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Health Technical Memorandum 07-02: $EnCO_2de$ – making energy work in healthcare

Environment and sustainability

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Contact Details	Lorraine Brayford Department of Health Quarry House Leeds Email: lorraine.brayford@dh.gsi.gov.uk		
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Health Technical Memorandum 07-02: EnCO$_2$de – making energy work in healthcare

Environment and sustainability

London: The Stationery Office

Encode was funded by the Carbon Trust and written by the Building Research Establishment (BRE) as a collaborative project between the Department of Health, NHSScotland Properrty and Environment Forum, Welsh Health Estates and Northern Ireland Health Estates. For further information about these organisations, please visit the following websites:
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Front cover photograph: Causeway Hospital, Coleraine
An atrium and roof lights – affording good levels of natural light to the hospital interior

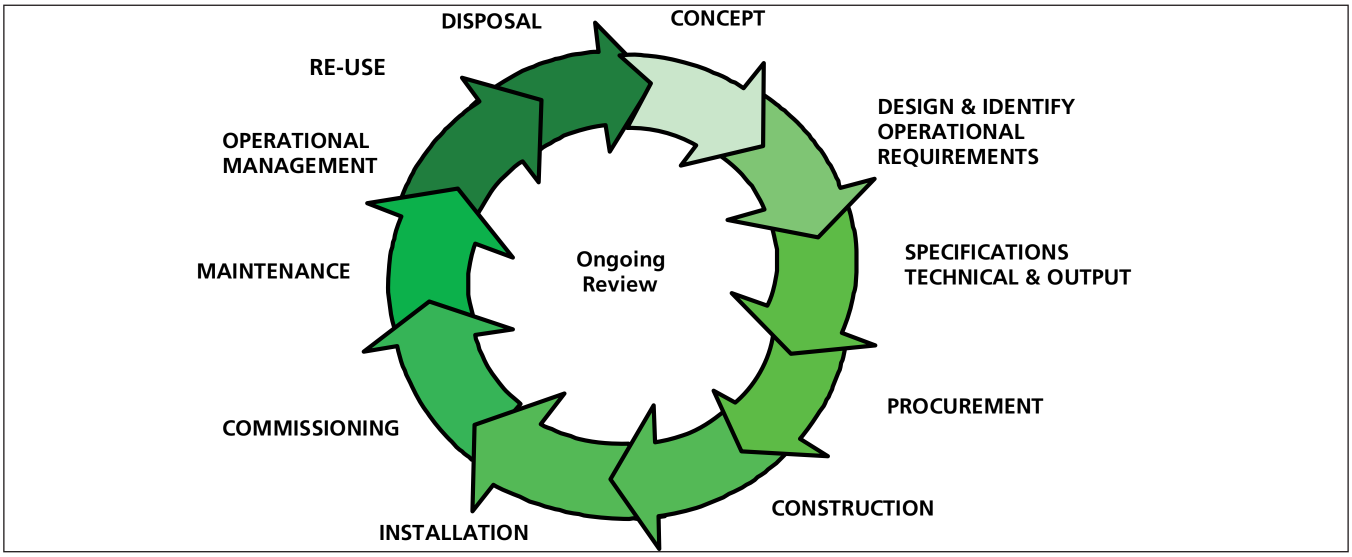
Preface

About Health Technical Memoranda

Engineering Health Technical Memoranda (HTMs) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

The focus of HTM guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle:

Figure 1 Healthcare Building Lifecycle



Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Engineering Health Technical Memorandum series provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this suite of documents to unnecessarily repeat international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Health Technical Memorandum guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The new core suite of nine subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.

Structure of the Health Technical Memorandum suite

The new series of engineering-specific guidance contains a suite of nine core subjects:

Health Technical Memorandum 00
Policies and principles (applicable to all Health Technical Memoranda in this series)

Health Technical Memorandum 01
Disinfection and sterilization

Health Technical Memorandum 02
Medical gases

Health Technical Memorandum 03
Ventilation systems

Health Technical Memorandum 04
Water systems

Health Technical Memorandum 05
Fire safety

Health Technical Memorandum 06
Electrical services

Health Technical Memorandum 07
Environment and sustainabilty

Health Technical Memorandum 08
Specialist services

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

Example: Health Technical Memorandum 06-02 Part A will represent:

Electrical Services – Safety – Low Voltage

In a similar way Health Technical Memorandum 07-02 will simply represent:

Environment and Sustainability – EnCO_2de.

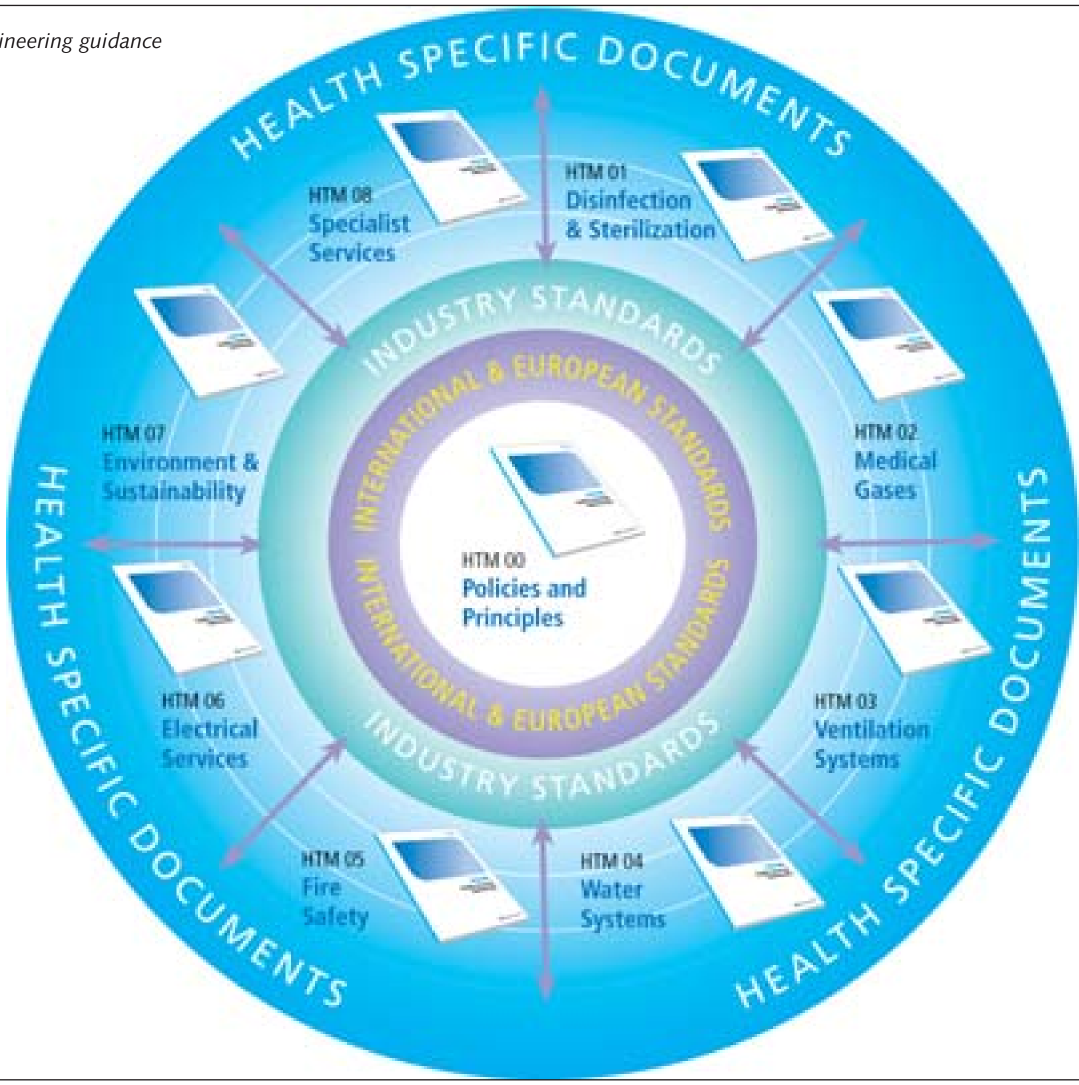
All Health Technical Memoranda are supported by the initial document Health Technical Memorandum 00 which embraces the management and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.

DH Estates and Facilities Division acknowledges the contribution made by professional bodies, engineering consultants, healthcare specialists and NHS staff who have contributed to the review.

This document was developed in partnership with the devolved administrations, and where HTM appears in this document, it should also be taken to refer to the Scottish equivalent, that is, SHTM.

Figure 2 Engineering guidance



Executive summary

Preamble

Encode 2006 – which comprises this document and a CD-ROM of resource materials – is the primary guidance on energy efficiency in healthcare facilities. It has been produced as a comprehensive guide to all issues relating to the procurement and management of energy in the NHS.

Encode was funded by the Carbon Trust and written by the Building Research Establishment (BRE) as a collaborative project between NHS Estates, NHSScotland Property and Environment Forum, Welsh Health Estates and Northern Ireland Health Estates.

Encode is not prescriptive. It draws together best practice guidance so that healthcare organisations can determine a way forward that best suits their situation.

This version of Encode replaces all previous versions.

Introduction

Electricity and fossil fuels have been used in the delivery of healthcare for more than 100 years, and reliance on energy has grown to a point where only the most basic healthcare can be delivered without it. The challenge for the twenty-first century is to continue to deliver world-class healthcare without compromising the global environment.

Encode 2006 sets the foundations for meeting this challenge.

Aim of the guidance

The aim of Encode is to ensure that everyone involved in managing, procuring and using buildings and equipment thinks about the implications of energy use; today and in the future. In short – it puts energy at the heart of the health service.

The most important step on the way to achieving energy and carbon savings is strong leadership. Strong leadership and commitment from the chief executive will enable staff, patients, suppliers and visitors to take the necessary actions to gain control of energy use, keep that control, and make the right choices for the future. Encode explains how cost savings – and environmental benefits – can be achieved.

Who should use Encode?

Encode provides sufficient information for any healthcare organisation to manage its daily energy-saving activities, and to plan effectively to make the most of the opportunities that lie ahead. Each chapter deals with a different aspect of energy management and is colour-coded for easy reference:

- Chapter 1 deals with policy-related issues, and is therefore aimed at senior managers.
- Chapter 2 provides guidance for those responsible for managing the organisation's energy use.
- Chapter 3 provides guidance to anyone who is involved with both capital and revenue spending decisions.
- Chapter 4 looks in detail at the issues to be considered for all those involved with commissioning new buildings, services or refurbishments.
- Chapter 5 provides technical background information to support the design team's design and energy management decisions.

Recommendations

- It emphasises the need for an organisation to have an energy and carbon management policy (or an environmental policy) which is endorsed by the chief executive and supported by an "energy champion" who sits on the board.
- It recommends a five-step approach to energy management, which has successfully been adopted by numerous companies and organisations across the UK.
- It provides a project design checklist that it recommends should be used during the design, construction and hand-over phases of all capital

projects to confirm that the aims of the organisation's energy and carbon management policy have been taken into consideration and correctly addressed.

- It recommends that all sites should have a site-wide energy plan that explains how the energy needs of the healthcare organisation are to be met, and suggests that the plan be reviewed when any change to heat and power or equipment are planned.

Chief executives should ensure that:

- Encode is distributed to board members and departmental leaders;
- departmental leaders brief their colleagues and staff on the specific recommendations set out in Encode;
- Encode is given to suppliers and contractors – perhaps as an appendix to contractual requirements – so that they too can play their part in helping to cut energy usage and carbon emissions.

Acknowledgements

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About the sponsor

Prime Minister Tony Blair set up the Carbon Trust four years ago as an independent not-for-profit company that would spearhead low-carbon innovation and help Britain lead the way in the international fight against climate change. Fundamental to achieving all these goals is the creation and establishment of the British low-carbon economy.

Our role is to help all businesses and public-sector organisations, whatever their size or location, make a difference and integrate proactive carbon management and energy efficiency strategies into their everyday operations. We also need to help Britain's senior managers to understand the business benefits to be gained as well as the corporate risks to be avoided. Consumers, investors, shareholders and other stakeholders will focus on carbon emissions as a priority concern.

We work with UK business and the public sector to help them cut carbon by creating practical business-focused solutions to carbon emission reduction, encompassing both energy efficiency and carbon management. We also invest in the development of low-carbon technologies, which will have a crucial role to play in the future energy mix.

Our annual funding is in excess of £69 million in grants from the Department for the Environment, Food and Rural Affairs (Defra), the Scottish Executive, the Welsh Assembly Government and Invest NI.

We also promote the Enhanced Capital Allowance (ECA) Scheme for energy-saving investments on behalf of Defra and manage the associated Energy Technology List.* This ECA scheme is a tax relief that enables businesses to claim 100% first-year capital allowances on investments in energy-saving equipment listed on the approved Energy Technology List. Further details on qualifying products and ECAs are available at http://www.eca.gov.uk/

For further information on the Carbon Trust, our products and services, please visit our website at http://www.thecarbontrust.co.uk or call the helpline on 0800 085 2005.

* This scheme is not available in the public sector.

Contents

1 An introduction to managing energy usage and carbon emissions

1 An introduction to managing energy usage and carbon emissions

Introduction

1.1 Encode is the primary source of guidance on managing energy use and carbon emissions in the healthcare sector. Encode is not prescriptive. It draws together best practice guidance so that healthcare organisations can determine a way forward that best suits their situation.

1.2 This chapter presents essential background information, and it should be read by anyone who is involved in managing resources and services – not just energy. In addition, it should be read by suppliers of goods and services so that they also understand the need for energy efficiency.

1.3 This chapter includes:

- a summary of why we need to take steps to control energy usage;
- a summary of how energy is measured and where it is used in the healthcare sector;
- an explanation of the need for an energy and carbon management policy, endorsed by the chief executive;
- a summary of how the subsequent chapter of Encode should be used to deliver the policy objectives.

Energy and carbon savings

Context

1.4 The UK's healthcare sector now spends more than £400 million per year on energy, but a significant proportion of this energy is wasted – and that means money is being wasted too. Taking steps to control energy usage will bring immediate financial benefits, but there are other benefits:

- energy-efficient buildings provide better indoor conditions for patients and staff;
- taking control of energy usage will enable the organisation to achieve mandatory government targets;
- energy-efficiency campaigns cut across departmental boundaries or specialisms, fostering an inclusive atmosphere that improves general morale;
- organisations that publicise their energy-efficiency achievements receive positive feedback from stakeholders and the local community.

1.5 More than a quarter of healthcare organisations are already feeling the value of these benefits. But there is another reason why action should be considered. The global environment – and by implication, the health of nations – is being damaged by the burning of fossil fuels (coal, oil and gas) to supply an ever-increasing demand for energy. The UK, together with many of the world's governments, has pledged to curb its reliance on fossil fuels so that it can cut carbon emissions to a sustainable level (see box "The carbon challenge").

1.6 In his 2003 budget speech, the chancellor of the exchequer announced that NHS expenditure would rise from £61 billion to £128 billion by 2008. A significant proportion of the chancellor's additional investment is for construction projects. The NHS Plan calls for 100 new hospitals by 2010; many more properties are to be renovated. This is a major opportunity to improve the energy performance of healthcare buildings – not least because actions taken now will influence the energy use of these buildings for the next 30 years or more.

1.7 It is also likely that the ever-growing reliance on technology in the healthcare sector will continue. Most of the equipment used for healthcare relies on electricity which, at the point of use, is responsible for approximately three times the carbon emissions of other fossil fuels. This means that energy-efficiency measures – particularly "good housekeeping" – will be essential to prevent escalating damage to the global environment.

The carbon challenge

Burning fossil fuels releases carbon dioxide (CO_2) into the atmosphere. There is strong scientific evidence that this could warm the Earth's climate by as much as 3°C over the next 100 years, resulting in floods, droughts, storms and widespread disruption to the weather. The social, environmental and economic costs associated with this could be huge.

The Kyoto Protocol established a framework for nations to work towards the achievement of sustainable emissions levels. This commits the UK government to reducing emissions of CO_2 to 12.5% below 1990 levels by the year 2008–12. In addition, the UK has set a domestic goal to reduce emissions by 20% by 2010, with a further goal of 60% by 2050.

The Climate Change Programme (CCP) and the Energy White Paper (2003) set out an action plan for achieving these reductions. One stated aim is for government to ". . . set an example throughout the public sector by improving energy efficiency in buildings and procurement". As one of the UK's largest employers and purchasers, healthcare organisations have a major role to play in meeting this challenge. In addition, as guardians of the nation's health, they have a duty to ensure that it does everything within its power to minimise risks and improve health. This can be achieved through effective energy and carbon management strategies.

The healthcare sector has already achieved a previous target of a 20% reduction from 1990 by March 2000, but further reductions are needed. In April 2001 the Secretary of State for Health wrote to all chief executives and senior managers of healthcare organisations setting out the government's mandatory energy targets for England. The devolved administrations of Scotland, Wales and Northern Ireland also set new targets (see Table 1).

First steps to savings

1.8 The most important step on the way to achieving energy and carbon savings is strong leadership from the front – by the chief executive and an "energy champion" at board level. Strong leadership will involve:

- publicly endorsing the organisation's "energy policy";
- empowering staff to take the necessary actions;
- encouraging a willingness to explore alternatives.

1.9 With strong leadership as a starting point, organisations should then look to introduce changes to the procurement process, because early changes to procurement will have the greatest impact on energy and carbon management.

1.10 Existing practices of like-for-like replacement and "business as usual" proposals will not help to meet efficiency goals; nor is "best value" synonymous with "lowest cost". Procurement specialists will need to adopt a holistic approach to decision-making – that is, they need to consider the environmental, social and economic implications of every purchase, as well as satisfying clinical needs.

Understanding energy use in the healthcare sector

1.11 Everyone involved in managing healthcare facilities should be aware of the mandatory energy targets set in 2001 for England and the devolved administrations of Scotland, Wales and Northern Ireland, which are shown in Table 1.

1.12 These targets are part of the government's overall aim to reduce emissions of the greenhouse gases – particularly carbon dioxide (CO_2) – which are released when fossil fuels are burnt to produce energy.

1.13 It is relatively easy for an organisation to find out how much energy it has purchased – the delivered energy – by looking at data from the energy supplier, or from on-site meters. But a headline figure for delivered energy hides the true cost to the environment. This is because electricity generation in most thermal power stations is not very efficient and results in the emission of two or three times more carbon than direct use of fossil fuels per delivered unit of energy. Figure 1 illustrates this point.

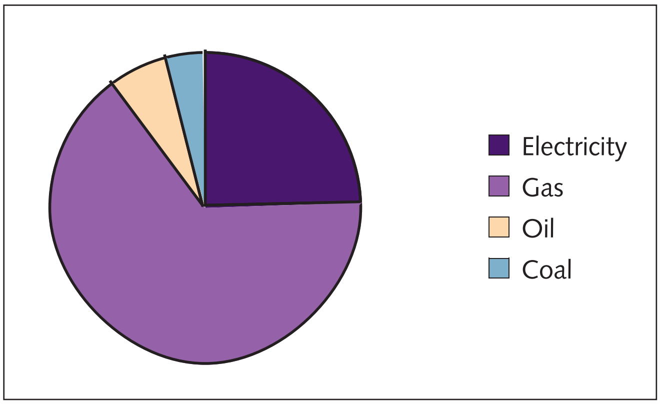
1.14 The amount of carbon released during the process of electricity generation is a very significant issue for the healthcare sector, where electricity consumption is rising rapidly because of the growth in the use of IT, medical equipment and

Table 1 Mandatory energy and carbon targets

	Energy consumption	Delivered energy use	
		New capital developments, major redevelopments or refurbishments	Existing facilities
England	Reduce primary energy usage by 15% (0.15 million tonnes of carbon) from a base year of 1999/2000 to March 2010	35–55 (GJ/100 m^3)	55–65 (GJ/100 m^3)
Scotland	2% improvement in delivered energy use per year (based on 2001); 18% by 2010		
Wales	15% reduction in primary energy use by 2010 (based on 2000) or an equivalent amount of carbon		
Northern Ireland	15% reduction in energy efficiency in the DHSSPS estate by 2010–2011 relative to 1999–2000 (GJ/100 m^3)		

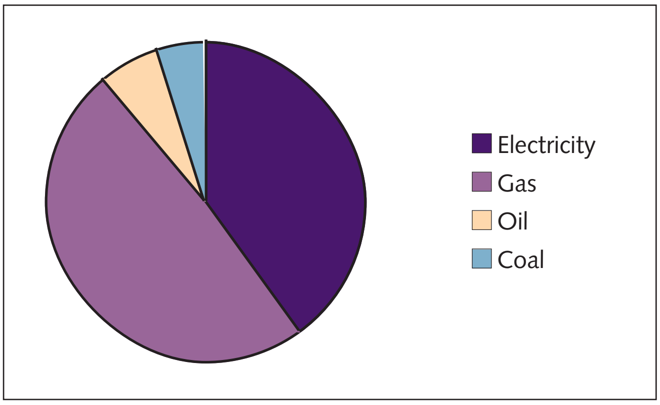
i Energy use is quoted in gigajoules (GJ) per 100 m^3, which is the measurement used for national data-gathering systems. Appendix 1 explains the calculation method that is to be used when comparing energy performance against these targets.

Figure 1(a) Total delivered energy for UK healthcare facilities in 2003/4, by fuel type



Source: Chris Le Breton research report (see Appendix 2)

Figure 1(b) Total carbon emissions from UK healthcare facilities in 2003/4, by fuel type



Source: Chris Le Breton research report (see Appendix 2)

air-conditioning. It is even more important for new buildings, where electricity will account for a larger proportion of total energy use (see Figure 2). (Such buildings will have lower space-heating demands, because of better overall thermal performance; yet they have ever-increasing electricity requirements.)

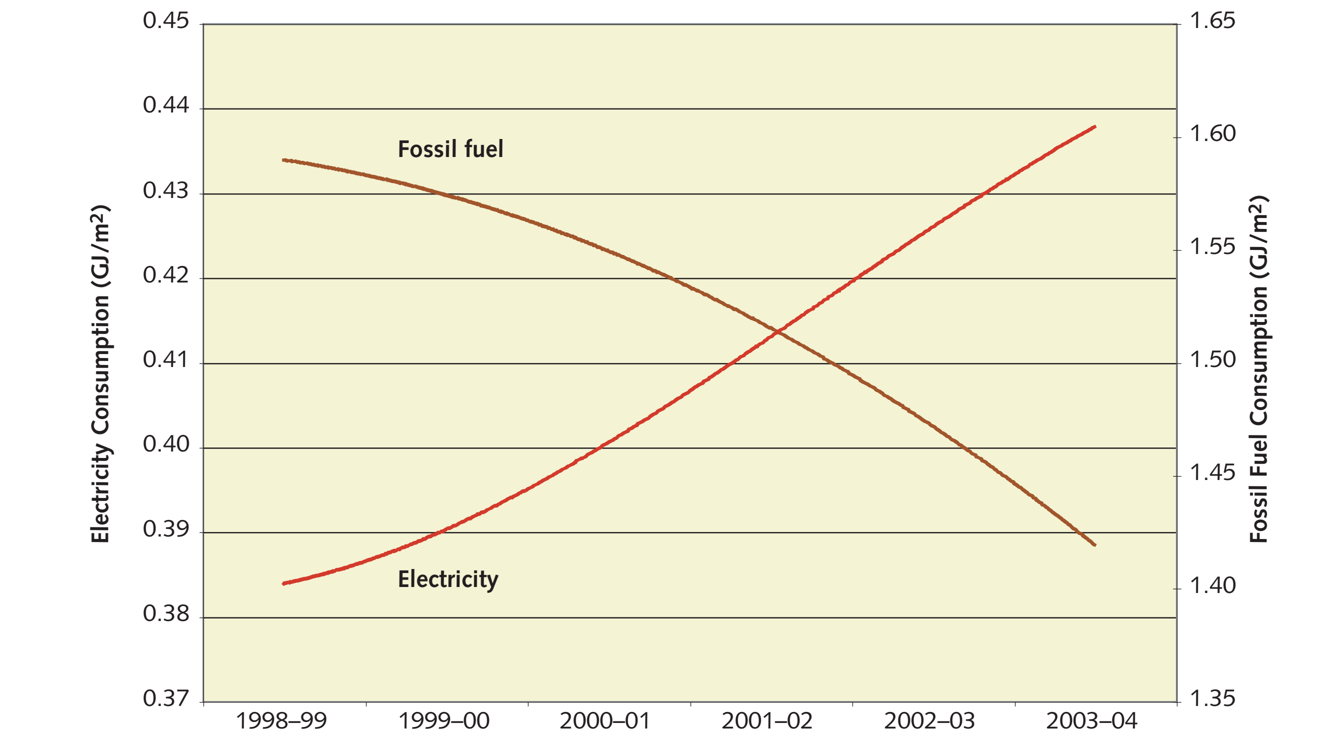
1.15 That is why the government's headline targets look at "primary energy consumption" instead of focusing on the amount of energy purchased.[1] Primary energy consumption is a measure that includes the power station losses incurred in generating electricity, as well as the metered consumption of fossil fuel and electricity delivered to the site.[2] Overall, the UK healthcare sector now uses almost equal quantities of fossil fuel and electricity, when measured in this way.

1.16 One major advantage of using primary energy consumption as the measurement is that it opens

1 However, the targets for Scotland are based on delivered energy.

2 It is possible to obtain an approximate figure for the primary energy consumption of a site: multiply the delivered electricity consumption (GJ) by 2.6, then add that figure to the delivered consumption of fossil fuels (GJ). Note, however, that the multiplying factor changes from day to day, depending on the daily mix of fuel sources being used at power stations.

Figure 2 Current trend in electricity growth compared with fossil-fuel usage in healthcare buildings (GJ/m^3)



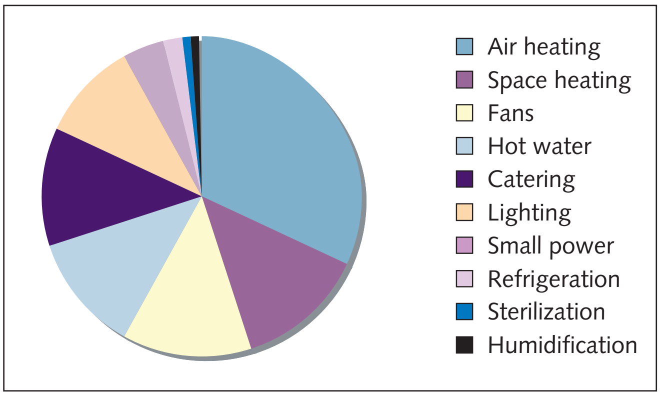
the door to a range of new technologies and techniques – such as the on-site generation of electricity using combined heat and power (CHP) plant, heat from waste incineration, or renewable sources such as wind or sunlight. Such technologies may not diminish the actual amount of energy purchased, but they will have a positive effect on carbon emissions as Table 2 illustrates.

Table 2 Annual delivered energy consumption and related carbon emissions (healthcare sector)

	Delivered energy (GJ)	Carbon (tonnes)	Tonnes of carbon per GJ
Electricity (renewable sources)	1,656,000	0	0
Electricity (grid sources)	10,083,600	397,233	0.039
Gas	28,112,400	404,648	0.014
Oil	3,229,200	61,159	0.019
Coal	2,455,200	55,800	0.023

1.17 Figure 3 gives an indication of the various ways that the delivered energy consumption may be used to provide services in a typical hospital.

Figure 3 Energy consumption in a typical hospital, by end use



The energy and carbon management policy

1.18 Everyone involved in a healthcare organisation – staff, patients, suppliers, visitors and contractors – will have an impact on energy usage, and each has a role to play in ensuring that this is kept to a minimum. However, energy savings will not appear spontaneously. A coordinated campaign is needed so that everyone knows what is expected of them, so that consumption can be measured, and so that cost savings can be redirected in an efficient manner. Regardless of the industry sector they serve, organisations that have run successful energy-efficiency campaigns over the past 20 years have three things in common:

- the campaign is endorsed at the very highest level – usually by the organisation's chief executive;
- the campaign is supported at board level by an "energy champion", who ensures that energy is always on the organisation's agenda;
- the campaign is underpinned by a strong energy and carbon management policy (or environmental policy), which succinctly states the organisation's intentions.

The policy in context

1.19 An energy and carbon management policy should be closely linked to the organisation's existing policies on purchasing and on environmental issues, and also to the wider question of sustainability.

1.20 Sustainable development involves:

- taking a holistic view of all activities and considering their environmental, social and economic implications;
- thinking about whole-life issues when planning, designing, building and maintaining the estate;
- making sure that everyone thinks about the way resources are used – every day.

1.21 Whatever the size of the organisation, adopting a sustainable approach will result in best value solutions; better healthcare outcomes; improved working environments; and less impact on the local and global environment.

1.22 Sustainability in the healthcare sector is driven by a range of government-wide policies and healthcare-specific initiatives, such as:

- the Greening Government Initiative;
- the energy White Paper (2003);
- the NHS Plan;[3]
- Department of Health policies on sustainability and environmental management;[4]
- the initiatives that support public and private funding for construction projects (for example ProCure21);[5]
- environmental assessment tools;[6]
- the Government's stated aims for increasing the use of "good quality" combined heat and power (CHP) and electricity from renewable sources;
- the Emissions Trading Scheme and the Climate Change Levy (where applicable).

3 In Scotland 'Our National Health'.

4 In Scotland 'Scottish Executive Health Department Environmental Policy for NHSScotland'.

5 Not in Northern Ireland.

6 Examples of these are the NHS Environmental Assessment Tool (NEAT) or Greencode (Scotland)(environmental management system)

Emerging issues

The European Energy Performance of Buildings Directive (EPBD), which takes effect from 2006, will be implemented through the Building Regulations. The Office of the Deputy Prime Minister (ODPM) will take the lead for implementing the measures contained within the Directive, as it has responsibility for much of the legislation that will be used to transpose the Directive into law. As mentioned, most measures will be dealt with via the Building Regulations, a major revision of which came into effect during 2005. Although energy matters are generally reserved to the UK Government, building legislation and promotion of energy efficiency are delegated to the three devolved administrations.

One of the main changes coming from the EPBD is the need for an energy certificate and an energy "label" (if appropriate) for all new buildings; existing buildings, when they are sold or rented out; and existing buildings when they undergo substantial refurbishment. In addition, all public buildings that are over 1000 m^2 will need to display the energy label – the "operational rating" – for the public to see.

The EU Emissions Trading Scheme (ETS) gives organisations the flexibility to manage their carbon emissions within a pre-set limit, with the added advantage of being able to sell their "unused carbon emissions" to those who are finding it hard to meet their own energy-saving goals (for example, if the organisation is going through a period of expansion). Participants can either reduce their own emissions to the limit; reduce their emissions below the limit then sell or bank the excess emission allowances; or buy an "allowance" from an organisation that has "spare" capacity. (Further details of the ETS are given in Appendix 3.)

The Government has also set a nationwide target to source at least 10% of electricity from renewable sources by March 2008. Renewable energy can be generated from a range of power sources including wind, wave, tidal, solar thermal and photovoltaics (PV), hydro-generation, geothermal and biomass (energy from forestry or crops). All of these technologies are applicable to the healthcare sector, and there are various financial incentives to encourage organisations to introduce these (see box "Grant funding" in Chapter 3).

Further details of these policies and documents can be found on the websites of the relevant government departments:
http://www.hmtreasury.gov.uk
http://www.dh.gov.uk
http://www.odpm.gov.uk
http://www.scotland.gov.uk
http://www.show.scot.nhs.uk/sehd
http://www.show.scot.nhs.uk/PEF
http://www.detini.gov.uk
http://www.dfpni.gov.uk
http://www.ehsni.gov.uk/environment/industrialPollution/industrialpollution.shtml

1.23 These various recommendations should be reviewed when drawing up or revising an energy and carbon management policy. There are also emerging issues to be taken into consideration (see box "Emerging issues").

Drafting a policy

1.24 Senior managers are responsible for ensuring that the organisational structure, operational processes, staff and facilities are in place to deliver a high standard of healthcare. This includes ensuring that appropriate organisation-level policies are in place and communicated to stakeholders. The energy and carbon management policy (or the environmental policy) may come under the remit of the organisation's estates department (or equivalent), even though various departments may have responsibility for its day-to-day implementation.

1.25 The fundamental objective of the policy is to ensure that energy is considered at every opportunity – from the purchasing of new office equipment to changing the set-point on local radiator thermostats – but the real value of a strong energy and carbon management policy is that it sets a firm foundation without being prescriptive about the route to achieving the goals.

1.26 For some organisations, the energy, carbon and environmental issues are very effectively combined in one policy. The example below, which is adapted from an actual source, sets out a generic environmental policy for healthcare organisations. It is also possible to draft a more detailed policy statement that includes specific energy-saving goals, such as recommended temperatures for wards, or purchasing policy recommendations such as avoiding products that contain ozone-depleting substances (CFCs, halon, carbon tetrachloride and so on).

The Carbon Trust's Good Practice Guide GPG376: 'A strategic approach to energy and environmental management' (available on the CD-ROM) explains the basic principles of writing an energy policy.

1.27 Once written, the energy and carbon management policy should be signed off by the chief executive to signal commitment at the highest level, and by the board member who has taken on the role of energy champion.

1.28 In the healthcare sector, the overall policy and its supporting strategy will have a life-span of around five years, so any existing policy should be given an annual health check. In particular, policies should be reviewed when NHS-specific guidance is issued by the Department of Health and the devolved administrations. For example, all healthcare organisations should have reviewed their policies and strategies in 2001, after the Secretary of State for Health and the devolved administrations of Scotland, Wales and Northern Ireland issued new mandatory energy targets (see paragraphs 1.11 and 1.12 for details of these targets).

1.29 The interest generated by the development of the policy statement provides an excellent opportunity for raising management awareness generally, and consolidating senior management commitment. The signing and distribution of the policy statement itself are also key events that can be publicised to stakeholders, helping to raise awareness of energy – the fundamental requirement of any successful policy.

From policy to practice

1.30 With the policy statement as a starting point, the next step is to draw up a detailed strategy to deliver the policy commitments.

Detailed guidance on developing the strategy can be found in the Carbon Trust's Good Practice Guide GPG376: 'A strategic approach to energy and environmental management' (available on the CD-ROM).

1.31 The strategy sets out the detailed actions that are needed to deliver the policy commitments. To be effective, the strategy should be accompanied by a management system, and together the management system and the strategy should:

- relate actions to individual objectives and goals which in turn can be traced to specific policy commitments;

Example

Mission statement

The [organisation name] recognises that energy consumption is necessary for the provision of healthcare services, but it has a responsibility to be energy and resource efficient by minimising unnecessary energy costs and the thereby associated environmental impacts.

As far as is practical and consistent with the operational needs of our healthcare organisation, the [organisation name] shall commit to:

- **Operating in an energy efficient way** (to reduce consumption and costs etc)
- **Producing a local energy/carbon strategy and action plan** (providing the effective use of staff and financial resources)
- **Establishing an energy/carbon management structure** (with clearly defined roles and responsibilities)
- **Achieving local energy efficiency measures** (in line with national NHS targets) [see Table 1, page 3]
- **Minimising environmental impacts** (arising from our energy consumption, finite fossil fuel use, CO_2 emissions, waste etc)
- **Investing in energy/carbon efficiency opportunities** (such as new, clean energy-efficient technologies where they are cost-effective and deliver value for money)
- **Including energy in the procurement evaluation process** (that is services, fuel, equipment and capital projects etc, taking into account whole life costs)
- **Informing and motivating staff** (raise awareness at all levels starting with the induction process so that energy/carbon management is communicated and integrated throughout the organisation)
- **Continual improvement** (of performance through regular reviews of policies, procedures and working practices)
- **Demonstrating that energy/carbon policy is being implemented** (raise the profile by open reporting and being auditable so that stakeholders can confirm that the organisation is achieving all it claims)

The policy shall be implemented by undertaking the following provisions:

- Monitor, audit and review efficiency measures in order to prevent pollution and contribute to the Government's national Climate Change Programme.
- Actively seek to promote good energy/carbon management practice through good working relationships with the relevant agencies; local authorities and the community.
- Promote energy/carbon efficiency awareness among staff, patients, visitors through the distribution of this policy.
- Maintain an open line of communication for employees and members of the public

Signed: ....
Chief Executive

Date: ....

- assign actions to individuals, with clear deadlines for reporting progress and completion;
- indicate the person responsible for approving or signing off the action when it has been successfully discharged;
- describe the resources that may be required;
- be used to inform budget negotiations and confirm that adequate budget provisions have been made.

1.32 The strategy should be agreed and approved at the appropriate level of line management and presented to the board champion, who is ultimately accountable for energy and environmental management.

Using Encode to drive the change process

1.33 Developing an energy and carbon management policy and strategy will involve much inter-departmental communication, with representatives from the estates department (or equivalent) guiding discussions and advising on suitable actions. There are three main issues to discuss:

- day-to-day management of energy use;
- procurement of equipment and services;
- changes to the fabric of buildings, or the procurement of new buildings.

1.34 Day-to-day energy management can be led by the estates department or its equivalent, but will possibly be implemented by staff across the organisation. Therefore all staff should buy in to the idea of saving energy; they are the key to achieving considerable daily savings and improving indoor comfort. Chapter 2 looks in detail at energy management.

1.35 Procurement is also an inter-departmental issue, because practitioners and specialist staff are involved in purchasing decisions. Procurement covers everything from photocopiers to MRI scanners, and from energy-saving lamps to whole buildings. Although the overarching aim of procurement is to achieve value for money, there is much that can be done to enhance energy efficiency and reduce carbon emissions, such as adopting a whole-life-costing approach to purchasing (that is, looking at the ongoing energy implications of each purchase). All staff should understand the importance of such changes in emphasis. The procurement process, and how an energy and carbon management policy should influence this, are discussed in more detail in Chapter 3.

1.36 Chapter 4 explains the specific actions that ensure energy and carbon emissions are considered at the earliest opportunity when designing and refurbishing buildings and services, including guidance on putting a team together, and early decisions on site, fuel and building form.

1.37 Chapter 5 provides technical background information to support the design and energy management decisions described in Chapters 2, 3 and 4. Although Chapter 5 is important to the staff and contractors who manage buildings and services, many of the solutions described there may require support from senior decision-makers in the organisation, or from clinical staff who will be responsible for daily energy management issues.

An internal view of the atrium at Chelsea and Westminster Hospital, affording good levels of natural light to the hospital interior (see box "Atria" in Chapter 4 for further guidance on the use of atria for saving energy)

2 Energy and carbon management

2 Energy and carbon management

Introduction

2.1 Energy is a controllable cost – it is not a fixed overhead. It is important for everyone involved in the healthcare sector to realise that individuals hold the key to controlling energy usage (and therefore carbon emissions).

2.2 Chapter 1 emphasised the need for an energy and carbon management policy (or an environmental policy) that is endorsed by the chief executive and supported by an energy champion who sits on the Board.

2.3 This chapter explains how healthcare organisations can control daily energy use by introducing a tried-and-tested five-step management technique. It summarises the technique and explains the resources and actions that are likely to be needed when adopting this approach.

The five-step approach

2.4 The five-step approach to energy management,[7] which is described in this chapter, has been successfully adopted by numerous companies and organisations – large and small – across the UK. It is the approach recommended by Encode for the following reasons:

- cost savings can be easily identified and reported to stakeholders. Money saved through energy efficiency can then be redirected to delivering healthcare;
- having tangible evidence of the benefits creates the right climate for developing the programme;
- the five-step approach fits in with the strategies of other management programmes (for example quality management).

2.5 The five-step approach is summarised in Figure 4.

7 Throughout this chapter the term "energy management" is used – for conciseness only – instead of "energy and carbon and/or environmental management"

i The five-step approach is explained in full in the Carbon Trust's Good Practice Guide GPG376: 'A strategic approach to energy and environmental management' (available on the CD-ROM).

Step one – Getting commitment

2.6 A clear and simple energy and carbon management policy, endorsed by the chief executive and senior managers (as described in Chapter 1), sets the foundations for good energy management.

2.7 It is recommended that the Board give consideration to providing the resources that will be needed to implement an energy management strategy. The main resource is likely to be staff time, which will be needed for:

- preparing and implementing the management strategy;
- communicating it to others;
- training and raising awareness.

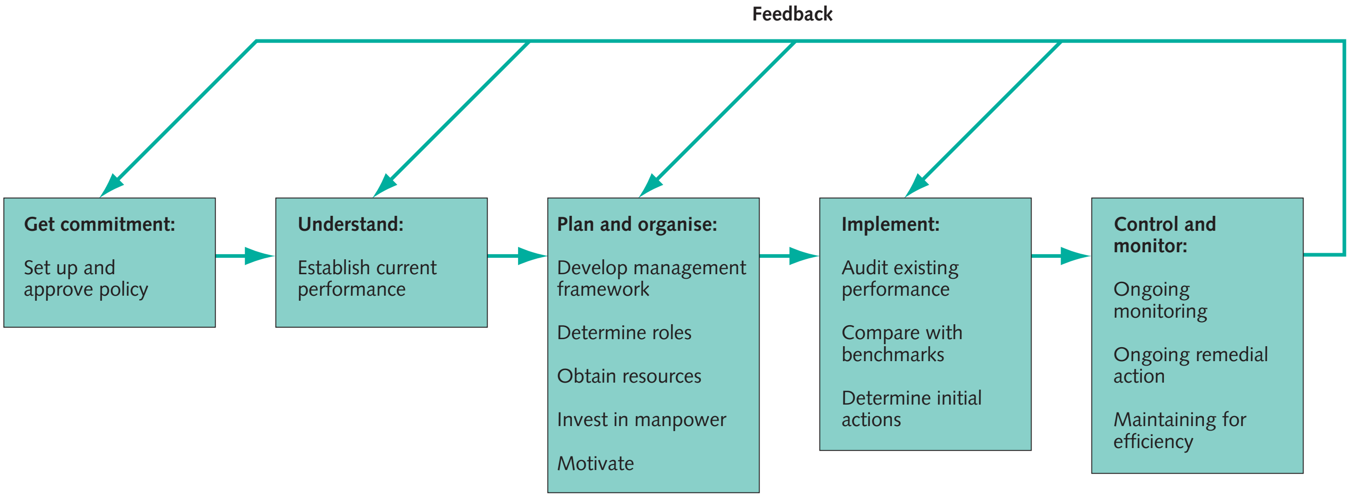
2.8 Detailed planning of resources is very much recommended and is discussed in step three.

Step two – Understand

2.9 To develop an effective energy management strategy, it is important to gain a basic understanding of the status quo. For example, some organisations may have run energy-saving campaigns in the past, but let them dwindle; others may have decided to gain control of their energy use for the first time. The energy management matrix (Table 3) provides sufficient information upon which to base an energy management strategy, because it answers the simple questions:

- Where are we now?
- Where do we want to get to?
- How much further do we need to go?

Figure 4 The five-step approach to energy management



How to use the matrix

2.10 The energy management matrix shows five levels of performance, ranging from level 0 where there is no provision for energy management to level 4 representing best practice. For each column, decide which phrase best describes the organisation and mark that box. Then assess the scores by looking at the level attained for each of the six columns.

2.11 For example, scoring mostly level 2 would be typical of an organisation that is watching its expenditure on energy and may be reducing costs through prudent purchasing of gas and electricity, but which is not necessarily reducing energy consumption.

2.12 It is not necessary to reach level 4 in each column – that will depend on the needs and nature of the organisation.

Step three – Plan and organise

2.13 This step is about deciding what resources will be needed to manage energy usage across the organisation.

Resources

2.14 It is recommended that all organisations should have an energy champion. This person will be the "public face" of the policy, and their role is to keep energy on senior managers' agenda. In addition, it is recommended that all organisations should have:

- someone to take on the role of energy manager;
- an energy information system that is designed to aid the reporting process;
- a budget.

The energy manager

2.15 Although energy efficiency is a team effort, it is important not to underestimate the significance of the energy management function. An energy manager provides a focal point for the energy efficiency programme, even though specialist support may be necessary from time to time.

2.16 Most healthcare organisations have someone who is responsible for energy, even if they are only responsible for checking the fuel bills.

2.17 Designating a dedicated member of staff is a good example of "invest to save"; some organisations designate an energy manager on the basis that the post should be self-financing through energy cost savings. Alternatively, the role could be part-time or shared among several members of a team with a broader remit.

i For more information on designating members of staff to energy management, see CIBSE Guide F: 'Energy efficiency in buildings' (paragraph 15.3.3.2, pages 15–16).

2.18 Regardless of the staffing route chosen, the responsibilities of the person (or people) who take on the energy manager role are wide-ranging. Responsibilities are likely to include:

- checking fuel bills and local tariffs against meter readings and asking questions about anomalies;

Table 3 The energy management matrix

Level	Energy policy	Organising	Motivation	Information systems	Marketing	Investment
4	Energy policy, planning arrangements and regular review have commitment of top management as part of an environmental strategy	Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption	Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels	Comprehensive system sets objectives, identifies faults, quantifies savings and provides budget tracking	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it	Positive discrimination in favour of "green" schemes, with detailed investment appraisal of all new-build and refurbishment opportunities
3	Formal energy policy, but no active commitment from top management	Energy manager accountable to energy committee representing all users, chaired by a member of the management board	Energy committee used as main channel together with direct contact with major users	Monitoring and targeting (M&T) reports for individual premises based on sub-metering, but savings not reported effectively to users	Programme of staff awareness and regular publicity campaigns	Same payback criteria employed as for all other investment
2	Unadopted energy policy set by energy manager or senior departmental manager	Designated energy managers, reporting to ad-hoc committee, but line management and authority unclear	Contact with major users through ad-hoc committee chaired by senior departmental manager	M&T reports based on supply meter data. Energy unit has some involvement in budget setting	Some ad-hoc staff awareness training	Investment using short-term payback criteria only
1	An unwritten set of guidelines	Energy management the part-time responsibility of someone with only limited authority or influence	Informal contacts between engineer and a few users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency	Only low-cost measures taken
0	No explicit policy	No energy management or any formal delegation of responsibility for energy consumption	No contact with users	No information system. No accounting for energy consumption	No promotion of energy efficiency	No investment in increasing energy efficiency in premises

- raising awareness of energy wastage and promoting good housekeeping throughout the organisation;
- measuring performance and reporting achievements to senior decision-makers in a simple and clear way;
- maintaining control by keeping up everyone's enthusiasm for conserving energy; ensuring that people receive due praise and credit for making savings.

Example

One Trust in Oxfordshire was spending £2.5 million on energy each year, but had no dedicated energy manager. The Trust designated an energy manager on the basis that savings made through the energy manager's work would pay the salary. The energy manager achieved substantial savings through energy efficiency measures and the introduction of combined heat and power (CHP) plant, and thus recovered the cost of the salary.

2.19 Although the specific tasks will change over time as energy management becomes established, the energy manager will:

- work closely with the estates director (or equivalent) or the energy champion during the formulation of the energy and carbon management policy;
- oversee day-to-day energy management activities;
- introduce and maintain cost-effective ways of providing management information about energy consumption and environmental impact (that is, carbon emissions);
- introduce and maintain effective good housekeeping and plant-operating practices throughout the organisation;
- identify the organisation's training needs for energy-related skills and awareness;
- participate in key procurement decisions, including identifying cost-effective opportunities for increasing energy efficiency – whether in new or existing premises;
- consider formulating an investment programme for reducing energy consumption and environmental impact;
- introduce and maintain review procedures so that the financial value of energy management activities can be communicated to senior managers and other relevant staff;
- provide guidance on energy efficiency to non-technical staff.

The energy information system

2.20 As the saying goes: "You can't manage what you can't measure." An effective energy information system (EIS), ideally as part of a larger information system (environmental or otherwise), is recommended for adopting an integrated approach to energy or carbon management. The EIS should help the energy manager to:

- track and report on progress easily (that is, the system should use widely understood terms and performance indicators);
- provide management information for budgeting and financial control purposes;
- verify and demonstrate ongoing benefits of completed energy improvement projects;
- provide alerts and exception reports that indicate when energy usage exceeds expectations;
- provide reliable records from which business cases for new projects can be developed.

Budget

2.21 As well as the need for an energy manager and an energy information system – both of which may already be available within the existing estates department (or equivalent) structure – a budget should also be considered. A budget can be justified on the grounds that energy management will:

- reduce operating costs;
- increase patient and employee comfort;
- improve cost-effectiveness;
- protect the environment.

2.22 Furthermore, planned capital investment can produce rapid revenue savings, and healthcare organisations can take advantage of this by introducing a degree of flexibility over accounting practices. For example, allowing slightly longer pay-back periods for some energy-efficient equipment can enhance the viability of such schemes. Another option is to look at energy-efficiency proposals in terms of their potential to reduce carbon emissions, because such proposals may help the organisation to avoid incurring a financial penalty for excessive emissions (see box "Emerging issues" in Chapter 1). As a guideline, the level of annual investment ear-marked for energy management could be up to 10% of the annual expenditure on energy. (For example, the Building Regulations require 10% of expenditure on refurbishments valued at over £8000 to be ear-marked for energy-efficiency measures.) This percentage figure could be exceeded in the early stages of an energy management strategy, when there are more opportunities for investment. A lower figure may be considered adequate in a well-developed programme until new opportunities arise. Other options include:

- reinvesting some of the revenue savings made by energy management;
- allowing a share of the energy cost savings to be used for other purposes by those who achieve the savings (for example, the staff working in a particular building or department);

- treating some energy management costs as an overhead that contributes to staff comfort and productivity;
- allowing use of revenue for capital expenditure when it can be recovered by revenue savings within the accounting period.

Strategy

2.23 The work done to gain commitment and formulate the policy (Chapter 1) will inevitably draw attention to key areas for action and other issues where there is potential for improvement. There may be many things that could be done, so it will be necessary to prioritise actions and set achievable and realistic goals – that is, to develop a strategy.

2.24 The overall objectives set out in the organisation's policy are the starting point for developing the strategy. The strategy breaks down these long-term objectives into medium-term goals, which in turn will be achieved by a series of daily actions. It is then part of the management process to check whether these actions are being implemented.

2.25 In other words, the overall objectives cascade down to small daily actions that are managed, with outcomes feeding back into a review process.

2.26 The strategy should be similar to those developed for other management systems and will work best if integrated with these. At the detailed level, each task should be designated to specific individuals or teams, and the individuals involved should discuss, agree and work together to implement these arrangements.

2.27 To be effective, the strategy should:

- be agreed and approved at an appropriate level of line management;
- relate actions to specific policy commitments.

i Further guidance on the development of energy management plans can be found in the Carbon Trust's Good Practice Guide GPG376: 'A strategic approach to energy and environmental management' (available on the CD-ROM).

2.28 Strategies and detailed plans can be developed in-house, but some organisations seek the guidance of consultants.

Seeking specialist help

There are various government-funded schemes that offer specialist support to healthcare organisations which are seeking energy-saving opportunities and guidance on appropriate actions.

For example, one scheme available in 2005 enables consultants to visit the site (or sites) and:

- hold meetings with key staff to review and analyse existing energy consumption and agree the general areas for investigation;
- review energy management practices;
- carry out a technical survey of particular energy-using systems;
- develop proposals for specific energy saving actions.

The consultants will also draw up a report and present it to senior managers.

Details of current assistance can be obtained from the Carbon Trust helpline.
Tel: 0800 585794

Motivating stakeholders

2.29 Motivating stakeholders is not a question of dictating actions from above; it is about getting the appropriate people to understand and accept the need for energy efficiency. This requires an insight into what interests people and what demotivates them.

2.30 Many healthcare organisations have found that motivation can be achieved by appealing to people's concern for the environment, for patient (and their own) comfort, and by stressing the positive benefits of savings. For example, providing natural daylight in some patient departments will save energy, but it will also make patients and staff feel more comfortable, and it aids the healing process.

2.31 Conversely, demotivators include low awareness of the need to save energy; no appreciation of the role that individuals can play; a lack of knowledge of saving opportunities; and a lack of knowledge of energy-efficient practices.

2.32 Overcoming these barriers is one of the main functions of energy management. Successful energy management campaigns use a wide range of communication techniques to raise awareness, including:

- posters;
- newsletters and leaflets;
- staff training and briefing meetings;
- general staff meetings;
- e-mails;
- the staff handbook.

Example

The energy manager at Wolverhampton City Primary Care Trust realised that ordinary energy awareness posters around the building were "wallpaper", so he and his colleagues designed new ones, using gentle humour to attract attention. The posters featured "Energy Bill" (the silent robber), Squandering Sidney, Drippy Dora and their wasteful colleagues. Posters were changed or moved regularly to make sure people noticed them.

i Further guidance on motivation can be found in the Carbon Trust's Good Practice Guide GPG84: 'Managing and motivating staff to save energy' and Good Practice Guide GPG172: 'Marketing energy efficiency – raising staff awareness' (available on the CD-ROM).

2.33 It is particularly important to take account of staff views because they are the people who can make all the difference when it comes to the success of an energy-saving campaign. For example, "easy win" activities such as turning off lights, keeping doors closed, or closing windows when the heating is on can lead to real and sometimes substantial savings.

2.34 Some organisations have found that it helps to nominate someone to take on the role of "energy monitor". This person has a list of good housekeeping actions and is responsible for checking that they are achieved each day – for example, as part of a security check at the end of the shift.

2.35 Good communication with staff often identifies problems quickly and generally improves good housekeeping achievements. When changes to building plant or systems are necessary, good communications help staff to accept new services or controls rather than raising objections to the innovation.

Example

The energy management team at Blackburn, Hyndburn and Ribble Valley Health Care NHS Trust encourages all staff to contribute energy-related information. For example, porters walking around the site may spot leaking taps or lights left on unnecessarily; office staff sometimes report overheating or places where air-conditioning is making them feel too chilly.

2.36 Although there may be initial enthusiasm for an energy management exercise, it is important to keep up the momentum. This can be achieved, in part, by reporting back on progress so far. If savings can be quantified in cash terms, or patient or staff benefits, so much the better – and that is one of the positive reasons for having a well-developed energy information system.

Example

The energy management team at Worcester Royal Infirmary set up an incentive scheme with inter-departmental competitions. This helped to give everyone a sense of ownership of the corporate policy. After only ten months, the hospital had saved £35,000. As a result, the Health Authority awarded a £3500 cash prize to the hospital, which used the money to buy a foetal heart monitor.

2.37 It is also helpful to remember that the audience for energy awareness-raising campaigns is not static. There is a constant stream of new patients, visitors,

Example

The University of Leicester NHS Trust ran an energy-awareness week. This involved 13 staff-level presentations across the Trust's three sites. The presentations were scheduled to coincide with break periods and included night-time meetings to cover the night shift (meetings at 9 pm and midnight).

The energy manager secured sponsorship from utilities (Severn Trent Water, Scottish and Southern Energy, and Powergen) to finance the production of a colour booklet to back-up the campaign. He also worked with local groups such as Leicester Energy Efficiency Advice Centre and the city council's recycling advice centre, who helped set up lunchtime information sessions for staff.

staff and suppliers who will not be aware of the energy and carbon management policy. For this reason many organisations require energy, carbon emissions and wider environmental issues to be discussed as part of the standard induction procedure for all staff. The message to staff on such occasions is not just about their own behaviour, but that they should spread the word to other people who are using the healthcare facilities.

Step four – Implementation

2.38 This step involves undertaking a detailed analysis of the organisation's energy usage so that actions can be prioritised.

2.39 There are four main ways to analyse energy usage: energy audits; energy walk-arounds; benchmarking; and energy surveys. Each of these is discussed below. However, it is important to remember that any analysis is not, in itself, a solution to energy wastage. The techniques are very useful to identify priorities – but unless specific actions follow, wastage will continue.

2.40 In addition, the pattern of energy usage (and therefore waste) in healthcare organisations is constantly changing – under the influence of the weather, demand for services, wider development plans and so on. This means that priorities for actions to save energy change too. Therefore it is recommended that an organisation's energy team regularly reviews energy consumption and reassesses the actions needed to reduce consumption.

Energy audit

2.41 An energy audit uses readily available data (for example, from fuel bills) to identify where energy is being used.

2.42 For smaller healthcare organisations, or facilities housed in a single building, the energy manager can do a quick and effective audit simply by looking at the organisation's fuel bills or meter readings – the type of information that is supplied to the national healthcare energy usage databases – and ranking the organisation's buildings in order of their energy consumption. This gives a rough-and-ready guide to prioritising subsequent activities. For example, the building with the highest electricity consumption should be the one that is visited first when the energy manager begins an energy walk-around.

2.43 However, the scale of the exercise depends on the size and complexity of the organisation. If the organisation has multiple sites and monthly bills, or if the energy management team is inexperienced, it may be necessary to engage the assistance of specialist energy consultants. If this is the case, it will be more cost-effective to ask the energy consultants to perform the audit as the preliminary stage before they begin the other activities described in paragraphs 2.38–2.68.

i Further information about energy audits can be found in General Information Report GIR047: 'Controlling energy use in buildings' (available on the CD-ROM).

i More detailed information can be found in CIBSE Guide F: 'Energy efficiency in buildings'.

Energy walk-around

2.44 At least once per year – and certainly at the start of an energy-saving campaign – the energy manager should conduct an energy walk-around. This is a user-friendly survey of where energy is being used around a building or estate using simple checklists. It can be a great opportunity for raising awareness of energy use, particularly if the organisation's energy champion is invited to join in. It is also likely that obvious wastage will be spotted and can be corrected immediately – lights left on in unoccupied areas, for example.

2.45 The best time to do the walk-around is when people are least expecting it. (If they are aware that a walk-around is planned, people will make a special effort to switch off unused equipment.) However, patient care and confidentiality should not be compromised:

- alert the appropriate person before visiting patient care areas (for example, suggest to staff that the walk-around is comparable to a health and safety spot-check, in that staff should not take actions in advance of the visit);
- if a member of the energy management team spots obvious energy waste during the walk-around, **they should not take action themselves**; discuss it with clinical staff first (after all, this is an *awareness-raising* exercise).

i Generic checklists and further guidance on conducting an energy walk-around can be found in General Information Report 47: 'Controlling energy use in buildings' (available on the CD-ROM).

i See also Appendix 6 for a set of standard stationery forms that can be used in a site energy audit.

2.46 The information gathered during a walk-around can form the basis of a good-housekeeping system. For example, once particular wastages have been identified during a walk-around, these could be added to a daily checklist to be used by the person who has agreed to be energy monitor for that area. The information can also be used to:

- develop a more detailed energy management campaign;
- highlight areas where maintenance procedures should be tightened;
- provide evidence that remedial action such as renovation or investment in equipment is needed.

2.47 For example, if during an energy walk-around it became clear that there were many electric kettles for staff and patient use, the energy manager might consider the benefits of providing hot-water dispensers for drinks. There would be an initial capital outlay, but these devices would save energy and would also have long-term safety benefits.

Benchmarking

2.48 Benchmarking is a well-established management technique for assessing local performance. In the case of energy usage, the Carbon Trust publishes energy benchmarks for a wide range of building types. These benchmarks use measured data on energy consumption in a sample of buildings of a particular type (usually categorised by end use), and the data is analysed to derive a set of figures that represent good practice and typical energy performance. These figures are sometimes known as the "headline" benchmarks (see paragraphs 2.54–2.57).

2.49 The idea is to see how local data compares with the published benchmarks, then take steps to improve local performance. Priority should be given to those buildings or areas that are performing worst against the benchmarks. This is fairer than asking for an across-the-board percentage reduction, where buildings that are already performing well are asked to reduce as much as those that are performing badly.

2.50 Benchmarking can be used in other ways, too. For example:

- it can be used to set energy-saving goals;

Example

There are approximately 25 properties in the Wolverhampton City Primary Care Trust portfolio. Once, when the energy manager was using annual energy figures to compare the performance of similar buildings, he noticed that one community health centre was faring much better than its comparators. When he investigated further, he found that one person's hard work to encourage everyone to switch off lights and electrical equipment had led to a significant reduction in the centre's electricity bills.

- if the organisation has several similar buildings, it is also possible to benchmark these against the best performer of the group. This can help to identify unexpected energy use, for example one piece of plant or equipment that is in need of maintenance.

i Appendix 2 gives the most up-to-date benchmarks for delivered energy use (and carbon emissions) in healthcare facilities. These benchmarks acknowledge that energy consumption depends on the building type and the services offered, and separate benchmarks are therefore given for teaching and specialist hospitals; general acute hospitals; community and mental health in-patient facilities; GP surgeries; and health centres and clinics.

i Further guidance on using benchmarks in the healthcare sector can be found in the Carbon Trust's Energy Consumption Guide 72: 'Energy consumption in hospitals' (available on the CD-ROM). However, it is important to note that the benchmark values in this guide have now been superseded by those in Appendix 2.

2.51 The raw data for a benchmarking exercise can be obtained from the organisation's energy consumption data (that is, the information that is supplied to the national healthcare energy database) or, preferably, a building management system (BMS; discussed in more detail in Chapter 5). Providing there are sufficient energy meters around the site (see Chapter 4), BMS data usually gives sufficient information to derive detailed benchmarks; and the software associated with some BMS systems can perform the calculations automatically.

2.52 It should be noted, however, that comparing the organisation's data with nationally-based

Example

The energy manager of three trusts in London uses data gathered for the ERIC database to benchmark the buildings at Parkside NHS Trust. The data is used to calculate consumption in terms of GJ/m^3 and $cost/m^3$ for each building, and then to compare different buildings across the organisation's portfolio. The results of this analysis are then e-mailed to each building's manager so that they know how their building is performing. The analysis is also used to draw up "league tables" of performance.

This system has highlighted several areas of substantial savings potential. For example, one particular hospital was performing very badly compared with the benchmark. The energy manager approached the management of the hospital and helped them to identify areas where good housekeeping could make energy savings. The managers assigned responsibility for energy good housekeeping to certain staff, and within just one year the hospital had reduced its total energy usage by 30%.

benchmarks does not fully take account of the differences between the wide range of healthcare facilities that can be grouped under generic headings such as "general acute hospital" or "health centres and clinics". Nevertheless, the benchmarking technique described here will give the energy manager sufficient information to identify where improvements can be made. Even if the building is better than the "good practice" benchmark, there is usually some further improvement that can be made.

2.53 Comparing the performance of the same building year on year with the national benchmarks will show whether performance is improving or deteriorating, and again attention can be directed towards those buildings most needing it. This will help to prioritise action, even where the whole stock of a particular health sector organisation is consistently worse than "typical", perhaps because the buildings are old.

Benchmarking specific services and building types

2.54 The "headline" benchmarks are appropriate for presenting an overall assessment of performance to prioritise action. A subsequent step is to understand which of the services within a building is causing energy consumption to go over the benchmarks. This can be achieved by monitoring local performance closely for a set period or by gathering energy usage data from sub-meters (or via the BMS), then comparing performance year on year or comparing with benchmarks that are published for other sectors (for example, IT equipment benchmarks are available for offices).

2.55 Many healthcare organisations will have properties and services that are not covered by the national healthcare benchmarks (Appendix 2) or the healthcare-related guidance documents published by the Carbon Trust. Therefore it will be necessary to use benchmarks that apply to other building and function types:

- for a building that is mainly for administration, benchmarks for offices will be appropriate;
- benchmarks for small offices may also be more appropriate for GP surgeries;
- for a teaching hospital that has lecture theatres and laboratories as part of its estate, benchmarks for higher education buildings (universities) should be used (choose only the detailed benchmarks for the appropriate functions);
- for care homes, specific benchmarks are available;
- where hydrotherapy pools or gymnasia are part of the healthcare service, benchmarks for sports facilities should be used.

2.56 Buildings or groups of buildings on one meter should have benchmarks compiled from the above sources, amended to take account of the proportional area of each building use.

i The Carbon Trust publishes benchmark data for a wide range of building types. Energy Consumption Guide 19: 'Energy use in offices' and Energy Consumption Guide 57: 'Energy consumption guide for nursing and residential homes' will be useful for most healthcare organisations, and can be found on the CD-ROM. Benchmarks for other building types can be found via the Carbon Trust website at http://www.thecarbontrust.co.uk

2.57 Benchmarking can be as complex as the situation demands, and energy consultants will usually benchmark performance as part of a wider survey. Some energy managers, however, find that they can develop their own benchmarking techniques as part of their ongoing monitoring and targeting (M&T) activities (see Chapter 1).

Energy surveys

2.58 An energy survey is an on-site technical investigation of the supply, use and management of energy to identify specific energy-saving measures.

2.59 Typically, a survey will consider:

- the building – levels of insulation, ventilation, air infiltration etc;
- the pattern of use – periods of occupancy; the types of control; the temperatures and humidities maintained; the use of electric lighting; the activities and processes being undertaken, including their operating temperatures; insulation etc;
- energy supply and distribution arrangements – fans and pumps, insulation of hot water and steam pipes and air ducts, evidence of leakage etc;
- the main building services – primary heating, cooling and air handling plant, and the condition of plant;
- lighting – quality, efficiency and control of electric lighting, and the use of daylight.

2.60 It will also involve a review of the energy management strategy; a comparison of overall performance against certain benchmarks; and identification of opportunities for energy and cost savings with recommendations for action.

2.61 Surveys can be time-consuming and expensive. However, healthcare organisations can benefit from financial or technical assistance via the Carbon Trust (see box "Seeking specialist help" at paragraph 2.28). The cost of the survey, if done by in-house staff, depends on internal accounting procedures (that is, savings identified may cover the cost of the time spent doing the survey.) If consultants are called in, the cost will typically be a fixed sum or a function of a shared savings scheme. Whichever route is followed, the total cost should be no more than a small percentage of the annual cost of energy under investigation (for example, 3% or 5%)[8] and is usually recovered during the first year if recommendations are implemented fully.

2.62 For an estate with small energy demands, the other techniques described in this chapter should suffice, unless there is a major change in circumstances (for instance, revised working practices or occupancy patterns). It may also be appropriate to perform a survey before a major redevelopment to provide up-to-date information.

i General guidance on conducting a survey is available in the Carbon Trust's General Information Report GIR047: 'Controlling energy use in buildings' (available on the CD-ROM).

i More detailed guidance can be found in CIBSE Guide F: 'Energy efficiency in buildings'. In addition, CIBSE's energy assessment and reporting methodology (EARM) could be used. This is described in CIBSE TM22: 'Energy assessment and reporting methodology'.

Using the information

2.63 The information gathered during this implementation step will contribute to an ongoing energy-saving campaign. It should be fed back to senior managers in the form of a "paper to the board". The information can also be given to staff, patients and other stakeholders in the form of "performance league tables" to encourage further savings. It could also be used to launch an in-house competition between departments or services. As further data comes on-stream (for example from Step 5: monitoring and targeting), that can also be used to report back on progress.

2.64 The investigations carried out so far will invariably point to some areas where energy can be saved. But at this point the energy management team should think very carefully about the practicalities of their proposals and discuss options with various stakeholders.

- good housekeeping measures should be at the top of the list of actions, because these are generally no-cost or low-cost actions that will bring tangible savings or comfort improvements straight away;
- introducing or revising any maintenance strategy will likewise result in early success;
- fabric improvements and changes to plant and equipment – which have financial implications – should then be addressed.

8 The percentage may well be higher for an organisation with many small sites, even though the total energy bill may be several million pounds

Example

At the Mid-Cheshire NHS Trust, deputy department heads have added the checking of lights as part of wider security checks at the end of shifts. This ensures that lights are switched off if they are not required, and that any lights which should be left on for security reasons are working correctly.

Example

Theatres need to maintain positive pressures for infection control, but there is no need to run plant around the clock every day, providing the theatres can be returned to operational conditions within a specified time. Following extensive consultation with staff at Leighton Hospital (Mid-Cheshire NHS Trust), the energy management team arranged for changes to the building management system (BMS) so that, when the theatres are not being used, they go into set-back mode (fans at lower speed); cooling is shut off and the heating temperature goes to the set-back level (14/15ºC). There are nine theatres and they run in pairs (except one) Monday to Friday from 06.00 to 19.00 hrs. This measure saves £3.66 per hour per theatre – a potential saving of at least £1500 per week.

2.65 Whatever solutions are proposed, these should not interrupt the delivery of healthcare or result in conditions that are detrimental to the health and safety of staff and patients. For example, European Workplace Directives place particular responsibilities on building managers regarding ventilation, temperature and lighting.

i Health Technical Memoranda (HTMs) give specific advice on the indoor environmental conditions required for healthcare buildings.

i The provision of appropriate temperatures, humidities, ventilation rates and lighting levels is discussed in Chapters 4 and 5.

2.66 It is also important to make sure that all changes introduced are recorded in the overall energy management strategy documents, with specific dates for reviewing and, if possible, details of the particular outcome the measure is intended to achieve (for example, a specific energy or carbon saving; or a measurable improvement in patient comfort such as correct room temperature achieved).

2.67 The energy- and cost-saving benefits of all refurbishment work or renewals – fitting replacement windows, upgrading office computers, installing new plant and so on – should be considered carefully in accordance with the organisation's overall energy and carbon management policy. This is discussed in more detail in Chapter 3 (procurement) and Chapter 4 (major projects).

2.68 Major refurbishment that upgrades the building envelope should aim for energy use to be improved from "typical" to better than the "good practice" benchmarks.

i Further information and advice on identifying and providing remedial measures for existing buildings can be found in Appendix 18.A1 of CIBSE Guide F: 'Energy efficiency in buildings'.

Step five – Monitoring and targeting (M&T)

2.69 M&T – as it is known by energy management professionals – is a way of using energy-related data to drive continuous improvement. The objective is to keep a close eye on ongoing fuel consumption so that unexpected consumption can be investigated and avoided as quickly as possible. This is particularly important for electricity usage, which contributes two or three times more carbon to the atmosphere than the direct burning of fossil fuels.

2.70 Ongoing monitoring of energy use will identify a wide range of issues – from plant that is not working at its best to areas where housekeeping is being neglected. Monitoring individual departments or specific usages can even be used as a basis for re-charging departments – an excellent way to encourage people to take control of their energy use.

2.71 An M&T system will be based on the information from the energy audit, combined with the energy management strategy that assigns various actions to specific people. In addition, the energy management team will need a reliable stream of short-, medium- and long-term energy performance indicators for the whole estate and key elements within the estate. This may be obtained from simple meter readings or, more likely, sub-meter readings that record half-hourly energy usage.

Example

Most departments at Leighton Hospital, Crewe (part of the Mid-Cheshire Hospitals NHS Trust) have electricity sub-meters that feed data to M&T software. The data is used to monitor performance of departments and for re-charging some departments (including the on-site laundry and a private hospital on site). The M&T exercise has proved very useful for monitoring electricity usage. For example, when new catering equipment was installed in the kitchen, it consumed much more electricity than expected. Using data from the sub-meter made assessing the performance of the equipment more easy, and the data could be used as evidence when the performance of the equipment is reviewed.

Example

At Kings Mill Hospital (Sherwood Forest Hospitals NHS Trust), approximately 150 electricity and gas meters are checked each month. The data feeds into a custom-made database and is used to re-charge other organisations such as the "hospital association" shop and other tenants (including another trust). The database can produce reports and graphs automatically, which saves a great deal of time.

One added advantage of the metering system is that it has helped to identify water leaks. This is because on one occasion the data showed an unusually high consumption of energy for water heating; when the energy manager investigated further, it became clear that water leaks meant water was being heated unnecessarily. Fixing the leaks saved the hospital money on its water bills as well as its fuel bills.

2.72 Installing new meters can be expensive, but this measure should not be ruled out on the grounds of cost alone, because metering can bring additional advantages, as the example below illustrates.

2.73 Before consumption is analysed, meter data should always be checked against invoices, just as delivery notes for consumables are checked when goods are delivered. The validated data can then be analysed (using basic statistical techniques, off-the-peg or custom-built software packages) to obtain energy use profiles – graphs or charts showing the energy use in a particular building or by one specific service.

Example

The energy manager of North Staffordshire Hospitals NHS Trust worked closely with a utilities supplier who installed a remote monitoring and collection system that paid for itself through water savings alone.[9]

The system provides "live" data, so it was used to quickly and accurately step test the water supply system to identify leaks. The energy manager has also used it to look at peaks in performance on electricity. The peaks can be seen in real time and it is easy to see how this affects demand profiles.

The system normally uses mobile phone technology to gather data, but the energy manager asked for it to be customised to use radio communications instead across the 1.5-square-mile City General site. It also links to the Haywood Hospital five miles away.

i Good Practice Guide GPG312: 'Invest to save? Financial appraisal of energy efficiency measures across the government estate' describes the various techniques in detail. This document is on the CD-ROM.

2.74 The profiles should show:

- base load;
- night/weekend differences;
- the hours when the main consumption tends to occur ("shoulder hours").

2.75 The profiles will have a particular shape, so unusual consumption will show up because the graph will contain a spike, peak or trough. The energy management team should then check back with the people working in the department at the time to try to explain why this consumption has occurred.

i M&T techniques are described in detail in the Carbon Trust's Good Practice Guide GPG112: 'Monitoring and targeting in large companies' (available on the CD-ROM).

2.76 M&T is a highly iterative process, with successive measurements being compared with historical data. Clearly, the amount of time devoted to M&T

9 Note that water efficiency is often included in energy or environmental management strategies. This is, in part, because some of the water used needs to be heated, and most of it is pumped at some stage (both of these processes have energy implications)

should be proportional to the savings that can be achieved. Crucially, any M&T system will fail if the underlying management structure of the organisation does not support the feedback that M&T delivers.

M&T as part of the overall energy management strategy is discussed in Good Practice Guide GPG376 'A strategic approach to energy and environmental management', published by the Carbon Trust. This is available on the CD-ROM.

Maintenance

2.77 As well as identifying potential energy savings, the M&T system should be coordinated with the organisation's maintenance strategy. The two will then reinforce each other to everyone's benefit. For example, M&T data can highlight plant that has begun to operate at lower than optimum performance and alert the maintenance team that a service is required. This both prolongs the life of the plant and improves its energy efficiency.

M&T information may suggest that measures involving capital expenditure are necessary. This will involve both procurement and design issues (discussed in Chapters 3 and 4 respectively).

Feedback

2.78 The five-step approach described in this chapter can only succeed if the information gathered and the behaviours observed are linked back to specific energy-saving actions. For example, if benchmarking shows that one building consistently uses more power for air-conditioning than another comparable building, the information should trigger an investigation, which may involve the energy management team, front-line staff and financial decision-makers (who may need to approve an investment in new plant or equipment).

2.79 Managing energy use is an ongoing task, and there is a potential danger that the energy management team could spend too much time focusing on technical detail. That is why providing feedback – though not a step in itself – is so important. It gives energy users an incentive to keep up with the good housekeeping; but it also gives senior managers the information they need to be able to offer praise where it is due – to the energy management team.

Further information about feedback can be found in the Carbon Trust's General Information Report GIR047: 'Controlling energy use in buildings' (available on the CD-ROM).

3 Procurement of buildings, equipment and services

3 Procurement of buildings, equipment and services

Introduction

3.1 Healthcare organisations continually add to and improve their buildings, facilities and equipment – all of which use energy and therefore have an impact on the organisation's carbon emissions. This means that procurement decisions play a very important role in improving the organisation's energy and environmental performance.

3.2 The approach taken thus far in this guidance is that everyone in the healthcare organisation – staff, patients, visitors, contractors and suppliers – should take steps to reduce energy use (and therefore carbon emissions) at every opportunity. This chapter explains how this aim can be integrated into all procurement decisions taken by the organisation.

3.3 The basic steps of the procurement process are:

- identification of need;
- specification;
- appraisal and qualification of suppliers;
- tendering and tender evaluation;
- contract management and review.

3.4 At each of these steps, energy and environmental issues should be taken into consideration. This chapter therefore includes:

- an overview of the principles of procuring for energy efficiency in the context of overarching public procurement regulations;
- a summary of the various techniques used to aid the decision-making process, with specific reference to energy consumption;
- a summary of the issues to be considered when evaluating tenders.

3.5 It also describes in more detail the actions needed to ensure that energy efficiency is considered during the procurement of:

- equipment and services;
- publicly-funded capital projects;
- privately-funded capital projects (for example PFI schemes).

3.6 The processes described in this chapter are applicable to the various forms of procurement commonly used by healthcare organisations. The relative merits of the various energy-saving options (for example CHP compared with traditional fuel sources) are covered in Chapter 4.

Principles of procuring for energy efficiency

3.7 No energy and carbon management policy or strategy is complete without consideration of the procurement function. It could be argued that if procurement decisions are not taken with due regard for energy or environmental issues, no amount of proactive energy management can mitigate the impact of these decisions.

3.8 Overarching procurement rules for public organisations are laid down by the European Union, HM Treasury and other government departments. In the UK, the fundamental principle is that all public procurement should be based on "value for money", having due regard to propriety and regularity. The overarching rules should always be considered and complied with as the first priority, but within their boundaries there is considerable scope for addressing energy and environmental issues.

3.9 In the public sector, value for money is defined as the optimum combination of "whole-life cost" and quality (fitness for purpose) to meet the user's requirement. This is the definition that applies throughout this guidance.

3.10 It is a widespread misconception that value for money is synonymous with securing the lowest possible price. The correct interpretation is that organisations should seek the best option offered by tenderers **based on the specification they have set out**. This means that the purchaser is at liberty to decide what to buy and can set a specification that is appropriate to their organisation's overall objectives.

3.11 When procuring equipment, healthcare organisations should consider a whole-life-costing approach. Equipment may have an initial higher purchase cost, but when added to its whole-life running cost it should demonstrate value for money. Providing the specification clearly states that the equipment supplied should meet **specific** energy-saving goals, the procurement exercise can be conducted in accordance with the requirements of public-sector procurement rules.

The impact of the Climate Change Levy

It is important to bear in mind the impact of the Climate Change Levy (CCL) when analysing the costs of prospective purchases.

The CCL – which came into effect in April 2001 – increases the cost of purchasing electricity, coal and natural gas. It is generally regarded as being "revenue neutral" because the additional cost burden it introduced has been partially mitigated by a cut in National Insurance contributions. However, the CCL makes it more attractive to choose energy-saving equipment or to adopt energy-efficiency measures in new buildings or refurbishments, because these measures will not only save on fuel, but also reduce the amount of CCL that has to be paid overall.

In other words, the CCL strengthens the case for investment in energy-saving technologies.

3.12 In summary, whatever the route of procurement, there should be provision for energy-efficiency measures as part of the evaluation process, for example:

- contribute to a reduction in carbon emissions;
- achieve the required rating when using environmental assessment tools during the design of new buildings, services or refurbishments;
- reduce the organisation's exposure to significant risk of fuel cost increases (for example by using on-site renewable energy);
- reduce the risk of high cost of future adaptations to the building.[10]

Policy issues

3.13 Environmental purchasing reaches all parts of the organisation. A clear policy will ensure that:

- all parts of the organisation are sending consistent messages to suppliers;
- budget holders do not ignore or reject environmentally preferable alternatives without due consideration to the impact of their decisions.

3.14 Whether it is treated as a stand-alone policy, or incorporated into other relevant policies, environmental purchasing – like energy management – succeeds when it is:

- integrated with the organisation-wide energy management or environmental strategy;
- backed by board-level commitment and activity planning;
- well communicated throughout the organisation;
- supported by clear objectives and performance indicators;
- owned by those responsible for delivering its commitments.

3.15 The following example is a template for an environmental purchasing policy, which is the starting point for any healthcare organisation seeking to ensure that they procure energy-efficient buildings, equipment and services. The policy is supported by a list of purchasing preferences, which is also shown. Organisations wishing to use this template should adapt it to suit their local circumstances. (See also the Office of Government Commerce (OGC) and Defra's (2003) 'Joint note on environmental issues in purchasing', which can be downloaded from http://www.ogc.gov.uk/)

10 Future building regulations will require retrospective improvements to insulation and system efficiencies whenever changes or refurbishments are carried out, if not already carried out at the time of construction

Sample environmental procurement policy

[Name of organisation] Environmental Procurement Policy

General statement of intent

The [name of organisation] accepts its responsibility to reduce the adverse, and increase the beneficial, environmental impacts of its purchasing and supply activities in recognition and support of:

- the key and influential role of purchasing and supply activities in environmental management, risk management and patient care;
- the link between environmental quality, public health and patient episodes;
- stakeholder expectations – in particular, to contribute and participate in the Greening Government and Greening the NHS initiatives, the UK's wider commitment to sustainable development, and the Local Agenda 21 plan for our local community.

It is therefore our overarching aim to ensure that the goods, works and services we purchase are manufactured, delivered, used and managed at end-of-life in a safe and socially and environmentally responsible manner and that the associated risks are appropriately managed by the controls assurance framework.

Strategic objectives

To this end, while paying due cognisance to EU rules and domestic policy governing public procurement, we will:

- integrate environmental considerations into our procurement strategy, purchasing procedures and, in accordance with Government and EC guidelines, into our procurement process in general;
- continually improve our environmental purchasing and supply performance through the setting and annual review of relevant objectives that are identified through the conduct of an environmental risk assessment and agreed through consultation with stakeholders;
- specify and exercise a preference for environmentally preferable products that offer demonstrable value for money;
- define, maintain and implement, on the basis of wider Government guidance, a database of those substances, products and product types to be avoided at all costs; favoured at all costs; preferred where value for money can be demonstrated (see sample list, below);
- take account of whole-life costs in the evaluation of tenders, wherever practical;
- maintain an environmental supply-chain programme that engages suppliers in a programme to improve their environmental awareness and the environmental performance of their activities and products;
- promote, monitor and report on environmental legislative compliance and pollution prevention within the supply chain;
- reduce the environmental impact of purchasing and supply activities by reducing paper flow through the procurement process, avoiding replication and minimising the administrative burden on suppliers;
- provide sufficient resource for successful implementation of this policy and ensure employees engaged in purchasing activities have access to appropriate guidance and training;
- work in partnership with public-sector purchasing organisations and service providers, especially those operating within our local community;
- ensure our purchasing and supply activities contribute positively to our overarching environmental policy and to our local community's Local Agenda 21 plan;
- communicate this policy widely to suppliers, employees and other key stakeholders and periodically report on progress in the public domain.

This policy was agreed by [eg Chief Executive, Board etc]

The following stakeholders were consulted in the development of this policy: patients, unions, employees, local community, strategic health authority, Government representatives [delete as appropriate].

The [enter name of Board lead for procurement] is responsible for ensuring this policy is implemented and maintained.

The [eg internal audit] is responsible for monitoring and reporting on compliance to [eg the board].

This policy will be reviewed by the Chief Executive, or their representative, within a three-year period and will be made available widely.

Signed: ....
Chief Executive

Date: ....

Sample list of substances and products to be avoided, promoted and preferred

The [enter name of Trust] will only purchase:

- timber and timber products that have independent evidence that they have originated from sustainable and legal sources, in accordance with Government guidelines;
- the most energy-efficient, and where applicable, water-efficient electrical domestic appliances [for example, energy efficiency rated “A”];
- recycled paper products, where virgin pulp is not essential to the performance of the product.

Wherever possible, [name of Trust] will avoid the purchase of:

- products or equipment containing/using/manufactured with ozone-depleting substances such as CFCs and HCFCs;
- products or equipment containing/using/manufactured with substances with a high global warming potential such as HFCs, PFCs, methane etc;
- products containing toxic substances such as mercury;
- products with excessive packaging, where a packaging recovery scheme is not offered by the supplier;
- batteries and products containing batteries, especially where they are non-rechargeable.

Where value for money can be demonstrated, [name of trust] will show a preference for:

- substances and/or products with proven reduced toxicity compared with the alternatives;
- products containing recycled content;
- products that are designed for re-use and/or recycling at end-of-life;
- energy-efficient electrical and electronic appliances;
- energy and materials that derive from sustainably-managed renewable resources;
- low-emission vehicles;
- products that have otherwise been purposefully designed to reduce their environmental impact or with improved environmental performance that are accompanied by appropriate evidence.

[This template is an extract from the NHS Purchasing and Supply Agency’s (NHS PASA) ‘Guidance on the development of an environmental procurement strategy’ (2003) available at http://www.pasa.nhs.uk. The document is Crown copyright, and it is reproduced here by kind permission of NHS PASA.]

Example

There are approximately 5000 PCs managed by the University Hospitals of Leicester NHS Trust. The typical annual running cost for a PC with a traditional screen (VDU) is around £30, but if the VDU is replaced by an LCD flat screen, the total running cost is only £9. The energy manager persuaded the Board to adopt a new policy, which states that when equipment is being replaced it must incorporate a flat screen. This saves on electricity, but also cuts heat emissions, so reducing the need for comfort cooling in offices. Flat screens are also better for users, because they allow flicker-free viewing.

Making the case for energy-efficient purchase – EU guidance

3.16 European Union public procurement directives apply to all public-sector purchasing. In July 2001, the European Commission published an 'Interpretative communication', which clarified how environmental considerations can be integrated into public procurement procedures. The communication explains how environmental concerns may be taken into account at each separate stage of the contract award procedure. It makes it clear that there are numerous possibilities for the greening of public procurement under the directives. This is particularly so if three guiding principles are followed: non-discrimination; transparency; and thought about where in the tender process environmental elements should be taken into account. The earlier in the tender process environmental considerations are included (definition of the subject of the contract, technical specifications etc), the more is possible. The following list contains excerpts from a set of frequently-asked questions (FAQs) issued with the 'Interpretative communication':

- *In the technical specifications of the tender, process and production methods can be requested where these help to specify the performance characteristics of the performance or service. This includes both process and production methods that physically affect the end product (for example absence of chemicals) and those that do not but nevertheless affect the nature of the end product (for example organic food, or furniture produced from sustainable timber). Note, however, that it is not possible to require that the factory producing the goods should use recycled paper in its office, because this does not relate to the production of the goods.*
- *It is possible to ask for specific materials to be used in an object supplied or in a works contract and also to ask for a type of material not to be used. For example, it is permissible to state that windows be made of wood or that they are not made of a specific material.*
- *Only those criteria that have a link to the subject matter of the contract and give the contracting authority a direct economic benefit can be used at the award stage. This could include giving a bonus to products that are more energy-efficient, that will last longer, or that will cost less to dispose of. In case the environmental aspects do not bring an economic benefit to the contracting authority, these aspects can only be taken into account at the beginning of the tender procedure, where the contracting authority defines the technical requirements of the contract.*
- *Although green products will often save the public purchaser money in the longer term, they may have a higher up-front cost. If contracting authorities want to make a balance between environmental choices and budgetary restraints, they may define one or more variant options in addition to their basic option. In the variants they can define a higher environmental performance. At the end of the tender procedure, contracting authorities can decide which variant best meets their needs.*

[Source: Commission of the European Communities (2001) 'Commission interpretative communication on the Community law applicable to public procurement and the possibilities for integrating environmental considerations into public procurement'.]

Evaluation techniques for procurement

3.17 Procurement always involves an element of options appraisal. This activity compares possible solutions to a particular problem to arrive at the optimum solution. However, it is not a purely financial exercise. For example, buildings-related procurement usually involves an appraisal of capital and operating costs, but it may also cover environmental impact as well as practical issues such as plant location and the flexibility to cope with changes in building use and occupancy (all of which, of course, have a financial dimension).

3.18 Options appraisal is a highly iterative process. Some options might be eliminated early in the process because of the constraints on the project, such as the physical limitations of the building (for example, the size of an existing plantroom). Conversely, other options may come to light during the analysis. It is important, therefore, to consider even the most unlikely options – nothing should be fixed until final recommendations are made.

3.19 Good appraisal entails:

- allowing time to carry out calculations and to apply for grants, if applicable;
- estimating and presenting the costs and benefits of each potentially worthwhile option;
- taking full account of associated risks and uncertainties;
- undertaking the appraisal early enough to avoid abortive work being undertaken on traditional but poorer-value design solutions.

3.20 When evaluating the relative merits of specific energy-saving or low-carbon measures (or packages of measures where they work best together), any options appraisal exercise should involve:

- calculating the capital and revenue cost implications of realistically-estimated energy and carbon emission changes brought about by the measure, and their timing;
- calculating savings due to other benefits, and their timing;
- undertaking a whole-life cost analysis;
- correctly apportioning the risk.

3.21 Note that the choice of time horizon can be important for energy-related decisions. Normally, the time horizon for appraisal is determined by the economic or physical life of the main asset in question or the period over which the service is required. Time horizons should usually be sufficiently distant to encompass all important cost and benefit differences between the options. The Treasury's 'Green Book' – the primary Government guidance on procurement in the public sector – says that time horizons ". . . should not be artificially constrained by department or agency planning or budgeting systems".

3.22 In addition, the Treasury recommends post-project evaluation – which reviews the original options appraisal exercise to see whether the process could have been improved so that this knowledge can improve subsequent purchasing processes and decisions.

i The general principles of appraisal and decision-making are discussed in detail in 'The Green Book: Appraisal and evaluation in central government' – the Treasury's primary guidance document – which

Investment criteria

Energy-efficiency measures should be assessed on the same basis as other investments, but taking full account of the wider benefits that can accrue.

For low-cost/low-risk measures with quick returns, simple methods of appraisal are generally acceptable.

Appraisals of large or long-term investments should take account of interest rates, inflation, project life and risk. It is also advisable to undertake a sensitivity analysis to check the impact of reasonable future changes, for example in ambient temperature (as measured by degree days), equipment performance, energy prices or staff costs. Advice on likely relative price movements should be obtained from the appropriate in-house expert, or from external bodies or economists.

Expressing costs and benefits at present value means that, where particular prices are expected to increase at a significantly higher or lower rate than general inflation, this relative price change will be brought into the calculation.

The full implementation costs should always be considered – including equipment, material and labour costs, consultants' fees, builders' work and any disruption costs. In-house staff time, whether carrying out work directly or supervising the work of others, should also be included.

i Methods used in investment appraisal are outlined paragraphs 3.23–3.27, and are discussed in more detail in CIBSE's (2000) 'Guide to ownership, operation and maintenance of building services'.

i Further guidance can also be found in Good Practice Guide GPG312: 'Invest to save? Financial appraisal of energy efficiency measures across the government estate'.

i See also Good Practice Guide GPG165: 'Financial aspects of energy management in buildings' (all available on the CD-ROM).

can be downloaded from the Treasury website at http://www.hm-treasury.gov.uk.

Options appraisal and other financial techniques are discussed in the Carbon Trust's Good Practice Guide GPG312: 'Invest to save? Financial appraisal of energy efficiency measures across the government estate' and Good Practice Guide GPG165: 'Financial aspects of energy management in buildings' (available on the CD-ROM).

Techniques for financial assessments

3.23 There are four well-established techniques for analysing procurement decisions based on value for money. These are described briefly below, arranged in order – simplest to most comprehensive.

Simple payback

3.24 The crudest test of cost-effectiveness is "simple payback period", which is the time taken for the initial capital expenditure to be equalled by the saving in energy and other operating costs. The Department of Health's (2005) 'Carbon/energy management in healthcare: best practice guide' for England states that:

"NHS healthcare organisations should consider, as financially viable, the implementation of longer payback schemes of up to eight years if there is serious commitment to deliver the reduction in energy and carbon emissions."

3.25 The simple payback technique does not account for interest rates or the benefit of ongoing savings to the end of the life of the plant. For this reason, using this method in isolation may lead to under-investment and a failure to seize good investment opportunities where payback periods are somewhat longer than anticipated.

3.26 Although it is possible to set payback times of up to eight years, the simple payback technique is generally used for measures showing a return within five years for measures involving only minor investment, or for an initial assessment of measures that involve more substantial investment. (For investments that do not meet these criteria, other appraisal techniques should be used.)

3.27 If the simple payback technique is to be used, it is important to specify whether costs and savings are based on firm quotations or budget estimates. Where it is already established that some action is needed (for example, replacement of a failed boiler) the technique can be used to compare options by balancing the marginal capital cost of one measure over another against its incremental benefits.

Net present value techniques

1. *Discounted cash flow:*

Large projects and long-term measures usually require the preparation of a cash-flow statement to evaluate their true economic worth. Discounted cash flow (DCF) takes into account the timing of capital and revenue costs and savings. DCF methods should be applied when:

- benefits continue beyond the usual maximum allowed payback period;
- the assets are long-lived;
- costs and benefits vary over time.

Such methods use a discount rate of, for example, 3.5% (the actual rate is fixed by the Treasury). This is, in effect, saying that such a return on capital obtained by an alternative investment and an energy efficiency investment should yield a return no less than this. The results are often expressed as discounted payback or as the break-even period.

Up-to-date discount rates are published on the Treasury website, http://www.hm-treasury.gov.uk

2. *Net present value:*

Net present value (NPV) indicates the discounted cash flow over the life of the project by calculating the difference between the discounted cash flows and the initial investment. The effects of taxation (including the Climate Change Levy) can be taken into account, as can changes in energy prices. The true worth of the proposed measure can then be seen as a sum of money in present-day values. If the NPV of a project is positive, it should be considered, but a negative NPV would indicate that the project would lose money.

3. *Internal rate of return:*

Internal rate of return (IRR) is an alternative approach to NPV, representing the rate of interest that money would have to earn elsewhere to be a better investment. The higher the IRR, the better the project.

IRR is defined as the discount rate at which the net present value of the project reduces to zero. The interest rate at which the NPV becomes zero is determined by successive approximations.

Whole-life costing

3.28 Whole-life costing (WLC) is another way to assess the relative merits of various procurement options, but it takes a broader definition of cost than conventional accounting techniques. WLC considers all costs over the life of goods and services that are procured. In this way, WLC provides the means of determining whether it is cost-effective to invest in a product that is initially more expensive in order to reduce costs in the long run – a very useful tool when considering energy-efficiency measures.

3.29 WLC is not as comprehensive as a full environmental impact assessment (which would consider the emissions produced in the manufacture of the product, for example), but it does allow for some of the environment-related cost dimensions to be considered. For example, WLC will take account of the end-of-life costs involved in a decision – such as disposal costs, opportunities for recycling and so on.

3.30 Any WLC exercise should therefore take account of:

- direct running costs – resources such as energy, consumables and maintenance used over the lifetime of the product or service;
- indirect costs – for example, additional loading on cooling plant arising from equipment that is not energy-efficient and hence emits surplus heat;
- additional administration costs – the overheads associated with buying a standard solution, for example purchasing hazardous products that have special requirements such as additional controls and special handling and disposal;
- spending to save – investing in higher levels of insulation to save heating and reduce bills;
- recyclability – which might include creating markets for the organisation's waste by buying recycled products;
- cost of disposal – perhaps paying a premium at the outset to reduce waste, for example by choosing a product that is more durable, re-usable, recyclable, includes disposal costs, or is free of hazardous materials which would otherwise require its disposal in a special way.

3.31 In addition to direct financial returns, there are nearly always wider benefits that should be taken into account, including:

- improved manageability, for example through better control and monitoring;

Example

This example, for photocopiers, illustrates how whole-life costing can influence purchasing decisions.

Product	Speed of output	Product purchase price	Product life in pages	Whole life cost per page in pence	Cost for 600,000 pages	Percentage greater than cheapest
A	15	£1,600	600,000	1.3	£7,800	210%
B	27	£3,000	1,200,000	0.77	£4,620	83%
C	35	£3,100	2,500,000	0.65	£3,900	55%
D	45	£3,900	2,500,000	0.64	£3,840	52%
E	55	£8,900	9,000,000	0.52	£3,120	24%
F	90	£15,300	30,000,000	0.42	£2,520	0%

At first glance it seems that Product A is the cheapest at £1600. However, when the products are ranked in order of "whole-life cost per page" (in pence), it is clear that Product A is no longer the best option because its output speed is slow, and it will only produce 600,000 pages over its life. In fact, over the required life-expectancy of the photocopier, Product A would have been £3000 more expensive than the next cheapest option, Product B.

(This example was supplied by NHS PASA. The original analysis also took account of the photocopiers' environmental ratings under the Nordic Swan scheme.)

- reduced maintenance and staff costs after replacing or upgrading plant;
- reduced harmful emissions to the atmosphere (CO_2, NO_x, SO_x and so on) – particularly important because it reduces the health impact locally to both the building users and the surrounding community;
- improved management information and decision-making;
- improved services, comfort and productivity.

3.32 The final item in that list is often missed but is commonly one of the greatest benefits. Experience has shown that a combination of benefits result from this – including optimum levels of energy efficiency, people satisfied with their environment, and high productivity. This does not mean that installing measures will always directly improve productivity, but rather that healthcare organisations with well-managed buildings tend to have satisfied occupants who pay attention to energy management.

3.33 Another factor that can be taken into account using WLC is the cost savings for any items that would otherwise have had to be provided and maintained, for example omission of façade or roofing materials where photovoltaic or solar panels are proposed; or the reduced costs of engineering systems where heating or cooling requirements are reduced, and the value of their attendant plant and distribution space.

3.34 It should also be noted that WLC allows for the differences between certain quality principles to be taken into account.

3.35 For example (subject to EU rules), if tenderer A does not have the particular certification stipulated in the specification, but tenderers B and C do have the correct certification, the purchaser needs to account for the additional cost of obtaining the desired certification for A's product.

Tender evaluation

3.36 The Office of Government Commerce (OGC) and Defra's (2003) 'Joint note on environmental issues in purchasing' states that, under the EU rules, contracting authorities should choose the tender that is the most economically advantageous. (In other words, it is acceptable to take account of the whole-life costs of the product or service.)

3.37 Criteria for evaluating the economically most advantageous tender include:

- price;
- delivery date;
- delivery period;
- period for completion;
- aesthetic and functional characteristics of the goods or services;
- after-sales service;
- technical assistance;
- running costs;*
- cost-effectiveness;*
- quality;*
- profitability;*
- technical merit.*

3.38 Criteria marked with * are those under which low-carbon technologies or carbon emissions could be weighted and scored, as long as tenderers are told in advance. As stated previously (see paragraph 3.16), it is important to note that any environmental criteria used should be relevant to the subject-matter of the contract, and energy and environmental recommendations should be stated in the outline specification that carries forward into the invitation to tender (ITT).

3.39 There are two further points to note:

- it is helpful to produce a weighted pro-forma for tender analysis, and tenderers should be given appropriate information so that they understand how their tender will be evaluated;
- where there is a design element to the tender (for example, in the procurement of building services, substantial renovations or whole buildings), sufficient time should be allowed for the analysis of the technical aspects of the tender and in particular for interrogation of the different energy profiles of the comparable schemes (see paragraphs 3.59–3.60 and 4.29–4.42).

Procuring equipment, services and fuel

Equipment and services

3.40 Purchases begin with someone identifying a need for an item or service. The person with the need is not usually part of the organisation's purchasing team, and therefore may not be aware of the obligation for environmental purchasing. In addition, the users of the equipment may ask for particular performance outcomes, without due regard to the energy implications of their request. Having an energy policy and an environmental purchasing policy in place will support the purchasing teams' need to reconcile such requests with the overall objective to influence energy usage.

3.41 Under an environmental purchasing policy the need for each purchase should be considered and re-evaluated – in terms of level, scope and purpose – before embarking on any procurement activity. Ideally, this will be done by the person who first identified the need in conjunction with the organisation's purchasing team, or energy manager, or both (depending on the size and value of the item).

3.42 As part of this activity, alternative types of product, equipment or service should be considered, because this is the time when some quick wins can be made (for example, considering whether it is necessary to purchase printers for every desk or provide fewer, networked, multi-functional devices which include the most up-to-date energy and paper-saving features). It is also important not to look at products in isolation, as it may be that a wider service would better suit user requirements.

3.43 Once the nature of the purchase has been determined, focus should shift to writing a specification that addresses energy issues of relevance to the product or service. This could include:

- option of "power down" or "sleep mode" with various cut-off times to suit different frequencies of use;
- ability of equipment to be networked or sequenced;
- inclusion of timers/energy consumption monitors within equipment to better control operation and usage;
- ease of use of products and services;
- effectiveness/suitability of products/services;
- reliability of products and equipment, in terms of repair and maintenance;
- the total energy equation associated with the product/service from cradle to grave.

3.44 For some product groups, an eco-label can be used to specify energy performance. An eco-label identifies a product or service as environmentally preferable based on life-cycle considerations (including acquisition of raw materials, production, manufacturing, packaging, distribution, re-use, operation, maintenance and disposal). An environmentally preferable product or service is one that is less detrimental to human health and the environment when compared with competing products or services that serve the same purpose.

3.45 A key characteristic of eco-labelling is that the product or service in question must comply with an agreed set of criteria, which typically include energy performance. The most stringent and well-respected eco-labels are those based on criteria set by a third party and the product's life-cycle impacts. The awarding body may be a governmental organisation or a private non-commercial entity. Examples include the EU eco-label (EU flower), the Nordic Swan and the German Blue Angel. These eco-label schemes cover a range of products and services including dishwashers, heat pumps, light bulbs, computers, refrigerators and televisions. The evaluation criteria are updated regularly to ensure that they represent best practice.

3.46 There is also a specific, mandatory EU energy label which applies to a range of household products, some of which are likely to be used within healthcare facilities:

- refrigerators, freezers and fridge-freezer combinations;
- washing machines;
- electric tumble dryers;
- combined washer-dryers;
- dishwashers;
- lamps;
- electric ovens.

3.47 The more efficient the product, the less energy it needs and the more financial savings can be realised. A-rated products are the most efficient and G-rated products are the least efficient. The US Energy Star rating can also be found on many products.

3.48 Care should be taken not to confuse eco-labelling schemes with "green claims" made by suppliers, which may be less rigorous and not independently assessed.

3.49 Relevant eco-label standards can be referenced in the specification. The criteria on the standards can be listed in the specification document or supplied with any tender documentation. However, public-sector purchasers should exercise caution, and the following is recommended to ensure compliance with public procurement rules (see also paragraph 3.16):

- an eco-label certificate can be accepted as proof of compliance with eco-label criteria, but other means of proof should also be accepted;
- if referencing an eco-label standard, such as Nordic Swan, the specification should clearly state that compliance with the standard or similar will be acceptable.

3.50 In the absence of a relevant eco-label there are other ways to specify energy-saving equipment. However, if other labelling systems are to be used instead of established standards, their basis should be evaluated by the procurement team and they should be declared to any intending tenderers.

i See, for example: 'The Green Guide to Specification'; Green Purchasing Good Practice Guide GPG, International Council for Local Environmental Initiatives (2001); and 'Environmental Purchasing in Practice – guidance for organisations', published by IEMA, CIPS and NHS PASA, September 2002.

i Information on European eco-labels can be found at http://europa.eu.int/ecolabel.

i UK Epic provides information about the environmental and energy credentials of products at http://www.ukepic.co.uk, and the Global Ecolabelling Network (http://www.gen.gr.jp/) provides information from around the world.

Contract/supplier management

3.52 It is important to remember that energy-efficiency gains can also be made during the life of contracts. For example, if equipment needs upgrading or replacing at end-of-life, it should be replaced with a better model that has improved performance on a whole-life-cost basis. The benefit may or may not be related to energy performance, but overall performance should be better. For instance, the reliability of a piece of equipment may have increased three-fold, necessitating fewer maintenance and repair visits, but energy consumption may have increased slightly. Hence there is a trade-off, which is why consideration of whole-life costs is so important.

3.53 Suppliers should not be permitted to introduce products or services that have poorer overall performance – this would be a retrograde step and contrary to good procurement practice. Suppliers should be continually innovating, developing higher quality, better value, more environmentally preferable products and services, and these benefits should be available to purchasers.

Fuels

3.54 The procurement of fuel – including all electricity and fossil fuels – affects the overall cost of energy to healthcare organisations. Collectively, healthcare organisations have substantial buying power, and by forming purchasing groups they can achieve more competitive deals than individual organisations.

3.55 Before entering into any energy purchasing contract, the following general points should be considered:

- Is the site energy use likely to change in the foreseeable future and could this have an effect on choice of tariff?
- If a stand-by fuel is required, would it be beneficial to use this at peak times?
- Have renewable fuels or use of renewable generation on site been considered?
- Should green electricity be considered (subject to validation of the renewable sources used to generate electricity)?
- Is there potential to use energy from other local users such as waste heat, exported electricity from CHP, of fuels from waste?

- Will meter reading be frequent and accurate and encourage efficient use of energy?
- Will site managers be made aware of and feel responsible for their site's energy use?

See the Carbon Trust's Good Practice Guide GPG289: 'Getting signed up' (available on the CD-ROM).

3.56 National energy supply contracts are placed by the NHS purchasing agencies. Buying in bulk achieves lower prices than those achievable by lone tender activities by individual healthcare organisations or other consortia/consultancies. Typically, contracts cover firm and interruptible gas; small-medium firm gas; domestic gas; half-hourly electricity; sub-100 kW electricity; bulk oil and coal.

3.57 In addition to lower prices, the NHS purchasing agencies provide (free of charge) a contract management service, which includes site registrations/transfers at contract start and ongoing contract support for the lifetime of the contract. This can take the form of face-to-face meetings with the organisation and/or suppliers (mediation) or representing the organisation's concerns to the supplier as a third party. Periodic contract review meetings are held with each supplier for each contract, where problems are highlighted and progressed, site amendments are identified and processed, and supplier concerns are taken on board by the purchasing agency.

Capital projects

3.58 Whatever form of procurement is used, energy efficiency should be built into the project objectives and into the financial case from the outset, otherwise good intentions will be lost among other competing demands. An integrated project team, which involves procurers as well as designers, is the ideal, and this is discussed in detail in Chapter 4.

3.59 It is also recommended that potential energy-saving measures be properly evaluated during the procurement process. This may require:

- time to carry out the calculations and evaluation that will demonstrate whether a measure is worth pursuing, and time to apply for grants, if applicable;
- time to consider less familiar technologies (such as renewables) and to research and visit sites where such technologies have been applied;
- a commitment from both the client and the designers to implement measures that fall within agreed investment criteria;
- suitably-qualified people to design and implement less familiar technologies (for instance groundwater cooling).

Note: if *any* capital project will result in having a combustion installation (that is, boilers or similar) that has a related thermal energy input greater than 20 MW, it must be registered with the EU Emissions Trading Scheme (ETS). This is a legal requirement.

Appendix 3 explains the ETS and the requirements for healthcare organisations. Further information can also be found at http://www.dh.gov.uk, or by contacting these helplines: EThelp@environment-agency.gov.uk and EU.ETS@defra.gsi.gov.uk

See also http://www.ehsni.gov.uk/environment/industrialPollution/industrialpollution.shtml

The importance of the project conception stage

3.60 Combined heat and power (CHP) plant, absorption cooling, renewable energy technologies and other emerging technologies can be viable if assessed in terms of whole-life costing. However, such opportunities will be missed if they are not considered from the very earliest opportunity – that is, at project conception. Therefore, adequate funding provision should be made at the project conception stage to allow for any as-yet-undetermined energy-saving or low-carbon technologies.

3.61 The opportunity to include low-carbon and energy efficiency measures should then be carried through subsequent stages of the business cases, and detailed costs inserted as feasibility studies are carried out and the building design develops. (Chapter 4 discusses the various options that should be considered at each stage of the procurement process for capital projects. It also includes a table that shows the personnel who should be involved in the decision-making process.)

Making the case – through the structure of the NHS

3.62 The management structure of major capital projects is set out in the 'Capital investment manual', and any decisions relating to financial matters should be routed through this structure.

Grant funding

When considering any major procurement of a building or of central plant, it is worthwhile investigating grant availability. In particular, there are grants for renewable energy sources and for community energy schemes. However, grant schemes tend to be limited in their lifespan and either change or are replaced by other schemes; therefore, information will become out of date very quickly.

Some schemes offer funding not only for the actual scheme but also for the feasibility study, so it is worthwhile looking for grant funding very early in the design process.

For current information visit http://www.grantfinder.co.uk, or the Carbon Trust website at http://www.thecarbontrust.co.uk.

(All capital investment within NHSScotland is subject to the guidance and principles set down in the 'Scottish Capital Investment Manual' (SCIM). This document is under revision.)

3.63 A typical structure applied to the procurement of a building is shown in Figure 5.

3.64 This structure means that:

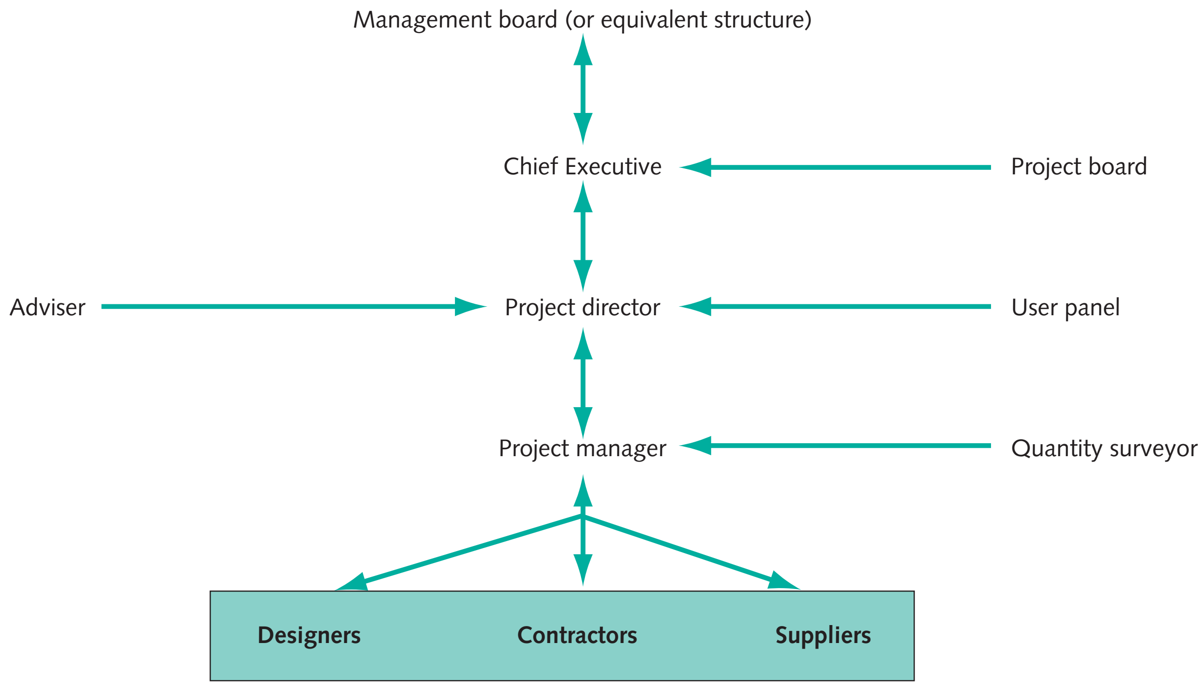
- the project board (internal) takes ownership of the investment decisions based on affordability and cost justification;
- the project team (internal and external) defines the scope and contents of the project and delivers the desired project objectives as established by the client;
- the external resources – designers, contractors and suppliers – create the outcomes.

3.65 It is important to note that the mixture of internal/external sources and the different hierarchies could pose challenges to energy efficiency. Having a clearly defined policy will mitigate some of these challenges. Therefore it should be fed into the investment decision-making process at the earliest opportunity; those who are responsible for project ownership and project direction should maintain control over the external resources to ensure the project objectives are delivered.

3.66 In the context of the structure illustrated in Figure 5, it is recommended that:

- a project director and project manager are designated with responsibility – set by the management board and the chief executive – for procuring buildings that comply with NHS mandatory energy targets (see paragraphs 1.11 and 1.12) or better (the project director would take on the role of "sustainability champion" for that specific project);
- the project manager and project director should ensure that everyone involved in the project is

Figure 5 Typical structure applied to the procurement of a building



aware of, and understands, the organisation's policy on energy and environmental issues and that all members of the project team are instructed to refer to 'Encode' and its supporting documents for guidance;

- the payment mechanism to handle energy costs and energy management as part of a privately-funded deal, or retained by the healthcare organisation, should be clear and communicated to all parties including members of the project team. This is a critical factor in ensuring that the party paying the bill has sufficient influence on the design and management of the facilities/equipment/services.

Using design evaluation tools

3.67 The design tools that have been specifically developed for healthcare organisations (see paragraphs 3.71–3.74) should be used by bidders and evaluated by the healthcare organisation's advisers to confirm that sustainability and energy efficiency issues have been dealt with by all bids consistently – especially where tenders for buildings include a design element, such as privately-funded or design-and-build arrangements. (Where the buildings are traditionally procured, the responsibility for applying these tools rests with the design team.)

3.68 These tools should be used at the tender stage and they should also be used at key stages of the design and construction process to make sure that commitments made at tender stage are being kept.

3.69 However, the tools are not a substitute for ensuring that designers and contractors have carried out energy modelling of the development to check that it will perform to energy objectives. This technical matter should be kept as a separate issue for design monitoring through the procurement process.

Design evaluation tools for England and Wales

3.70 Environmental assessments should be completed by the tenderer or designer based on all aspects of the tender or design within their control. Aspects of the assessment that are within the control of the healthcare organisation should be included with the tender documents or advised to the design team. The score obtained should be used as part of the tender or submission evaluation and as part of ongoing design evaluation.

3.71 Carbon efficiency forms a significant proportion of the score. NHS guidance expects that new buildings obtain an "excellent" rating and refurbished buildings obtain a "very good" rating.[11]

3.72 AEDET (Achieving Excellence Design Evaluation Toolkit) Evolution is the design quality toolkit which forms part of the benchmarking for major schemes. It includes broad questions relating to selection of energy-efficient systems and equipment. It scores energy efficiency as part of the overall evaluation.

3.73 DART (Design and Risk Tool) used for ProCure21 projects includes AEDET Evolution as part of a wider risk and quality evaluation process.

Design evaluation tools for Scotland

3.74 At the time of publication of this document, discussion is underway between the Scottish Executive Health Department and the new public body – Architecture and Design Scotland – with a view to instigating design review panels and design champions for NHSScotland.

Design evaluation tools for Northern Ireland

3.75 AEDET – Pel (04)05 – Health Estates.

Energy considerations for partnership schemes

3.76 Where energy performance is procured as part of the scheme, procurers should take note of the following recommendations:

- Ensure that the performance indicators set in the financial agreement are better than the NHS's mandatory targets for new build as detailed in Table 1, but are specific to the project. For example, it should be relatively easy for a community health building that is used primarily during the daytime to operate at the lower end of the range (35–55 GJ/100 m^3) – so a more challenging level should be set if realistic efficiencies are to be achieved.
- Ensure that the standard payment mechanism for PFI schemes set by the Department of Health is not modified during final negotiations (that is, the mechanism should not be modified to discourage contractors from

11 This follows from the requirement for all Government projects given in 'Constructing the best government client – achieving sustainability in construction procurement', June 2000, OGC/GCCP/M4I

considering energy efficiency measures – see paragraphs 3.76–3.84).

- Ensure that enough metering (with electronic graphical output) is included from the outset, so that accurate degree-day-corrected energy profiles can be provided (although BMS-generated heating degree-day profiles should not be used) and can be compared with the performance indicators.
- Ensure that adequate monitoring arrangements (such as provision of metering, and a reading, recording and comparison procedure) are built into the project agreement so that energy use can be accurately and comprehensively collated and reported, and so that restitution for under-performance can be made under the terms of the payment mechanism.
- Ensure that there is a person within the healthcare organisation's structure who is responsible for receiving and analysing these reports, and who is able to determine whether performance indicators are being met.
- Use the utility manager section of the service level agreements in the standard contracts and agreements for PFI projects to ensure that the PFI provider has in place staff who are responsible for energy awareness training and monitoring of energy use.[12]

i See NHS Standard Service Level Specifications on the Department of Health website, http://www.dh.gov.uk (in particular, see "Utilities Management"). This website includes a standard clause that can be put into the project management company contract.

Payment mechanisms

3.77 Under PFI schemes, the purpose of the payment mechanism for energy is to arrange for the appropriate sharing of risks and responsibilities for energy costs between the healthcare organisation and contractors providing a construction or operational service.

3.78 It is very important to understand the impact that the payment mechanism can have on the final design and operation of the building – particularly if the building is privately funded using procurement routes such as PFI/PPP/DBFO and LIFT.

3.79 For instance, there is a perceived risk to the PFI provider that if usage or equipment in the buildings increases, they will be penalised for failing to meet the performance indicators, even though these factors are beyond their control. This has led to the concept of payment for energy by the private sector being rejected in favour of "pass-through" arrangements where the healthcare organisation pays for all energy used.

3.80 In the past, private sector providers have viewed as onerous the additional capital, maintenance and monitoring commitment needed to meet performance indicators year on year. This misunderstanding can be easily rectified if the procurer of the building makes sure that an equitable payment mechanism is developed. The ultimate goal is to achieve an energy-efficient design and to ensure that the building and its services are maintained at peak efficiency without either the healthcare organisation or the contractor being given unexpected costs.

3.81 The standard payment mechanism should be used to drive energy efficiency considerations during both the design phase and the subsequent management of the building. Under the standard payment mechanism, a site-specific energy consumption (or carbon emissions) goal is set for the scheme and sanctions are set, which are applied if the scheme fails to meet this level. The mechanism also provides for ongoing monitoring and revision of the energy consumption level to meet changing usage of the facility and changes to external factors.

i Appendix 1 explains the calculation methods that should be followed when setting the project-specific energy consumption or carbon emission goals.

3.82 The key issues to be specified in the contract with the project company are:

- the site-specific energy usage or carbon emissions goal should be a single figure rather than a range);
- the annual "operational energy objective", set by reference to hospital heating degree-day analysis

12 The service level agreements form part of an output specification for a PFI scheme covering all service provision such as cleaning, catering etc and give the minimum standards for that provision. Failure to meet those standards accrues penalties which affect the payment to the provider. Not all schemes adopt the utility manager section of the agreement, but if used, this sets minimum performance standards for issues such as energy awareness training, reporting of energy use and other energy management issues

and to the expected energy consumption during the operational period of the facility;[13]

- a mirrored painshare-and-gainshare mechanism, which gives commercial incentive to the project company to reduce energy consumption;
- water should be excluded from the energy payment;
- the healthcare organisation will procure energy via a framework contract (for example with the NHS Purchasing and Supply Agency);
- there will be no energy payment as part of the unitary payment.

3.83 The contract should also state that, if the energy performance objectives are not met during that period, either:

- rectification/remedial works will be undertaken such that the agreed construction energy objective can be met. Such works will be undertaken at the Project Company's expense; or
- the project company will make a payment to the healthcare organisation to compensate for the breach of the construction energy objective. This payment could be an annual reimbursement or a lump sum.[14]

3.84 The healthcare organisation's strong preference should be for the consortium to rectify any fault so that the original energy consumption/carbon emissions goal can then be achieved. If the failure is marginal, the healthcare organisation, acting reasonably, may consider accepting compensation rather than insisting on rectification.

3.85 The Department of Health standard payment mechanism can be found at http://www.dh.gov.uk.

13 Energy consumption for the first two full years of operation will be used to determine whether the facilities have achieved the construction energy target. If the first two years are not "average", the monitoring period is extended until the first two average years (or 24 rolling months) are found in a five-year period

14 The payment amount will be calculated by an appropriately qualified representative of CIBSE and will be designed to compensate the organisation for the cost of procuring the excess energy consumed by it to the end of the project term as a result of the relevant defect. In the event of a lump sum payment, the lump sum should be calculated at the Treasury's current discount rate

4 Energy considerations during the design process

4 Energy considerations during the design process

Introduction

4.1 This chapter looks in greater detail at the early stages of procurement. For the purposes of simplicity, the term “project” is used to describe a major capital project, a major refurbishment, a substantial investment in new plant or significant changes to facilities or services – in other words, anything involving a design element to procurement (as opposed to procurement of goods and services).

4.2 Whatever the nature of the project, the desired aim of using energy efficiently and reducing carbon emissions can only be achieved by considering these issues at the very earliest stage of the project – that is, from the project conception stage. This is because early design decisions – even those which are apparently unrelated – can have an impact on the energy use of the final building or service throughout its life. Energy considerations cannot be successfully bolted on during the later stages of a project.

4.3 Designing for energy efficiency should include the following processes:

- understanding and identifying user requirements;
- establishing an integrated design team with a brief and contract that promote energy efficiency;
- setting realistic energy consumption or carbon emission objectives for the project and designing to meet these;
- designing to meet users’ requirements with minimal energy use;
- designing for manageability, maintainability, operability and flexibility;
- checking that the final design meets the energy objectives.

4.4 This chapter looks at each of these and explains the energy-related issues that should be considered at each step along the way to preparing the full and detailed specification for the project.

4.5 Making sure that all the stakeholders in the project are brought into the design process at the very earliest stage can dramatically improve communications and avoid costly reworking of initial designs. Therefore, this chapter stresses the importance of adopting an integrated approach to commissioning and designing a project.

4.6 The measures discussed are applicable to any project or any proposal, regardless of the (financial) method being used to procure the project.

4.7 As stated in Chapter 1, this guidance should be given to suppliers and contractors (perhaps as an appendix to contractual requirements) so that they can play their part in helping to cut energy usage and carbon emissions. In particular, their attention should be drawn to the project design checklist at the end of this chapter (see paragraph 4.147).

4.8 The project design checklist should be used during the design, construction and hand-over phases of all projects to confirm that the aims of the organisation’s energy and carbon management policy have been taken into consideration and correctly addressed. The project design checklist may be photocopied and distributed to contractors and suppliers or it may be adapted for specific circumstances. However, it is preferable to ask all parties to be familiar with the relevant sections of ‘Encode’, so that they are fully aware of the significance of the organisation’s energy efficiency aims.

4.9 Chapter 5 discusses detailed energy-saving considerations for each of the main energy-consuming services that healthcare organisations require – heat and power; ventilation and cooling; lighting; motors and drives; electrical “small power” items; and specialist services. Chapter 5 also provides the linking information relating to procurement and energy management of these services.

Project conception

4.10 In the healthcare sector, projects are born out of a clinical need; that is, someone in the organisation identifies a problem that requires a solution. For example, a general practice surgery wishes to offer an on-site pharmacy service and therefore needs a small extension to its premises; or two small town-centre hospitals realise that the demographic changes of their respective towns mean that there are more patients requiring acute services in one area than another, so one department needs to expand while another will contract.

4.11 Even at this very early stage, energy considerations should not be overlooked. In the two examples given above, the organisation will consider whether to:

- do nothing;
- adapt existing facilities with minimal refurbishment;
- refurbish existing accommodation;
- build new on a brownfield site;
- build new on a greenfield site.

4.12 This is a complex decision-making process. For instance, doing nothing or adapting existing facilities may appear to be a highly sustainable option because it minimises the use of new materials, and it may have a lower capital cost. On the other hand, it may preclude the opportunity to install more efficient systems, and it may have implications for other sustainability issues such as transport energy.

4.13 The impact of the European Energy Performance of Buildings Directive (EPBD) should be considered, under which all new buildings and existing buildings (when they undergo substantial refurbishment) will be given an energy certificate and an energy label for the whole building (see box "Emerging issues" in Chapter 1). In addition, all public buildings that are over 1000 m^2 will need to display the energy label – the "operational rating" – for the public to see.

4.14 The solution is to consider all possible options, making sure that energy efficiency and sustainability issues are not ignored even though they may not be uppermost in the minds of the decision-makers at this time. For this reason, it is important to make sure that energy or sustainability advisers are involved as soon as ideas start to surface – whatever the size of the project.

4.15 The advisers may be drawn from in-house resources (for example the energy manager) or may be external technical experts (see box "Designating a design team" at paragraph 4.27). The early actions of these advisers should include the following:

- establish whether there is an organisation-wide energy and carbon management policy in place (that is, an energy policy approved at board level), whether the policy is up to date and whether it is relevant to any new build or refurbishment activity that may be required. If there is no policy, or it is out of date, action should be taken as a matter of top priority (see Chapter 2);
- ensure that all parties to the decision-making process are aware of the energy-related aspects of their decisions;
- establish principles and, preferably, the specific objectives for issues such as carbon emissions and sustainability before there is a building or any other preconception to defend.

4.16 If the project is to create a new site, the relative merits of potential sites should be considered at this point. This will involve an evaluation of the overall environmental impact of a development on potential sites (and whether the impacts could be mitigated, if adverse).

4.17 Once it is clear that there is a need for a project that involves design input, the next step is to identify users' needs. At this point a project director should be nominated to determine and collate those needs.

4.18 It is important that the project director "buys in" to the importance of the energy (and wider sustainability) issues which are relevant to the project.

Refurbishment projects

The objective of a refurbishment should be to identify, retain and develop the good features while eliminating or minimising the bad ones.

A condition survey should be commissioned (or conducted by in-house staff). The survey should review the fabric, the services and the indoor environmental conditions currently being achieved.

For example, many older buildings have potentially good natural light and ventilation, but may suffer problems such as:

- excessive heat losses through the walls, windows and roof;
- excessive solar gains if the building is over-glazed;
- high infiltration losses and draughts, plus cold radiant effects in winter for staff near windows (particularly if perimeter heating is not fitted);
- poorly located and or poorly operating services;
- poorly positioned and inadequate controls;
- inadequate briefing or supervision of fit-out designers and contractors whose installations have compromised energy-efficient operation.

If available, the findings of staff surveys may help to identify specific weaknesses and to establish the refurbishment requirements.

The principles described in this section of 'Encode' apply equally to refurbishments and new-build projects; namely that simple designs and simple building services promote good operation and maintenance. Such buildings or services are simpler to understand and therefore simpler to manage – which in turn has a positive impact on the task of controlling energy usage and carbon emissions.

Interpreting users' needs

4.19 The needs of potential users of the healthcare facility or service should be investigated at this stage – for example, using questionnaires or focus groups. Needs will be expressed in terms of the medical objectives of the organisation. It is possible that staff may also take this opportunity to ask for their working and healing environment to meet certain conditions (although this is more likely to happen later in the design process).

4.20 If this does happen, the project director and the advisers should be aware that some requests can have an inadvertent impact on the energy efficiency and sustainability of the resulting building and systems. Therefore it is important that requests are scrutinised carefully before these user needs become embodied in the design parameters – which may later inadvertently become a mandatory part of the specification. This can be avoided by identifying preferences and essentials.

4.21 When assessing users' perceived needs, it is also important to remember that the level of occupant control can have a very significant impact on the way systems are used and hence on future energy consumption. In general, the occupants' response to their environment is influenced by:

- the quality of the environment;
- the perceived level of individual control;
- the quality of the management of services and response to complaints;
- the desire to be close to a window.

4.22 This means that buildings which make good use of natural light and ventilation, and in which occupants have the opportunity to make local adjustments, often provide more acceptable environments and hence greater energy efficiency. It is as well to be aware, when conducting or analysing user needs surveys, that past experiences of badly managed and poorly designed buildings will affect survey results.

The design team's role in saving energy

4.23 Early – and sometimes apparently unrelated – design decisions will have an impact on the energy use of the facility throughout its life. It is far better for the design team to anticipate energy implications early on than to provide technical fixes later. It is therefore important to establish an integrated design team, which is given a brief and contract that promotes energy efficiency, as early as possible in the life of the project (see box "Designating a design team" at paragraph 4.27).

4.24 A well-programmed process will help to ensure that members of the design team work together effectively to interpret the client's requirements and to identify the best way to meet them.

4.25 Integrated design works at its best when all members of the team can discuss ideas and experiences with each other to show how economies can help to improve the value of the building, without compromising its effectiveness as a healthcare facility or its appearance. For instance, increasing the floor-to-ceiling height would increase building fabric costs; but the additional height could improve the penetration of natural daylight.

4.26 Members of the team should take every opportunity to stress the importance of an integrated approach to energy efficiency, as part of their brief for the project. Both the client and the design team should look back over energy objectives periodically during the design process using the project design checklist given in paragraph 4.147.

4.27 Everyone in the team needs to remember that the criterion for including any measure is its value over the lifetime of the facility, not just its first cost.

Further guidance on the selection and designation of project team members is provided in the Department of Health's 'Guide to the Agreement for the appointment of architects, surveyors and engineers for commissions in the NHS' and 'Guide to the Agreement for the appointment of project managers for commissions in the NHS'. In Northern Ireland, 'The project manager's

Designating a design team

Any contract used for designating team members should promote energy efficiency by emphasising the need for all building professionals to work together creatively to achieve an integrated and energy-efficient design.

Energy-efficient buildings often require greater professional skill and design input. Therefore the team should be allowed sufficient time at an early stage to formulate an integrated sketch design.

On many construction projects, fee structures for the design team have been based entirely on the capital cost of the building services. This approach may not encourage energy efficiency, which often requires more design input and a lower plant capital cost. Instead, the organisation should consider alternative approaches which allow greater scope for energy efficient design, such as:

- lump sum fees based on the estimated time spent;
- a proportion of fees based on anticipated performance of the building;
- a proportion of fees based on actual performance of the building when completed;
- allocating a portion of the budget for fees for feasibility studies to demonstrate whole-life benefits of carbon-efficient measures.

Members of the design team should commit themselves to:

- making the client aware of the implications that decisions have on life-cycle costs and hence long-term best value;
- providing an energy-efficient design that takes account of energy management and maintenance needs;
- providing projections of energy performance and running costs;
- proposing further options for energy efficiency, highlighting their potential benefits;
- producing good documentation which makes the design intent clear.

These commitments should also be required of others in the project supply chain – perhaps through a requirement for suppliers to have ISO14001 certification.

Note that the role of the quantity surveyors is particularly important, as this is traditionally linked to achieving the least capital cost option for every element of the project. It is very important that any quantity surveyors involved in a project understand the different imperatives of the whole-life-costing approach.

Advisers

Advisers should be considered on the basis of their expertise and experience, but also on their ability to demonstrate a good environmental track record and a genuine interest in sustainability issues. Their skills should include a technical and strategic understanding of energy and carbon efficiency.

They should be fully aware of the organisation's energy, environment and sustainability policies and strategies, and indeed may have been involved in helping to formulate them, either as independent consultants or as members of staff. In any case, it is recommended that they should be contractually obliged to implement the appropriate national and organisation-level policies.

If necessary, there should be a coordinator of the advisers, who could either be an employee of the healthcare organisation or an external adviser, able to negotiate among advisers to produce an optimum energy/sustainability solution when there are competing demands between disciplines.

handbook' (published by Health Estates) should be used.

Appendix 4 shows the typical roles in a major construction project, and links these with the various stages of procurement. It also highlights the energy-efficiency considerations at each stage and suggests sources of further information. Note, however, that the titles of roles within a team may vary from project to project and also depend on the particular procurement process being employed.

Helping the team to work effectively

4.28 There should be effective communication and collaboration between all members of the project design team so that they can review options and negotiate solutions, as well as keep one another informed of progress. Getting the team members together, even for a few days at the start of a project, can encourage interdisciplinary teamwork, the development of a shared vision, and a spirit of common ownership of the total project across the whole team.

Setting project-specific energy and carbon objectives

4.29 Adopting a project-specific energy strategy will ensure that energy efficiency and carbon savings are considered from the outset. This project-specific strategy should be closely linked to the organisation's overall energy and carbon management policy; any subsequent design process should state the points at which emerging proposals are to be reviewed and audited against the project's energy objectives.

4.30 The project-specific strategy should state energy requirements in terms of delivered energy, primary energy or carbon emissions (or all three). The relationship between delivered energy and primary energy was discussed in Chapter 1, but to reiterate this:

- delivered energy is the amount of fuel or electricity delivered by the public supplier to the site or building at a point where it can be metered and paid for. Thus it is convenient for measuring and comparing with predictions or objectives;
- primary energy is the energy released when fossil fuels such as oil, gas and coal are burnt to release heat (which is then converted to another form such as electricity, steam or hot water).

4.31 The provision of electricity for the National Grid involves losses because the generation process involves the primary energy being converted to mechanical energy to drive generators. There are also distribution losses in the grid. Therefore, heating by electricity generated by burning fossil fuels in a power station results in more carbon emissions per delivered kWh of heat than directly burning fossil fuel at the point of use. This means that using conventionally generated electricity has a greater environmental impact than fossil fuels; but electricity generated from renewable sources will have a far smaller environmental impact than either conventional electricity or gas. (However, note that although some electricity providers supply renewable electricity via the National Grid at a different tariff, this should not be seen as a quick fix for a health sector consumer to meet environmental objectives, unless the source is guaranteed to continue to be renewable in the long term.)

Using carbon emissions to set project-specific energy objectives

4.32 For projects where there are several different energy sources in use, it is necessary to take into consideration the point at which the incoming delivered energy is measured. For example, if gas is being used to drive CHP plant in order to provide electricity and heat, it is possible that the delivered energy (kWh) for the project will be higher than a conventional solution, but overall the environmental impact actually decreases.

4.33 For this reason, it is advisable to use carbon emissions when assessing the relative merits of project proposals that involve a mixture of fossil fuels, conventional electricity or power from renewable sources (wind, solar etc).

4.34 Even if there is only one fuel source for a particular project, comparing the amount of carbon emitted by various measures to achieving comfort is a good way of determining the relative environmental impacts of the measures. (That is why international comparisons of the environmental impacts of different fuel and energy sources are made in terms of carbon emissions, rather than delivered or primary energy.) The additional benefits of using carbon emissions to set project-specific energy objectives are:

- it is easy to see what impact the project will have on the organisation's progress towards the national mandatory energy/carbon targets (which are stated in Chapter 1);
- it clearly highlights the higher carbon emissions associated with electricity usage.

Up-to-date figures for CO_2 kg/kWh can be obtained from the Defra environment website at http://www.defra.gov.uk/environment/envrp/gas/05.htm.

Appendix 1 explains the calculation methods that should be used when calculating energy usage or carbon emission objectives for projects.

Setting energy objectives by end function

4.35 While calculating the energy requirements for the project, the design team should also calculate the total expected carbon emissions for the project. This process starts at the roots of energy consumption, for example, by considering the installed power density of lighting together with assumptions about occupation densities and operating hours. In other words, the total carbon emission for a project is the summation of many individual calculations for all possible energy-related activities.

4.36 Information gathered during user surveys is invaluable to this process. At this early stage in the project's development, very fine detail is not necessary; but the user information – together with other project objectives – will help the design team to achieve a sensible early estimate of the total carbon emissions for the project.

4.37 At this stage, energy consumption levels for particular end functions should be set to be ambitious but realistic. Setting objectives by end use focuses attention on each service, which in turn will help the designers to identify particular aspects of the project where further savings might be possible.

Annual energy consumption levels in various types of healthcare building are given in Appendix 2.

Further guidance on this technique is given in CIBSE Guide F: 'Energy efficiency in buildings' (the EARM "Tree diagram").

Using room data sheets (ADB sheets)

4.38 Activity DataBase (ADB) is an information (software) package created for healthcare planners, architects and teams who are involved in the briefing, design and equipping of healthcare environments (http://adb.dh.gov.uk).

4.39 The package, in common use, contains data drawn directly from Health Building Notes (HBNs), which support the Department of Health's National Service Frameworks identifying the way care will be delivered in the future, as well as data from Health Technical Memoranda (HTMs).

4.40 The ADB sheets contain environmental specifications as part of the pre-programmed software, and these specifications should tie into the recommendations of the various Health Technical Memoranda.

4.41 All new projects should use the most up-to-date version of Activity DataBase. The project director (who will be responsible for the user group meetings) and the designers should evaluate ADB sheets to ensure that requirements are appropriate and do not result in unnecessary systems, cooling or energy use.

4.42 As part of the process of setting energy (or carbon) objectives for the project, the designers should set specific performance markers for each room that will be part of the project (or, in the case of boiler upgrades for example) affected by the project. For instance, each ADB sheet should include the specifications for air infiltration and leakage rates, fresh air, cooling loads, acceptable internal temperatures and humidity levels, noise levels and lighting levels. For each of these, acceptable tolerance levels should also be stated. (Unnecessarily tight control over temperature or humidity ranges may lead to energy penalties whereas, for example, higher internal summer temperatures may be acceptable to occupants if they have the freedom to open the windows.)

Early design decisions for building projects

4.43 At the beginning of any building project that has a core objective of minimising carbon emissions, the design team should consider potential concerns over the interrelationship between architecture and building services, looking in detail at their respective contributions to the energy efficiency of the building. This will involve considering:

- the site – location and layout;
- the orientation, shape and size of the building;

- the choice of construction (lightweight/heavyweight);
- the choice of fuel, and any specific requirements of the fuel sources chosen (for example groundwater cooling or CHP); and
- in general, how these engineering solutions fit with healthcare needs.

Geography and site

4.44 Having decided to create a new building, the process moves on to assessing which of a number of potential sites would best serve the organisation's needs.

4.45 The nature of the site will have a strong influence on built form and orientation, as well as contributing to decisions on services design (for example, does the geology of the site make it suitable for applications such as groundwater cooling?). Planning requirements, local and national bye-laws and fire protection requirements may further restrict the building shape and orientation, affecting its services and energy performance. The position of approach roads and the requirements for vehicle parking could also influence the energy efficiency of the design.

4.46 The site options available should be explored not only in the context of medical needs, but also in terms of their match to the organisation's energy efficiency and sustainability policies. The integrated team approach will ensure that the relevant advisers are in place during the site evaluation process and that conclusions on the energy-related impacts of the various options are presented clearly to key decision-makers.

4.47 It is important to note that clinical and environmental requirements need not be in conflict. At this stage, the main objective is to avoid decisions being made which, while having a neutral effect on the clinical effectiveness of the facility, would have a negative impact on energy efficiency. For instance, a sketch plan showing a new block on a greenfield site might be instantly appealing, but on further investigation a careful appraisal of the benefits of one orientation over another, on the same site, may have a big impact on the need for cooling and heating throughout the life of the building. The effect of clinical adjacencies can also have a major impact on the energy use and ultimate system choice.

Local weather and microclimate

4.48 Geography, topography, landscape, shelter, shading and surrounding buildings all influence the development of built form and services, sometimes in different ways on different façades. An effective design will take advantage of any local variations in climate, for instance by using local wind conditions to drive natural ventilation or by preventing funnel-like gaps between buildings which increase wind speeds and pressures.

4.49 The opportunities and constraints presented by each potential site should also be reviewed in terms of:

- prevailing wind direction;
- microclimate;
- sunshine;
- overshadowing;
- views;
- noise;
- external pollution.

4.50 If the choice of site is limited, consider mitigating some of the negative aspects of the site.

4.51 It is possible to take advantage of the site's geography by advantageous orientation of the building or by adding landscape features (for example using an embankment to protect against a strong prevailing wind). The level of external pollution and noise, particularly in urban areas, may influence the choice of ventilation system and could preclude natural ventilation as an option. In these cases, careful design can provide acceptable solutions, for example by placing areas requiring low noise levels furthest away from noise sources. Designers should think carefully about the impact of hard landscaping – light-coloured landscaping reflects solar radiation upwards, possibly towards absorptive façades, resulting in overheating. Most conventional software modelling techniques fail to recognise such effects and therefore all thermal models should be assessed by experienced designers as early as possible in the design process.

Orientation

4.52 Choosing the optimum orientation to maximise daylight and to minimise summer heat gain and winter heat loss can have a significant impact on energy efficiency, particularly if the choice makes it possible to avoid or minimise air-conditioning. For example, north-facing windows suffer very little solar gain and benefits are often gained by having the major building axis pointing east/west. East- or west-facing glazing is harder to shade from direct sunlight, as the sun angles are low at some times of year. High sun angles make control of gains relatively easy on southerly façades in summer.

4.53 While it might be thought that south-facing windows are most likely to give rise to overheating, glazing facing between north-west and south-west poses a greater problem because:

- shading can be difficult when the sun is low in the sky;
- peak solar intensity occurs at about the same time as the maximum ambient temperature;
- peak solar and ambient heat gains occur towards the end of the day when other internal gains have built up.

Shape and size

4.54 A major decision is whether the building should be narrow- or deep-plan. Essentially, narrow-plan buildings, correctly orientated, can take maximum advantage of natural light, natural air movement and the contribution of the sun in different seasons, whereas deep-plan buildings maximise the use of the site, but need to use energy to maintain the internal environment.

4.55 The shape and size of the building will, in part, be determined by its surroundings. When assessing alternative sites it is important to consider the life-long impact that the shape of the building may have on energy usage. This decision is particularly significant because, coming so early in the overall process, locations and orientation may become fixed by the act of making a planning application.

4.56 The following energy-efficiency factors should be considered:

- compact building forms have a relatively small exposed surface area for a given floor area; this reduces the influence of the external environment;
- a compact design may be advantageous because it requires less space for the distribution of horizontal and vertical services (particularly for air ductwork), but if site pressures and/or a compact design lead to a deep plan (more than 15 m deep), there may actually be a greater complexity of servicing; the core of the building may require continuous electric lighting, and mechanical ventilation or air-conditioning may become necessary for the internal areas;
- taller constructions can increase energy consumption due to greater exposure (higher winds) and the need for lifts.

4.57 Designers should also consider the relative merits of a simple compact form to minimise the surface-to-volume ratio against those of narrow plan to enable natural ventilation and daylighting.

4.58 Imaginative use of three-dimensional form can give occupants access to natural light and ventilation and help to reduce electric lighting, heating, cooling and ventilation loads, even where the building needs to be air-conditioned. Spaces with low occupancy or requiring mechanical ventilation or air-conditioning for functional reasons can be located internally.

4.59 To avoid deep-plan implications, consider introducing courtyards, light-wells or atria – these can introduce light and air deep into the building, provided that they are of sufficient size in relation to the height of the surrounding buildings. They may be used to protect adjacent areas from climatic extremes and to preheat ventilation air.

Atria

Atria are rarely incorporated in designs for the main purpose of saving energy: the most likely motivation is architectural, or the desire to make effective use of the site, but their impact on the building services design can be significant. Energy-efficient atria work best as a buffer between the inner and outer environments and should be carefully integrated into the sketch design and related to the heating, ventilation and daylighting strategies. The Building Regulations set out requirements aimed at avoiding energy-inefficient atria and conservatories.

Atria in hospitals are often used as entrance, reception, retail and dining spaces. Thermal comfort and the acoustic environment are frequently problematical for these applications, and designers should consider incorporating sub-divisions to ensure that comfort can be maintained.

Points to consider:

- the atrium should be used as a heat recovery/buffer space, for example pre-heating incoming fresh air or passing exhaust air through the atrium on its way out of the building;

- shading and high rates of ventilation should be provided in summer to prevent overheating;
- daylighting levels should be maximised by using reflective finishes and clear glazing to reduce the need for daytime electric lighting. The electric lighting should then be controlled to gain the benefits.

i A detailed design methodology can be found in The LT Method Version 2 (LTMETHOD), published by the Carbon Trust, and available on the CD-ROM.

i Atrium design is discussed in BRE IP3/98 Daylight in atrium buildings (ISBN 1860811949).

i Atrium ventilation is discussed in CIBSE's AM10: 'Natural ventilation in non-domestic buildings'.

i For guidance on noise and acoustics, see Health Technical Memorandum 2045 – 'Acoustics'.

The advantages of passive solar design

4.60 Passive solar design (PSD) uses the fabric and orientation of a building to capture the sun's energy. It reduces the need for artificial heating and lighting – and therefore can have a very significant effect on the building's overall carbon emissions.

4.61 In general, people prefer daylight and appreciate the other benefits of windows, for example providing a view and natural ventilation. There is increasing evidence that high levels of natural lighting and natural ventilation can significantly improve the working environment inside buildings. There is also a growing body of evidence that these features are beneficial to general health and to the speed of recovery from illness.

4.62 The overall objective of PSD is to use the natural advantages of the site (including any surrounding buildings) and to use the available daylight to its full extent, together with providing any shading necessary to avoid overheating and glare.

4.63 The basic principles behind PSD are as follows:

- heating – orientating buildings, laying out rooms and distributing glazing in a way that allows the interior to be heated by solar radiation, while at the same time minimising heat losses from shaded façades and maintaining thermal comfort of the building's occupants;
- lighting – arranging glazing to increase the amount of daylight available, so reducing the need for artificial lighting, while maintaining visual comfort;
- ventilation and cooling – using solar-heated air to help drive natural ventilation (by the stack effect), thus minimising the need for mechanical ventilation; and using cool night-time air to minimise the use of mechanical cooling systems.

4.64 However, the design team should note that PSD will only save energy if adequate attention is paid to good design to avoid problems such as glare and overheating (which could result in additional energy use through increased need for artificial lighting and air-conditioning).

i CIBSE Lighting Guide LG10: 'Daylight and window design' and BS 8206-2:1992 provide simplified design guidance.

i See also BRE's (1999) 'Solar shading of buildings'.

i Dalke et al (2004), 'Lighting and colour for hospital design' provides guidance on the use of light and colour design in hospitals.

Building depth: ventilation and daylighting

4.65 The depth of the building plan (that is, the maximum distance from a window) is crucial in determining the likely success of a PSD or natural ventilation scheme.

4.66 Rules of thumb – such as having a practical depth of 15 m where there is cross-ventilation or 8 m if ventilation is single-sided – are often cited, but there is more to this issue than just depth. Ceiling height, window and shading design, internal layout density of occupation and equipment heat gains all have a part to play.

4.67 For example, single-sided ventilation alone is unlikely to provide an acceptable summertime environment for hospital ward areas, given the typical density and the amount of equipment per patient (which is likely to increase). Planning should therefore consider solutions such as cross-ventilation (perhaps using clerestory windows or stacks) or mixed-mode ventilation.

4.68 In general, daylight can penetrate to areas up to 6–8 m (depending on room width and window-head height) from a side window. In rooms looking onto courtyards, daylight penetration is much reduced, limited to those areas that receive a direct view of the sky. (Light strategies are discussed in more detail in Chapter 5.)

Room outlook

The practical range of glazed area is 20–40%. Below the lower limit, the building can seem too dark and gloomy inside, and occupants may not feel in contact with the outside world. Above this upper limit, the increased solar gains are likely to result in overheating and glare.

External window-head shading (using, for example, light shelves or brise soleil) has the advantage of retaining an external view and is more effective at reducing solar heat gains than internal shading. Internal shading is more flexible and should usually be used to augment external shading. However, infection control measures may preclude the provision of internal blinds and shading. In this case, either interstitial blinds or external shading should be used instead; otherwise, significant solar gain will occur, contributing to overheating.

Tinted glazing should be avoided in clinical areas because it rarely discriminates enough between light and heat, often causes increased lighting use as the exterior appears duller than it really is, and hinders true colour rendition, which is vital for clinical diagnosis.

Use the LT method or other techniques to optimise the relative merits of daylighting, heat loss and heat gain by varying glazed area and overhanging shading from eaves, shelves, deep window reveals, brise soleil or other external structures.

i The Carbon Trust's 'The LT Method Version 2 (LTMETHOD)' is available on the CD-ROM.

Early decisions for building projects – building fabric

4.69 Energy-efficient healthcare buildings seek to improve patient and staff comfort, while at the same time meeting the demands of increased internal gains – particularly from electrical equipment – without recourse to ever-increasing use of comfort cooling (air-conditioning).

King's College Hospital, London. An external view of the Golden Jubilee Wing at King's College Hospital showing effective window design with external shading to reduce unwanted solar gains

4.70 An energy-efficient building design should provide:

- control over unwanted ventilation;
- the correct quantity of fresh air for health and odour/moisture control and for the rejection of excessive heat gains (if needed);
- a driving force to move air into and around the building;
- a means of controlling the air movement to and from the right place and at the right time, preferably involving the occupants so that it can match their needs.

4.71 Typically, an air-conditioned building uses twice as much energy as one without air-conditioning. Therefore natural ventilation should be the preferred option for an environmentally smart healthcare facility. A ventilation system that does not need to be driven by electrical systems has a clear advantage – zero cost and zero carbon emissions. In addition, a well-designed natural ventilation system will minimise the need for other services (fans, for example).

4.72 However, some buildings and services will inevitably require mechanical ventilation and cooling. The objective at this point in the design process is to identify these areas and ensure that passive measures are used as far as possible. The options for the building's ventilation strategy are (starting with the most preferable):

- natural ventilation;
- mixed-mode ventilation;
- mechanical ventilation;
- heating and cooling (without humidity control);
- full air-conditioning (with humidity control).

4.73 With each step down this list there will be an increase in energy consumption, capital cost, running costs, maintenance and complexity. Such decisions should only be made using Health Technical Memoranda, Health Building Notes and clinical need as the reference guidance.

4.74 An early decision is crucial because natural ventilation relies on the fabric of the building to absorb heat gains during the day (and thus avoiding over-heating) and to warm incoming fresh air.

4.75 Further detail on ventilation and cooling strategies is given in Chapter 5.

The role of thermal mass

4.76 The building envelope is a climate modifier – not just a means of excluding external climatic conditions. The envelope generally has four main functions:

- in cold weather, to reduce heat loss, to maximise the benefits of solar and internal heat gains, and to reduce losses associated with uncontrolled air infiltration;
- in warm weather, to minimise solar heat gain and to avoid overheating;
- to allow optimum levels of natural ventilation;
- to allow optimum levels of daylighting.

4.77 "Dynamic thermal response" is the ability of a building to exchange heat with its environment when subjected to daily variations across the seasons. This ability smooths out transient temperature variations and is especially important in reducing maximum summertime temperatures, thus avoiding or minimising the use of air-conditioning. Buildings that are designed to make use of this capability generally have lower energy consumption than conventional buildings and provide a more natural environment for occupants.

4.78 This technique relies on the ability of the thermal mass that is provided by the building's structure to absorb daytime heat gains – the admittance of the building. It results in longer heat-up and cool-down periods and smooths out transient heating/cooling loads.

4.79 A well-managed heavyweight building with high admittance can cope with a wide variation in gains (for example from the sun's heat, or from IT equipment). However, a high thermal mass does not guarantee a comfortable environment; night ventilation is critical to avoiding summer overheating.

4.80 Thus the choice of heavyweight or lightweight structure is linked to ventilation strategy, to the location of the building, and to the activities that will happen inside the building.

- If the building could be subject to high heat gains, it may benefit from a high thermal response to slow down temperature swings, reducing the need for mechanical cooling (and the energy to drive such systems).
- If an intermittent heating regime predominates, a less thermally massive building would have shorter preheat periods and use less heating energy, provided that any tendency to overheat is well controlled.
- If night ventilation cannot be assured, a lower thermal mass may be more appropriate (although mass can still be useful because it will restrict peak temperatures and air-conditioning loads). In this situation it is more important to minimise solar and internal gains and maximise useful daytime ventilation.

4.81 When reviewing the possibility of utilising thermal mass and night ventilation, the following questions should be asked:

- Are the assumed gains and ventilation rates realistic?
- Are the gains calculated using real power consumption values (rather than "safe" high ones)? Do the values include allowances for diversity?

- Can the window area be reduced or shaded more effectively?
- Can the window design and/or internal layout be altered to increase ventilation rates and air movement?
- Can the high gain areas either be spread around to share the load, or grouped and treated separately (by isolation, extraction or local air-conditioning)?

4.82 Ventilation strategies – including night cooling options – are discussed in more detail in Chapter 5.

4.83 The following points should also be considered:

- heavyweight buildings may have areas that perform as lightweight buildings; for example a large glazed entrance hall. Such areas may receive excessive solar gain and will also be subject to higher heat losses than the remainder of the building, so they should be zoned separately using appropriate fast-response zone controls;
- the building's thermal response will be different depending on where the mass is placed – in floors, façades, internal walls, contents and so on. To make effective use of this mass it is necessary to ensure a good heat transfer to and from the structure, for example by using embedded coils or ducts. But the ability to clean clinical spaces is vital, so dust traps and ledges should be avoided, making this an impractical solution for heavily serviced areas.

i Further guidance on exploiting thermal inertia is given in CIBSE AM13: 'Mixed mode ventilation'.

4.84 The majority of healthcare buildings that provide acute services are occupied 24 hours a day; thus, a thermally heavyweight building would not be particularly advantageous. Instead the emphasis should be on preventing heat gains in the first place (for example by solar shading or by choosing low-energy equipment). However, there are many buildings and departments within acute hospitals that are intermittently occupied and where thermal mass, in conjunction with careful concealment of services and flush finishes, could be used in a limited form.

4.85 For intermittently occupied areas – such as administration (where such areas are grouped together) and community healthcare buildings – improving the thermal capacity of roofs, walls, floor slabs and internal partition walls can help to stabilise internal temperatures and delay peak solar heat gains until after the occupied period, reducing the need for, and capacity of, any air-conditioning. Exposing ceilings and passing air over or through the floor slabs, especially cool night air, can remove the absorbed heat later.

Health considerations

4.86 Although natural ventilation is undoubtedly the most energy-efficient option, there are specific issues relating to healthcare that should be considered:

- the openings for air to enter the building should not admit excessive noise and/or uncontrolled pollution;
- window openings should maximise the potential for ventilation, so all options should be considered; that is, think about window designs that have top and bottom opening, rather than side, top or bottom only;
- window openings for most patient-accessible areas should be carefully considered for security reasons (see Health Technical Memorandum 55 – 'Windows').

4.87 When choosing natural ventilation, it is also vital to consider actions that will prevent cross-infection. Air should flow from clean to transitional to dirty areas. Clean areas are areas such as theatres; transitional include most patient areas. Dirty areas would include dirty utility, WCs and waste storage areas, which should always have mechanical extract ventilation.

4.88 If an natural ventilation strategy is to be used, the directions of air flow should be studied carefully – initially using an explicit method, such as that described in CIBSE Guide A: 'Environmental design' and CIBSE AM10: 'Natural ventilation in non-domestic buildings'. Once the design has evolved beyond the outline stage, more detailed methods should be used, such as zonal modelling or using computational fluid dynamics (cfd) software.

The people factor

Automation will be particularly beneficial to a natural ventilation strategy that relies on night cooling. This is because automation will minimise the possibility that the building's occupants will make manual adjustments during the day that could interfere with the overall strategy. For example, if external shades or interstitial blinds have been drawn during the day, or if high-level windows have been closed, the automatic controls will return them to the desired positions so that the desired level of night cooling can be achieved.

If automation is to be used, the system should be correctly commissioned. It should also be monitored during operation so that adjustments can be made simply if necessary.

The benefit of high ceilings

4.89 When refurbishing spaces that already have high ceilings, it is certainly worth considering retaining this height. In the past, it has been argued that the high ceilings are a disadvantage because the volume is larger, so ventilation heat loss would be greater (if it is calculated in terms of air change rates). However, this is not necessarily the case, and any air leakage should be deduced from wind pressures and air permeability or joint/crack length between building components rather than assuming estimated changes of air volume.

4.90 Many existing healthcare buildings are cellular and are densely fitted out with furniture and equipment; it might be expected that the thermal response would tend to be in the medium–heavy range. However, such buildings often become thermally lightweight because suspended ceilings (albeit at a height of 2500 mm to 2700 mm) are installed for servicing, partitioning or acoustic reasons. This isolates the slabs from the thermal environment. Heavyweight behaviour can be restored by incorporating under-floor ventilation.

4.91 Higher ceilings increase the thermal mass of a room, because there is an increase in the relative area of the wall and partitioning exposed to the room. An increase of ceiling height from 2500 mm to 3500 mm in a medium-weight intermittently occupied space can reduce peak temperatures by approximately 1.5ºC if the glazed area and ventilation rates are kept constant.

4.92 Other benefits of high ceilings are:

- they allow stratification so that heat accumulates above the occupied zone, from where it can be removed by high-level cross-ventilation;
- there is space for future ducts (if mechanical cooling becomes necessary later);
- there is increased daylight penetration (if window-head height is increased);
- they improve comfort by increasing radiation losses from occupants to the greater areas of walls and ceilings;
- there is an increased feeling of spaciousness; the psychological effects may be more significant, as a high ceiling space tends to be more visually interesting as well as feeling less claustrophobic.

The importance of airtightness

4.93 The building envelope should be as airtight as possible to take advantage of a well-designed ventilation strategy. "Build tight, ventilate right" is true for both naturally-ventilated and mechanically-ventilated buildings.

4.94 Although infiltration is an issue that is best considered at the detailed design and the construction stages, the overall design concept – the building's orientation, shape and number of openings – will ultimately determine how easily infiltration can be controlled.

4.95 The reduction of infiltration relies on good building detailing and on the quality of the building construction, so the architect and builder should collaborate to ensure that energy efficiency and comfort conditions are not compromised by infiltration through the building envelope.

4.96 Typical infiltration points include:

- the openable perimeter of windows and doors;
- the window/doorframe-to-wall interface;
- wall-to-wall, wall-to-ceiling and wall-to-floor junctions;
- porous and semi-porous building materials;
- perimeter leaks around penetrations such as service ducts;
- open flues;
- open doorways.

i Infiltration standards are given in the appropriate Health Technical Memoranda.

i Procedures to reduce infiltration and the requirements to pressure-test buildings are given in the Building Regulations 2000.

i Air leakage tests are described in CIBSE TM23: 'Testing buildings for air leakage'.

Insulation

4.97 Reducing the thermal transmittance of the building envelope by adding insulation can help reduce heating demand and therefore results in lower heating energy consumption.

4.98 However, in buildings with high internal heat gains, it is important to think carefully about the effect insulation will have on total energy use. If the building fabric cannot readily dissipate internal heat gains, ventilation systems or mechanical cooling may be necessary for part of the year. The impact of increasing heat gains (particularly in ward areas), coupled with very well-insulated low-leakage buildings, has undoubtedly contributed to the increase in retro-fitted ventilation and cooling to reduce gains.

4.99 Points to note:

- internal insulation: the structure is likely to be cold, leading to a greater likelihood of interstitial condensation or frost damage. Condensation can be avoided with extra ventilation and/or extra heating to raise surface temperatures, but this has an energy cost;
- interstitial insulation: there is the possibility of thermal bridging at openings or junctions with internal walls and floors, with the risk of condensation or excess heat loss;
- composite structure: fixing details are critical to avoid thermal bridging, particularly where masonry penetrates insulated components for structural reasons;
- external insulation: the structure remains warm with less risk of surface condensation. The full benefit of the thermal capacity of the structure is obtained.

4.100 The Building Regulations calls for measures to ensure the continuity of insulation in non-domestic buildings. The requirements can be met either by using approved design details or by conducting infrared inspections.

Early decisions about heat and power

4.101 It is recommended that all sites should have a site-wide energy plan, drawn up following a detailed investigation into the most cost-effective and environmentally-sensitive way of supplying the energy needs of the site or of the healthcare organisation as a whole. The plan sets out the heat and power requirements for each building or facility on the site and how these are to be met. Therefore the plan may need to be modified when substantial changes are made to the services, facilities or buildings on the site change.

4.102 Developing the site-wide energy plan includes consideration of:

- legislation;
- energy-saving measures;
- heat-reclaim techniques;
- traditional energy sources;
- natural resources;
- environmental issues;
- future healthcare trends;
- operational policy.

4.103 Whatever the size of the projects, the design team should assess the relevant options for the supply of heat and power to the project in sufficient detail to determine which option is best for the particular healthcare facility. Failure to do this may impose a cost or functionality burden throughout the life of the particular building or facility; or it might even have a detrimental impact on the whole site.

4.104 Developing or modifying a site-wide energy plan is an iterative process which involves asking questions and testing various solutions. Key questions include:

- What fuel is required?
- Is a back-up fuel required, and would dual fuel offer tariff advantages?
- What resilience is needed in the system – what functions should be covered by contingency?
- What is the most efficient form of heating for the application?
- Is steam required for laundries or sterilization? If so, where, and can it be generated locally?
- What is the best location for the heating plant?
- How will heating (or cooling) distribution be routed – underground, overground, in ducts, within buildings?
- What is the optimum temperature and pressure at which to distribute heating or cooling media?

- What is the cost-effectiveness of more efficient boiler plant and equipment?
- What facilities are required for pipework cleaning and subsequent water treatment?
- What is the potential for using waste heat recovered from other plant or processes?
- What are the most appropriate control systems?

4.105 The team should also assess the energy loads and profiles for the various services and areas of the site, identifying daily weather patterns for summer, winter and mid-season. This level of data will be useful in determining the extent to which heat recovery can be effectively utilised on site. It will also help to assess the viability of combined heat and power (CHP) schemes – which may not be cost-effective for a development on part of a site, but could be a benefit for the site as a whole.

4.106 Some services, such as catering, can be provided either by electricity or by fossil fuels. The extent to which this fuel substitution can be economically achieved should also be explored during the development of the site-wide energy plan.

4.107 Once the answers to these questions have been supplied, solutions should be proposed, investigated and then adopted. One of the advantages of adopting an integrated design approach is that all parties will be involved in these early activities. This will help to ensure that the site-wide energy plan is as coherent and environmentally sustainable as possible.

4.108 The following solutions should be considered:

- where possible, include renewable sources of energy as an integral part of the building design;
- where possible, include on-site generation using combined heat and power (CHP), photovoltaics or wind power;
- if cooling is required, consider integration with CHP by absorption cooling or consider using any other waste heat;
- consider using groundwater either for direct cooling use or via heat pumps;
- where conventional fuels are necessary, select those that are least harmful to the environment;
- include metering and sub-metering (see box "Metering") to ensure that future building performance can be continually monitored by the building operator.

4.109 The remainder of this chapter reviews the decisions that should be taken during the early development of a project – in order of priority. These issues are revisited in Chapter 5, where the detailed design aspects of heating and cooling systems are discussed and further guidance is referenced.

Metering

Metering and sub-metering should be included in the design to ensure that future building performance can be continually monitored by the building operator. It is generally cheaper to install sub-meters as part of the design than to incorporate them at a later stage. Sub-metering is particularly important where there are large loads (other than for the usual building services), which may mask the true performance of the building. Generally, actions taken as a result of installing and monitoring meters can often save 5–10% of the energy being metered and sometimes much more than this.

The Building Regulations include requirements for sub-metering in non-domestic buildings and seek to ensure that building designers include appropriate metering and sub-metering at the design stage, providing building operators with a clear procedure to establish where the majority of energy is being consumed. Building operators should also be given sufficient instructions and a metering strategy.

A reasonable provision of meters should:

- be sufficient to account for at least 90% of the estimated annual consumption of each fuel;
- include incoming meters in every building or department greater than 500 m^2 gross floor area (including separate buildings on multi-building sites);
- include meters for measuring any heating or cooling supplied to separately billed spaces, such as different departmental accounting areas;
- include meters for measuring any special load that is to be discounted from the building's energy consumption when comparing measured consumption against published benchmarks. This should include the process loads, including water

heating for laundries, catering and sterile services departments. It should also be considered for other areas that have significant equipment loads such as imaging, pathology, mortuary and pharmacy. Meters should be per utility and differentiate equipment loads, including heat source, from general building services;

- include meters measuring energy consumed by plant items with significant input power.

i Further guidance on metering can be found in CIBSE Guide F: 'Energy efficiency in buildings'.

For privately-funded schemes, there is provision in the standard payment mechanism for metering, which should be adhered to. Healthcare organisations should ensure that agreements with bidders not only include the provision of meters, but the subsequent monitoring and reporting of the data provided by the meters (see Chapter 3).

Centralised versus decentralised systems

4.110 The question of a centralised or decentralised heating system rarely produces a clear-cut answer. However, options should be reviewed as early in the design of a project as possible, because once such a decision is made it is extremely difficult to change it. Furthermore, the decision is not to choose one or the other – it is possible to have most of a site operating under a centralised system, with one or two buildings on a decentralised system. If the site is likely to have significant cooling loads, the option of centralised or decentralised cooling should likewise be considered at this point.

4.111 The most important point to bear in mind is that a centralised solution is not necessarily the best option. For example, if a primary care health centre has multiple functions with diverse periods of occupancy, the use of decentralised services could match the type of operation better than a centralised arrangement. However, for a hospital having a large energy demand with a high load factor, the use of centralised plant working at high efficiencies (and possibly using dual-fuel facilities) may provide a better solution.

4.112 The option of decentralised heating often hinges on the price and availability of fuels, the space available for plant and distribution pipework, flueing arrangements and the losses in a centralised system and the size of the loads involved.

4.113 Tables 4 and 5 summarise the relative merits of these two options.

Minimising distribution losses

4.114 Distribution lengths are influenced by:

- the nature of the site;
- the shape of the building(s);
- the number and location of plantrooms;
- the provision of space for distribution (riser shafts and ceiling voids).

Table 4 Centralised heating systems

Advantages	**Disadvantages**
Capital cost per unit output falls with increased capacity of central plant	Capital cost of distribution systems is high
Convenient for some healthcare organisations	Space requirements of central plant and distribution systems are significant
Central plant tends to be better engineered, operating at higher efficiencies (where load factors are high) and more durable	As the load factor falls, the total system efficiency falls as distribution losses become more significant
Some systems (eg those that run on heavy oil) will naturally require central plant	In the event of failure, larger areas are affected or disrupted
Flexibility in the choice of fuel	
Better utilisation of CHP etc	
There is the option of interruptible contracts	

Table 5 Decentralised heating systems

Advantages	Disadvantages
Low capital cost; savings made on minimising the use of air and water distribution systems	Equipment tends to be less robust with shorter operational life
Zoning of the systems can be matched more easily to occupancy patterns	Flueing arrangements can be more difficult
Maintenance is less specialised	Fuel needs to be supplied throughout the site
Can be readily altered and extended	Plant space needed in most buildings – will increase cost of future developments
Energy performance in buildings with diverse patterns of use is usually better	Very limited potential for CHP and renewable sources of fuel
Plant failure only affects a smaller area	Plant failure could affect critical areas unless stand-by plant and stand-by fuel provided
	Flexibility for future changes of fuel source very limited
	Loss of dual-fuel tariffs

4.115 The aim should be to avoid transmission losses by minimising distribution lengths – of ducts and pipework for heating, steam and water – by siting boilers, pumps and fans as near as possible to the final loads. Therefore, the provision of plantrooms is an integral part of the centralised/decentralised discussion.

4.116 It is also possible to reduce transmission losses by opting for decentralising plant, although this should be balanced against possible reduced plant efficiencies and increased maintenance costs.

4.117 The choice of distribution temperatures and pressures is also very significant on larger schemes. For example, choosing to extensively distribute steam, rather than stepping down to low-temperature hot water (LTHW) more frequently, will increase distribution losses, as will the choice of lower-than-necessary chilled water temperatures (see Chapter 5).

4.118 Where possible, external distribution, particularly of steam and chilled water, should be avoided because of the increased losses at peak demand periods and also due to the increased life-cycle costs of maintaining external insulation and pipeline ancillaries.

Renewable energy sources

4.119 The market for energy-efficient products and technologies is changing rapidly. Government incentives are driving forward significant developments such as solar power and renewable fuel sources. Forward-thinking healthcare organisations are already adopting proven technologies and more will follow, as renovations, refurbishments and new-build projects create opportunities for environmentally sensitive and sustainable investment.

4.120 Renewable energy is the term used to cover those energy resources which occur naturally or repeatedly in the environment, for instance energy from the sun, wind and the oceans, from plants, waste and flowing water. Most renewable energy technologies produce no emissions of gaseous pollutants (that is, CO_2, oxides of nitrogen/sulphur and particulates). Thus they should be the first-choice energy sources, where economically justifiable, in order to minimise environmental impact. Renewable energy options include:

- solar – daylighting, photovoltaics, solar thermal;
- wind – a range of different devices including wind turbines;
- bio fuels – such as site waste, straw and wood for direct heating or gasification, and sewage for gas generation (which can be used to drive CHP);
- ground linking – geothermal, groundwater, ground linking either for cooling or heating with or without heat pump gearing.

i For further information on renewable energy technologies, see the Carbon Trust's Good Practice

Guide GPG379: 'Renewable energy guide for the government estate' (available on the CD-ROM).

See also Appendix 7.

Example

The United Hospitals Trust in Northern Ireland has installed a 660 kW Westas V47 wind turbine at Antrim Area Hospital. This installation is expected to provide nearly 1.9 million units (kWh) of electricity per year, which equates to an annual electricity saving of more than £90,000. If the turbine gives the energy yield expected of it, this will also mean a saving of 1530 tonnes of carbon dioxide, 20.4 tonnes of sulphur dioxide and 5.1 tonnes of nitrous oxide.

The total installed cost of the project was £500,000. Grant funding of £400,000 was obtained to assist with the installation. The project took two years to complete, once planning permission had been obtained, and it has generated considerable interest among staff and visitors.

One early problem identified was that the turbine blades caused flicker when the sun was low in the sky. This is a seasonal problem that only occurs during strong sunlight, and has been remedied by supplying black-out blinds to affected areas.

Heat pumps

4.121 Heat pumps can produce high coefficients of performance (CoP) when operating at low temperature differentials. Heat pumps have found wide use in applications where low-grade heat is available, for instance from:

- groundwater;
- ground source (coils in soil);
- outside air (although the CoP tends to decline as the air temperature drops);
- low-grade process heat which would otherwise be dumped;
- ventilation extract heat recovery such as in hydrotherapy pools.

The 660 kW wind turbine at Antrim Area Hospital was the first to be installed on a hospital site in Northern Ireland. The scheme is on track to save £90,000 in its first year of operation.

4.122 When used to provide heating only, the CoP of heat pumps does not usually compensate for the increased financial and environmental cost of using electricity. Nevertheless, if there is a substantial source of heat that is otherwise going to waste, but is at too low a temperature to be used directly, the case for using a heat pump to upgrade that heat should be investigated. In addition, where mains gas is not available, and for small to medium cooling applications, groundwater and ground source heat pumps offer sustainable and economically viable energy sources.

Biomass

For most larger acute sites, resilience of heat supply is required, resulting in dual-fuel boilers being installed. The simplest way to provide dual fuel is via an interchangeable or dual-fuel burner, the combination of fuels normally being natural gas and light fuel oil. However, there is potential to consider using alternative fuels such as biomass, particularly in areas where natural gas is not available.

Biomass includes: wood residues, forestry residues; recovered wood waste; straw; short-rotation crops (such as coppiced hazel); and poultry litter and livestock slurry.

Continuity of supply is an issue, but many organisations are finding several potential suppliers in their area. In south-east England, forestry organisations are currently unable to find recipients for their wood waste.

Combined heat and power (CHP)

4.123 CHP should be a successful option for healthcare organisations that have a significant year-round base load.

4.124 It is unlikely that the CHP plant will be able to meet all the organisation's power and heat requirements, and additional heat and/or power will usually be required from conventional sources. However, the CHP plant should always operate as the lead boiler to increase its efficiency.

4.125 Beyond these requirements, there are numerous possibilities ranging from engine-based solutions supplying media from low-temperature hot water (LTHW) to steam through to turbine-based solutions supplying steam and high-pressure hot water.

4.126 The electricity generated by CHP is best utilised on site, although it is also possible to export electricity back to the electricity companies.

4.127 Any decision that involves CHP should be made with reference to the site-wide energy plan (see paragraphs 4.101–4.108). This is particularly important if CHP is being considered when existing boilers are to be replaced, because there is likely to be considerable interdependence between the services. Due attention should also be given to other major issues such as security of supply, safety, maintenance, noise, flue and chimney arrangements and planning considerations.

Example

The Royal Free Hampstead NHS Trust is a compact site in an urban area. In 1997 the comfort cooling system, which contained a CFC-based refrigerant, needed to be upgraded. The Trust decided to maximise the potential of its CHP system and invested in new chillers (£185,000 per chiller) that are now driven by steam from the CHP system. The new scheme has a performance coefficient of 1:1 compared with 5:1 for the old electrical-driven system, and electrical running costs are down from £150,000 a year to £10,000 a year. In addition, utilising waste steam has improved the quality index of the CHP plant, thus leading to exemption from the CCL.

4.128 CHP engines start at a few kWe and run up to installations from 2.5 MWe to over 5 MWe. (These are the typical sizes used by healthcare organisations; much larger engines are available.) Turbine-based solutions traditionally became viable at around 5 MWe, but there is a new generation of turbines, supplying a few hundred kWe, having the capability to generate steam, which can be very useful for sites that have steam loads.

4.129 In building applications, the CHP generator is most commonly connected to the low voltage distribution network. The grid can then either meet only the peak demand or supply the whole demand if the CHP is not operating. To operate the CHP unit in parallel with the grid, technical approval should be obtained from the electricity supplier. This will involve ensuring that the CHP unit can be isolated from the grid in the event of a failure of either the CHP unit or the grid. The existing electrical services may require some modification in order to achieve this when installing CHP.

i The Carbon Trust has developed the "CHP Sizer" software (CDCHP002) to assist with a preliminary evaluation of CHP. The software provides capital cost estimates, annual cost savings and details of financial return. The CHP Sizer Version 2 is available via http://www.thecarbontrust.co.uk/energy/pages/home.asp.

i For further guidance, see the following documents by the Carbon Trust: Good Practice Guide GPG388: 'Combined heat and power for buildings'; Good Practice Guide GPG234: 'Guide to community heating and CHP'; Good Practice Case Study GPCS291: 'Long-term operation of combined heat and power in a small hospital'; and Good Practice Guide GPG060: 'The application of combined heat and power in the UK Health Service' (available on the CD-ROM). See also CIBSE AM12: 'Small-scale combined heat and power for buildings'.

i The following websites also provide guidance: http://www.est.org.uk/communityenergy; http://www.cibse.org/chp (the CIBSE CHP Group); and http://www.chpclub.com

i See also "Systems for supplying heat and power", paragraphs 5.5ff.

Conventional options for heat and power

4.130 Once renewable power sources and CHP have been considered, and perhaps adopted as the lead heat source, the next best option (for sites where mains gas is available) is condensing boilers, which are especially suited to applications where the heating system can operate in low-temperature mode. (Technical notes and additional sources of information for conventional boilers are given in Chapter 5.)

Innovative cooling techniques

4.131 The power required to drive cooling systems can be considerable and, because such systems are usually driven by electricity (for fans, pumps etc), these systems are responsible for a significant proportion of the healthcare organisation's carbon emissions. As far as possible, the requirement for cooling should be minimised. But where there is an unavoidable need for cooling, consideration should be given to the wide range of innovative cooling techniques described in paragraphs 4.132–4.135. The opportunity to use these techniques is very closely linked to the geography and geology of the site and should therefore be explored at the earliest possible opportunity.

4.132 Opportunities include:

- *groundwater coupling using air:* by passing air through underground pipes at depths of 2–5 m to take advantage of the 12ºC or lower soil temperatures. Cooled air from the underground pipes can be used directly to provide cooling, although close temperature/humidity control is difficult. Alternatively, during the heating season, ground temperatures can be above ambient and these systems can then be used to pre-heat ventilation air;
- *groundwater cooling (from aquifers):* water, which has a greater thermal capacity than air, can be pumped from one well (a borehole drilled below the building) into another well via a heat exchanger. It is also possible to use the same system in winter to extract heat for space heating. Suitable groundwater can also be used, after simple filtration, directly to cooling coils. Where there is an inherently high water table, some water authorities will allow discharge to drain, thus avoiding the second borehole;
- *groundwater heat pumps:* using the thermal mass of the ground as a heat sink to improve the coefficient of performance (CoP) of a reversible heat pump;
- *surface water cooling (sea/river/lake):* by pumping water from these sources and extracting cooling via a heat exchanger, it is possible to directly cool the space/supply air or to pre-cool the chilled water circuit. Great depth is required to reach cold water, and fouling/corrosion problems should be taken into consideration. Alternatively the surface water can be used as a heat sink/source for a heat pump.

i See the Carbon Trust's General Information Report GIR085: 'New ways of cooling' (available on the CD-ROM).

i See CIBSE Guide B2: 'Ventilation and air conditioning'.

4.133 All of these techniques should be matched to the occupancy patterns and the other methods of heating and cooling being employed.

4.134 Active thermal storage devices, such as water tanks and ice storage, have been used effectively to smooth out peak demands, reducing the peak capacity of plant. This can also help to keep plant operating at improved load factors and better efficiencies. Thermal storage can result in reductions in plant capital costs due to lower capacities, although the costs of the storage and the more complex controls can sometimes outweigh the savings. Reduced efficiency can arise from losses where there are less favourable operating regimes, for example in the case of ice storage, where the coefficient of performance of the chiller tends to be reduced and pumping increased. (See also 'The building management system and other controls' in Chapter 5 (paragraphs 5.176–5.191).)

Other early considerations

4.135 While 'Encode' necessarily puts energy to the fore, there are other factors that play a part in achieving value for money (which is defined in Chapter 3). Some of these spin-off benefits are derived from the energy-saving imperative. For example, patient recovery may be enhanced by better thermal comfort, daylight, and external views – all of which are features of energy-efficient healthcare buildings.

4.136 The integrated design approach advocated in this guidance presents enhanced opportunities to tackle issues such as manageability, maintainability and resilience.

Manageability and maintainability

4.137 Many buildings do not realise their full potential for energy efficiency. This is often due to over-complex design, which makes the buildings and plant difficult to manage and maintain.

4.138 Buildings can be more or less technologically complex and have higher or lower management input. Acute hospitals, by their very definition, will tend to be complex and will have on-site management, whereas community facilities will tend to be relatively simple, with periodic maintenance. Newer buildings tend to be more complex because they have been designed to service an increasing range of activities, facilities and user needs. Avoiding unnecessary complexity and agreeing management requirements can improve energy efficiency, but this will only be achieved by adopting a strategic approach at an early stage.

4.139 Ease of maintenance will influence future energy efficiency and should be addressed at the design stage. The requirements of space, position, access, repair and replacement of services should be considered so that equipment can be commissioned, monitored and maintained. Therefore, designers should include adequate access and monitoring facilities. For example, it should be easy to check or change features such as set-points, control authority, filter elements, boiler and chiller efficiencies, and also for alarms and faults to be registered quickly and easily. For energy-hungry or complex systems it is worthwhile specifying feedback from valves and dampers such that the control system monitors the actual position of the device compared to the signal sent out – faults can then be alarmed.

4.140 Energy efficiency will only be achieved in practice if the building is operated as the designer intended. The specification should also make clear the need for, and extent of, properly planned operating and maintenance procedures so that the design objectives for the minimum use of energy are achieved. (Maintaining buildings for energy efficiency is covered in Chapter 2.)

4.141 The healthcare organisation (as client) and its advisers should think carefully about how the building will be used and operated. Suitable operating staff should be designated at an early stage. They should be involved in commenting on the proposals, witnessing commissioning and preparing for hand-over and occupancy. The client should ensure that there is seasonal commissioning; that is, if a project is completed and commissioned in the winter, a repeat visit should be made in the summer months to prove and carry out checks on the control strategy.

Resilience

4.142 Designs that simply minimise first cost may not be as robust as those that are evaluated on the basis of value for money, where the costs over the lifetime of the building are taken into account.

4.143 To aid the development of a resilient design, a comprehensive description is needed of the nature of the activities and equipment which the building is to contain. For heavily serviced departments, it is beneficial – before even sketching a scheme

Princess Royal Hospital, Bromley. A view of the standby electricity generator plantroom showing good access space for maintenance etc design – to have at least generic equipment schedules and capacities to avoid under- or over-engineering, and particularly under-provision of plant and distribution space. Such departments would include theatres, pathology, pharmacy, mortuary, catering, laundry, sterile services and diagnostic imaging. Lack of space or capacity often leads to abandonment of energy-saving technologies.

4.144 For less highly serviced departments, where the equipment requirements are unknown, a range of possibilities should be drawn up. However, note that the organisation's stated aim for flexibility should not be met by over-specifying, but rather by contingency planning.

Commissioning

4.145 The design team should address the issue of commissionability of building services early on, and the client should be encouraged to participate in this exercise. Adequate time should be allowed and a suitable budget provided for commissioning by competent personnel. If this completion stage is shortened, poor operation and high energy consumption are likely throughout the life of the building. Therefore, commissioning should not be overlooked.

4.146 The commissioning period in any project should be planned so that it remains a phased part of the contract period. It should not be regarded as a buffer period during which earlier delays can be absorbed.

Hand-over

The detailed decisions taken at the early stage of a project, and during the design and construction/installation phases, will be wasted – as will energy – if the people using and managing the building do not understand how it works and how their actions will affect its performance.

Regardless of the size or scale of the project, the client should be given:

- full documentation on the commissioning of the building services, including a comparison with the original specifications to ensure compliance with the design intent and a check on the control of all systems under operating conditions;
- design set-points of all controls;
- operating and maintenance manuals for the building operator;
- the building "log book" (as required by Building Regulations);
- for larger developments, department-by-department user guides.

In the log book, the design team should provide a brief overview of:

- the overall design and control strategy and the building services operation;
- a clear summary of the overall energy supply strategy and the metering strategy (if appropriate);
- how to operate the plant efficiently in relation to seasonal changes, out-of-hours use, start-up and shut down;
- the issues that management should pass on to the building occupants, including the way to operate controls, windows, shading and so on.

The contract should include provision for the contractor and designer to carry out familiarisation and training sessions for operators and managers.
If the client intends to outsource all or part of the maintenance work, this should be arranged well in advance of the training to ensure that the maintenance contractor attends.

Project design checklist

4.147 This checklist should be used as an aid to assessing the energy-efficiency aspects of each major department in a large development or for individual buildings for smaller schemes. It is recommended that the checklist (or an adapted version of it) be used during the early stages of the project's life. However, it is also recommended that it should be used periodically throughout the project's development to check that considerations about energy efficiency or carbon emissions are not being sacrificed unnecessarily and that the project remains in line with initial objectives and with the healthcare organisation's energy and carbon management policy (or environmental/ sustainability policy).

How to use the project design checklist

For each item, ask "Yes/No" and then "if not, why not?" Then the design team should review options to establish whether the proposal/sketch design/final project (etc) meets the healthcare organisation's original intentions and the design brief.

The checklist is arranged so that the items raised correspond approximately to the descriptions and explanations given in Chapters 4 and 5.

It may be photocopied and distributed to all parties in the design process, although it is recommended that anyone who completes the checklist has read the full 'Encode' to ensure that they understand the principles and values that the healthcare organisation is working towards. The checklist may also be adapted to suit particular circumstances.

This checklist is based on one presented in CIBSE Guide F: 'Energy efficiency in buildings'.

Project design checklist	Yes/No (tick)	Follow-up actions
1. Has the brief been met?		
Have clients' requirements and Encode design guidance been satisfied?		
Have project-specific energy objectives been met?		
Have the mandatory annual energy and carbon targets been met or exceeded?		
Have the original environmental objectives (eg achieving an "excellent" rating) been met?		
Have whole-life cost objectives been achieved?		
2. Energy regulations		
Have the Building Regulations been satisfied (particularly those relating to energy usage)?		
Has every effort been made to go well beyond the minimum energy standards set in the Building Regulations?		
Has a building log book been prepared showing design estimates of future consumption?		
Has the building been certified in accordance with the Energy performance of Buildings Directive (EPBD)? (post-2006)		
Has there been an investigation to determine whether the building or project will need to be registered under the EU Emissions Trading Scheme?		
3. Design integration		
Has every effort been made to include renewables?		
Can thermal storage, heat recovery, free cooling be used to minimise services further?		
Has natural ventilation been optimised to minimise services?		
Has daylight been optimised to minimise services?		
Has every effort been made to minimise requirements for services?		
Will individual services operate without conflict?		
4. Building fabric		
Is this the best building orientation?		
Is this the optimum shape?		
Is this the optimum site layout to improve orientation, shading and footprint?		
Is this the most appropriate thermal response (ie heavyweight or lightweight)?		
Is this the optimum level of insulation?		
Is this the optimum percentage of fenestration?		
Are the windows the most appropriate design for this situation?		
Has every effort been made to minimise/utilise solar gains?		
Will design detailing help to minimise unwanted air infiltration?		

Project design checklist	Yes/No (tick)	Follow-up actions
5. Overall building		
Is the building simple, avoiding over-complexity?		
Is the building easy to commission?		
Is the building easy to manage and operate?		
Is the building easy to maintain?		
Is the building flexible enough to meet the needs of future changes in working practices?		
6. Ventilation		
Has every effort been made to use a natural ventilation strategy?		
If natural ventilation is not possible, can a mixed-mode approach be used?		
If mixed-mode ventilation is not possible then has every effort been made to use the most efficient ventilation in accordance with Health Technical Memorandum guidance?		
Has every effort been made to avoid humidification and/or dehumidification?		
Has night cooling been considered?		
For full fresh air systems, has ventilation heat recovery been incorporated?		
Where mechanical plant is essential, is it the most efficient possible?		
Is ductwork designed to give low pressure drops?		
Does the ventilation design have effective controls (including variable speed drives (VSDs), good zoning and local user controls)?		
7. Cooling and internal gains		
Has every effort been made to reduce cooling loads and minimise internal gains?		
Have free cooling, thermal storage and heat recovery been considered?		
Where mechanical plant is essential, is it the most efficient possible?		
Have absorption cooling, zero ozone-depleting refrigerants and/or ground source cooling been evaluated?		
Can cooling plant be inhibited until an agreed internal set-point is reached?		
Can the evaporating temperature be increased and/or the condensing temperature be reduced to increase the coefficient of performance (CoP)?		
Does the cooling system have effective controls (including VSDs, good zoning and local user controls)?		
8. Heating and hot water		
Has CHP been considered?		
Has every effort been made to reduce heating loads, heat losses and hot water demands?		
Are heating and hot water plant separate and has a decentralised approach been considered?		
Is heating and hot water plant the most efficient possible?		
Have boiler controls been specified to give optimum performance across the likely range of operating conditions?		
Do the systems have effective controls (including VSDs, good zoning and local user controls)?		

Project design checklist	Yes/No (tick)	Follow-up actions
9. Metering		
Has a metering strategy been developed and included in the building's log-book?		
Has a strategy been developed for monitoring and reporting measurements from meters?		
Are all departments or smaller individual buildings individually metered?		
Are all sub-meters shown on the design drawings?		
Have detailed operation and maintenance manuals been prepared including details of design, commissioning, equipment and so on?		
10. Lighting		
Has every effort been made to bring in additional daylight?		
Will the daylight be utilised in conjunction with responsive controls?		
Have lighting controls been zoned in relation to occupants needs?		
Has every effort been made to avoid over-lighting compared to recommended illuminance levels?		
Can lighting be provided by more localised systems (e.g. task lighting)?		
Are the light sources (lamps, luminaires and control gear) the most efficient possible?		
11. Motors		
Have high-efficiency motors been specified throughout the design?		
Have variable speed drives (VSDs) been specified where appropriate?		
12. Building management system and other controls		
Is there a suitable balance between central and local control?		
Will the facilities management team have suitable overall controls that encourage good operation (eg building management system (BMS))?		
Do occupants have good local controls with simple interfaces?		
Does the BMS provide central control, monitoring and alarms with a good user interface?		
Will controls cause conflicts between systems?		
Is the building zoned appropriately using controls?		
Has variable flow control (using VSDs) been included?		
13. Electrical small power		
Has equipment been specified and chosen on the basis of whole life cost (including energy use)?		
Does the equipment include provision to minimise or avoid heat emissions to occupied spaces?		
Has heat been recovered where possible from equipment and specialist systems?		

5 Technical notes for building services

5 Technical notes for building services

Introduction

5.1 This chapter provides additional information on energy-saving opportunities and options for each of the main energy-consuming services that healthcare organisations require:

- heat and power sources;
- space and water heating;
- ventilation and cooling;
- lighting;
- motors and drives;
- controls;
- “small power”;
- specialist services.

5.2 This chapter also provides the linking information relating to the procurement and energy management of these services.

5.3 In each case, the information is presented in the order of most energy-efficient option to least energy-efficient option.

5.4 The notes in this chapter are not intended to be comprehensive design guidance; rather they highlight the main energy-related issues that the design team should address, and suggest sources of further information (such as Health Technical Memoranda (HTMs)) that provide the detailed design parameters that are to be achieved.

Systems for supplying heat and power

5.5 Chapter 4 discussed the importance of having a site-wide energy plan that explains how the energy needs of the healthcare organisation are to be met and suggests that the plan should be reviewed when any changes to heat and power plant or equipment are planned. It also highlighted the importance of early consideration of all possible fuel options – renewable energy sources, combined heat and power (CHP) or fossil fuels to drive boilers.

5.6 This chapter presents additional design guidance and points to additional sources of information that should be considered when making decisions about heat and power delivery. For information on renewables, see the Carbon Trust’s Good Practice Guide GPG379: ‘Renewable energy guide for the government estate’ and Section A3.1.3 of NHS Wales’s ‘Energy efficiency strategy guidance and implementation’ (available on the CD-ROM).

Combined heat and power (CHP)

5.7 CHP is the generation of thermal and electrical energy in a single process. CHP units use a “prime mover” (usually either a gas-fired reciprocating engine or turbine) to drive a generator. The heat generated in this process is recovered to produce hot water or steam. This process of heat recovery raises the overall efficiency to between 70% and 85%. The high efficiencies achieved are much greater than conventional power stations, thus reducing the amount of primary energy required to satisfy a given heat and electrical load. Site energy cost can be reduced significantly using CHP. The delivered thermal energy consumed on a site will increase, but overall energy consumption will decrease. CHP normally provides an acceptable economic return on sites that have a simultaneous demand for heat and power over a prolonged period of time, at least 4500 hrs/yr, although CHP can sometimes be cost-effective with fewer operating hours. These criteria apply to most hospitals, though the economics of CHP are critically dependent on the balance between gas and electricity costs available to the organisation. Nevertheless several hospitals have taken the long-term view and installed CHP to help reduce their primary energy consumption and give a strategic advantage.

5.8 CHP installations can run on natural gas, bio-gas or diesel (gas oil). They have a similar reliability to conventional boilers, and high availability factors. CHP should always operate as the lead boiler to maximise savings.

Examples

The two natural gas CHP units run by Milton Keynes General NHS Trust date back to the early 1990s and have shown ongoing savings in electricity. The first unit, installed in 1992, saved 8755 MWh over the first nine years of operation. Both machines qualify for exemption from the Climate Change Levy (CCL). Together, the units provided around 20% of the hospital's total electricity consumption during 2000/01 and ran at around 30% electrical efficiency.

The two gas-fired CHP plants installed in 1991 and 1994 at Glenfield Hospital (the University Hospitals of Leicester NHS Trust) have helped to reduce electricity consumption by 21.5% – a reduction of 1,256,272 kWh. The hospital operates a dual-fuel boilerhouse strategy, with interruptible gas, using gas oil as a backup fuel. The gas contract includes penalties if the hospital exceeds its allowance for "firm" gas, so a control system is used to monitor CHP gas consumption and avoid penalties by ensuring that any reduction in CHP output occurs at night when electricity imports are cheaper. A key benefit of the CHP system is the security of the energy supply to the hospital's operating theatres and critical care facilities. In addition, the hospital saves around £20,000 a year through exemptions from the CCL.

Nevill Hall Hospital, Gwent Healthcare Trust. Micro-turbine combined heat and power plant. Six micro-turbines – each rated at 100 kW electrical and 150 kW thermal output. The units can be sequenced much like a modular boiler installation. Electricity is used to offset import requirements and the heat output services heating and hot water demands in the winter and cooling in the summer

Courtesy of Gwent Healthcare Trust and Welsh Health Estates

5.9 Most small-scale CHP installations in buildings are packaged units, based on reciprocating engines, with an electrical output not exceeding 1 MW and usually less than 500 kW. Small-scale units are most commonly retrofitted to existing installations, although CHP can prove to be even more beneficial in new buildings. Small gas turbines and mini-turbines are now available for these applications. Larger multi-building installations (for example hospitals) commonly use gas turbines, although some are reciprocating engines. Gas turbines are favoured particularly when high-grade heat is required for steam raising or if a high ratio of electricity to heat is required through operation in combined cycle mode.

i Assessment and certification under the CHPQA Programme will determine the eligibility of CHP schemes for business rating. See http://www.chpqa.com

i Detailed design guidance for CHP schemes can be found in CIBSE AM12: 'Small-scale combined heat and power for buildings'.

i The CHP Sizer Version 2 (CDCHP002) (software) is published by the Carbon Trust and is available via http://www.thecarbontrust.co.uk/energy/pages/home.asp.

Financial considerations

5.10 The government recognises that good-quality CHP can make a significant contribution towards meeting the national objectives for reducing carbon emissions and consequently has ensured that "good-quality" CHP is exempt from the Climate Change Levy (CCL). This exemption applies to the fuel in, heat out and electricity used on site (or sold directly to others). The exemption from the CCL reduces the payback period for CHP and increases the actual cost savings that can be achieved, as illustrated in Table 6.

Table 6 The benefits of the CCL on an actual example of a CHP installation

	2000–2001 (£)	2001–2002 (incl CCL) (£)
Capital cost	350,000	350,000
Annual savings	78,000	95,000
Simple payback (years)	4.5	3.7

5.11 This tax break makes CHP a more affordable option for hospitals. For a typical 600-bed acute hospital, a 600 kW unit can provide substantial revenue savings, approaching £100,000 per annum. This is in addition to the savings made as a result of reductions in National Insurance contributions under the CCL proposals. Furthermore, the installation of CHP alone would, in most cases, be sufficient to reduce the organisation's emissions in line with the national mandatory targets.

5.12 However, it should be noted that if a decision is taken to investigate the opportunities of CHP, the design team should also review the requirements set out by the EU Emissions Trading Scheme (see Appendix 3).

5.13 Another option is to obtain energy and cost savings without risking capital through the energy services approach. This could be via discount energy purchase (DEP) and contract energy management (CEM) or under the private finance initiative (PFI) as part of a major project to upgrade services. Again, based on a 600-bed hospital and taking into account the tax benefits, a healthcare organisation could expect to receive energy cost savings of between £30,000 and £40,000 per annum at no cost to the organisation. Under such arrangements the supplier provides the necessary finance, operates and maintains the CHP plant, and also provides guarantees concerning availability and performance, as well as compensation for any resultant loss in savings.

5.14 Note, however, that PFI providers do not generally directly benefit when CHP is included as part of a PFI-funded redevelopment or new-build project. They can be encouraged to embrace the option of CHP by including carbon emissions and primary energy objectives within the PFI output specification, as well as by having a stake in the savings. (Further information on the advantages of CHP and funding routes can be found at http://www.est.org.uk/communityenergy/index.cfm)

Example

The contribution that CHP can play in any energy reduction strategy is demonstrated at Withybush Hospital, a 384-bed hospital that is part of Pembrokeshire and Derwent NHS Trust. The hospital has introduced CHP using its own funds and more recently through a DEP arrangement. It now generates over 90% of the site's electricity requirement and at times exports excess electricity to the grid.

Before the introduction of modern CHP, energy costs represented 3.48% of the Trust's annual budget; today this figure is 0.65%. At the same time, primary energy use at Withybush has reduced from 176 GJ/100 m^3 to 75 GJ/100 m^3. The total energy cost is currently £3.94 per square metre. This compares very favourably with the typical value for similar hospitals of £6.60 per square metre. Taking the CCL into account limits the additional annual energy costs to 5.75% (£7100 gas, £2100 electricity) compared to the 17% rise faced by many acute hospitals.

Boiler selection

5.15 When choosing boilers, a technical appraisal will be necessary; proposed schemes should be ranked in order of technical suitability.

5.16 For larger acute sites, resilience of heat supply is required, so dual-fuel boilers are installed. The simplest way to provide dual fuel is via an interchangeable or dual-fuel burner, the combination of fuels normally being natural gas and light fuel oil. Where natural gas is not available, or to minimise the potential risk of future fossil fuel price rises, it is worth considering alternative fuels such as biomass (Chapter 4) or heat from waste.

Example

Queen Mary's, Sidcup, in south-east London, has a waste incineration plant that is, in effect, the hospital's number one boiler.

In the 1990s, an existing small waste incinerator at the site was replaced by new, larger incineration plant. The plant is owned and operated by White Rose Environmental. In effect, the hospital "hosts" the plant for the company, but gains some useful benefits.

The incineration process generates heat that cannot be emitted to the environment. This waste heat is used to supply around 80% of the Trust's heating requirement for central heating, hot air, domestic hot water and a hydrothermal treatment pool. The incineration service is provided free to the Trust; waste heat is supplied at very low cost. The Trust estimates that this saves around £60,000 per year in heating energy bills. If for some reason the plant is not supplying sufficient heat for the Trust's needs, the Trust's gas-fired boiler cuts in.

The plant runs at around one tonne of clinical waste per hour. Waste from Queen Mary's takes up only 10% of the plant's capacity; the other 90% of the capacity is used by other organisations.

Overall the process brings Queen Mary's both cost savings and operational advantages.

Condensing boilers

5.17 The most energy-efficient conventional boilers are the condensing type.

5.18 Their efficiency can be even greater if return water temperatures are reduced. There are a number of hydraulic arrangements and controls that can promote these lower temperatures (for example weather compensation). The usual barrier to lower return temperatures is that low-temperature hot water (LTHW) is being used to generate domestic hot water (DHW) and also to supply constant-temperature circuits to heater batteries and fan convectors. This problem can be circumvented by having DHW generated by direct gas-fired generators (where possible). This enables the heating boilers to run in condensing mode. For more complex sites, or where DHW is generated from mains, a detailed evaluation of the system may be required. This should consider the economical viability of:

- segregating constant temperature (CT) and variable temperature (VT) systems – perhaps running CT and VT from separate boiler plant, with interlinking for emergency use and summer boiler provision for DHW and CT loads;
- existing steam systems for CT loads, with condensing boilers for heating loads only.

5.19 The feasibility of each measure will depend on the extent of each development and the distances between heat generation and usage.

5.20 Where condensing boilers are used only for weather-compensated (VT) heating circuits, the boiler flow temperature set-point should match the compensated flow temperature.

5.21 Although a condensing boiler will be more efficient than an existing conventional boiler, it needs to have high flow and return temperatures, so it should not be used as direct replacement for the conventional boiler unless a thorough evaluation of the performance of the whole system has been carried out.

5.22 Condensing boilers need a route to drain the condensate – ideally this should be by gravity, but it may be pump-assisted.

See the Carbon Trust's Good Practice Case Study GPCS40: 'Energy efficiency in hospitals: condensing boilers – a case study' and Good Practice Guide GPG16: 'Condensing boilers in commercial buildings' (available on the CD-ROM).

Multiple boiler arrangements

5.23 Multiple boiler arrangements, where individual modules are progressively switched on as the load increases, offer the greatest efficiency because:

- the system matches the demand for heat more closely;
- each boiler performs close to its individual design duty;
- the overall plant therefore provides an improved part-load efficiency characteristic.

5.24 However, it should be noted that careful sequence control is fundamental to this approach. In any multiple boiler arrangements, whether using an integrated package of modules or independent boilers, the most efficient plant should take the base load (for example the CHP plant first and the condensing boilers second).

5.25 Within practical limits, and where the dilution effect of parallel connected boilers is not significant, the greater the number of stages of sequence control, the better the efficiency. In some instances, particularly for low-temperature systems, it can be economical to specify all the boilers in a multiple arrangement as condensing. However, in most instances it is more economical to specify the lead boiler(s) as condensing, with high-efficiency boiler(s) to top up. This optimises capital cost while still keeping overall plant efficiency high.

5.26 It is also possible to specify boilers of different sizes, where one acts as the summer boiler for hot water services. However, complete segregation of hot water services is normally more efficient.

5.27 For larger and steam-raising plant, modulating control should be used to progressively increase the output of each boiler. Care should be taken in specification and comparison of such plant to evaluate the efficiency at each stage of capacity and to ensure that full modulating control is available across as wide a range of the boilers' output as possible ("turn-down ratio") at the best possible efficiency. Boilers should be sized to satisfy the maximum hourly steam demand while operating within their maximum continuous rating (MCR).

5.28 Whatever solution is preferred, boilers should be sized to operate at as high a loading as possible and preferably within their turndown range.

i The software sizing tool in the Carbon Trust's Good Practice Guide GPG227: 'How to appraise CHP – a simple investment appraisal methodology' is designed to aid boiler selection. This document is available on the CD-ROM.

i CIBSE Guide F: 'Energy efficiency in buildings' gives further guidance on the efficient control of boiler plant, including pipework arrangements for multiple boiler arrangements, and the operation of stand-by boilers.

Distribution systems

5.29 Heat (and cooling) distribution systems should be considered carefully in order to obtain maximum overall efficiency. The following points should be noted:

- ensure that the heat or cooling from the boiler/chiller reaches the point of use with minimum pumping energy; that is, the system should be designed for low resistance;
- ensure that the heat or cooling from the boiler/chiller reaches the point of use with minimum change to the temperature inside the pipe by using the optimum level of insulation and considering the route of the mains. Exposed external mains in general lose or gain more heat than those routed internally;
- ensure that the optimum level of insulation to all heating and cooling pipework and ancillaries is specified. Steam final connections, final legs of DHW systems and chilled water equipment are all often missed from specifications;
- ensure that mains are not too closely packed in service voids, ducts etc to prevent unnecessary heat transfer between them;
- choose distribution temperatures and pressures carefully on larger schemes. For example, choosing to distribute steam widely, rather than stepping down to LTHW more frequently, will increase distribution losses, as will choosing chilled water temperatures that are lower than necessary;
- ensure that all routes of mains (particularly steam and condensate) are safely accessible for maintenance and can be routinely and easily monitored for leakage and damage to insulation. The building management system (BMS) should be capable of detecting major mains which are not readily visible or are underground;
- ensure that systems are controllable to match the needs of the heat/cooling emitters in the conditioned spaces;
- avoid hydraulic interference between different parts of the systems, for example between primary and secondary systems;
- provide sufficient flow to give control by valves.

Valves

5.30 Energy losses can be reduced by using insulated valve boxes and flexible insulation jackets.

5.31 New technology in heat distribution systems includes high-standard pre-insulated pipe lengths incorporating leak detection equipment and fusion-welded jackets for terminations. These reduce distribution losses and maintenance substantially and increase system reliability. Care should be taken to specify jackets that can be removed and replaced readily. Aluminium-clad valve and flange boxes should be avoided, because these are often difficult to replace, get damaged, and it is not apparent if the insulation within them has been removed.

Pipework

5.32 On larger pipes, particularly those carrying steam and chilled water, flanges and joints should be insulated. Key considerations are:

- ensure that the pipework for supplying heat to the main building(s) has adequate levels of insulation based on a 25-year WLC analysis. The economic thickness of insulation calculations should be reviewed on major schemes. Bear in mind that if energy prices rise, thicker insulation than is currently required for healthcare buildings/service may be an advantage;
- the Building Regulations require that all pipework, ductwork and vessels for space

heating and hot water supply should be insulated to the standards in BS 5442(23). Further recommendations are given in the appropriate Health Technical Memoranda.

i See the Carbon Trust's Fuel Efficiency Booklet FEB008: 'The economic thickness of insulation for hot pipes' (available on the CD-ROM).

Heat emitters

5.33 Before choosing a delivery mechanism for space heating, it is important to make sure that the various elements of building or site design minimise the need for space heating using passive measures (see Chapter 4). The decision will then be confined to which system is the least intrusive to the design and most efficient for the purpose.

5.34 Emitters are generally categorised as either convective or radiant (although there are usually elements of both processes at work). A convection system heats the air, and the heated air rises, setting up a convection current that moves the warmed air around the space; whereas a fully radiant system heats occupants directly without heating the air to full comfort temperatures.

- For spaces where there is a high ventilation rate, a radiant heating system should result in lower energy consumption. This is because the radiant heat energy warms the occupants directly and has little effect on the air temperature. Radiant heaters are often used in large spaces such as warehouses and plantrooms, where there is no need to heat the entire space. (Note that the low-temperature radiant panels used extensively in larger acute hospitals are not true radiant panels; they are actually ceiling-mounted radiators which operate primarily by convection.)
- If a convection system is to be used to heat a tall space, care should be taken to avoid the vertical temperature stratification that leads to accumulation of heat at a high level. This can be avoided by encouraging air circulation within the space.

5.35 The choice of heat emitters should be made in conjunction with a consideration for the health and safety of occupants. This is particularly pertinent to clinical areas such as wards where systems may inadvertently harbour dust and germs or where occupants may be injured by touching hot emitters.

i See the Department of Health's 'The revised guidance on contracting for cleaning'.

i See also Health Guidance Note: '"Safe" hot water and surface temperatures'.

Radiant panels

5.36 Ceiling-mounted radiant panels are useful in areas such as wards where there is little floor space and where wall-mounted radiators present a health and safety hazard. Radiant panels can be supplied with low-, medium- or high-temperature hot water, or steam, and can have a radiant component of up to 65%. (In practice, steam and high-temperature hot water (HTHW) are rarely used in ward areas due to the comfort problem in relatively low spaces and the cost of components.)

5.37 If used, each area served should have remote sensing individual control, located away from other heat sources to ensure the panel can respond to fluctuating internal gains.

Radiators

5.38 Radiators have a convective component of between 50% and 70%. They provide a positive room air temperature gradient. They are cheap and easily controlled, with a reasonably quick response. However, care should be taken to keep surface temperatures low where vulnerable patients who are unable to move unaided might come into contact with the radiator.

i See Health Guidance Note: '"Safe" hot water and surface temperatures'.

Natural convectors

5.39 Natural convectors have a radiant/convective split of 20/80 and tend to produce a more pronounced vertical temperature gradient that can result in inefficient energy use. They are best used in well-insulated rooms with low air change rates.

Fan convectors

5.40 Fan convectors, like natural convectors, may be suitable in non-clinical areas such as administrative offices or waiting areas, subject to meeting acoustic criteria. Fan convectors:

- provide good temperature control;
- respond rapidly to control;
- can have a variable speed and, hence, a variable output;

- require constant-temperature circuits with a high minimum flow temperature and should be separated from circuits serving other types of emitter;
- require additional wiring for fan interlock with time control.

5.41 In order to maintain optimum efficiency, the minimum flow temperature for circuits serving fan convectors should not be below 50–55ºC.

Underfloor heating

5.42 Underfloor heating usually consists of a low-temperature warm water distribution system set into the floor slab. This gives a slow response that is more suited to areas of continuous occupation. These systems have several energy efficiency advantages:

- they have some built-in self-regulation: as the room warms up, the temperature difference between the floor and the room air decreases, reducing the heat output;
- they deliver heat at a low level, which is where the occupants will feel the maximum benefit;
- they provide an ideal opportunity to use condensing boilers because seasonal efficiencies of over 90% can be achieved due to the low return water temperature.

5.43 However, underfloor heating is not always suitable for healthcare buildings. This is because there is frequently a need to drill into the floor slab to make fixings for large pieces of equipment, which would potentially damage the underfloor distribution network.

5.44 The selection of heating zones and their control will have a considerable impact on comfort and energy, because there is a high thermal inertia with underfloor heating and less opportunity to respond to local heat gains. For this reason, underfloor heating circuits should have a separately optimised and compensated circuit. Without this, for intermittently heated areas, the optimum start will bring the entire building on to satisfy the demand for longer heat up to the areas served from underfloor heating. (Conversely, if the sensor is in zones served by radiators, the underfloor heated areas will not achieve the required pre-occupancy temperature.) Alternative solutions include booster radiators, which are also useful where doors are likely to be open for protracted periods.

Technical notes for space-heating circuits

5.45 The successful operation of controls for heating circuits depends heavily on good circuit design. A constant, or near constant, water flow is normally required for modern boilers. A variable flow is created by the action of automatic back-end valves and individually pumped boilers. Therefore, for most applications, systems should be designed with:

- separately pumped secondary circuits which are decoupled from the primary circuit by a common header or buffer vessel avoiding any interaction between circuits that could destabilise the controls;
- a single primary pump driving a constant flow primary circuit to ensure that the sequence control sensor can then detect a temperature that is representative of the load on the system.

i Detailed design guidance can be found in CIBSE Guide F: 'Energy efficiency in buildings'.

i See the Carbon Trust's Good Practice Guide GPG287: 'The design team's guide to environmentally smart buildings – energy efficient options for new and refurbished offices' and available on the CD-ROM.

Water heating

5.46 Designers should not overlook the simple efficiency improvements that can save water and the energy needed to heat it. A correctly-designed hot water system will lead to:

- lower energy and water use;
- lower maintenance costs;
- improved water hygiene;
- a reduction in the risk of *Legionella*.

i See the Health and Safety Executive's 'Approved Code of Practice, Legionnaires' disease: the control of *Legionella* bacteria in water systems'.

5.47 Hot water can be generated either centrally (and pumped around the building or site) or locally at the point of use. In either case, effective design will yield energy cost savings. Whatever system is chosen, the combined storage capacity and heater output should be maintained at no less than 60°C under design-continuous demand conditions.

5.48 When considering hot water installation options, the design team should:

- assess whether it is feasible to generate hot water by recovering waste heat from air compressors or refrigeration plant;
- ensure that hot water plant is sized correctly to minimise capital and running costs;
- ensure that circulation temperatures are not compromised.

Local systems

5.49 Decentralised storage water heaters close to the point of use can significantly improve efficiency because standing and distribution losses are greatly reduced, particularly for larger healthcare buildings or sites. The risk of *Legionella* is also normally reduced with localised systems. Capital and maintenance costs can be higher, but this is normally more than offset by the increased efficiency. This option can also be useful for catering, laundry and recreation facilities with high peak demand.

5.50 Local electric storage systems are usually designed to take advantage of off-peak electricity tariffs and can be located close to the point of demand.

5.51 The installation of dedicated, gas-fired, local DHW boilers should be considered, because these will operate efficiently all year with minimal pipe losses. They also maintain minimum storage volumes, thus reducing storage losses. Where the need for DHW is small and isolated, instantaneous point-of-use heaters should be considered (see paragraphs 5.52–5.53). However, it is important to note that localised gas-fired systems will dramatically reduce the base load that could be met by CHP.

5.52 If decentralisation of DHW is not feasible, high-efficiency plate heat exchangers should be considered, provided that they are designed so that the temperature does not fall below acceptable limits (to reduce the risk of *Legionella*). Load

Water-saving measures

Opportunities should be taken to save water, which will in turn reduce the heating and pumping requirement, both of which save energy (and reduce carbon emissions).

The table below shows a number of measures that could help to save water. In particular, taps (and toilet-flush mechanisms) that have infrared controllers are an excellent idea because they reduce the opportunity for the spread of infection.

Measure	Comments	Annual saving
Tap restrictors	Valuable for providing equal flow at a number of taps in a wash room	Typically reduces water flow by 15%
Push taps	Ideal for areas where taps may be left running	If a tap drips at 3.5 L per hour this would save 31 m^3 of water per year
Shower regulators	Valuable for providing equal flow at a number of outlets	Typically reduces water flow by 20% of water used in showers
Push-button showers	Ideal for areas where showers may be left running	Between 5% and 15% per shower, depending on location
Infrared controllers	Water only runs when required, then turns off automatically	Between 5% and 15% per year

i Energy Efficiency strategy guidance and implementation support pack for the NHS Trusts in Wales

i See the Carbon Trust's Good Practice Guidance GPG228: 'Water-related energy savings – a guide for owners and managers of sports and leisure centres', and Fuel Efficiency Booklet FEB021: 'Simple measures for energy and water efficiency in buildings' (available on the CD-ROM).

i CIBSE Guide F: 'Energy efficiency in buildings'.

levellers or buffers could be installed to help maintain temperatures and resource under load variations.

See the Health and Safety Executive's (2001) 'Approved Code of Practice, Legionnaires' disease: the control of *Legionella* bacteria in water systems'.

Point-of-use water heaters

5.53 Monitored projects suggest that point-of-use instantaneous water heating is extremely economical where hot water demand is low, such as hand-washing in administrative areas. Capital cost and delivered energy consumption is generally low. In some hard-water areas, water softening may be desirable to prevent units scaling up, and thus avoiding premature failure.

5.54 Electricity is often the best choice for point-of-use water heating because of its low installation/maintenance costs. Its high unit price is less of an issue, provided that water use is low. Point-of-use gas heaters can also be used where there are widespread gas distribution mains.

Centralised storage systems

5.55 The following energy efficiency considerations should be noted:

- ensure that hot water storage volume is matched to the required demand and the recovery times;
- avoid excessive storage volumes because this will lead to high standing heat losses and increased risk of bacteriological infection;
- in general, ensure that hot water is produced independently of the building's heating system (for example by using a separate water heater);
- plate heat exchangers, or copper-fin water heaters, transfer heat more effectively than traditional storage-type water heaters. They are more expensive, but they can be very cost-effective where larger quantities of hot water are required, for example for process use, and they reduce the need for storage;
- in hard water areas, consider base exchange water softeners and other means to prevent scale formation;
- ensure distribution pipework and valves are well insulated. Avoid dead-legs where water can stagnate (for example long distribution runs that serve outlets with low or intermittent utilisation);
- ensure the system is adequately controlled with regard to operating times and temperature;
- fit commissioning valves to regulate larger systems;
- ensure temperatures are maintained to the end of systems and reduce water waste.

Central calorifier systems

5.56 Where hot water loads are high and distribution systems compact, a well-controlled central boiler/calorifier plant can operate reasonably economically. However, where hot water loads are not substantial, particularly in the summer, separate heating and hot water systems will be more energy-efficient.

5.57 Note that combination boilers can provide an energy-efficient approach to both heating and hot water in small (domestic-sized) centralised systems. Hot water is heated almost instantaneously on demand, although interaction between the heating and hot water may occur where winter demand is high.

Central self-contained systems

5.58 Self-contained central hot water systems are normally much more efficient than systems combined with the main heating. This is because standing losses are lower and the poor part-load efficiencies, which are characteristic of boilers sized for the full heating duty, are avoided during summer operation. Relatively high-efficiency storage water heaters are commonly used, and condensing versions offer a further high-efficiency option.

5.59 Electric immersion heating is generally only economical where there is adequate capacity for off-peak storage. Suitable tariffs should be available, and the systems should be well controlled to minimise daytime top-ups. This method can be used in smaller buildings as an alternative to using the heating boiler during the summer, with hot water generation via the main boilers during the winter. Although highly efficient in terms of delivered energy, with comparable running costs to storage water heaters, the primary energy consumption and CO_2 emissions are relatively high.

Minimising losses

5.60 Primary and secondary distribution losses should always be minimised as part of an energy-efficient design. Hot water circulation loops should be compact and well-insulated, while dead-legs should be kept to a minimum size and length.

5.61 As with space heating systems, it is extremely energy-efficient and cost-effective to insulate pipes. Key considerations are as follows:

- to maintain the temperature to minimise the risk of *Legionella* (for example), an absolute minimum temperature of 50ºC is required. Therefore the distribution system should be provided with a secondary circulation system that is designed to supply water at 60ºC; the minimum temperature at the return connection to the water heater should be 50ºC. In all but domestic systems, if recirculation is not used, some form of trace heating will be required. This should be designed such that the minimun temperature at the most distant taps or outlets is 55ºC;
- all temperatures should be sustainable under the prolonged maximum continuous demand conditions (of at least 20 minutes) for which the system was designed;
- it is not permissible to shut down the pumped circulation overnight.

i See the Health and Safety Executive's (2001) 'Approved Code of Practice, Legionnaires' disease: the control of *Legionella* bacteria in water systems'.

i Detailed guidance on storage, distribution and delivery temperatures can be found in Health Technical Memorandum 04: 'The control of *Legionella*, hygiene, "safe" hot water, cold water and drinking water systems'.

Ventilation and cooling

5.62 A successful natural ventilation strategy is, without doubt, the most energy-efficient and environmentally-sensitive solution for healthcare buildings.

5.63 The full potential of natural ventilation can only be achieved if this technique is chosen at the very early stages of the design process (for a new building); and natural ventilation is rarely an option for building refurbishments. For this reason, natural ventilation was discussed in Chapter 4. However, there are further technical points to be noted, which are also pertinent to mixed-mode ventilation strategies; and these are presented in paragraphs 5.66–5.70.

5.64 Once all possible passive measures have been considered, the next best option is to adopt a mixed-mode strategy; then mechanical ventilation; and finally full air-conditioning.

5.65 Regardless of the ventilation or cooling technique adopted, designers should be aware of the ventilation rates that are appropriate to specific functions in healthcare buildings. These are set out in Health Technical Memorandum 2025 – 'Ventilation in healthcare premises'.

Natural ventilation – technical notes

5.66 The design of a naturally ventilated building should reflect the different requirements for winter and summer occupancy:

- in winter, excess ventilation should be minimised, with background ventilation controlled by trickle ventilators;
- in summer, ventilation rates may need to exceed what is required for moisture and odour removal in order to avoid overheating. Therefore, care should be taken when designing the distribution of fresh air within the space so that draughts are avoided.

5.67 Ventilation controls should be ergonomically efficient and should respond rapidly; their use should also be explained to the occupants. Where ventilation controls do not work properly (for example inaccessible window catches or insufficient fine control), occupants will often undermine the original strategy by taking alternative steps, such as introducing desk fans or making requests for air-conditioning.

i Guidance and case studies on natural ventilation are provided in CIBSE AM10: 'Natural ventilation in non-domestic buildings', and BSRIA TN 11/95: 'Control of natural ventilation'.

i CIBSE Guide A: 'Environmental design' and BS 5925:1991 give simple equations to estimate ventilation flows. BRE Digest 399: 'Natural ventilation in non-domestic buildings' shows various natural ventilation strategies.

Night cooling

5.68 When natural ventilation is employed, high summer temperatures are avoided by increasing ventilation at night. This will remove heat that has built up in the building's structure during the daytime (see Chapter 4).

5.69 Night ventilation in well-insulated buildings with high thermal response factors can reduce the maximum daytime temperatures by 2–3ºC, providing the thermal mass is exposed and a good control strategy is deployed.

5.70 A range of passive and active night cooling strategies can be used to achieve this objective; the simplest relies on good window design to allow ventilation at night. A more sophisticated solution is to use the thermal capacity of the building by passing air through the building structure, for example in hollow core slabs. It is possible for the system to be "reversed" to condition incoming air for space heating in cold weather (although this technique has only been used in a handful of buildings in the UK). However, such systems may need to rely on fan energy used to move the air through the structure.[15]

i Further guidance on night cooling can be found in CIBSE AM13: 'Mixed mode ventilation' and BRE IP4/98: 'Night ventilation for cooling office buildings'.

i See BSRIA TN 11/95: 'Control of natural ventilation' and TN 5/96: 'Night cooling control strategies – final report'.

i See also the Carbon Trust's General Information Report GIR031: 'Avoiding the need for air-conditioning'; Good Practice Guide GPG287: 'The design team's guide to environmentally smart buildings – energy-efficient options for new and refurbished offices'; Good Practice Guide GPG237: 'Natural ventilation in non-domestic buildings – a guide for developers and owners'; General Information Report GIR085: 'New ways of cooling' (all available on the CD-ROM).

Mixed-mode ventilation

5.71 Mixed-mode buildings deliberately combine natural and mechanical systems for ventilation and cooling. The fabric of the building is designed as far as possible to create good internal conditions, while mechanical ventilation and cooling are provided, but are only used when they are essential or for particular areas/services that demand a more tightly controlled environment.

15 It is essential that fan energy usage is minimised in all mechanical systems, with a design criterion of 1 W/m^3.

5.72 Mixed-mode designs typically save energy and satisfy occupants. But they also have the advantage of being adaptable to a wide range of future requirements. For example, they can revert to being totally naturally ventilated (unlike a building that relies on mechanical conditioning, which will be uncomfortable to occupants if the mechanical systems are simply switched off).

i See page 22 of the Carbon Trust's General Information Report GIR056: 'Mixed mode buildings and systems' (available on the CD-ROM).

5.73 A mixed-mode strategy uses mechanical ventilation in conjunction with natural ventilation in one of a number of ways:

- the building can be naturally ventilated, with a mechanical system providing extra ventilation when it is needed;
- the building can be mechanically ventilated, with openable windows to provide some extra ventilation and air movement;
- the building can be mechanically ventilated, with openable windows to provide a psychological "safety valve", which allows more variation of the internal conditions;
- any of the above, in conjunction with local fans, which are relatively effective in promoting comfort during warmer periods. (If these are planned at the outset, they can be integrated into the design, by use of ceiling-mounted fans, for example. Implemented in this way, they are less likely to be perceived as failure of the ventilation to control overheating than if added at a later date.)

5.74 Mixed-mode systems are classified according to their configuration and the way the system would be used:

- *contingency:* a minimum level of environmental control is provided at the outset, with provision for further control at a later stage. For instance, leaving space in air handling plant for cooling coils to be added in future should the need arise, or installing to the maximum specification only the parts of the distribution system that would be inaccessible for a later upgrade;
- *zoned:* where different systems are used to serve separate areas of the building; in hospitals this usually happens where air-conditioning is

provided for operating theatres but not in wards, but the same principle could, for instance, give local cooling in computer server rooms yet natural ventilation in administrative areas;

- *changeover:* where different systems are used according to the seasons. For instance, mechanical ventilation could be used to improve air movement and night cooling in summer and to provide background ventilation with heat recovery in winter, with just natural ventilation in spring and autumn;
- *parallel/concurrent:* where mechanical systems work in parallel with openable windows. The possible clash between systems has to be considered carefully in all seasons.

5.75 Extra space may have to be provided for future plant and service routes. Also, mechanical and natural ventilation systems should be designed so that their controls and configurations work independently of, but in conjunction with, each other.

5.76 Mechanical ventilation or air-conditioning may become necessary where there are:

- solar gains, predominantly through windows;
- heat gains from lights, equipment and people;
- limits on opening windows for reasons of security, noise or pollution.

5.77 If Health Technical Memoranda, Health Building Notes, clinical requirements or other drivers recommend full air-conditioning, it should be designed to operate at maximum energy efficiency. Design goals should be set for the intrinsic efficiency of the plant; attention should be paid to controllability, sub-metering and to the ability of the healthcare organisation's staff to manage the systems provided.

Free cooling

5.78 Generally, free cooling uses the cooling capacity of ambient air to directly cool the space. By increasing the fresh air supply rate when the external air is at an appropriate temperature, part of the cooling load can be met, hence reducing the energy consumed by mechanical refrigeration plant. Many areas in acute healthcare buildings supply full fresh air, and the system design needs to ensure that maximum use is made of free cooling.

5.79 This includes the following:

- ensuring that areas served from each air handling system have broadly similar demand characteristics so that reheat is avoided;
- ensuring that heat recovery systems can be bypassed when cooler air is required for cooling;
- ensuring that control of frost coils and heater batteries is linked to internal temperature in spaces – very often air is supplied at constant discharge temperatures regardless of the internal temperature, losing the opportunity to cool;
- where appropriate, using a full fresh air system to an intermittently occupied area to provide night cooling.

5.80 Because the maximum cooling requirement usually coincides with maximum outside temperature, free cooling will not reduce the peak cooling load. However, it can reduce the running hours of the chiller and associated equipment, particularly when internal gains occur all year. These savings usually occur at lower periods of cooling demand and hence at lower chiller efficiencies. Enthalpy controls should be used in air recirculation systems to automatically increase the amount of fresh air when the ambient conditions can provide a useful cooling and/or dehumidification effect.

5.81 Free cooling can also be achieved using a mixed-mode (changeover) approach. Fan energy consumption can be reduced by shutting off the air-conditioning system in winter, provided that adequate ventilation is maintained by natural means and the air handling unit allows the coils to be bypassed.

Mechanical ventilation

5.82 Including mechanical ventilation and/or air-conditioning in a design can increase electrical energy consumption by up to 50%. This is a particularly serious issue because it is electrical energy that is being used, which contributes up to three times more carbon dioxide to the atmosphere than the direct combustion of fossil fuels (see Chapter 1).

5.83 There are instances where some form of forced ventilation system is unavoidable, for example deep-plan buildings, or areas with high internal gains or exacting environmental conditions. But even then, designers should seek to make effective use of ambient conditions with a view to minimising demand. Good zoning and controls are key factors in making any mechanical ventilation strategy energy efficient, although controlling humidity will always increase energy consumption.

5.84 In hospitals, air treatment is typically the single largest energy user. It can account for up to 46% of the total energy consumed (air heating, cooling, fan power and humidification).

5.85 Central mechanical ventilation systems for clinical areas in hospitals differ from those in most commercial buildings in one critical respect:

where infection control is paramount, ventilation must be full fresh air with no recirculation.

5.86 This can create very high energy demands during cold or hot weather, when the difference between outside and required inside temperatures is high, compounded by generally high air-change rates. Therefore, it is important to distinguish between separate non-clinical areas such as administrative areas, stores, waiting and circulation areas which do not have this constraint, as some further energy-efficiency measures may apply to them.

5.87 In general, therefore, air should flow from clean to neutral to dirty areas, and outlet grilles should be sited at locations that do not present a health and safety risk.

5.88 Where substantial ventilation is required for clinical needs, and for the comfort of patients and staff, the focus of energy-efficient design should be on effective heat recovery. Designers are advised to review Chapter 4, which discusses interpreting users' needs, and the use of room data sheets and Activity DataBase (ADB) (see paragraphs 4.38–4.42).

i Fuller guidance, including appropriate ventilation rates, is given in Health Technical Memorandum 2025 – 'Ventilation in healthcare premises'.

i Designers should also consult the Department of Health's 'Revised guidance on contracting for cleaning'.

5.89 For any clinical areas that do require the use of full fresh air systems, any variable flow control should be carried out by means of changes to the total flow in the system rather than use of recirculation. This is already common practice in theatres by use of set-back controls and, where possible, it should be used in other areas. Variable flow should be by means of inverter control to central systems. The same inverter can also be used to ensure constant flow across filters under varying degrees of soiling.

i The Building Regulations 2000 (as amended) set out requirements aimed at minimising the energy consumed in air-conditioning and/or mechanical ventilation systems.

Technical notes

5.90 It is generally desirable and energy-efficient to adopt a balanced ventilation system, comprising independently-ducted supply and extract. The advantages and disadvantages of balanced ventilation are shown in Table 7.

Table 7 Advantages and disadvantages of a balanced ventilation system

Advantages	Disadvantages
Contaminants removed at source	The building should be sealed effectively to prevent air ingress by infiltration
Incoming air can be conditioned and cleaned	Expensive, requiring two complete ductwork systems
Potential for heat recovery from exhaust air	Regular cleaning and maintenance is necessary
Weather-independent, provided structure is effectively airtight	Electrical energy consumed in fans

5.91 The choice of design supply conditions and the range of acceptable room conditions have a significant effect on coil sizing, plant sizing, the energy use of a system and the capital cost. If off-coil conditions are chosen to satisfy a range of acceptable conditions, rather than a single set-point, and controls permit room conditions to float within that range, there is potential for energy savings.

5.92 For example, in a cooled space, an acceptable range of temperature may be 21ºC ± 2ºC. Designing to set-point, off-coil temperatures would typically be 14–16ºC, but designing to the upper limit of 23ºC would allow supply temperatures to rise to 16–18ºC, resulting in smaller coil, lower chiller water flow rate, and an increased amount of time during the year at which free cooling is available. Similar arguments can be made for air-conditioned spaces, also taking into consideration the range of acceptable humidities.

5.93 Other considerations include:

- consider using passive infrared controllers (PIRs) to set back systems which are in intermittent use, such as theatres;
- air volume supply should be determined with reference to the activity and to maintain space conditions (subject to the specific minimum requirements for health);
- the areas of highest heat gain should be identified and steps should be taken to reduce heat gains if that area is the one which is bringing on the main chiller plant. Alternatively, outside-air free cooling should be used rather than running large chiller plant inefficiently at part load;
- consider whether full air-conditioning is necessary. Consider free-cooling systems using outside air or groundwater instead of chillers, but any free-cooling benefits should be reconciled with the extra fan or pump power needed plus operating hours;
- the ventilation plant should be controlled using measured CO_2 levels in the areas being ventilated;
- infrared set-back controls should be considered where areas are either used intermittently or used only at certain times (for example operating theatres). However, if this option is to be used, staff should be aware of it and understand how it operates, and the correct infection control measures should be in place;
- with air-conditioning, annual fan energy consumption usually exceeds chiller consumption. Minimise specific fan power, typically an average of 1 W/L/s (Watts per litre per second) for energy-efficient systems;
- systems that serve summertime and daytime loads should be separated from those serving 24-hour loads. This will avoid excessive fan and pump energy and the operation of centralised systems at low part-load efficiencies;
- consider driving absorption chilling using the waste heat from CHP if this is available on site and if it can be operated to help cut the peak demand for electricity;
- if there is an option, choose systems which minimise fan, pump and chiller energy in preference to saving heating, because the former use electricity which is more costly and emits more carbon than using fossil fuels.

5.94 For extract systems:

- for small localised systems, consider packaged units which supply make-up air via a heat exchanger;
- for individual fans, in intermittently occupied areas, consider using passive infrared (PIR) or humidity controls with run-on timers if necessary;
- centralised systems should be zoned to ensure that daytime-only areas can be controlled separately;
- heat should be recovered from extract systems wherever possible.

Special considerations – kitchens

5.95 Key considerations for kitchens:

- where possible, use kitchen canopies that also supply unheated make-up air;
- speed controls should be fitted to major canopies so that occupants can reduce extract volume during lighting cooking/preparation periods;
- individual time controls should be fitted to canopies over dishwashers, and other similar applications, because these are often used at different times to the main cooking islands;
- ensure that most of the heat rejected from refrigeration equipment is external; a central cold room is more energy-efficient, if sized properly, than multiple refrigerators rejecting heat into an occupied space;
- ensure that make-up air to kitchens is not drawn from cooled or air-conditioned spaces.

Special considerations – process ventilation

5.96 Process ventilation should operate only when needed. Depending on the application, time controls, alarms, good management and user training can all be used to ensure process ventilation is operated efficiently. Key considerations for process ventilation are as follows:

- consider centralised variable-volume systems where multiple fume installations are being considered;

- ensure that make-up air systems match extract volumes and, if possible, use variable speed drives in preference to motorised dampers.

Heat recovery

5.97 Heat recovery from exhaust air can cut the overall energy consumption by as much as 15%. Heat recovery should always be adopted, where practical, in mechanical ventilation systems, and it is imperative for 100% fresh air systems in which recirculation is not available or appropriate.

5.98 If any form of heat recovery is being considered, the use of centralised supply and extract plant will assist its installation and make it more economical. However, it is important to ensure that ventilation rates have been minimised and adequately controlled.

i See Health Technical Memorandum 2025 – 'Ventilation in healthcare premises' for guidance on ventilation rates.

5.99 The following options should be considered:

- extracting heat from exhaust air ducts – using either run-around coils where the ducts are separated or plate heat exchangers (or heat pipes) when ducts are adjacent. These recuperative systems keep supply and exhaust air streams separate to avoid cross-infection. Ideally, the supply and extract ducts should be positioned as close to one another as possible;
- where cross-infection is not a concern, consider heat recovery via thermal wheels or other regenerative heat exchangers on full fresh air handling units including tempered air systems. In this case, supply and extract systems should be designed so that heat recovery can be utilised or fully bypassed. Using these systems, up to half of the ventilation heat can be recovered when it is needed.

Princess Royal Hospital, Bromley. A view of plate heat exchangers in a plantroom at the Princess Royal Hospital

5.100 Whichever option is preferred, it is important to calculate the balance between the value of cutting fossil fuel consumption and the extra electricity required to drive the fans that are needed because of higher air resistance. Heat exchangers should be bypassed when not required.

5.101 Simple and cost-effective opportunities for heat recovery include:

- using packaged heat recovery ventilation plant;
- cascading air from high-quality to lower-quality requirements together with any necessary fresh air (for example exhaust office air can be moved to atria, toilets, storerooms and car-parks);
- drawing in air where appropriate through atria and sunspaces.

5.102 Some of the design issues that have an effect on energy efficiency are now highlighted. (Further guidance should be sought from Health Technical Memorandum 2025 – 'Ventilation in healthcare premises'.)

Air-handling units

5.103 The plant should have a high standard of airtightness. The double-skin method of construction, with insulation sandwiched between two metal faces, is recommended. The plant should be tested to the classification appropriate for the total fan pressure.

5.104 Access should be provided adjacent to filter, cooling and heating coils, heat recovery devices, attenuators and humidifiers to facilitate easy cleaning and maintenance.

Layout of plant

5.105 The plant should be arranged so that the majority of items are under positive pressure.

5.106 Separate extract plant will generally be required for the area served by each supply plant. If energy recovery equipment is used, it should be protected from internal contamination using a suitable grade of air filter.

Provision of dampers

5.107 Motorised dampers should be rigid, with square connections fitted with end and edge seals of a flexible material, and with minimal play in linkages. The leakage on shut-off should be less than 2%.

5.108 A main volume control damper should be provided in the main plant to set the design flow rate during commissioning. However, if the size of the system is significant, it is more efficient to provide a variable-speed drive, because a damper increases the system resistance and thus energy use.

Fans

5.109 Fans should be selected for good efficiency and minimum noise levels, but the overriding factor should be the selection of fan characteristic such that the air quality is not greatly affected by system pressure changes due to filters becoming dirty, or external wind effects.

5.110 Specific fan power should be 2 W/L/s or less to achieve good practice. If special care is taken when specifying duct size and position, it is possible to have a very efficient system running at around 1 W/L/s. Fans can, in theory, operate at better than 80% efficiency.

5.111 Where used, centrifugal fans should preferably be of the backward-blade type and give an efficiency of not less than 78%.

i Further guidance is available from the Carbon Trust's Good Practice Guide GPG287: 'The design team's guide to environmentally smart buildings – energy efficient options for new and refurbished offices' (on the CD-ROM) and CIBSE Guide F: 'Energy efficiency in buildings'.

Heater batteries

5.112 Electric-, water- or steam-heater batteries may be considered. However, electric-heater batteries are expensive to operate and where there are alternatives, their use should be restricted to low-power use, for example trimming control.

- If steam-supplied heater batteries are used, their venting, trapping and condensate systems should be designed so that a vacuum cannot occur within the coil and in such as way that the condensate does not back up as a result of excessive back-pressure in the condensate main.
- Water-heater batteries should be connected to a constant temperature heating circuit. Fog/frost coils should be controlled by an off-coil temperature sensor operating a two- or three-port motorised valve to provide a minimum plant on-temperature of between 2°C and 5°C. The main heater battery should also be

controlled in this way, controlled by either an off-coil temperature sensor or a room-temperature sensor (depending on the plant configuration and method of control). Trimmer-heater batteries are generally controlled by one or more averaging temperature sensors within the room or rooms served by the zone.

Selection of fans

5.113 The fan performance figures given by manufacturers in their catalogue data are based on tests carried out under ideal conditions, which include long uniform ducts on the fan inlet/outlet. These standard test conditions are unlikely to occur in practice; the designer should therefore ensure as far as is practical that the fan performance will not be significantly derated by the system. This objective can be approached by ensuring that the fan inlet flow conditions comprise uniform axial flow velocities with low levels of turbulence.

5.114 Where the outlet duct is larger than the fan discharge connection, there should be a gradual transition with a following section of straight duct having a length equivalent to three duct diameters.

5.115 The design of the fan inlet connection should be carefully considered to avoid swirl in the airstream. When the air spins in the same direction as the impeller, the performance and power consumption of the fan are reduced. When the air spins in the opposite direction to the impeller, the power consumption and noise will increase with hardly any pressure increase. Airstream swirl is usually induced by large variations across the fan inlet eye caused by the air passing round a tight bend immediately before the eyes.

5.116 The total fan pressure, and thus energy used by the motor, is a function of the system resistance plus the air-handling unit resistance. The latter should be as low as possible by the selection of low face velocities; low resistance components; and appropriate (not too high) levels of filtration.

5.117 When assessing the life-cycle least cost of high-efficiency filters, the extra cost of early replacement of filters before they generate high airflow resistances should be compared to the savings of fan energy that results. Using variable-speed drives to overcome increased flow reesistance from dirty filters will increase energy use.

Humidity control

5.118 Establish whether humidity control is necessary for clinical or process reasons (see Chapter 4). Human comfort is satisfied by a broad range of at least 40–70%. Even without humidity control, conditions outside this range rarely last for more than a few tens of hours per year and are usually tolerated.

5.119 Humidification is mainly required to overcome build-up of static electricity in winter when incoming fresh air is dry. This is generally only necessary when outside air is at 0ºC or below. At other times, moisture gains from people, washing or other processes bring humidity inside the building up to acceptable levels.

5.120 If humidity control is needed, ensure that the set-point range is as broad as possible, for example plus or minus 10%.

5.121 Dehumidification is generally only required in summer and can be carried out in the following ways:

- desiccant dehumidification by exposure of the air to chemicals such as calcium chloride or silica gel is the preferred option. For the desiccant to be re-used, it has to be regenerated by heating to drive off the moisture. It is particularly appropriate if there is a need for dehumidification without the need for significant sensible cooling, for example clean rooms or extreme desiccation;
- a more energy-intensive option is to cool the air to its dew-point using a chilled water cooling coil so that moisture condenses out. For close control of relative humidity, the air may be cooled further than needed for sensible temperature control to obtain the required moisture content and then reheated to bring it back to the required temperature.

5.122 Steam injection manifold-type humidifiers are the only suitable option where there is extra concern to prevent the spread of *Legionella*, for instance in clinical environments. Steam may be derived from the central steam supply or generated locally either within or adjacent to the humidifier. Electric and gas-fired local humidifiers are available. Gas and electric humidifiers may not be fully modulating, and selection should take into account the control range required. Other methods may be acceptable for, say, administrative areas.

The design, installation and operation of any plant that may cause release of *Legionella* bacteria into the air should comply with the recommendations of the Health and Safety Executive's 'Approved Code of Practice, Legionnaires' disease: the control of *Legionella* bacteria in water systems'.

Further guidance can be found in Health Technical Memorandum 2025 – 'Ventilation in healthcare premises'.

Duct systems

5.123 The economic thickness of insulation for ductwork is a function of:

- hours of operation;
- ambient conditions through which the ductwork runs;
- temperature of the air;
- the energy cost of conditioning the air.

5.124 It should be noted that the energy cost and carbon impact of electrically-generated cooling is greater than the cost of heating from, say, a gas-fired source.

5.125 The thickness of insulation required for healthcare buildings (as described in Health Technical Memorandum 2025 – 'Ventilation in healthcare systems') is generally greater than for commercial applications because hours of operation tend to be longer. It is worth noting, however, that the specification of insulation has important implications for the whole-life cost of a project, and the specified thickness should not be reduced as a cost-cutting measure without a full evaluation of the whole-life impact of such a decision.

5.126 The resistance of ductwork systems should be designed for low velocities as far as possible.

Ductwork systems should be tested in accordance with the Heating and Ventilating Contractors' Association's (HVCA) DW143: 'A practical guide to ductwork leakage testing' (http://www.hvca.org.uk). (This is mandatory for high-pressure ductwork.)

Maintenance of ductwork is discussed in HVCA's (2005) TR19: 'Guide to good practice: cleanliness of internal ventilation systems'.

Conventional cooling techniques

5.127 Building cooling requirements should be minimised through appropriate building design as discussed in Chapter 4. In particular the following key points should be addressed before the building cooling requirements are finalised:

- the proportion of the building that requires cooling should be minimised by maximising the area that can use natural ventilation or mechanical ventilation;
- night cooling in conjunction with natural or mechanical ventilation should be considered for all areas that have intermittent occupancy, such as offices and out-patient areas. Note that the success of night cooling depends critically on having sufficient exposed thermal mass;
- external heat and solar heat gains to the building should be minimised;
- internal heat loads due to equipment, lighting and people should be assessed taking account of diversity factors;
- equipment heat gains should be assessed carefully taking account of actual power consumption rather than the plated electrical supply rating;
- the use of medical equipment with high power consumption should be restricted to specific areas or zones to limit the areas of the building that require cooling. Ideally these areas should be in core zones and close to main duct and chilled water risers;
- office equipment such as printers and photocopiers that have high power consumptions should be grouped and located in dedicated rooms or zones where local extract ventilation may avoid the need for cooling and minimise the spread of heat to adjacent areas;
- specialist areas that have local humidity control and user overrides, such as operating theatres, may require dehumidification when the rest of the building needs little or no dehumidification. Consideration should be given to supplying these areas from a dedicated chiller so that the temperature of chilled water supplied to the rest of the building can be kept as high as possible.

5.128 It is beneficial to look ahead to find out whether there may be any increase in the use and complexity of medical equipment which might mean that additional cooling is required. If this is the case, it would be wise to plan additional cooling capacity. Ideally, any projected growth in equipment usage should be restricted to areas that have existing cooling requirements and to areas close to existing risers.

Cooling sources

5.129 Large healthcare buildings, such as hospitals, often use electrically-driven vapour compression chillers as the cooling source. Chillers normally provide chilled water to air-handling units and a distributed chilled water system with local cooling terminals such as local fan-coil units or, in some cases, chilled beams.

5.130 Split and multi-split air-conditioning units should be considered where small localised areas require cooling or in small buildings such as GP surgeries or small clinics; but efficient, easy-to-use controls should be incorporated to prevent energy wastage. Reversible heat pump systems should be considered where there is also a heating requirement in cold weather.

5.131 Dedicated cooling systems should be considered for specialist areas such as mortuaries, which are either remote to other parts of the main building or operate with a significantly different delivery temperature. This reduces fan or pump energy and prevents the main system having to operate at a temperature to suit a specific specialist area.

5.132 It is usual for the annual energy consumption of the fans and pumps to exceed the electricity consumption of the refrigeration system. Therefore special attention should be given to minimising pressure drops in the pipe and duct systems and other components including heat exchangers. For example, wherever possible, long-radius bends and generous pipe and duct sizes should be specified. This will require a trade-off between higher initial construction cost and lower annual energy consumption. Variable-speed fans and pumps and suitable controls should also be considered for all distribution systems with variable loads.

5.133 Where a CHP system is being considered, or where another free source of waste heat exists, heat-driven absorption chillers should also be considered as an alternative to electrically-driven vapour compression chillers. Single-effect absorption chillers can be powered from either hot water or low-pressure steam, and more efficient double-effect absorption chillers can be driven from a higher-temperature heat source such as engine exhaust gas. Absorption chillers are normally water-cooled and have a significantly lower coefficient of performance (CoP) than an equivalent vapour compression system. This means that they require significantly larger condenser heat rejection systems (at least 50% larger), which has implications for plant space and roof loads.

5.134 Groundwater is available in many areas of the UK and should be considered as a free environmental cooling source (see Chapter 4).

Refrigerant choice

5.135 CFC- and HCFC-based refrigerants have been phased out and they have largely been replaced by HFC refrigerants. However, HFCs are powerful greenhouse gases, and their use in some applications will be restricted by an EU regulation on greenhouse gases (Proposal for a Regulation of the European Parliament and of the Council on certain fluorinated greenhouse gases). Avoiding the use of HFCs will support long-term, climate-change-related environmental objectives.

5.136 Suitable alternatives to HFCs are ammonia and various hydrocarbons. These are used in a number of commercially-available chillers and other air-conditioning equipment, although their suitability depends on a number of safety and engineering issues related to where they are installed.

i Guidance on these issues is given in CIBSE Guide B4: 'Refrigeration and heat rejection'.

Refrigeration efficiency

5.137 The CoP of any proposed refrigeration or cooling system should be optimised through consideration of the following:

- an efficient chiller or other air-conditioning unit should be chosen, taking into account the likely range of operating conditions. This may require a life-cycle-based appraisal of alternative equipment;
- minimise the refrigeration temperature lift – the difference in temperature between the cooling medium (usually air or water) and the heat sink (usually ambient air). Appropriate control strategies can be used to keep the air or chilled water temperature as high as necessary

to satisfy prevailing building cooling demands. The use of chilled ceilings and beams allows a higher chilled water temperature than fan-coil units (although for a given cooling load a higher water flow rate is required);

- the separation of building loads that require different temperatures, for example dehumidification cooling coils, and supplying them from different refrigeration equipment allows the highest possible delivery temperature for the main system;
- good siting of air-cooled chillers and other heat rejection equipment can reduce the heat rejection temperature. Examples include avoiding air recirculation caused by space restrictions or hot roof-top locations;
- special attention should be given to detecting refrigerant leakage, as this can cause a hidden but very significant reduction in CoP. Legislation (EC Regulation 2037/2000 on ozone-depleting substances) now requires regular leak checks;
- where multiple chillers are used (which is usually the case for a large hospital), the number and the size of the chillers should be related to the cooling demand profile. An appropriate control strategy should be devised to ensure that the instantaneous cooling load is met by the optimal number of operating machines;
- ice-based thermal storage allows chiller operation to be displaced to the time of day when advantage can be taken of lower electricity tariffs or cooler ambient temperatures. They can also reduce the total chiller capacity required. However, these systems are expensive, and operating a chiller at a temperature low enough to produce ice may decrease its CoP by more than the gains from operating under lower ambient temperatures.

5.138 Chilled ceilings and beams are an alternative method of cooling a room or space. Compared with conventional fan-coil units, they allow the chilled water supply temperature to be raised from a typical value of 6ºC to 14ºC. As long as they are supplied from a separate chiller operating at this temperature, they reduce the temperature lift and therefore result in a higher CoP, although chilled water pump energy consumption will be higher.

Methods of heat rejection

5.139 Most chillers used in healthcare buildings are air-cooled. Care is needed to specify acceptable noise-rating criteria. The units should be sited to prevent short-circuiting of the air or heat pickup from nearby roof surfaces and other heat rejection equipment.

5.140 Using water-based cooling with either evaporative cooling towers or evaporative condensers should result in a significantly higher CoP because these methods reduce the temperature lift. However, cooling towers require scrupulous maintenance to minimise the risk of *Legionella* infection and may not be acceptable in healthcare buildings, although they have been used in the past.

5.141 Evaporative condensers reduce the risks of *Legionella* compared with conventional cooling towers and they result in the highest chiller CoP. All forms of evaporative cooling reduce the size and weight of the heat rejection equipment compared with dry cooling.

Chilled-water free cooling

5.142 Large deep-plan hospitals will generally retain some cooling requirement when the ambient air temperature is low. Ideally, fresh-air-based free cooling should be used in these situations, but where this is not possible, chilled-water free cooling systems should be considered. There are several methods of providing chilled-water free cooling:

- *dry-air-cooler-based free cooling.* When the ambient temperature is low enough, the chilled water is diverted through a dry-air cooler instead of the chiller. Some special chillers incorporate integral free cooling coils and diverter valves;
- *air-handling-unit free cooling.* Cooling coils or dehumidification coils in air-handling units may be used for free cooling and provide fresh-air pre-heat at the same time;
- *cooling-tower free cooling.* This is only possible if the *Legionella* risk from cooling towers is acceptable. In the past, systems have cooled the chilled water directly by passing through the cooling tower (often called the “strainer cycle”). However, this is rarely acceptable nowadays, and usually a heat exchanger is used to physically separate the chilled water from the cooling-tower water;

- *condenser-water/chilled-water heat recovery.* All of the other methods of chilled-water free cooling are limited to when the water return temperature from a cooling tower or dry-air cooler is lower than the required chilled water supply temperature. By locating a free-cooling heat exchanger in series with the chilled-water return, the warmest water in the building cooling system is in contact with the water from the cooling tower or dry-air cooler. This extends the availability of free cooling by allowing the chiller to top up the cooling to meet the building load. This system is especially effective with chilled-water systems that employ two-port valves and variable water flow rate because the chilled-water return temperature rises at part load.

i Full details of these systems are provided in CIBSE Guide B4: 'Refrigeration and heat rejection'.

5.143 Another form of free cooling for chilled-water-based systems is based on using refrigerant migration or thermosyphon chillers. These chillers achieve free cooling when the required chilled water temperature is higher than the ambient air temperature by allowing the refrigerant to bypass the compressor and the refrigerant flow to be driven by density difference, much like a heat pipe. To maximise the free-cooling opportunity, the system should comprise several individual chillers connected in series on the water side. This allows some free cooling to be achieved even if one or more chillers need to be operated to meet the whole building load. (Further details are given in CIBSE Guide B2: 'Ventilation and air conditioning'.)

Lighting

5.144 Good lighting design maximises the use of natural daylight, minimises installed lighting loads and lighting consumption and, thereby, reduces heat gains generated by electric lights. A daylight strategy therefore has a strong effect on the requirement for mechanical ventilation and air-conditioning.

5.145 The additional capital cost of improving daylighting should be offset against the running-cost savings in lighting and the capital and running costs of mechanical ventilation or air-conditioning needed to remove the heat that the artificial lighting would have produced.

5.146 The overall design concept will have a significant influence on the daylighting strategy as discussed in Chapter 4.

Making the most of daylight

5.147 As part of an overall lighting strategy, daylighting can be optimised by:

- ensuring that electric lights remain off when there is sufficient daylight;
- ensuring that daylight does not produce glare or discomfort, because this can lead to a "blinds-down/lights-on" situation, particularly where there are display screens or where people cannot move away from incoming light (for example in wards);
- ensuring that daylight is usable through good distribution using splayed reveals, light shelves, prisms etc;
- avoiding dark internal surfaces that absorb useful daylight;

Light pipes have been found to be extremely successful in corridors and deep-plan locations, the purpose being to supplement any artificial lighting with natural light, thus removing the need for lights in the hours of daylight
Courtesy of North Devon District Hospital

- introducing light into deep-plan rooms and corridors by means of atria, lightwells or light pipes (light tubes) in order to minimise the use of electric lights (although the depth of light-penetration needs to be considered);
- ensuring that lighting controls take account of daylight availability, workstation layout and user needs; careful integration of manual and automatic control often provides the most effective solution.

5.148 A balance between useful daylight and unwanted solar gains should be achieved. Increased daylight may result in less use of electric lighting and hence reduced cooling loads. However, without careful design, excessive solar gains during the summer could outweigh the benefits.

i The LT Method provides a "ready-reckoner" for optimising daylight penetration. See the Carbon Trust's 'The LT Method Version 2 (LTMETHOD)' (available on the CD-ROM).

5.149 The amount and distribution of daylight depends on:

- the size and position of the windows;
- the ratio of room-to-ceiling height to room depth;
- the window construction;
- the external and internal obstructions;
- the type of glazing material.

5.150 It is also important to remember that the level and availability of daylight varies with time, season, latitude and weather conditions. In temperate climates like the UK, where an overcast or diffuse sky predominates, the availability of daylight is quantified in terms of "daylight factor" – a measure of the amount of daylight reaching the working surface in the room. The amount of daylight illuminance for particular tasks will be the same as for electric lighting.

5.151 Another consideration is privacy. Consulting rooms on ground floors, for example, may require blinds to be drawn for a considerable proportion of the day; in ward areas, patients may prefer to draw the curtain around their beds to enhance privacy. This behaviour will have a significant impact on the availability of daylight. Instead of providing a "blanket cover" of electric lighting on the assumption that blinds or curtains will be closed, this problem can be minimised by ensuring that adequate task lighting is provided.

i See CIBSE Lighting Guides LG02: 'Hospitals and health care buildings', LG03: 'The visual environment for display screen use', and LG10: 'Daylighting and window design', and CIBSE Guide J: 'Weather, solar and illuminance data'.

5.152 The average daylight factor indicates the appearance of the interior in daylight. A room with an average daylight factor of less than 2% will require electric lighting for most of the day. Rooms where the occupants expect daylight should have an average daylight factor higher than this.

5.153 Whatever the daylighting strategy, the following factors should also be considered:

- a regular schedule for cleaning windows and internal room surfaces is necessary to ensure that daylighting levels are maintained, thus avoiding energy waste;
- to maximise the use of daylight, room surfaces should have high reflectance to promote good distribution of light;
- effective control of the electric lighting is the key to realising the potential energy saving from daylight. The electric lighting control system should reduce light output when daylighting levels are adequate and when the space is unoccupied.

Example

At Leighton Hospital, part of the Mid-Cheshire Hospitals NHS Trust, three sensors (on the north, east and west of the hospital) monitor natural light levels and adjust internal lighting accordingly. But in addition, lighting levels in specific areas are pre-programmed into the building management system. For example, in Estates, lighting is set to a minimum level automatically at 17.30 hrs. On the wards, minimum lighting is from 23.00–07.00, but if it is still dark outside at 07.00 hrs, additional artificial light is supplied.

Zoning for daylighting

5.154 To maximise daylighting, the electric lighting installation should be zoned to take account of occupancy patterns and daylight distribution. Zones should start at the perimeter and work towards the central area. They should be parallel to windows and, depending on the glazing ratio of the building façade, solar shading etc, the daylit zone may reach to a depth of over 6 m.

5.155 The number of zones and complexity of the lighting system should be balanced against the value of the likely electricity saving. Infrared or similar hand-held controllers should be investigated, because this might reduce wiring costs. The control or switching system also needs to be fully integrated with these zones in order to achieve potential savings.

5.156 The use of bedhead lighting in ward areas and task lighting in many staff areas should be integrated in the strategy.

Reducing solar gains

5.157 Daylight can be controlled either actively (for example with external adjustable manual or automatic blinds) or passively using architectural features such as orientation and overhangs to reduce solar gains when the building may be susceptible to overheating (see Chapter 4).

Electric lighting

5.158 Lighting is the largest single user of electricity in most healthcare buildings, taking 21% of the total primary energy use or 37% of the electricity used in a typical hospital. Refurbishing lighting can yield significant savings, improve internal conditions and reduce maintenance. In addition, good lighting design can also reduce internal heat gains, thus reducing the need for air-conditioning.

5.159 Designers should know the tasks that may be undertaken in each of the areas in order to decide on the lighting requirements. This information will have been gathered early in the design process (see Chapter 4).

i Guidance on electric lighting can be found in Health Technical Memoranda 55 – 'Windows' and 2014 – 'Abatement of electrical interference'.

i See Dalke et al's (2004) 'Lighting and colour design for hospital environments'.

i See also CIBSE's 'Code for lighting' and CIBSE Lighting Guide LG02: 'Hospitals and health care buildings' and CIBSE Lighting Guide LG03: 'The visual environment for display screen use'.

i Appendix 5 gives advice on drafting a low-energy lighting specification for healthcare buildings together with two case studies on identifying lighting problems and solutions.

Lighting controls

5.160 Energy control devices and systems fall into two categories:

- systems that switch selected luminaires by mains signalling or signal wire;
- systems that vary the light output from selected luminaires.

5.161 Both types respond to information about the environment which may be sensed locally, for example by an attached photocell, time switch or occupancy detector, or remotely via a central controller.

5.162 Existing building management systems can be used to control lighting. The method of control should be compatible with the lamps, controls and luminaires used. The control system should not override any safety lighting considerations.

Note: Mains signalling is not recommended in hospitals and other healthcare buildings because of the electrical interference that may be caused to electro-medical equipment. Similarly, energy limiters are not recommended because they can cause luminaires or lamps to fail prematurely.

Example

St Charles' Hospital in London, managed by the Parkside NHS Trust, knocked £1200 a year off electricity bills by installing a microprocessor-controlled lighting system in the main corridors. Each controller sets the light level depending on the amount of natural daylight available. At night, light switching is controlled by presence detectors. The system is also linked to the fire-alarm system so that lights respond to emergency situations. This measure was introduced during refurbishment, and cost no more than a traditional lighting scheme.

5.163 The following control strategies can be used (subject to the above considerations):

- passive infrared (PIR) control for intermittently-occupied areas (ensure that sensors respond rapidly and lamps strike immediately);
- daylight sensing to dim the lighting;

- arrange switching so that unwanted lights can be turned off, for example perimeter lights;
- ensure that there are enough switches to enable lighting to be controlled in larger areas;
- arrange switching so that it is convenient for occupants to turn off lights.

i See the Carbon Trust's Good Practice Guide GPG287: 'The design team's guide to environmentally smart buildings – energy efficient options for new and refurbished offices' (available on the CD-ROM); and 'Energy efficiency strategy guidance and implementation support pack for the NHS Trusts in Wales, 15 May 2003'.

i CIBSE Guide F: 'Energy efficiency in buildings'.

Example

Glenfield Hospital, managed by The University Hospitals of Leicester NHS Trust, has a 65-metre-long picture gallery where a new lighting scheme has brought considerable savings. Before the scheme, the lights were being left on for 15 hours a day. The corridor now features 40 picture lights (at a cost of £1520) and eight banks of 6 x 600 mm recessed fluorescent lights. The two systems are wired so that, when the corridor lights are off, the picture lights can be on. PIR sensors in the corridor turn lights on when necessary at night. Coincidentally, this has also improved security at night, because staff see lights switching on to indicate that someone is coming.

Example

Maintenance staff at Blackburn, Hyndburn and Ribble Valley Health Care NHS Trust noticed that the lights in the sluice rooms tended to be left switched on. To combat this, they have replaced traditional switches with intelligent lighting that incorporates passive infrared and motion detection. This means that the lights come on when someone enters the room, but go off if no motion is detected after a pre-set period. This measure not only saves energy, but helps to prevent the spread of disease, because staff no longer need to touch switches. Similar systems have been installed in some corridors too.

Energy-efficient lighting in the waiting room at King's College Hospital, London

External lighting

5.164 External lighting of healthcare premises includes lighting of entrances, car parks, pedestrian routes and roads on site. It should be designed to provide a safe and welcoming atmosphere around the building while maintaining energy efficiency. Key areas for security lighting include:

- pharmacy drug stores;
- laboratories;
- residential accommodation.

i Guidance on lighting provision is given in BS 5489-1:2003; CIBSE Lighting Guide LG06: 'The outdoor environment'; and in the draft EN 12464-2.

5.165 Illuminances should be appropriate to the area to be lit. Over-lighting should be avoided because it wastes energy, but also because it may make it harder to see in darker areas of the site. However, the lighting design should take into account the benefits of external lighting in ensuring safe circulation of pedestrians and vehicles, in enabling the supervision of the site and providing a feeling of safety and security for staff and visitors, allowing them to see and recognise people on site. Extra lighting above the recommended illuminances may be required for people with visual impairment, but glare should be avoided. Key areas include stairs, ramps and disabled bays in car parks to facilitate transfer to wheelchairs.

5.166 Unwanted spill light should be minimised. As well as improving energy efficiency, this will help to avoid disturbance to patients in wards and nearby householders, and to reduce sky glow.

5.167 Luminaires should have a high downward-light output ratio with little or no upward light. Where fittings are close to either the site boundary or to bedded areas of the hospital, cut-off luminaires should be chosen to reduce spill light reaching windows or adjacent properties. Lamps should not be located near trees, because this may cause disturbing moving shadow patterns in wards.

i The Institution of Lighting Engineers gives detailed recommendations in its document 'Guidance notes for the reduction of light pollution and recommendations'. See also the draft EN 12464-2.

5.168 The choice of lamps is a balance between lamp efficacy and colour:

- in general, tungsten and tungsten halogen lamps should not be specified for external lighting because of their poor efficacy and limited life;
- low-pressure sodium lamps are highly efficient, but generally unsuitable for healthcare premises because of their poor colour rendering. Where moderate colour rendering is required, for example when viewing coloured signs or simply to make an external space look reasonably attractive, a colour rendering index of at least 60 is recommended.

5.169 Colour appearance is important too. High-pressure sodium lamps are efficient but give a warm (2000–3000 K) orange light. Therefore they are only suitable for applications where seeing the colour of the surroundings is not important, such as car parks. A whiter light source with a higher colour temperature can appear brighter for the same illuminance level.

5.170 For fluorescent and compact fluorescent lamps, high-frequency control gear will give energy savings of around 20%. High-frequency ballasts are also available for some metal halide lamps.

5.171 External lighting should be controlled so as to be switched off during the day and when not required at night. Photoelectric control is generally used because this can allow for the lighting to come on earlier under dull, cloudy conditions. It can be supplemented by time-switching for areas where lighting is not required after a particular time. Dimming or step switching is also possible. An adequate level of lighting may still be needed for security purposes, especially if closed-circuit television systems are in use.

5.172 The use of security floodlighting in external areas, with high-power tungsten halogen lamps and movement sensors, is not recommended. While they are on, the lamps use a lot of energy and cause glare and deep shadows. Unfortunately most energy-efficient lamps are not suited to this type of security system as they are slow to warm up and cannot re-strike rapidly.

Motors and drives

5.173 Motors are generally out of sight, sometimes running 24 hours a day, 365 days a year. The value of the electricity consumed by an electric motor over its life is typically 100 times the purchase price of the motor itself. It is therefore important to ensure that the motors (and their associated drives) are as efficient as possible. Motors typically account for 19% of primary energy consumption in acute hospitals.

5.174 Considerable energy savings can be achieved by good system design to minimise the motor load. Accurate calculations of system resistance should be carried out for effective fan and pump selection. The underlying mathematical relationships that govern performance mean that a small increase in duct or pipe size can significantly reduce system losses and thus greatly reduce the fan or pump power required.

5.175 Low-loss motors, variable-speed controls and effective control can realise savings of more than 50%.

Example

At Leighton Hospital (Mid-Cheshire Hospitals NHS Trust) an inverter retro-fitted onto a 7.5 kW boiler fan saved £2365 in the first year. This measure was later incorporated on all four boilers with a payback of 4.2 years. The capital outlay was £2000 for a 50% energy saving.

5.176 Key considerations:

- systems should be designed to minimise pressure loss and hence reduce energy consumption;

- high-efficiency motors (HEMs) should always be specified. These are designed to minimise the inherent losses and save, on average, 3% of energy consumption compared with standard motors. They are often no extra capital cost, and generally use better-quality materials and have enhanced design features;
- variable-speed drives (VSDs) should be used where possible. As an alternative to VSDs, the use of two-speed motors is a simple way of providing a degree of speed control for fans and pumps. They are most typically applied to air-handling plant to provide either a boost or a set-back facility;
- direct drives are preferable to belt drives, where practical, except where motors need to be kept out of the airstream;
- if belt drives are used, consider modern, flat, synchronous or ribbed belt drives rather than traditional V-belts to reduce drive losses;
- sensors should be added to check the motor load so that the motor can be switched off if idling;
- avoid using greatly oversized motors. Motors should be sized correctly to avoid the greater losses when part-loaded;
- consider permanent reconnection of the motor electrical supply in star-phase as a no-cost way of reducing losses from lightly-loaded motors;
- check should be made to ensure that voltage imbalance, low or high supply voltages, harmonic distortion or a poor power factor is not causing excessive losses;
- in pump or fan applications where the cube law (relationship between power and volume) applies, even a small reduction in speed can produce substantial energy savings;
- for belt drives only, a low-cost option is to change the pulley ratio.

Example

North Staffordshire Hospitals Trust invested £10,000 in a project to fit six VSD kits in the main plantroom. The energy services engineer monitored electricity consumption before and after the installation and found that running costs were reduced by around 40%, giving a payback of just 1.8 years on the installation. (Running costs were reduced to £27 per day from £50 per day.)

i See also the Carbon Trust's Good Practice Case Study GPCS162: 'High efficiency motors on fans and pumps'; General Information Report GIR 040: 'Heating systems and their control'; and General Information Report GIR 041: 'Variable flow control' (all available on the CD-ROM).

i See 'Energy efficiency strategy guidance and implementation support pack for the NHS Trusts in Wales, 15 May 2003'.

i CIBSE Guide F: 'Energy efficiency in buildings'.

The building management system (BMS) and other controls

5.177 Control systems ensure that plant can operate efficiently to provide building services when they are needed and to the level required. Therefore, a clear and integrated control strategy is recommended for an energy-efficient building.

5.178 Controls also provide the main interface between the occupant and the building services. It is therefore important to include user controls within the strategy. This will involve paying close attention to:

- operational requirements;
- user capabilities;
- the engineering specification of control systems;
- documentation, commissioning, hand-over and in-use checking of performance.

i General guidance on controls can be found in the Carbon Trust's Good Practice Guide GPG132: 'Heating controls in small commercial and multi-residential buildings' (available on the CD-ROM).

5.179 Appropriate, well-managed controls can cut energy use by 10–15%. Well-controlled buildings provide the optimum indoor environment and the highest levels of thermal and visual comfort in an energy-efficient manner. However, even well-designed systems can perform badly if the controls are inadequate, incorrectly installed, misused or misunderstood.

5.180 Occupants should enjoy reasonable comfort under automatic control, but should also be able to alleviate discomfort manually when necessary. Occupants should have good perceived control, and the design team should note that this does not necessarily require a plethora of building services control devices. It is a choice between a closely specified environment with relatively low perceived control and a less-exactly controlled one which offers more adaptive opportunity. Staff satisfaction and comfort can also be linked to better health and productivity.

5.181 When designing controls for specific services – such as heating systems or lighting – the design team should refer to best practice guidance published by CIBSE.

The BMS

5.182 The building management system (BMS) should be a fundamental component of the site or individual building. It can provide intelligent control of a single service, a building, a site or an estate. The BMS can also be expanded to incorporate new buildings or functions; and it can be interrogated to provide energy management information (see Chapter 2). Energy savings of 10–20% can be achieved by installing a BMS, instead of independent controllers for each system.

5.183 Well-designed electronic BMSs can be very powerful for large buildings or estates, but they should be regarded as an adjunct to good management, not a substitute for it. In smaller buildings, BMSs should not be too complicated for the level of management skills available.

5.184 If it is to be used effectively, the BMS should be well-specified and well-engineered, with good documentation and user-friendly interfaces. The monitoring facilities of a BMS allow plant status, environmental conditions and energy to be monitored, providing the building operator with a real-time understanding of how the building is operating.

Example

At Milton Keynes General NHS Trust, the BMS dates back to 1984 and has been expanded and updated since. It controls the temperatures across the site, monitoring air-handling units and the compensated heating system. It also provides an early warning of impending boiler failure. The BMS monitors external, internal and flow temperatures and adjusts the system accordingly. The performance figures for the system correlate well with heating degree-days, indicating that the system is performing to a high standard of control.

Example

The BMS at Barnsley District General Hospital NHS Trust was installed in the mid-1980s and has since been upgraded. There are approximately 4500 monitoring points around the site, covering everything from heating to lighting.

Without the BMS it could take some time before anyone noticed that a pump had failed in the boiler system. The team at Barnsley wrote a piece of software into the BMS system which enables them to monitor the temperature of the returning condensate in relation to outgoing steam temperature – that is, monitoring pump performance. Thus the BMS warns of failure or poor performance of the pump, and remedial action can be taken before the efficiency of the system drops.

The BMS is also used to control non-energy-related issues – Legionella prevention, for example.

5.185 Key considerations:

- check whether the BMS can integrate with other hardware and software. In particular, a BMS that integrates with an energy monitoring and targeting software package can benefit energy management;
- make sure that the chosen system has an interface and documentation that are suitable for the people who will operate it (for example, a graphical user interface that uses colour dynamic displays aids fault diagnosis);
- choose systems that can be engineered and maintained by several different companies so that extensions and maintenance can be put out to competitive tender;
- avoid gimmicks such as messaging to pagers or phones, except for systems that are safety-critical;
- look for simple system architectures that avoid heavy use of IT networks. These will be much more reliable because there is less hardware and software to go wrong;
- consider the scope for system expansion at each outstation;
- think carefully about the ability to interrogate local outstations when selecting a BMS. Some systems provide a communication interface to allow local override control and local checking

of functional integrity following maintenance action;

- a formal hand-over is recommended, with two demonstrations to take account of seasonal variations. The greater the understanding, the more likely are the energy savings.

5.186 In particular, the BMS supplier should provide a significant level of support during commissioning and to prove systems software.

- Ensure set-points are recorded at commissioning.
- Ensure that enough field measurement devices are provided to diagnose problems.
- Ensure that valves, dampers and detectors are actually responding to control signal and doing so accurately. Consider using positional feedback on high-energy-consuming systems.

Alarms

5.187 Alarms are an important tool in maintaining energy efficiency. A prudent selection of detectors, able to signal when systems are becoming inefficient, is very useful. Note, however, that too many alarm signals can make users lose confidence in the system and disregard alarms that ought to be attended to.

5.188 Consider including alarms for:

- dirty filters;
- systems left in “hand” rather than “auto” mode;
- sample internal temperature detectors;
- BMS recognition of simultaneous heating and cooling;
- valves and actuators failing to respond to signal output (where positional feedback is used).

5.189 It is imperative that there is ownership of the system and that there is someone who will monitor and respond to alarms – particular out-of-hours.

Using contractors

5.190 When using controls contractors, the specification is the key to ensuring that the equipment is correctly installed and that it is correctly set up, commissioned, explained and documented. The specification should:

- state how the contractors are to actually control the services – after discussion with relevant staff;
- specify the layout of software graphics and user interfaces – again, after discussion with the relevant staff;
- state the documentation required;
- specify key items of equipment, for example actuators (There are good and bad makes of actuator for certain applications; hence, it is important to listen to feedback from relevant staff, find a make that is reliable and then stick to it across all works);
- state how the controls are to be tested to demonstrate the required control.

5.191 Ensure an ongoing link with the contractor for at least a year via an agreed retention on the contract to rectify/alter any ongoing problems. This continuous commissioning is very important with controls, particularly as controls are very rarely right first time round. Ensure that at the end of this period, all the control descriptions, documentation and back-up software is updated.

5.192 In addition to this, the budget should allow for the contractor to return to retrain operating staff when there are changes to staffing levels or to the system software.

i Further information can be found in the Carbon Trust’s Good Practice Guide GPG303: ‘The designer’s guide to energy-efficient buildings for industry’ and Good Practice Guide GPG287: ‘The design team’s guide to environmentally smart buildings – energy efficient options for new and refurbished offices’ (available on the CD-ROM).

i See also CIBSE Guide F: ‘Energy efficiency in buildings’.

Electrical small power

5.193 Stand-alone electrical devices are found in all healthcare organisations, as indeed they are in all businesses. Equipment that comes under the title “small power” includes:

- IT equipment;
- catering;
- portable electrical medical equipment (such as monitors);
- staff supplementary heaters;

- personal small power (such as kettles and air-movement fans);
- vending machines (for use by patients, visitors and staff);
- telephone networks;
- TV systems.

5.194 Items such as these use a considerable amount of electricity, and therefore contribute to the organisation's total carbon emissions. For example, vending machines for hot or cold drinks may only be used during office hours, but are frequently left switched on all year round. Fitting timers to such devices is a very effective low-cost way to save electricity and the associated carbon emissions.

5.195 Electricity consumption for IT, medical and other small power equipment accounts for 18–24% of total electricity use within healthcare organisations. With the amount of equipment needed doubling every few years, this is likely to become increasingly important, as discussed in Chapter 1.

5.196 Some thought needs to be given as to how this energy consumption can be controlled or restricted:

- in existing buildings, it should be relatively easy to locate such devices, because legislation requires them to be tested periodically for electrical safety. Once located, these items can be controlled and monitored as part of an ongoing energy management campaign (see Chapter 2);
- the need for an environmentally sensitive approach to procurement of small power items is discussed in Chapter 3;
- as far as possible, the need for personal small power items can be "designed out" – for example by providing local water heaters for making hot drinks; or by eliminating draughts so that people do not feel the need to bring fan heaters from home.

5.197 There are also a number of special energy-consuming services that need particular attention – such as laundries and catering facilities – and these are discussed in this chapter.

5.198 Regardless of where the equipment is being used, there is another important issue that should not be overlooked:

- small power use is often over-estimated at the design stage, and leads to oversized or unnecessary air-conditioning and consequent energy wastage.

Design issues – predicting the load

5.199 Power demands for small items of electrical equipment are quoted in terms of watts per square metre (W/m^2) of floor area. During the design process, such figures are used to assess installed loads, calculate heat gains and size electrical distribution. However, this is not a very accurate way of predicting power demands because:

- equipment use will be heavily influenced by occupancy density, occupancy patterns, type of activity etc;
- there is uncertainty about the precise floor area definition being used (net, gross and treated floor areas are measured in different ways).

5.200 There is also the added complication that the original functions intended for a space may be changed to meet medical needs and totally different equipment introduced. This is particularly significant where portable equipment is moved into an area and contributes to uncomfortable levels of heat gains. ADB sheets (see paragraphs 4.38–4.42) should be used when predicting the load, and questions should be raised about likely future changes. Clearly, however, it is not possible to plan for all eventualities, and the preferred course of action is to exercise caution so that the services are not over-designed.

5.201 It is also important to remember that the operation, hours of use and range of activities within healthcare organisations are extremely diverse, so there are different power demands in different areas of any building.

5.202 The pertinent point to bear in mind is that actual energy used by electrical equipment is often far less than design calculations predict. For example, the widely quote allowances of 15 W/m^2 are more than adequate for all but the most intensive users; less than 10 W/m^2 of treated floor area in a naturally-ventilated office can be regarded as good practice.

5.203 By way of illustration, consider office equipment. Typically, desktop and associated IT equipment such as computers and printers average about 160 W per work location. However, the average power consumption can vary between similar items of office equipment – even from the same manufacturer. Therefore, it is advisable to obtain energy consumption data on specific equipment, if possible. However, not all manufacturers provide representative data. (Some may only provide maximum power demand values rather than representative average loads.)

5.204 In addition, actual use of equipment depends heavily upon the individual's job function and routines. The average operating time for a computer and, hence, the average power demand, should be assessed by taking into account the percentage operating time for intermittent users and allowing for the time that staff are absent from the workstation.

5.205 The number of computers in operation within each user group will also vary from hour to hour and day to day. For example, if 100 computers are in operation in a hospital for an average of 20% of the time, it is probable that up to 30% of them could be in use simultaneously. To determine the likely maximum power demand, a "usage diversity factor" has to be applied to the average percentages to determine the likely maximum number of computers in use at any one time.

5.206 Most modern office equipment has a stand-by or "sleep" mode whereby power consumption is considerably less than that for normal operation. Typical levels of stand-by power consumption are shown in Table 8.

i See the Carbon Trust's Good Practice Guide GPG118: 'Managing energy use. Minimising running costs of office equipment and related air-conditioning' (available on the CD-ROM).

i Further guidance on estimating power consumption for small electrical items can be found in the following documents published by the Carbon Trust: Good Practice Guide GPG287: 'The design team's guide to environmentally smart buildings – energy efficient options for new and refurbished offices'; and Good Practice Guide GPG054: 'Electricity savings in hospitals. A guide for energy and estate managers' (available on the CD-ROM).

i CIBSE Guide F: 'Energy efficiency in buildings'.

Portable medical equipment

5.207 It is far more difficult to predict the impact of portable medical equipment. While the designer may be supplied with a list of such items for a particular area of a building, it is not possible to predict the amount of time that these items will be in actual use. There are three points to bear in mind:

- purchasing policy can play a significant role here – choosing the most energy-efficient equipment will reduce energy use and heat gains (see Chapter 3);
- the unnecessary use of energy can be controlled by energy management techniques (for example by encouraging staff to switch off devices when they are not being used, or to make use of the equipment's built-in stand-by or power-down facilities – see Chapter 2);
- the heat gains generated by medical equipment should be dealt with in the context of the building's overall design strategy. For example, instead of installing air-conditioning for an

Table 8 Typical levels of energy used by office equipment

Item	Peak rating (W)	Average power consumption (W)	Stand-by energy consumption (W)	Typical recovery time (seconds)
PCs and monitor	300	120	30–45	Almost immediate
Personal computers	100	40	20–30	Almost immediate
Monitors	200	80	10–15	Almost immediate
Laser printers	1000	90–130	20–30	30
Ink-jet printers	800	40–80	20–30	30
Photocopiers	1600	120–1000	30–250	30
Fax machines	130	30–40	10	Almost immediate
Vending machines	3000	350–700	300	Can be almost immediate

Source: adapted from GPG118

entire clinic, consider local comfort cooling (that can be switched on automatically only when needed) for a cardiac function testing unit where treadmills and heart monitors are used only intermittently. (Alternatively, ensure that heating supplied to these areas takes advantage of casual gains by installing local thermostatic controls that will reduce heating demand when equipment is in full use.)

Specialist services for healthcare organisations

Medical gases

5.208 Medical gases are supplied either in bottles or other storage vessels and connected to manifold systems that have negligible energy use. However, in the case of medical compressed air, medical vacuums and anaesthetic gas scavenging, which use pumps and compressors, there is significant energy demand. Therefore, consider:

- selecting plant and equipment using whole-life costing techniques (see Chapter 3);
- monitoring (but not controlling) plant operation via the BMS (to identify unexpected usage and aid predictive maintenance);
- using localised systems for applications such as dentistry, medical physics, laundry and sterilizers (to minimise distribution energy and potential leakage).

Example

One healthcare organisation recently replaced ageing equipment and in the process carried out measures that reduced energy consumption by 15% and reduced water consumption to zero. The replacement plant was designed based on present consumption plus 10% for growth. The existing two compressors were replaced with three smaller units, all air-cooled, with a load match control that staggered compressor running. At the busiest times, one compressor would run with the second compressor cycling in support. At quiet times, only one compressor would run cycling to maintain the reservoir. The control philosophy rotated the compressors' roles, thereby sharing duties and reducing the ageing process. Full alarm measures were employed. There was also an interface with the local BMS which recorded plant running hours and duty periods (important information for plant maintenance schedules).

Example

Compressors that served the medical gas system (to operate ventilators and air tools) managed by East Cheshire NHS Trust dated back to 1984 and needed to be overhauled. This would have cost around £2000–£3000. The energy manager ran a test on the system to find out the typical usage, and discovered that the maximum requirement for compressed air was 8 L/s, but the compressors were sized to deliver 45 L/s. The compressors were constantly switching on and off, and wasting energy. Instead of overhauling them, the Trust decided to downsize to rotary screw compressors. The existing compressors were costing £1925 each to run, but the new ones cost only £713 to run, an immediate saving of £1212 per year. Installation of the new equipment gave a three-year payback.

Catering

5.209 Some healthcare organisations run large catering facilities, often providing these services to others in their area.

5.210 Energy-efficient catering facilities can reduce the energy requirement per meal by 70%. The provision of energy-efficiency rating figures – independently assessed – for each item of equipment should be an integral part of any catering equipment specification. Sometimes innovative solutions provide significant savings, as the example below illustrates.

Example

One trust in central England tested out insulated "hot boxes" as replacements for traditional electrically-heated food trolleys and found that, after making a few minor adjustments to working routines, food could reach patients at the correct temperature without the need for trolleys. The trust withdrew 33 traditional trolleys at a saving of almost 145,000 kWh per year.

i See Health Building Note 10 – 'Catering department' and 'EC3 Energy conservation, excessive and uncontrolled heat losses in kitchens'.

i See the Carbon Trust's Good Practice Guide GPG222: 'Reduced catering costs through energy efficiency – a guide for kitchen designers, contract caterers and operators' (available on the CD-ROM).

Laundries

5.211 In most laundries the energy used is the second-highest cost after labour. Water usage is also an issue.

5.212 The presence or likelihood of a future need for laundries should be accounted for in the site-wide energy strategy (see paragraphs 4.101–4.107). For example, combined heat and power (CHP) can prove viable for a stand-alone laundry and should therefore be evaluated for any site that will incorporate a laundry.

5.213 Most steam-heated laundries will generate excess low-grade heat that can be conveniently re-used, so consideration should be given to using this elsewhere across the site.

5.214 Water recovery, by recycling the rinse water from washer extractors, is a proven means of reducing water usage. Total water recovery (grey water recycling) is becoming more acceptable, and should be investigated during the early stages of the design process.

5.215 Heat recovery via heat exchangers from hot effluent is standard practice and can be used on all types of machine. (It will also reduce the likelihood of hot-water discharging to sewers.) This should be thoroughly investigated at the design stage. However, care should be taken to determine the viability of any composite scheme that combines tunnel washers with washer extractors, particularly where dedicated washer extractors are used to launder infected materials. The temperature of recovered hot water should not exceed 38ºC, if it is to be used for the first wash. (A higher temperature may cause stain-setting in dirty linen.)

Example

Fife Acute Hospitals NHS Trust's laundry washes 8 million items per year (some under contract to other trusts). The laundry system was very old and inefficient and had to be replaced. Steam from the gas-fired boiler powers the system, which now includes a two-line, ten-batch washing machine. The Trust spent approximately £100,000 on electronic controls for the system. Among other things, these controls enable the system to maximise water re-use, which cuts down both water and heating costs. The enhanced efficiency of the machines means that the amount of moisture in cleaned laundry is cut, reducing the energy needed for drying. At the same time, old steam traps were replaced with new ones that reduce leakage and cut down on maintenance. They also installed a steam meter so that performance of the steam heating system can be monitored.

i See the Carbon Trust's Good Practice Case Study GPCS023: 'Calender covers in a hospital laundry' and ECG049: 'Energy efficiency in the laundry industry' (available on the CD-ROM).

Sterilization and disinfection

5.216 These departments supply sterile products and equipment to healthcare organisations or individual hospitals. They require high-energy-using equipment and plant. Packing areas need to be clean rooms. The ventilation to this department is filtered by high-efficiency particulate air (HEPA) filters and usually air-conditioned.

5.217 Key considerations are:

- use cascade systems where conditioned air from the cleanest space (packing) flows to neutral then to dirty areas;
- ensure this area is located in such a way that it is accessible to central cooling and, if used, site steam services;
- ensure that sterilizer plantrooms are on an outside wall, preferably at ground-floor level, to enable heat within the plant area to dissipate naturally. Sterilizers can emit 4 kW to the plant space, which can require either large volumes of conditioned air, or even split air-conditioning systems to keep internal plantrooms below 35ºC;
- extract from sterilizer plantrooms should incorporate heat recovery; heat is emitted 24 hours per day;
- choose sterilizing and disinfecting equipment on the basis of energy usage as well as performance – energy usage and whole-life costs can differ widely between manufacturers (see Chapter 3);
- consider heat recovery from washer-disinfection extracts, provided the device can withstand moist, corrosive air;
- consider heat recovery from heat exchangers in sterilizer drainage (water cannot be re-used);

- ensure that a low-carbon strategy is adopted for the primary energy source: steam should be used for sterilizers. If generated locally, do not use electric generators; ensure early planning to allow space and flue routes for gas or gas/dual-fuel generators;
- recover condensate from as much equipment as possible, and return to steam generators or site condensate system;
- insulate sterilizer bodies and pipework connections, valves, flanges etc to minimise stand-by losses;
- use steam rather than electricity for rinse-water heating, reverse osmosis (RO) plant heating and drying;
- when sizing steam plant, allow adequate steam capacity in the design to accommodate combined starting of sterilizers to avoid wet loads or increasing the size of the plant;
- ensure that the steam plant selected is as efficient as possible across the likely very wide range of operating conditions (that is, overnight stand-by to maximum simultaneous demand);
- use continuous monitoring of total dissolved solids (TDS), automatic blow-down and heat recovery if viable from the blow-down;
- consider de-aeration plant, preheated feed-water and variable-drive feed-water pumps for larger steam boiler installations;
- when sizing plant, change loads from peak to steady state where possible to avoid oversized plant. For example, if sizing a new boiler plant, choosing storage calorifiers for domestic hot water (DHW) instead of plate heat exchangers will reduce the overall boiler generation size;
- consider CHP: mini turbines supplying steam are available;
- generate steam at as low a pressure as possible: maximum end-use pressure is usually 4 bar;
- meter the department for each utility and specify individual energy metering for each major washer and sterilizer;
- consider metering RO production;
- hot RO ring mains should be insulated;
- regeneration of softeners should be based on demand measurement rather than time controls to avoid waste of water.

Mortuaries

5.218 Mortuaries use services that have already been discussed in this chapter. However, the following case study serves to illustrate that mortuaries present as wide a range of energy-saving opportunities as other healthcare services.

Example

A recent new-build of a mortuary at one trust allowed environmental and energy considerations to be employed while still ensuring that the facility delivered its role.

The refrigerated store required two levels of temperature. The design engineer took the opportunity to specify super-efficient insulated units and special door arrangements to ensure a good sealing process. The refrigeration plant was designed to use the new environmentally-friendly refrigerants, and the compressors were given stage control to ensure their running matched the load. This control philosophy allowed cycling of the compressors to ensure the duty was shared.

The hot and cold water services were designed in full compliance with the Water Regulations, Health Building Note and Health Technical Memorandum requirements, but high standards of lagging and the installation of a mini-plate heat exchanger have ensured savings.

Free cooling, local heat extraction with proximity controls and heat reclamation have assisted savings within the ventilation plant.

Within the building, T5 high-frequency lighting is used and, where practical, proximity sensing equipment has been employed.

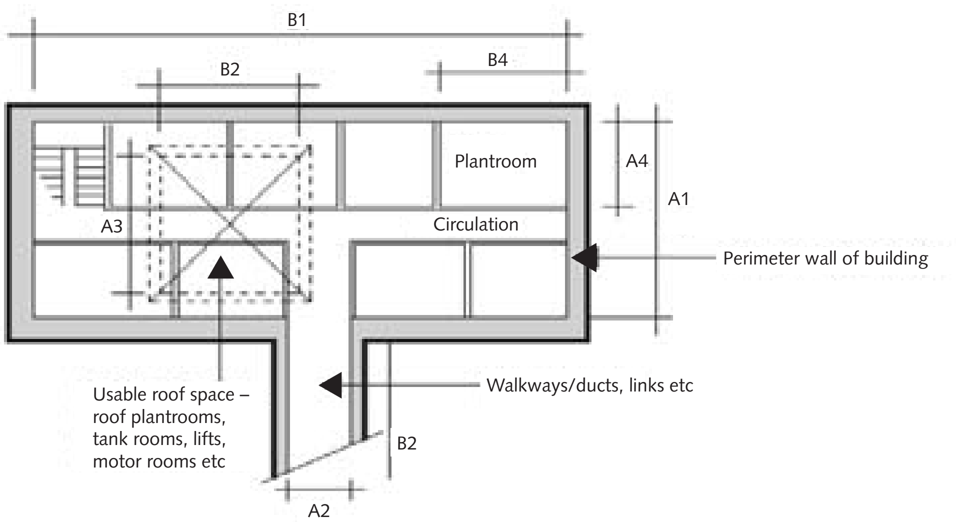
To complement the whole project, the application of full BMS control has ensured high building efficiency levels.

Appendices

Appendix 1 Analysis of building measures in relation to energy

Gross internal floor area (GIA)

Figure A1 Gross internal floor area



The gross internal floor area (GIA) is calculated as follows:

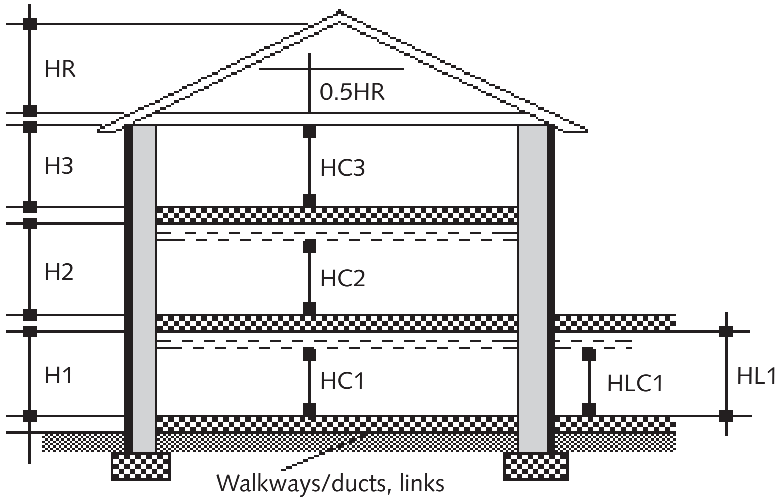
Gross internal floor area (m^2) should be the overall internal floor area within the perimeter of the external walls (for example measuring the building or premises externally and by deducting from the overall length and width the thickness of the external walls, and then multiplying the resultant length by the resultant width (Figure A1)).

Allowances should be made for projections, indentations, insets, voids and courtyards. This is repeated for each storey of the building and added together to obtain the total gross internal floor area. The floor areas of plantrooms, circulation spaces and internal walkways are included.

Gross internal floor area = [(A1 x B1) + (A2 x B2) + (A3 x B3)] + GIA of other floors.

Heated volume

Figure A2 How heated volume should be calculated



Heated volume is the total occupied internal floor area which is heated, multiplied by the height between the floor surface and the room ceiling minus floor area covered by internal walls and partitions (taken as 6%).

Heated volume should exclude unheated spaces such as plantrooms, boilerhouses, ceiling voids, pipe ducts, covered ways etc. The void above false ceilings should only be taken into account in the calculations if this space is heated. If the false ceiling is insulated, the void above it should not be taken into account in the calculations. Figure A2 (in conjunction with Figure A1) shows diagrammatically how heated volume should be calculated.

Heated volume =
[(A1 x B1) x (HC1 + HC2 + HC3 + ...) x 0.94] + [(A2 x B2) x (HLC1+ HCL2 + ...)] – [(A4 x B4) x HC1]

(See Figure A1 (floor areas) for A1, B1, A2, B2, A4, B4.)

Gross volumes with pitched roof =
[(A1 x B1) x (H1 + H2 + H3 + ... + 0.5HR) x 0.94] + [(A2 x B2) x (HL1 + HL2 + ...)]

Gross volumes with flat roof =
[(A1 x B1) x (H1 + H2 + H3) x 0.94] + [(A2 x B2) x (HL1 + HL2 + ...)] + (A3 x B3 x HRP)

Note: 0.94 represents the 6% reduction in overall floor area to allow for the internal walls and partitions and 0.5 m represents a notional compensating height to allow for a pitched roof. (HRP is the mean height of roof-top plantroom – here, A3 x B3 floor area.)

Taking account of degree-day data

The energy use of a building can be predicted by reference to changes in outside temperature. Some energy use is largely independent of outside temperature, for example lighting and energy used in catering. Energy use which does not vary with outside temperature changes comprises the baseload energy consumption.

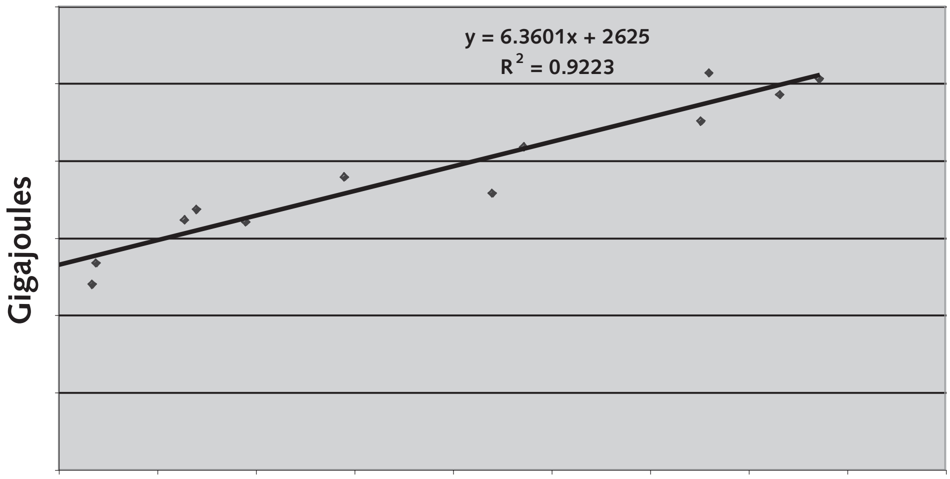
The Department of Health's Estates and Facilities Division publishes degree-day data on a monthly basis for several different geographic areas of the country. Hospital degree-days are based on a temperature of 18.5 degrees. Thus, if the average outside temperature, taken over any particular month, was 18.5 degrees or higher, the degree-day figure for that month would be zero. At this outside temperature, no heating energy load would be needed. If the average temperature was, for example, 8.5 degrees and the month had 30 days, the degree-day figure would be:

(18.5 – 8.5) x 30 = 300 degree-days

Therefore, the higher the month's degree-day figure, the colder the month's average temperature.

It is possible to construct a simple straight-line graph from measured energy consumption plotted against published degree-day data. A real example is shown in

Figure A3 Energy consumption plotted against degree-day data



Each month's energy consumption is plotted against that month's degree-day figure.

Once the points are plotted on a graph of energy (vertical axis) against degree-days (horizontal axis), the best fit straight line is drawn through the 12 plotted points. The best straight line can be calculated using linear regression analysis – a simple tool available in, for example, Microsoft Excel® software. In the example above, the best-fit straight line is represented by the formula:

$$Y = 6.3601X + 2625$$

The R^2 number (in this example, 0.9223) is a measure of how well the plotted points correlate. R^2 (the correlation coefficient) ranges from 1, where all the points fall exactly on the straight line, to zero, where the points are scattered so randomly that there is no one best-fit straight line that can be implied or derived.

After the formula of the straight line is derived by linear regression analysis, this can now be used to predict annual energy consumption.

Y is the predicted energy consumption in gigajoules for an annual degree-day value of *X*. The slope of the straight line (measured in gigajoules per degree-day) in this example is 6.3601 GJ/DD. The baseload, in this example 2625 GJ, is the point on the energy axis where the straight line passes through that axis.

The derived slope and baseload can be calculated from at least one complete year's data, or more accurately from at least two years' data.

Once the baseload and slope are calculated, these numbers can be fed into the formula using (readily available) 20-year-average degree-day figures. In this way the annual energy target can be predicted. An operator's performance against the 20-year average can then be used to calculate volume variances (up or down).

The main advantage of this method over simply using the total energy consumption averaged for two years as the target is that the annual energy target will change each year as new 20-year-average degree-day figures become available.

Further information on this topic can be found on the Carbon Trust website: http://www.thecarbontrust.org.uk, or from the Department of Health's Estates and Facilities Division.

A note on gigajoules

A gigajoule = 10^9 joules = 1,000,000,000 joules

Most people will be familiar with kilowatt-hours (kWh), often referred to as a unit of electrical energy. Gigajoules (GJ) are referred to in standard contract documentation.

All energy values can be converted to joules, including all fossil fuels and electricity.

For interest, the conversion is:

1 kWh = 0.0036 GJ

Also:

1 litre of light fuel oil = 0.0381 GJ.*

*This value should be checked with suppliers for (any) local variations.

Appendix 2 Benchmarks for energy performance and carbon emissions in healthcare buildings

[This appendix has been adapted from a report by Chris Le Breton, 'Benchmarks for energy performance and CO_2 emissions in healthcare buildings'.]

Introduction

This appendix sets out to establish benchmarks for energy performance and CO_2 emissions for healthcare buildings.

It also provides the rationale used in the determination of the values.

The process

To establish the benchmark values of energy performance and CO_2 emissions, the following steps were taken:

a. collating energy data for 2003/4 from across the UK (Northern Ireland 2002/3);

b. analysing the data by types of site within each trust type;

c. defining principal types of healthcare site;

d. re-collating data in accordance with the defined site types;

e. deriving typical annual delivered energy performance and CO_2 emissions for each site type;

f. analysing the distributions of energy performance for all sites in each healthcare type;

h. using the analysis of distributions to establish benchmarks (see page 111).

Types of healthcare site

Analysis of health service site-energy data from across the UK established typical values of energy performance and CO_2 emissions. This indicated where groupings of site types could be consolidated into related bands.

Five principal types of healthcare site were defined. These are shown in Table A1.

The "typical descriptions" will be used for further analysis and be represented under the headings:

- teaching/specialist hospital;
- general acute hospital;
- community and mental health hospitals;
- GP surgeries;
- health centres and clinics.

Table A1 Healthcare site types

	Facility	Service	Typical descriptions
1	In-patient High concentration of energy-intensive engineering services & specialist equipment	Diagnostic & Treatment services for physical healthcare together with specialist services Consultant-led	Teaching Hospital Specialist Acute Hospital
2	In-patient Medium concentration of energy-intensive engineering services & specialist equipment	Diagnostic & Treatment services for physical healthcare Consultant-led	General Acute Hospital
3	In-patient Basic engineering services & equipment	Limited Diagnostic & Treatment services for physical healthcare Nurse- or GP-led Care services for physical healthcare Nurse- or GP-led	Community Hospital Cottage Hospital Hospice Nursing Home
		Mental health & learning disability services Consultant- or nurse-led	Mental Health Hospital/Unit Learning Disability Unit
4	Non in-patient Use typically 50–65 hours/week Basic engineering services & equipment	Primary care consultation GP-led	GP surgery
5	Non in-patient Use typically 35–45 hours/week Basic engineering services & equipment	Primary care & mental health Nurse/dental/visiting consultant or specialist	Health Centre Clinic

Typical energy performance

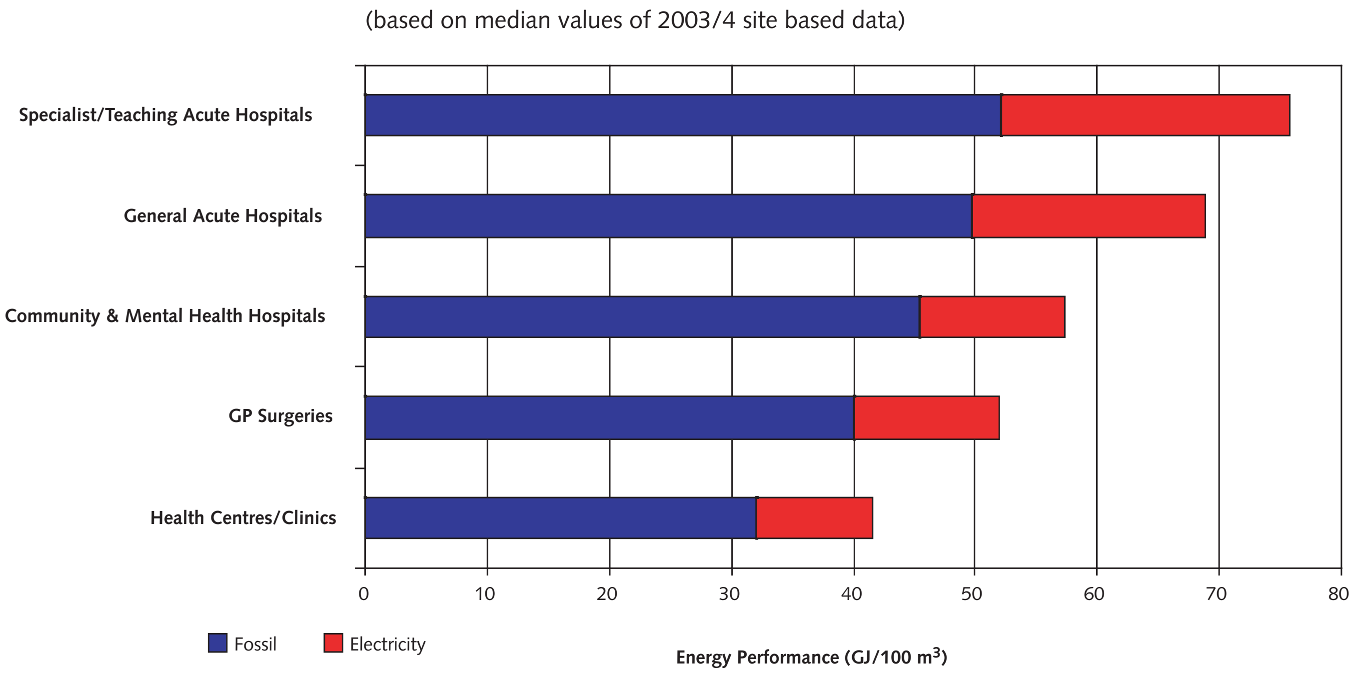
The "typical" performance has been defined as the median value for each of the types of healthcare site as described in Table A1.

Table A2 shows the key values from the analysis of actual energy performance data. This is also illustrated in Figure A4.

Table A2 Energy performance of healthcare sites (GJ/100 m³)

Site Type	1st Quartile	Median	3rd Quartile	Average	% Electricity	% Fossil
Teaching/Specialist Hospital	62.4	**75.7**	90.6	77.7	31.2	68.8
General Acute Hospital	58.5	**68.8**	81.0	72.0	27.7	72.3
Community & Mental Health Hospitals	45.4	**57.4**	73.4	61.9	20.9	79.1
GP Surgeries	43.3	**51.9**	57.0	50.5	22.9	77.1
Health Centres & Clinics	30.5	**41.6**	53.3	42.9	22.9	77.1

Figure A4 Typical annual delivered energy performance



Typical CO_2 emissions

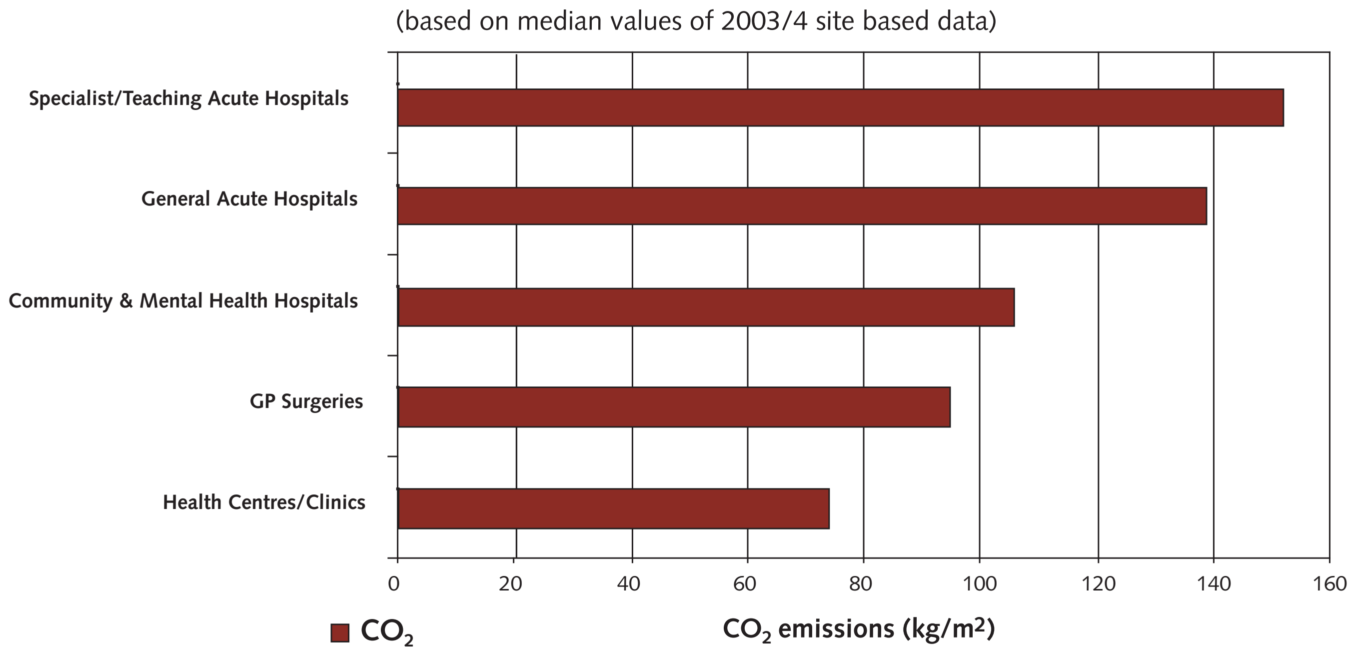
The "typical" emissions have been defined as the median value for each of the types of healthcare site.

Table A3 shows the key values from the analysis of CO_2 emissions data. This is illustrated in Figure A5.

Table A3 CO_2 emissions from healthcare sites (kg/m^2)

Site Type	1st Quartile	Median	3rd Quartile	Average
Teaching/Specialist Hospital	134.1	**151.7**	177.3	158.0
General Acute Hospital	118.1	**138.8**	164.1	145.2
Community & Mental Health Hospitals	84.8	**105.5**	132.3	114.0
GP Surgeries	79.4	**94.8**	94.8	89.4
Health Centres & Clinics	59.0	**74.0**	94.8	78.4

Figure A5 Typical annual CO_2 emissions



Energy performance distribution

Table A2 shows the 1st quartile and median values of energy performance for the different types of healthcare site. A more detailed analysis of the distribution of energy performance in the lower part of the distribution is given in Table A4.

Table A4 Distribution of energy performance by site type (by % of total sites in each type)

Median energy performance (GJ/100 m^3)	Health Centres & Clinics	GP surgeries	Community & Mental Health Hospitals	General Acute Hospitals	Teaching & Specialist Hospitals
0–4.9	0.6	3.5	0.4	0.4	0.0
5–9.9	0.6	1.8	0.8	0.0	0.0
10–14.9	2.5	1.8	1.0	0.0	0.0
15–19.9	4.5	3.5	1.1	0.4	0.0
20–24.9	5.1	3.5	2.2	0.4	0.0
25–29.9	8.9	3.5	2.4	1.4	0.0
30–34.9	14.0	0.0	4.1	0.0	1.4
35–39.9	11.5	1.8	4.8	1.4	0.0
40–44.9	12.7	8.8	7.7	2.5	5.7
45–49.9	9.6	7.0	9.7	5.8	2.9
50–54.9	8.9	35.1	10.9	6.5	7.1
55–59.9	8.3	12.3	11.1	10.5	5.7
60–64.9	1.9	8.8	9.3	7.6	7.1
65–69.9	4.5	1.8	6.0	17.0	7.1
70–74.9	1.9	0.0	5.9	11.6	12.9
75–79.9	0.6	1.8	5.3	9.4	5.7
80–84.9	1.3	0.0	3.0	5.8	11.4
85–89.9	0.6	0.0	2.5	6.5	7.1
90–94.9	0.6	0.0	2.3	4.0	5.7
95–99.9	0.0	1.8	2.8	3.3	5.7

Key to highlighted figures

Green	Highest band
Blue	Secondary bands
Yellow	Tertiary bands

Setting of delivered energy performance benchmarks

Basis of setting values

It is essential in the setting of targets, and benchmark values, that they are realistic and can be achieved.

The establishment of the "good practice" benchmark for each site type was based on 2003/2004 NHS performance data:

- for existing buildings, set at approximately the value of the best 30%;
- for new-build/refurbishments, set at approximately the value of the best 15–20%.

Good practice benchmarks are compared with two different typical values:

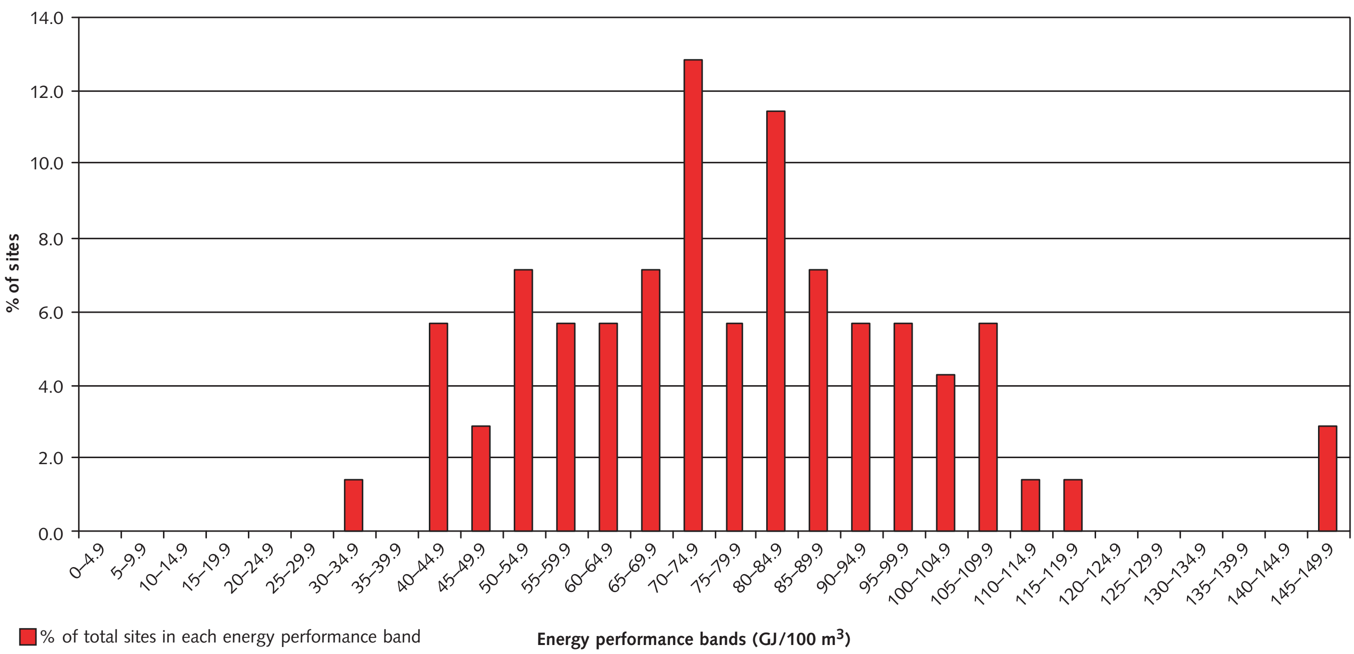
- for existing buildings, the median value for each type of site is given as a comparison with good practice;
- for new-build/refurbishments, the first quartile value is given as a comparison with good practice. This is because there is still not a sufficiently large, and robust, database of new build/refurbishments. However, it is noted that a number of new-build developments feature in the best-performing 25% of sites.

The rationale for the determination of values for each site type is given in the following sections.

Teaching and specialist acute hospitals

The distribution of energy performance by site can be seen in Figure A6.

Figure A6 Teaching and specialist acute in-patient sites (in energy performance bands)



Reference to Tables A2 and A4 and Figure A6 shows that of the sites of this type:

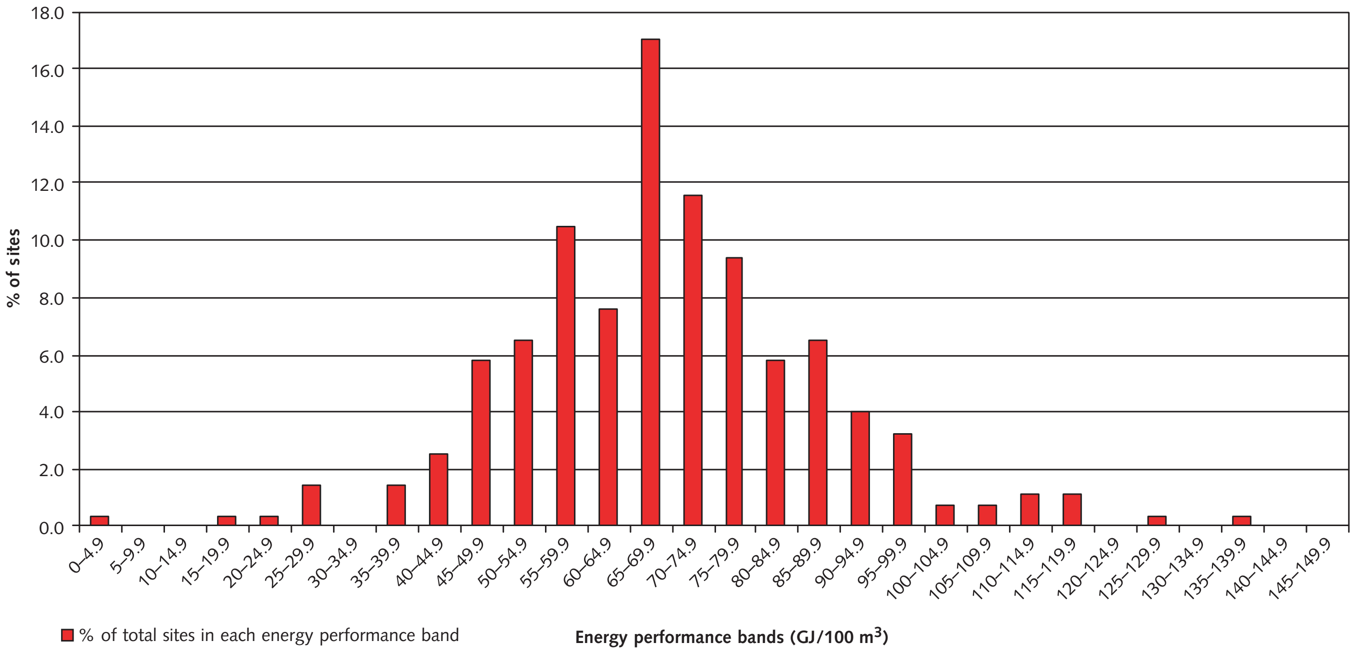
- the median performance value is 75.7 GJ/100 m^3;
- the first quartile performance value is 62.8 GJ/100 m^3;
- 30% meet the mandatory target for existing buildings of 65 GJ/100 m^3;
- 17% meet the mandatory target of 55 GJ/100 m^3 for new-build/refurbishment;
- 10% perform below 50 GJ/100 m^3.

It is clear that whilst the mandatory targets set are challenging for teaching and specialist acute hospitals, they are achievable.

General acute hospitals

The distribution of energy performance by site can be seen in Figure A7.

Figure A7 General acute in-patient sites (in energy performance bands)



Reference to Tables A2 and A4 and Figure A7 shows that of the sites of this type:

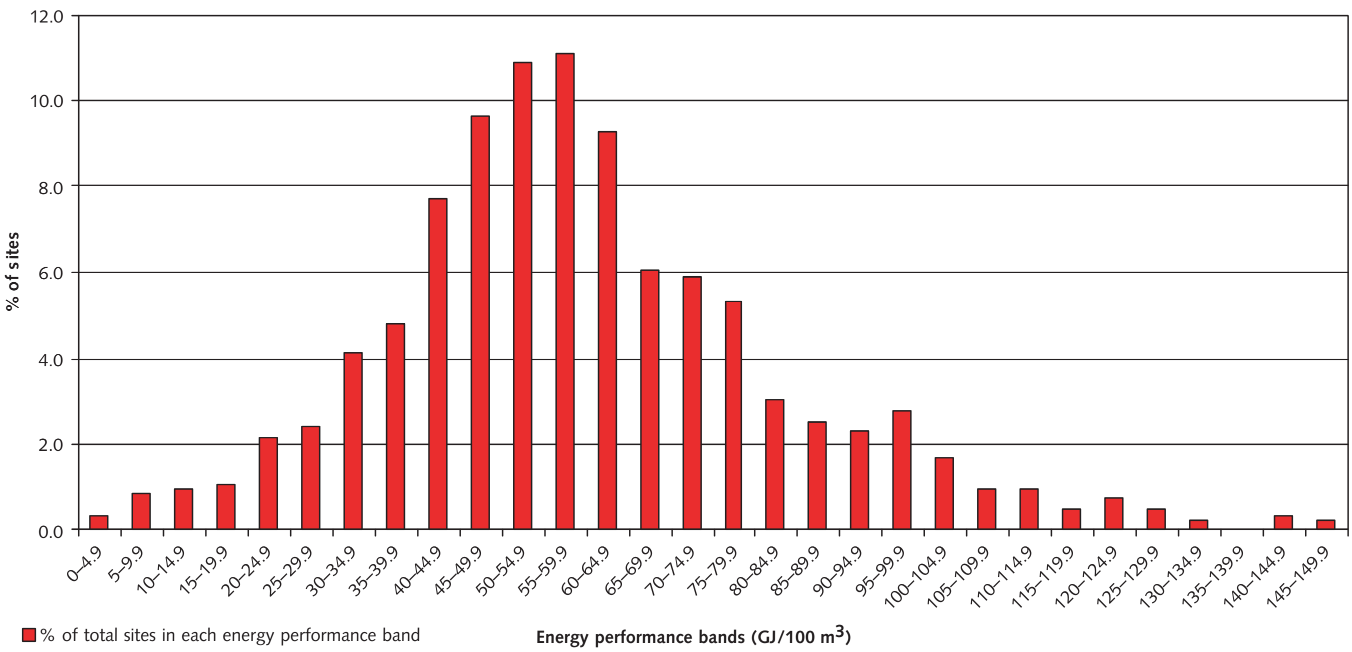
- the median performance value is 68.8 GJ/100 m^3;
- the first quartile performance value is 58.5 GJ/100 m^3;
- 35% meet the mandatory target for existing buildings of 65 GJ/100 m^3;
- 17% meet the mandatory target of 55 GJ/100 m^3 for new-build/refurbishment;
- 12% perform below 50 GJ/100 m^3.

The mandatory targets are clearly achievable for existing general acute hospitals. For new-build/refurbishment the challenge is greater but already being met on an increasing number of sites.

Community and mental health in-patient facilities

The distribution of energy performance by site can be seen in Figure A8.

Figure A8 Community and mental health in-patient sites (in energy performance bands)



Reference to Tables A2 and A4 and Figure A8 shows that of the sites of this type:

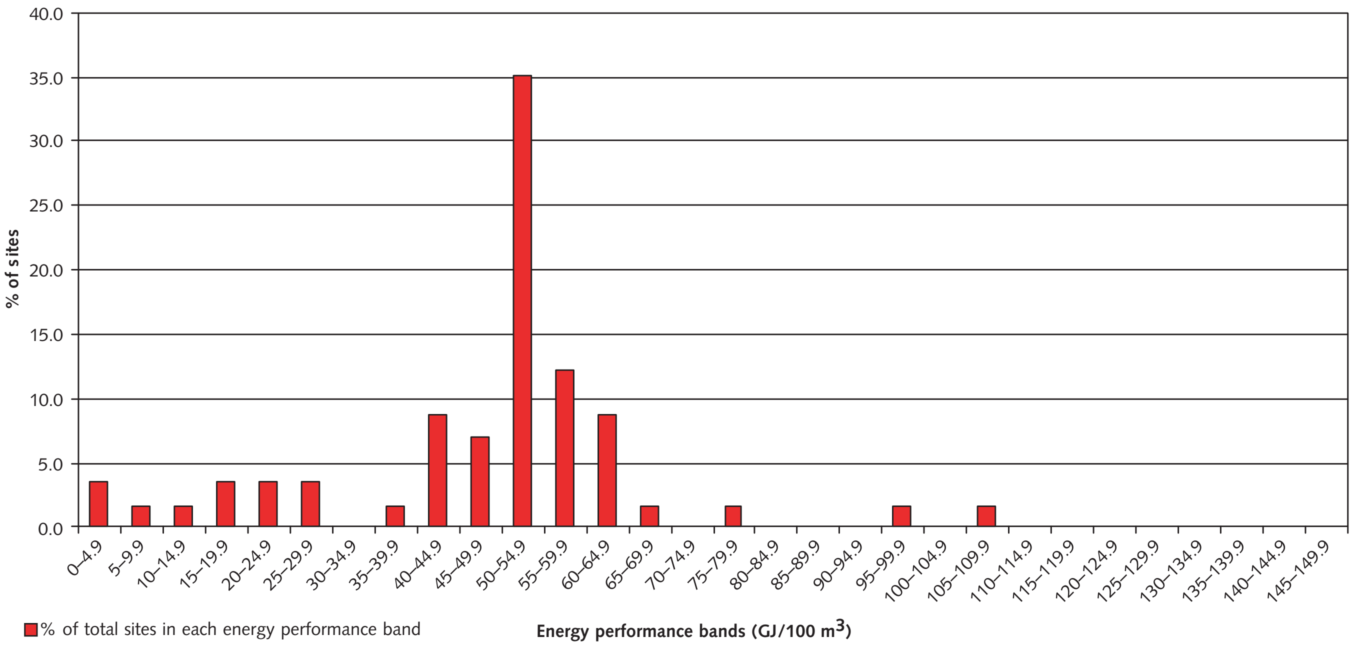
- the median performance value is 57.4 GJ/100 m^3;
- the first quartile performance value is 45.4 GJ/100 m^3;
- 65% meet the mandatory target for existing buildings of 65 GJ/100 m^3;
- 45% meet the mandatory target of 55 GJ/100 m^3 for new-build/refurbishment
- 17% perform below 40 GJ/100 m^3.

The mandatory targets are clearly very achievable for sites of this healthcare type. It is essential that "good practice" benchmarks are set that will ensure these sites perform at levels significantly better than the overall mandatory targets.

GP surgeries

The distribution of energy performance by site can be seen in Figure A9. It should be noted that a proportion of the data supplied included aggregated sites, which has had a distortion effect on the distribution chart.

Figure A9 GP surgeries (in energy performance bands)



Reference to Tables A2 and A4 and Figure A9 shows that of the sites of this type:

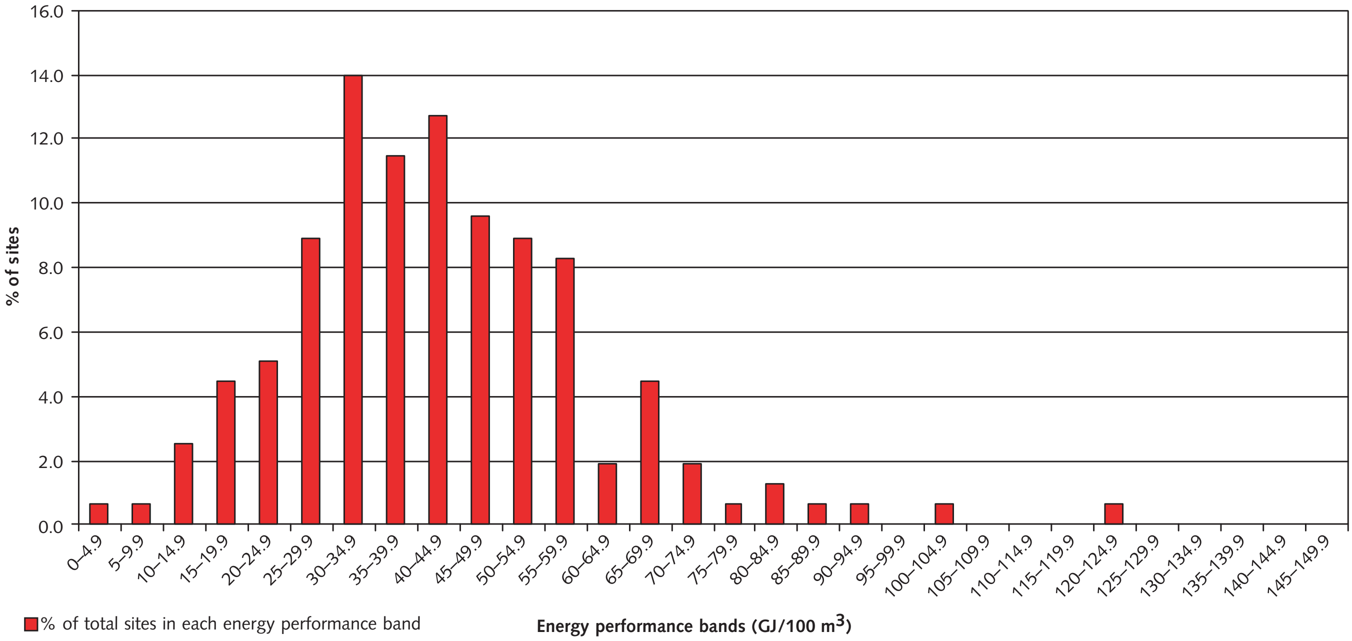
- the median performance value is 51.9 GJ/100 m^3;
- the first quartile performance value is 43.3 GJ/100 m^3;
- 91% meet the mandatory target for existing buildings of 65 GJ/100 m^3;
- 70% meet the mandatory target of 55 GJ/100 m^3 for new-build/refurbishment;
- 19% perform below 40 GJ/100 m^3.

The mandatory targets are clearly very achievable for sites of this healthcare type. It is essential that "good practice" benchmarks are set that will ensure these sites perform at their optimal levels. These will be significantly better than the overall mandatory targets.

Health centres and clinics

The distribution of energy performance by site can be seen in Figure A10.

Figure A10 Health centres and clinics (in energy performance bands)



Reference to Tables A2 and A4 and Figure A10 shows that of the sites of this type:

- the median performance value is 41.6 GJ/100 m^3;
- the first quartile performance value is 30.5 GJ/100 m^3;
- 89% meet the mandatory target for existing buildings of 65 GJ/100 m^3;
- 79% meet the mandatory target of 55 GJ/100 m^3 for new-build/refurbishment;
- 22% perform below 30 GJ/100 m^3.

The mandatory targets are clearly very achievable for sites of this healthcare type. It is essential that "good practice" benchmarks are set that will ensure these sites perform at their optimal levels. These will be significantly better than the overall mandatory targets.

"Good practice" delivered energy performance benchmarks

The "good practice" benchmarks in Table A5 were derived from the analysis of the data as described in this section.

The benchmarks for teaching and specialist hospitals are the same as the mandatory Department of Health targets. Benchmarks for other types of healthcare site are less.

Table A5 Delivered energy performance benchmarks (GJ/100 m^3)

Site type	Good practice		Typical	
	New/ refurbishment	Existing buildings	Best 25%	Median
Teaching & Specialist Hospitals	<55	<65	62.4	**75.7**
General Acute Hospitals	<52	<62	58.5	**68.8**
Community & Mental Health In-patient Facilities	<40	<50	45.4	**57.4**
GP Surgeries	<36	<46	43.3	**51.9**
Health Centres & Clinics	<25	<35	30.5	**41.6**

From the conclusion shown in Table A5, it is clear that the delivered energy performance benchmarks are achievable.

Setting of CO_2 emissions benchmarks

Basis of setting values

Fundamental to the Government's objective of carbon reductions is the setting of benchmarks for emissions.

Table A3 and Figure A5 illustrate the CO_2 emissions of each of the healthcare site types based on 2003/4 data.

CO_2 emission benchmarks have been developed by a conversion from the delivered energy benchmarks shown in Table A5.

The conversion is based on:

- gas as the fossil fuel (Table A6);
- the percentage of electricity use for each site type as recorded for 1999/2000.

As with energy performance, "good practice" benchmarks for CO_2 emissions are compared with two different "typical" values:

- for existing buildings, the median value for each type of site is given as a comparison with "good practice";
- for new-build/refurbishments, the first quartile value is given as a comparison with "good practice". This is because there is still not a sufficiently large, and robust, database of new-build/refurbishments. However, it is noted that a number of new-build developments feature in the best-performing 25% of sites.

For areas where gas is not available (particularly parts of Northern Ireland and Scotland), Table A7 is provided, using oil as the fossil fuel.

"Good practice" CO_2 emissions benchmarks

Table A6 CO_2 emissions benchmarks (kg/m^2; gas as the fossil fuel)

Site type	Good practice		Typical (all fuels)	
	New/ refurbishment	Existing buildings	Best 25%	Median
Teaching & Specialist Hospitals	<115	<135	134.1	**151.7**
General Acute Hospitals	<105	<125	118.1	**138.8**
Community & Mental Health In-patient Facilities	<75	<95	84.8	**105.5**
GP Surgeries	<70	<90	79.4	**94.8**
Health Centres & Clinics	<50	<70	59.0	**74.0**

Table A7 CO_2 emissions benchmarks (kg/m^2; oil as the fossil fuel)

Site type	Good practice		Typical (all fuels)	
	New/ refurbishment	Existing buildings	Best 25%	Median
Teaching & Specialist Hospitals	<135	<160	134.1	**151.7**
General Acute Hospitals	<120	<145	118.1	**138.8**
Community & Mental Health In-patient Facilities	<90	<115	84.8	**105.5**
GP Surgeries	<85	<105	79.4	**94.8**
Health Centres & Clinics	<60	<80	59.0	**74.0**

Tables A6 and A7 show conversion of the delivered energy target into CO_2 values.

Definitions

Delivered energy

The benchmarks for "delivered" energy should be regarded as applying to end-use. Thus, in the measure of "delivered" energy, that supplied from CHP units would be used, not that delivered to them. In this way, the use of CHP systems can be encouraged as a means of reducing carbon emissions whilst the additional fuel supplied to them will not impact adversely on "delivered" energy targets.

For the purpose of establishing a target performance where combined heat and power (CHP) systems operate on a site, they should be treated as "off site" in the measure of delivered energy.

External temperature reference

The mandatory "delivered" energy targets of 2001 for the NHS in England are not linked to a reference value of degree-days.

The lack of any reference ambient temperature creates anomalies when comparing the performance of healthcare buildings in different parts of the UK. This is illustrated by examination of the 20-year, hospital degree-day averages for the year ended March 2000. The value for the Severn Valley area was 2752 whilst the value for north-west England was 3492; a difference of 740. The difference when compared with north-east Scotland is even more pronounced at 992. This is reflected in part by Table A8 comparing 2003/2004 performance figures of Strategic Health Authorities and devolved administrations.

Table A8 Comparison of energy performance and CO_2 emissions by SHA and devolved administrations

SHAs and devolved administrations	Total energy consumption (GJ/100 m^3)	CO_2 emissions (kg/m^2)
West Yorkshire	52.72	120
South West Peninsula	56.29	112
Norfolk, Suffolk and Cambridgeshire	57.11	122
Wales	58.59	125
Leicestershire, Northamptonshire and Rutland	60.18	118
Surrey and Sussex	60.20	119
Avon, Gloucestershire and Wiltshire	60.73	127
North West London	61.10	122
Cheshire and Merseyside	61.54	120
Kent and Medway	62.70	113
Dorset and Somerset	63.25	124
Hampshire and Isle of Wight	63.82	131
County Durham and Tees Valley	64.18	145
Northumberland, Tyne & Wear	65.03	133
West Midlands South	65.79	130
South Yorkshire	65.87	129
North and East Yorkshire and Northern Lincolnshire	66.23	126
South East London	66.51	128
Trent	67.09	153
Northern Ireland	67.60	144
Cumbria and Lancashire	68.39	125
Scotland	68.55	135
Bedfordshire and Hertfordshire	68.91	133
South West London	69.09	131
Essex	69.86	136
Birmingham and the Black Country	70.68	154
Thames Valley	71.66	131
North East London	72.11	165
Greater Manchester	74.41	149
Shropshire and Staffordshire	76.70	153
North Central London	77.28	167

The 'Energy efficiency guide for health care buildings' published in 1988 used a figure of 3448 degree-days as a reference. The decreasing value of the 20-year average suggests that the median value for England for the initial target year (ended March 2000) would be more appropriate.

From the above details, it is established that the good practice benchmark in Table A5 is linked to a reference degree-day value of 3122 hospital degree-days (18.5°C).

Appendix 3 EU Emissions Trading Scheme requirements

Introduction

As of 1 January 2005, companies from sectors covered by the Emissions Trading Scheme (ETS), including qualifying healthcare organisations, must limit their carbon dioxide (CO_2) emissions to allocated levels in two periods: from 2005–2007 and 2008–2012 (to match the first Kyoto commitment period). Only CO_2 will be included in the first phase, with the potential to expand this to the other five greenhouse gases (GHG) from 2008.

This is a mandatory requirement for those who are covered by the scheme.

How will I know whether I will be part of the scheme?

The EU Greenhouse Gas Emissions Trading Directive details the range of installations covered by the scheme. For the NHS this will relate to "installations", which are defined as:

Energy activities (on a single site basis) – Combustion sites with a related thermal input exceeding 20 MW (excepting hazardous or municipal waste installations) – Greenhouse gas – carbon dioxide.

[Extract from Table 1, Annex A from EU Greenhouse Gas Emissions Trading Directive]

Importantly, the EU ETS scheme rules also specify that where one operator carries out several activities falling under the same sub-heading, in the same installation or on the same site, the capacities of such activities should be added together. If the total capacity fulfils the requirement (for example you have multiple combustion facilities giving a total which exceeds the 20 MW thermal input threshold), you will be incorporated in the scheme. Special conditions may apply if there is contract energy management on the site.

Any healthcare organisation that is in the process of a major extension or PFI should ensure that the proposed carbon emissions for the development are known. If the development is likely to increase the site-wide carbon emissions to a level above the threshold of 20 MW, registration should be carried out in advance of the development being completed.

How will the EU ETS work?

All installations must hold a greenhouse gas emissions permit or risk incurring financial penalties. Although the scheme may be expanded in the future to accommodate other greenhouse gases, for the initial phase at least it only covers carbon dioxide.

The scheme will work on a "cap and trade" basis. The UK Government is required to set emissions limits or "caps" for all installations that are covered by the scheme. Each installation will then be allocated allowances equal to that cap for the particular phase in question. For the first phase (2005–2007), all allowances will be allocated free of charge.

The allowance allocations for each installation for any given period (the number of tradable allowances each installation will receive) will be set down in a document called the National Allocation Plan. The overall allowances for the period will then be broken down into annual amounts.

Installations that reduce their annual emissions to below their allocation of allowances can trade their surplus allowances on the market or bank them (storing them for use in future years). Installations that need additional allowances to cover their annual emissions will be able to buy them from the market. This reconciliation of allowances and emissions will need to take place on an annual basis, completed by 30 April each year, for the preceding calendar year.

What will I need to do to comply with the scheme?

The EU ETS scheme rules make it clear that the responsibility lies with the operator of the installation to apply to the competent authority for a permit. If any installation covered by the EU Scheme operates without a permit, it will be liable to financial penalties.

The permits will be issued by the appropriate national environment agency.

Process of activities:

- begin to plan a strategy for energy and carbon management – see Chapters 1 and 2;
- adopt appropriate systems for monitoring and reporting of carbon dioxide emissions (and possibility for the longer term, other greenhouse gases) – see Chapter 2;
- all operators of installations to prepare an annual report and submit it to the competent authority. These reports will need to be verified by an accredited body;
- identify primary and secondary account representatives (PAR and SAR) to be responsible for the carbon trade account.

Further information is available at http://www.defra.gov.uk, http://www.environment-agency.gov.uk, http://www.sepa.gov.uk and http://www.ehsni.gov.uk/environment/industrialPollution/emissionstrading.shtml

Appendix 4 Energy-saving issues during the procurement phase of major construction projects

Introduction

Table A9 lists the recommended actions to ensure that the aims of improving energy efficiency and reducing carbon emissions are considered at each stage of the procurement process.

The table refers repeatedly to NEAT (NHS Environmental Assessment Tool). NEAT, and its implications for energy, are described more fully on the Department of Health's Estates and Facilities Division's website at http://www.dh.gov.uk/PolicyAndGuidance/OrganisationPolicy/EstatesAndFacilitiesManagement/SustainableDevelopment/fs/en.

The principles detailed above apply equally to Scotland. Scottish Executive policy on construction procurement will be issued, on completion, as the 'Construction Procurement Manual', with Scottish Executive Health Department specific procedures in the 'Scottish Capital Investment Manual'. NHSScotland procurement guidance 'Procode' is published by the NHSScotland Property and Environment Forum. References to NEAT in this section should be read in Scotland as references to Greencode and further advice if necessary should be sought from the Property and Environment Forum.

Table A9 Roles, responsibilities and actions (best practice measures)

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
	Concept Stage – this could be during the preparation of a development control plan (DCP) or when it becomes apparent that there is a need for a healthcare facility	Consider energy provision in the wider context of the site and site-wide energy plan. Choose prospective sites with regard to energy Prepare policy for all future developments	Review or draw up site-wide energy plan and prepare or update energy policy for all future developments Ensure that other developments at more advanced stages would allow a sustainable energy-efficient solution for any new development When considering new sites, consider energy implications (for example, choice of noisy congested sites may ultimately force a sealed air-conditioned building)	Healthcare organisation Board CEO Director of Developments or Capital Planning	
1	Strategic Outline Case	Evaluate options for site selection Get expert advice Start to develop sustainability and energy strategy for proposed development Establish energy efficiency aspects in relation to user needs Choose advisors with commitment	Establish the key energy efficiency and sustainability objectives for the project. Get an energy efficiency advisor on the project board if expertise does not exist in the healthcare organisation's team. Start the NEAT process and develop a strategy to achieve energy targets as early as possible in the project process.	Healthcare organisation Board CEO Project Director	Department of Health (Estates and Facilities Division), *Sustainable development in the NHS*; Department of Health (Estates and Facilities Division), *Sustainable development: environmental strategy for the National Health Service*; Department of Health (Estates and Facilities Division), *Environmental Management in Healthcare*
2	Identify user needs		Coordinate and establish energy efficiency aspects in relation to user needs	Project Director	Department of Health (Estates and Facilities Division), *Sustainable development in the NHS*

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
3	Outline Business Case		If employing project advisors, try to use those with a good environmental track record and a genuine interest in energy efficiency and sustainability issues and ensure that their terms and conditions include contractual requirements to implement NHS and organisation-specific policies. This should apply to financial and legal advisers for privately-financed schemes as well as technical advisers Evaluate the energy efficiency and sustainability impacts of the key project options (usually do nothing; do minimum; refurbish; refurbish and renew; new building on existing site; new building on new site). For example, at the time when options for the site and building form are being considered, the orientation and planning of the building may determine whether the development can be largely naturally ventilated with passive cooling, or whether mechanical ventilation and cooling will be necessary. Clearly this will impact on both the energy used and the NEAT rating Include a sum in budget costs for fees for feasibility studies for energy-saving measures and for energy modelling for major schemes	Project Director reports to CEO and the healthcare organisation's Board Project Manager and design team/advisers appointed with brief for achieving energy efficiencies and sustainability issues	
4	Create project team	Choose environmentally aware advisors Ensure all advisors' briefs require energy performance targets to be met Energy champion holds responsibility for overall achievement of energy performance	When forming the project team, select project advisors with a good environmental track record and genuine interest in energy efficiency and sustainability issues. The Project team should be willing to work in an integrated way and should show "buy in" to energy efficiency and sustainability principles. Obtain energy advice as early as possible in the project. Many healthcare organisations have in-house energy advisers and they should be given the opportunity to attend planning meetings and assess proposals. The capital developments manager, project sponsor, project manager or whoever is responsible for the key decisions in the project should give a clear instruction that the energy performance indicators are to be met and that the introduction of building economies that would result in higher energy use where this gives rise to increased whole-life cost (WLC) shall be resisted.	Project Director to ensure Project Manager and design team/advisers appointed with brief for achieving energy and sustainability performance indicators	

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
4 *contd*			This nominated person should ensure that energy and NEAT issues are kept on the design and construction agenda.		
5	Initial project brief	Project requirements developed incorporating energy performance measures and NEAT	At this stage the energy efficiency and sustainability objectives should be confirmed with the project team and it should be ensured that the initial brief documents would deliver these objectives Develop a scoring system for measuring the sustainability of bids received The person(s) responsible for delivering energy efficiency and sustainability should regularly attend project meetings and advise on key issues (workshops and focussed meetings may be useful in this regard) Each question in the NEAT assessment should be allocated to the member of the development team who is able to take responsibility for that aspect of the design, construction or management The allocation of responsibilities will be broadly divided into the following categories: * Design – architectural, structural and engineering * Construction * Existing and future site issues, including land, transport, waste, etc * Policy and management Clearly there should be a strong input from the healthcare organisation and this process cannot be subcontracted entirely to the design or advisory team The sustainability advisor and any in-house or retained energy advisors to advise on meeting energy performance indicators	Project Manager, design/ advisory team, Healthcare organisation Project team reporting to Project Director	Department of Health (Estates and Facilities Division), *Advice to Healthcare organisations on the main components of the design brief for healthcare buildings*

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
6	Feasibility study options	Carry out more detailed studies on energy saving and sustainability measures	Continue to assess options for sustainability impacts. Determine key energy saving or sustainability measures for which feasibility studies would be valuable and commission the studies. Implement the recommendations in the project documents, design and business case At the end of this stage the design team should reach a consensus on the conceptual design of the energy consuming services (as well as other features such as the structure and spatial layout). This is so that individual design team members can work on the detail secure in the knowledge that changes within the responsibility areas of other team members will not undermine the viability of their part	Project director to commission feasibility studies	
7	Set procurement strategy		Consider how the procurement route may affect energy efficiency and sustainability outcomes	Project director and project manager	Department of Health (Estates and Facilities Division), *The Design Development Protocol for PFI Schemes*; Department of Health (Estates and Facilities Division), *ProCure21 folder*
8	Prepare Full Business Case	Detailed design and financial cases prepared incorporating energy saving/sustainable design measures	The healthcare organisation and the sustainability advisors should finalise the energy efficiency and sustainability objectives and prioritise measures to ensure that they are met Continue to use energy advisors to discuss strategy issues. Obtain commitment of the design team as to how the energy efficiency objectives are to be realised across the whole design Ensure energy efficiency and sustainability measures are included in the budget by integrated teamwork with the Quantity Surveyor to methodically cost measures identified by team Submit a full NEAT assessment with the Full Business Case Apply for grant funding on the basis of feasibility studies built into business case if applicable	Project Director to report to CEO/Healthcare organisation Board	

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
9	Final brief design	Final project documents prepared incorporating energy saving/ sustainable design measures Checks on targets and NEAT Checks that enough plant and distribution space has been allowed Checks that all proposals are affordable, maintainable and buildable	Continue to update the NEAT prediction assessments throughout the brief's development to ensure that it will support sustainability performance indicators Check that the brief asks for information that will allow bids to be compared on a like-for-like basis For traditional procurement/ProCure21, ensure emergent design meets performance indicators Ensure that the output specification documents will incentivise and require bidders, through their scheme proposals, to meet a NEAT excellent for new build (very good for refurbishments) and the NHS energy targets Modelling the energy use should take place to determine that energy targets will be met The key manager should encourage all team members to work together to achieve the performance indicators The Architect, Structural Engineer and Quantity Surveyor should ensure that there will be sufficient plant and distribution space to allow the Services Engineer to incorporate energy efficient plant (including plant such as heat recovery equipment) in the designs. Adequate provision also needs to be made for maintenance to ensure efficient operation in the future	Project Director and Project Manager	Department of Health (Estates and Facilities Division), *Better Health Buildings*
10	Contract preparation		If the project is to be procured through PFI, monitor the ITN and contract documents to ensure they state that NEAT and energy performance indicators should be met For other types of procurement also check the final design/ brief documents to ensure that NEAT and energy performance indicators will be met Energy modelling should be carried out for traditional/ ProCure21 projects to predict project's energy use.	Project Manager	

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
10 *contd*			Design and build or PFI/PPP contracts should include clauses that require the contractor/provider to carry out modelling to demonstrate that the design meets an agreed energy performance level. The requirements will be enforced through the use of incentives and/or penalties Ensure that the energy payment mechanism in the contract fairly allocates responsibilities, risks and benefits, so that discontinuities between them do not affect the overall Best Value outcome		
11	Invite Expressions of Interest – PFI/ LIFT		Assess the expressions of interest, received from potential bidders, for sustainability track record Research each company's track record on sustainability and review their environmental policies/statements	Project Manager	
12	Tender process PFI/LIFT	Score and evaluate proposals Ensure modelling has been carried out and is accurate	Evaluate Pre Qualification Questionnaires (if applicable) for energy efficiency and sustainability Evaluate intermediate and final bid submissions for energy efficiency and sustainability Use a defined methodology and scoring criteria to establish the sustainability rating for each bid Bids should show evidence of a holistic approach to the achievement of performance indicators eg the architect, structural engineer and quantity surveyor should provide sufficient plant and distribution space to facilitate the installation of energy efficient plant, by the Services Engineer, and for its future maintenance Check bids for modelling of predicted energy use by the Services Engineer or Energy Adviser and compliance with Building Regulations, Energy Performance of Buildings Directive and locally set energy performance indicators The scheme should include for monitoring of the energy use by the development during the operational phase. Metering should be included to facilitate this	Project Manager	

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
12 *contd*		Maintain commitment to project energy criteria	Assess the Supply Chain Management Action Plan for sustainability Monitor negotiations to maintain criteria for meeting NEAT/Energy performance indicators Appoint a coordinator for the NEAT process The appointee should have the authority to acquire all information required to make the assessment and should: * Be able to advise on how to achieve the rating as economically as possible * Be kept in the loop of design and construction decision-making processes * Warn if ratings are falling as a result of design changes or value engineering * Update the assessment as the design evolves		
13	Award contract	Final checks	Undertake a final assessment of proposals to ensure that the performance indicators for NEAT Assessment energy will be met, before awarding contract	Project Director Project Manager	
14	Work contract	Ongoing auditing of emergent detailed design and construction proposals to ensure that energy and sustainability commitments are kept	Audit the emerging detail design/construction process for the achievement of energy efficiency and sustainability performance indicators and compliance with the contract documents Update the NEAT allocations and energy performance indicator responsibilities as other organisations become involved. Allocation of responsibilities will be broadly divided into: Design, Construction, Existing and future site issues including land, transport, waste, and Policy and Management There needs to be a strong input from the healthcare organisation and this process cannot be subcontracted entirely to the design team	Project Director Project Manager	

	Procurement stages	Activity	Healthcare organisation team	Key responsibilities	Key reference documents
15	Deliver project	Audit programme and commissioning process	Allow time and budget for supervision during construction and also for commissioning so that optimum building operating conditions may be achieved. The commissioning process is critical. It is important to realise that there is a wide range of operating conditions under which a building will be perceived to "work", but a narrow range of conditions through which optimum efficiency will be achieved The designer and/or energy adviser should remain involved throughout the commissioning process to ensure that the design intent is met and that the building is commissioned for optimum energy use	Project Director Project Manager	
16	Feedback		Monitor during the construction process to ensure energy efficiency and sustainability requirements are being adhered to	Project Director Project Manager	
			Monitor during the commissioning of Building Management Systems and Mechanical and Electrical Services	Project Director Project Manager	
			Ensure that adequate training of building operatives and users takes place including staff within the Healthcare organisation		
			Ensure that final NEAT Assessment is carried out after suitable building commissioning period	Project Director Project Manager	
			Ensure that a monitoring schedule is set up and figures reported back to a nominated qualified person at the Healthcare organisation at regular intervals. Consumption figures should be regularly reviewed and analysed for wastage	Project Director Project Manager	
17	Post-occupancy review		Carry out an independent evaluation of building systems to ensure performance indicators are being met and monitor user satisfaction Feed back any successes and concerns in the procurement process to the Department of Health to enable the advice in Encode to be updated	Project Director	

Appendix 5 Low-energy electric lighting specification

Electric lighting control should be designed to enable electric lighting only when daylight is insufficient to meet specified conditions.

Lighting design should take into consideration:

- the CIBSE Code for Interior Lighting (2004);
- the Department of Health's 'Lighting and colour for hospital design';
- CIBSE's Hospital Lighting Guide LG2.

Where there are differences in illuminance recommendations, those in CIBSE's Code for Interior Lighting should be used. Colour rendering recommendations should be implemented.

Consideration should be given to the integration of high-efficiency task lighting with scheme lighting to reduce overall installed loads.

Lighting in offices and other areas where computer screens are in use should comply with the recommendations in CIBSE Lighting Guide 3 and its addendum.

Fluorescent fittings should incorporate low-loss high-frequency control gear. To avoid possible consequential interference with medical equipment, the guidelines in Health Technical Memorandum 2014 – 'Abatement of electrical interference' should be followed.

The lighting energy targets recommended are:

- 100 lux – illuminance level of 3 W/m^2;
- 200 lux – illuminance level of 5–6 W/m^2;
- 300 lux – illuminance level is 7–8 W/m^2;
- lighting performance of 20 kWh/m^2 per annum should not be exceeded.

Case studies

The Royal Hospital, Belfast

A short survey[16] of a new extension (phase 1) showed many areas had been over-lit. For example, corridors were lit to twice the recommended level, the pharmacy to three times the recommended level, and many toilets to six times the recommended level. Over-lighting is waste in both energy and maintenance.

Some of the problems also came down to contractual philosophy in utilising as many of the same luminaires as possible. In this hospital, three tube-recessed luminaires were used in the main areas where they were suitable and then extended to the corridor areas where they provided excessive illumination.

Prince Charles Hospital at Merthyr Tydfil

A £150,000 contract is under way to refit identified areas of concern highlighted by a design advice lighting specialist.[17] The recommendations of the design advice survey showed that although repositioning of the luminaires was not practical due to the ceiling make-up, it was possible to convert the existing 1.5 m luminaires and diffusers. At the inception of the project, these concepts appeared revolutionary and so it was decided to install two pilot schemes in the corridors. The outcome of the pilot scheme is that energy consumption has been substantially reduced while lighting levels have been increased where necessary. The two schemes were to:

a. provide new 1.2 m fluorescent luminaires with high-frequency control gear and UV-stabilised prismatic diffusers;

b. provide retro-fit, 1.19 m T5 fluorescent high-frequency gear trays within existing luminaire bodies with new UV-stabilised prismatic diffusers.

The test showed that there was a measured energy reduction from 83 W to 32 W per luminaire (61%), with the lighting levels improving from 100 lux to 300 lux.

16 Funded by the Carbon Trust's Design Advice service

17 Funded by the Carbon Trust's Design Advice service

Appendix 6 Standard stationery

ENERGY MANAGEMENT
Phase 2 Energy Saving
Schedule of Hospital Site Buildings

Form 1 A/B

A

Health Authority: .... Hospital: ....

Type: .... No. Beds: .... Exposure (1): ....

Notes

(1) ie Sheltered, Normal and Severe (ref CIBSE Guide).
(2) The heated volume should *exclude* all unheated spaces, eg roof spaces, basements, subways, plantrooms etc.
(3) The *gross* volume should be the total internal floor area within the perimeter of external walls to the height of each storey from the floor surface to the underside of structural floor or roof, including roof spaces, plantrooms and subways etc.
(4) Indicate approx age of building.
(5) Identify basic form of construction, eg Traditional brick/pitched tile roof, System built/flat roof, Prefab asbestos/pitched roof etc.

Bldg Group Ref	Title and Function	Volume m^3		No. of floors	Age Yrs (4)	Type of construction (5)
		Heated (2)	Gross (3)			
Totals				Continued over →		

ENERGY MANAGEMENT
Phase 2 Energy Saving
Schedule of Hospital Site Buildings

Form 1 A/B

B

Bldg Group Ref	Title and Function	Volume m³		No. of floors	Age Yrs (4)	Type of construction (5)
		Heated (2)	Gross (3)			
Totals						

ENERGY MANAGEMENT
Phase 2 Energy Saving
Hospital Building Details

Form 2 A/B

A

Health Authority: .... Hospital: ....

Building (Form 1A) Ref: .... Title/Function: ....

Occupation requirements		**Notes**
Type of occupancy		Note 1
Period of occupancy		
Continuous	Yes/No	
If No Number of days/week		
From (time)		
To (time)		
Total hrs/day		
Building parameters		
Heated volume m^3		Note 2
Gross volume m^3		Note 3
Floor/roof area m^2		
Number of floors		Note 4
Floor to ceiling height m		
External wall area m^2		

Construction details		**Notes**
Walls Type		
Thickness		
Materials		
Cavity size		
Insulation		
Glazing Single/Double		
% Glaze/wall area		
Roof Type	Flat/pitched	
Plan area m^2		
Materials/thickness		
Other information		
Floor Type	Solid/ventilated	
Materials/thickness		
Other information		

ENERGY MANAGEMENT Form 2 A/B
Phase 2 Energy Saving
Heating System and Controls

B

Form of heating (5):	Note 5
Circulation mains (6):	Note 6
Heating plant: Type	
Age	
Heating controls (7): Building	Note 7
Age	
Plant	
Age	

Notes

(1) Where there is mixed occupancy to a significant extent, identify as such with the forms of occupancy, eg Mixed occupancy: Admin (2000 m^3 approx), Dining rooms (600 m^3) etc. For large buildings of "continuous" construction containing a number of departments, complete a separate sheet for each department and/or each discrete part of the building, eg male and female wings.
(2) *Heated* volume as Form 1.
(3) *Gross* volume as Form 1.
(4) To include any heated basement but exclude plantrooms and service ducts or voids.
(5) Identify type(s) of heating surface and forms of circulation, eg single or two pipe.
(6) For buildings with mixed occupancy and departments or areas with intermittent occupation, do/could circulation mains serve these separately from adjacent areas.
(7) Identify type and age (if necessary age range) of heating system controls on heating, plant and in the building(s).

ENERGY MANAGEMENT
Phase 2 Energy Saving
Hospital Building Details

Form 3 A/B

A

Strategic Health Authority: .... Hospital: ....

Building (Form 1A) Ref: .... Title/Function: ....

Diagrammatic sketch of heating system and controls

Identify with a simple single line diagrammatic sketch, heating system layout, indicating position and type of existing controls, time switches and sensors. Indicate control manufacturer.

See over

ENERGY MANAGEMENT
Phase 2 Energy Saving
Information on Energy Consuming Equipment

Form 3 A/B

B

Strategic Health Authority: .... Hospital: ....

Building (Form 1A) Ref: .... Title/Function: ....

Describe items of energy consuming equipment.
For each item, identify the consumption rating and any practical energy-saving modifications.

Item	Energy consumed GJ	Notes

ENERGY MANAGEMENT
Phase 2 Energy Saving
Hospital Building Heating Energy Assessment

Form 4 A/B

A

Strategic Health Authority: .... Hospital: ....

Building (Form 1A) Ref: .... Title/Function: ....

1. Heat loss on existing building structure

Element	Heat loss† A	Intermittent htg factor B	Area/volume C‡	Heat loss* D = A x B x C	Notes
Wall					
Roof					
Floor					
Ventilation					
			Total		
Degree day correction =					

2. Heat saving through modified building structure

Element	Structural change	Heat loss factor†	Int't heating factor	Area or volume‡	New heat loss*	Heat saving*	Cost per GJ £	Annual cost saving £
Wall								
Roof								
Floor								
Ventilation								
				Totals				
Degree day correction =								

3. Heat saving through modification to control system

Description of modification	% improvement	Existing heat loss*	Heat saving*	Cost per GJ £	Annual cost saving £

Degree day correction = $\frac{\text{Heat Loss x 20 year District Av. DD}}{\text{Base DD 20 year National Average}}$

† GJ/Annum/m^2 (m^3)
‡ m^2 (m^3)
* GJ/Annum

ENERGY MANAGEMENT
Phase 2 Energy Saving
Summary of Energy Saving

Form 4 A/B

B

Item or modification	Energy consumption prior to change GJ/Annum	Energy saving due to change GJ/Annum	Cost per GJ £	Annual cost saving £

ENERGY MANAGEMENT
Phase 2 Energy Saving
Central Boiler Information

Form 5 A/B

A

Strategic Health Authority: .... Hospital: ....

Boilers

Type	
Rating	
Age	
Condition	
Feed pumps	
Fuel storage and handling	
Log sheet records	
Blowdown	
Water treatment	
Other equipment	

Instrumentation and metering

Location and parameter	Manufacturer	Reading

ENERGY MANAGEMENT
Phase 2 Energy Saving
Boiler Assessment

Form 5 A/B

B

Summary of performance

Measured commissioned efficiency	
Assessed annual efficiency	
Potential annual efficiency	
Annual consumption	
Potential saving	

Summary of boilerhouse energy-saving measures

Energy-saving measure	Saving GJ/annum	Cost per useful GJ £	Annual cost saving £

ENERGY MANAGEMENT
Phase 2 Energy Saving
Site Energy Summary

Form 6 A/B

A

Strategic Health Authority: .... Hospital: ....

Introductory Notes

1. Building heating requirements (details from Form 4A series)

Bldg ref	Title/function		Energy reqmt GJ/annum	Bldg ref	Title/function		Energy reqmt GJ/annum
						Total	

2. Other energy requirements

Use	Consumption norm GJ/m^3	Heated volume m^3	Energy reqmt GJ/annum	Form of energy and its % (Steam, HPHW, Gas, Elec)
DHWS				
Cooking/Incin.				
Light & power				

3. Boiler efficiencies and site utilisation

Efficiency	%	Source of assessment and comments
Assessed annual operation		
Assessed potential operation		
Assessed utilisation		

ENERGY MANAGEMENT
Phase 2 Energy Saving
Energy Audit Balance Sheet

Form 6 A/B

B

Introductory Notes

Energy source	Indirect energy assessment GJ/annum A	Potential annual efficiency B	Potential utilisation efficiency C	Indirect energy assessment total D = A/BC	Direct energy total GJ/annum E	Site total energy assessment GJ/annum F = D + E	Site actual total energy consumption GJ/annum G
Oil (Sec/CV)							
Oil (Sec/CV)							
Coal (CV)							
Gas (CV)							
Electricity							

Resulting characteristic norms for the site:

Space heating GJ/D.Day

Base load GJ/Month

(This includes mains loss of GJ/Month)

Assessment total		
Assessment margin		
Sub-total		
Potential saving = G – F		
Balance		

ENERGY MANAGEMENT
Phase 2 Energy Saving
Energy Saving Identification Chart

Form 7 A/B

A

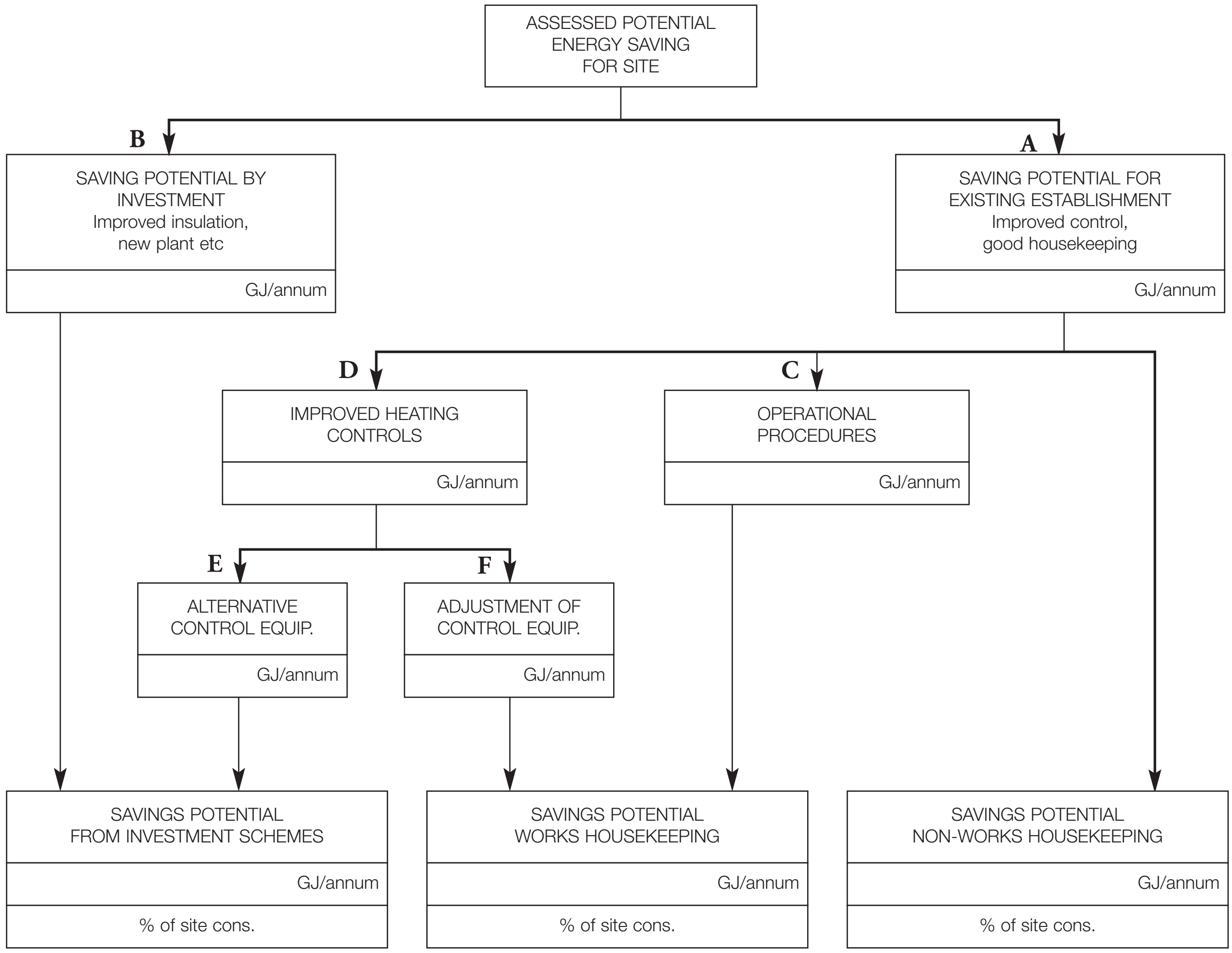
Strategic Health Authority: .... Hospital: ....

A Energy-saving potential (balance sheet 6B)

B Investment schemes excluding heating controls (sheets 4B and 5B)

C Non-investment schemes with Works responsibility (sheets 4B and 5B)

D Improved space heating controls; **E** by investment; **F** by improved housekeeping (sheet 4A)



ENERGY MANAGEMENT
Phase 2 Energy Saving
Energy Saving Proposals

Form 7 A/B

B

Building group ref	Description of proposal	Capital cost £	Saving GJ/annum	Saving £	Pay-back Years

Appendix 7 Renewable energy sources

[This extract is reproduced from the 'NHS Wales: energy efficiency strategy guidance and implementation' report (courtesy of Energy for Sustainable Development Ltd, the Carbon Trust and Welsh Health Estates). The full version is available on the CD-ROM that accompanies this publication.]

Renewable energy sources

What is renewable energy?

Renewable energy is the term used to cover those energy resources which occur naturally or repeatedly in the environment, for example energy from the sun, wind and the oceans, from plants, waste and flowing water. Most renewable energy technologies produce no emissions of gaseous pollutants (that is, CO_2, oxides of nitrogen/sulphur and particulates). There are two possible options for exploiting this green energy; these are described in the following sections.

Buying from electricity suppliers

Most electricity companies offer green electricity under special green tariffs, that is, electricity guaranteed to have been produced from renewable sources. Usually there is a premium charged and supplies are limited. All electricity supply companies have an obligation to source an increasing proportion of their electricity from renewable sources (up to 10% by 2010), and frequently the green tariffs are provided to those customers who want to pay more for a larger share of this renewable supply.

Welsh Health Estates has negotiated green electricity supplies for a number of health trusts in Wales. As a first step towards using renewable energy, this should be encouraged; however, there are a number of reasons why simply buying green electricity through a green tariff should not become the main method for reducing a trust's CO_2 emissions.

1. If electricity purchased under green tariffs is also being counted as part of an electricity supplier's renewable obligation (and there is nothing to stop this) it cannot count towards the trust's Welsh CO_2 targets as this would mean double-counting the benefits of the same measure.
2. There is insufficient renewable electricity generation available for all trusts to purchase a significant proportion of their electricity use as green tariffs.
3. Green tariffs do not reduce the impact of fossil fuel use for heating and hot water.
4. Relying on a green tariff to meet trust CO_2 targets will mean that the trust is unable to select cheaper electricity supplies and is effectively tied to this form of contract.
5. The low-carbon benefit of a green tariff is lost when the contract ends. Once a trust goes back to a conventional "brown" tariff, its carbon emissions go back up to the baseline level. Since there is no guarantee that a green tariff may be competitive from one year to the next, this is a risky approach to emissions reduction.

Generating green energy within the trust

NHS trusts are in an ideal position to benefit from generating their own supplies of green energy: most trusts are significant property owners; have 24-hour year-round demands for electricity and heat; and expect to be in business for decades to come. These make an excellent match for green energy. The most suitable renewable resources for use within NHS trusts are:

- solar energy – solar electric (PV) and solar water heating;
- wind energy – harnessed using wind turbines;
- biomass (wood) – burning for heat or gasification for CHP;
- hydro power – run-of-river hydropower.

Other renewable technologies, including large-scale hydro, wave and geothermal sources, are not expected to be appropriate for on-site green generation in Wales.

For solar, wind and hydro power sources which have no fuel costs and very low operating costs, once the capital cost has been recovered, the avoided electricity cost savings provide a straight cash benefit.

As an alternative to straight capital purchase of renewable technologies, there are an increasing number of CEM/lease schemes available from suppliers in return for long contracts and shared savings once the capital cost has been recovered:

- **Solar electricity (photovoltaics)**

  The solar photovoltaic (PV) industry is well established and PV systems are very reliable. It is an ideal sustainable energy technology – no moving parts, long life, and it uses a resource that is available throughout the world. In fact the whole of the world's annual energy demand is delivered to the earth by the sun every 18 minutes. There are two drawbacks – the cost and the intermittent nature of the resource. Costs have dropped in recent years as the market expands and they will drop further in the next few years – probably by 40%. In order to support market development, governments offer either premium electricity tariffs or grants. In the UK, the Department of Trade and Industry (DTI) has a three-year grant scheme that is aiming to stimulate 12 MW of installations (current levels in the UK are 0.6 MW). Grants of around 50% are possible.

  Even with the grants, PV projects cannot be justified on cost grounds, but small demonstration projects could be included to engage the stakeholders and demonstrate commitment. It will also give engineering and maintenance staff experience with the technology.

- **Solar thermal**

  The use of solar-thermal hot water heating panels is widely established. Even in winter, panels can make a useful contribution to the pre-heating of domestic hot water (DHW). Solar thermal panels are most effective in raising water temperature from ambient levels (normally 10ºC) to 30 or 40ºC; they become less efficient at higher temperatures. Hospitals can benefit from solar hot water heating more than many other sectors because they have a steady demand for hot water throughout the day – which can allow optimum efficiencies to be maintained by the solar system – if solar pre-heating of hot water is included.

  The principal health trust applications for solar-thermal heating are:

Photovoltaic installation at Bronllys Hospital, Powys. Courtesy of Powys Local Health Board and Welsh Health Estates

1. to provide pre-heating of cold water via pre-heat tanks for supply existing DHW systems;
2. to provide heating for swimming pools and other treatment pools.

Costs have fallen so that reasonable payback periods are possible for the right application. Grant funding is also available to contribute to capital costs. Maintenance costs should be minimal.

- **Wind turbines**

  Apart from large-scale hydro, the wind industry is the most successful and developed of the renewable energy industries. Over the past 15 years, costs have been driven down and electricity can be produced at costs below nuclear and coal. Wind farm developers have gone for sites with the biggest return – hill-top sites in remote areas with as many large wind turbines as possible. Individual wind generator size has increased and now 2 MW systems on 100–150 m towers are commercially available.

  Smaller wind turbines (0.1–50 kW) have been developed for remote power and small energy loads, and these are more suitable for use in urban environments. These are all horizontal-axis rotors, but there is some development work on vertical-axis machines. Smaller, horizontal-axis systems cost in the region of £1000–£1500 per kilowatt and are a low-risk, highly-reliable technology. At this stage of development, the vertical-axis systems should be regarded as high-risk, with high potential for failure.

- **Biomass heat**

  Biomass-fuelled heating is well established in Scandinavia and also in countries such as Denmark and France where biomass fuels are low-cost. In the UK, the Government is supporting attempts to develop the market. At present, costs are high because there is no established market and hence no established biomass fuel supply chain.

  However, the technologies are well proven and automated. Issues of using biomass are to do with additional transport movements and stack height of a biomass boiler. Operating costs would increase because of the higher cost of biomass compared with gas. But biomass can make a very big contribution to CO_2 targets and has one of the lower costs per tonne of CO_2 saved.

- **Biomass gasification of waste and energy crops**

  Disposal of waste is becoming an increasing problem, and landfill disposal costs are set to rise as taxes increase and the UK runs of out space for landfill. Incineration of waste is not viewed with approval by local authorities or the public – even when energy is extracted from the incinerator – and it is becoming increasingly difficult to get approval for incinerators, not least because of the stack height and perception of increased localised emissions.

  Gasification of biomass (either waste or energy crops) is a much more efficient and low-emission process. A number of companies offer gasification equipment, but there is not much commercial operating experience worldwide, and the industry has poor perception caused by failed projects such as the Arbre project in Yorkshire (after an expenditure of £34 million, the company is in liquidation).

  This perception should not detract from the potential of gasification as a technology. For example, Compact Power has developed and now operates a successful waste gasification plant in Bristol. This is a very clean process and has Environment Agency approval. In fact the emissions are so low that it does not require a high stack.

Further information on renewable energy can be found at http://www.dti.gov.uk/renewable. Sources of funding for renewable energy projects are given in Chapter 10 of the main guidance document.

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