, with separate electric storage water heaters in remote toilets and in the printing department. Summertime fuel efficiency of the central system was very low because of losses from the large central boilers.

When the new system was installed in 1983, the kitchen was no longer in use and the central hot water system was replaced by a modestly sized gas fired water heater. Hot water was thus no longer generated from the central boilers which were switched off in summer giving large savings.

Heating Control

A multi-purpose controller with the following features replaced the earlier separate compensator and time switches:

- A 7-day heating programme with optimum start and pump run-on to dissipate heat from the boilers into the system at the end of the timed heating period
- Weather compensation with room temperature correction
- Fixed time control for domestic hot water
- Frost protection.

Energy Saving

The installation of the new gas boiler, independent hot water system, and new controls reduced fossil fuel consumption by a further 43% giving an overall heating energy saving of 60%.

Lighting

In 1980 the lighting was predominantly tungsten, often with low illuminance levels. Since then most of the office lighting has been replaced by fluorescent tube fittings, to an improved standard with desk lamps available, while miniature fluorescent fittings were installed in corridors and stairs.

8.2 Quadrant House, Sutton

Quadrant House is a large speculative air conditioned office completed in 1980. The building accommodates a wide range of activities from editorial and advertising to photographic processing. Typical occupancy is 1,000 staff.

Quadrant House has a central air conditioning system with small room heat pumps which are somewhat unusual, but the energy saving measures are relevant to buildings with more conventional air conditioning systems.

Measures to reduce gas consumption

Gas consumption was cut to one-third by:

- Careful control of primary air temperatures to minimise simultaneous heating and cooling.
- Fine tuning of the optimum start and stop arrangements. For example, it was found that the offices often stayed warm enough with the boilers turned off at 4.30 pm.
- Switching off boilers in summer and providing hot water by local electric heaters.

Measures to reduce electricity consumption

Electricity consumption was cut by 15% despite increased use of office equipment and the change to electric heating of hot water in summer.

The building energy management system was used to monitor plant operation and then adjust time programmes and control logic in order to:

- Ensure that pumps, fans and cooling towers only operate when needed.
- Restrict use of the main chillers. This measure is effective in all air conditioned buildings but gave particularly high savings with the system at Quadrant House.

Originally lights in all the offices were controlled from large switch panels in the corridors, and many lights were switched on and left on unnecessarily. An automatic lighting control system was introduced and commissioned to the requirements of the occupants, reducing lighting energy consumption by one third:

- The system was programmed to turn perimeter lights off at 10am and 1pm when daylight was sufficient, and to switch internal lights off hourly after 6pm. Staff could use wall switches to turn local lighting back on when needed.
- Since the internal corridors were overlit (a common fault) the automatic controls were arranged to light two out of every three fittings in the daytime and one in three at night.
- Any adverse reaction from lights going off unexpectedly was generally dealt with by altering the local lighting controls in each zone.

Further lighting savings were made by reducing the wattage of decorative tungsten lights in the restaurant and reception areas, and replacing selected lights with compact fluorescent lamps.

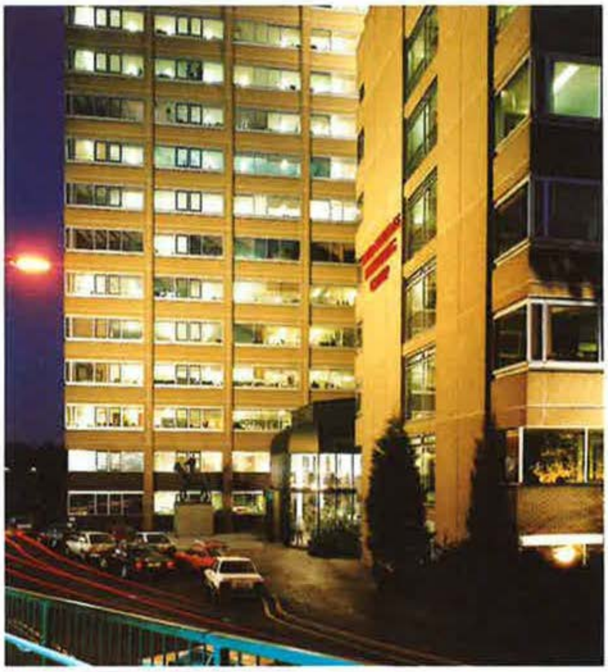
The expertise and funding required for these improvements were made available through a contract energy management arrangement. In return for a share of savings achieved and an initial fee, the contractor was responsible for plant operation, maintenance, repairs, replacement, fuel purchasing and maintaining comfort standards for staff.

Performance Indices

For this building an overall yardstick is appropriate; the fossil fuel and electric yardsticks are not relevant separately as heating is provided by both gas boilers and the electric room heat pumps.

The index is calculated in terms of carbon dioxide (CO_2) emissions. The example calculation uses consumptions after the measures were implemented.

The energy saving measures improved the CO_2 index by 27% from 171 to 125 kg/m² per year.



CO_2 Performance Index

	Column 1 Annual energy use kWh/m²	Column 2 CO_2 conversion factors kg/kWh	Column 3 Annual CO_2 emissions kg/m²
Gas	62	x 0.20	12
Oil		x 0.29	
Coal		x 0.32	
Electricity	162	x 0.70	113
Total CO_2 emissions per m²			125

Treated floor area = 23,475 m²

	Overall CO_2 index (kg/m²)	Performance assessment	Savings in gas consumption	Savings in electricity consumption
Before implementation of energy saving measures	171	Medium emissions		
After implementation of energy saving measures	125	Medium emissions	67%	15%

8.3 One Bridewell Street, Bristol

One Bridewell Street, in the centre of Bristol, was developed as the South-West regional office of accountants Ernst & Young. It is a fully air conditioned building with normally 310 occupants.

One Bridewell Street is a multi-tenanted building. Effective energy management is often difficult in multi-tenanted buildings, but most problems have been resolved because:

- The main tenant manages the building and has a policy of involving all the tenants with decisions on energy management actions.
- The building is managed with the occupants' requirements as the prime concern, and the plant and its associated controls are seen as tools to achieve the required conditions at minimum cost.

Energy Consumption

The comparisons with yardsticks for a Type 3 air conditioned office are as follows:

Treated floor area = 5,020 m²

Fossil fuel index (kWh/m²)	Fossil fuel performance assessment	Electricity index (kWh/m²)	Electricity performance assessment
86	Low consumption	53	Low consumption

Lighting

The lighting is very economical for what is largely an artificially lit building.

Low energy lamps and luminaires are installed throughout providing normal office lighting levels with only 12 Watts of lighting per m² of floor area (20 Watts per m² is more typical). This is achieved using

- High efficiency fluorescent tubes with high frequency control gear and reflective fittings (luminaires).
- Compact fluorescent lamps for decorative, circulation and WC lighting.

An effective combination of manual and automatic control gives occupants choice while limiting waste:

- Working lights are switched on locally. The system turns lights off at selected times at the end of the day, and at lunch time in some areas.
- There is a reduced level of lighting for times when the building is being cleaned.
- Lights in circulation areas and other selected safety points are switched on automatically during working hours on each floor.
- Car park lighting is time-controlled during peak hours and otherwise responds to movement sensors at the entrances.
- Highly responsive management ensures that users view the lighting controls as a benefit and not a burden.

Heating and domestic hot water

The building energy management system (BEMS) minimises the boiler use:

- Boilers turned off in summer as hot water is generated by local electric heaters and the air conditioning system has no heating requirement in summer.
- Avoiding use of two boilers when one is sufficient (boiler sequencing).
- Optimum start to delay boiler switch-on as long as possible each day.

Ventilation and Air Conditioning

The efficient lighting means there is less heat to be dissipated, reducing air conditioning plant size and cost as well as energy consumption. The ventilation and air conditioning systems have a number of characteristics which make them efficient.

- The building manager operates the system so that chillers and boilers never run simultaneously - the refrigeration plant normally operates only from May to September, and then often only in the afternoon.
- Fan power - often the largest cost after lighting - is very low due to the use of variable speed fans and generous duct sizing.
- Each floor is separately controlled, and air is not provided to unused floors after the working day.
- The main air conditioning plant is carefully controlled to avoid overcooling the supply air and unnecessary use of the chillers.

Building Fabric

The building has a white finish and modest, but adequate, window areas to limit unwanted solar gains, and massive construction with external insulation to provide pleasant, stable conditions for room comfort.

Summary

This case study demonstrates that by attention to every stage from inception through to management, high comfort standards and low running costs can be obtained using proven and readily available technology, without exceptional energy saving features.

ADVICE AND HELP

9.1 The Energy Efficiency Office

The Energy Efficiency Office (EEO) is part of the Department of the Environment.

The EEO currently aims to achieve environmental and economic benefits by promoting cost effective energy efficiency measures in the industrial, commercial, domestic and public sectors of the economy by:

- Raising awareness
- Identifying and overcoming barriers to action
- Providing financial incentives where appropriate
- Regulation where necessary
- Providing technical advice.

9.2 Best Practice Programme

The EEO's Best Practice programme gathers and disseminates authoritative information on cost effective energy saving measures. The Best Practice programme for buildings is managed on behalf of the EEO by the Building Research Energy Conservation Support Unit (BRECSU) and for industry by the Energy Technology Support Unit (ETSU).

A range of publications is available under the Best Practice programme, normally free of charge. Relevant titles for offices are listed here.

Energy Consumption Guides give data on the way in which energy is currently used in specific building types and for industrial processes, enabling organisations to compare their current energy usage with others in their sector or occupying similar building types. Titles available relating to offices are:

10 Energy Efficiency in Offices. Energy Consumption Guide for Senior Managers

19 Energy Efficiency in Offices. A Technical Guide For Owners and Single Tenants.

35 Energy Efficiency in Offices. Small Power Loads.

Good Practice Guides give advice on how to implement energy saving measures. Titles available relating to offices are:

33 Understanding energy use in your office

34 Energy efficient options for new offices - for the design team

35 Energy efficient options for refurbished offices - for the design team

46 Heating and hot water systems in offices

71 Selecting air conditioning systems

84 Managing and motivating staff to save energy

117 Energy efficiency in the government estate - for accommodation managers.

General Information Leaflets and Reports also give advice on how to implement energy saving measures. General Information Leaflets relating to offices are:

1 The success of condensing boilers in non-domestic buildings. A user study

6 Energy efficiency in office lighting

10 Magnus House, Bridgewater

12 Posford House, Peterborough.

Information on energy management is contained in these General Information Reports:

12 Organisational aspects of energy management

13 Reviewing energy management

14 Energy management of buildings including a review of some case studies.

Good Practice Case Studies provide examples of proven techniques which are already enabling the better energy users to be more energy efficient. Titles relating to offices are:

1 Policy Studies Institute. Low cost major refurbishment of a naturally ventilated office.

13 NFU Mutual and Avon HQ. A new headquarters office avoiding full air conditioning.

14 Cornbrook House. A new naturally ventilated building designed for minimum heating and cooling costs.

15 Hempstead House. A simple naturally ventilated speculative office.

16 Heslington Hall. Cost effective improvements to a listed building with naturally ventilated offices.

17 Hereford and Worcester County Hall. 1970's civic offices designed and managed for low energy consumption.

18 Quadrant House. A 1980 high-rise air conditioned office improved through upgrading and energy management.

19 South Staffordshire Water Company. New offices designed to maximise natural lighting and minimise heating requirements. Naturally ventilated open plan.

20 Refuge House. New owner occupied offices designed for both natural ventilation and air conditioning.

21 One Bridewell Street. A new high quality air conditioned office with low energy costs.

39 Condensing gas boilers for heating and hot water in offices.

62 BRE Low Energy Office. 1981 offices designed for low energy consumption and comprehensively monitored.

Fuel Efficiency Booklets are working manuals which provide detailed technical guidance on specific areas of energy use in buildings and industry. Relevant booklets are:

1 Energy audits for buildings
7 Degree days
8 The economic thickness of insulation for hot pipes
9 Economic use of electricity in buildings
10 Controls and energy savings
12 Energy management and good lighting practices.

In addition, a wide range of events is organised to promote the results of the Best Practice programme. These include seminars, workshops and site visits and are targeted at different sectors and professionals.

Details of publications and events can be obtained from:

BRECSU (for buildings)
Building Research Establishment
Garston
Watford WD2 7JR
Tel: 0923 664258
Fax: 0923 664097

ETSU (for industrial sectors)
Harwell
Didcot
Oxon OX11 ORA
Tel: 0235 436747
Fax: 0235 432923.

9.3 Other publications available from BRECSU

Energy Efficient Lighting in Offices (1993). A THERMIE Maxibrochure.

9.4 Free Publications From the EEO

The Introduction to Energy Efficiency series. There are 13 Guides in this series, of which this is one:

Catering establishments
Entertainment buildings
Factories and warehouses
Further and higher education
Health care buildings
Hotels
Libraries, museums, galleries and churches
Offices
Post Offices, banks and agencies
Prisons, emergency buildings and courts
Schools
Shops
Sports and recreation centres

Choosing an Energy Efficiency Consultant (EMAS 2)

Practical Energy Saving Guide for Smaller Businesses (ACBE 1)

The above are all available from:
Department of the Environment
Blackhorse Rd
London SE99 6TT
Tel: 081 691 9000

The 'Energy Management' journal. Published bi-monthly and available from the EEO.
Tel: 071 276 6200.

9.5 Other EEO Programmes

Making a Corporate Commitment Campaign

The 'Making a Corporate Commitment' campaign seeks board level commitment to energy efficiency. It encourages directors to sign a Declaration of Commitment to responsible energy management, prepare a business plan for energy efficiency and ensure that it becomes an item that is considered regularly by their main board.

Publications:

Chairman's Checklist
Executive Action Plan
Energy, Environment and Profits - Six case studies on corporate commitment to energy efficiency.

Further information is available from the Campaign Offices on 071 276 4613.

Energy Management Assistance Scheme

The Energy Management Assistance Scheme may provide support for small and medium sized businesses (up to 500 employees) to employ an energy consultant. This aims to upgrade the expertise in energy efficiency among smaller companies, and tackle the capital priority barrier through financial support.

Further information can be obtained on 071 276 3787.

9.6 Sources of Free Advice and Information

Regional Energy Efficiency Officers

11 Regional Energy Efficiency Officers (REEOs) around the UK can provide copies of all the EEO's literature and give specific advice on:

- opportunities for better energy efficiency in your organisation
- technologies and management techniques you should be thinking about
- appropriate sources of specialist advice and assistance in the private sector
- EEO programmes
- regional energy managers' groups.

REEO Northern Region
Wellbar House
Gallowgate
Newcastle Upon Tyne NE1 4TD
Tel: 091 201 3343

REEO Yorkshire and Humberside
City House
New Station Street
Leeds LS1 4JD
Tel: 0532 836 376

REEO North West
Sunley Tower
Piccadilly Plaza
Manchester M1 4BA
Tel: 061 838 5335

REEO East Midlands
Cranbrook House
Cranbrook Street
Nottingham
Nottinghamshire NG1 1EY
Tel: 0602 350 602

REEO West Midlands
Five Ways Tower
Frederick Road
Birmingham B15 1SJ
Tel: 021 626 2222

REEO Eastern
Heron House
49-53 Goldington Road
Bedford MK40 3LL
Tel: 0234 276 194

REEO South West
Tollgate House
Houlton Street
Bristol BS2 9DJ
Tel: 0272 218 665

REEO South East
Charles House
Room 565
375 Kensington High St
London W14 8QH
Tel: 071 605 9160

REEO Scotland
New St Andrews House
Edinburgh
Scotland EH1 3TG
Tel: 031 244 1200

REEO Wales
Cathays Park
Cardiff
Wales CF1 1NQ
Tel: 0222 823 126

REEO Northern Ireland
Dept of Economic Development
Netherleigh House
Massey Avenue
Belfast
N Ireland BT4 2JT
Tel: 0232 529900.

9.7 Other Programmes

Energy Design Advice Scheme

The Energy Design Advice Scheme is a Department of Trade and Industry discretionary initiative aimed at improving the energy and environmental performance of the building stock by making low energy building design expertise more accessible for the energy efficient design and refurbishment of buildings. The scheme offers support, via a number of Regional Centres, to design teams or clients in the energy aspects of design of new buildings or refurbishment projects over 500m² gross area.

Further information can be obtained from the following Regional Centres:

For Scotland
Tel: 031 228 4414

For South East England
Tel: 071 916 3891

For Northern England
Tel: 0742 721 140

For Northern Ireland
Tel: 0232 364 090.

EU Programmes

Several EU programmes aimed at demonstrating energy efficiency measures and encouraging energy efficiency R&D. Details change periodically. For further information contact BRECSU for buildings and ETSU for industry.

9.8 Other Publications

Chartered Institution of Building Services Engineers (CIBSE):

CIBSE Applications Manual, AM 5:1991, Energy Audits and Surveys

CIBSE Applications Manual, AM 6:1991, Contract Energy Management

CIBSE Applications Manual, AM3, Condensing Boilers

CIBSE Applications Manual, AM8, Private and Standby Generation of Electricity

CIBSE Code for Interior Lighting (1984)

CIBSE Lighting Guide 3(LG3)(1989). Areas for Visual Display Terminals.

Available from:

CIBSE, 222 Balham High Rd,
Balham,
London SW12 9BS.
Tel: 081 675 5211
Fax: 081 675 5449.

Heating and Ventilating Contractors Association (HVCA):

Standard Specification for Maintenance of Building Services. Volumes 1 - 5. 1990 - 1992.

Available from:

HVCA Publications, Old Mansion House, Earmont Bridge, Cumbria, CA10 2BX
Tel: 0768 64771.

9.9 Other Useful Addresses

Energy Systems Trade Association Ltd (ESTA)
PO Box 16, Stroud, Gloucestershire
GL5 5EB
Tel: 0453 886776
Fax: 0453 885226

Major Energy Users' Council
10 Audley Road
London W5 3ET
Tel: 081 997 2561/3854
Fax: 081 566 7073.

APPENDIX 1

Development of Building Performance Indices (PI)

Introduction

This section outlines how to calculate environmental and cost indices for the energy used in your offices. It describes the effect of weather, building occupancy and exposure on the performance of a building, with a method to allow for these factors if required.

Adjustments of the PI for these factors produces a 'Normalised Performance Index' (NPI) which is compatible with earlier versions of this guide. For many purposes, the effect of these factors on performance indices is small enough to be ignored.

Overall performance indices

Overall performance indices provide a single measure of building performance, and can be expressed in terms of carbon dioxide (CO_2) emissions or energy cost. Overall energy indices are useful for comparing a stock of buildings or for assessing the performance of buildings with electric heating or combined heat and power (CHP). However, separate fossil fuel and electricity performance indices are more useful to assist in deciding a course of action.

To calculate overall performance indices you need the annual energy use indices as obtained in figure 6.1 and conversion factors for each of the fuels - some of which are given in figures A1.1 and A1.2. The calculation procedure is to enter the kWh/m² figure in Column 1, and multiply by the relevant conversion factors in column 2 to get either the kg of CO_2 per m² or the cost per m² in column 3.

The conversion factors shown are broadly representative of the current fuels used in offices, and can be used if a consistent set of factors is required. CO_2 factors, particularly for electricity, may vary from this data. Cost factors will also vary over time and as a function of use. Energy unit costs in larger buildings tend to be cheaper than for smaller supplies. You may wish to use your own costs from your own bills instead of those given here.

Overall yardsticks for CO_2 emissions or energy costs can also be calculated, by inserting yardstick energy consumptions (given in figure 6.2) into column 1. These can be compared with the actual index for your building to give an overall assessment. CO_2 and cost yardsticks calculated on the basis that the fossil fuel is gas are presented in figure A1.3.

Figure A1.1
CO_2 Performance Index Calculation

	Column 1 Annual energy use kWh/m²	Column 2 CO_2 conversion* factors kg/kWh	Column 3 Annual CO_2 emissions kg/m²
Gas		x 0.20	
Oil		x 0.29	
Coal		x 0.32	
Electricity		x 0.70	
Total CO_2 emissions per m²			

*typical 1993 emission factors

Figure A1.2
Cost Performance Index Calculation

	Column 1 Annual energy use kWh/m²	Column 2 Cost conversion factors £/kWh*	Column 3 Annual cost £/m²
Gas		x 0.014	
Oil		x 0.012	
Coal		x 0.009	
Electricity		x 0.071	
Total energy cost per m²			

*typical 1992 prices

Effect of weather on energy use

Weather changes from year to year for a given site cause variations in fossil/heating energy use of typically ±5% from the average values or ±10% in more extreme years.

Weather differences across the country cause variation in heating requirements of typically ±10% from average values and ±20% in more extreme areas.

The effect on electricity use will be small unless electricity is used for space heating, or in air conditioned buildings where the cooling energy will be higher during a warm summer.

Exposure

If a building is very exposed (on an exposed hill for example), heating energy increases by 5-10% and likewise a completely protected building may use 5-10% less. In many cases steps will have been taken on exposed buildings to improve draught sealing which will offset the increase. Electricity use is largely unaffected except in electrically heated buildings.

Hours that the building is occupied (occupancy)

Occupancy affects buildings' energy use in different ways for different systems. Heating energy in a naturally ventilated heavy building varies very little with occupancy - say 5%. If a building has a light weight structure, or is mechanically ventilated or air conditioned, the heating energy may increase in more direct proportion to the occupied hours, giving 20% variation or more from the typical occupancy.

Electricity consumption of a badly controlled building will be almost independent of the occupancy, owing to lights and services left on from early morning to last thing at night. But for a well controlled building, both lights and plant may operate in direct proportion to occupancy.

Normalised performance indices

It is possible to adjust (normalise) performance indices for weather, exposure and extended occupancy, but care is needed as incorrectly applied adjustments, or adjustments that are too simplistic, may introduce larger errors than the typical variations discussed above. For example, the effect of extended hours of use on energy consumption can easily be exaggerated, making the building performance seem better than is really the case.

Note also that while a normalised performance index is a better measure of a building's efficiency than an unnormalised index, the latter shows the building's actual performance. So a building with a low normalised performance index, but a high performance index before adjustment, is efficient, but since it is still a high user of energy, it may well offer good opportunities for cost effective energy saving.

The worksheet in figure A1.4 can be used to obtain performance indices which are normalised to standard conditions of weather, exposure and occupancy. This is useful if:

- You require normalised performance indices for compatibility with previous work
- Any of the factors cause significant errors (see above sub sections to evaluate this).

A normalised performance index based on overall CO_2 emissions or energy cost is obtained by using figure A1.1 or A1.2 and inserting the normalised performance indices for each fuel into Column 1. If more than one fuel is used for heating, calculate a separate normalised performance index for each fuel first and then use this procedure.

Figure A1.3 Carbon dioxide and cost yardsticks

CO_2 Performance Assessment

Low Emissions Less than → ← **Medium Emissions** Between → ← **High Emissions** Greater than

Office Type	Yardsticks in kg CO_2/m^2	Yardsticks in kg CO_2/m^2
1. Smaller office	44	74
2. Naturally ventilated open plan	62	100
3. Air conditioned open plan	112	186
4. Headquarters type (including computer room and catering)	209	307

Cost Performance Assessment

Low Cost Less than → ← **Medium Cost** Between → ← **High Cost** Greater than

Office Type	Yardsticks in £/m²	Yardsticks in £/m²
1. Smaller office	3.7	6.0
2. Naturally ventilated open plan	5.5	8.5
3. Air conditioned open plan	10.5	17.0
4. Headquarters type (including computer room and catering)	20.0	29.0

Performance indices - summary

- Simple performance indices are for initial energy assessments. Separate performance indices are calculated, one for fossil fuels and one for electricity use, and no adjustments are made.
- Overall performance indices, based on carbon dioxide (CO_2) or cost, are normally used when the energy supply arrangement is not typical or when a number of buildings are to be compared. Also, you may want to know the cost or the CO_2 performance for a single building.
- Normalised performance indices are used when more sensitive comparisons are required and the effect of factors such as weather and occupancy become significant. But if you choose to normalise, be aware of introducing errors.

Figure A1.4 Normalised Performance Indices calculation

	Fossil fuel: Gas	Fossil fuel: Oil	Fossil fuel: Other		Total of Fossil Fuels	Electricity
Total energy consumption (kWh)				(A)		
Space heating energy (kWh)				*(B)		
Non space heating energy (kWh)				A-B = (C)		
Find the degree days for the energy data year				*(D)		
Weather correction factor = 2462 ÷ D =				(E)		
Obtain the exposure factor below				*(F)		
Obtain occupancy factor for heating energy use from below				*(G)		
Annual heating energy use for standard conditions				BxExFxG = (H)		
Obtain occupancy factor for non-heating energy from below				*(K)		
Annual non-heating energy use = C x K =				(L)		
Normalised energy use = H + L =				kWh (M)		
Find floor area				m^2 (N)		
Find the Normalised Performance Indices = M ÷ N =				kWh/m^2 (P)		

* Notes:
(B) Estimation of weather-dependent heating energy use is discussed in section 7.
(D) For degree day information, see Fuel Efficiency Booklet 7 - Degree Days
Monthly degree day figures are published in 'Energy Management' (see section 9.4)
(F) Exposure factors from figure A1.5.
(G) and (K) Occupancy factors from figure A1.6.

Figure A1.5 Exposure factor

	Factor
Sheltered. The building is in a built-up area with other buildings of similar or greater height surrounding it. This would apply to most city centre locations.	1.1
Normal. The building is on level ground in urban or rural surroundings. It would be usual to have some trees or adjacent buildings.	1.0
Exposed. Coastal and hilly sites with little or no adjacent screening.	0.9

Figure A1.6 Occupancy Factors

	Factor for heating energy (G)	Factor for non-heating energy (K)
Normal building occupancy: (5 - 5½ days), 11 hours per day	1.00	1.00
Lightweight building Extended occupancy	0.85	0.80
Other buildings Extended occupancy	0.95	0.80

APPENDIX 2

Energy Conversion Factors

The unit of energy used in this guide is the kilowatt - hour (kWh). One kilowatt - hour is consumed by a typical one bar electrical fire in one hour. For fuels which are metered in other units, multiply the metered value by the relevant conversion factor from the following table to obtain the value in kWh.

Figure A2.1 Conversion to kWh

	kWh conversion
Light Fuel Oil	11.2 kWh/litre
Medium Fuel Oil	11.3 kWh/litre
Heavy Fuel Oil	11.4 kWh/litre
Gas Oil (35 second)	10.8 kWh/litre
Kerosene - burning oil 22 second	10.4 kWh/litre
Electricity	[Metered directly in kWh]
Natural gas	29.31 kWh/therm
Liquid Petroleum Gas (LPG) (Propane)	6.96 kWh/litre
Coal (washed shingles)	7,900 kWh/tonne
Coal (washed smalls)	7,800 kWh/tonne

BEST PRACTICE PROGRAMME

Energy Efficiency Office

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