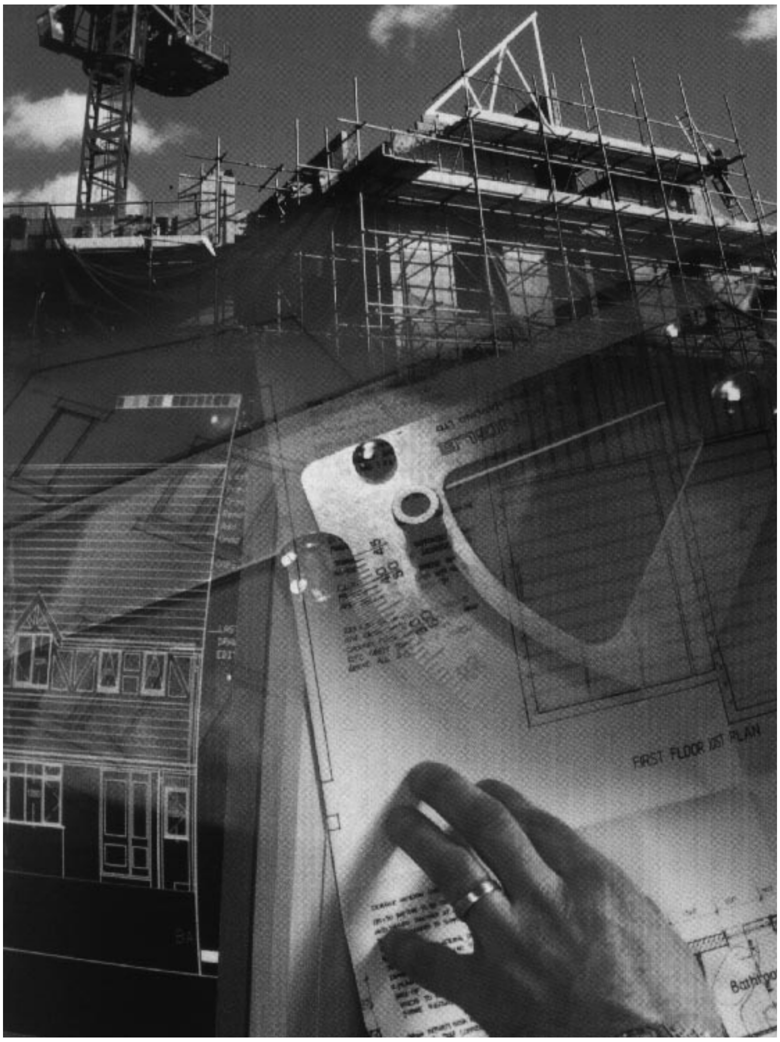
ENERGY CONSUMPTION GUIDE 54

Energy efficiency in further and higher education

– cost-effective low energy buildings



- Assess energy performance and identify savings
- Achieve major reductions in fuel bills
- Improve comfort for students and staff
- Reduce impact on the environment

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

ENERGY CONSUMPTION GUIDE 54

CONTENTS

1 INTRODUCTION

This Guide provides a method for assessing energy usage and costs in a range of academic and residential building types found in the further and higher education sector.

It is primarily intended for use by estates personnel who are actively involved in the management of energy. It will also help senior managers to understand the role that energy plays in the operation of their institution.

The Guide discusses factors which have a significant impact on energy consumption in academic and ancillary buildings and space functional types and quantifies their saving potential. It also describes ways of assessing campus/site energy performance and the potential for making savings.

Advice on how to realise the benefits of energy efficiency is provided by four inserts inside the back cover. These focus on:

- fabric and building form
- management strategy
- energy purchasing
- services.

The University of Wales at Cardiff

THE SECTOR

The further and higher education sector in the UK includes some 200 universities and 550 colleges of further education. The wide range of building types, user occupancy patterns and research activities provides a challenge for the energy manager.

In England alone annual energy costs for the sector total more than £200 million, resulting in the release of at least 3 million tonnes of carbon dioxide (CO_2) into the atmosphere.

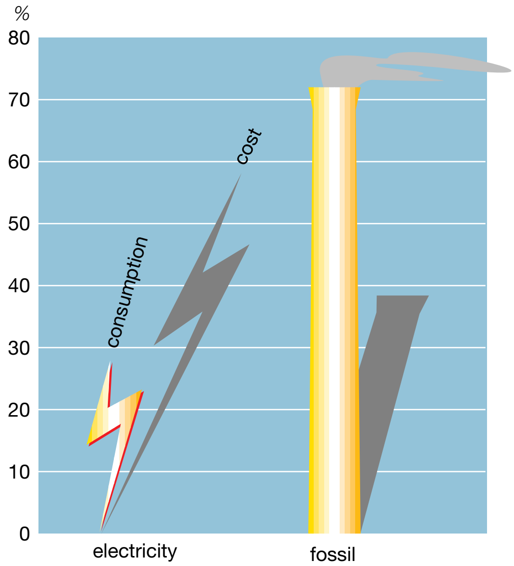
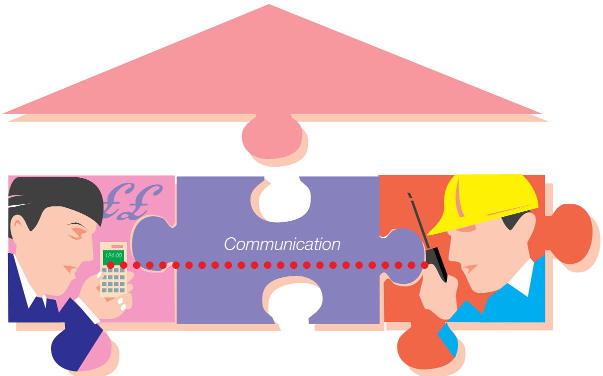


Figure 1 Comparison of energy costs and consumption for electricity and fossil fuels

Annual energy costs per institution range from under £200 000 to over £3 million, and generally account for around 25% of building-related revenue spend. This is a sizeable portion of any estates budget. It is also potentially one of the most controllable.

2 REALISING THE POTENTIAL



Reducing energy consumption not only reduces costs, but helps to minimise the environmental impact of an institution by reducing emissions of CO_2 and other gases associated with global warming.

Responsibility for energy consumption and cost needs to be shared by all those involved in its use. However, it is normally necessary to give a senior members of the organisation overall responsibility for energy. Where this is so, the cost of energy is often handled by the finance department, while energy use is the responsibility of the estates department. Monitoring and controlling energy consumption and cost are two aspects of energy management which are inter-dependent, so good lines of communication are essential.

Reducing the energy cost associated with operating a building is possible each time a project is implemented. New build offers the greatest potential for investing in energy efficiency, but even basic maintenance activities have a part to play in reducing costs.

Energy efficiency checklist

- ✔ Collect electrical and fossil fuel use and cost data for at least a year
- ✔ Survey all significant buildings to arrive at gross floor areas for each functional space type
- ✔ Compare your building stock benchmarks on page 9 and calculate your potential fuel consumption
- ✔ Evaluate your buildings and try to identify any features or characteristics that might cause energy consumption to be out of the ordinary, either particularly high or low
- ✔ Install sub-meters and data acquisition links to check the level and profile of energy consumption, particularly for those buildings of the estate that appear to have high usage figures
- ✔ Review information and data on a regular basis to establish trends
- ✔ Prioritise energy efficiency measures to provide the best value for money
- ✔ Exploit all opportunities to implement cost-effective energy efficiency measures. Many maintenance projects provide potential for incorporating more energy efficient systems as well as refurbishment and new build.
- ✔ Employ simple solutions which can often be effective without the potential operational burden of more complex technologies
- ✔ Refer to guidance material, canvas the opinions of your peers and, if appropriate, seek professional advice

Case studies show that for typical buildings in this sector energy costs can be reduced by as much as 25% without major capital expenditure. Focusing appropriate measures on the most receptive building types will help to maximise potential savings.

UNDERSTANDING ENERGY USE

A realistic assessment of typical and potential energy consumption levels for a project is needed to provide a sound base for investment appraisal.

Understanding where energy is consumed and identifying waste are significant steps towards making reductions in fuel bills. Some key points that will help to formulate a structured approach to energy efficiency are provided in the checklist below.

Designing for energy efficiency

In any project the starting point for achieving energy efficiency is the initial brief prepared by the client. This should maximise the potential savings and ensure that all possibilities are considered.

Commissioning a design team with a good track record in low energy buildings will help in achieving these objectives. Guidance on developing an energy efficient brief is available in Good Practice Guide 74 'Briefing the design team for energy efficiency in new buildings' (GPG 74).

As well as providing cost and environmental benefits, pursuing a low energy design can lead to a more comfortable working environment and more satisfied occupants.

Evaluating energy efficient options is a balance of technical, financial and strategic issues. Taking a short-term view may rule out many measures. As an owner-occupier it is likely that buildings will be retained within the institution's estate for the medium- to long-term, and this view should be adopted for option evaluation purposes.

There are many strategies for producing a low energy building. The choice of approach is influenced by a variety of factors concerning both site and building use.

3 FACTORS INFLUENCING PERFORMANCE

BUILDING FACTORS

It is necessary to understand the types of building and categories of space on a college or university campus in order to evaluate potential energy usage.

Often, buildings have been significantly modified from their original design both in terms of fabric and services. This is symptomatic of a long-term owner-occupier culture, and can result in a mixture of buildings with no clear energy characteristics.

A building's characteristics can play an important part in focusing attention on possible energy efficiency measures.

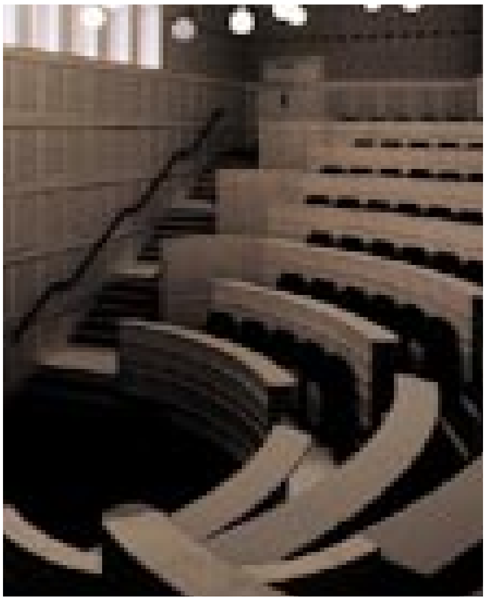
Using representative space types for the wide range of activities contained within a campus (see table 1 overleaf) is useful for evaluating the site's overall energy performance and also for focusing on areas with the greatest potential for savings. If the data is available to allow meaningful separation of functional space types, a more detailed evaluation is possible. Representative space types, however, can still be a valuable tool for carrying out an initial evaluation.

The categories used in the table are comparable with those developed for the Higher Education Funding Council for England's (HEFCE's) 'Value for Money' initiative.

PEOPLE FACTORS

How the occupants use a building or space can have quite an impact on energy consumption. The duration and nature of the period of occupation will affect consumption, as will the allocation of control responsibility.

North-facing room for study



Lecture theatre at the University of East Anglia

Occupied period

The longer a space is in use, the greater the potential for energy usage and waste. This relationship, though, is not always straightforward.

In a lightweight construction with extensive glazing, typical of 1960s' buildings, extended occupancy can lead to a marked increase in heating costs, because the buildings are usually poorly insulated. Extended heating is required to maintain the required comfort conditions. However, with thermally heavy construction, such as in many Victorian buildings, the heating system requires a lot of fuel to warm up the building. Maintaining comfort conditions will have less impact on energy consumption, whether the building is occupied for long periods or not.

Although the control of most fossil fuel consumption is out of the hands of a building's users, electricity consumption is associated mainly with user activities and thus has a closer relationship with occupancy duration. The method of control is particularly relevant to this area.

Type of occupancy

The density and nature of the occupied period is relevant to how an area is serviced and the resulting energy usage.

FACTORS INFLUENCING PERFORMANCE

Dense, transient occupancy, for example in refectories, can require more energy intensive services such as mechanical ventilation or even comfort cooling. However, it is possible to detail these spaces to function passively and minimise the energy required to maintain comfort conditions.

Long duration sedentary occupation, such as in resource centres and tutorial rooms, presents different challenges depending on the space provision per person. Low density occupancy can be handled with basic background heating only, while dense occupancy often requires mechanical air movement which is far more energy intensive.

Control responsibility

Many of the space types found on campus, such as libraries, lecture halls and refectories, are supervised in such a way that the occupant has little, if any, control over energy usage.

In other spaces, such as study bedrooms, single occupancy offices and tutorial rooms, virtually all energy use is under the control of the occupant.

Having the most appropriate control strategy for each space is essential. It is also important that the operation of the controls is fully understood by the building user.

Generic space type	Areas covered	Occupancy characteristics
Teaching	Classrooms Tutorial areas Seminar rooms	Variable occupancy pattern, some transient periods but generally medium- to long-term use
Research	Laboratories Workshops	Variable occupancy pattern Potential for high process loads
Lecture hall	Lecture theatres Halls	Dense occupancy for mid- to short-term. Large room volumes with mechanical ventilation and additional specialist electrical loads
Library	Resource centres Reading rooms	Long-term occupancy, some at high density. Increasing use of computer terminals along with traditional book-based study
Office	Administration Department offices	Mainly cellular space with single occupancy. Natural ventilation and local control much in evidence
Catering	Central kitchen Refectories, Canteens Common rooms Bars	Staff areas tend to be long-term, low-density occupancy whilst the public spaces are subject to transit use which can be high density
Recreational	Sports halls Swimming pools	Large volume spaces with occasional short-term high-density occupancy as well as more regular low-density use
Residential	Study bedrooms En-suite bathrooms Shared ablutions and catering facilities	Domestic usage pattern with long-term local occupancy of some areas

Table 1 Representative space types and their characteristics

4 ASSESSING PERFORMANCE

The broad range and mix of space and building types found in colleges and universities make it unwise to give a single set of targets to cover all institutions. The space types in tables 1 and 2 make up most of those on a typical campus. However, not every institution will contain all these elements and the weighting for those space types present will need to be adjusted.

Target consumption figures are provided in table 2, along with the sector averages for their contribution to the typical higher education campus.

The steps required to evaluate the institution's energy performance are summarised in Figure 2 overleaf.

The chart features three levels of self-assessment depending on available consumption data:

- **Level 1** based on gross academic and residential floor areas, gives an initial overview of college energy performance.
- **Level 2** provides greater insight into the energy usage pattern of academic areas, thereby highlighting the greatest potential for savings within an area.
- **Level 3** depends on the availability of detailed space and energy use data for building types, such as offices and bars, which are addressed directly by other Energy Consumption Guides (see Further Information on page 10).

Space Type	% of average higher education campus	Electrical target (kWh/m^2)	Fossil target (kWh/m^2)
Teaching	25	22	151
Research	20	105	150
Lecture hall	5	108	412
Office	30	36	95
Library	10	50	150
Catering	2.5	650	1100
Recreational	7.5	150	360
Total academic	100 of academic (75% of total)	75	185
Residential	100 of residential (25% of total)	85	240

Table 2 - Annual target consumption figures (typical higher education campus) for representative space types

ASSESSING PERFORMANCE

Obtain electrical and fossil fuel consumption figures for one year

Level 1

Do you know the gross floor areas for your residential and academic building stock?

Can you further disaggregate your academic building area by functional space categories?

Level 2

Compare your percentages to the sector averages and fill in any blanks and adjust to summate to 100%

Calculate the overall yardstick by weighting each category-specific yardstick in accordance with your blend of space types

Level 3

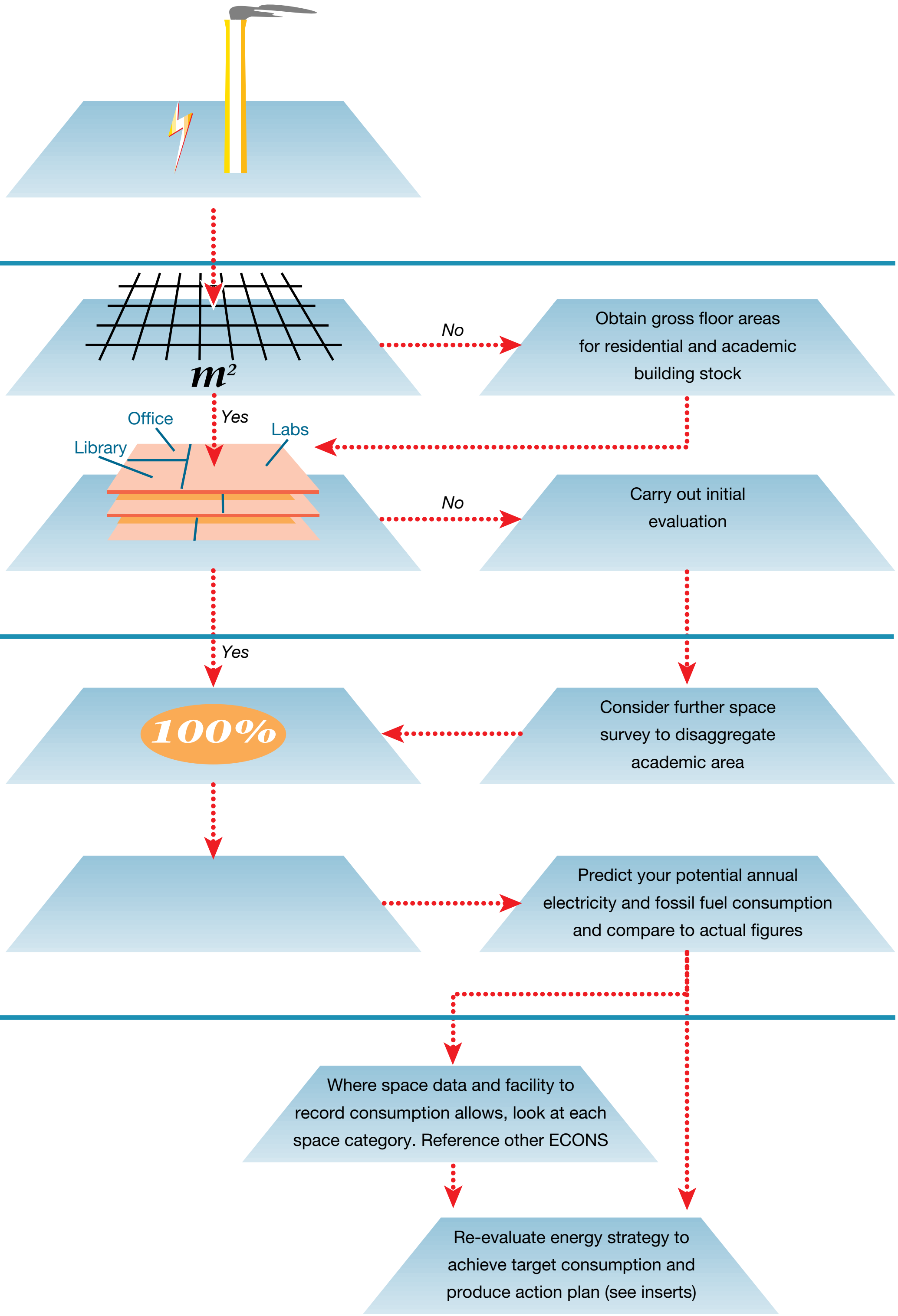


Figure 2 Steps to self assessment

ASSESSING PERFORMANCE

Initial evaluation

Following the route suggested in figure 1 and using the data to complete table 3 provides an initial overview of energy performance.

Where energy consumption is higher than the target, the initial evaluation will not enable the institution to identify academic areas or functions where the use of energy is excessive so the **Level 2** aims to provide a greater insight into the pattern of energy usage.

Second level of evaluation

For **Level 2**, academic space data is broken down into functional space categories. Table 4 shows examples of benchmarking consumption using sector advantages. The figures shown in blue are sector averages and should be used for comparison.

Electricity benchmarking			
		Yardstick	*Target*
Gross academic floor area	*m²k*	*kWh/m²*	*kWh*
Gross residential floor area	*m²k*	*kWh/m²*	*kWh*

Fossil fuel benchmarking			
		Yardstick	*Target*
Gross academic floor area	*m²k*	*kWh/m²*	*kWh*
Gross residential floor area	*m²k*	*kWh/m²*	*kWh*

***Table 3** Using gross academic and residential floor areas provides an initial overview of energy performance*

Electricity benchmarking (example using sector averages)			
Space/category	**% area**	**Category specific yardstick (kWh/m²)**	**Weighted component for overall yardstick**
Office	30	36	11
Library	10	50	5
Catering	2.5	650	16
Sports	7.5	150	11
Lecture theatre	5	108	5
Laboratory	20	105	21
Teaching	25	22	6
		Calculated overall yardstick (kWh/m²)	75

Fossil fuel benchmarking (example using sector averages)			
Space/category	**% area**	**Category specific yardstick (kWh/m²)**	**Weighted component for overall yardstick**
Office	30	95	29
Library	10	150	15
Catering	2.5	1100	28
Sports	7.5	360	27
Lecture theatre	5	412	21
Laboratory	20	150	30
Teaching	25	151	32
		Calculated overall yardstick (kWh/m²)	182

***Table 4** Examples of benchmarking electricity and fossil fuel consumption using sector advantages*

FURTHER INFORMATION

SOURCES OF ADVICE

Regional Energy Efficiency Officers (REEOs)

REEOs provide a local point of contact, source of information and support.

Scotland	0131 244 7130
Wales	01222 823126
North East	0191 202 3614
Yorkshire and Humberside	0113 283 6376
North West	0161 952 4282
East Midlands	0115 971 2476
West Midlands	0121 212 5300
Eastern	01234 796194
South West	0117 900 1700
South East	01483 882255
Northern Ireland	01232 529900

Energy Design Advice Scheme (EDAS)

EDAS offers support to design teams or clients in the energy aspects of new buildings or refurbishment projects. The scheme pays for an initial one-day consultancy and advice may then be offered, and a proportion of these costs can be reimbursed by the scheme.

Regional Centres are:

Scotland	0131 229 7545
South East	0171 916 3891
Northern Ireland	01232 364090
Northern	01742 721140

Local Energy Advice Centres

Smaller businesses can obtain free independent advice from Local Energy Advice Centres in the UK. For further details contact the Energy Savings Trust, telephone 0171 931 8401.

Energy Systems Trade Association (ESTA)

This is a trade association of suppliers of services and equipment for improving energy efficiency (including energy consultants, heating, ventilation and air conditioning, boilers, lighting, control equipment, metering and monitoring, building energy management systems, contract energy management, CHP and heat recovery).
Telephone: 01453 873568.

DOE ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Energy Efficiency Best Practice programme (EEBPp) publications are available from BRECSU Enquiries Bureau. Contact details are on the back cover.

Energy Consumption Guides

10 Energy efficiency in offices. Energy consumption guide for senior managers
19 Energy efficiency in offices. A technical guide for owners and single tenants

General Information Leaflets

1 Condensing boilers in non-domestic buildings. The success of condensing boilers in non-domestic buildings – a user study
6 Energy efficiency in lighting. Energy efficiency in office lighting

General Information Reports

12 Aspects of energy management. Energy management guide
13 Reviewing energy management
14 Energy management of buildings including a review of some case studies

Good Practice Case Studies

150 Energy management. Manchester University
333 Energy management practices in further education, Southwark College of Further Education – a low-cost pragmatic approach
334 The benefits of including energy efficiency early in the design stage – Anglia Polytechnic University
335 Investment in energy efficiency at the University of Warwick (in press)
336 Energy efficiency in further and higher education – Monitoring and targeting, University of Wales, Cardiff

Case Studies in the ‘Energy efficiency in offices’ series (GPCS 13-21) and the ‘Energy efficiency in mixed use business space’ series (GPCS 105, 107, 118, 119, 132) may also be useful.

(continued on page 12)

The pocket of this Guide contains the following inserts:

Fabric and building form
Strategic management issues
Energy purchasing
Services issues

FURTHER INFORMATION

DOE EEBPp continued

DOE ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

Good Practice Guides

27 Energy audit and survey guide: for commercial and industrial buildings. Energy audit and survey guide: for building financiers and senior managers
28 Energy audit and survey guide: for commercial and industrial buildings. Energy audit and survey guide: for building managers and engineers
33 Energy efficiency in offices. Understanding energy use in your office
34 Energy efficiency in offices. A guide for the design team. Energy efficient options for new offices for the design team
35 Energy efficiency in offices. A guide for the design team. Energy efficient options for refurbished offices
46 Energy efficiency in offices. Heating and hot water systems in offices
71 Selecting air-conditioning systems. A guide for building clients and their advisers
74 Briefing the design team for energy efficiency in new buildings
192 Multi-residential design guide (in press)
207 Further and higher education – cost-effective low energy buildings (in press)

New Practice Final Report

80 New low energy multi-residential accommodation. Constable Terrace, University of East Anglia

OTHER PUBLICATIONS

The following publications are available from the Chartered Institution of Building Services Engineers (CIBSE), Delta House, 222 Balham High Road, London SW12 9BS.

AM3 Condensing boilers (1989)
AM5 Energy audits and surveys (1991)
AM6 Contract energy management (1991)
LG5 Lighting Guide - Lecture, teaching and conference rooms (1991)
CIBSE Code for Interior Lighting (1993)

The Government's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at **www.energy-efficiency.gov.uk**
Call the Environment and Energy Helpline on **0800 585794**

For further specific information on:

Buildings-related projects contact:
Enquiries Bureau
BRECSU
BRE
Garston, Watford WD25 9XX
Tel 01923 664258
Fax 01923 664787
E-mail brecsuenq@bre.co.uk

Industrial projects contact:
Energy Efficiency Enquiries Bureau
ETSU
Harwell, Oxfordshire
OX11 0RA
Tel 01235 436747
Fax 01235 433066
E-mail etsuenq@aeat.co.uk

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy-efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.

FABRIC AND BUILDING FORM

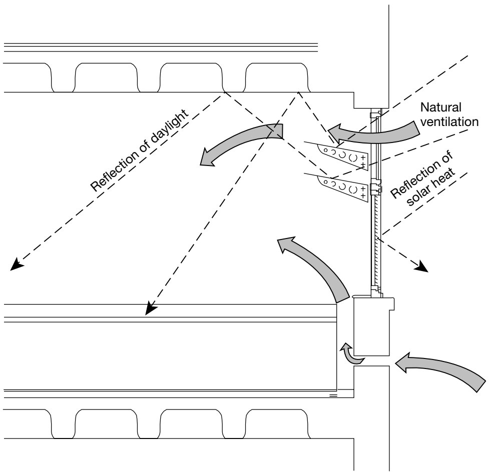
An energy efficient project should be designed so that the orientation, layout, insulation, and services systems work together. While providing an adequate environment, an integrated design maximises cost-effectiveness in construction and minimises fuel costs. BS 8207 Code of Practice for Energy Efficiency in Buildings (1985) sets out an approach. A useful tool to assist the client and their professional is Good Practice Guide 74 'Briefing the design team for energy efficiency in new buildings' (GPG 74).

ORIENTATION

Consider access to daylight and sunshine, protection from winds, access to services, public transport, redevelopment of existing buildings, impact on local environment, and planning restrictions. If the site is predetermined then consider the above issues in terms of building location.

LAYOUT

The shape of the building is important in determining the rate of heat loss through the fabric, although it is only one element of the total energy consumption of a building. Buildings which require mechanical ventilation or permanent artificial lighting will consume large amounts of energy, whatever their shape.



Caption???????????????

The layout and configuration of internal spaces can have a significant effect upon the occupant's experience and the energy consumed. External influences such as daylight, sunshine, heat loss, noise, wind and privacy need to be considered. Windows should preferably face south, east and west to benefit from solar heat gain. East- and south-facing windows receive sun earlier which can warm the building for most of the day. West-facing windows provide evening warmth but they may be difficult to shade in the summer months. A more detailed analysis of the optimum window area can be obtained from the CIBSE Window Applications Manual and the Lighting and Thermal (LT) Method.

INSULATION

All external elements of buildings should be insulated to produce an integrated insulation envelope. Particular attention should be paid to avoiding thermal bridging.

Case study

QUEENS BUILDING, DE MONTFORT UNIVERSITY

The Queens building at De Montfort University has a highly insulated, thermally massive envelope with a shallow plan and generous ceiling heights to promote natural ventilation and daylighting. Summertime temperatures are limited by exposure of the building's thermal mass and night-time ventilation. Using the building fabric, high-efficiency building services and responsive control systems has resulted in energy consumption in the first year of operation being about half that for a typical sector building.

This page forms part of Energy Consumption Guide 54 (ECON 54), 'Energy efficiency in further and higher education', produced by BRECSU as part of the Department of the Environment's Energy Efficiency Best Practice programme. For further information on building-related topics contact: Enquiries Bureau, BRECSU, Building Research Establishment, Garston, Watford, WD2 7JR. Tel 01923 664258. Fax 01923 664787. E-mail brecsuenq@bre.co.uk

FABRIC AND BUILDING FORM

External walls
Masonry walls constructed with fully filled cavity insulation are likely to be the lowest cost option for energy efficient buildings and provide adequate resistance to rain penetration, except in very severe exposure areas. Other wall constructions – partial fill, wide internal insulating blockwork and timber frame construction can all produce reliable, well-insulated walls, although costs may be higher.

Roofs and ceilings
Roof insulation to a thickness of 150 mm is already widely used. Increasing to 200 mm involves small additional cost. The insulation should be laid in two layers, one between and up to the top of the joists, the second across the joists, to reduce thermal bridging. A gap at the eaves ensures a free ventilation path and allows moisture to disperse, preventing condensation.

Floors
Heat loss through ground floors (suspended and solid) depends on the size and shape of the floor as well as the type and conductivity of the ground below the floor. Insulation of 50 mm thickness gives a good standard for most floor types. A method for the calculation of ground floor U-values is given in BRE IP 3/90.

Windows
The 1995 Approved Document L of the Building Regulations allows window areas of up to 30% of the exposed wall area, providing the windows are double glazed and have a U-value no greater than 3.3 W/m^{2}K. Larger window areas can be included in a design if higher performance windows are used.

Gaps between panes of up to 20 mm are recommended for minimising heat loss. A space of at least 20 mm is also desirable for maximum sound insulation. However, the larger the gap the higher the cost of the window, and gaps of 12 mm usually provide an acceptable level of insulation.

Thermal bridging
Thermal bridges occur when all the main elements of the structure are insulated, but there are local poorly insulated pathways from the outside to the inside of the building. In a well-insulated building these may be significant in heat loss terms (about 10%). Equally important are the effects of condensation and the marking and discolouration of decorations. Further information on preventing thermal bridging is available in the NHBC guide 'Thermal insulation and ventilation', the BRE publication 'Thermal insulation: avoiding risks' and Department of the Environment detail guides.

Air leakage
Air leakage provides some background ventilation but is uncontrollable and, under cold windy conditions, can give rise to excessive heat loss. The aim should be to minimise background air leakage (uncontrollable ventilation) and provide controllable ventilation by means of trickle ventilators and, when required, mechanical systems.

CONSTRUCTION AND HANDOVER
For a project to achieve its energy efficient potential, the client and user need a building that has not only been well designed but has been completed and handed over with the same attention to detail.

Most energy efficient features of a building do not involve unique or unfamiliar forms of construction, but they do rely on attention to detail. It is wise to ensure that the design documents not only provide the contractor with technical guidance on the installation but also on the operating intent and the rationale of any novel features.

During the construction stage it is essential that adequate provision is made to inspect the installation and verify that the design intent and performance targets are being met. Regular communication between all parties concerned will minimise potential problems.

Use of verification techniques enables straightforward and accurate checking of the design and construction standard of any heated building. Infrared thermographic surveys, U-value test and infiltration rate tests can be useful.

STRATEGIC MANAGEMENT ISSUES

To obtain the maximum financial, environmental and building quality benefits from energy efficiency it is necessary to take an organisation-wide strategic approach. Ideally this should involve six key activities:

- policy
- organisation
- motivation
- information systems
- marketing
- investment.

These activities are inter-linked and frequently mutually supportive. A generic approach to strategic energy management is described in a number of Best Practice documents (eg GPG 200). This insert relates the general principles to the further and higher education sector.

POLICY

To be effective an energy policy should be developed through consultation and formally published. The policy should set general objectives to be achieved within a realistic time frame.

It is proposed to reduce the university's energy bill by 15% over three years up to July 2000, by implementing no-cost and low-cost measures, combined with a comprehensive monitoring and targeting scheme and updating the building energy management system.

The policy should allow for future developments and establish the principle of setting energy and environmental targets for all new buildings and refurbishment projects. In this way it should have a strong link to the estates strategy.

The policy should be produced by a team representing estates, academics and technical support functions and should include the person with responsibility for energy management. The policy can form the introduction to a more comprehensive strategy document which addresses the other five areas identified above. Either way, it should be reviewed annually when specific action plans should be formulated and associated budgets agreed.

ORGANISATION

Successful organisation for achieving energy efficiency requires:

- effective management
- appropriate reporting structures
- adequate resources.

The appointment of an energy manager or the designation of energy management duties to an individual or department will not in itself achieve long-term benefits. The energy management function needs to be properly integrated into the structure of the organisation and it should have adequate resources to implement action plans. In institutions of further and higher education this means that the energy manager must have access to the finance department with authority to review invoices for energy (and water), preferably before they are paid, and a key role in the negotiation of fuel supplies. If finances for residences are dealt with separately, then equivalent access and authority is necessary.

Many estates departments are divided between the day-to-day management (operations) and future developments. The energy management function is typically located in the former, but it must have access to, and influence over, the latter, if the efforts expended on the existing building stock are not to be undermined by inefficient new projects.

The energy manager must have access to sufficiently senior management to ensure that the energy efficiency perspective is considered in all situations where benefits can be obtained. Such access can be achieved either by the energy manager sitting on a range of committees, or probably more effectively by the formation of an energy and environment committee which draws in interested representatives from other committees.

This page forms part of Energy Consumption Guide 54 (ECON 54), ‘Energy efficiency in further and higher education’, produced by BRECSU as part of the Department of the Environment’s Energy Efficiency Best Practice programme. For further information on building-related topics contact: Enquiries Bureau, BRECSU, Building Research Establishment, Garston, Watford, WD2 7JR. Tel 01923 664258. Fax 01923 664787. E-mail brecsuenq@bre.co.uk

STRATEGIC MANAGEMENT ISSUES

MOTIVATION

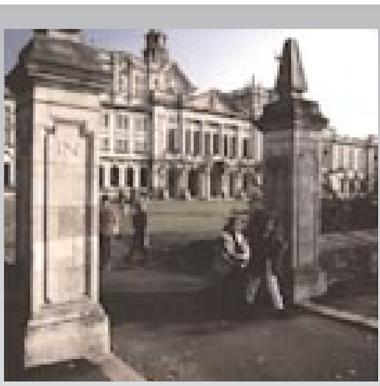
Significant amounts of energy (and hence money) can be saved by simple good housekeeping measures. These often rely heavily on the cooperation, interest and enthusiasm of staff and students. It is therefore important to keep them informed about the energy efficiency campaign, its benefits and the role they play in achieving the objectives. This can usually be best achieved by regular meetings with user groups and through user involvement in energy and environment committees. Motivation may be inspired by a judicious balance of the carrot and stick approach. For instance, the regular publication of a league table of building or departmental energy performance could be accompanied by an offer to return savings above a certain level to the departmental budget.

INFORMATION SYSTEMS

It is often said that 'you cannot control what you do not measure', to which might be added 'measurements without a target for comparison are meaningless'. At its crudest level monitoring and targeting can involve little more than comparing the fuels bills for each period of the year with bills for the same period in previous years. Indeed, the bottom-line cost analysis presented by this approach may be compelling information for senior management.

Case study

UNIVERSITY OF WALES



Ensuring that buildings operate to their full energy saving potential is aided by reliable data being readily available. The University of Wales had made a significant investment in improving their buildings but accepted that monitoring was required to ensure the best management of energy. Good housekeeping was also recognised as having an important role in controlling energy costs. The installation of sub-metering and a building energy management system led to energy cost savings of £63 000 per year. Start-up costs were recovered within six months.

Investment in a comprehensive system of energy metering and monitoring can be worthwhile where there is a wide range of building types in use, different periods of occupancy, a range of building services and/or a diversity of energy/fuel supplies. The volume of data produced by such systems can be enormous and it is crucial that this data is processed into meaningful packages of relevant information for senior management, staff and students.

MARKETING

A number of initiatives can be taken to motivate people and provide incentives to save energy. For instance:

- a publicity campaign within the institution can seek the views of staff and students on methods of saving energy
- information leaflets can explain how energy is used within the college and the resulting environmental implications
- the regular publication of a league table of building performance can encourage healthy competition between users of individual buildings.

When targets are achieved it is important to share the rewards among all those involved.

INVESTMENT

There are significant savings to be made without large outlays of capital. However, it is important to establish the criteria for investment in energy saving measures so that individual measures can be compared with each other and against other non-energy projects. These principles can be based on a simple payback period or a more advanced life-cycle cost analysis taking account of future maintenance and replacement costs.

In order to attach some priority to energy efficiency it is preferable to identify an annual budget for projects which are under the control of the energy manager or energy committee. Many organisations have been able to make substantial savings through negotiation of electricity and fossil fuel supply contracts. The reinvestment of some of these savings in energy efficiency projects can ensure that savings continue to made in future years as fuel prices stabilise, or even rise.

ENERGY PURCHASING

Privatisation of the electricity and gas industries has created opportunities to reduce charges by negotiating energy supply contracts. To enable negotiation of the most favourable terms and conditions, a college must understand both its site consumption and the nature of the energy supply industries. Consumption data can be collected by in-house personnel, a specialist consultant or possibly from suppliers, while negotiations can be undertaken individually or as part of a consortium.

UNDERSTANDING CONSUMPTION

Plotting fuel use against time provides a valuable insight into the pattern of energy consumption. The appropriate degree of refinement – that is whether monthly, weekly, daily or half-hourly data should be plotted – depends on the price structure by which the fuel is sold.

Invoices provide data for an initial evaluation. However, the breakdown of consumption data will correspond to the price structure at that time which may simply have incorporated price variations for season, day and night.

Privatisation has led to fuel price variation over shorter time bands. Therefore manual or electronic recording of consumption at these time intervals may be justified to provide the information necessary for identification of the most appropriate contract.

In some circumstances load profiles may be used as part of the tender documents but will in any case increase confidence in information essential for management decisions. Possible future changes in the demand pattern arising from, for example, new buildings or changing fuel sources including on-site generation from combined heat and power (CHP), must be considered at the time of contract negotiations.

Electricity

Privatisation has separated generation, transmission and supply. Trading between the first, initially National Power and Powergen, and third, regional electricity companies (RECs), takes place via the second, The National Grid Company (NGC) through a mechanism known as the 'pool'.

The majority of further and higher education establishments are likely to be eligible for the non-franchise, that is competitive, market either within the 1 MW or 100 kW categories.

All electricity contracts will include cost elements for the following:

- energy charge
- NGC transmission charge
- REC distribution charge
- fossil fuel levy
- VAT.

Only the energy charge is negotiable. The price at which electricity is sold from the pool varies each half hour in response to the relationship between available generating capacity and demand. Eligible customers can purchase electricity at this varying half hourly rate, thereby taking the risk of price fluctuations. Alternatively, a fixed price supply contract can be made. There are two basic concepts.

- Suppliers favour sites with steady demand profiles. The causes of peaks in demand should be identified and the possibility of reduction considered together with an evaluation of the cost effectiveness of energy efficiency measures.
- RECs may offer funding for customer investment in demand control if it removes the need to upgrade their distribution system.

Customers eligible for the competitive market can approach any REC or a generator to purchase electricity. For evaluation, offers must be broken down into various elements and only the energy rate nett of system losses used in comparison.

The flow chart illustrates when a site qualifies for the open electricity market. It shows the main tariffs available from the RECs, and which ones may be appropriate for a given site.

Gas

Privatisation separated the transportation and trading activities of British Gas. Transco is now responsible for both the national and regional distribution networks. British Gas has reduced its trading market share and there is now competition from independent suppliers.

This page forms part of Energy Consumption Guide 54 (ECON 54), 'Energy efficiency in further and higher education', produced by BRECSU as part of the Department of the Environment's Energy Efficiency Best Practice programme. For further information on building-related topics contact: Enquiries Bureau, BRECSU, Building Research Establishment, Garston, Watford, WD2 7JR. Tel 01923 664258. Fax 01923 664787. E-mail brecsuenq@bre.co.uk

ENERGY PURCHASING

Sites where consumption exceeds more than 2500 therms (73 000 kWh) per year can negotiate ‘firm gas’ supply contracts, while ‘interruptible gas’ supply contracts are available to sites consuming more than 200 000 therms (5 860 000 kWh) per year.

The major influences on a gas bill are:
- site useage profile and annual consumption
- beachead price
- transportation; commodity and capacity charges
- supplier profit.

Separate rates are levied for the use of the national and regional transport networks. The national rate takes account of the geographical relationship between the input terminal, of which there are five, and the location of the site. Rates offered for use of the regional network are based on the site load factor.

$$\text{Load factor} = \frac{\text{AVERAGE DAY DEMAND}}{\text{PEAK DAY DEMAND}}$$

To enable better load balancing of the network (a requirement of the Network Code), suppliers are required to input sufficient gas to match their customer demands every day. Substantial penalties will be incurred if actual volumes vary from nominated volumes by more than 25% either way. This has increased emphasis on peak-day and forward-demand projections, obviously favouring those sites with detailed knowledge of consumption. Colleges will benefit from monitoring actual consumption against predictions and having control over consumption, so avoiding potential penalty charges which could be passed through by suppliers.

To summarise, it is important to consider a number of points when negotiating a gas supply contract.
- Ensure that a competition clause is inserted if a long-term contract is signed (ie for two years or more) to enable a review of the contract price after 12 months.
- Are there maximum daily, monthly or annual consumption schedules for which penalties apply if exceeded?
- Is there a penalty for dropping below minimum up-take?
- What is the location of the input terminal?

Oil

The wholesale price of oil depends more upon worldwide market trends than trends within the UK. Supply prices consist of this plus the supplier margin which includes distribution and duty. While a customer cannot negotiate the wholesale price of oil, an understanding of the factors which determine it will help define the scope for negotiations with the supplier over their margin. When deciding on the method of buying, consideration should be given to:
- knowledge of the consumption pattern
- control over consumption
- on-site storage
- the amount of time that can be designated to studying the market.

The answers will indicate how a college should seek to apportion the risk of varying wholesale prices between themselves and the supplier in negotiations.

CONCLUSION

Increased knowledge of site energy consumption provides greater opportunities for savings. The potential for savings is enhanced further by increased control over consumption. However, while negotiating a reduced unit price can provide savings for the duration of that contract, continued opportunities are market dependent. The only sure way to reduce energy charges in the long term is to reduce demand. Knowledge of consumption can identify areas/activities of highest return in energy efficient investment.
All will require an investment of time on behalf of some staff and it may be that to fully optimise the opportunities for savings the expertise of a specialised company should be considered.

SERVICES ISSUES

To make the most effective use of limited management time, it is essential to concentrate on the target areas which offer the greatest potential energy/cost saving. Having carried out an evaluation of where energy is used in the various space types, it is then a matter of deciding which services it is best to concentrate on first.

Clearly it is best if all aspects of each area are addressed, but should time or resourcing prevent this then the decision matrix below can help to establish priorities (the lower the number, the higher the priority).

LIGHTING

Lighting has an impact on all areas and is one of the most costly services – typically accounting for 35% of the energy bill. Lighting is required to satisfy a wide range of functions:

- general lighting to all areas
- task lighting in specific locations to suit function
- utility lighting for cleaning
- security lighting for protection
- safety lighting for emergency power failure.

It is important that the lighting levels, layout and controls are appropriate to provide these different conditions around buildings and at various times of day.

Daylight can contribute to a low-cost high-quality lighting scheme. Ideally it should be used together with responsive controls to reduce electric lighting requirements. Lighting should be selected to achieve the desired light levels and colour rendering for a particular task.

Conventional tungsten filament light bulbs use almost 10 times the amount of electricity as the most efficient fluorescent tubes to produce the same level of light. The selection of the lamp and design of the fitting affects how well the light is distributed. Inefficient lamps and fittings have a direct impact on electricity costs. They also incur indirect costs because the waste energy is emitted as heat, which requires additional ventilation, or even air-conditioning, to maintain comfort.

CONTROLS

Although good controls will have limited benefit if systems are incorrectly sized or detailed, poor controls can render the best systems inefficient. The control philosophy spans the evolution of buildings from the estates strategy to an occupied state, starting with their design and continuing through to their operation. The intent of the control strategy needs to be communicated to the building operators and also elements need to be explained to the occupants and users.

Periodic reviews of each control system can often identify mismatches of services to altered space requirements which can waste significant amounts of energy. A flexible and adaptable control system can therefore pay dividends in the long term. Making use of the information and data available from control systems, even if not fully automated as with a building energy management system (BEMS), will provide a fuller understanding of how energy is being used. To set up a monitoring and targeting regime will require reliable data that is current and accessible.

HEATING

A lot of energy efficiency measures have already been implemented in many institutions, especially where central or district plant is utilised. However, there are many opportunities still to be exploited. If a centralised boiler installation is to be retained, distribution system losses and pumping costs need to be fully factored into the financial evaluation. Upgrading insulation, especially if done when modification is required to any part of the system, can be cost-effective. Ensuring that valves, strainers and other fittings are also insulated to at least the same standard as the pipework is now possible with easily refittable jacket systems.

Boiler technology has developed to provide increasingly high efficiencies, both for condensing and non-condensing models. Although replacing boilers that have a useful life remaining is rarely cost-effective the opportunity to reconfigure a heating system can often be factored into another building project. Reviewing your heating strategy when preparing a project brief can help to identify this potential.

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SERVICES ISSUES

Monitoring the thermal demand profiles of the various space types that make up a campus can aid in matching system configuration and control to loads in the most energy efficient manner.

HOT WATER SERVICE

Most domestic hot water service demands exist all year round, although loads will vary. This makes it an energy intensive service with a correspondingly large potential for saving.

To reduce inefficient part load operation of main boiler plant during the summer it is normally worthwhile looking at providing domestic hot water from a separate system to space heating.
If a low-cost heat source, such as from an electrical demand controlled CHP unit, is available then a common system can still be cost-effective.

VENTILATION

Careful consideration during the design stage can often allow a solution incorporating natural ventilation to be produced, so incurring minimum energy use.

Case study

BIRMINGHAM UNIVERSITY

The need to replace time-expired central boiler plant at Birmingham University was seen as an opportunity to consider the campus heating strategy for future years. Following detailed evaluation a proposal including a 7 MWe combined heat and power installation was implemented.
A dedicated operating company was set up to run the central installation. Projected annual savings were over £1 million and the payback period is likely to be about eight years.

If mechanical ventilation is essential, then careful equipment sizing and matching operation to demand will avoid excessive use. Minimising the proportion of outside air, and making full use of recirculating inside air, during periods of low occupancy can reduce the additional energy needed to heat the incoming fresh air. Additional savings can be made by recovering heat from the extract air using heat exchangers, and using variable speed air distribution fans.

Reviewing the operation of existing plant against current needs can allow a more energy efficient operating regime to be adopted.

To provide cooling is expensive in both capital and running costs. Many premises can avoid air-conditioning by good design practice. For example, shading or insulating the building from unwanted solar gains, or exposing as much of the solid building fabric to the air space as possible, can help maintain a cool interior. Night-time cooling is another method used to reduce internal temperatures during unoccupied periods.

Ceiling or wall mounted fans giving local air movement can provide a degree of cooling.