Introduction to Energy Efficiency in Entertainment Buildings

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INTRODUCTION

1.1 Who this guide is intended for

This guide is aimed at managers of individual cinemas, theatres, bingo and social clubs. 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. It shows how to gain an understanding of energy use in entertainment buildings 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 entertainment buildings.
- The case studies (section 8) give examples of 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

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 environment for customers and staff. This can give rise to better customer satisfaction, improved staff 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:

Leeds Grand Theatre and Opera House Ltd

Odeon Cinema, Leicester

The Rank Organisation

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, turnover, etc).
- Compare your energy use to previous years, to other sites, 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.

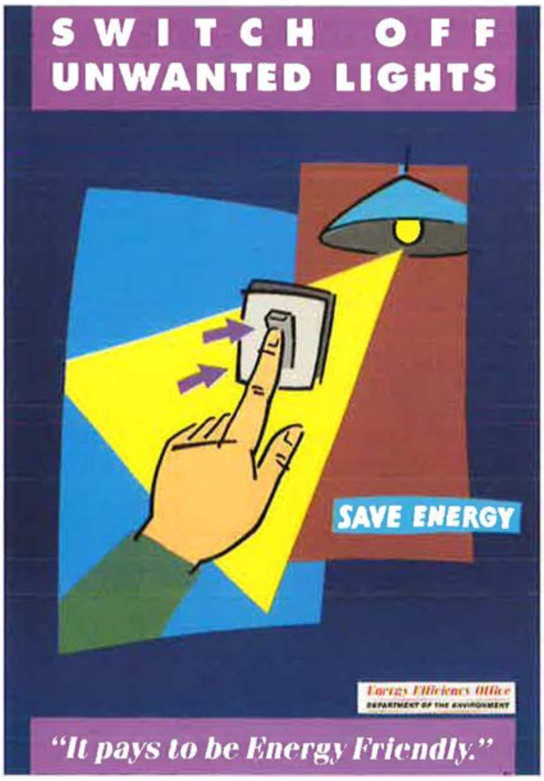
Tariff savings usually incur little or no initial cost and may be used to help finance measures to reduce energy costs further. Reviewing tariffs should therefore be one of your first actions:

- 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).

For further information see:

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

Energy Efficiency Poster



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 entertainment buildings

In larger 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 staff. 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 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 premises, take the opportunity to select or specify:

- Energy targets
- 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 71 - Selecting air conditioning systems.

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

2.9 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. 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:

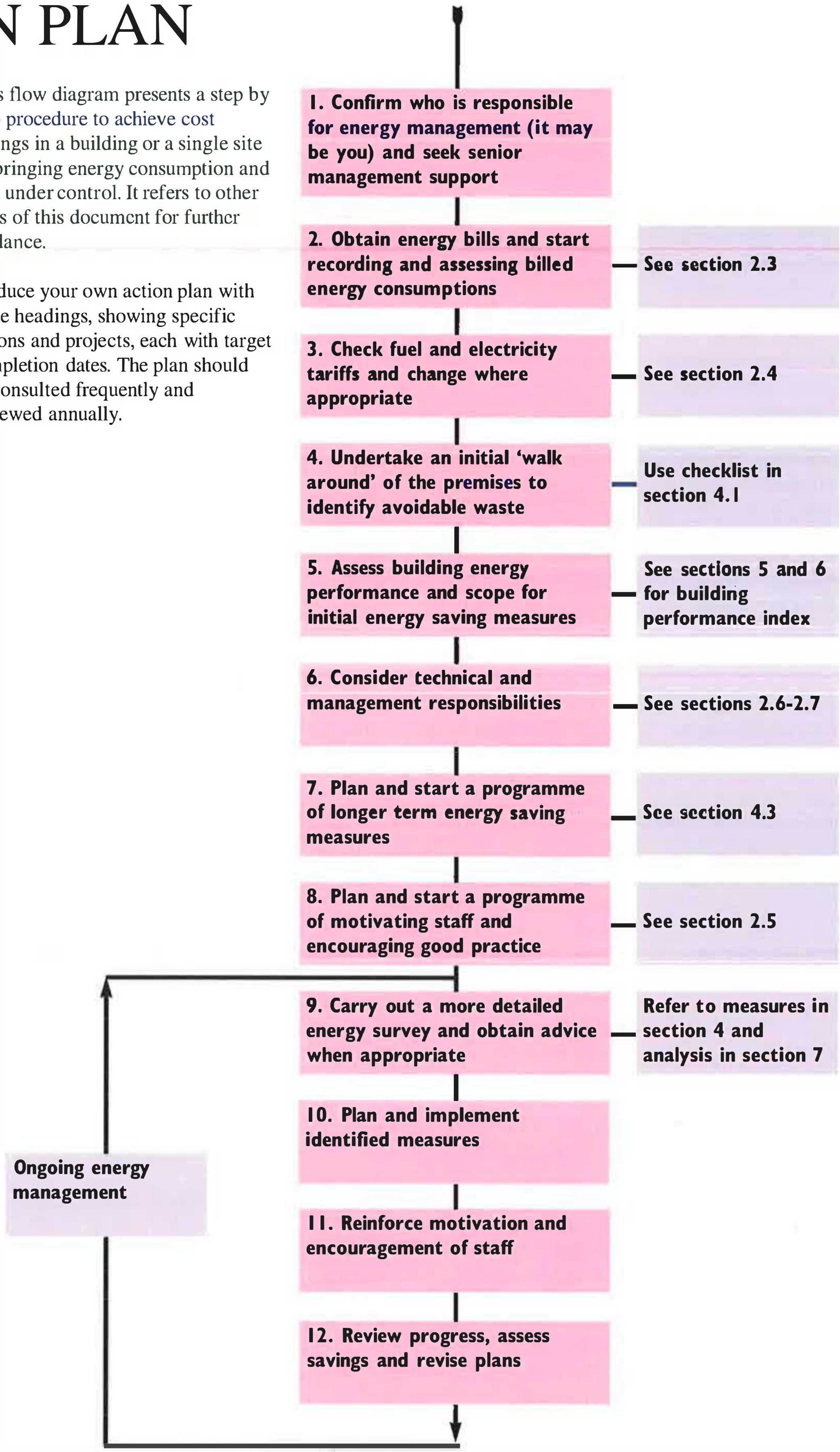
Choosing an Energy Efficiency Consultant (EEO).

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 buildings 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 customers and 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 when the building is not being used.
- 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.
- Investigate existing lighting controls to see if the hours of use of artificial lighting 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.

Catering

- Ensure that catering equipment is only being turned on when it is actually needed. Minimise pre-heat times and where possible switch off ovens early.
- Check that hot water is not wasted by continual open tap washing.
- Make regular checks to ensure that dishwashing machines are fully loaded before operation.

Controls

- Ensure all controls are labelled to indicate their function and, if appropriate, their new reduced settings.
- Establish responsibilities for control setting, review 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, humidistats and air quality sensors 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 13).
- Clean lamps and luminaires regularly and replace at the manufacturer's recommended intervals.
- Check that draft seals and door closing mechanisms are effective.

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
- 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 Guide 15
Energy efficient refurbishment of public houses

Energy Efficient Lighting in Buildings. 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.

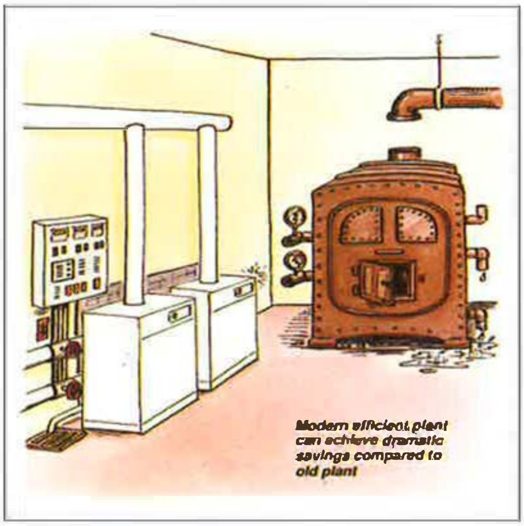
If energy-saving initiatives are taken during refurbishment or extension work, capital cost is often substantially reduced and interference with normal working practices is kept to a minimum.

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 or expertise is holding up promising measures, it may be worth considering contract energy management as described in section 2.9.

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.



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
- Sequence control: 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

- Separate the heating system into zones so that areas of the building with different heating requirements can be controlled separately.
- 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.
- Install set-back controls to enable heating/cooling to be reduced between shows.
- 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.

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.
- 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, and that it is used for the pre-cooling of spaces where appropriate.
- 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.
- Use ventilation controls based on carbon dioxide (CO_2) sensors to match ventilation rates to the level of occupation.
- 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.

LIGHTING

Good savings can be achieved by ensuring that the 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.

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.

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 older discharge lamps need control gear to strike up and maintain light output. Old 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 should be possible to control lights in each area of the building from local switches. Some automatic control may also help to reduce the length of time for which lights are left on.

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

Photographs supplied by Philips and Fitzgerald.

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

- 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.

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

Automatic 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.

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 resistive control gear in fluorescent fittings with electronic, high frequency ballasts.
- If light fittings are over 15 years old, replace with new efficient fittings and consider installing new lighting controls.
- Replace resistive dimming controls with more efficient electronic controls.
- Use metal halide or sodium discharge lamps for outside areas such as car parks.

Improve lighting controls, including:

- time controls for areas with regular patterns of use
- time controls or daylight detection controls for external lighting
- presence detection controls for areas which are infrequently used, such as stores.

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.

Compact fluorescent lamps

Caution: Insulation measures should be checked for condensation and water penetration risks.

BUILDING FABRIC MEASURES

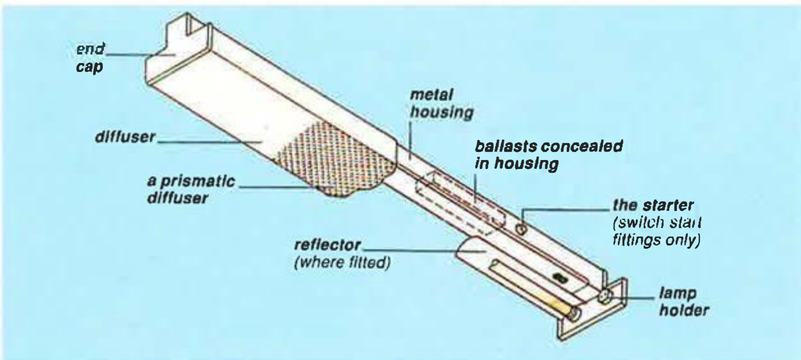
- Insulate roof voids.
- Draught proof around windows and doors.
- Fit door closers to front doors.
- Fit secondary glazing.
- Fit draught lobbies.
- Install cavity wall insulation or internal or external insulation.
- Reduce excessive glazing areas by replacing the glass with insulated wall panels.
- 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.

The parts of a fluorescent light fitting



5

ENERGY USE IN ENTERTAINMENT BUILDINGS

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 within an organisation 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 entertainment building helps to concentrate attention on priority areas, especially where the use of one of the fuels is particularly high.

5.2 Types of entertainment building and their energy use patterns

The guide covers four types of entertainment building: theatres, cinemas, social clubs and bingo clubs.

Multipurpose concert halls and civic centres are not specifically covered although their energy use may be similar to the buildings covered for comparable usage.

Figure 5.1 Typical energy costs in Entertainment Buildings

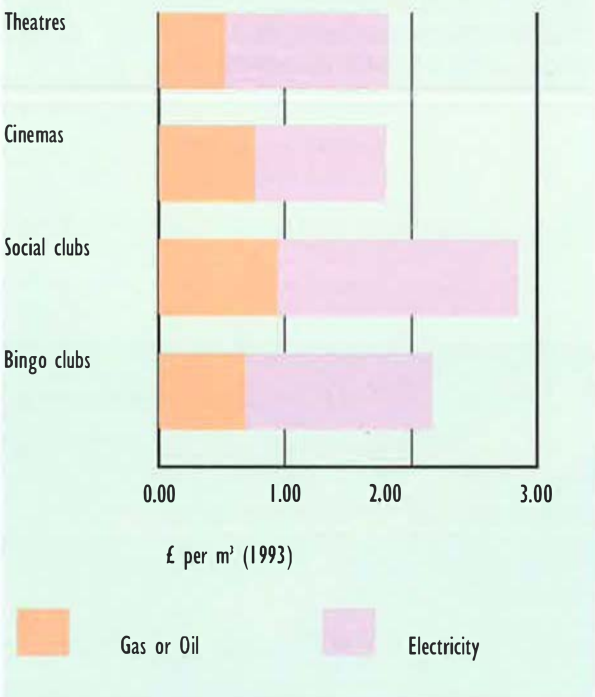


Figure 5.2 Typical energy cost breakdown of cinemas

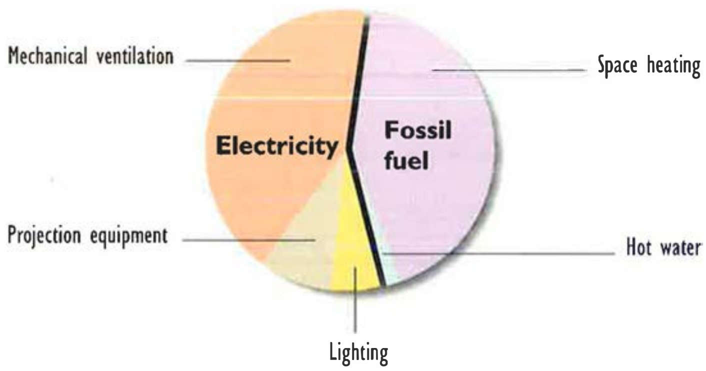
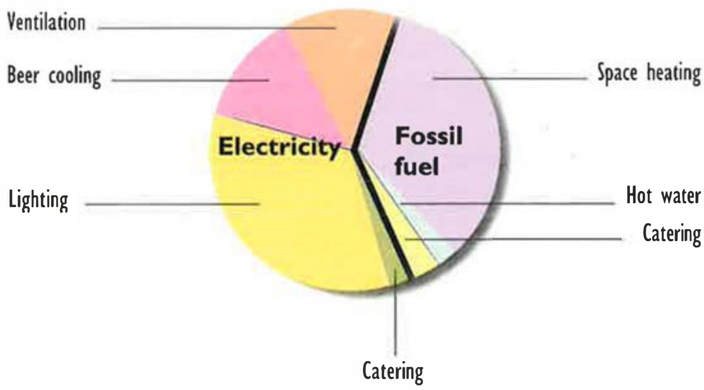


Figure 5.3 Typical energy cost breakdown for social clubs and bingo clubs



Energy costs

Figure 5.1 shows typical annual energy costs per unit volume for the four types of building covered in this guide.

These examples are for typical entertainment buildings. The good practice equivalents tend to use 20 to 40% less energy, mostly achieved by good management and simple measures. Still lower energy consumption is achievable in new buildings and major refurbishments.

Energy cost breakdown

Typical energy cost breakdowns by end use for cinemas and social and bingo clubs are shown in figures 5.2 and 5.3. The consumptions of energy for different purposes in any one building may be significantly different from the typical breakdowns given here.

The precise split depends upon the type of building and the extent and sophistication of equipment and services.

In theatres as well as cinemas a large proportion of the energy costs will be due to ventilation requirements. Lighting costs are likely to be higher in theatres than cinemas because of stage lighting.

These breakdowns are useful for identifying areas that you should concentrate on if one or both of the energy performance indices (see section 6) are high.

6

COMPARING WITH ACCEPTED STANDARDS - PERFORMANCE INDICES

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 of buildings.

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.

The performance indices are obtained by dividing the annual building energy use by the building volume or floor area. Yardstick values for the different building types are given in figures 6.2 and 6.3, 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 volume or floor area of the building in column 4.
4. Divide the energy use of each fuel by the figure in column 4 to get energy use per unit area (kWh/m²) or per unit volume (kWh/m³) 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 or 6.3 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).

The volume (or floor area) of the building

Use the volume of the parts of the building which are directly or indirectly heated, including corridors, toilets, and storage spaces. Take the total internal floor area of each hall bounded by the external walls, and multiply this by the average height of the hall. Exclude completely any unused or unheated areas such as basements and ceiling voids.

Alternatively the floor area of the building may be used as the basis of comparison. In this case the floor area of the auditoria in cinemas and theatres should be taken as the ground floor area ie excluding upper balcony and circle areas.

If the volume or area is available in units other than m³ or m² then apply the following correction factors:

To convert from	Multiply by to get m³
Cubic feet (ft³)	0.0283
Cubic yards (yd³)	0.765
To convert from	**Multiply by to get m²**
Square feet (ft²)	0.0929
Square yards (yd²)	0.836

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) or volume (m³) divide by	Column 5 Annual kWh/m² or kWh/m³
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 extensive catering facilities.

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 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 buildings with electric heating.

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 based on Building Volume

Performance Assessment - Energy use per m³

Low consumption: Less than | Medium consumption: Between | High consumption: Greater than

	Yardsticks in kWh/m³	Yardsticks in kWh/m³
Theatres		
Fossil fuels	28	42
Electricity	12	18
Cinemas		
Fossil fuels	47	56
Electricity	12	15
Social clubs		
Fossil fuels	37	67
Electricity	16	28
Bingo clubs		
Fossil fuels	40	49
Electricity	17	21

The performance yardsticks detailed in figure 6.2 are based on the volume of the building, because of the major variations in height and the large proportion of total energy used for space heating in entertainment buildings. Although volume is the preferred measure of building size, alternative yardsticks in terms of floor area are also provided for comparison with older building types or where the building volume is difficult to obtain.

Figure 6.3 Alternative Yardsticks Based on Floor Area

Performance Assessment - Energy use per m²

Low consumption: Less than | Medium consumption: Between | High consumption: Greater than

	Yardsticks in kWh/m²	Yardsticks in kWh/m²
Theatres		
Fossil fuels	420	630
Electricity	180	270
Cinemas		
Fossil fuels	515	620
Electricity	135	160
Social clubs		
Fossil fuels	140	250
Electricity	60	110
Bingo clubs		
Fossil fuels	440	540
Electricity	190	230

Note: the following average floor to ceiling heights have been used in deriving the yardsticks based on floor area.

Cinemas	11.0m
Theatres	15.0m
Bingo clubs	11.0m
Social clubs	3.8m

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.

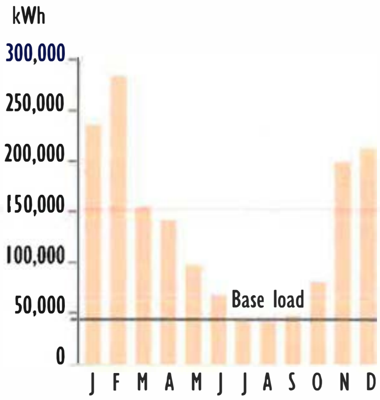
Larger sites have monthly energy bills. By looking at how these vary with the seasons some valuable insights can be obtained. Produce a monthly consumptions bar chart plot for each energy source over a year.

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.

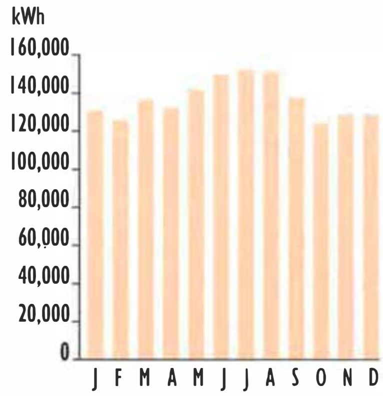
Example monthly fossil fuel use



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

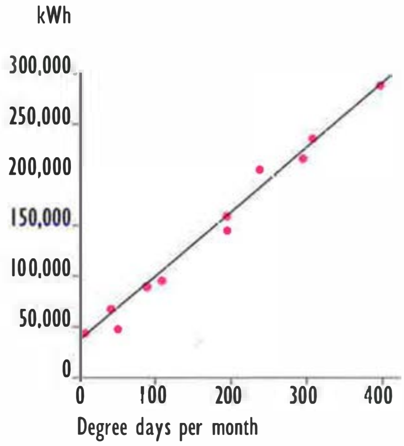


The figure above shows monthly electricity consumption. The increase in winter may be due to increased artificial lighting and/or electric heating. The summer increase is a result of energy use for air conditioning.

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 consumption 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).

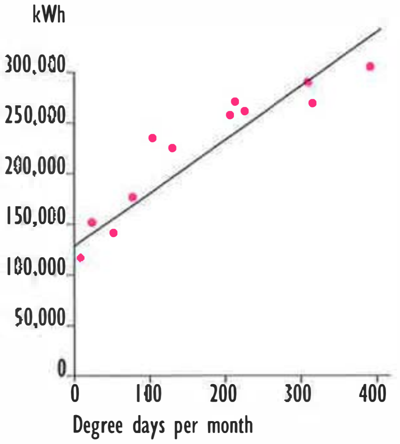
Example monthly heating energy use in a well controlled building



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.

8

CASE STUDIES

This section gives examples of buildings where energy saving measures have been implemented. The use of the Performance Index 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.

Heated volume = 65,640 m³	1983/84	1984/85
Fossil fuel consumption (kWh)	1,153,333	893,955
Fossil fuel Performance Index (kWh/m³)	17.6	13.6
Fossil fuel Performance Assessment	Low consumption	Low consumption

8.1 Leeds Grand Theatre and Opera House - energy saving from zoned heating with a modular boiler system

The Leeds Grand Theatre and Opera House was opened in 1878 and is one of the finest Victorian theatres in the country. The seating capacity is 1,554 with standing room for 80. It is a complex building with a vast auditorium and stage with an area of 9,000m², and a total building volume of 65,640m³. Backstage there are 19 dressing rooms, rehearsal rooms, a scenery painting room, and other auxiliary areas.

In 1969, the Grand Theatre changed from solid fuel to an oil-fired heating system. By 1983 the two oil-fired boilers were nearing the end of their useful life and their replacement offered an opportunity to reassess the design of the whole heating system.

The new heating system had to accommodate the differing requirements for temperature level and occupancy times between the various parts of the theatre building. The control of the system also had to be able to respond to rapid changes in internal conditions introduced by the influx of a large audience and the mixing of large volumes of air at different temperatures created when the curtain separating stage and auditorium rises.

Energy efficiency measures

A gas fired modular boiler system, fitted with modern heating controls was adopted as the scheme most likely to meet these special requirements.

1. The two large oil-fired boilers were replaced by a gas-fired modular boiler rated at 645 kW to provide space heating. The 7 boiler modules were fitted with individual pumps to ensure that on low load water only circulates through those boilers that are actually firing. In addition, a 37 kW gas-fired boiler was provided to meet the hot water service requirements via an existing calorifier.

2. The main theatre space-heating system was divided into 7 zones, each with its own thermostat, to provide for the differing heating requirements.

3. A step controller provides weather compensation with an outside temperature sensor and an internal sensor on the return water flow to the boiler module. Two time switches give programmed time control for the seven separate heating circuits.

Energy Savings

The introduction of a modular boiler system with zoned heating controls has resulted in a 22% saving in fossil fuel energy consumption. The improved performance index of 13.6 kWh/m³ is considerably better than the fossil energy yardstick of 28 kWh/m³ which represents a low consumption level for a theatre.

8.2 Odeon Cinema, Leicester

The Odeon Cinema at Leicester, operated by The Rank Organisation, comprises three auditoria obtained by internal division of the original circle and front and back stalls of an old-style Odeon. The largest of the three auditoria seats approximately 1,200 people and the two small auditoria have 110 seats each. Programmes run almost continuously from 1.00 pm to 10.30 pm each weekday, although occupancy varies according to the films showing and the day of the week. The total heated volume of the cinema is 17,686m^3.

Heating is provided by two 440 kW oil-fired boilers which supply a heater battery in the full fresh air ventilation system. This supplies most of the space heating load but there is also a radiator circuit for background heating.

Before the installation of ventilation control with carbon dioxide (CO_2) sensing in December 1983, neither the warm air system nor the radiator circuit had any thermostatic controls and the ventilation fans were switched on and off manually. Thus there was no means of matching ventilation rate to occupancy. In cinemas, where the level of occupancy can vary considerably, a constant ventilation rate results in excessive fresh air supply for much of the time with consequent wastage of heating fuel.

A recirculation system was not considered practicable at this cinema due to the distance between supply and exhaust air systems.

The 'Building Breathaliser'

An electronic control unit senses the concentration of carbon dioxide in the air approaching the extract fan from the auditorium and this is directly related to the occupancy level. An output signal from the controller can be made to operate the dampers and control the rate of ventilation.

Effective temperature control is essential in order to realise fuel savings from monitoring of the CO_2 levels. Temperature sensors were fitted in the inlet and extract air ducts and linked to the heater battery via a control panel. In addition, thermostatic radiator valves were fitted to the radiator circuit.

The current fresh air requirement of 28m^3/hour/person in places of public entertainment can be achieved in CO_2-controlled ventilations systems by a control setting of approximately 1,000 parts per million CO_2 concentration.

A similar project has also been successfully undertaken at the bingo and social club operated by The Rank Organisation at Hounslow.

Annual energy and cost savings

Annual oil consumption was reduced by 7,847 litres (83,177 kWh), an energy saving of 13%.

Cost savings and payback

Installation cost (Dec. 1983)	£6,073
Fuel savings 83,177 kWh @ 1984/85 prices	£1,763
Simple payback period on installation	3.4 years
Estimated maintenance costs	£230/year

Substantial savings can be expected where CO_2-controlled ventilation is applied in public and commercial buildings with forced ventilation systems, particularly those with variable occupancy.

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 entertainment buildings are listed are.

Good Practice Guides give advice on how to implement energy saving measures. Relevant titles available are as follows:

15 Energy efficient refurbishment of public houses

71 Selecting air conditioning systems

84 Managing and motivating staff to save energy.

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

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

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

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 buildings (1992). 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, building societies 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 Tel: 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.

Figure A1.3 Carbon dioxide and cost yardsticks

CO_2 Performance Assessment

	Low Emissions Less than	**Medium Emissions** Between	**High Emissions** Greater than
	Yardsticks in kg CO_2/m^3	Yardsticks in kg CO_2/m^3	
Building type			
1. Theatres	14	21	
2. Cinemas	18	22	
3.Social clubs	19	33	
4. Bingo clubs	20	25	

Cost Performance Assessment

	Low Cost Less than	**Medium Cost** Between	**High Cost** Greater than
	Yardsticks in £/m^3	Yardsticks in £/m^3	
Building type			
1. Theatres	1.2	1.9	
2. Cinemas	1.5	1.8	
3. Social clubs	1.7	2.9	
4. Bingo clubs	1.8	2.2	

CO_2 and cost yardsticks are based on factors given in figures A1.1 and A1.2

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.

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 and must be adjusted. But if you choose to normalise, be aware of introducing errors.

Figure A.1.4 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 volume or floor area				m^3 or m^2 (N)		
Find the Normalised Performance Indices = M ÷ N =				kWh/m^3 or 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 A.1.6 Occupancy Factors

	Factor for heating energy (G)	Factor for non-heating energy (K)
Normal building occupancy:		
Theatres (7 days, 8 hours per day)	1.00	1.00
Cinemas (7 days, 8 hours per day)	1.00	1.00
Social clubs (7 days, 8 hours per day)	1.00	1.00
Bingo clubs (7 days, 10 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

DEPARTMENT OF THE ENVIRONMENT

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