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## **Health Technical Memorandum 07-02** *EnCO<sub>2</sub>de – making energy work in healthcare.*

*Environment and sustainability.*

*Part B: Procurement and energy considerations for new and  
existing building facilities*

**2015**

# **STATUS IN WALES APPLIES**

**This is a Department of Health document that applies in Wales with  
the following note attached:**

The policy sections in the document generally refer to English only policy and the document is based upon English specific data and statistics. These, as well as references to English-specific organisations, should be treated with caution when used in Wales.

All technical content in the document is applicable to Wales, and the document's general principles can be applied when followed in conjunction with relevant policy documents and regulatory requirements. However, the previous HTM 07-02:2006 EnCO<sub>2</sub>de guidance remains available through the Specialist Estates Services document archive (and from the link below) and may be used to support the new 2015 documents as a source of useful technical information.

**[Link to HTM 07-02:2006 EnCO<sub>2</sub>de](#)**

**For specific queries about how to apply or interpret the EnCO<sub>2</sub>de guidance documents,  
please contact Christopher Lewis, Environmental Management Advisor, Specialist Estates  
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**Status Note created April 2016**

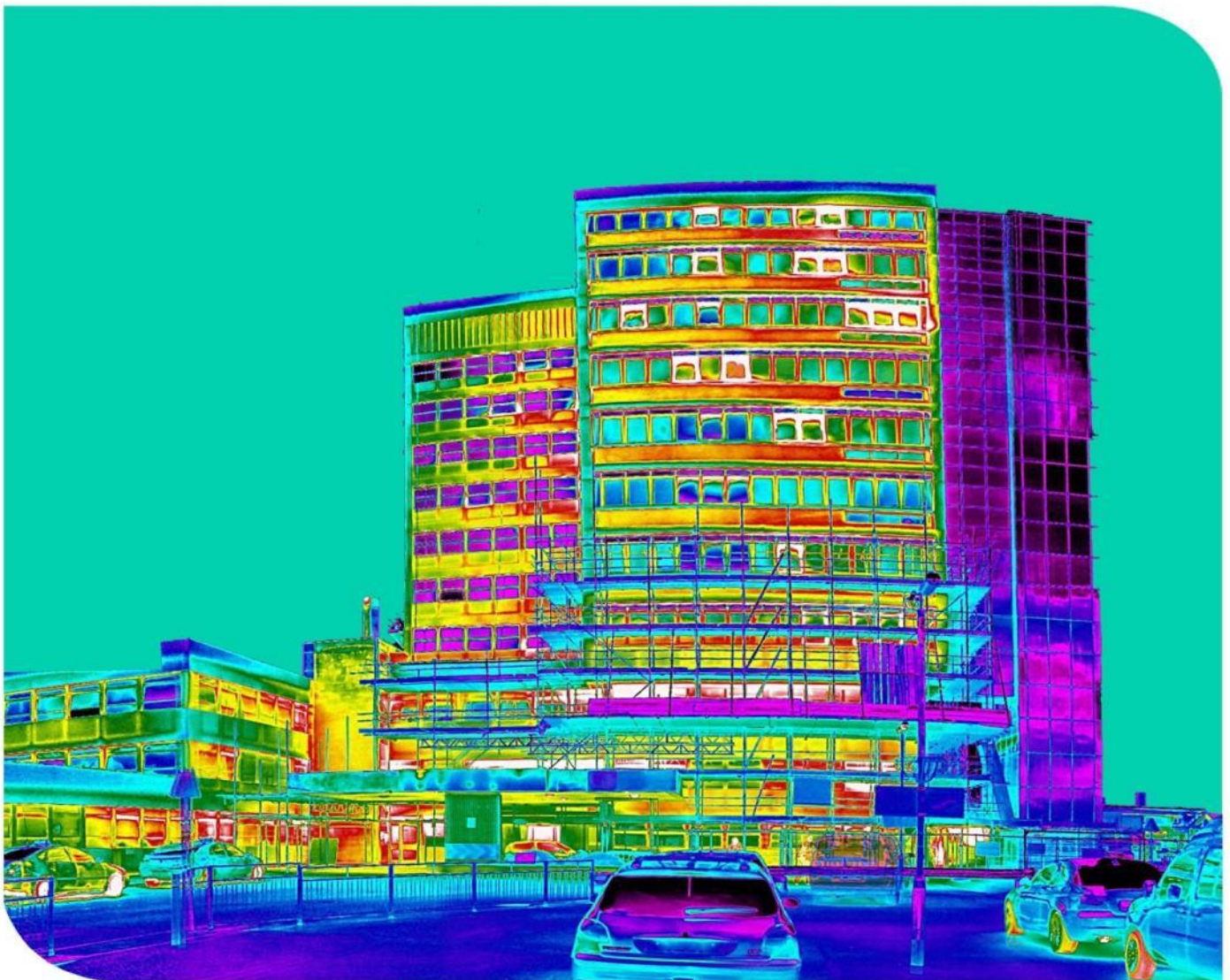


Department  
of Health

# Health Technical Memorandum 07-02: EnCO<sub>2</sub>de 2015 – making energy work in healthcare

Environment and sustainability

*Part B: Procurement and energy considerations for new and existing building facilities*



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# Health Technical Memorandum 07-02: EnCO<sub>2</sub>de 2015 – making energy work in healthcare

## Environment and sustainability

### *Part B: Procurement and energy considerations for new and existing building facilities*

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# Preface

## About Health Technical Memoranda

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 Health Technical Memorandum 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 (see diagram below).

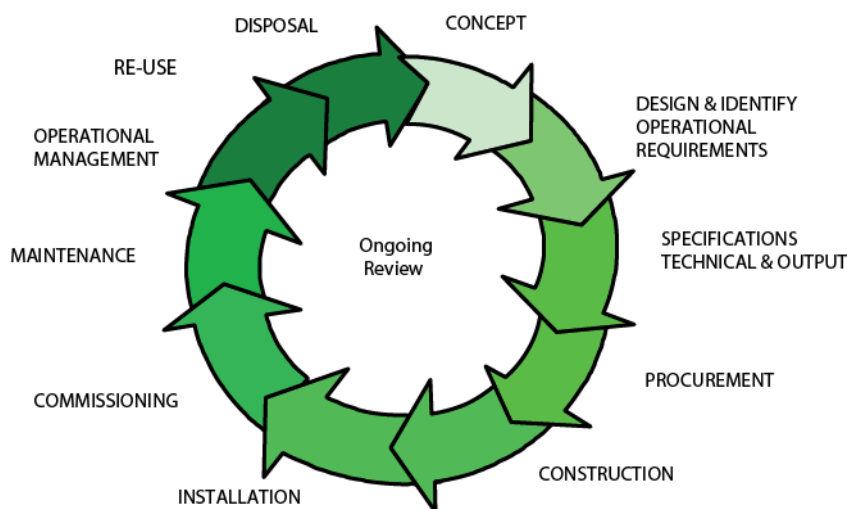
Healthcare providers have a duty of care to ensure that appropriate governance arrangements are in place and are managed effectively. The Health Technical Memorandum series provides best practice engineering standards and policy to enable management of this duty of care.

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 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, technology and sustainability;
- provides a structured reference for healthcare engineering.



## Structure of the Health Technical Memorandum suite

The series contains a suite of nine core subjects:

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

Choice Framework for local Policy and Procedures 01  
Decontamination

Health Technical Memorandum 02  
Medical gases

Health Technical Memorandum 03  
Heating and ventilation systems

Health Technical Memorandum 04  
Water systems

Health Technical Memorandum 05  
Fire safety

Health Technical Memorandum 06  
Electrical services

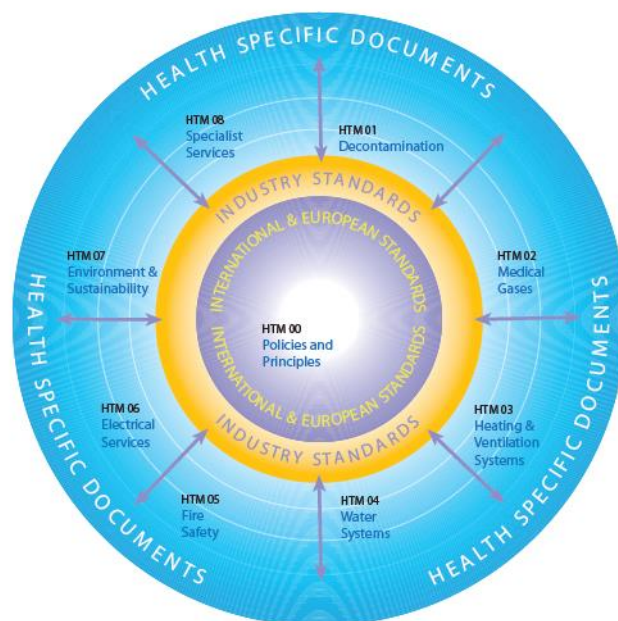
Health Technical Memorandum 07  
Environment and sustainability

Health Technical Memorandum 08  
Specialist services

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 wishes to acknowledge the contribution made by professional bodies, engineering consultants, healthcare specialists and NHS staff who have contributed to the production of this guidance.



## Other resources in the DH Estates and Facilities knowledge series

### Health Building Notes

Health Building Notes give best practice guidance on the design and planning of new healthcare buildings and on the adaptation/ extension of existing facilities.

They provide information to support the briefing and design processes for individual projects in the NHS building programme. All Health Technical Memoranda should be read in conjunction with the relevant parts of the Health Building Note series.

### Activity DataBase (ADB)

The Activity DataBase (ADB) data and software assists project teams with the briefing and design of the healthcare environment. Data is based on guidance given in the Health Building Notes and Health Technical Memoranda.

For ADB technical queries only, contact the ADB Helpdesk. Telephone number: 01939 291684; email:

[support@talonsolutions.co.uk](mailto:support@talonsolutions.co.uk)

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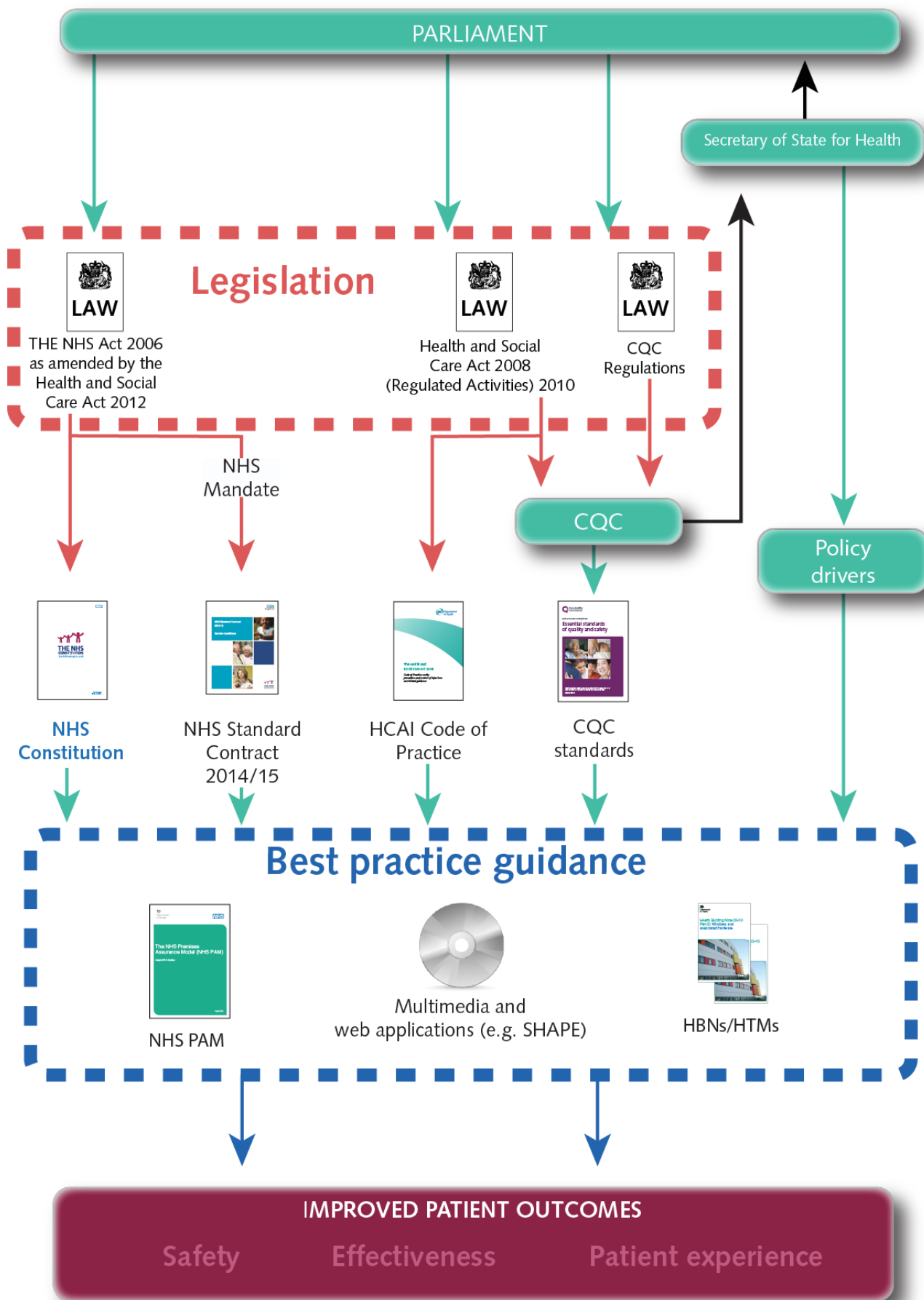
[adblicencerenewals@dh.gsi.gov.uk](mailto:adblicencerenewals@dh.gsi.gov.uk)

### How to obtain publications

Health Technical Memoranda are available from the UK Government's website at:  
<https://www.gov.uk/government/collections/health-technical-memorandum-disinfection-and-sterilization>

Health Building Notes are available from the same site at:

<https://www.gov.uk/government/collections/health-building-notes-core-elements>





# Foreword

The National Health Service (NHS) is responsible for the management of its publicly funded healthcare estate. This includes the provision of an efficient, safe and resilient estate that supports both clinical services and improves the experience that patients have of their care and treatment. It should be a public sector exemplar for the implementation of Climate Change adaptation and mitigation strategies.

The NHS estate has an important contribution to make in reducing running costs and delivering savings for investment in frontline patient care. These must be undertaken to meet the challenges of funding the NHS in the future and will form part of the government's drive to increase the efficiency of the public sector estate in parallel with the dual challenges of an ageing population and Climate Change. A significant step change in the way this estate is managed has to be achieved.

The opportunities for the NHS to achieve efficiency savings and reduced running costs in the estate are considerable. These efficiencies need to be driven by:

- more efficient plus effective running and use of the estate;
- improved efficiency, including value for money, in capital procurement and construction;
- improved energy efficiency and associated carbon reduction.

Building energy use (gas and electricity) is 18% of the NHS England carbon footprint<sup>1</sup> at a metered energy cost of £636 million<sup>2</sup>. This cost equates to approximately 9% of the total estates budget of £7bn.

In 2013/14 the Department's NHS Energy Efficiency Fund (NHS EEF) of £49.3M was

allocated to 117 energy efficiency projects across 48 NHS organisations in England. The Fund enabled the NHS to go further, faster in mitigating the effects of climate change, by improving energy efficiency, whilst retaining the resulting benefits within the NHS organisations for re-investment directly into frontline patient services. The lessons learnt from these energy efficiency projects are embedded in Encode 2015 as best practice guidance.

The current NHS Estates Efficiency programme has the challenge of reducing the current estates budget as part of the contribution to help ensure the continued delivery of a sustainable NHS. Improving energy efficiency of the NHS estate will deliver a contribution to this important initiative whilst also assisting the NHS to meet the necessary reductions in carbon emissions of 34% compared to 1990 levels by 2020.

**Peter Sellars**  
**Head of Profession for NHS Estates & Facilities Policy**  
**Department of Health**

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<sup>1</sup> Sustainable Development Unit - Goods and services carbon hotspots (published 2012)

<sup>2</sup> ERIC 2013/14 returns from the NHS

# Executive summary

## Preamble

*'Health Technical Memorandum 07-02: EnCO<sub>2</sub>de 2015 - making energy work in healthcare'* is the primary guidance on energy efficiency in healthcare facilities in England. It has been produced as a guide to all issues relating to the procurement and management of energy in the NHS and energy efficiency in new build and existing buildings.

Encode 2015 incorporates the learning from projects implemented under the NHS Energy Efficiency Fund (EEF) which was undertaken during 2013/2014. Encode 2015 has been written by the University of Cambridge Department of Architecture and the University of Cambridge Centre for Sustainable Development in the Department of Engineering. It incorporates their observations and examples of good practice following their role of monitoring the differing nationwide EEF projects.

Encode 2015 is not prescriptive. It draws together best practice guidance so that healthcare organisations can determine a way forward that best suits their situation.

Encode 2015 replaces all previous versions of Health Technical Memorandum 07-02: making energy work in healthcare.

Encode 2015 is published in two parts:

- Part A deals with the policy context, organisational carbon management, building energy management and behaviour change in healthcare environments.
- Part B covers energy efficiency in new build and the refurbishment of existing buildings, as well as energy efficient building services and low and zero carbon technologies.

## Introduction

The Intergovernmental Panel on Climate Change highlights three major issues: that warming in the climate system is unequivocal, that the effect of humans on the climate is clear, and that climate change mitigation requires significant reduction of greenhouse gas emissions.

This poses a double challenge for healthcare facilities:

- to reduce their carbon emissions and contribute to the national and NHS targets for climate mitigation, identify opportunities for adapting to expected climate change and build resilience to extreme climate events;
- to support resilient communities including planning services for expected changes in health needs and providing high quality healthcare particularly focusing on needs during adverse climatic conditions.

Encode 2015 sets the foundations for meeting this challenge and for assisting in the delivery of a resilient healthcare estate as detailed in [HBN 00-07: Planning for a resilient healthcare estate](#) (published April 2014).

## Aim of the guidance

The aim of Encode 2015 is to ensure that everyone involved in managing, procuring, designing and using buildings and equipment thinks about the implications of energy use and carbon reduction whilst putting patients first; today and in the future. In short, it puts climate change mitigation and adaptation at the heart of the health service.

## Who should use this guidance?

The audience of this Encode 2015 includes those managers involved in the strategic,

and day to day, management of energy consumption, energy efficiency and carbon reduction within their organisation. It is also includes those responsible for the procurement, design, construction and handover 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.

### **Main changes from Encode 2006**

This Health Technical Memorandum has been revised to reflect the latest carbon reduction targets set on a national and NHS level. It includes an update on the latest low and zero carbon technologies and lessons learnt from their use to date. Encode 2015 has a major contribution regarding the refurbishment of existing buildings and provides relevant information combined with the outcomes and lessons learnt from the NHS Energy Efficiency Fund, which financed 117 energy efficiency projects delivered through 2013 to 2014 in 48 NHS organisations.

### **Other key issues – Recommendations**

- It emphasises the need for an organisation to have a Sustainable Development Management Plan including sections on energy and carbon management and environmental policy. This should be board approved with updates annually by an 'energy champion' who sits on the board.

- It highlights the importance of energy and carbon management at an organisation level and the significance of feedback mechanisms in this process.
- It highlights the significance of patients' comfort in healthcare buildings, especially under adverse weather conditions affected by climate change.
- It provides information on the policies related to energy efficiency and carbon reduction in healthcare organisations.
- It provides a project design checklist that it recommends should be used during the design, construction and handover 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 provides information on the refurbishment of existing building facilities, the evaluation of different options and potential challenges faced during this process.

Chief executives should ensure that:

- Encode 2015 is distributed to board members and departmental leaders;
- Departmental leaders brief their colleagues and staff on the specific recommendations set out in Encode;
- Encode 2015 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.

# Acknowledgments

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Philip Ashcroft, Department of Health  
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Julie Braidwood - Crown Commercial Service  
**Robert Cohen**, Verco Advisory Services  
**Kathryn Dapre**, NHS Facilities Scotland  
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**Carbon Trust**  
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**CIBSE**  
**Paul Davidson**, DECC  
**Joseph Little** of Building Life Consultancy  
**Philip Steadman**, UCL  
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# 1 Sustainable procurement

## 1.1 Introduction

**1.1.1** Healthcare organisations purchase a wide range of goods and services in connection with their activities and premises. This chapter is concerned with setting out policies and practices to ensure awareness of sustainability criteria in decision making about procurement at all levels in an organisation.

**1.1.2** As the largest public sector employer in the UK and the one with the largest carbon footprint, the NHS has the potential and indeed the responsibility, to lead change and promote the creation of a more sustainable economy.

**1.1.3** By procuring more sustainably, the NHS can help to reduce the UK's environmental impacts including its emissions of greenhouse gases and improve people's health and quality of life.

**1.1.4** Sustainable procurement can:

- stimulate demand for innovative and more energy efficient buildings, products and services;
- increase uptake of the best products on the market and, through increased demand, help to reduce their cost through economies of scale;
- support 'best practice';
- increase competition and reduce prices.

**1.1.5** Sustainable procurement and purchasing involves effective engagement with suppliers, establishing appropriate purchasing policies, being clear in what you want, supporting innovation and ensuring sustainability is treated as a relevant criterion in all purchasing decisions.

**1.1.6** Government's policy paper **Procuring the future** offers the following definition: 'Sustainable Procurement is a process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole

life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment.'

**1.1.7** A footnote adds:

'Sustainable Procurement should consider the environmental, social and economic consequences of: design; non-renewable material use; manufacture and production methods; logistics; service delivery; use; operation; maintenance; reuse; recycling options; disposal and suppliers' capabilities to address these consequences throughout the supply chain.'

**1.1.8** Sustainable procurement makes sound business sense, for only when the whole life cost of goods and services is taken into account will true value for money be achieved. These whole life costs include not just the initial purchase price, but also operating costs and environmental impact, such as atmospheric pollution, greenhouse gas emissions and end of life.

**1.1.9** Procuring sustainably needs to be given high priority, incorporated into policies, promoted in practice and communicated to staff and stakeholders including suppliers.

**1.1.10** The basic steps in the procurement process are:

- identification of need and preparation of the business case;
- choice of contract route, i.e. Procure 21, Local Improvement Finance Trusts (LIFT), Private Finance Initiatives (PFI), Energy Performance Contracts, lease payback, conventional, or payback;
- specification;
- appraisal and qualification of suppliers;
- invitation to tender;
- tender evaluation;
- award and negotiate contract;
- contract management and review.



**1.1.11** Sustainability issues should be considered at each of these steps. This chapter therefore includes:

- an overview of the principles of procuring for energy efficiency in the context of overarching public procurement regulations and best practice;
- 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 inviting and evaluating tenders, including signposting of a range of key resources depending on what is being procured.

**1.1.12** 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).

**1.1.13** It is important to be aware that Encode is intended as a guidance and signposting document. It is not and should

not be used as, a comprehensive or definitive technical manual. Appropriate legal, financial, contractual and/or technical advice should be sought from the sources it signposts and/or from those with appropriate expertise and experience.

## 1.2 Principles of procuring for energy and sustainability issues

**1.2.1** 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’. Box 1 presents a summary of HM Treasury’s guidance. You may need to check whether Treasury Guidance is applicable to your circumstances.

**1.2.2** Box 2 presents a summary of the Government’s Common Minimum Standards for the procurement of built environments in the Public Sector.

### Box 1 HM Treasury Green Book

**The Green Book: Appraisal and Evaluation in Central Government** is a best practice guide on how publicly funded bodies should prepare and analyse proposed policies, programmes and projects to obtain the best public value and manage risks. It describes how economic, financial, social and environmental assessments of a project should be combined. The Green Book draws attention to the ROAME appraisal and evaluation method:

- Rationale – identification of the business need, assurance that the project is worth the cost;
- Objectives – setting out the desired objectives and outcomes to identify the range of options available to deliver them;
- Appraisal – based on the identification of options (including the ‘do minimum’ option) and detailed appraisals of their respective costs and benefits;
- Monitoring – following option appraisal, the best option should be refined into a solution for implementation, with procurement routes considered;
- Evaluation – taking place after implementation, the purpose of evaluation is to find out how well the original objectives have been achieved and ensure the lessons are widely learned when assessing new proposals.

The Green Book contains extensive practical advice in support of all these stages, with

specific emphasis on methods for analysing costs and benefits including non-monetary benefits. A wide range of supplementary Green Book guidance is also available on the [Green Book website](#).

## NHS Standard Contract

**1.2.3** The NHS Standard Contract is mandated by NHS England for use by commissioners for all contracts for healthcare services other than primary care. The 2014/15 NHS Standard Contract is available for use by commissioners both in paper form and as an electronic document through the eContract system. Information and technical guidance about its use is available in the [NHS Standard Contract website](#).

### Box 2 Government Construction: Common Minimum Standards for the procurement of built environments in the Public Sector

Government's Construction Strategy calls for the use of integrated supply teams working constructively with clients to drive out waste and with the aim to reduce the cost of construction by 15-20%. Its provisions include procurement routes that support integrated team working, the use of regular progress reviews, checks on supplier competence and health & safety performance, a commitment to design excellence and to the principles of environmental sustainability including use of an appropriate environmental assessment process appropriate to the nature and scale of the project.

Website:

<https://www.gov.uk/government/publications/common-minimum-standards>

## 1.3 EU Procurement Directives and their implementation (known as transposition)

**1.3.1** All public procurements in the UK have to comply with the relevant principles of the EU Treaty and contracts with a value above certain thresholds are subject to the

procedural rules in the EU Procurement Directives.

**1.3.2** The core requirements of the EU Procurement Directives are transparency and non-discrimination. Transparency requires equality of information for all potential bidders. Above EU thresholds, all contract opportunities must be advertised in the Official Journal of the European Union (OJEU). Pre-qualification criteria, specifications and evaluation criteria must be clearly and openly stated before bids are invited. Unsuccessful bidders are entitled to debriefing, whilst the identity of successful bidders must be announced on contract award. Non-discrimination requires that all EU public sector opportunities are open to competition by all EU suppliers, regardless of country of origin; contracts cannot be awarded on the basis of location or nationality. Finally, all pre-qualification criteria, specifications and evaluation criteria must be relevant to the subject matter of the contract.

**1.3.3** EU Procurement Directives are implemented (or transposed) into UK procurement regulations. More information, together with training material, can be found on the [gov.uk website](#). The [Crown Commercial Service](#) (CCS) also provides training.

## 1.4 Intangible non-monetary health benefits

**1.4.1** Good design of facilities or equipment can contribute to physical and mental health and to well-being, of both staff and patients. In buildings, natural daylight, views to the outside, thermal comfort, good ventilation, a calm and quiet environment and perceptions of cleanliness, are typical criteria. Well-designed buildings affect staff morale, goodwill and performance and engender a sense of pride, with the further potential to

improve staff recruitment and retention. Benefits to patients may include quicker recovery rates, leading to increased patient throughput. At best, good design is part of a virtuous circle in which well-motivated and satisfied staff contribute to good patient recovery rates, see Box 3.

## 1.5 Resilience

**1.5.1** Resilience is the ability of an organisation to continue to function when faced with hazard, threats, or other disruptive changes. Climate change, with its associated risks of storms and gales, increased rainfall intensity, greater extremes of ambient temperatures, flooding and even wild fires, is a key hazard. **Health Building Note 00-07 2014 Planning for a resilient healthcare estate**, provides extensive advice on risk assessment, resilience planning and the design of more resilient facilities. It recommends that resilience is considered early and then throughout any procurement process, with particular attention paid to flexibility in facility design to accommodate surge capacity and peaks in demand.

## 1.6 Taking a 'whole life cost' approach

**1.6.1** Value for money is achieved by the optimum combination of 'whole life cost' and fitness for purpose to meet users' requirements. Value for money is not

synonymous with lowest initial price. Rather, organisations should seek the best option based on the specification they have set out to meet their needs.

**1.6.2** In considering a whole life-costing approach, healthcare organisations should be aware that equipment and facilities may have an initial higher purchase cost but, when its whole life running cost is taken into account, 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.

**1.6.3** Whatever the procurement route chosen, there should be provision for energy efficiency measures as part of the evaluation process, for example to:

- 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 in respect of energy conservation and/or climate change.

### Box 3 Evidence for the impacts of good environmental design

A study on **the role of the physical environment in hospitals** sets out the evidence base from the medical literature for a wide range of benefits including:

- Reduced staff stress and fatigue and increased effectiveness – from good ventilation, low noise and good equipment ergonomics;
- Improved patient safety including reductions in hospital acquired infections – from good air quality, hand-washing facilities and single-bed wards;
- Reduced stress and improved patient outcomes – from less noisy equipment, acoustic design to reduce ambient noise levels, good signage and way-finding systems and positive distractions provided by art or music;
- Improved overall healthcare quality, including reduced length of patient stay – from good daylight levels and views of nature.

An acknowledged issue with these types of benefits is they are 'hard to measure' or intangible and therefore difficult to translate into monetary terms. Nevertheless they are significant and evidence of intangible benefits will help to sustain the business case in favour of good design and ergonomics.

Further information can be found in [Health Building Note 00-01 General design guidance for healthcare buildings](#).

## 1.7 Collaborative purchasing power: procurement services

**1.7.1** For most procurement needs, there is no need to start from a blank sheet or re-invent the wheel. Many others will have faced similar issues to the ones you face and there may be off the shelf solutions. By identifying and collaborating with similarly situated organisations you can exercise collaborative purchasing power and gain the benefits of shared expertise as well as greater leverage and economies of scale. The Crown Commercial Service is an example of a public sector procurement organisation, see Box 4.

## 1.8 Procurement services in Scotland

**1.8.1** In Scotland, [National Procurement](#) (NP) is the centre of procurement expertise for health established as part of the wider procurement reform activity across the

Scottish Public Sector. NP operates through teams in Logistics, Sourcing, eProcurement and Programme Management. National contracts and combined buying power ensure the best deals on goods and services and NP offers a range of web-based procurement tools.

## 1.9 Procurement services in Wales

**1.9.1** In Wales, the National Procurement Service (NPS) is an initiative of the Welsh Government, working on behalf of the public sector and seeking to find the best available deals in common and repetitive spending areas. The categories of business served are:

- ICT;
- Fleet and transport;
- Professional services;
- Corporate and business support services;
- People services and utilities;
- Construction and facilities management.

### Box 4 Crown Commercial Service

The Crown Commercial Service is one of several public sector procurement organisations with a wide range of options to help the public sector to buy a variety of goods and services. The options available include:

1. Self-service options: framework agreements and the eMarketplace
2. Procurement support: spot buy, eAuctions and managed contract service
3. Fully managed services
4. Advice and Guidance on large and complex procurement projects, commercial intelligence and cross government work.

CCS resources include a range of procurement tools including eSourcing and electronic request for quote (eRFQ).

The CCS has in place a range of framework agreements with suppliers, with terms and conditions already established that meet government best practice standards for procurement. A good first step is to identify whether a CCS framework already exists for the goods or services that you require. If so, you will be able to gain all the benefits from economies of scale that centralised purchasing offers and avoid the need (and the associated risks) of devising your own form of procurement agreement. As of November 2014, CCS has in place more than 80 framework agreements, under headings that

include:

- Construction;
- Energy;
- Vehicle fleet;
- ICT;
- Office supplies;
- Property;
- Travel.

Other frameworks are in the process of being negotiated.

**1.9.2** Value Wales is a separate organisation from the NPS and seeks to improve public procurement on goods and services. Value Wales is responsible for shaping procurement policy, monitoring procurement practice, supporting and advising procurement professionals, developing the procurement profession and compliance with EU regulations. Value Wales oversees the Welsh Government's procurement through the Corporate Procurement Service (CPS) and is a customer of the NPS in the area of common and repetitive spend.

**1.9.3** Serving the health sector in Wales, the NHS Wales Shared Services Partnership (NWSSP) is an independent organisation, owned and directed by **NHS Wales** and which provides a comprehensive range of high quality, customer focused support functions and services including procurement. NWSSP's **Procurement Services** provide a sourcing, supply chain, purchasing and accounts payable service to health boards and NHS trusts across Wales, while supporting the Welsh Government in the deployment of its procurement strategy and providing procurement expertise in specialist project areas.

**1.9.4** **Designed for Life: Building for Wales** is a framework for construction procurement and delivery operated by the NWSSP under its Facilities Services. The framework is applicable to major capital projects with a total cost in excess of £6 million. The framework is based on the principles of:

- Integrated Supply Chains;
- Collaborative Working;

- Continual Improvement.

**1.9.5** The overarching Framework Agreement is between each Framework member and the Welsh Government and separate Project Agreements are entered into between the NHS Trust and their selected Framework partners.

## 1.10 Procurement services in Northern Ireland

**1.10.1** Health and Social Care Organisations in Northern Ireland are required to carry out their procurement activities by means of documented Service Level Agreements (SLA) with the Department of Finance and Personnel (DFP) Central Procurement Directorate or a relevant accredited Centre of Procurement Expertise (CoPE). This is to ensure that procurement is compliant with EU and UK legislation and is efficient, effective and in line with best practice.

**1.10.2** Capital Construction Projects for Health with a value greater than £500K, shall be procured through the CPD-Health Projects CoPE.

**1.10.3** Capital Construction Projects with a value less than £500K may be procured by the individual organisation by following the mandatory requirements of the Estates Procurement Manual Version 5 issued under PEL(13)10.

**1.10.4** Goods and Services for the HSC shall be procured through Business Service Organisation (BSO) Procurement and

Logistics Service (PALS) - the accredited CoPE for this service.

- supported by clear objectives and performance indicators;
- owned by those responsible for delivering its commitments.

## 1.11 Policy issues

**1.11.1** Environmental purchasing needs to reach all parts of the organisation. A clear policy that commits your organisation to the inclusion of sustainability/environmental/energy efficiency criteria in its procurement practices will help to ensure that all parts of the organisation are sending consistent messages to suppliers. It will also help to ensure that your suppliers are aware of your commitment to sustainability and that budget holders include sustainability criteria in their purchasing and procurement practices and do not ignore or reject environmentally preferable alternatives without due consideration to the impact of their decisions.

**1.11.2** 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 environmental or sustainability strategy;
- backed by board-level commitment; well communicated throughout the organisation;

**1.11.3** The example in Box 5 is a template for a purchasing policy that supports environmental sustainability, which is the starting point for any healthcare organisation seeking to ensure that they procure energy efficient buildings, equipment and services. It may need adapting to suit local circumstances.

**1.11.4** Government Buying Standards (GBS) were developed by the Department for Environment Food and Rural Affairs (DEFRA) as a set of easy to use product specifications for public sector procurers. Box 6 presents a summary of GBS and the government website provides additional [sustainable procurement tools](#).

## 1.12 Sustainable Development Unit advice on sustainable procurement

**1.12.1** The Sustainable Development Unit provides extensive advice on sustainable procurement, see Box 7.

### **Box 5 Sample procurement policy for environmental sustainability**

**[Name of organisation]**

#### **Procurement Policy for Environmental Sustainability**

##### **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;
- the expectations of stakeholders – at international, national, regional and local levels – as part of the UK's wider commitment to sustainable development.

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 meet these responsibilities, while paying due cognisance to EU rules and domestic policy governing public procurement, we shall:

- 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;
- 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;
- communicate this policy widely to suppliers, employees and other key stakeholders and periodically report on progress in the public domain.

### **Adherence to Government Buying Standards**

Across all areas covered by Government Buying Standards we shall comply with these standards and at the best practice levels wherever it is possible and practical to do so.

This policy was agreed by [e.g. 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 [e.g. internal audit] is responsible for monitoring and reporting on compliance to [e.g. 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: .....

### Box 6 Government Buying Standards

Across the public sector, **Government Buying Standards** are mandatory for central government departments and encouraged for the wide public sector. They have been endorsed by the Sustainable Development Unit. Specifications for the following product groups are available on the GBS website. They represent easy-to-use specifications for public procurers and include mandatory and best practice levels. Each product group comprises a number of different products within the group:

- **cleaning products and services;**
- **electrical goods;**
- **furniture;**
- **horticulture and park services;**
- **office ICT equipment;**
- **paper and paper products;**
- **textiles;**
- **transport (vehicles);**
- **construction projects and buildings;**
- **water-using products;**
- **food and catering services.**

### Box 7 The Sustainable Development Unit Procuring for Carbon Reduction (P4CR) initiative

The Sustainable Development Strategy for the NHS, **Sustainable, Resilient, Healthy People & Places** is supported by a module on Commissioning and Procurement (<http://www.sduhealth.org.uk/areas-of-focus/commissioning-and-procurement.aspx>).

Sustainable procurement requires the health and care system to work in partnership with suppliers and the supply chain to take into account the whole lifecycle, environmental, social and ethical impact of procured goods and services. It takes into account the carbon emissions released and resources used at all stages of the products life i.e. from extraction, processing, manufacture, distribution, use and disposal or recovery. Procuring for Carbon Reduction is a pragmatic approach to sustainable procurement.

The P4CR Toolkit includes:

- a **roadmap** in the form of a slide set with an overview of the P4CR programme showing the scale of the challenge to keep NHS in line with regulatory UK carbon emissions reduction targets
- a **Guidance and Toolkit** workbook based around a **flexible procurement framework**
- a **supply prioritisation tool** to allow organisations to calculate an approximate carbon footprint using expenditure data category by category

Other P4CR tools include self-assessment methods, a spreadsheet for analysis of the energy efficiency of medical devices and a power point presentation of possible interventions.

The P4CR **Guidance and Toolkit** document recommends a four stage process:

1. Identify a sustainability champion, ideally holding a senior management role, so they have access to resources, communication channels and a broad



understanding of other policies and strategies.

2. Benchmark your organisation against the P4CR Flexible Framework to determine its strengths and weaknesses and to help identify priorities issues for action.
3. Use the P4CR SCO<sub>2</sub>PE tool to start identifying carbon hotspots among your different areas of expenditure.
4. Start to raise awareness of sustainability issues using a shared terminology; build confidence and capacity among key procurement staff and promote dialogue with other key stakeholders.

The P4CR **Flexible Framework** emphasises five key areas:

- Policy and Communication: a strong business case endorsed by senior management and communicated to key procurement staff;
- People: Senior level champion to develop, implement and monitor sustainable procurement;
- Procurement Process: identification and prioritisation through measurement and monitoring;
- Engaging Suppliers: structured supplier engagement process;
- Measuring and results: implementation is reviewed with results reported internally and externally with comparisons against peer organisations.

The Flexible Framework is presented in the form of a matrix in which each of these five areas is summarised at each of five maturity levels, allowing progress towards best practice to be reviewed. The Guidance and Toolkit provides wide-ranging advice on how to improve policies and practices and so develop increasing maturity across the organisation.

we need to buy in expertise or outsource?

## 1.13 Where to start procurement to protect energy efficiency

**1.13.1** Possible starting points in the procurement process are to ask yourself the following questions:

- Has someone else done the same thing before? If so, how did they do it and what was the outcome?
- Are there existing call-off frameworks with suppliers? If so, can we join them?
- Is there someone else who wants to do the same thing? If so, are the opportunities to benefit from collaborative purchasing power?
- What are our current consumption levels of energy and what is our current extent of avoidable waste?
- What are our current resources and do we have the in-house expertise to manage our use of energy effectively? If not, can we provide training? Or do

## 1.14 Option appraisal: evaluation techniques for procurement

**1.14.1** 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).

**1.14.2** Options appraisal is an iterative process. Some options may be eliminated

early in the process because of 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.

#### 1.14.3 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 to avoid abortive work being undertaken on traditional but poorer-value design solutions.

**1.14.4** 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;
- assessing and apportioning risk.

## 1.15 Techniques for financial assessments

**1.15.1** There are four well-established techniques for analysing procurement decisions based on value for money: simple payback, discounted cash flow, net present value and internal rate of return, see Box 8.

### Box 8 Techniques for assessing cost effectiveness

**1 Simple payback:** 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. Simple payback is useful as a quick ‘back of an envelope’ assessment to identify the viability of particular energy efficiency measures. However, it 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 underinvestment and a failure to seize good investment opportunities where payback periods are longer than anticipated.

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.

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.

**2 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>

**3 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.

**4 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.

## 1.16 Whole life costing

**1.16.1** 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.

**1.16.2** 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.

**1.16.3** Any WLC exercise should therefore consider:

- 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, reusable, recyclable, includes disposal costs, or is free of hazardous materials which would otherwise require its disposal in a special way.

**1.16.4** 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;
- reduced maintenance and staff costs after replacing or upgrading plant;

- reduced harmful emissions to the atmosphere (CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub> 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, well-being and productivity.

**1.16.5** The final item in that list is often missed but is commonly one of the greatest benefits. A combination of benefits can result from a virtuous circle – a well-managed environment, optimum levels of energy efficiency, leading to occupants satisfied with their environment and raising their well-being and 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.

**1.16.6** 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.

**1.16.7** WLC allows for the differences between certain quality principles to be taken into account. For example (subject to meeting 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.

**1.16.8** Whole life costing for buildings and constructed assets is dealt with in detail in

International Standard **BS ISO 15686** – see Box 14.

## 1.17 Tender evaluation

**1.17.1** Criteria for evaluating the economically most advantageous tender should be stated in the invitation to tender. Price and quality issues should be weighted separately. They should include:

**Value criterion:**

- price;

**Quality criteria:**

- 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.\*

**1.17.2** Criteria marked with \* are those under which low carbon technologies or carbon emissions could be weighted and scored, provided tenderers are told in advance. It is important that any environmental criteria used are relevant to the subject-matter of the contract. Client requirements for energy and environmental criteria should be stated in the outline specification that carries forward into the invitation to tender (ITT).

**1.17.3** There are two further points:

- 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.

## 1.18 Procuring equipment, services and fuel

**1.18.1** 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.

**1.18.2** 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).

**1.18.3** 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. 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.

## 1.19 Eco-labelling

**1.19.1** The International Organization for Standardisation (ISO) has identified three broad types of voluntary environmental performance labelling as follows:

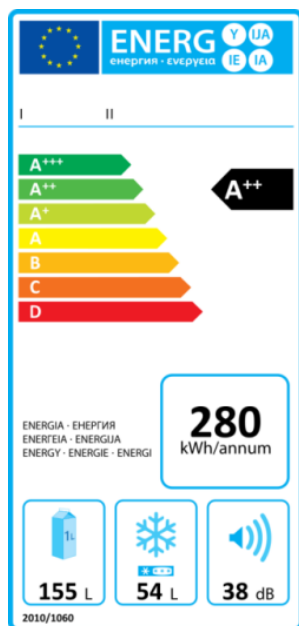
- Type I** a voluntary, multiple-criteria based, third party program that awards a license that authorises the use of environmental labels on products indicating **overall environmental preferability** of a product within a particular product category based on life cycle considerations;
- Type II** informative environmental **self-declaration** claims;
- Type III** voluntary programs that provide quantified environmental data of a product, under **pre-set categories** of parameters set by a qualified third party and based on life cycle assessment and verified by that or another qualified third party.

**1.19.2** Although differing in strength and authority, the different label types have been identified by the ISO as sharing a common goal, which is: '...through communication of verifiable and accurate information that is not misleading on environmental aspects of products and services, to encourage the demand for and supply of those products and services that

cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement.’

**1.19.3** Eco-labelling fits under the Type I designation. In the case of household products, many of which are likely to be used in healthcare facilities, there is a mandatory EU energy labelling scheme that applies to:

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



**Figure 1** Example of a European Union energy label for a refrigerator

**1.19.4** 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 D-rated products are the least efficient. The US Energy Star rating can also be found on many products.

**1.19.5** Relevant eco-label standards may 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:

- 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 a specific eco-label standard, the specification should clearly state that compliance with the standard or similar will be acceptable.

## 1.20 Contract/supplier management

**1.20.1** 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.

**1.20.2** 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, environmentally preferable products and services and these benefits should be available to purchasers.

## 1.21 Fuels

**1.21.1** 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.

**1.21.2** 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 combined heat and power (CHP), or 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?

**1.21.3** 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. (If you are considering interruptible supplies, be aware of their possible impact on service requirements and resilience.

**1.21.4** 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.

## 1.22 Energy Performance Contracts and ESCos

**1.22.1** Energy Performance Contracts involve a contractor, known as an Energy Service Company (ESCO), devising and implementing energy efficiency projects intended to achieve specified energy savings. When combined with third party financing, the intention is that the value of energy savings will exceed the cost of repaying the third party capital. ESCOs are likely to be energy supply companies, facilities management companies, or equipment manufacturers (such as energy controls companies) and of a size to be able to offer a credible performance guarantee. ESCOs identify appropriate energy efficiency measures, develop and install them and guarantee that a set level of energy savings will be achieved. In some cases they arrange finance to pay for the projects, with repayments less than the value of the resulting savings.

**1.22.2** The approach has been widely promoted in UK and internationally, but the main barriers are the long term nature of the payback periods, the likelihood of changes in the quantity and pattern of energy usage over time and for both these reasons, the inherent long term and complex nature of the agreements needed between client and ESCo. Negotiations may be prolonged and legal costs are likely to be high.

**1.22.3** Once a contract is in place, significant resources may be needed to manage it. It is important to ensure that you have an exit strategy in place in case the performance of the implemented measures

fails to match your original expectations. A risk assessment should be undertaken to review possible outcomes under different scenarios, such as changes in demand, changes in energy prices and underperformance of the technical measures implemented. Alternatives to using an ESCo are to earmark and use savings achieved through energy management to purchase new efficient energy technologies, or to purchase the equipment from other internal funding sources, or even to borrow from a third party. Unlike electricity which is regulated, heat supply is unregulated; so if the ESCo becomes bankrupt, there is the possibility of losing your heat supply.

**1.22.4** As part of the UK Government's promotion of Energy Performance Contracting, The **Department of Energy and Climate Change** (DECC) issued **A guide to energy performance contracting best practices** in January 2015.

## 1.23 Finance: loans for energy investment

**1.23.1** The Energy Efficiency Deployment Office (EEDO), located within the DECC, has recently published **A guide to financing energy efficiency in the public sector**. This guide outlines some of the ways by which public sector budget holders can secure funding for energy efficiency measures. The guide is intended to help public sector organisations appreciate the benefits of energy efficiency and help them to overcome the barrier that access to finance can sometimes present. In addition to summaries of Salix and the Green Investment Bank (described below) the guide also covers Public Sector Borrowing opportunities, RE:FIT and European funding sources. There is advice on incentivising facilities management contracts, on measurement and verification of achieved energy benefits and a selection of case studies illustrating various financial arrangements.

**1.23.2** The **Salix Finance Scheme**: Salix is a not-for-profit organisation funded by the DECC, the Department for Education, the Welsh Government, the Scottish Government and the Higher Education Funding Council for England. Salix provides interest-free capital to public sector organisations to help reduce their energy costs by enabling the installation of energy efficient technologies. Over 120 technology types are supported including building energy management systems, cavity wall insulation, CHP systems, evaporative cooling, heat recovery systems, LED lighting, lighting controls, loft insulation, pipework insulation, server virtualisation, T5 lighting and variable speed drives. Once the loan has been repaid, future savings accrue to the organisation.

**1.23.3** The **Green Investment Bank**: The Green Investment Bank (GIB) was created by the UK Government, to provide funding to support green projects, on commercial terms, across the UK and mobilise other private sector capital into the UK's green economy. The bank supports building retrofits, on-site generation and infrastructure projects such as street lighting and heat networks and projects can combine multiple technologies.

**1.23.4** GIB has developed the GIB Health Sector Energy Efficiency Programme tailored to the needs of the NHS and claimed to be priced competitively, long term (up to 25 years) and highly flexible. GIB has earmarked several hundred million pounds to back NHS energy efficiency projects through financial partners and direct GIB lending.

**1.23.5** A specific example is the energy innovation centre in Cambridge serving Addenbrooke's and Rosie hospitals. Here a £36 million funding package led by GIB and Aviva Investors is a 25 year contract. Providing a combined heat and power unit, biomass boiler, dual fuel boilers and heat recovery from medical incineration, the innovation centre will reduce costs by £6



million a year before capital and interest repayments.

**1.23.6** A market report **A healthy saving: energy efficiency and the NHS** is available from the GIB website.

## 1.24 Maintenance contracts and the optimisation of performance and efficiency

**1.24.1** Maintenance of the services and fabric of healthcare buildings is essential to ensure optimum performance and efficiency. In this sense, buildings are like cars: everyday usage leads to gradual drift or decline in efficiency which is often invisible unless careful checks are undertaken. Unfortunately without the demands of an MoT test, so long as continued operation and comfort levels are reliably achieved, there is sometimes little or no incentive for those responsible for maintenance and operation to ensure specified conditions are being achieved without unnecessary waste.

**1.24.2** To counter the risk of avoidable waste, maintenance contracts need to include clauses designed to ensure ongoing efficient operation with periodic checks built in. For example, a rigorous check should be undertaken annually of the mechanical, electrical and plumbing systems to ensure timers, programmers, switches and controls are set up correctly and operating properly to deliver specified conditions where, when and to the extent required by occupants. Unnecessary provision, for example at night and at weekends (unless required by operational needs) should be prevented by control settings. Settings, timings and achieved conditions should be systematically documented.

**1.24.3** 'Like for like' replacement of unserviceable items should be discouraged. Instead, as and when components and systems become obsolete and need to be replaced, new and improved alternatives should be investigated for their suitability

and installed wherever they will result in improved performance and less waste.

**1.24.4** The Building Services Research and Information Association (BSRIA) publishes **a guide to the procurement of a maintenance regime for building services**.

### ISO 14001 Environmental Management Systems

**1.24.5** ISO 14001 is an internationally accepted standard that outlines how to put an effective Environmental Management System (EMS) in place. It is intended to help organisations reduce their waste and avoid unnecessary use of energy, potentially driving down costs and demonstrating corporate social responsibility. The Standard does not state requirements for environmental performance, but maps out a framework that a company or organisation can follow to set up an effective EMS. Related standards focus on specific environmental aspects such as life cycle analysis, communication and auditing. Further information is available from the ISO website.

### BS EN 15221 Facilities Management

**1.24.6** BS EN 15221 is a suite of standards concerned with facilities management. The suite includes standards concerned with terms and conditions, quality and how to prepare facilities management agreements. Part 7: Guidelines for Performance Benchmarking refers to energy management data as part of an overall assessment, benchmarking the effectiveness of facilities management.

### European Legislation and its effect on procurement

**1.24.7** Procurement rules established by the European Union govern the way in which public bodies purchase goods, services and works and seek to guarantee equal access to and fair competition for, public contracts within the EU market. At

the time of writing the relevant EU directive on public procurement is Directive 2014/24/EU and is available in the [Official Journal of the European Union](#).

**1.24.8** A briefing on the Directive on procurement and its implications prepared by the NHS European Office is [available](#).

**1.24.9** The implementation of the Directive came into force on 26 February 2015 in the form of the Public Contracts Regulations 2015 and all NHS organisations need to comply with them when purchasing goods and services. Guidance notes and support resources to help organisations comply with the rules are available on the gov.uk website.

## Green Public Procurement

**1.24.10** Green Public Procurement (GPP) is a process initiative whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured. GPP is a voluntary instrument and public authorities can determine the extent to which they implement it. Examples of GPP in practice, together with publications and the GPP Toolkit can be found on the GPP website.

## 1.25 Capital projects

**1.25.1** In embarking on a capital project, you should check whether there are existing framework agreements that you can join, such as Procure 21+, or those established by the Crown Commercial Service or Designed for Life (in Wales).

**1.25.2** The ProCure21+ National Framework is a framework agreement with six Supply Chains (PSCPs) selected via an OJEU Tender process for capital investment construction schemes across

England up to 2016. An NHS Client or joint-venture may select a Supply Chain for a project they wish to undertake without having to go through an OJEU procurement themselves.

**1.25.3** NHS Client and the PSCP follow the ProCure21+ procurement principles and process for design and construction of the proposed works as set out in the ProCure21+ NEC3 Contract Template and associated guidance. Training and implementation support is available from the ProCure21+ team throughout the all stages of the scheme. ProCure21+ is a suitable procurement route for the following types of work:

- a. Service planning or reconfiguration reviews;
- b. Major Works Schemes (or refurbishments);
- c. Minor Works programmes, in which each task value does not exceed £1m;
- d. Refurbishments;
- e. Infrastructure upgrades (roads, plant, etc.) and non-health buildings (car parks, etc.);
- f. Feasibility studies.

**1.25.4** The typical stages that a capital project passes through are shown in Box 9.

## 1.26 Building a team

**1.26.1** 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, see Box 10.

<b>Box 9 Procurement stages for capital projects (drawn from information on the SHINE network website)</b>	
Establish the business case	Review demand to reduce or eliminate the need for a new product or service. Examples include: sharing, upgrading or refurbishing existing assets; using accurate forecasting to reduce volume; delivering an asset as a service with incentives for supplier to manage sustainability and whole life costs.
Agree specifications and tender documents	Specifications are documented in the Invitation to Tender, setting the minimum standards that bids must meet to satisfy user requirements. They are the most effective way to address sustainability. Examples include: energy/water efficiency, recycled content, reusable/recyclable packaging, no hazardous materials, sustainably managed timber, renewable energy. Independently certified Eco-Labels are available for some products, for which detailed specifications are available on-line. Buyers can demand that products possess these labels or meet the underlying specifications. Examples include the European 'Flower' Eco-label, Nordic Swan and Blue Angel. The Building Research Establishment (BRE) manages a similar system to evaluate the sustainability of building materials in their 'Green guide to specification'.
Advertise tender	All contracts exceeding EU thresholds must be advertised in the OJEU journal. The local economy can be supported by advertising in local papers, public sector websites or through inviting Small and Medium-size Enterprises (SMEs) and Social Enterprises to 'meet the buyer' events. Although too small to act as prime contractors, these firms can be encouraged to act as sub-contractors.
Pre-qualify suppliers and issue Invitation to Tender	There is some scope to promote sustainability through Pre-Qualification. If suppliers are providing a service on-site, they can be required to have an Environmental Policy or Environmental Management System. Suppliers with Health and Safety or Environmental convictions in the past three years may be excluded. Builders or architects could also be pre-qualified on the basis of their experience in sustainable design and construction. In general, factors taken in to consideration during pre-qualification cannot be re-visited as part of tender evaluation. As such, care should be taken not to limit the more important tender evaluation stage.
Evaluate bids	The contract is awarded by scoring bids against weighted evaluation criteria, such as price, quality and delivery. Evaluation criteria should be used to reward performance over and above the specifications. Their use avoids limiting competition by setting specifications too high. Suppliers can also be invited to submit method statements or case studies describing their approach to sustainability, which can also be assessed during evaluation. To carry any influence, sustainability should carry at least a 20%

	weighting. Bids can also be evaluated on the basis of whole life costing, reflecting the lower operating and disposal costs of sustainable alternatives.
Negotiate and award contract	Although they should be carried over from the ITT and tender submissions, final agreement of terms and conditions occurs during contract negotiation. These should include sustainability monitoring and reporting requirements and penalties and incentives.
Monitor performance	Performance of the contract should be monitored to ensure that the product or service is performing to specification. As part of continuous improvement, opportunities for performance improvement should be identified and benefits shared with the supplier. Examples include: waste minimisation, packaging reduction, hazardous materials elimination, energy and CO <sub>2</sub> audits.

### Box 10 Integrated teams

According to the Specialist Engineering Alliance report **Sustainable buildings need integrated teams**:

Public sector clients for each major project should:

- create a Sustainability Working Group made up of key individuals with appropriate knowledge and expertise;
- insist upon and commission integrated delivery teams that include specialists from the supply side and those who will be responsible for operating the facility; and
- set a realistic budget and use whole life costing methods in preference to seeking to minimise capital cost.

Integrated teams should:

- be able to demonstrate their technical proficiency, their commitment to training and health & safety and the adequacy of the resources available;
- maintain records of the performance of past projects for which they have been responsible as proof of their capability and use these to inform the design of new projects;
- respond to an overall budget by an integrated solution that demonstrably represents the optimum balance between capital cost and performance in use over an agreed life for the facility.

Designers and consultants should:

- focus on ensuring that stringent targets for operation and use are emphasised throughout the design process;
- involve specialists early - as this is when their expertise can have the greatest impact in meeting operating and performance targets;
- use best practice advice and specify only approved products whose performance has been officially certified.

## 1.27 Appointment of designers, briefing and fees

**1.27.1** As well as ensuring that the business case includes your expectations for environmental sustainability of the completed facility, it is essential to convey your commitment to designers and contractors. This will ensure that all those engaged in the project are aware of the importance you attach to energy and environmental issues.

**1.27.2** The designers you appoint need to have sufficient technical expertise and the ability to devise and assess options against capital and operation cost information.

**1.27.3** Be careful of professional fee arrangements based on a percentage of the capital cost of Heating, Ventilation and Air Conditioning (HVAC) plant. Conversely, a fee based on a percentage of the total cost of the project should encourage services engineers to integrate their designs for the services with the building fabric and to contribute positively to design decisions such as thermal mass and controlling solar gains so as to minimise installed plant.

## 1.28 Design strategy and calculation of energy targets

**1.28.1** Energy use targets and other environmental performance targets should be established early in the process and emerging designs checked against them periodically. It is all too easy for inferior products to be unthinkingly substituted but that will weaken delivered performance.

**1.28.2** You should:

- agree with the design team an energy strategy for the building;
- ensure the design team are instructed: to establish appropriate energy targets and confirm them with you; to calculate the predicted performance of alternative designs using an industry standard calculation procedure and to present

them to you and to agree a scheme with you that will meet the targets;

- prevent oversized plant being specified (and then running inefficiently at part-load) by using the most up to date design tools;
- ensure the design is manageable, by specifying a Building Energy Management System (BEMS) in the building that has an operating interface appropriate to the facilities management expertise that will be available. Avoid over-complexity. BRE Information Paper 1/14 Understanding the choices for building controls and Information Paper 2/14 Operating BEMS: a practical guide to building energy management systems contain useful guidance;
- where a BEMS is inappropriate, a simple system of sub-meters will enable you to monitor energy use in different parts of the facility, so that areas (or end-uses such as small power loads) where poor performance is suspected, can be checked and investigated.

## 1.29 Allowing time to evaluate energy savings measures

**1.29.1** Energy savings measures need to 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).

**1.29.2** 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.

## 1.30 Design Quality Indicators

**1.30.1** The Design Quality Indicator for Health is a facilitated process to support stakeholder engagement through the briefing and design stages of a building project, see Box 11.

## 1.31 Soft Landings - from inception to handover

**1.31.1** Soft Landings is a programme intended to ensure that the hand-over of a building or facility is supported by a period of professional aftercare from the design and construction team, helping to ensure the performance promised at the design stage is delivered in practice, see Box 12.

### Box 11 Design Quality Indicators

The Design Quality Indicator (DQI) tool is a way of assessing building project proposals against a range of criteria gathered under three main headings of impact, functionality and build quality.

**DQI for Health** is a process for evaluating and improving the design and construction of new buildings and building refurbishments. Its focus is on involving a wide group of stakeholders covering those who will finance, use and be affected by the building. It aims to set and track design criteria at key stages of a building's development, bringing together representatives from both demand and supply side to talk about their project in a structured way. The key stages are:

1. Briefing
2. Concept Design
3. Detailed Design
4. Ready for Occupation
5. In-use

At its heart is the DQI questionnaire that presents a series of non-technical statements under the three main headings of Functionality, Build Quality and Impact. A facilitator assists stakeholders to allocate scores against a wide range of criteria (from interior finishes and colours, to external appearance and weathering). A spreadsheet records the results and shows a profile of the stakeholders' opinions. Weighting of criteria can be used to emphasise specific aspirations. A spider diagram displays the average of the stakeholders' scores, illustrating how well the design is thought to have performed.

### Box 12 Soft Landings

**Soft Landings** is a programme **originally devised** by the Usable Buildings Trust with architects RMJM for the University of Cambridge. It went on to be championed by BSRIA which supported publication of the **Soft Landings Framework** in 2009 and the **Core Principles** in 2012 as open source procedures. Written for construction clients and their professional teams, these documents offer design guidance for new build and refurbishment projects. Although initially envisaged as a way for designers and constructors to stay involved with buildings beyond practical completion as a form of *initial aftercare* to help fine-tune the systems and ensure that occupants understand how to operate their buildings, today Soft Landings provides a comprehensive approach to the achievement of good building performance that covers better briefing, realistic performance benchmarking, reality-checking of design and procurement decisions, a graduated handover process and a period of professional aftercare by the project team.

The intention is to promote an open and collaborative working culture. There are five stages:

1. **Inception and Briefing** to clarify the duties of members of the client, design and building teams during critical stages and help set and manage expectations for performance in use.
2. **Design Development and Review** (including specification and construction). This proceeds much as usual, but with greater attention to applying the procedures established in the briefing stage, reviewing the likely performance against the original expectations and achieving specific outcomes.
3. **Pre-Handover**, with greater involvement of designers, builders, operators and commissioning and controls specialists, in order to strengthen the operational readiness of the building.
4. **Initial Aftercare**, during the users' settling-in period, with a resident representative or team on-site to help pass on knowledge, respond to queries and react to problems.
5. **Aftercare** in years 1 to 3 after handover, with periodic monitoring and review of building performance.

During 2011, the Cabinet Office adopted Soft Landings as part of the Government's Construction Strategy with the aim to ensure it becomes standard practice for government building projects as **Government Soft Landings** (GSL). GSL is intended to go beyond the original soft landings to include social and economic outcomes as well as environmental ones. High level outcomes will be defined at the start of each project, periodically reviewed during the design and construction process and monitored after handover to tie back to ownership and provide lessons for future projects. FM staff will be involved in the early planning phase of projects and there will be an appropriate hand-over with the design team involved. GSL is due to be applied on public sector projects from 2016 and is being rolled out by the **BIM Task Group**.

## 1.32 The importance of checking building services prior to hand-over

**1.32.1** Commissioning is the term used for the checking of the mechanical, electrical and plumbing services in a building (and to some extent items of the fabric such as windows, doors, shutters and blinds) prior to the handing over of a building or facility. It involves ensuring they operate effectively together and in accordance with the design intent prior to handover. Inadequate commissioning may prevent an otherwise good design from meeting its full potential and in turn affect the success of the whole project. Sufficient time for proper commissioning needs to be included in the job programme and protected against the effects of slippage elsewhere. Mechanical services to be commissioned include the central plant, distribution systems, controls and timers and the user interface of the

Building Energy Management System. Electrical systems include the power and lighting distribution systems, sensors, switches and controls and achieved illumination levels. In complex hospital projects there will be numerous other service distribution systems also needing to be checked. If fitting out is a separate activity after completion of the shell and primary services, the design team should provide guidance to those responsible about the building's energy strategy and the features that are critical to achieving the expected performance standards. This might include the logic of the zoning systems, paths for cross ventilation, access for occupants to windows and controls and the preservation of access for maintenance purposes.

**1.32.2** The commissioning process involves the suppliers and the designers who have expertise in the technologies installed and provide training in management and

operation to facilities managers and occupants.

## 1.33 Building Information Modelling

**1.33.1** Building Information Modelling (BIM) is being strongly supported by Government in the construction of new buildings, enabling better visualisation of the eventual building for clients, helping to improve collaboration across the professions, supporting integration between design and construction, reducing construction risk though improved visualisation of construction sequencing, providing a more comprehensive asset register at handover

and with improved operating and maintenance information, see Box 13. BIM is likely to become a mandatory requirement for public sector buildings under the Building Regulations by 2016.

## 1.34 Service Life Planning for Buildings

**1.34.1** Whole life costing is a process of considering not just initial capital cost of a building or a facility but also its operation and maintenance costs over a predicted life. It is covered by an International Standard summarised in Box 14.

### **Box 13 BIM – Building Information Modelling: energy simulation and operating manuals**

BIM has come to prominence in the last decade for the compilation and transmission of digital building data and information. Full exploitation of BIM on a project requires clients, consultants, constructors, product makers and facility managers to participate digitally. A building information model can be regarded as a three dimensional digital model of a building linked to a comprehensive database of project information that is developed collaboratively among the design team, exploited during the construction process and then handed to the building user as comprehensive documentation for the asset.

Extensive claims are being made for BIM, for example by a Construction Industry Council report on **Growth through BIM**. Pre-construction benefits are claimed to be: greater certainty of out-turn costs at an early stage; more careful evaluation against functional requirements through the use of a 3D schematic model and simulation and analysis of design alternatives to assess performance (such as daylight, ventilation and energy) against criteria and targets. During the construction phase, simulation of assembly can precede actually construction. After handover, the comprehensive documentation of the facility should be of benefit for all aspects of operating and maintaining the facility, as well as for fit-outs, re-modelling, refurbishment and ultimately demolition.

The adoption of BIM is strongly promoted in the Government's Construction Strategy and various trial projects are reported as **case studies** on the **BIM Task Group website**.

### **Box 14 BS ISO 15686 – Buildings and constructed assets: Service life planning**

Whole life costing is covered by a British and International Standard: BS ISO 15686 – dealing with service life planning of buildings and constructed assets. Service life planning addresses the design of a structure or a building with a view to its operation through its whole life. It means looking at long term performance and overall operating costs at the design stage and earlier, enabling the design to be tailored to meet clients' long term needs. The Standard is in eleven separate parts covering:

1. **General principles and framework**
2. **Service life prediction procedures**
3. **Performance audits and reviews**
4. **Service life planning using IFC based Building Information Modelling**
5. **Life Cycle Costing**
6. Procedures for considering environmental impacts



7. Performance evaluation for feedback of service life data from practice
8. Reference service life and service-life estimation
9. Guidance on assessment of service-life data
10. When to assess functional performance
11. Terminology

## 1.35 Energy considerations for partnership schemes

**1.35.1** 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 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 – so a more challenging level should be set if realistic efficiencies are to be achieved.
- Ensure that the standard payment mechanism Schedule 18 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 considering energy efficiency measures).
- 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 underperformance 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 responsible for energy awareness training and monitoring of energy use. See NHS Standard Service Level Specifications on the Department of Health [website](#) (in particular, see 'Utilities Management'). This website includes a standard clause that can be put into the project management company.

**1.35.2** Be careful with performance guarantees. When establishing the conditions of a performance guarantee, it is important to cover what happens if the performance isn't met. For example if a guarantee offers to save 15% of your energy use, but saves only 10%, you will have to find the difference – the 5%. However, when purchasing this quantity of energy you will end up paying a high premium on the spot market. Therefore it is important that the conditions of the guarantee cover your refund put you in the same position you would have been if the performance had been achieved in practice. In the absence of this sort of detailed consideration, a performance guarantee will be of limited worth.

## 1.36 Payment mechanisms

**1.36.1** Under Private Finance 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.

**1.36.2** The payment mechanism deals with how ongoing repair and maintenance affects energy usage, but there is also the issue of the initial construction requirements in terms of energy efficiency and how it is established that the building meets these, immediately following construction. This issue is addressed in Clause 17 of the standard PFI contract.

**1.36.3** It is 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.

**1.36.4** 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.

**1.36.5** 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. This removes any incentive by the PFI contractor to ensure energy is used efficiently. There have been many discussions with private sector bidders about this.

**1.36.6** Essentially there are two categories of increased energy usage:

- Category 1: The Trust uses more energy than it projected; this could be because they increase the use of medical equipment with a high energy usage; it could also be because the nurses leave the windows open or bring in their own toasters. Clearly the private sector cannot be expected to take the blame if this happens.
- Category 2: The building wasn't designed in an energy efficient way or

isn't maintained properly, so that it becomes inefficient in its use of energy. This definitely is something the private sector have control of in a PFI/PF2 scheme and they should accept responsibility for it. This led to adoption of a pain/gain sharing formula in the current standard payment mechanism, although the 2012 PF2 guidance from HM Treasury implies that such approaches are not liked by bidders and may need to be changed.

**1.36.7** 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.

**1.36.8** 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 established, 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.

**1.36.9** 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 and to the

- expected energy consumption during the operational period of the facility;
- a mirrored pain-share-and-gain-share mechanism, which gives commercial incentive to the project company to reduce energy consumption;
- water should be excluded from the energy payment. All of the above is covered if Trusts just adopt the standard DH mechanism;
- the healthcare organisation will procure energy via a framework contract (although in practice many Trusts get the PFI/PF2 provider to do this and charge the cost back to the Trust).

**1.36.10** 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.

**1.36.11** 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.

**1.36.12** The Department of Health standard payment mechanism can be found at <http://www.dh.gov.uk>. Box 15 presents a case of procurement in the Rotherham NHS Foundation Trust.

### Box 15 New hospital lighting for Rotherham NHS Foundation Trust

*Rotherham NHS Foundation Trust wanted to improve the lighting in its hospital wards at the same time as saving money and improving the environment for patients and staff.*

*Through **Forward Commitment Procurement (FCP)** it stimulated innovation in the supply change as it embarked on an eight year refurbishment programme.*

## 2 Energy considerations for the refurbishment of existing building facilities

### 2.1 Introduction

**2.1.1** From a financial and resource efficiency perspective, the refurbishment of an existing building is often a superior option to constructing a new one. There is a range of opportunities to enhance the social, environmental and economic sustainability of an existing building and thereby extend its useful life. This can involve physical changes and/or operational improvements which enhance the environmental performance of the organisation and provide a better level of healthcare to patients.

**2.1.2** When physical changes are implemented, the objective is often to ensure a better healthcare environment or to provide new services in a refurbished area. There may be varied reasons leading to the need for refurbishment which may include:

- need for new or different spaces, expanding existing services or providing new ones;
- malfunctions in systems and controls;
- insufficient building controls;
- lack of thermal and/or visual comfort;
- effort to save energy.

**2.1.3** Moreover, energy efficient refurbishment is a response to the need for climate resilience and mitigation and to the specific targets set by the UK government and the NHS, analysed in Chapter 1 of Encode 2015 Part A.

**2.1.4** This chapter focuses on energy efficient refurbishment measures which will assist hospitals aiming to reduce carbon emissions, while saving costs and improving patients' care. The chapter draws significant experience from a recent energy efficiency programme which funded 117

projects delivered across 48 NHS organisations in England during 2013/14. The projects were funded through the Department of Health NHS **Energy Efficiency Fund** (EEF), derived from an allocation of Public Dividend Capital. The aim of the NHS EEF was to accelerate current NHS measures to mitigate the effects of climate change by improving energy efficiency across the NHS Estate.

**2.1.5** In 2010, the NHS England was responsible for 24.7 million tonnes of CO<sub>2</sub>e (MtCO<sub>2</sub>e), from which approximately 17% (4.07 MtCO<sub>2</sub>e) was due to energy use in buildings. To be in line with the 28% carbon emissions reduction by 2020 compared to a 2013 baseline (see **Sustainable, Resilient, Healthy People & Places: A Sustainable Development Strategy for the NHS**) this would require a reduction of 0.1628 Mt CO<sub>2</sub>e annually (around 4% savings every year). Investing nearly £50 million in the Energy Efficiency Fund in 2014 is expected to reduce carbon emissions by 0.1006 MtCO<sub>2</sub>e (see **NHS Energy Efficiency Fund**). Therefore, investment in retrofit projects achieving approximately 1.6 times the EEF savings would be needed every year to deliver this level of carbon emissions reduction.

**2.1.6** Some projects involved discrete single measures; others linked a series of complementary projects to fulfil pre-existing energy masterplans. The individual NHS organisations' implementation of their specific energy efficiency projects were monitored by the University of Cambridge in order to enable the independent identification and analysis of the benefits and lessons learnt. There was a large variety of energy efficient refurbishment measures implemented. The projects included Building Management System

(BMS) controls; electrical usage controls; lighting; optimising electrical equipment (e.g. transformer replacement); optimising electricity supply (voltage optimisation); ventilation plant upgrades; mechanical cooling; optimising mechanical equipment (e.g. mechanical steam traps' replacement); Combined Heat and Power (CHP); heating upgrades; heat recovery; renewable energy and building fabric upgrades.

## 2.2 The organisational approach of energy efficient refurbishment

**2.2.1** The organisational management, as well as building energy and carbon management have been analysed in Chapters 2 and 3 of Encode 2015 Part A. This chapter focuses specifically on the process involving energy efficient refurbishment. It omits the aspects of benchmarking and monitoring which have been analysed in Encode 2015 Part A Chapter 1.

**2.2.2** Figure 2 focuses on the steps that need to be followed by an organisation aiming to improve their energy performance. It starts with the diagnosis of the actual energy use and performance through data collection. It then identifies problems and opportunities in which resilience and comfort should be prioritised. The next step is the analysis of available options with regards to their cash-releasing potential and additional benefits for patients. Once the options are analysed and the optimal ones are chosen, the early engagement of stakeholders in the process becomes essential. The project implementation which should include the use of sustainable procurement methods is the next step. If possible, energy monitoring could be put in place to aid the evaluation of the project and to ensure ongoing performance at the optimum level. The post project evaluation and the request of feedback from stakeholders is the last but very significant step. This step evaluates

the project outcomes and teaches lessons for future projects and their implementation.

## 2.3 Establishing your initial performance

**2.3.1** Energy performance and benchmarking: The first thing to do when considering refurbishing a building is to establish the initial energy performance. Box 16 describes the case study of Southend University NHS Foundation Trust, which successfully established their energy performance and identified opportunities for refurbishment.

**2.3.2** CIBSE TM22: Energy assessment and reporting methodology<sup>3</sup> explains how the energy performance of an occupied building can be understood in terms of the performance of the building's systems, such as lighting and ventilation. The use of benchmarks is suggested in order to allow the achievement of high quality internal environments, while keeping financial and carbon impacts at low levels. This approach is explained in detail in CIBSE TM22.

**2.3.3** The simple building assessment is merely based on meter readings of a building of a single type and its energy consumption per unit floor area. The assessment is based on overall energy use. However, electricity and other types of energy use are metered separately, so that the different costs and carbon emissions can be identified and assessed.

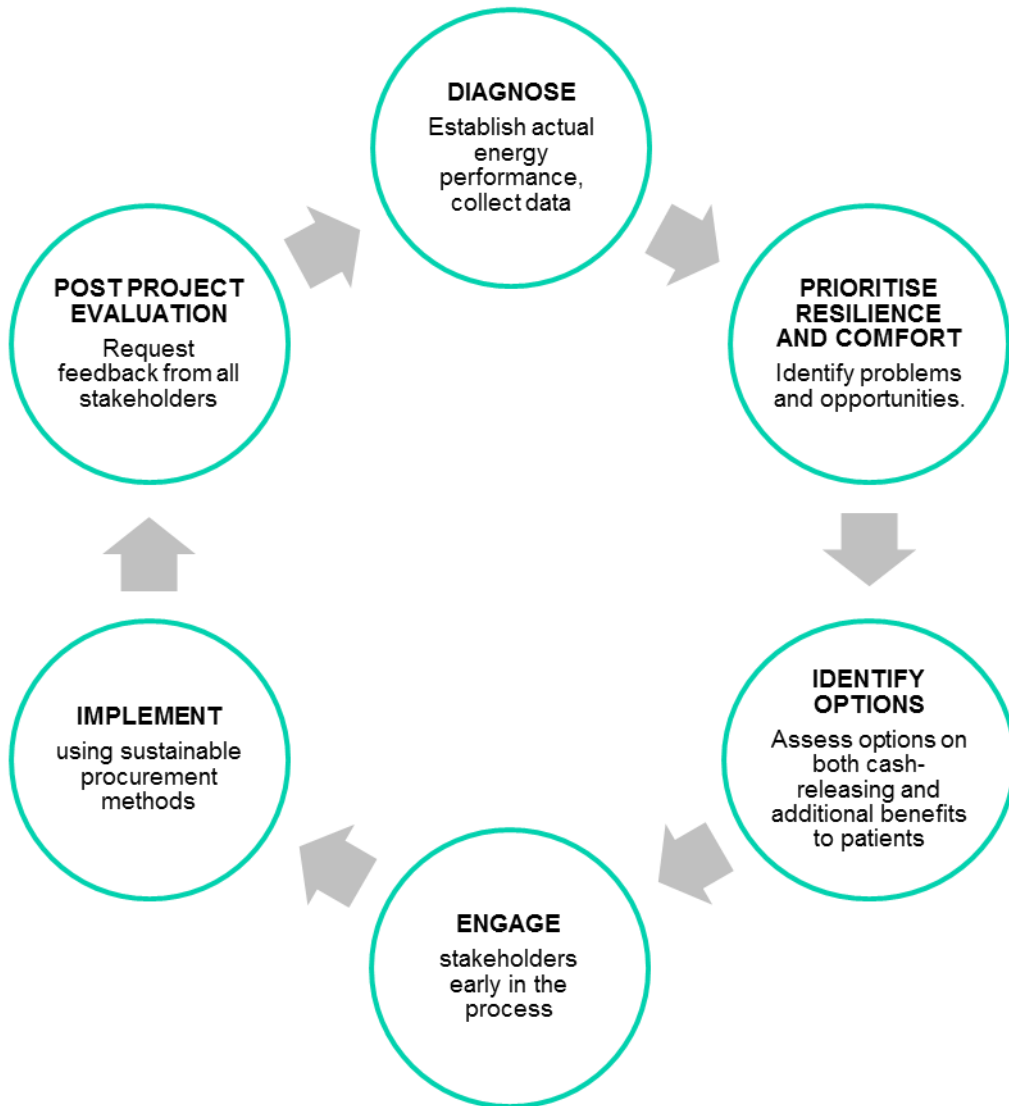
**2.3.4** The general building assessment refers to more complicated buildings, consisting of different building types, with up to five energy supplies and non-standard energy usage, for which adjustments and exclusions are made.

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<sup>3</sup> CIBSE is the Chartered Institution of Building Services Engineers

**Box 16 Southend Sustainable Development Plan**

Southend University NHSFT has assessed its sustainability with regards to procurement, facilities management, workforce and buildings. It established a solid knowledge of the organisation’s initial condition, allowing them to identify needs and possibilities and to prioritise actions. They identified the carbon cost of different activities within their organisation and the potential energy efficiency projects. For each of these projects, they calculated capital cost, energy and carbon savings, as well as the relevant payback times. Finally, they identified risks and relevant mitigation plans. This knowledge of their organisation’s performance meant they were in a good position to act when the EEF was on offer.



**Figure 2 The 6-step approach to achieving energy efficiency in NHS organisations’ estates**

**2.3.5** System assessment refers to specific systems within a building. Other than the metered energy usage, information is provided through energy modelling and detailed plant surveys.

**2.3.6** The Carbon Trust provides guidance on energy efficient refurbishment in the following documents:

- Managing refurbishments: **CTV038: Low carbon refurbishment of buildings: management guide**

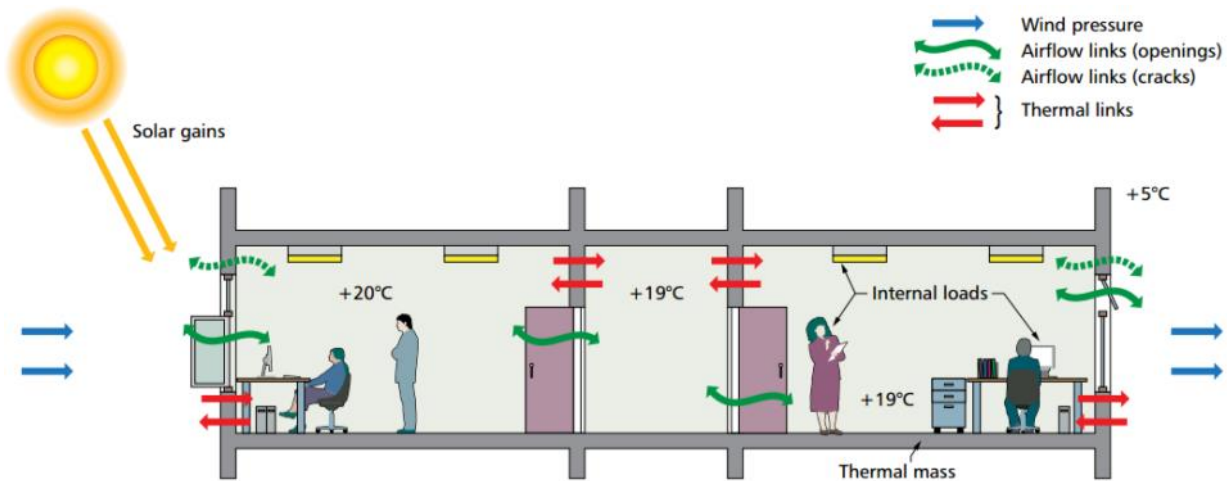


Figure 3 Building heat gains and airflows. Reproduced from **CIBSE TM53: Refurbishment of non-domestic buildings** by permission of CIBSE

- Building refurbishments: **CTG049: Refresh and reduce: Maximising carbon savings in internal refurbishment**

**2.3.7** The following paragraphs describe the most important aspects of a successful energy efficient refurbishment.

**2.3.8** Identifying spaces in need of refurbishment: As part of a refurbishment assessment, it is worth identifying spaces that are in particular need of refurbishment, whether this is because they have low/high heat gains, due to construction types or space use: for example patients' wards compared to maintenance and facilities areas of the building. Figure 3 visualises an example of building heat gains.

**2.3.9** In order to prioritise low or no cost refurbishment options, **CIBSE KS12** recommends conducting pre-refurbishment energy checks to identify the potential measures that might result in significant energy and carbon savings at little or no financial cost. A list of tasks to consider for this purpose can be found in CIBSE KS12.

**2.3.10** Assessing occupant satisfaction: Although the assessment of occupant satisfaction might be to some extent dependent on anecdotal evidence and feedback, an occupant satisfaction survey should be conducted; **this** will allow an

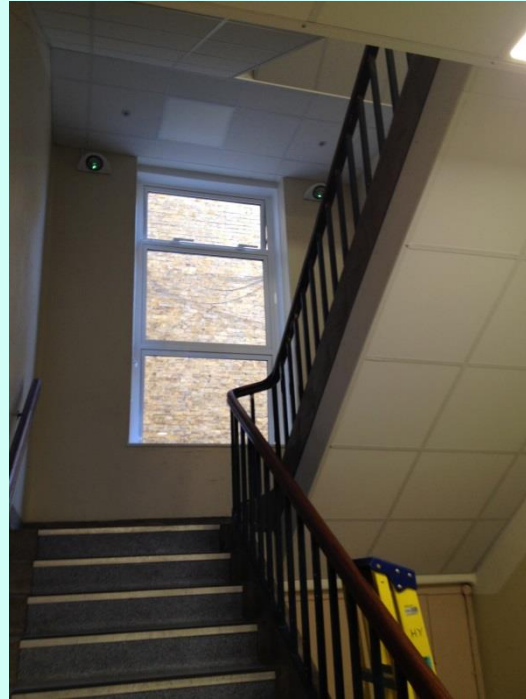
improved interaction with building occupants. CIBSE KS12 explains the reasons why this method is particularly useful:

- Design teams have the opportunity to interact with the buildings occupants and thus make informed design decisions.
- Building users feel they contribute to the design and the relevant decision making and that their opinions are heard and valued.
- Designers will acquire better information regarding building controls and the trade-off between conflicting aspects of design, such as noise and ventilation, or natural light and electric light.
- The occupant satisfaction before and after the refurbishment can be compared, thus assessing the success of the design and the refurbishment measures implemented. Potential discrepancies can be addressed and resolved.

**2.3.11** Feedback from maintenance and operational procedures: The building services condition survey is a thorough method to identify system malfunctions and potential for improvements. Nevertheless, the feedback from the routine maintenance of systems can be invaluable. In addition, utilising data from BMS (Building

### Box 17 Southend University NHSFT: lighting upgrade improves maintenance

*An unexpected benefit of the lighting upgrade at Southend University NHSFT came from feedback from the maintenance staff: in the past maintenance staff was concerned with the amount of time they spent cleaning insects off the old light fittings. The lighting upgrade and the replacement of all luminaires with LED, airtight units, meant that insects could not find their way into the light fittings. Figure 4 illustrates this benefit.*



**Figure 4** Maintenance costs and times were reduced after the successful lighting upgrade in Southend University NHSFT.

Management Software) can provide detailed information on the actual operational performance of the building's individual systems and even of the building as a whole. This can be achieved using the BMS's data monitoring and display functions.

**2.3.12** The systems should be easy to understand and adjust, so that they function efficiently and provide useful information. Graphics presenting the operation of building systems, such as Heating, Ventilation and Air Conditioning (HVAC) and Air Handling Units (AHUs) should be user-friendly with additional information provided separately, in order to simplify their everyday use as required by the facilities managers. The BRE [Information Paper IP 2/14: Operating BEMS: A practical approach to building energy management](#)

[systems](#) provides more detailed information on the topic.

**2.3.13** Constraints: The decision making for an existing building is in many ways more complicated than that for a new one, due to the numerous given constraints that have to be taken into consideration when selecting the optimum refurbishment measures to be installed. Especially in the case of systems' replacement and of equipment upgrade, physical constraints have to be accounted for. These include the type and material of construction and building structure, dimensions, especially those related to floor to ceiling heights and void sizes, as well as weight restrictions. Finally, the access to specific spaces for the removal or installation of systems has to be planned in detail in advance.

**2.3.14** Planning requirements and historic environments: It is worth highlighting potential planning requirements and



constraints when organising a building refurbishment. For example, in conservation areas, or listed buildings, specific consents are required. Some interventions may not be permitted and the process may increase the amount of time required for refurbishment. Solar panels or wind turbines require significant planning permission.

## 2.4 Decision making on refurbishment measures

**2.4.1** After establishing the initial performance of a healthcare building, there is most likely a variety of options available regarding refurbishment options. The advisory report provided together with the Display Energy Certificate (DEC) as described in Encode 2015 Part A, is a good place to identify potential options. Further professional advice should be asked before deciding on the implementation of any of those measures. This section discusses the factors that influence decision making and the selection of the optimal refurbishment option.

**2.4.2** Encode 2015 Part A explains why resilience is important. Climate change predications include temperature increase and potential summer overheating in buildings, flood risks, deterioration of air quality and the necessity for hospitals to operate under extreme weather conditions. The refurbishment options also have to be evaluated according to their provision of resilience for future climatic conditions. This is a very relevant point when considering insulation options. The increased temperatures during summer months might influence the choice and/or level of insulation methods; the need to cater for cold weather during the winter months needs to be balanced by the consideration of the risk of summer overheating.

**2.4.3** After assessing occupant satisfaction, the needs of occupants and especially of patients should be prioritised. It is worth highlighting again the significance of designing for different

groups of building occupants in the case of healthcare buildings, where infants, the elder and people with certain medical conditions are in need of particular care and special thermal comfort conditions.

**2.4.4** The energy and cost savings as well as the initial capital expenditure have to be calculated. Calculations should involve savings in maintenance and resources, or any other change that will occur as a result of implementing a specific refurbishment measure. Consideration should be given to payback periods, the period during which savings are expected to continue occurring and last but not least any other benefits to the patients, the NHS organisation and the wider community. Section 2.5 describes the Benefits Framework developed by the University of Cambridge and the DH for the EEF; this sets an example of an organised manner to identify, evaluate and report the co-benefits of energy efficient refurbishment.

**2.4.5** Incorporation of energy efficiency initiatives into other hospital projects can provide additional opportunities for energy efficient refurbishment. For example, if re-flooring and redecoration of rooms is scheduled, changes such as replacing lighting and servicing controls can be implemented at the same time. This type of opportunity should be identified and used to improve the organisation's energy efficiency.

## 2.5 The co-benefits of energy efficient refurbishment

**2.5.1** The Benefits Framework was developed for the EEF, aimed at capturing all benefits accruing from the investment at a project level, at least all those that could be identified by the NHS and researchers. The template outlined in Table 1 identifies cash-releasing and non-cash-releasing benefits and outlines how:

- resources have been deployed effectively to deliver clinical improvement;

Benefit level	Description of project outcome	Associated cash releasing benefit	Associated non-cash releasing benefit	Evidence
<b>Direct impact on energy use</b>	Description of how the project directly influences energy efficiency.	Quantitative estimates on the significance of the gains in energy efficiency.	General non-cash releasing benefits directly associated gains in energy efficiency.	Sources of evidence to prove these gains (e.g. ERIC data).
<b>Work practice / business process</b>	Description of project outputs that have an impact on practice/ process.	Resulting cash releasing benefits for the NHS organisation in terms of work practice/ business process.	Resulting non-cash releasing benefits for the NHS organisation in terms of work practice/ business process. Alternatively, this may be a benefit.	Sources of evidence to prove gains.
<b>Patient and/or staff services</b>	Description of project outputs that have an impact on patient and/or staff services.	Resulting cash releasing benefits for the NHS organisation in terms of patient and/or staff services.	Resulting non-cash releasing benefits directly benefited by patients and/or staff.	Sources of evidence to prove these benefits (e.g. Post project evaluation).
<b>Wider community</b>	Description of project outputs that have an impact on the wider community.	n/a (cash releasing benefits reported in this framework are limited to benefits for the NHS organisation).	Resulting benefits for the wider community (this includes injection of capital into the community).	Sources of evidence to prove these benefits.

**Table 1 Generic framework for measuring benefits, taken from the EEF**

- benefits have been realised within local communities, local enterprise, local Small to Medium Enterprises (SMEs), subcontractors and suppliers, the local and regional economies;
- benefits have been realised through compounding the benefits of interlinked but discrete projects;
- benefits will continue to be delivered over successive years, possibly decades, through the expected lifespan of equipment and systems installed and improvements to building fabric.

**2.5.2** Other than the energy savings, the categories benefitting from the energy efficient refurbishment of hospitals are the following:

- work practices and business processes;
- patient and/or staff services;
- wider community.

**2.5.3** Thermal and visual comfort improvements: Other than the obvious benefits of refurbishment, commonly associated with energy and financial savings, refurbishment also creates better environments in terms of occupant comfort. The occupant comfort factors influenced by refurbishment are the following:

- thermal comfort associated with air temperature, relative humidity, mean radiant temperature and air velocity;
- internal air quality influenced by ventilation levels, exterior air quality and sources of internal air pollution – specifically for hospitals, the risk of airborne infections is added;
- visual comfort associated with illuminance levels and glare;
- acoustic comfort related to potential noise from building services or the

exterior environment, as well as to the acoustic conditions of spaces.

- occupant control over environment e.g. dimmable light switches by beds.

**2.5.4 Acoustics performance:** One of the findings from the EEF regarded acoustic performance and the improvement of acoustic conditions in a building due to the change of ceiling tiles, for the purposes of lighting refurbishment. The requirement to improve acoustic performance on an existing area should be considered during the design and implementation of lighting schemes in order to maximise any co-benefits.

### Box 18 Lessons learnt from Southend University NHSFT

*Acoustics can be enhanced by energy efficient refurbishment measures even if the measures are not directly linked to acoustics. In Southend University NHSFT, improved acoustic performance through upgrading the ceiling tiles was an additional benefit of lighting upgrade.*

*Note: The organisation purposefully picked up better acoustic tiles.*

**2.5.5 BREEAM<sup>4</sup> UK Refurbishment and Fit-out 2014 for Non-domestic buildings** suggests that additional credits apply specifically for Healthcare buildings with regards to their acoustic performance. The criteria in this category involve sound insulation, indoor ambient noise level and reverberation times. The requirements on these properties are defined by the Department of Health and the relevant Health Technical Memoranda. Airborne sound insulation performance standards are described in **HTM 08-01: Acoustics**. The same document provides criteria for compliance with internal indoor ambient

noise levels, as well as with reverberation criteria.

**2.5.6 Additional financial benefits:** Finally, due to NHS organisations participating in schemes such as the EU Emissions Trading System (EU ETS) and the Carbon Reduction Commitment (CRC) (described in Encode 2015 Part A), the reduction of energy consumption, as well as the ability to predict their energy use with higher accuracy, can reduce the risk of CRC payment penalties and the indirect costs related to carbon emissions.

## 2.6 Typical historical issues in hospital design that are likely to require addressing

**2.6.1** Although the NHS Estate is extensive, there are certain building types and forms that are typical of specific eras and are recognisable in the NHS typology. The regularly recurring types of buildings, according to the '**Robust hospitals in a changing climate**' article in the Design & Health Scientific Review, are the following:

- Pre-1939 buildings, typical 'Nightingale' wards, arranged as finger-like pavilions
- 1950s to early 1960s type ward buildings, heavyweight or lightweight, high or low rise; a tower of wards and a lower podium ('matchbox on muffin' type)
- 1970s and 1980s lower rise buildings punctured by courtyards; over 100 such schemes were built using the DH 'Nucleus' template planning system

**2.6.2** The film 'Robust Hospitals in a Changing Climate' has won the 2013 tv/e Global Sustainability Film Award at BAFTA. You can see it at: <http://sms.cam.ac.uk/media/1559781>

**2.6.3** Of the historic NHS building stock, very few were designed to be air-conditioned, whilst many of them have too much glazing and/or poor insulation levels. The combination of these characteristics creates additional risks of summer

<sup>4</sup> BREEAM is the Building Research Establishment Environmental Assessment Methodology

overheating. This is a particular issue with regards to the higher temperatures predicted as a result of future climate conditions of the UK.

**2.6.4** 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 patients and other building occupants 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.

**2.6.5** If available, the findings of patient and staff surveys may help to identify specific weaknesses and to establish the refurbishment requirements. Potential remedial actions might include the upgrade of the building envelope or of systems and building services, the improvement of controls and finally the production of energy on-site through the use of renewables. The following section explains the 'fabric-first' approach and the potential of different energy efficient refurbishment measures. Each one of these measures includes lessons learnt from the recent EEF, as well as relevant case studies. Where applicable, information on the legal requirements and more sources of information are provided.

## 2.7 The fabric-first approach to energy efficiency

**2.7.1** Building heat losses are a very significant aspect of building energy performance and thermal comfort. As Figure 5 demonstrates, buildings lose heat through their walls, roofs and floors, as well as through their doors and windows. Expending energy to heat up a building with high heat losses is very inefficient. The building is also likely to exhibit poor thermal comfort levels. The fabric-first approach is generally recommended, in order to improve the effectiveness of energy efficient refurbishment in buildings, to increase energy savings and to improve thermal comfort. Therefore the building envelope and fabric upgrades are generally the point to start. Figure 6 presents the recommended order that should be followed.

## 2.8 Building envelope upgrade

**2.8.1** Although not classed as building services, the building fabric has a profound effect on the operation of services. In addition, the building services engineer may often have the opportunity to influence changes to the building fabric. Indeed where the refurbishment includes the adoption of passive ventilation, cooling and lighting techniques this will be essential.

**2.8.2** There are numerous opportunities to upgrade the building fabric of a healthcare building and thus reduce energy costs and improve interior thermal comfort conditions. The following paragraphs describe different options regarding building envelope upgrade, including walls, roof and floor insulation, as well as windows and glazing upgrade.

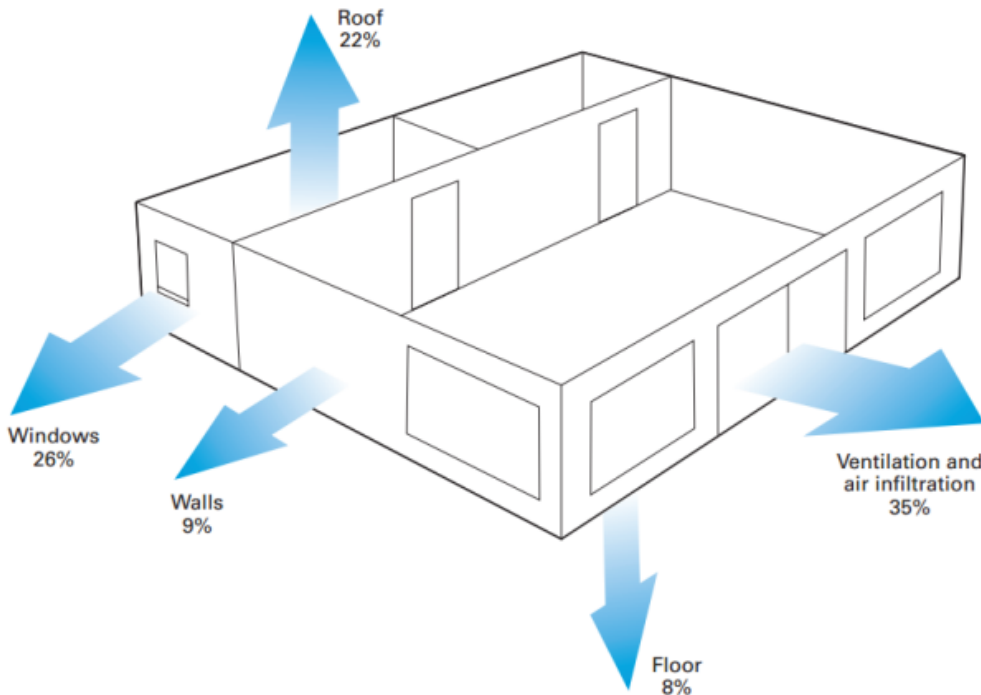


Figure 5 Heat loss from a non-domestic building. Reproduced from **CTV069: Building fabric: Energy saving techniques to improve the efficiency of building structures** by permission of the Carbon Trust

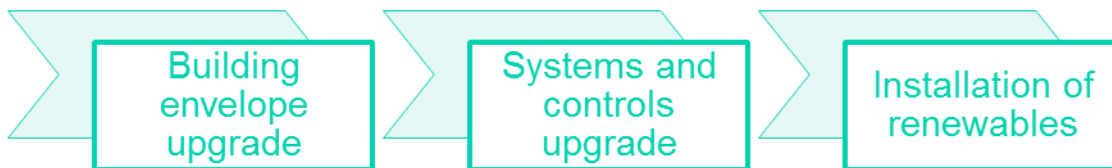


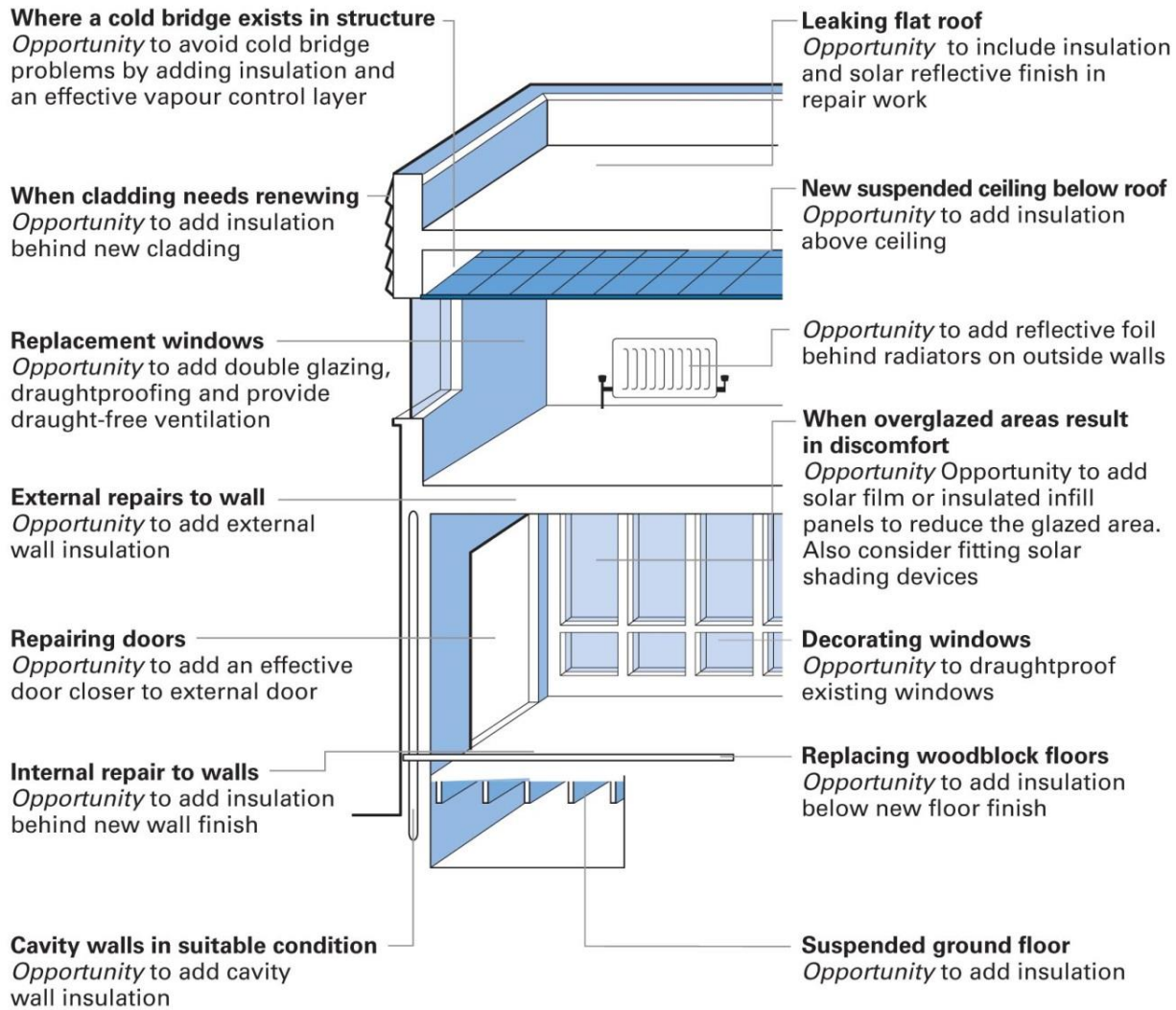
Figure 6 Prioritising energy efficient refurbishment measures

**2.8.3** Figure 7 presents the various opportunities for building fabric improvements in a non-domestic building.

**2.8.4 Thermal bridging:** The aim of fabric upgrade is to minimise the uncontrolled air infiltration which results in cold air being brought into the building. The most common way of describing the thermal properties of a building element is its U-value, which expresses the amount of heat transferred through a specific area of the building element for a given temperature difference between the interior and the exterior of the building. Nevertheless, thermal bridging can be a significant source of heat loss through the building fabric and should therefore be considered when an insulation retrofit is planned. Thermal

bridging occurs in areas which have lower thermal resistance compared to adjacent areas of the building fabric; they often occur in junctions, such as floor-wall, roof-wall or ceiling-wall and can result to condensation if not treated in time. Good construction detailing when implementing insulation retrofit of any type should be ensured to avoid thermal bridges and their unwanted consequences.

**2.8.5 Condensation:** The air in the interior of buildings is typically warmer and more humid than that in the exterior. When air leaks from the interior to the exterior of the buildings it is likely that a considerable amount of moisture is transferred at the same time. This is known as interstitial



**Figure 7 Opportunities for building fabric upgrade in non-domestic buildings. Reproduced from CTV069: Building fabric: Energy saving techniques to improve the efficiency of building structures by permission of the Carbon Trust**

condensation. Therefore, providing a vapour permeable weatherproof finish externally minimises the risk of interstitial condensation, especially when insulation is applied externally.

**2.8.6** In the case of internal insulation, airtight linings are crucial for the same purpose.

**2.8.7 Risk of overheating:** Finally, there is the risk of increasing air tightness and thermal properties to an extent that higher risks of overheating are created, especially in the case of inadequate ventilation controls. Therefore, special consideration should be given, ensuring enough but not

excessive amounts of insulation materials are installed. More information on this can be found at Carbon Trust’s **CTV069: Building fabric: Energy saving techniques to improve the efficiency of building structures.**

**Wall insulation**

**2.8.8** Insulation generally can be applied on walls, roofs or floors. Insulation strategies have to be selected for each building, depending on its initial condition and heat losses and its construction materials and structure. Moreover, constraints, such as space loss and aesthetics on the outside of the building,

have to be taken into consideration when making a choice.

**2.8.9** The most common wall types in the UK are solid walls, cavity walls and timber frame walls. There are three options for wall insulation: external (EWI) or internal wall insulation (IWI) and cavity wall insulation (CWI). Cavity walls can be filled with the appropriate type of insulation if the building is not susceptible to rain penetration. More information can be found in [CIBSE KS12: Refurbishment for improved energy efficiency: an overview](#).

**2.8.10** Other options to insulate cavity walls, also applicable to solid walls, are the installation of insulation externally or internally. This is done through fixing insulation boards to the external fabric and applying a specialist render. Similarly, insulation can be installed on the interior of a building. EWI can eliminate more thermal bridges but changes the building aesthetics and is thus more difficult to apply in historic environments. Internal insulation, although usually less expensive, is more disruptive, due to the need to move components such as pipes, skirting boards and radiators as the insulation is applied. Internal wall insulation also involves loss of space and this can be a barrier when space is limited. More information on external and internal wall insulation, as well as on their advantages and disadvantages can be found in the [Energy Analysis Focus Report: A study of Hard To Treat Homes using the English House Condition Survey - Part II: Investigating improvement scenarios for Hard To Treat Homes](#).

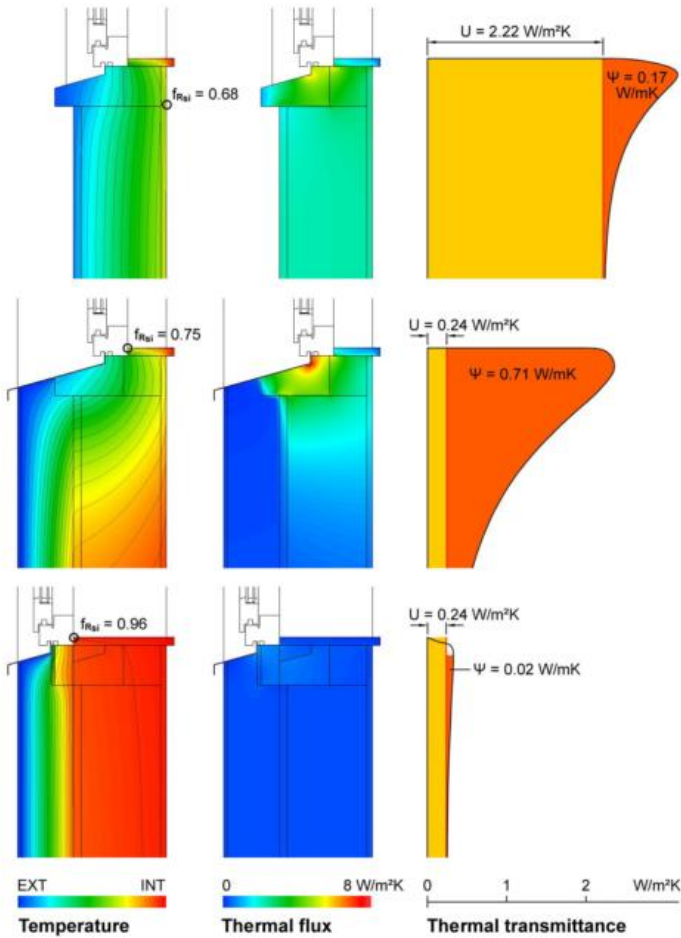
**2.8.11** Due to the disruption that this type of interventions can cause, especially in a healthcare environment, it is more appropriate to schedule them at the same time as other activities, such as painting, re-fitting bathrooms in the interior or rainwater pipes on the exterior etc. Moreover, well organised and combined refurbishment works will achieve reduced cost, for example through the use of scaffolding once during refurbishment.

**2.8.12** In cases of pre-1919 and heritage healthcare assets, different research projects have shown that the assumed U-values are not always accurate. Examples include the [Historic Scotland Technical Paper 10: U-values and traditional buildings](#) and the [SPAB<sup>5</sup> Research report 1: U-value report](#). Therefore, in those cases, in-situ U-value measurements should be carried out, in order to ensure accurate calculations of expected energy savings when planning the refurbishment.

**2.8.13** As explained earlier in this section, heat losses occur through different building components. It is worth adding here, that heat losses are derived through two different ways: plane element heat losses and thermal bridging. The former value is measured as U-value in  $W/m^2K$  and refers to the uniform heat loss through a building element, for example a wall. Thermal bridging is the additional heat loss at junctions of plane elements and is not included in the U-values. It is measured as linear thermal transmittance (as opposed to the U-value which expresses thermal transmittance). Figure 8 presents this idea, through diagrams of a window sill with external wall insulation. The diagrams refer to temperature, thermal flux and thermal transmittance, with the condition pre and post refurbishment, as well as a considered, not optimal solution. Figure 9 presents the condition of a building as it has been depicted in a picture taken with a thermal camera. The figure demonstrates the thermal bridges occurring on the building due to missing insulation material or uninsulated joints.

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<sup>5</sup> SPAB is the Society for the Protection of Ancient Buildings



Thermal bridges due to missing insulation material or uninsulated joints between wall and roof

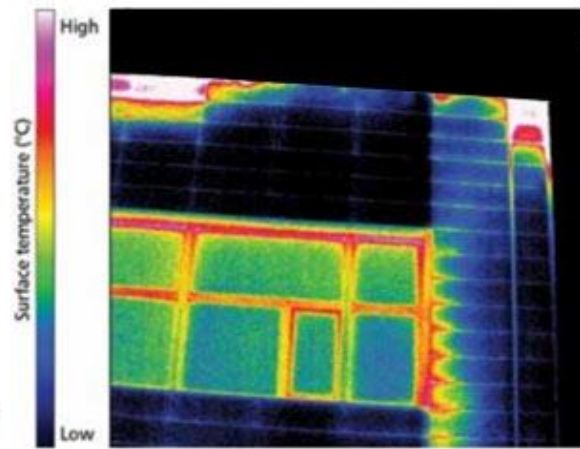


Figure 8 Diagrams for a window sill on a wall where external insulation has been applied. Top: existing sill, Middle: sub-optimal considered EWI refurbishment, Bottom: good EWI refurbishment. Reproduced from **Thermal bridging: understanding its critical role in energy efficiency** by permission of Joseph Little of Building Life Consultancy

Figure 9 Heat leaks at poorly insulated joints between different thermal elements, shown on a picture taken with a thermal camera. Reproduced from **CIBSE TM53: Refurbishment of non-domestic buildings** by permission of CIBSE

**2.8.14** The application of insulation, especially when this is internal, can still allow the occurrence of thermal bridging and consequently not derive the expected energy savings. The correct design and selection of materials and installation methodology is important in order to achieve the energy savings and thermal comfort levels required.

**2.8.15** Specifically for traditional buildings, the appropriate repair of building fabric may also influence the effectiveness of the insulation installation, especially in relation to moisture. A systematic approach

considering thermal performance, air permeability and moisture is required to achieve the best results. In historic environments or listed buildings it may be a requirement to obtain listed building consent and planning approval prior to the installation of insulation.

**Roof and loft insulation**

**2.8.16** Loft insulation is very easy to install and if installed correctly, it is easy to avoid dampness and condensation issues. However the installation of roof insulation can be more challenging. When insulation is installed between the roof joists, as part



of a refurbishment process, care needs to be taken to avoid the potential creation of thermal bridges in the places where joists are located. Finally, in the case of a flat roof, it is preferable to install insulation externally, either on top of the roof's waterproof layer or on top of the timber roof surface with a new waterproof layer on top of the insulation. Installing insulation in the interior is also possible as a refurbishment option; however, this is more prone to causing condensation problems if inappropriately installed.

**2.8.17** Specifically for older buildings, English Heritage provides guidance on 'Insulating roofs at rafter level', ceiling level and on 'Insulating flat roofs'. English Heritage has a series of documents focusing on [Energy Efficiency and Historic Buildings](#).

### Floor insulation

**2.8.18** Floor insulation is installed either on floors situated next to the ground, or on floors adjacent to non-heated spaces, such as storage areas. There are two main categories of floors: solid and suspended timber floors. Specifically for older buildings, English Heritage provides guidance on 'Insulating solid ground floors' and [suspended timber floors](#).

### Windows and glazing

**2.8.19** The previous paragraphs referred to heat losses through walls, roofs and floors and briefly described relevant insulation options. Heat losses can also occur through windows and glazed surfaces. Therefore, building fabric upgrade and heat losses reduction can also be achieved through upgrading existing windows and glazing.

**2.8.20** Methods of upgrading windows can include minimising the air leaking in or out around the windows, but also reducing the heat lost through the glazing area. Double-glazing is the most common upgrade for a single-glazed window. Triple glazing is also available, although still very costly. Energy

efficient windows also use gases such as argon in the gap between the sheets of glass. Finally, to reduce the air leakage through the window edges, pane spacers are used to separate the two panes of glass.

**2.8.21** According to the [BREEAM UK Refurbishment and Fit-out 2014](#), energy retrofit of glazing can have a positive contribution on the daylight levels or the views out of the building, under certain circumstances. BREEAM (Building Research Establishment Environmental Assessment Methodology) motivates building stakeholders by giving credits for these improvements.

**2.8.22** Glare control strategies have to be implemented to disable glare in all building areas, without the glare control resulting into higher energy consumption. More details on this can be found on the [BREEAM Technical Manual for Refurbishment and Fit-out 2014](#). Finally, the improvement of daylight levels and views out is an advantage when pursuing a BREEAM certification; especially for healthcare buildings, daylight improvements and enhanced views outside are considered particularly beneficial for occupied patients' areas, such as wards and consulting rooms.

**2.8.23** Additional benefits are identified resulting from window refurbishment in hospitals through the EEF. Other than the thermal comfort improvement, the enhanced appearance of the building is recognised, as described in Box 19.

#### Box 19 Additional benefits through window replacement at the University Hospital Southampton NHSFT

*Higher thermal comfort for patients and staff through airtight and double-glazed windows and reduced draft in corridors*  
*Exterior appearance of 1960s building improved through new windows*

### 2.8.24 The 'Health Building Note 00-10 Part D: Windows and associated hardware'

suggests considering the following when selecting windows:

- natural lighting;
- natural ventilation;
- view;
- weather tightness;
- energy conservation;
- sound insulation;
- security;
- safety;
- fire spread.

**2.8.25** It also provides information on each of these aspects and relevant documents to consult. Classification by weather tightness is based on test pressures for air permeability, water tightness and wind resistance as set out in **BS 6375-1: Performance of windows and doors**.

### Air-tightness and infiltration

**2.8.26** Since insulation refurbishment reduces buildings' heat losses, the relative importance of air infiltration on a building level, increases. The same issue arises during the summer with regards to cooling loads. As mentioned in the previous section with regards to thermal bridging, the joints between different materials and building components provide common paths of leaks for heat. In addition to these elements, permeable building materials and gaps around services passing through the construction, are additional paths of heat leaks towards the exterior of buildings. Appropriate sealing around services is also important in terms of fire prevention. More details can be found in the 'Health Technical Memorandum 05-02: Firecode: Guidance in support of functional provisions (Fire safety in the design of healthcare premises)'.

**2.8.27** In the process of reducing infiltration depends on the level of refurbishment conducted. The use of elastic and elastomer sealants, draught stripping membranes and films are some of the

potential remedies for high air infiltration rates in existing buildings.

**2.8.28** A list of guidance regarding building fabric upgrade by the Carbon Trust is provided in Box 20.

### Box 20 Building fabric upgrade guidance by the Carbon Trust

CTV069: Building fabric

CTV032: Building controls

CTL178: How to implement roof insulation

CTL176: How to implement cavity wall insulation

CTL063: How to implement draught-proofing

CTL065: How to implement solar shading .

CTL061: How to implement rapid roll doors

## 2.9 Building services systems upgrade

**2.9.1** The refurbishment of building services systems usually happens when the systems have passed their designated asset life, or present problems in their operation. According to **CIBSE KS12**, refurbishing specific parts or a whole system, if required, has multiple benefits, including:

- the reduction of energy use and associated carbon emissions;
- reduction of potential health and safety risks;
- improved reliability and availability of spares;
- reduced maintenance costs;
- improved ease of access for maintenance and inspection.

### Space heating systems

**2.9.2** Heating can be responsible for considerable percentages of energy use in

buildings. Therefore, the replacement or upgrade of heating systems and controls can provide a significant opportunity for energy savings.

**2.9.3** The aspects that can contribute to an energy efficient heating system are related to the primary plant and technologies that utilise the heat or hot water distribution. Control systems are an important component in ensuring a heating system delivers its energy output in an efficient manner, ensuring that heat is only provided when and where it is required, responding to changes in the external climate, internal solar and heat gains, as well as occupancy.

**2.9.4** **CIBSE KS12** advises designers to follow these suggestions regarding the refurbishment of heating systems:

- 'segregate hot water services generation wherever possible
- consider de-centralised heating and hot water services generation plant on large sites to reduce standing losses and improve load matching;
- locate plant to minimise distribution system losses;
- check distribution systems are sized correctly to minimise pump and fan energy consumption;
- insulate pipework, valves etc. effectively;
- check base load is provided by the most efficient plant;
- utilise condensing boilers where feasible and appropriate;
- select fuels and tariffs that promote efficiency and minimise running costs, while bearing in mind that tariffs are temporary and should not be given undue weight when making design decisions;
- meet the requirements of the 'Non-domestic heating, cooling and ventilation compliance guide' (**CIBSE KS12**, page 30).

**2.9.5** Detailed, thorough and conscientious design by an experienced designer is needed, rather than a mere focus on technologies. Following a whole system

approach, with fine-tuning and continuous improvement and development thought the procurement and installation stages are essential to optimise the efficiency of systems.

### **Combined Heat and Power (CHP)**

**2.9.6** CHP systems generate electricity and then recover the waste heat from the generation process for use in space or water heating. The electricity generated reduces the reliance on mains supplied electricity. This results in increased gas consumption (or alternative CHP fuel), but reduced electricity use. Due to the relative carbon intensities and energy costs of the different fuels (mains electricity presently has a higher carbon intensity per unit cost than natural gas) the result is reductions in carbon emissions and running costs.

**2.9.7** CHP units are typically financially and environmentally most beneficial when there is a high and constant demand for heat (e.g. heating a therapy pool). Nevertheless, it should be noted that even when smaller amounts of heat are required, a high cooling demand can also make the use of CHP more advantageous. A schematic diagram demonstrating the energy savings achieved through the use of CHP compared to conventional sources of heat and power generation is presented in Figure 10.

**2.9.8** According to the **CIBSE TM53**, CHP is likely to become more popular for the refurbishment of larger buildings or campuses where there is a strong seasonal heating demand. CHP units should therefore be used in the right situations and careful sizing is required. The principle is that the CHP should be sized to cover the heating demand and any excess electricity can then be exported to the grid. The Carbon Trust document '**CTV044: Introducing Combined Heat and Power**' can provide a good starting point for this information. Sizing appears to be a challenging process in practice and specialised knowledge is required.

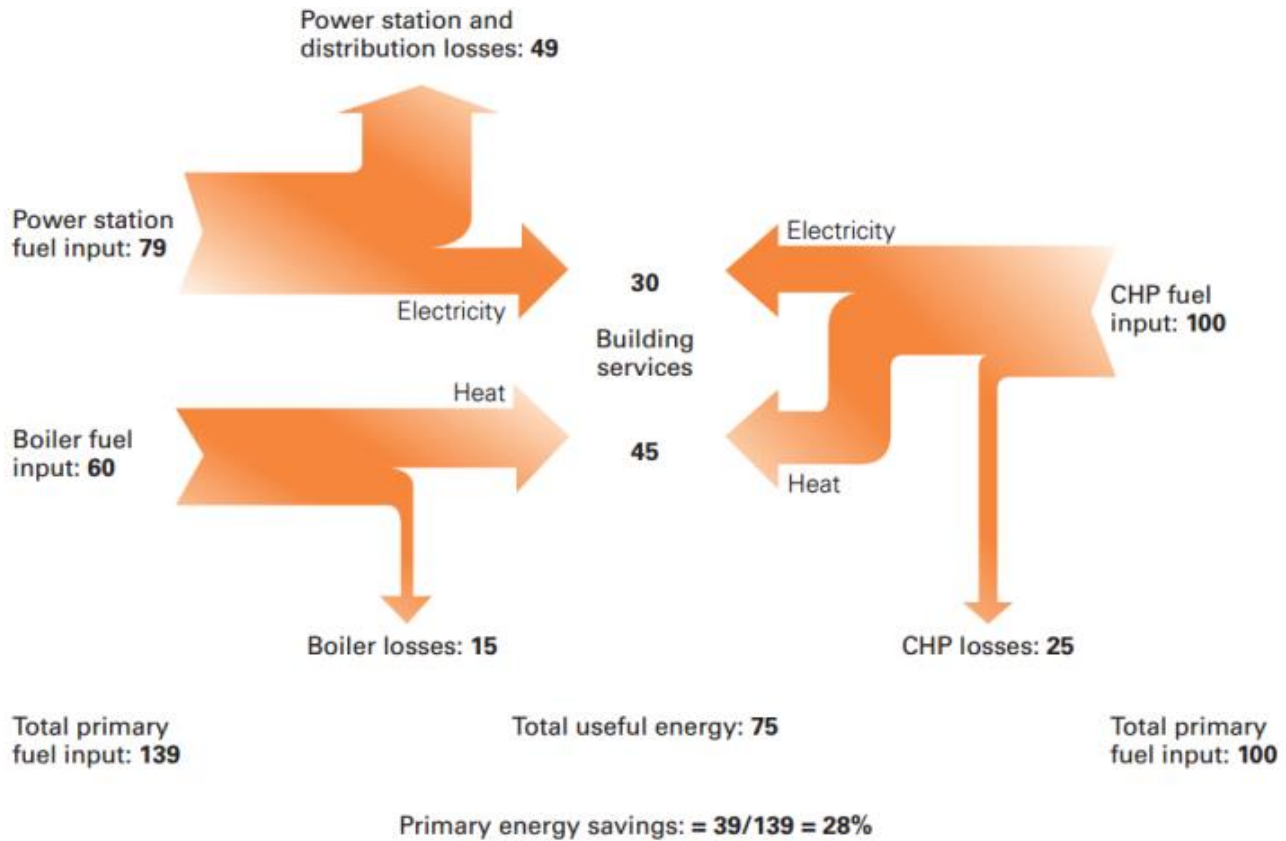


Figure 10 Energy savings through typical new small-scale packaged CHP compared to conventional sources of heat and power generation (shown in units of energy). Reproduced from **CTV044: Introducing combined heat and power** by permission of the Carbon Trust

**2.9.9** The use of CHP is encouraged by the **European Cogeneration Directive**, which provides incentive to increase the use of cogeneration throughout the EU member states in order to improve energy efficiency and security of supply. In the UK, CHP, either fossil fuel or renewable fuel fired, may qualify to be supported by Enhanced Capital Allowances, the Climate Change Levy (CCL) exemption and Business Rates Exemption. Renewable fuel fired CHP can qualify for the Renewables Obligation scheme, the Renewable Heat Incentive (RHI) and the Feed-in Tariff (FIT). More details on these incentives can be found in the relevant page of the UK Government: '**Government incentives for CHP schemes**'.

**2.9.10** Due to the increased risk of overheating in the summer, tri-generation (i.e. Combined Cooling, Heating and Power

(CCHP)) systems for providing heating, domestic hot water, cooling with absorption chillers and electrical power may be increasingly used. Figure 11 shows a schematic of a tri-generation/CCHP system complementing a boiler farm for a larger building complex. Moreover, it is worth mentioning the potential of using the CHP excess output for neighbouring areas and thus promoting carbon reduction on a community level. This also promotes the implementation of the **Energy Performance of Buildings Directive** (EPBD) which is analysed in Encode 2015 Part A and recommends the use of low or zero carbon technologies in buildings.

**2.9.11** Three of the EEF projects where CHP systems have been installed are described briefly in Box 21. The following paragraphs discuss the relevant benefits and the lessons learnt in more detail.

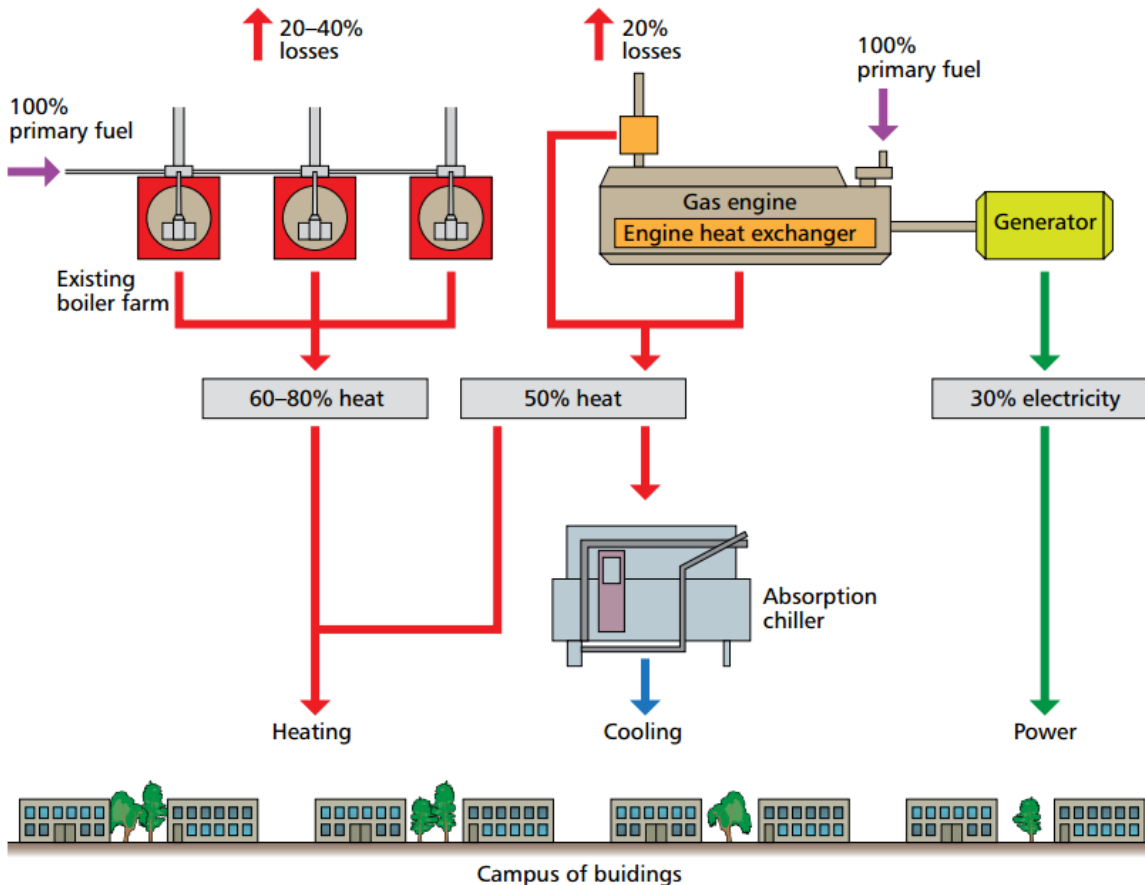


Figure 11 Schematic representation of a CCHP system as a refurbishment solution in an existing boiler farm of a larger building complex. Electrical power, heating, domestic hot water and cooling are produced simultaneously. Reproduced from **CIBSE TM53: Refurbishment of non-domestic buildings** by permission of CIBSE

**2.9.12** Beyond the direct benefits associated with heating and energy savings, Homerton University Hospitals NHSFT have reduced their reliance on oil as a fuel supply and existing oil storage space has become redundant as a result of this project. The site previously required space for two 90,000 litre tanks for the boilers and one smaller tank for an on-site emergency generator. Only one tank is now required for the emergency generators and the standby dual-feed to the boilers. Thus, an indirect benefit from the CHP installation is that approximately 71 m<sup>2</sup> of land previously allocated to oil storage has been allocated for expansion of pathology labs.

**2.9.13** The Homerton University Hospitals NHSFT site consumed up to 6,000 litres of oil each day during peak season. The oil

was delivered to the hospital by tankers, three to four times per week. It is estimated that a round trip for fuel deliveries from the Midlands could amount to around 240 kgCO<sub>2</sub> per delivery<sup>6</sup>. These deliveries from the Midlands were a source of additional local emissions and increased the local traffic.

**2.9.14** Weekly deliveries are no longer required as the site now only retains oil as emergency supply. This is a notable example of how energy efficiency projects can bring multiple benefits beyond savings on the energy bill.

**2.9.15** Key lessons learnt from these projects are associated with the

<sup>6</sup> Assuming diesel delivery trucks of 2.63 kgCO<sub>2</sub> per litre of diesel consumed and 10 mpg

complexities of CHP projects on existing sites, particularly within the tight timeframes stipulated in the provision of the EEF. An observation from the EEF is the reliance of the NHS organisation on external suppliers to deliver and install the systems. For example, there were issues with the delivery times of CHP boilers coming from Germany or with timing the loan of temporary boilers, as reported by Homerton University Hospitals NHSFT.

**2.9.16** This may become a critical risk in the successful implementation of projects, where timing of installation can be difficult. The discussion below provides further context to particularly pertinent issues identified in the case studies.

**2.9.17** Selling energy to the grid can require considerable negotiation; at Milton Keynes, energy is purchased through a consortium with an NHS-backed procurement service.

This includes agreements to purchase minimum amounts of energy annually. Consequently the installation of energy generating equipment (e.g. CHP or two recent medium voltage generators), that will both reduce the demand for energy and result in times when electricity is sold back to the grid, requires considerable negotiation with the various stakeholders. For example, finalising G59 agreements with electricity providers can prove to be very time consuming.

**2.9.18** Due to the critical role that external stakeholders play in CHP installations, it is crucial that hospitals are aware of these potential delays and allow sufficient time for finalising agreements in the programme. This is particularly important in heating installations, compared with more stand-alone installations (e.g. solar panels) where, depending on the season, delays could impact on the running of the hospital.

### Box 21 From three CHP projects in the EEF

- *Frimley Park NHSFT*
- *Homerton University Hospitals NHSFT*
- *Milton Keynes NHSFT*

#### Objectives

- *Increase efficiency of energy consumption – both in terms of energy use and carbon intensity of fuel*
- *Increase reliability of heating and hot water supplies*

#### Lessons learnt

- *Time constraints*

*Tight time-scales can be challenged by unexpected issues: There are potential issues beyond the common risks linked to cost escalation and manufacture delay. For example, Homerton University Hospitals NHSFT experienced issues in securing a wayleave agreement for a gas main and in obtaining temporary boilers.*

- *Calculation review*

*Clear guidance is needed for reality check on calculations: Given the potential lack of in-house expertise on more complex systems (renewables, CHP, etc.), clear guidance on sizing, emissions saving potential, forms of contract and potential system benefits is crucial.*

- *Teething issues*

*Expect issues during early months of use: Milton Keynes NHSFT experienced teething problems during the first few months after installation of the new system, including issues with the telemetry and faults necessitating the replacement of small components. This has impacted on the ability of the new system to fully function and produce the expected savings.*

- *Energy purchase negotiations*

*Selling energy to the grid can require considerable negotiation: In the case of Milton Keynes NHSFT, energy is purchased through a consortium with an NHS-backed procurement service. This includes a minimum annual purchase agreement. Consequently, reducing the need to purchase electricity and (at times) being in a position to sell to the grid required considerable negotiation with the various stakeholders.*

## **Benefits**

### *Direct impact on energy use*

- *CHP units generate electricity and recover waste heat.*
- *Reduced reliance on mains electricity leads to reduced carbon intensity of supply.*
- *Reduced CRC commitment.*

### *Work practice / business process*

- *Increased resilience in supply.*

*Homerton University Hospital NHSFT: Reduced insurance and maintenance requirements.*

- *Savings enable reallocation of funding towards replacing existing lighting with low-energy LED lighting.*
- *Removal of oil storage frees 71m<sup>2</sup> of land. This space is allocated for expansion of the hospital.*
- *Reduced local pollution through switching from oil to gas (less particulates, NOx and SO<sub>2</sub>).*
- *Reduced deliveries of oil per week (had been receiving 3-4 deliveries per week).*

### *Patient / staff services*

- *Milton Keynes NHSFT: Planned savings reinvestment into supporting revenue maintenance costs.*
- *Frimley Park NHSFT: Re-commissioned AC and ventilation systems will improve internal environment.*

### *Wider community*

- *Support of wider economy through employment of local/regional SMEs*
- *Frimley Park NHSFT: Informal knowledge share with West Suffolk Hospital – a similar site with CHP.*

**2.9.19** CHP installations are complex projects and proper sizing is one of the challenges that need to be addressed. Issues that often appear to be challenging in this process include the following:

- need to balance heat and electrical demands;
- calculating carbon savings due to methodological and systematic errors;
- CHP plants may be 'turned down' during hot weather when the heat generated cannot be fully utilised, temporarily reducing the electricity generated and impacting on the system's carbon emissions savings.

**2.9.20** Therefore, it is important to ensure that a team with appropriate expertise is responsible for the sizing and the correct installation of CHP systems.

### Air conditioning

**2.9.21** AC systems can account for up to a considerable percentage of electricity costs so there is a cost benefit in ensuring the AC system is correctly operated and maintained. The requirement for AC inspection has been analysed in Encode 2015 Part A. Though not mandatory there is a need to act upon the recommendations from the Energy Assessor. The information and advice provided by the Inspection will highlight possible improvements to:

- the energy efficiency of the system;
- electricity consumption and operating costs;
- carbon emissions.

**2.9.22** This information will help the building occupier to improve the overall energy efficiency of their building and reduce their carbon emissions. This should result in an improved Display Energy Certificate rating for their building. Recommendations from the AC Energy Inspection should be factored into AC refurbishment programmes.

**2.9.23** **CIBSE KS12** on the Refurbishment for improved energy efficiency comments that when AC is necessary, energy

efficiency can be improved by the following measures where appropriate:

- 'provide heat recovery in AHUs;
- provide effective control of dampers for minimum fresh air and free cooling on recirculation systems;
- check that fresh air and exhaust dampers will close when the building is not occupied;
- check that only the minimum fresh air required is treated, preferably by varying the minimum fresh air content during occupied periods with respect to air quality; CO<sub>2</sub> sensors can be used to infer likely levels of air quality;
- minimise duct lengths and bends and provide adequately sized ducts;
- check that ducts will be airtight
- correctly select and size the most efficient fans;
- select low energy motors; where possible use DC motors with variable speed control;
- check that the control strategy considers all full and part load conditions and is fully described and correctly configured. Check that the requirements of the Non-domestic heating, cooling and ventilation compliance guide will be met' (**CIBSE KS12**, page 23).

### Ventilation

**2.9.24** The role of indoor air quality is very significant especially in healthcare buildings. The **BREEAM New Construction Technical Manual 2014** describes its most important aspects to be the minimisation of air pollution sources and the ventilation strategy being flexible to potential future building occupant needs and climatic scenarios.

**2.9.25** Moreover, occupants comfort must always be a priority in refurbishment options, especially in hospitals, where some of the building occupants belong to higher risk or more vulnerable categories. The topic of thermal comfort in healthcare buildings is extensively discussed in Encode 2015 Part A.



**2.9.26** Ventilation requirements for the refurbishment of existing buildings are the same in principle as those for new buildings, described specifically for hospitals in **HTM 03-01 Part A** and **HTM 03-01 Part B**. It should be noted that the refurbishment of existing buildings may influence the existing ventilation strategies. For example the replacement of windows is likely to affect the solar gains, infiltration rates and heat losses, therefore the ventilation required would be influenced. The same would happen following changes on a building layout or even different window opening patterns which can be very specific especially on an NHS organisation level. Table 2 shows the potential consequences of building design related refurbishment decisions for the ventilation strategy. CIBSE TM53 also recommends measures for enhancing natural ventilation efficiency, presented in Box 23. Note that

these measures are not specific to healthcare environments, therefore special care should be given to ensure the required thermal comfort conditions and safety levels are achieved while introducing strategies for the improvement of a building's ventilation.

**2.9.27** Reasons of concern in healthcare environments are related to the patients' safety when opening the windows and to infection control.

### Free cooling

**2.9.28** According to the CIBSE KS12, free cooling options for use with mechanical cooling plant can be a viable refurbishment option.

### Box 22 HVAC improvements at the Barts Health NHS Trust

*As part of the EEF, Barts Health NHS Trust improved its AC by replacing bag filters within the AC plant and also by installing variable speed drives (VSD) on any of the AC plant where it was previously not installed on-site. These changes are not only expected to achieve energy savings, but also to reduce maintenance costs and materials' use due to the longevity of the new filters. Their recommendation is to identify the characteristics of filters and drive units and the values that need to be maintained on completion. This has to be complete before the beginning of the project. They comment that this enables the contractor to quote for all the work and it shortens the procurement time.*



**Figure 12** AC upgrades in the Barts Health NHS Trust included the installation of new energy filters (left) and VSD invertors on the AC plant (right). Courtesy of Barts Health NHS Trust

Building design change	Potential consequence/risk	Possible measures to address risks	
		Natural ventilation	Mechanical ventilation
Building fabric U-value/ airtightness improvement	Less air infiltration/night-time heat loss in summer Trapped solar gains	Night purge ventilation Larger window opening depths More window panes that open External shading	Mechanical night purge ventilation Capacity/air velocity increase Plant upgrade/replacement External shading
Façade appearance (material, colour, removal of overhangs)	Higher solar gains	Night purge ventilation Larger window opening depths More window panes that open	Mechanical night purge ventilation Capacity/air velocity increase Plant upgrade/replacement
Window opening mechanism	Less fresh air supply	More window panes that open or additional dedicated vents  Localised mechanical ventilation	
Floor plan design	Cross flow/air paths no longer adequate	Trickle vents between zones  Localised mechanical ventilation between zones, i.e. fans (as a last resort due to noise)	Redistribution of grilles/change of index run

**Table 2 Influence of alterations to the building design on the ventilation strategy post refurbishment. Reproduced from CIBSE TM53: Refurbishment of non-domestic buildings by permission of CIBSE**

**2.9.29** Free cooling uses favourable weather conditions to enable chiller plant to be shut down for periods of time. Adding free cooling as a potential option to an existing mechanical cooling system can significantly increase its energy efficiency in terms of cooling. ‘The viability of free cooling is increased if:

- there is a significant cooling load during winter months, typically greater than 20% of full design cooling load;

- there is a continuous 24-hour demand for cooling;
- chilled water can be circulated at increased temperatures;
- a high performance building envelope is provided’.

**Box 23 Measures for enhancing natural ventilation efficiency from CIBSE TM53: Refurbishment of non-domestic buildings**

Measures for enhancing natural ventilation efficiency include:

- fitting windows with high and low level openings
- increasing the amount of ventilation openings (new ventilation openings/stacks, exchange of fixed windows with openable windows)
- increasing the opening angles of existing ventilation openings where feasible
- increasing extract ventilation stack size (as permitted by the roof profile)
- zoning internal spaces and modifying room layouts in order to enhance air flow

patterns/cross ventilation where feasible without creating unacceptable draughts

- reducing ventilation requirements related to solar gains by:
  - providing external shading
  - replacing the existing glazing with glazing of a low g-value
  - reducing the glazed surface area where the building is highly glazed, provided that this reduction would not adversely affect daylighting
  - exposing existing thermal mass such as ceiling soffits
- reducing ventilation requirements related to internal heat gains by installing lighting with daylight control and high luminous efficacy
- introducing night purge ventilation
- ensuring that open windows are compatible with blinds (consider mid-pane blinds within double glazing)

**2.9.30 CIBSE KS12** describes a variety of solutions for achieving free cooling.

### Electrical services

**2.9.31 CIBSE TM53** describes electrical services as those relevant to the building electrical infrastructure, as well as fixed electrical accessories; this includes luminaires, fans, flex outlets and sockets. After the condition of existing electrical services is assessed, a refurbishment strategy can be decided. An electrical survey allowing his assessment should be conducted to include the following:

- 'an assessment of the existing supply capacity from the grid;
- investigations of the structure of the existing electrical supply and distribution infrastructure (back-up generation plant, uninterruptible power supply, primary/secondary distribution);
- measurements of the electrical parameters at each distribution point (fault level, load current, circuit resistances, harmonic distortion and earth path continuity);
- load capacity assessments, including switchboard and distribution board spare (unequipped) ways;
- the existence of power factor correction and harmonics control equipment;
- single line schematics of the complete electrical infrastructure (of all areas, including the intake);
- floor plans with accurate single line arrangements of the existing electrical containments;

- assessments of the condition of the wiring and the appropriateness of the containments;
- the original design data/specifications and previous alterations (as far as information is available);
- spatial constraints (including central plant, risers and ductwork, access for maintenance);
- fire segregation;
- the position and condition of fixed electrical accessories' (**CIBSE KS12**, pages 53-54).

**2.9.32** The Department of Health provides guidance for electrical services:

- **HTM 06-01: Electrical services supply and distribution-Part A: Design considerations;**
- **HTM 06-01: Electrical services supply and distribution-Part B: Operational management;**
- **HTM 06-02: Electrical safety guidance for low voltage systems;**
- **HTM 06-03: Electrical safety guidance for high voltage systems.**

**2.9.33** Additional benefits of electrical optimisation schemes have been identified by four of the EEF projects where relevant measures have been implemented and analysed in more detail. From these projects, valuable experience has been collected regarding the actual implementation of this type of measures and potential difficulties that might arise. These are briefly mentioned as 'Lessons learnt' in Box 25. The following paragraphs discuss these lessons in more detail.

### Box 24 From the VO project at the Great Western Hospitals NHSFT

*Representatives from Great Western Hospitals NHSFT commented that they would embark on this type of project again, this time a lot wiser as to the implications and the risks of installation. Lessons learnt involve the installation as a technical process, as well as the complexity of PFI and the agreements for delivering a secure energy supply.*

**2.9.34** In healthcare environments, it is crucial to ensure that supply remains appropriate for sensitive medical or building equipment. In the case studies funded and examined under the EEF, estates staff highlighted the need for care when lowering the voltage to existing buildings, in

particular those with older cabling. Relevant guidance is provided in 'HTM 06-02: **Electrical safety guidance for low voltage systems**'. Surveys carried out during the design phase can help identify any equipment that might be at risk of failure. Box 24 presents the case study of Great Western Hospitals NHSFT and the challenges it faced during voltage optimisation (VO).

**2.9.35** The need to be aware of the key external stakeholders and allocate sufficient time in the planning process to reaching appropriate agreements is vital to major refurbishment works such as these.

**2.9.36** Finally, while projects can go well with temporary support, temporary project management roles require good handover plans. Also, projects may be delayed beyond the contract term, requiring in-house staff to take over project responsibility.

### Box 25 From four electrical optimisation projects in the EEF

- *Great Western Hospitals NHSFT*
- *Southend University NHSFT*
- *Stockport NHSFT*
- *University Hospital of South Manchester NHSFT*

#### Objectives

- *More efficient operation of electrical equipment, saving energy and extending equipment life.*
- *Reduce voltage losses.*

#### Lessons learnt

- *Flow-on effect of changing voltage*

*Ensure that supply remains appropriate for sensitive medical or building equipment: care is needed when lowering the voltage in buildings.*

- *Data collection*

*Various factors affect identification of real savings: Issues with metering, limited time and changes in use/behaviour affect ability to collect data and see savings.*

- *In-house management beneficial*

*Project management in-house helps to maintain project momentum and to quickly address problems and ensure a smooth process, particularly for stakeholder liaison. In-house teams can also draw on prior experience at the site.*

- *PFI arrangements require time*

*PFI arrangements add a layer of complexity: PFIs can provide benefits to refurbishment works, e.g. they can provide support for procurement or project management. However negotiations of agreements can take time and potentially delay project implementation.*

- *Performance guarantees possible*
- *Investigate possibilities of performance guarantees from suppliers: For Great Western Hospitals NHSFT, suppliers guaranteed savings up to the cost of the capital investment.*

### **Benefits**

*Direct impact on energy use*

- *VO and transformer replacement reduce site electricity consumption.*
- *University Hospital of South Manchester NHSFT: Less likely to exceed set energy limits, providing greater opportunity for future expansion.*

*Work practice / business process*

- *VO helps to reduce operating temperature of transformers and improve plant lifetime.*
- *Reduction in maintenance requirement allows reallocation of resources for greater impact.*
- *Implementation does not impact ward occupants, resulting in minimal disruption.*

*Patient / staff services*

- *Great Western Hospitals NHSFT: Savings to be invested into a dedicated Theatres Admissions Lounge. This facility will improve the hospital environment for both patients and staff. Savings will also be invested in staff training to improve knowledge on dementia.*
- *Southend University NHSFT: Savings across all EEF projects to be invested in a capital programme of projects aimed at improving the hospital environment for patients and staff.*

*Wider community*

- *Support of local/regional economy through SME contracts.*
- *Knowledge sharing and partnership benefits.*

## 2.10 Lighting upgrade

**2.10.1** According to the **BREEAM New Construction Technical Manual**, internal and external lighting systems are designed to avoid flicker and provide appropriate illuminance (lux) levels. Improved lighting design can reduce the relevant energy use and internal heat gains, therefore also reducing the need for mechanical cooling during the summer months. The aims of energy efficient lighting are to maximise natural daylight, to avoid excessive illuminance, to incorporate efficient luminaires and components and to use effective lighting controls.

**2.10.2** During lighting upgrade, factors to be considered include the need for general illuminance level or task lighting in specific areas, the source and the properties of lighting options, aesthetic qualities, continuity of use and even the differences between horizontal and vertical planes. Aspects to consider also include products' lifespan and the recyclability of lighting components. CIBSE KS12 lists energy efficient light sources, as well as specific advantages and disadvantages of each category.

**2.10.3** Moreover, lighting controls are not only an important aspect influencing lighting and occupant visual comfort, but it can also be a significant factor increasing capital costs. Depending on the type of space and the required level of control, the options vary from manual controls to occupancy

detection, as well as time and photoelectric controls. The type of control used can also be very significant in terms of achieving energy efficiency and reducing the hours when lighting is used. It is worth highlighting here that this latter requirement for efficiency should not be at the expense of visual comfort or safety concerns.

**2.10.4** The following regulations and standards are relevant to lighting in refurbishment projects:

- **Commission Regulation 245/2009** regarding eco-design requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps and for ballasts and luminaires able to operate such lamps
- The **Building Regulations L2B**. Relevant amendments are available online and the current Building Regulations L2B should be viewed together with them.
- **BS EN 12464-1: 2011: Light and lighting. Lighting of work places. Indoor work places**
- **BS 5266-1: 2011: Emergency lighting. Code of practice for the emergency lighting of premises**

**2.10.5** A list of guidance regarding lighting by the Carbon Trust is provided in Box 26. Finally, more information on lighting specifically for hospitals and other healthcare buildings can be found in **CIBSE Lighting Guide 02: Hospitals and Health Care Buildings (SLL LG2)**.

### Box 26 Lighting guidance by the Carbon Trust

[CTV049: Lighting overview guide](#)

[CTL161: How to implement lighting controls](#)

[CTL162: How to implement external lighting](#)

[CTL163: How to implement lighting refurbishments](#)

[CTL164: How to implement LED lighting](#)

[CTL165: How to use retrofit kits to convert fluorescent light fittings to T5 fluorescent or LED](#)

**2.10.6** Light Emitting Diodes (LED), are currently considered to be the most energy efficient form of lighting. Although LEDs have been in use for many years it is a relatively new technology with respect to the general internal and external lighting use. There are numerous companies with differing products and standards of lighting performance and suitability. Therefore, selecting a supplier who understands the principles of healthcare lighting requirements will help to ensure NHS organisations can meet their requirements with regards to lighting quality and energy efficiency. It is also advisable to engage

with consultants rather than manufacturers' representatives, so that independent objective information is provided. The Carbon Trust [CTV049: Lighting Overview Guide](#) is a good place for information on the different lighting technologies available.

**2.10.7** The EEF included twenty projects with lighting upgrades and has identified some very interesting lessons learnt and additional benefits generated by lighting refurbishment. These are presented in Box 27.

### Box 27 Twenty lighting projects in the EEF

*Twenty EEF projects involved some element of lighting. Projects ranged from replacing less than 100 lights to replacing over 8,000 lights.*

#### Objectives

- *Upgrade lighting to more efficient technology*
- *Improve lighting levels and spectrum to improve patient and staff environment*
- *Design systems appropriate for each hospital area – ensuring lighting levels and controls meet occupant needs*
- *Ensure compliance with current standards*
- *Reduce lamp change maintenance*

#### Lessons learnt

##### Cost effectiveness

*Several factors influence return on investment: There is not a uniform cost-benefit ratio for the lighting projects. While LEDs provide energy savings in a like-for-like comparison with older technology, several auxiliary costs influence the savings achieved. Factors include: possible need for wiring upgrades, replacing fittings, removal of asbestos and other ceiling improvements. Occupancy sensors may be fitted at additional cost, where they increase expected savings per lamp through reducing hours of use. Finally, a refurbishment may require additional lights to improve lux levels to current standards.*

##### Implementation

*Coordinating light replacement with other refurbishments helps logistics: Replacing lighting in patient areas is intrusive and the logistics of transferring patients from wards can be challenging. Some NHS organisations have managed this issue through partnering lighting upgrades with other refurbishment work.*

##### Contractual arrangements

- *Warranties can impact on cost effectiveness: It is important to review the conditions and length of warranty because a good warranty provides certainty over maintenance and replacement savings.*
- *Clear design objectives required: There are various ways to achieve improved lighting. If employing design consultants, it is important to discuss options to ensure the design meets the project's priorities.*

### **Benefits**

#### *Direct impact on energy use*

- *More efficient lamps save electrical energy*

#### *Work practice / business process*

- *Reduced operation and maintenance costs*
- *Improved inventory management (fewer lamp types required)*
- *Reduced patient interruption for maintenance of lighting*
- *A visible intervention helping to promote environmental awareness and energy saving behaviour.*
- *Enabled faster implementation of health and safety upgrades (meeting current standards for lighting)*
- *Reduced need to work at heights to replace lights*
- *Reduced problematic disposal of fluorescent lighting*

#### *Patient / staff services*

- *Improved patient and staff comfort*
- *Improved environment for visual tasks*
- *Improved control over room environment*

#### *Wider community*

- *Employment of local/regional SMEs to deliver projects*

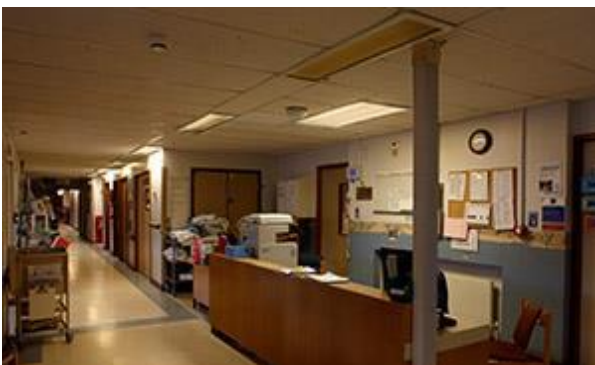


Figure 13 Before (left) and after (right) in a corridor reception area of the Royal United Bath NHSFT.

Source:

[http://www.ruh.nhs.uk/media/media\\_releases/2014\\_06\\_16\\_Lighting\\_the\\_way\\_for\\_good\\_care.asp](http://www.ruh.nhs.uk/media/media_releases/2014_06_16_Lighting_the_way_for_good_care.asp)



**2.10.8** The key cash-releasing benefit of lighting replacement schemes is the reduction of energy use associated with the reduction in wattage of the lamps and reduction in hours of use. However, while not always explicitly accounted for, lower maintenance costs associated with using the longer-life LEDs provide additional benefits. This benefit is partly guaranteed through replacement warranties provided by suppliers (guarantees appear to range from 3 to 7 years). Other efficiencies can also be gained through streamlining the lighting scheme across the site. For example, one organisation reported reducing the number of lamp types from over 100 down to 20.

**2.10.9** The main non-cash releasing benefit is the improved lighting quality and lux levels. This provides improved conditions for both patients and staff. In Royal United Bath NHSFT (Figure 13), upgrading to LED lighting has transformed the interior environment, including clinical areas, wards and corridors.

**2.10.10** There are also potential improvements in safety through, for example, better illumination of trip hazards in car parks and reducing the frequency of replacing lights at a height where an extension ladder is required.

## 2.11 Controls upgrade

**2.11.1** Control systems' configuration and functions depend on the type of control and its age. The protocol used by the controls might be a significant limitation to potential upgrade; it might thus influence the decision on whether this control remains, is upgraded or entirely replaced. The rule of thumb is that the older the system, the less flexible it is.

**2.11.2** One of the first things to check in an existing system is its size, in order to assess if it operates effectively. The availability of BMS, Building Automation and Control System (BACS) or Building Energy Management Systems (BEMS) can

inform the refurbishment strategy for the associated services. Relevant data from these systems can be used to identify how different systems operate.

**2.11.3** According to CIBSE TM53, building control systems may cover the following functions:

- 'management of plant/system operation and their associated time schedules;
- matching of plant operation and outputs with the building demands;
- continuous optimisation of the plant/system usage in relation to the demands/external weather conditions;
- control of the indoor air temperature, humidity levels and/or air quality;
- monitoring of the operation of the building services in relation to their design specifications/set points ;
- support in maintenance scheduling;
- automatic detection of faults/failing components and generation of associated warnings and reports;
- avoidance of plant/system overlaps (e.g. cooling and heating operating at the same time in the same space);
- logging of plant operation, including generation of associated reports (e.g. reports on plant operation times, flow and return temperatures, demand profiles, energy consumption)' (CIBSE TM53, page 67).

**2.11.4** Upgrading controls can offer very significant improvements regarding existing buildings' energy efficiency. Box 28 describes the lessons learnt and the benefits regarding controls' upgrade at the Southend University NHSFT. Inadequate, inappropriately installed or not well understood controls can be responsible for inefficient building performance and can relatively easily be upgraded. The following points suggest potential changes on building controls, based on CIBSE KS12.

- Time controls should incorporate a seven-day timer and multiple on/off periods during each day. Extension time functions should also be provided for potential building occupancy outside the usual operational hours. Finally,

night setback of space heating can be used where fully intermittent operation is not appropriate.

- Optimum start/stop controls can be used and set to operate heating systems depending on the internal temperatures and thermal comfort requirements. Similar controls are available for cooling systems.
- Well thought and organised zoning should be applied, in order to cater for a variety of requirements for different areas during various times during the building operation. Criteria for zoning can include spaces' orientation, occupancy patterns, spaces' flexibility and modifications.
- Sensors should have appropriate levels of accuracy and be located in positions where they can provide information representative of the areas they control.
- Occupants' controls should be easy to use and understand, intuitive and to work effectively, with sufficient fine control to give the required level of adjustment. They should give an instant indication to the user that they are in operation and that the intended effect has occurred. Finally, they should not require too frequent intervention by the users (for example by restoring default conditions too rapidly) and they should be located as close to the point of need as possible.

**2.11.5** Once controls are installed or upgraded, an effective housekeeping regime has to be in place, with regular checks on times and set points. The following standards are related to the implementation of building controls in existing buildings:

- **BS EN 15232: 2012: Energy performance of buildings. Impact of building automation controls and building management**
- **BS EN ISO 16484-1: 2010: Building automation and control systems. Project specification and implementation**

### **Box 28 Lighting at Southend University**

*Heating control system gives control to staff to ensure temperatures meet needs of patients.*

*New lighting controls will only achieve energy reductions if used appropriately by the medical staff and/or patients.*

*Therefore, providing a formal way for hospital staff to voice their views on the projects is a useful means of engagement and helps to identify whether or not the new systems are being used effectively.*

**2.11.6** When considering building controls' upgrade, a refurbishment strategy has to be designed, taking into consideration the building users' requirements, financial limitations, set points and schedules, as well as types of functions. Documentation must be developed describing the operation of the control system and relevant customer interface should be designed. Finally, the maintenance technicians should be trained in operating any new controls system.

**2.11.7** When upgrading existing control systems, financial and operational benefits of this action should be evaluated against the potential system replacement. This should include the impact on building operation, the likelihood of system down-times after completion of the works as well as during the refurbishment in cases where the building remains occupied. Generally the capital and maintenance cost of a building control system increases in relation to the system's complexity and level of integration, as illustrated schematically by Figure 14.

## **2.12 Renewables**

**2.12.1** There is an extensive section on renewable and low carbon energy technologies, providing an overview of

different options in Chapter 4. When deciding on the use of a renewable or low carbon technology, there are certain things that have to be taken into consideration.

Questions to ask from the **CTG050: Power play: Applying renewable energy technologies to existing buildings** include:

- Are there any other low carbon measures suitable for your building that could also meet your objectives?
- What is your budget likely to be for upfront capital costs?
- Are there any financial criteria an investment would need to meet, such as particular payback time?

**2.12.2** A summary of technical aspects to consider for different options, as described in the CIBSE KS12 is provided in Table 3.

**2.12.3** Local planning authorities are responsible for the installation of renewable and low carbon energy technologies with capacity smaller than 50 MW. However, microgeneration is often allowed without the need to apply for a planning permission. More information on whether planning permission is needed and further guidance is provided in the [planning portal website](#). Section 2.14 highlights the need for planning permission for the installation of renewable energy technologies on an existing building and refers to challenging aspects identified in the EEF.

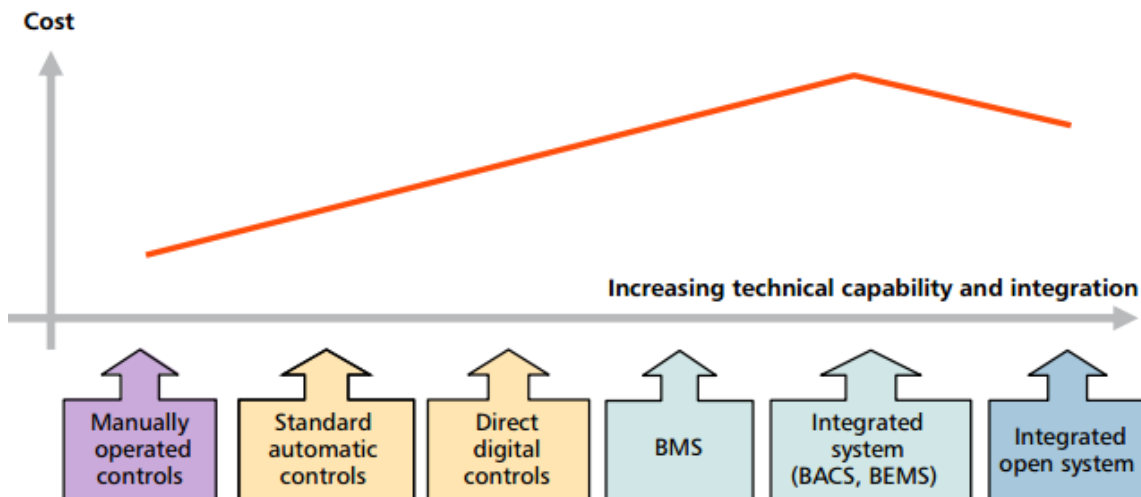


Figure 14 Indicative relationship between the overall cost of building control systems and their complexity. Reproduced from **CIBSE TM53: Refurbishment of non-domestic buildings** by permission of CIBSE

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## Photovoltaics

PVs generate DC electricity, therefore an inverter is required to convert to AC, unless the DC electricity can be used directly, e.g. DC electric motors, LED lighting systems

They can be integrated with the public electricity supply

They can be integrated with the fabric of a building with relative ease

Best performance is on buildings with a roof or wall that faces within 45° of south and with an elevation of 30 - 40°

Check for shading from nearby buildings and trees

Roof or supporting fabric must be strong enough to hold the weight of the panels

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## Solar thermal

Auxiliary or back-up systems are usually required when solar heat is insufficient to meet demand

A wide range of building types can use solar thermal systems: a range of installation options is possible

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Best performance with roof that faces within 45° of south

Check for shading from nearby buildings and trees

---

### **Wind power**

Average wind speeds of more than 6 m/s are typically required to generate worthwhile quantities of electricity

Average wind speeds will be reduced in urban locations

There is an argument that small, building mounted turbines are ineffective

Building mounted and augmented wind turbines will have potential structural, vibration and noise implications

---

### **Biomass**

Convenient and sustainable transport access to suppliers of biomass will be required

Sufficient fuel storage capacity will be required

Consideration will need to be made of any local traffic regulations preventing the movement of heavy vehicles and therefore making it impossible to deliver large quantities of biomass fuel

An on-site fuel handling system will be required

Start-up times are typically longer than for conventional gas-fired boilers

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### **Ground source cooling**

At a depth of about 12 m the ground temperature is relatively constant at between 9°C and 12°C which provides a source of 'coolth' that can be used to cool ventilation air directly or can be circulated through cooling plant such as chilled ceilings

A detailed ground survey will be required to determine the suitability of a particular site

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### **Ground Source Heat Pumps**

The output temperatures (typically 40 - 50°C) are most suited to low temperature systems such as underfloor heating systems and radiant panels

Higher output temperatures, e.g. for the heating of domestic hot water, are possible but at the expense of a far lower coefficient of

Ground collectors can either be horizontal or vertical

GSHPs are suitable for soil and rock types in most locations

GSHPs are most efficient when they operate continuously and so are best suited to buildings which are in constant use

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**Table 3 Application considerations for renewable and low carbon technologies on existing buildings.**

Reproduced from **CIBSE KS12: Refurbishment for improved energy efficiency: an overview** by permission of CIBSE

## **2.13 Refurbishment for resilience**

### **Responding to the potential of summer overheating**

**2.13.1** The need to refurbish the existing hospitals stock for climate change and to make decisions based on optimum design for resilience, has been identified as a priority. Recent research funded by the Department of Health and the National Institute for Health Research (NIHR) has identified significant factors in this process. A short film presenting the relevant findings

is presented in the [University of Cambridge website](#).

**2.13.2** The **BREEAM UK Non-Domestic Refurbishment and Fit-Out** includes credits aiming to encourage resilience in the refurbishment of buildings. A thermal model has to be run with future weather files, hence accounting for climate change. For the cases where the building does not comply with the credit requirements for climate change at present, it is required to demonstrate how the building is adapted or can be adapted in the future using passive design solutions.

**2.13.3** CIBSE KS12 describes how overheating can be avoided or minimised in buildings, through the introduction or improvement of solar shading. The type, size, shape and position of shading devices depend on the climate, orientation and use of the building. For refurbishment projects, there are several shading options available, including overhangs and awnings, external, internal and mid-pane blinds, as well as films and even coated glazing (where windows are being replaced).

**2.13.4** Interior shades protect from direct sunlight and glare, but ventilation or mechanical cooling is needed when infra-red radiation penetrates the glazing. Mid-pane blinds can be a good solution, as they also require less maintenance.

**2.13.5** Horizontal shading protects against solar gains in the summer and especially on southern facades, while vertical shading works better for east and west facades and lower solar altitudes. Finally, external fixed shading cannot be adjusted and they permanently obstruct natural light, which can be disadvantageous.

**2.13.6** Encode 2015 Part A, has described thermal comfort, focusing on the special conditions in healthcare environments and in relation to the changing climatic conditions.

## 2.14 Planning and building regulations

**2.14.1** Approved Document L2B: 'Conservation of fuel and power in existing buildings other than dwellings' details energy related requirements on the design of refurbished and extended existing buildings. It is the overarching document to consult when planning for a building refurbishment and its requirements apply to the following areas:

- consequential improvements;
- extensions;
- buildings subject to a material change of use;

- material alterations;
- provision of a controlled fitting;
- provision or extension of a controlled service;
- provision or renovation of a thermal element.

**2.14.2** As **CIBSE KS12** describes, 'refurbishment projects covered by the Building Regulations require notification to the local authority building control or an approved inspector. Certain aspects of refurbishment may be covered by self-certification schemes' (**CIBSE KS12**, page 3).

**2.14.3** Another aspect of legislation related to refurbishment is that of energy performance certificates. An Energy Performance Certificate (EPC) (see Encode 2015 Part A) is required 'if there are changes to the number of parts used for separate occupation and these changes involve providing or extending fixed heating, AC or mechanical ventilation systems'. More information can be found on the UK Government's website, in '**Energy Performance Certificates for your business**'.

**2.14.4** Several of the EEF projects have demonstrated the challenges resulting from legislation requirements and planning issues during a refurbishment process, especially when the installation of renewable energy sources is involved.

**2.14.5** Boxes 29 and 30 present the relative lessons learnt from Cornwall Partnership NHSFT during the installation of a PV farm and from James Paget NHSFT. Especially when tight timelines are involved, as in the case of EEF, planning permissions and processes might be very significant issues to consider.

## 2.15 Minimising disruption

**2.15.1** Disruption to the normal operation of the hospital is likely to occur during the refurbishment process, affecting patients and staff. This disruption can be minimised by performing works gradually, for example

on a floor by floor basis, or focusing on systems out of use during certain periods of time, such as refurbishing a heating system during summer. Relevant guidance is provided by the **Considerate Constructors Scheme**.

**2.15.2** Finally, **CIBSE Guide F** recommends implementing refurbishment in a planned way with the least disruption to the building. An additional suggestion which might be relevant in some cases is to combine the installation of different energy efficient refurbishment measures to each other or to other needed types of work on the building.

In fact, other needed works can sometimes be an additional driver for implementing energy efficient refurbishment.

**2.15.3** Box 31 presents some of the lessons learnt regarding the minimisation of disruption during refurbishment through the EEF.

**2.15.4** For infection control during refurbishment in healthcare premises, see **Health Building Note 00-09: Infection control in the built environment**.

### **Box 29 Lessons learnt from Cornwall Partnership NHSFT**

*Cornwall Partnership NHSFT aimed to reduce energy costs by electrification of their vehicle fleet and through the installation of solar PV panels to charge car batteries. 15 electric vehicles were purchased to reduce emissions from transportation, along with providing capacity for 20 accompanying charging stations. A 40 kW PV farm was installed in order to reduce upstream emissions, complementing the carbon saving benefits of the new electric vehicles.*

*The need to allow for enough time for planning permissions is significant. Moreover, the existing infrastructure and its capability to accommodate the production of renewable energy is something that requires early and careful consideration. Two separate sites were selected for the PV farms, since existing electrical transmission infrastructure could not accommodate the original design of a single site. An unforeseen issue with the electric vehicles involved a minor incompatibility between the charging posts and the vehicles. This was successfully resolved.*

### **Box 30 Lessons learnt from James Paget NHSFT**

*James Paget NHSFT decided to replace their initial wind turbine proposal with a substitute PV project. The lesson learnt from this process, is that planning permissions might need a considerable amount of time to finalise and should therefore be well planned in advance. The negotiation of feedback tariffs with energy suppliers is also an issue to consider when planning this type of project.*



Figure 15 Photovoltaic installation at the James Paget NHSFT

### Box 31 Lessons learnt on minimising disruption during refurbishment

**Southend University NHSFT:** *Combined projects prevent unnecessary disruption:*

*Southend University NHSFT estate management commented on the difficulty of getting access to the different hospital spaces to carry out the works. Given the short timescale of the overall EEF, the hospital emphasised the importance of engaging the stakeholders early in the process and agreeing on access plans, shutdown periods and a programme of works that would minimise the disruption to the hospital. This is particularly important for key areas, such as theatres. In order to make best use of the refurbishment time, estate management used, where possible, the EEF works as an opportunity to make wider improvements to areas. For instance, refurbishments were undertaken in the restaurant area and several wards, alongside the EEF lighting, HVAC and insulation improvement works.*

**University Hospital Southampton NHSFT:** *Refurbishment work in patient rooms is*

*challenging: In winter months, the bed occupancy of the NHS organisation was high. Implementation during times of lower demand would enable faster and less disruptive implementation. When deciding on the best times for refurbishment implementation, not only cold weather, but also potential heatwaves should be taken into consideration.*

## 2.16 Outside expertise for energy efficient refurbishment

**2.16.1** In an environment of constrained finances, estates management teams

cannot necessarily resource an in-house team that has the time, skills and experience for implementing more complex interventions such as CHP and renewable energy generation. These issues may present barriers to developing proposals for energy efficiency schemes, diagnosing existing energy performance and post-

commissioning management of new systems.

**2.16.2** EEF revealed that much of the pre- and post-contract work required ensuring the successful delivery of energy efficiency projects had been outsourced to external energy consultants and sub-contractors. The unexpectedly high cost of outsourced monitoring and diagnostics implementation at an early design stage has been commented upon by several NHS organisations.

**2.16.3** The EEF identified that lack of appropriate contract management resulted in large suppliers failing to meet their obligations thereby impacting on project delivery and actual performance. It is important to develop good relationships with contractors enabling them to understand the outcomes required from the project in relation to improving patient outcomes, patient and staff satisfaction and to adapt to moving work schedules to tie in with capacity flows. For example, major lighting providers often work more in line with energy savings rather than room function and aesthetics, which in the case of Royal United Bath NHSFT was realised after project completion.

**2.16.4** To ensure the efficient use of energy NHS organisations need to develop the in-house skills to be able to monitor, interrogate and diagnose their energy performance to ensure the most effective solutions are implemented. The interview analysis found that in-house project management was key to dealing swiftly and smoothly with the different hospital stakeholders. External consultants may undertake the design for the projects, at a cost; however, in-house capacity should focus on project-management and integrations between the various working teams. It is therefore crucial to have competent in-house energy and sustainability expertise, even if outside consultants are also appointed. Box 32 presents the case of Southend University NHSFT where an external project manager

had been appointed prior to the refurbishment projects.

### Box 32 Lessons learnt from Southend University NHSFT

*Southend University NHSFT hired an external short-term member of staff to project manage the EEF works. Although the projects generally went well, difficulties arose when the project manager's contract ended. Having 17 separate projects, several of which were ongoing at the time of the project manager's departure, meant that the handover process was not straightforward.*

## 2.17 Engagement of hospital staff, management and finance stakeholders

**2.17.1** Several hospitals highlighted the significance of engaging hospital staff, management and other hospital services in the refurbishment process, for numerous reasons. The knowledge of other actors, processes and operations which might be influenced by refurbishment is an essential part of the effort to ensure continuity of works and to minimise disruption.

**2.17.2** Moreover, the close collaboration between Estates and Finance of an organisation is necessary. This will specify processes, will clarify different actors' obligations and will allow the minimisation of disruptions while facilitating the successful completion of the refurbishment project.

**2.17.3** Finally, the participation of the hospital staff in any refurbishment and their involvement from the beginning of the project is likely to minimise disruption and enhance processes within the hospital for all stakeholders. Moreover, this is likely not



only to minimise disruption, but also to motivate and to convince the staff of the necessity of energy efficient refurbishment and its benefits.

## 2.18 What can go wrong?

**2.18.1** This section covers aspects of energy efficient refurbishment, focusing on lessons learnt and experiences by the EEF and different NHS organisations. Early planning, appropriate analysis of risks to the successful delivery of the project, high

levels of expertise and collaboration are key aspects of successful refurbishment projects. Based on projects within the EEF, Box 33 presents some examples of things that might go wrong and Box 34 describes how the Royal United bath NHSFT addressed practical issues. Unplanned safety and access issues, as well as failure to follow the initial schedule are identified as potential challenges in energy efficient refurbishment, especially in the complicated environment of an NHS organisation.

### Box 33 Lessons learnt from problems encountered on EEF projects

**Salisbury NHSFT:** *Solar thermal panels delayed: Due to delayed renovation works on the organisation's swimming pool, the solar thermal panels could not be installed at the time of reporting. A dependency plan and an early involvement of all involved stakeholders can minimize disruptions and delays.*

**Southend University NHSFT:** *Short timescale of EEF was a challenge: The energy manager emphasised the importance of engaging stakeholders early in the process and agreeing on access plans, shutdown periods and a process that minimises the disruption to patient care.*

**University Hospital Southampton NHSFT:** *Unexpected hurdles: Asbestos in ceiling voids and steam main and nesting swifts in wall cavities caused additional hurdles and delays. All building elements affected by a refurbishment should be checked in advance.*

*Nesting swifts discovered in a wall cavity on-site during the initiation of work in the spring delayed building fabric upgrades until local authorities and an ecologist could be consulted. Work was scheduled to resume when the birds had vacated in the autumn.*

*Bird boxes will be installed to provide replacement habitat.*

### Box 34 Lessons learnt from Royal United Bath NHSFT

*Open and transparent communication was the basis for gaining the support of hospital staff to complete the refurbishment processes.*

*To establish trust and engage stakeholders, a member of the team involved in the refurbishment, scheduled meetings with the nurses and doctors of the organisation.*

*Electronic newsletter updated staff on the project and its progress from the beginning.*

*Finally, senior members of staff were invited to project meetings, in order to enable open*

*channels of communication.*

*To determine practical issues likely to come up during the refurbishment, the project team organised a trial installation within two unoccupied bays. The lessons learnt from this process were implemented on another trial installation in occupied areas and then the actual refurbishment process started. Due to the success of this process, the staff welcomed the lighting upgrade and trusted the project team involved in refurbishment.*

## 2.19 Post Project Evaluation

**2.19.1** After the completion of the refurbishment measures' installation, a post project evaluation should be conducted to establish that all components have been installed and commissioned correctly and that the project is achieving the energy savings expected. Ensuring the expected energy savings are achieved is a process that requires the comparison of the actual metered energy consumption before and after the refurbishment work is completed. Therefore, a minimum of one year metering is required, in order to enable the comparison of energy usage, especially when the refurbishment measures installed are related to building performance aspects that vary during the year. For example, the effectiveness of insulation installation requires evaluation through the comparison of the winter months of the years before and after the refurbishment.

**2.19.2** According to the **CIBSE Guide F: Energy Efficiency in Buildings** the evaluation should establish the actual savings achieved, the impact of the refurbishment on the occupants, the actual final capital cost occurred, management

and maintenance issues, as well as other benefits achieved and practical pitfalls.

**2.19.3** It is essential that feedback mechanisms are integrated into the energy efficient refurbishment, allowing the evaluation of projects and the identification of aspects of the project that have more or less successful elements to them. Feedback mechanisms implemented that might distinguish important behavioural aspects or inappropriate installations and controls and their incorrect operation, will be particularly useful in identifying issues when expected reductions in energy use are not realised.

**2.19.4** As the CIBSE Guide F recognises, few buildings achieve their maximum energy efficiency potential from the beginning, especially when it comes to complicated buildings and systems. Troubleshooting is part of the feedback mechanisms and can result into the improvement of the building's energy efficiency and the achievement of its targets. Post project evaluation should include occupants' feedback and physical measurements. It identifies potential areas of improvement and can demonstrate to projects' sponsors that money has been well spent.

### Box 35 Lessons learnt from Southend University NHSFT

*Southend University NHSFT was one of the few interviewed to have formal, structured evaluation procedures in place to examine the successes and failures of refurbishment work (both real and perceived) from the perspective of the staff. For all projects above a certain size, the estate management carries out Post Project Evaluation. This includes surveys of the staff and is carried out at 6, 12 and 24 months after the project to monitor*

*the long term impacts of projects. The projects required staff consultation and cooperation to be effective. In terms of organising shutdowns and works, hospital staff engagement is crucial for achieving project outcomes. For example, new lighting controls or IT systems will only achieve energy reductions if used appropriately by the medical staff and/or patients. For these reasons, providing a formal way for hospital staff to voice their views on the projects is a useful means of engagement and helps to identify whether or not the new systems are being used effectively.*

## 3 Energy considerations for new building facilities

### 3.1 Introduction

**3.1.1** This chapter looks in greater detail at the design of new building facilities and issues to be considered from an energy efficiency perspective. 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.

**3.1.2** Designing for energy efficiency should include the following processes:

- understanding and identifying user requirements, especially focusing on the specific needs of patients and their thermal and visual comfort conditions;
- 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.

**3.1.3** This chapter looks at each one of these and explains the energy related issues that should be considered at each step towards preparing the full and detailed specification for the project.

**3.1.4** 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.

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

**3.1.6** This guidance should be made available to suppliers and contractors so that they can demonstrate their commitment in ensuring the reduction of energy usage and carbon emissions. In particular, their attention should be drawn to the project design checklist at the end of this chapter.

**3.1.7** A 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. An exemplar project design checklist provided in Section 3.10 may be utilised, or adapted as required, for use with contractors and suppliers. Ensuring all parties are familiar with the relevant sections of Encode 2015, will help to ensure the organisation achieves its energy efficiency aims.

### 3.2 Project conception

**3.2.1** 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.

**3.2.2** 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.

**3.2.3** 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.

**3.2.4** The impact of the EPBD should be considered, under which all new buildings and existing buildings (when they undergo substantial refurbishment) will be given an EPC for the whole building. In addition, all public buildings that are over 500 m<sup>2</sup> will need to display the Display Energy Certificate (DEC) for the public to view. These two types of certificates are described in Chapter 1 of Encode 2015 Part A.

**3.2.5** The solution is to consider all possible options, making sure that energy efficiency and sustainability issues are not ignored. 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.

**3.2.6** The advisers may be drawn from in-house resources (for example the energy manager or an in-house Capital Projects team) or may be external technical experts (see Box 6). 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 Encode 2015 Part A):
- 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.

**3.2.7** 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). Moreover, things to consider include the location in terms of public transport accessibility and proximity to amenities, to identify the impact a new building would have on congestion and transports in the area. Relevant information and criteria can be found in '**BREEAM New Construction for Non-Domestic Buildings**'.

**3.2.8** BREEAM encourages stakeholder consultation and for a sustainability brief being developed prior to concept design. This should set out the client requirements, the project sustainability targets, as well as project constraints, including technical, physical and environmental aspects.

**3.2.9** 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. 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.

### Interpreting users' needs

**3.2.10** 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. If this does happen, the project director and the advisers (see Box 6) 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.

#### Box 36 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.

**3.2.11** 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.

**3.2.12** 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 worth noting that past experiences of badly managed and poorly designed buildings will affect survey results.

**3.2.13** Finally, high levels for users' controls should still ensure and prioritise patients' well-being; they have to be in agreement with any specific requirements regarding the design and operation of hospitals and other healthcare buildings.

### The design team's role in saving energy

**3.2.14** 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 in the project than to provide technical fixes at a later stage. 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 37).

**3.2.15** 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.

**3.2.16** 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.

**3.2.17** 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 at the end of this chapter. Box 38 refers to integrating energy efficiency in the building design.

### **Box 37 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 an **ISO 50001** 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.

### Box 38 Integrating energy efficiency in the building design

Before even the building fabric or technologies are selected, the design of the building and an integrated approach can provide a very good basis for energy efficiency. For example, designing adequate and well located staircases, with clear access to the public, can increase the number of staff or even patients using them; this does not only reduce energy consumption through the reduced use of lifts, but it also improves health and increases physical activity levels.

**3.2.18** 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 initial cost.

**3.2.19** 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. Bringing 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.

**3.2.20** **BREEAM New Construction Technical Manual 2014** and the **RIBA Plan of Work 2013** provide information regarding the typical roles in a construction project during different stages.

## 3.3 Setting project-specific energy and carbon objectives

**3.3.1** Adopting a project-specific energy and carbon 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.

**3.3.2** As described in Chapter 1 of the Encode 2015 Part A, the NHS has specific targets regarding the reduction of carbon emissions from the health sector and a significant percentage of this is expected to be achieved through energy efficiency in its buildings. The **Building Regulations Part L2A** is compulsory to follow in England, for the conservation of fuel and power in new buildings other than dwellings.

**3.3.3** Moreover, the UK has set the target of zero carbon new build non-domestic buildings by 2019, which creates an additional legal requirement for all new healthcare buildings. Finally, new healthcare buildings are expected to achieve BREEAM Excellent, as described in Chapter 1 of the Encode 2015 Part A.

**3.3.4** 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 Encode 2015 Part A, 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).

**3.3.5** The provision of electricity from 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 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 remain renewable in the long term.

### Using carbon emissions to set project-specific energy objectives

**3.3.6** 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.

**3.3.7** The use of kWh provides the energy use, but not the actual carbon released to the environment; therefore, the use of different types of energy highly influences the carbon emissions figure and should be taken into consideration. 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.).

**3.3.8** 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 the following:

- It is easy to see what impact the project will have on the organisation's progress towards the national mandatory carbon targets (see Chapter 1 of Encode 2015 Part A);
- it clearly highlights the higher carbon emissions associated with electricity usage.

**3.3.9** Up-to-date figures for the conversion of kWh of different types of energy to tonnes of carbon emissions (tCO<sub>2</sub>) or to tonnes of carbon emissions equivalent (tCO<sub>2</sub>e) can be found on the [Greenhouse Gas Conversion Factor Repository](#) on the Department for Environment Food and Rural Affairs (DEFRA) website.

### Setting energy objectives by end function

**3.3.10** While calculating the energy requirements for the project, the design team should also calculate the total expected carbon emissions. 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 emissions for a project is the summation of many individual calculations for all possible energy-related activities.

**3.3.11** Information gathered during users' 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.

**3.3.12** 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. Box 39 explains how the use of room data sheets can help organise different space requirements and characteristics.

**3.3.13** For example, **CIBSE TM22** explains how the energy performance of an occupied building can be understood and explained in terms of the performance of systems, such as lighting and ventilation. The use of benchmarks is suggested in order to allow the achievement of high quality internal environments, while keeping financial and carbon impacts at low levels. This approach is explained in detail in **CIBSE TM22: Energy Assessment and Reporting Methodology**.

### **Embodied energy and carbon in new construction**

**3.3.14** A rather recent concern in the sustainable construction of the built environment is related to the embodied energy or embodied carbon. This refers to the energy used and the carbon emitted in extracting, manufacturing and transporting materials and products and in erecting a building. Embodied energy and carbon are also included in the stages of maintenance and refurbishment until the end of a building's lifetime. The last stage responsible for embodied energy and emissions is that of the building demolition and disposal at the end of its lifetime. The life cycle stages of construction works are presented in Figure 16. Based on this, it appears that the more energy efficient buildings we have, the more significant embodied carbon becomes as a percentage of the total carbon emissions in the construction and operation of our built environment.

#### **Box 39 Using room data sheets (ADB sheets)**

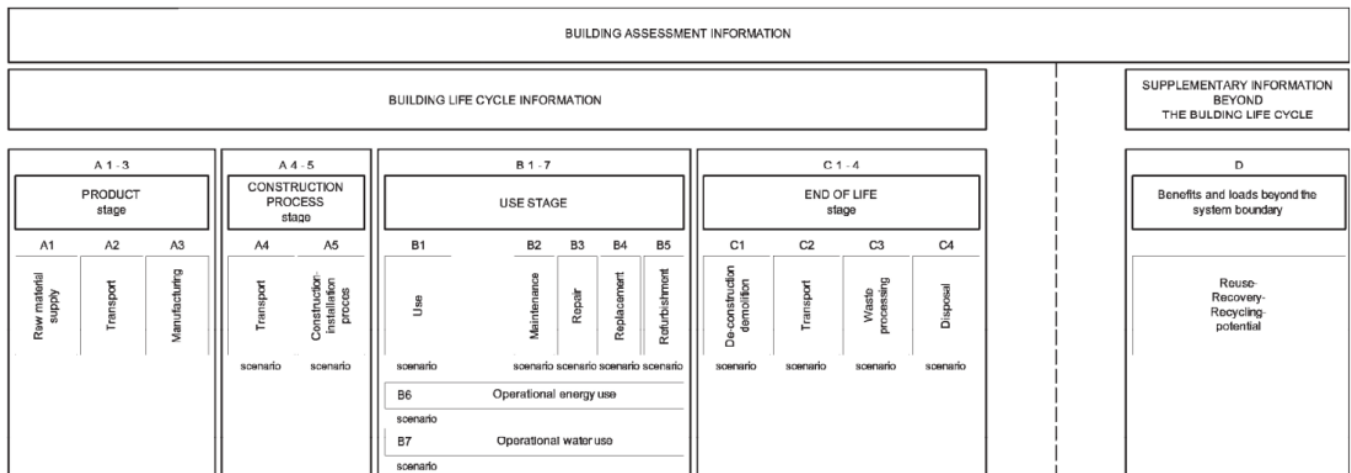
Activity Database (ADB) is an information (software) package created for healthcare planners, architects and teams who are involved in the briefing, design and equipping of healthcare environments. The package, in common use, contains data drawn directly from Health Building Notes (HBNs), which support 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).

The ADB sheets contain environmental specifications as part of the pre-programmed software and these specifications should tie into the recommendations of the various HTMs.

All new projects should use the most up-to-date version of ADB. 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.

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 one 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.



**Figure 16 Life cycle stages.** © British Standards Institution (BSI – [www.bsigroup.com](http://www.bsigroup.com)). Extract reproduced with permission. Source: BS EN 15978:2011 Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

## Passive design

**3.3.15** The **BREEAM UK New Construction 2014** encourages the use of passive design to reduce energy consumption and carbon emissions when designing new buildings. BREEAM highlights the need to combine passive design with ensuring thermal comfort for the building occupants, which is particularly significant in the context of healthcare environments. The project gains BREEAM credits for using passive measures which reduce the total heating, cooling, mechanical ventilation and lighting demand in line with the findings of the passive design analysis conducted by the project team. This should result in a demonstrable energy demand reduction. Within this credit, free cooling instead of mechanical cooling is particularly encouraged.

## 3.4 Hierarchy in achieving energy and carbon targets

**3.4.1** The previous sections described setting energy and carbon targets and briefly explained passive design. Passive design aims to reduce the energy demand for different uses, while ensuring thermal comfort is achieved. This should always be the first step in designing a building. It includes measures such as orientation,

shape, positioning of windows and roof lights (all to encourage natural ventilation and good daylight), as well as organising heavily serviced areas adjacent to one another to minimise long service runs. Moreover, it is worth mentioning here landscaping as a method of gaining maximum benefit from natural shading and reducing summer overheating.

**3.4.2** The next step is to specify efficient building materials and subsequently efficient equipment and services. This stage involves first of all high specification glazing and thermal insulation and then inherently efficient building services technologies (such as LED lighting), intelligent controls (such as time switches, daylight-sensors and/or occupation sensors).

**3.4.3** To cover the remaining energy demand, low carbon or renewable energy sources and on-site energy generation should be considered. This includes heat generation technologies (such as from solar water heaters) and electricity generation technologies (such as renewable energy from photovoltaics). Other low and zero carbon technologies that can be used are listed below:

- ground source heat pumps;
- air source heat pumps;
- biomass fuelled boilers;
- wind generation;

- small hydro generation.

**3.4.4** More details on relevant technologies can be found in Chapter 4. This hierarchy of actions to achieve energy and carbon targets for a new building are schematically presented in Figure 17.

**3.4.5** Incorporated into the overall design from the commencement of a project, these and similar measures might involve little or no additional capital costs and offer a substantial contribution to reducing carbon emissions over the life cycle. More information on how to ensure that buildings meet their design targets in practice can be found in Carbon Trust’s **CTG047: Closing the gap**.

### 3.5 Early design decisions for building projects

**3.5.1** 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);
- how these engineering solutions fit with healthcare needs.

**3.5.2** Figure 18 presents some of these interrelationships that should be considered during the building’s concept design.

#### Geography and site

**3.5.3** 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. 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?). Moreover, ensuring maximum green space and water features surround healthcare buildings can contribute to passive cooling. This is analysed in depth in **Health Building Note 00-07: Planning for a resilient healthcare estate**.

**3.5.4** Planning requirements, local and national byelaws 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.

**3.5.5** 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.

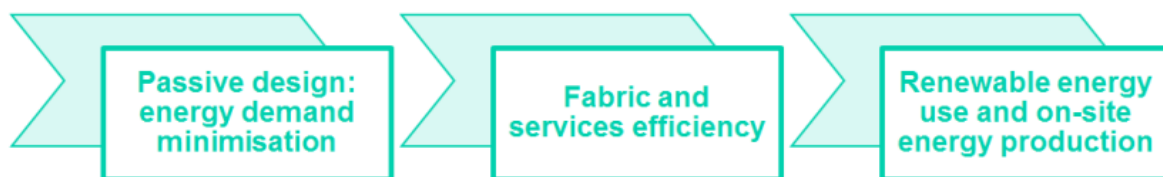


Figure 17 Hierarchy in achieving energy and carbon targets

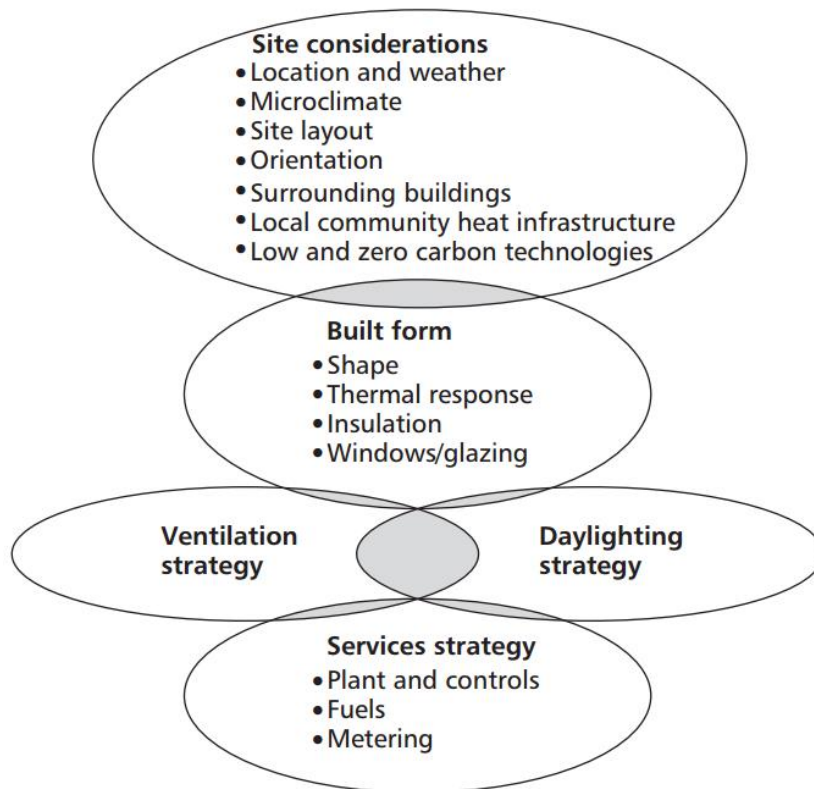


Figure 18 Concept design interrelationships. Source: **CIBSE Guide F: Energy efficiency in buildings**

**3.5.6** 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

**3.5.7** 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.

**3.5.8** The opportunities and constraints presented by each potential site should also be reviewed in terms of prevailing wind direction, microclimate, sunshine, overshadowing, views, noise and external pollution. If the choice of site is limited, consider mitigating some of the negative aspects of the site.

**3.5.9** 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.

**3.5.10** Especially for healthcare environments, water and green areas are very significant for the patients' health and well-being. Trees improve micro-climate in the summer; they provide shade and they allow cooler air to circulate. Trees also contribute to the reduction of air temperature when combined with water features, such as ponds and lakes, due to the cooling effect of evaporation.

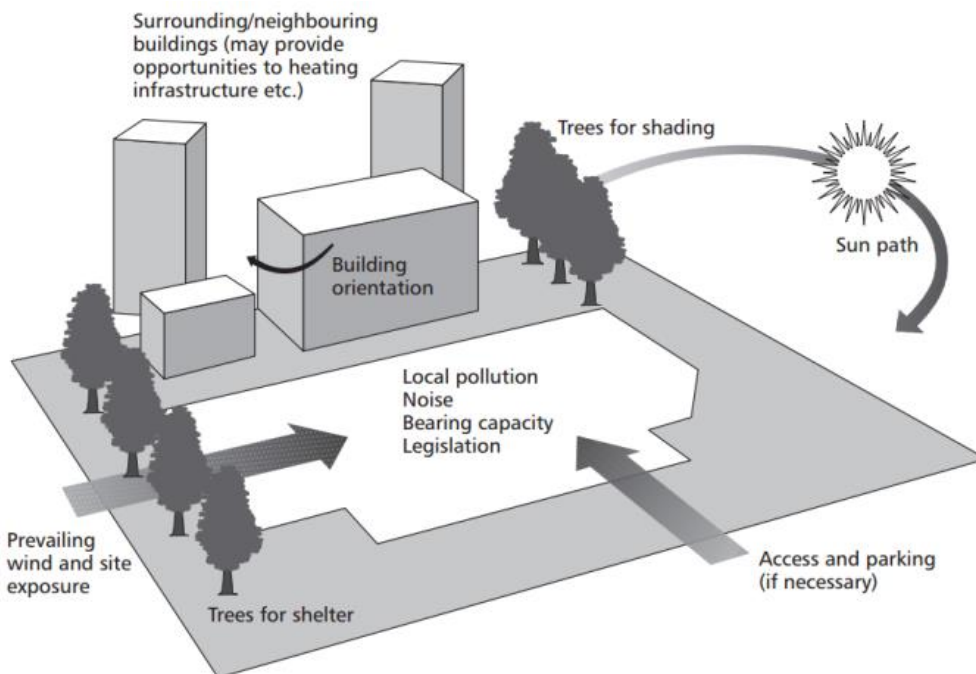
## Orientation

**3.5.11** 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 AC. 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. Figure 19 presents some concerns for site consideration.

**3.5.12** 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.



**Figure 19** Site considerations include the building orientation, trees for shading, the surrounding buildings, access and parking, as well as the site exposure and prevailing winds. Reproduced from **CIBSE Guide F: Energy efficiency in buildings** by permission of CIBSE

## Shape and size

**3.5.13** 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.

**3.5.14** 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 lifelong 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.

**3.5.15** 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 in terms of excluding urban noise and ensuring security. 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;
- 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 AC may become necessary for the internal areas;

- taller constructions can increase energy consumption due to greater exposure (higher winds) and the need for lifts. **Health Technical Memorandum 08-02: Lifts** provides information on planning and energy savings considerations regarding lifts.

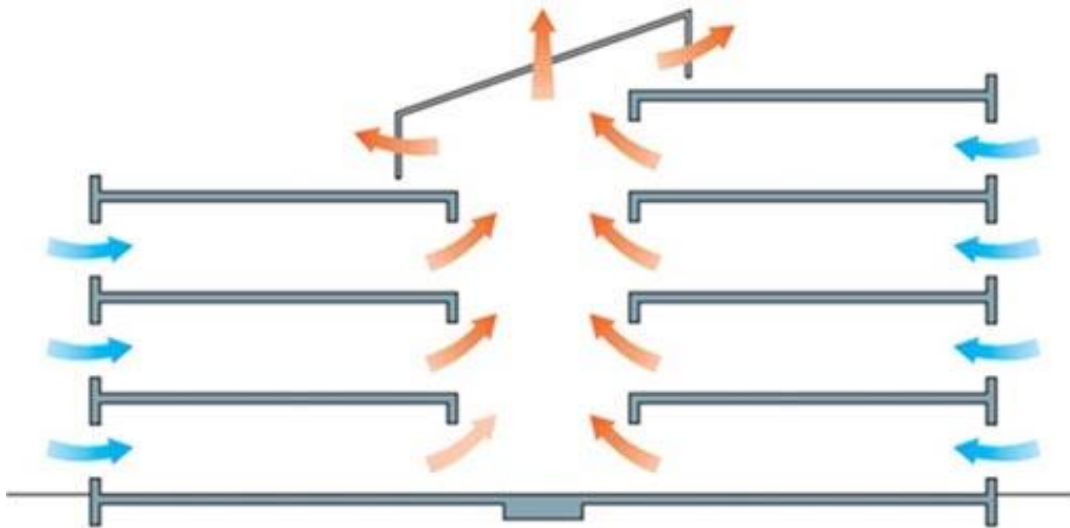
**3.5.16** Imaginative use of three-dimensional form can give occupants access to natural light and ventilation and help to reduce electric lighting, heating, cooling and ventilation loads, even where the building needs to be air-conditioned. Spaces with low occupancy or requiring mechanical ventilation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

**3.5.17** To avoid deep-plan implications, consider introducing courtyards, light-wells or atria (see Box 40) - 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.

### Box 40 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 acoustics are frequently problematical for these applications and designers should consider incorporating sub-divisions to ensure that comfort can be maintained.



**Figure 20** Application of stack effect to a building design. Reproduced from **CIBSE AM10: Natural ventilation in non-domestic buildings** by permission of CIBSE.

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.

Atrium ventilation is discussed in **CIBSE AM10 'Natural ventilation in non-domestic buildings'**.

For guidance on noise and acoustics, see **HTM 08-01: Acoustics**.

## The advantages of passive solar design

**3.5.18** Passive solar design 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.

**3.5.19** 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.

**3.5.20** The overall objective of passive solar design 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.

**3.5.21** The basic principles behind passive solar design 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. More information on the use of natural ventilation can be found in the Carbon Trust's **CTG048: A natural choice**.

**3.5.22** However, the design team should note that passive solar design 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 AC).

**3.5.23** The **CIBSE Lighting Guide LG10: Daylighting - A Guide for Designers: Lighting for the Built Environment** provides simplified design guidance. Moreover, the **CIBSE Lighting Guide 02: Hospitals and Health Care Buildings** demonstrates lighting strategies in modern hospital environments. See also BRE's '**IP 12/02 Control of solar shading**' and 'Summertime solar performance windows with shading devices'. Finally, 'Lighting and colour for hospital design' provides guidance on the use of light and colour design in hospitals. Box 41 refers to the room outlook and potential solutions regarding daylight and shading.

#### **Box 41 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.

**3.5.24** The depth of the building plan (that is, the maximum distance from a window) is crucial in determining the likely success of a passive solar design or natural ventilation scheme. Rules of thumb, such as having a maximum 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.

**3.5.25** 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.

**3.5.26** 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.

## 3.6 Early decisions for building projects – building fabric

**3.6.1** 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 AC.

**3.6.2** 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 AC (with humidity control).

**3.6.3** 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 needs as reference guidance. 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 overheating) and to warm incoming fresh air.

### The role of thermal mass

**3.6.4** 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.

**3.6.5** '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 AC. 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.

**3.6.6** 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.

**3.6.7** 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.

**3.6.8** 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 AC loads). In this situation it is more important to minimise solar and internal gains and maximise useful daytime ventilation.

**3.6.9** 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)?

**3.6.10** 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 (see [Health Building Note 00-09: Infection control in the built environment](#)), making this an impractical solution for heavily serviced areas. Further guidance on exploiting thermal inertia is given in [CIBSE AM13: 'Mixed mode ventilation'](#).

**3.6.11** 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.

**3.6.12** 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 AC. Exposing ceilings and passing air over or through the floor slabs, especially cool night air, can remove the absorbed heat later.

### Health considerations

**3.6.13** 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 Building Note 00-10 Part D: Windows and associated hardware](#)).

**3.6.14** 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.

**3.6.15** If a 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 software.

**3.6.16** 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.

**3.6.17** Typically, an air-conditioned building uses twice as much energy as one without AC. 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, such as fans.

**3.6.18** 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

**3.6.19** 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. Box 42 describes the example of the Bradford Royal Infirmary, where the high ceilings facilitated cross ventilation and improved the building's performance under hot weather conditions during the summer.

**3.6.20** 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.

**3.6.21** 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 1.5°C if the glazed area and ventilation rates are kept constant.

#### Box 42 High ceilings in the Bradford Royal Infirmary

Even in Nightingale wards<sup>7</sup>, which might be regarded as a redundant type of hospital, high ceilings have shown potential resilience in climate change. Two Nightingale wards at Bradford Royal Infirmary have been analysed for resilience in summer overheating in the **'Resilience of 'Nightingale' hospital wards in a changing climate'**.

It is expected that the narrow sections, the high floor-to-ceiling heights and the potential for cross ventilation, plus the mass inherent in the masonry and concrete construction, deliver the basic resilience, under climatic data expected to represent future climatic conditions.

**3.6.22** Other benefits of high ceilings are:

- they allow stratification so that heat accumulates above the occupied zone,

<sup>7</sup> 'Nightingale' hospital wards are open-plan dormitories for 24–30 patients. They were dominant form of UK hospital ward before 1948.

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.

## 3.7 Early decisions about ventilation

**3.7.1** As the **HTM 03-01: Specialised ventilation in healthcare premises: Part A: Design and validation** describes, ventilation aims to provide a safe and comfortable environment for patients and staff. More specialised ventilation is provided in primary patient treatment areas such as operating departments, critical care areas and isolation units. Ventilation is also used to ensure the required quality standards are maintained in specific departments, while staff is protected from toxic and harmful substances and organisms. Although ventilation is a very crucial area for the achievement of energy efficiency in hospitals, there are two very significant factors to prioritise: internal temperatures and comfort criteria and airborne infections.

**3.7.2** HTM 03-01 Part A states that 'Natural ventilation is always the preferred solution for a space, provided that the quantity and quality of air required and consistency of control to suit the requirements of the space, are achievable. If this is not the case, a mechanical ventilation system will be required'. Nevertheless, the specific requirements for thermal comfort conditions and environmental design criteria, demanding for example that internal temperatures in patient care areas do not exceed 28°C for

more than 50 hours annually, make natural ventilation very challenging.

**3.7.3** Infection control is a clear priority for the NHS. Ventilation should be designed with a view to diluting and controlling airborne pathogenic material and to minimising any potential risk. For detailed information, see [Health Building Note 00-09: Infection control in the built environment](#).

## **Achieving NHS energy targets in hospital buildings: focusing on ventilation strategies**

**3.7.4** A scoping exercise has been conducted regarding the design of a new large scale hospital project. The aim was to identify building characteristics and design decisions that would enable the achievement of the NHS target regarding energy consumption. These strategies were implemented on a notional hospital building. Box 43 provides the relevant details.

### **Box 43 Five ventilation strategies for a notional hospital**

*Five categories of ventilation methods have been analysed, presenting different levels of controls in terms of temperature and air filtering.*

- **Simple natural ventilation**

*Ventilation of outdoor air directly into the space through windows controlled by the occupants;*

*The air flowing out of the space might be led by the same or other windows or in some cases via stacks;*

*Areas are less sensitive in terms of specific ventilation requirements;*

*Lower resilience in summer overheating.*

- **Advanced natural ventilation with passive cooling**

*Outdoor air supplied via stacks fed from below-ground concrete plena providing passive cooling/warming;*

*Air leaves the space via ventilation stacks;*

*Air flow rates managed by BMS-controlled dampers;*

*Occupants can override the controls.*

- **Hybrid ventilation**

*Combination of natural and mechanical ventilation strategies;*

*Outdoor air is supplied via damper-controlled inlets and the exhaust is achieved via stacks;*

*Fans are used during peak heat load, to increase the cooling potential of ventilation;*

*Passive draught cooling may be used for additional cooling if and when needed;*

*Sensors and controls are used for the detection of down-draughting.*

- **Full mechanical ventilation**

*Air flow into and out of the space driven by variable speed fans providing full control over ventilation rates, but no mechanical cooling;*

*The system enables heat recovery via an AHU.*

- **Full AC and filtration**

*Reliable, very clean, temperature and humidity-controlled environments;*

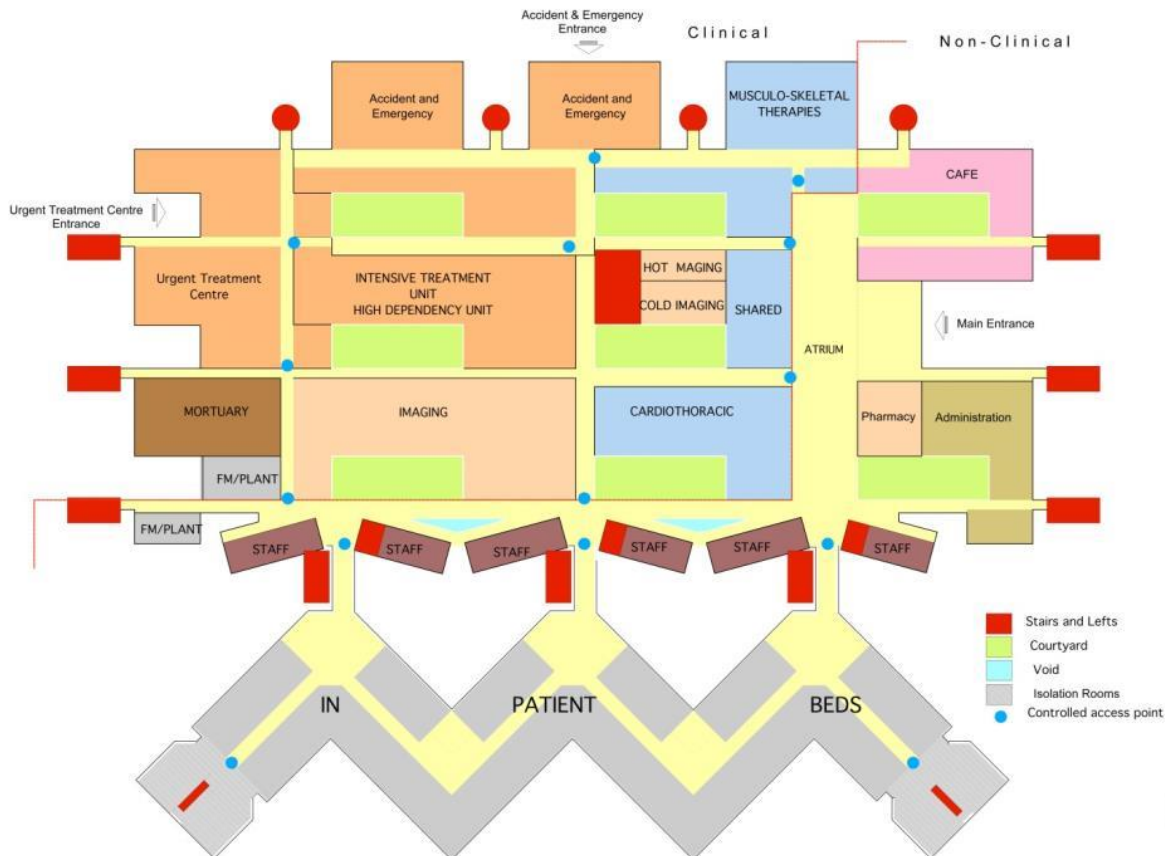
*Air is supplied to and exhausted from spaces via high efficiency particle arrestor filters, driven by a central AHU controlling temperature and humidity according to the requirements of each space;*

*It is impossible to overcome filter resistances with naturally driven airflows.*

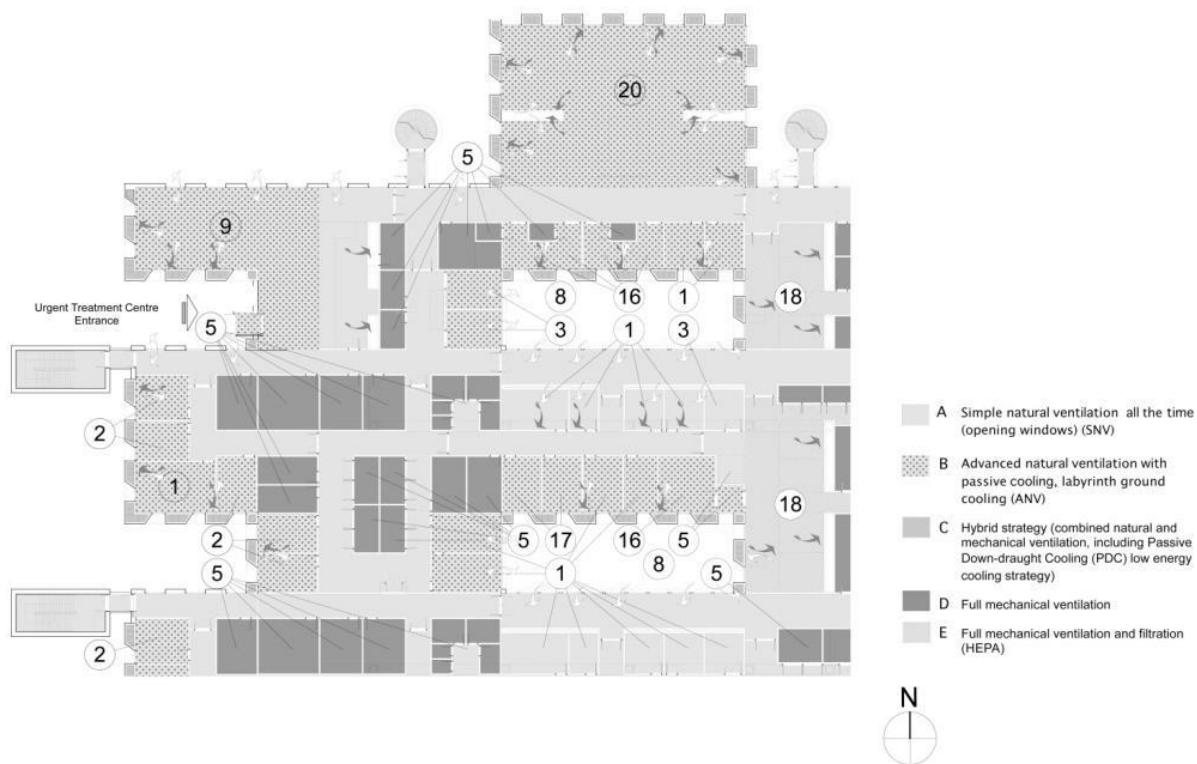
*More details can be found in the [Design strategy for low-energy ventilation and cooling of hospitals](#).*

**3.7.5** The results indicate that a significant volume of a small to medium-sized acute hospital can be naturally ventilated in a simple or more controlled manner. Ventilation is one of the key issues for achieving energy efficiency in hospitals. It appears that up to 70% of the net floor area can be wholly or partly naturally conditioned and another 10% can be conditioned under a hybrid

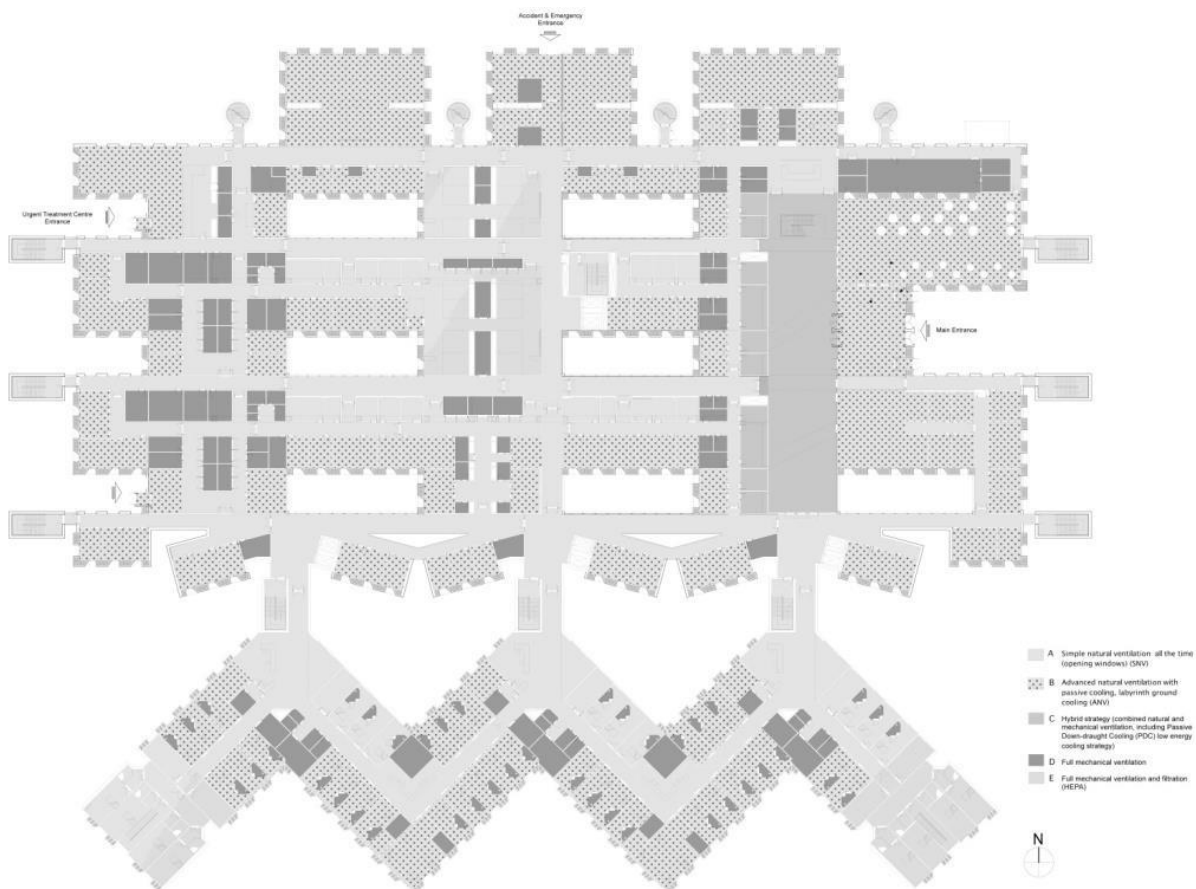
strategy. There is a need for more research in the area, especially to establish the potential of naturally conditioning more sensitive clinical spaces. Figures 21 to 24 present diagrammatic plans and a section for a notional hospital and explain the ventilation strategies followed.



**Figure 21** A functional diagram for the ground floor level of the notional hospital plan. Courtesy of Professor C. Alan Short

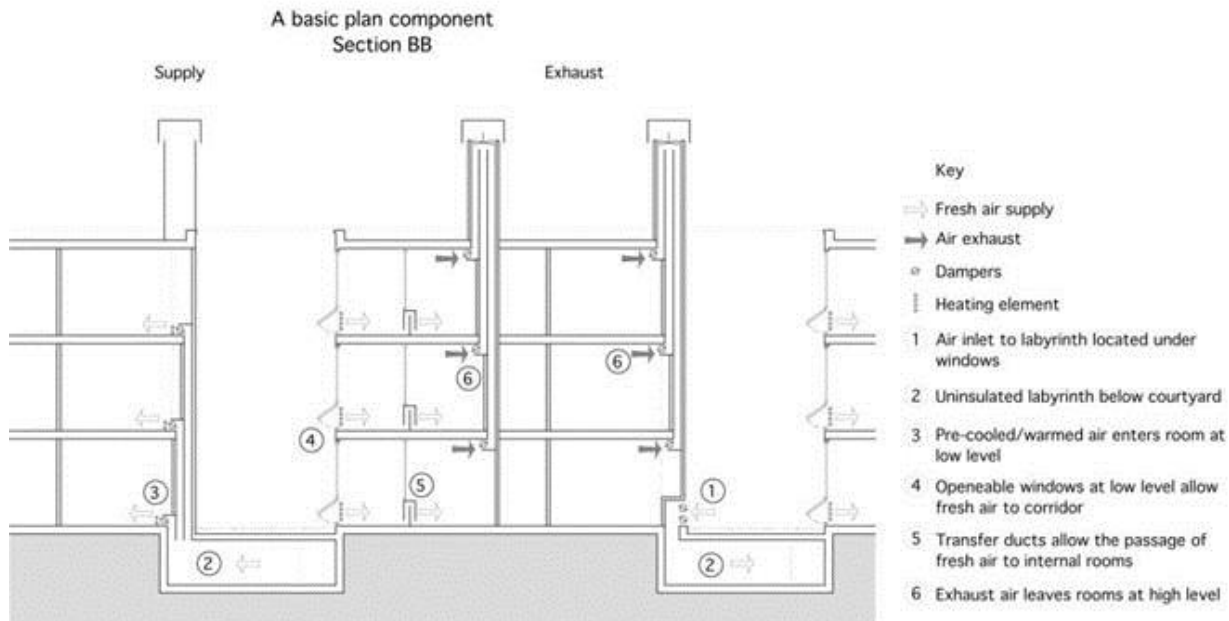


**Figure 22** A representative quadrant of the notional hospital plan. The lighter the shading, the more ‘natural’ the environmental strategy. Courtesy of Professor C. Alan Short



**Figure 23** First-floor plan of the notional 35,000 m<sup>2</sup> acute hospital. Courtesy of Professor C. Alan Short





**Figure 24** In the proposed new plan, supply air passes through a concrete labyrinth below the courtyard, feeding supply ducts within a double façade. Courtesy of Professor C. Alan Short

## 3.8 Fabric-first approach

### The importance of air tightness

**3.8.1** 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.

**3.8.2** 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.

**3.8.3** 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.

**3.8.4** 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 and open doorways.

**3.8.5** Infiltration standards are given in the [HTM 03-01 Part A](#). Procedures to reduce infiltration and the requirements to pressure-test buildings are given in the [Building Regulations 2013 L2A: Conservation of fuel and power in new buildings other than dwellings](#). Air leakage tests are described in [CIBSE TM23: Testing buildings for air leakage](#).

### Insulation

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

**3.8.7** [Building Regulations Part L2A: Conservation of fuel and power in new buildings other than dwellings](#) states that the building fabric construction should

ensure reasonable air permeability<sup>8</sup> and insulation continuity over the whole building envelope. The regulations also specify air permeability levels, as well as U-values for building elements, such as the walls, roof and floor. Finally, they provide construction details focusing on insulation continuity (minimising cold bridging) and airtightness.

**3.8.8** Due to the complexity of modern buildings, it is recommended that insulation continuity is considered at the strategic and the detail level of the design stage. At the strategic level, it involves identifying the primary construction and insulation method, typically varying between timber or steel frame and masonry cavity or solid walls. At this level, the air barrier elements should also be considered. The philosophy adopted now is important for the next detailed level of the design stage.

**3.8.9** It is worth noting here the more recent technology of Structural Insulated Panel systems (SIPs), which are prefabricated building systems. They shorten construction times; they are versatile, robust and potentially improve energy efficiency in construction. SIPs are lightweight building panels combining two high-density facings bonded to either side of a low density polymeric core. Typical materials of the core include foamed polyurethane or expanded polystyrene.

**3.8.10** At the detailed level of design, the designer has to identify the components forming the insulation and air barrier in each construction part. They have to develop details achieving continuity of insulation and air barrier between two different construction parts and finally communicate this to the builder. The Building Regulations L2A provide construction details for steel, timber frame, masonry cavity wall insulation and masonry internal/external wall insulation.

**3.8.11** 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 refurbished ventilation and cooling to reduce gains.

**3.8.12** The following points are worth noting with regards to the advantages of different types of insulation and relevant construction types and details:

- 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.

### Off-site construction

**3.8.13** A different construction method involves the off-site construction: this refers to structures built at a different location than the location of use. Individual modules of the building are constructed and then transported to the building site. This is a relatively new method, which might have advantages to consider when deciding on

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<sup>8</sup> Air permeability is the physical property used to measure air tightness of the building fabric.

the construction method. What is most relevant to the fabric quality is the minimisation or even elimination of building fabric defects. This is combined with reduced waste and benefits such as predictability and quality assurance, fewer workmen on-site and hence reduced noise and disruption, better and safer working conditions on-site and typically less programme risk and faster construction times through factory assembly.

### 3.9 Other early considerations

**3.9.1** While Encode 2015 necessarily puts energy to the fore, there are other factors that play a part in achieving value for money. 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.

**3.9.2** Energy managers have an important role in ensuring that energy efficiency and carbon reduction is embedded within the decision making process for capital projects. Their participation in the design team during the design and commissioning of projects related to the refurbishment and construction of buildings will endorse the importance the organisation holds for its energy policy.

#### Manageability and maintainability

**3.9.3** 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.

**3.9.4** 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.

**3.9.5** 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.

**3.9.6** 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.

**3.9.7** 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

**3.9.8** Designs that simply minimise cost first 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.

**3.9.9** 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 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.

**3.9.10** 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. Guidance for resilience in healthcare can be found in the [Health Building Note 00-07: Planning for a resilient healthcare estate](#).

## Commissioning

**3.9.11** 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. More information on commissioning building systems can be found in the Carbon Trust's [CTG051: Making buildings work](#).

**3.9.12** 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.

**3.9.13** 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';
- for larger developments, department by department user guides.

**3.9.14** 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.

**3.9.15** 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.

### 3.10 Project design checklist

**3.10.1** 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. The 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.

**3.10.2** 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. 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 2015 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.

<b>Project design checklist</b>	<b>Yes/No (tick)</b>	<b>Follow-up actions</b>
<b>1. Has the brief been met?</b>		
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 (e.g. achieving a 'BREEAM excellent' rating) been met?		
Have whole life cost objectives been achieved?		
<b>2. Energy regulations</b>		
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 EPBD?		
Does the building have an EPC?		
Does the building need a DEC? Does it have one?		
Has there been an investigation to determine whether the building or project will need to be registered under the EU Emissions Trading Scheme?		
<b>3. Design integration</b>		
Has every effort been made to include renewables?		
Do the building fabric and services work well together?		
Can thermal storage, heat recovery and 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?		
<b>4. Building fabric</b>		
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 (i.e. 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?

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## **5. Overall building**

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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?

Is the building designed to adopt flood resilience or resistance measures as and when needed in the future?

Have the usage patterns been analysed to optimise the numbers and sizes of escalators and lifts?

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## **6. Ventilation**

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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?

Is the ventilation strategy designed to be flexible and adaptable to future occupancy needs and climatic conditions?

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)?

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## **7. Cooling and internal gains**

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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?

Does the cooling system have effective controls (including VSDs, good zoning and local user controls)?

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## **8. Heating and hot water**

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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)?

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## **9. Metering**

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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?

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## **10. Lighting**

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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?

Have the appropriate external lighting controls been installed to prevent use during daylight or when not needed?

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## **11. Motors**

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Have high-efficiency motors been specified throughout the design?

Have variable speed drives (VSDs) been specified where appropriate?

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## **12. BEMS and controls**

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Is there a suitable balance between central and local control?

Will the facilities management team have suitable overall controls that encourage good operation (e.g. BMS)?

Do occupants have good local controls with simple interfaces?

Does the BMS provide central control, monitoring and alarms with a good user interface?

Are the BMS sensors at the right places?

Will controls cause conflicts between systems?

Is the building zoned appropriately using controls?

Has variable flow control (using VSDs) been included?

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## **13. Electrical small power**

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Has equipment been specified and chosen on the basis of whole life cost (including energy use)?

Has the equipment responsible for the highest unregulated energy loads been identified?

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?

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#### **14. Indoor air and acoustic quality and comfort**

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Have the sources of air pollution being minimised through appropriate building design and planning?

Have thermal comfort conditions been adequately investigated for current and projected climate change scenarios?

Does the building meet acoustic performance standards with regards to sound insulation, indoor ambient noise level and reverberation times?

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#### **15. Materials**

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Has the life cycle impact of materials been considered when selecting the main building elements?

Have materials been sourced in accordance with a sustainable procurement plan?

Does the building design incorporate measures to increase durability and resilience?

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#### **16. Handover**

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Do the building manager and occupants know how to use the different characteristics and technologies installed in the building?

Has the building manager been provided with comprehensive maintenance procedures and schedules?

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# 4 Building services and technologies

## 4.1 Introduction

**4.1.1** This chapter provides information on building services and technologies, with a focus on relevant opportunities for energy and carbon savings. It refers to heat and power sources, space and water heating, ventilation and cooling, lighting, motors and drives, controls, 'small power' and specialist services. The last part of the chapter describes low and zero carbon technologies.

## 4.2 Systems for supplying heat and power

### Early decisions about heat and power

**4.2.1** 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 ways 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.

**4.2.2** Developing the site-wide energy plan includes consideration of:

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

**4.2.3** 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.

**4.2.4** 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 sterilisation? If so, where? 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?

**4.2.5** 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 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.

**4.2.6** Once these questions have been answered, 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.

**4.2.7** The following solutions should be considered:

- where possible, include renewable sources of energy as an integral part of the building design;

- where possible, use low carbon technologies, such as ground, water and air source heat pumps;
- where possible, include on-site generation using CHP, photovoltaics, solar thermal 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 44) to ensure that future building performance can be continually monitored by the building operator.

#### **Box 44 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.

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<sup>2</sup> 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.

Further guidance on metering can be found in [CIBSE Guide F: Energy efficiency in](#)

**buildings** and in Carbon Trust's **CTG037: Green gauges**.

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.

## Centralised versus decentralised systems

**4.2.8** 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; 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.

**4.2.9** 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 dual-fuel facilities) may provide a better solution.

**4.2.10** The option of decentralised heating often hinges on the price and availability of fuels, the space available for plant and distribution pipework, fuelling arrangements and the losses in a centralised system and the size of the loads involved. Tables 5 and 6 summarise the relative merits of these two options.

### Box 45 Energy and water services

Energy and water services: Further advice on energy in relation to the provision of hot water services (including centralised and de-centralised provision) and Legionella prevention is given in **HTM 04-01 Part A**, **HTM 04-01 Part B** and **HTM 04-01: Addendum** and the Health and Safety Executive's **HSG274 Legionnaires' disease Part 2: The control of legionella bacteria in hot and cold water systems**.

## Combined heat and power (CHP)

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

**4.2.12** 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. A CHP system can also provide heat to an absorption or adsorption chiller, so that cooling is also provided. This production of heat, electricity and cooling is known as tri-generation.

**4.2.13** Beyond these requirements, there are numerous possibilities ranging from engine-based solutions supplying media from LTHW to steam through to turbine-based solutions supplying steam and high-pressure hot water.

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 (e.g. 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 4 Centralised 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	Fuelling 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

**Table 5 Decentralised heating systems**

**4.2.14** The electricity generated by CHP is best utilised on-site, although it is also possible to export electricity back into the grid if the correct infrastructure and agreements are in place. According to the

**Health Building Note 00-08 Part B**, ‘Trusts and Foundation Trusts are encouraged to support balancing the national grid through Demand Side Response schemes, which provide sites with a revenue stream in return for responding to calls at times of

system stress for periods of up to an hour at a time, several times a year'. The **Crown Commercial Service (CCS)** provides an income generation opportunity for the public sector estate via its **Demand Side Response Framework**.

**4.2.15** Any decision that involves CHP should be made with reference to the site-wide energy plan. 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. More details on the security of supply and planning for a resilient supply, can be found in **Health Building Note 00-07: Planning for a resilient healthcare estate**.

**4.2.16** 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.

**4.2.17** For further guidance, see the following documents by the Carbon Trust's **CTV044: Introducing combined heat and power** and the **CIBSE AM12: Combined heat and power for buildings**.

**4.2.18** 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.

## Boiler selection

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

**4.2.20** 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 or heat from waste.

## Multiple boiler arrangements

**4.2.21** 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.

**4.2.22** 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).

**4.2.23** 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.

**4.2.24** 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.

**4.2.25** 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.

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

**4.2.27** Carbon Trust's [CTL143: How to implement condensing boilers](#) and [CTL144: How to implement boiler sequence controls](#) provide more information on boilers. [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

**4.2.28** 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

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

**4.2.30** 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.

### Minimising distribution losses

**4.2.31** Distribution lengths are influenced by:

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

**4.2.32** 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 plant rooms is an integral part of the centralised/decentralised discussion.

**4.2.33** 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.

**4.2.34** 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.

**4.2.35** Heat losses from pipework can be significant; inspecting pipework insulation levels and installing thermal insulation as required is very important and quite simple to do. More information on the implementation of thermal insulation on HVAC systems can be found in Carbon Trust's [CTL145: How to implement thermal insulation to HVAC services](#).

**4.2.36** The Royal Devon and Exeter NHSFT inspected its pipework during plant room surveys and the results can be seen in Figures 25 to 27. Pictures demonstrate the pipework condition as seen with the naked eye and with a thermal camera.

### Heat emitters

**4.2.37** 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. The decision will then be confined to which system is the least intrusive to the design and most efficient for the purpose.

**4.2.38** 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.

**4.2.39** 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.)

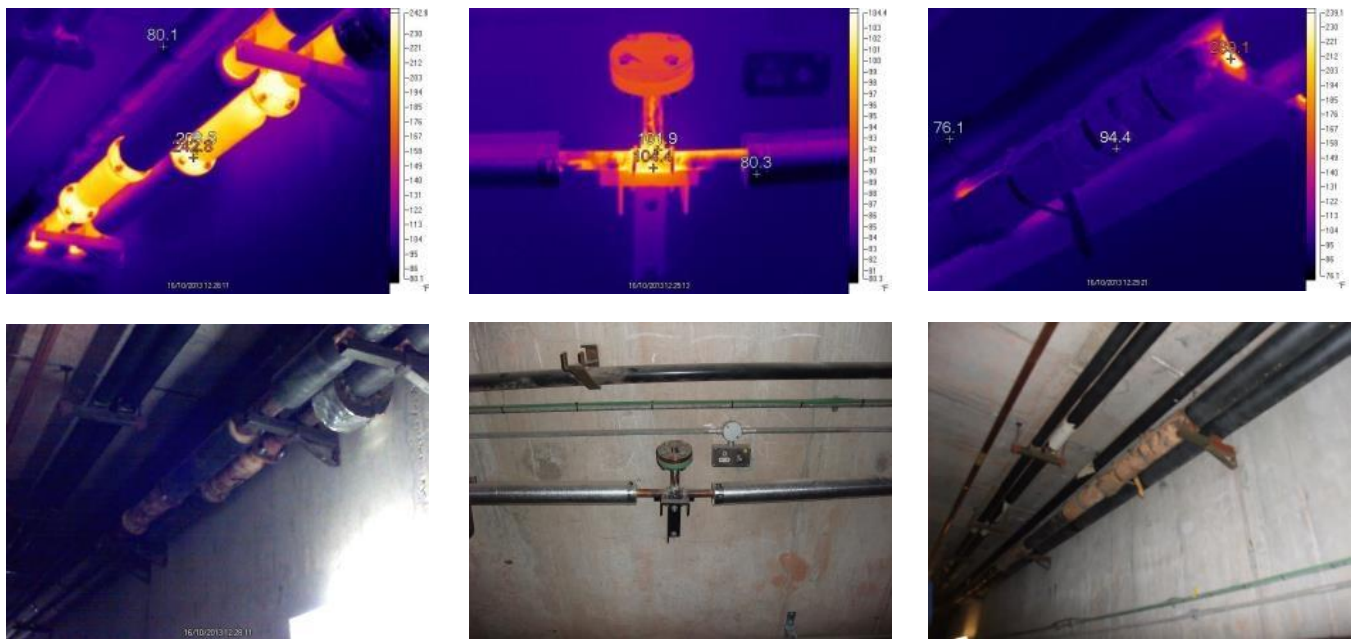


Figure 25 Condition of the Royal Devon and Exeter NHSFT Steam Tunnel before the EEF: missing insulation, flanges, brackets bridging insulation. Courtesy of the Royal Devon and Exeter NHSFT.

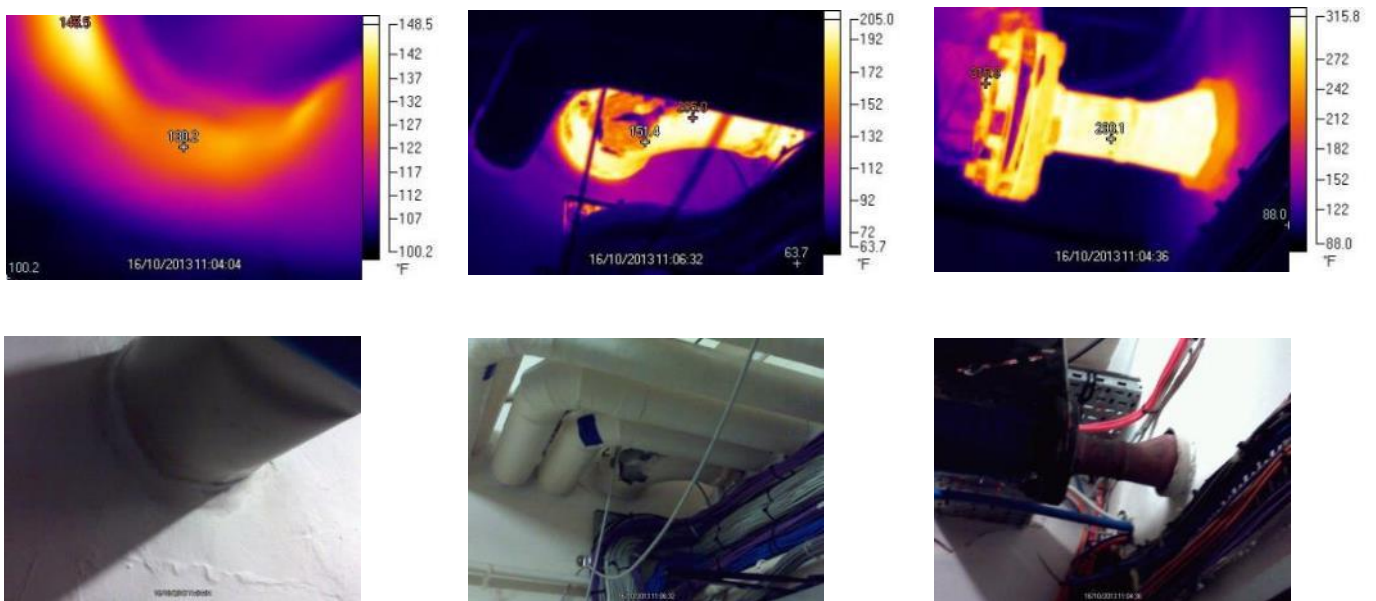
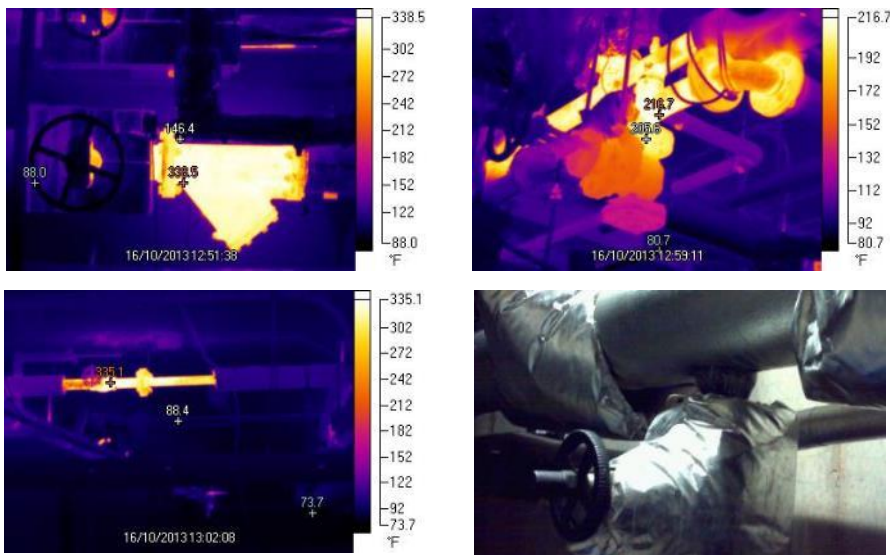


Figure 26 Condition of the Royal Devon and Exeter NHSFT Pathology Lab before the EEF: Hot pipes through chilled room. Courtesy of the Royal Devon and Exeter NHSFT.



**Figure 27** Condition of the Royal Devon and Exeter NHSFT Laundry Plant Room after the EEF: Valve insulation now much improved, reduced ambient temperatures. Courtesy of the Royal Devon and Exeter NHSFT.

**4.2.40** 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.

**4.2.41** Examples of heat emitters include the following:

- radiant panels;
- radiators;
- natural convectors;
- fan convectors;
- underfloor heating;
- skirting board heating.

**4.2.42** Detailed design guidance can be found in **CIBSE Guide F: Energy efficiency in buildings**.

**4.2.43** 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.

**4.2.44** For guidance on managing the risks of hot surfaces and infection control, see the **HSIS6: Managing the risks from hot**

**water and surfaces in health and social care, the Health Building Note 00-09: Infection control in the built environment and the PAS 5748:2014 Specification for the planning, application, measurement and review of cleanliness services in hospitals.**

### Water heating

**4.2.45** 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.

**4.2.46** 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.

**4.2.47** 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 the hot water plant is sized correctly to minimise capital and running costs;
- ensure that circulation temperatures are not compromised.

**4.2.48** More information on hot water systems and the control of Legionella for healthcare organisations can be found in [Health Technical Memorandum 04-01 Part A](#) and [Health Technical Memorandum 04-01 Part B](#).

## 4.3 Ventilation and cooling

**4.3.1** A successful natural ventilation strategy is the most energy efficient and environmentally-sensitive solution for healthcare buildings. However, caution is needed to ensure the provision of the right thermal comfort levels for the occupants (see Chapter 1 of EnCO2de 2015 Part A).

**4.3.2** 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); natural ventilation is very challenging for building refurbishments.

**4.3.3** 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.

**4.3.4** 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 the [Health Technical Memorandum 03-01 Part A](#). More information on the ventilation of healthcare buildings can be found in [Health Technical Memorandum 03-01 Part B](#).

## Heat recovery

**4.3.5** 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.

**4.3.6** 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.

**4.3.7** 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.

**4.3.8** 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.

**4.3.9** 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.

**4.3.10** Further guidance on heat recovery can be found in [CTG057: Heat recovery - A guide to key systems and applications](#).

### Humidity control

**4.3.11** Human comfort is satisfied by a broad range of at least 40–70% humidity. Even without humidity control, conditions outside this range rarely last for more than a few tens of hours per year and are usually tolerated.

**4.3.12** 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 0°C or below. At other times, moisture gains from people, washing or other processes bring humidity inside the building up to acceptable levels. [Health Technical Memorandum 03-01: Specialised ventilation for healthcare premises Part A: Design and validation](#) provides more information on humidity controls.

### Duct systems

**4.3.13** 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.

**4.3.14** The thickness of insulation required for healthcare buildings 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.

**4.3.15** The resistance of ductwork systems should be designed for low velocities as far as possible.

### Conventional cooling techniques

**4.3.16** Building cooling requirements should be minimised through appropriate building design. 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.

**4.3.17** 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.

### **Innovative cooling techniques**

**4.3.18** 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. 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.

**4.3.19** 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. 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. The following paragraphs describe potential opportunities.

**4.3.20 Groundwater coupling using air:** by passing air through underground pipes at depths of 2 to 5 m to take advantage of the 12°C 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.

**4.3.21 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.

**4.3.22 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.

**4.3.23 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.

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

**4.3.25** Absorption chillers use a silica gel as the refrigerant. This type of chillers offers reduced maintenance requirements and

higher efficiencies when operating with lower temperature heat sources. Attention should be given when sizing those systems, so that the chillers' heat requirement does not exceed the CHP heat output. More information on the topic can be found in [CIBSE AM12: Combined heat and power for buildings](#).

**4.3.26** 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 the 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.

## 4.4 Lighting

**4.4.1** 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 AC.

**4.4.2** 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 AC needed to remove the heat that the artificial lighting would have produced.

### Making the most of daylight

**4.4.3** 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;
- 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.

### Electric lighting

**4.4.4** Hospitals and other healthcare environments are particularly challenging when it comes to lighting design. Specific lighting level requirements for different spaces have to be met, while energy efficiency is also taken into consideration and accounted for. BREEAM for New Construction encourages visual comfort conditions, especially for healthcare buildings where the requirements are even higher.

**4.4.5** [CIBSE Lighting Guide 02: Hospitals and Health Care Buildings](#) provides guidance regarding the lighting levels in different areas of healthcare buildings. BREEAM assesses glare control, daylight levels, views out, as well as internal and external lighting. More details on energy efficient lighting and further guidance documentation on lighting in general can be found in the Appendix.

### Box 46 Operating theatres' lighting and ventilation

*Operating theatres generally require high levels of illumination and therefore lamps can create high internal heat gains. As a consequence, ventilation loads are likely to be increased, whilst this creates issues regarding air flows and energy consumption. LED lighting creates lower heat gains and assists in reducing the problem, however not all operating theatres utilise this lighting technology currently. Ventilation and lighting requirements in operating theatres should be designed with a holistic approach in mind, taking into consideration the levels of lighting and types of luminaires when specifying the ventilation loads.*

*When planning for general lighting, some or all of the following items of equipment may also be included in the ceiling layout: fixed X-ray machine, track mounted X-ray machine, fixed operating table luminaire, track mounted operating table luminaire, air conditioning grilles, medical gas pendant and electrical supply outlets, ceiling mounted operating microscopes, image intensifiers and closed circuit television (see [Lighting Guide 02: Hospitals and Health Care Buildings](#)).*

*This holistic and organised approach will ensure the right lighting levels, functional space use together with energy efficiency.*

### Improved lighting conditions for patients

**4.4.6** Bio-dynamic lighting is a recent development in lighting technologies, allowing the adjustment of lighting levels and colour depending on the time of the day and synchronising with patients' circadian rhythms.

## 4.5 Motors and drives

**4.5.1** 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.

**4.5.2** 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.

**4.5.3** Low-loss motors, variable-speed controls and effective control can realise savings of more than 50%. Box 47 provides links to relevant information by the Carbon Trust.

### Box 47 Guidance on motors and drives by the Carbon Trust

[CTV048: Motors and drives technology overview](#)

[CTG070: Variable speed drives technology guide](#)

[CTL023: How to implement de-stratification fans](#)

[CTL024: How to implement direct flat belt drives](#)

[How to implement motor power optimisers](#)

[CTL035: How to implement optimum start control](#)

[CTL042: How to implement inverter variable speed drives](#)

[CTL167: Variable speed motor driven air](#)



compressors

CTL154: Motors and drives checklist

CTL155: How to implement higher efficiency motors

- 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.

## 4.6 Electrical small power

**4.6.1** 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.

**4.6.2** 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.

**4.6.3** 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;
- following an environmentally sensitive approach to procurement of small power items;

**4.6.4** 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 AC and consequent energy wastage.

### Design issues: predicting the load

**4.6.5** 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).

**4.6.6** 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 when portable equipment is moved into an area and contributes to uncomfortable levels of heat gains. ADB sheets should be used when predicting the load and questions should be raised about likely future changes. Clearly, it is not possible to plan for all eventualities; the preferred course of action is to exercise caution so that the services are not over-designed.

**4.6.7** 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.

## 4.7 Specialist services for healthcare organisations

### Medical gases

**4.7.1** 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;
- 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 sterilisers (to minimise distribution energy and potential leakage).

### Catering

**4.7.2** Some healthcare organisations run large catering facilities, often providing these services to others in their area. Energy efficient catering facilities can reduce the energy requirement. The provision of independently assessed energy efficiency rating figures for each item of equipment should be an integral part of any catering equipment specification.

### Laundries

**4.7.3** In most laundries the energy used is the second highest cost after labour. Water usage is also an issue.

**4.7.4** The presence or likelihood of a future need for laundries should be accounted for in the site-wide energy strategy. For example, CHP can prove viable for a stand-alone laundry and should therefore be evaluated for any site that will incorporate a laundry.

**4.7.5** Most steam-heated laundries will generate excess low-grade heat that can be conveniently reused, so consideration should be given to using this elsewhere across the site.

**4.7.6** 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.

**4.7.7** 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 38°C, if it is to be used for the first wash. (A higher temperature may cause stain-setting in dirty linen.)

### Sterilisation and disinfection

**4.7.8** 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.

**4.7.9** 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 steriliser plantrooms are on an outside wall, preferably at ground-floor level, to enable heat within the plant area to dissipate naturally. Sterilisers can emit 4 kW to the plant space, which can require either large volumes of conditioned air, or even split AC systems to keep internal plantrooms below 35°C;
- extract from steriliser plantrooms should incorporate heat recovery: heat is emitted 24 hours per day;
- choose sterilising and disinfecting equipment on the basis of energy usage as well as performance;
- consider heat recovery from washer-disinfection extracts, provided the device can withstand moist, corrosive air;
- consider heat recovery from heat exchangers in steriliser drainage (water cannot be reused);
- ensure that a low carbon strategy is adopted for the primary energy source: steam should be used for sterilisers. 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 steriliser bodies and pipework connections, valves, flanges etc. to minimise stand-by losses;
- use steam rather than electricity for rinse-water heating, reverse osmosis plant heating and drying;
- when sizing steam plant, allow adequate steam capacity in the design to accommodate combined starting of sterilisers 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, 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;
- meter the department for each utility and specify individual energy metering for each major washer and steriliser;
- consider metering reverse osmosis production;
- hot reverse osmosis ring mains should be insulated;
- regeneration of softeners should be based on demand measurement rather than time controls to avoid waste of water.

## 4.8 Low carbon and renewable energy technologies

### What is renewable energy?

**4.8.1** Renewable energy or zero carbon 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<sub>2</sub>, oxides of nitrogen/sulphur and particulates). Thus they should be the first option for energy sources, where economically justifiable, in order to minimise environmental impact. There are different options for exploiting this green energy; these are described in the following sections. Further information on selecting renewable energy technologies and a better overview of different types can be found in the Carbon Trust's [CTV010: Renewable energy sources](#). Specifically for Northern Ireland, advice can be found in the Carbon Trust's [CTG011: Making sense of renewable energy technologies](#).

### What are low carbon technologies?

**4.8.2** The term 'renewable technologies' is often confused with 'low carbon technologies'; those are not completely renewable, as there are some emissions associated with them; nevertheless they are associated to lower carbon emissions compared to conventional technologies. Heat pumps, CHP and district-heating are examples of low carbon technologies.

### Buying from electricity suppliers

**4.8.3** Most electricity companies offer green electricity under special green tariffs, that is, electricity guaranteed under the Green Energy Supply Certification Scheme 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 and frequently the green tariffs are provided to those customers who want to pay more for a larger share of this renewable supply.

### Generating green energy within the NHS organisation

**4.8.4** NHS trusts are in an ideal position to benefit from generating their own supplies of green energy: most trusts are significant

property owners; they have 24-hour year round demands for electricity and heat; and they 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 (depending on seasonal river flows).

**4.8.5** 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.

**4.8.6** As an alternative to straight capital purchase of renewable technologies, there are an increasing number of lease schemes available from suppliers in return for long contracts and shared savings once the capital cost has been recovered.

### Selling to the grid

**4.8.7** It is also possible for NHS organisations to sell renewable electricity to an electricity distributor at a premium. One of the first things to check before making the decision to install renewable technologies is if the local energy supplier and the local network can receive the electricity an organisation is expected to produce and sell to the grid. Advice can be provided by the CCS.

**4.8.8** The Carbon Trust's [CTV010: Renewable energy sources](#) comments that the rising value of renewable energy in the market can make the installation of renewables and selling to the grid, an attractive option for NHS organisations. Initiatives such as the Renewables Obligation (RO) make selling electricity to the grid a profitable option under attractive commercial terms.

## Low and zero carbon technologies as sustainable investments

**4.8.9** 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.

**4.8.10** For example, the **RHI** is the first long term financial support programme for renewable heat. This scheme pays domestic and non-domestic participants for generating and using renewable energy for space heating in their buildings.

**4.8.11** Another scheme, the FIT, involves receiving payments from the energy supplier for producing electricity, for example through the use of solar panels. Other than the payment per kWh produced, FIT participants also receive payments for electricity they do not use and that they sell back to their energy supplier. More details can be found in the **UK Government website**.

### Low zero carbon (LZC) feasibility study

**4.8.12 BREEAM for New Construction** encourages carrying out 'low zero carbon feasibility study' by the time the concept design stage is complete. This should 'establish the most appropriate local (on-site or near-site) low or zero carbon energy sources for the specific healthcare building and site'. According to BREEAM, the 'low zero carbon feasibility study' should at a minimum cover the following:

- Energy generated from LZC energy source per year
- Carbon dioxide savings from LZC energy source per year
- Life cycle cost of the potential specification, accounting for payback

- Local planning criteria, including land use and noise
- Feasibility of exporting heat/electricity from the system
- Any available grants
- All technologies appropriate to the site and energy demand of the development.
- Reasons for excluding other technologies
- Where appropriate to the building type, connecting the proposed building to an existing local community CHP system or source of waste heat or power or specifying a building/site CHP system or source of waste heat or power with the potential to export excess heat or power via a local community energy scheme.

### Solar electricity (photovoltaics)

**4.8.13** 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 utilises 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. The main drawback in the UK can be the intermittent nature of the resource. Costs have dropped significantly in recent years due to the large market expansion generated by recent **FIT** schemes. Bespoke solutions and ancillary costs tend to increase the cost and therefore have to be accurately calculated and integrated in any cost estimate. In general, PVs are a tried technology with low maintenance costs and they can save more CO<sub>2</sub> per installed capital cost compared to other renewable technologies. More information on PVs can be found in the Carbon Trust's **CTG038: A place in the sun: Lessons learnt from low carbon buildings with photovoltaic electricity generation**.

### Solar thermal

**4.8.14** 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 DHW. Solar thermal panels are most effective in raising water temperature from ambient levels (normally 10°C) to 30 °C or 40°C; 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:

- to provide pre-heating of cold water via preheat tanks for supply existing DHW systems;
- to provide heating for swimming pools and other treatment pools.

**4.8.15** Information on calorifiers attached to solar heating systems and the control of legionella bacteria in hot and cold water systems can be found in the Health and Safety Executive's document **HSG274: Legionnaires' disease - Part 2: The control of legionella bacteria in hot and cold water systems**.

**4.8.16** 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

**4.8.17** Wind turbines produce electricity by capturing the natural power of the wind to drive a generator. In the UK, wind power is the most well-developed and economically viable form of renewable energy. Over the past years, costs have been driven down and electricity can be produced at very low costs. There are building mounted and free-standing wind turbines, with the first type being less developed at the moment. Free-standing turbines are available in different sizes, not only for wind farm developments, but also for single installations, such as those that are smaller than 1MW. More

information can be found in the Carbon Trust **CTC738: Small-scale wind energy: Policy insights and practical guidance**.

## Biomass heat

**4.8.18** Biomass-fuelled heating is well established in Scandinavia and also in countries such as Denmark and France where biomass fuels are low-cost. Within the UK, the Government is supporting attempts to develop the market via the RHI.

**4.8.19** The technologies are well proven and automated. Issues associated with biomass include the additional transport movements and stack height of a biomass boiler. Operating costs may increase depending on the cost of biomass compared with gas. However biomass can make a very big contribution to CO<sub>2</sub> targets (contributing to reduced CRC costs) and has one of the lower costs per tonne of CO<sub>2</sub> saved.

## Biomass gasification of waste and energy crops

**4.8.20** Disposal of waste is becoming an increasing problem and landfill disposal costs are set to rise as taxes increase and the UK runs out of 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. The Carbon Trust provides guidance regarding biomass in the **CTG061: Taking the heat: Lessons learned from using biomass heating in low carbon buildings** and the **CTG012: Biomass heating: a practical guide for potential users**. The Carbon Trust also has a page focusing on **biomass heating tools** and guidance documentation, which can be accessed.

### Box 48 The 'complex topic' of biomass

Biomass can take many forms including wood and wood waste products, as well as straw and even animal litter. In 2014, DECC published a study on [Life Cycle Impacts of Biomass Electricity in 2020](#). The report addresses the potential of North American woody pellets from saw-mill residues, pulpwood and dead trees, as well as from new dedicated plantations, used as feedstock for electricity generation in the UK. The report finds that for all scenarios investigated, the energy input requirement for biomass electricity generated from North American wood used by the UK in 2020 is significantly greater than for other electricity generating technologies, such as coal, natural gas, nuclear and wind. It suggests ways to keep these energy input requirements as low as possible, including minimising transport distances.

Linked to the report is a biomass calculator intended to help developers to make sure they are sourcing their biomass responsibly. The Chief Scientific Advisor at DECC and author of the report and the calculator, Professor David MacKay is quoted on the [DECC website](#) as saying:

'The calculator looks at the changes in the amount of carbon stored in forests in North America when assessing the benefits and impacts of various bioenergy scenarios. It gives new information about which biomass resources are likely to have higher or lower carbon intensities and so provides insight into a complex topic.'

**4.8.21** More information on the complex topic of using biomass and on how to use it responsibly is provided in Box 48.

### District heating and cooling

**4.8.22** District heating, also known as community heating, provides heat from one source to more than one building through a network of pipes. District heating does not have lower carbon emissions itself; it has the advantage that heat which could otherwise be dumped to the atmosphere is used because of the different demand in more than one building. Such a scheme may also provide the facility of cooling (or chilled water) for AC or process use. District heating systems are ideal for large buildings or several buildings within close proximity. They are often used in sites adjacent to large public sector buildings, such as hospitals, especially when those buildings have 24 hours a week heating or cooling demand during the whole year. Especially when combined with renewable and low carbon technologies, district heating systems can result in very significant carbon emissions reduction. More information can be found in [CIBSE TM38 Renewable Energy Sources for Buildings](#) as well as on the [Association for](#)

[Decentralised Energy](#) and the [UK District Energy Association](#) websites.

**4.8.23** District heating is also supported by the RHI under the condition that the heat is produced by an RHI-eligible installation. The renewable heat for this type of heating can be produced using any of the RHI eligible technologies, though biomass boilers and large heat pumps are most commonly used.

### Ground source heat pumps (GSHPs)

**4.8.24** Heat pumps use refrigerant gases and an electrical compressor to take heat from a source and deliver it to an output. The ideal source for maximum efficiency would be one in stable temperature. Heat pumps can produce high coefficients of performance 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;
- low-grade process heat which would otherwise be dumped;
- ventilation extract heat recovery such as in hydrotherapy pools.

**4.8.25** GSHPs require energy input, usually electricity but they can be very energy efficient. Heat pumps can also be operated in a reverse mode to provide cooling. There are other types of heat pumps available and they extract heat from other sources such as air or water. Those heat pumps save carbon compared to conventional forms of electrical heating; however, they are not as efficient as GSHPs. It is worth highlighting the importance of heat pump specifications

being appropriate for the specific site and building they are designed for. More information on GSHPs can be found in the Carbon Trust documents listed in Box 49.

**4.8.26** Box 50 provides a simplified summary of some key technical opportunities for low carbon buildings and Box 51 a list of guidance regarding HVAC by the Carbon Trust.

#### **Box 49 GSHPs guidance by the Carbon Trust**

**CTL150: How to implement guide on ground source heat pumps**

**CTG036: Down to earth: Lessons learnt from putting ground source heat pumps into action in low carbon buildings**

**CTL151: How to implement guide on air source heat pumps**

#### **Box 50 Building services, controls and metering**

- A design air change rate is agreed and before hand-over, the building is pressure tested and defects remedied to meet the rate specified;
- a programme for monitoring energy use in the building is agreed and appropriate sub-meters are installed in readily accessible locations to encourage monitoring and targeting;
- low energy light sources, such as LEDs, are used wherever practical;
- localised switching is provided with switches in accessible positions and clearly labelled and photoelectric controls and/or timer control are evaluated to reduce unnecessary use of lights;
- efficient heating and ventilating plant is provided; efficient boilers are evaluated; CHP is evaluated;
- the system is zoned to enable different areas to be independently controlled and good controls are provided to enable the plant to respond to external weather conditions and to weekday, weekend and holiday heating schedules in different zones;
- for DHW, capital and running costs of central systems versus localised water heaters are compared, standing losses from central systems are calculated and minimised and, if a central system is provided pipes and other parts of the system are well insulated;
- adequate accessibility to test points for inspection is provided and continues to be possible even after builders work is completed.

#### **Building maintenance and cleaning**

- Boiler replacement – use high efficiency boilers with improved combustion efficiency and low case losses;
- burners – reduce standing losses by ensuring boilers remain cold unless they are operating;
- burner maintenance – set correct flame shape using appropriate combustion instruments;
- controls set up – ensure systems operate only when, where and to the extent required by users;



- motor replacement – specify high efficiency motors using variable speed drives where appropriate;
- system balancing – ensure even supply of heating/cooling throughout facility.

### **Operating and maintenance instructions at hand-over**

Ensure that you are provided with a set of manuals which document:

- A general description of the operation of all the systems;
- a description of the engineering skills required to operate the plant;
- data on design parameters, operating pressures and temperatures;
- clear and comprehensive instructions on start-up, running and shut-down procedures for all systems, including description of emergency procedures;
- details of the suppliers and manufacturers' of major components manufacturers' equipment data, plus their instructions for operating and servicing including frequency and any precautionary measures.

### **Box 51 HVAC guidance by the Carbon Trust**

[CTV046: Heating, ventilation and air conditioning overview](#)

[CTG065: Heating control technology guide](#)

[CTL037: Industrial heat recovery equipment](#)

[CTG005: Air conditioning technology guide](#)

[CTL020: How to implement blowdown heat recovery](#)

[CTL025: How to implement electric heater controls](#)

[CTL030: How to implement heat recovery in HVAC systems](#)

[CTL038: How to implement process thermal insulation](#)

[CTL039: How to implement radiant heaters](#)

[CTL040: How to implement thermostatic radiator valves](#)

[CTL055: How to implement liquid amplification to a refrigeration plant](#)

[CTL058: How to implement advanced combustion control](#)

[CTL059: How to implement air quality sensors](#)

[CTL145: How to implement thermal insulation to HVAC services](#)

[CTL146: How to implement decentralised hot water systems](#)

[CTL147: How to implement oxygen trim control](#)

[CTL148: How to implement heating zone controls](#)

[CTG052: Taking control](#)

## Appendix: 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 following:

- the [CIBSE SLL Code for Lighting](#);
- the Department of Health's 'Lighting and colour for hospital design';
- [CIBSE's Lighting Guide 02: Hospitals and Health Care Buildings](#).

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 7](#).

Fluorescent fittings should incorporate low-loss high-frequency control gear. To avoid possible consequential interference with medical equipment, the guidelines in [HTM 06-01 Part A](#) and [HTM 06-01 Part B](#) should be followed.

CIBSE Lighting Guide 02: Hospitals and Health Care Buildings provides guidance regarding the lighting levels in different areas of healthcare buildings, starting with outpatients examination areas and wards and ending with pharmacies and plant rooms.

Regarding energy efficiency, the same guide introduces a Design Energy Efficiency Rating (DEER) system to encourage energy efficient lighting. The guidance is in agreement with the minimum lighting levels required by the relevant regulations in England, Wales and Scotland, but it also introduces two higher levels of energy efficiency as 'best practice'

and 'exemplary'. According to the CIBSE Lighting Guide 02, these three levels are defined as follows:

DEER level C = statutory minimum = 45 - 59 luminaire-lumens per circuit Watt (inclusive);

DEER level B = best practice = 60 - 65 luminaire-lumens per circuit Watt (inclusive);

DEER level A = exemplary = 66 and above luminaire-lumens per circuit Watt.

More details on the calculation of these values can be found in [CIBSE Lighting Guide 02](#).

# Abbreviations

<b>AC</b>	Air conditioning	<b>DHW</b>	Domestic Hot Water
<b>ADB</b>	Activity Database	<b>EEF</b>	Energy Efficiency Fund
<b>AHU</b>	Air Handling Unit	<b>EPBD</b>	Energy Performance of Buildings Directive
<b>BACS</b>	Building Automation and Control System	<b>EPC</b>	Energy Performance Certificate
<b>BEMS</b>	Building Energy Management Systems	<b>ETS</b>	Emissions Trading System
<b>BMS</b>	Building Management System	<b>EWI</b>	External Wall Insulation
<b>BRE</b>	Building Research Establishment	<b>FITs</b>	Feed-in Tariffs
<b>BREEAM</b>	Building Research Establishment Environmental Assessment Methodology	<b>GSHPs</b>	Ground Source Heat Pumps
<b>CCHP</b>	Combined Cooling, Heating and Power	<b>HEPA</b>	High efficiency particulate air
<b>CCL</b>	Climate Change Levy	<b>HVAC</b>	Heating, Ventilation and Air Conditioning
<b>CHP</b>	Combined Heat and Power	<b>IWI</b>	Internal Wall Insulation
<b>CIBSE</b>	Chartered Institution of Building Services Engineers	<b>LED</b>	Light Emitting Diodes
<b>CoP</b>	Coefficient of Performance	<b>LIFT</b>	Local Improvement Finance Trusts
<b>CRC</b>	Carbon Reduction Commitment	<b>LTHW</b>	Low Temperature Hot Water
<b>CWI</b>	Cavity Wall Insulation	<b>LZC</b>	Low Zero Carbon
<b>DEC</b>	Display Energy Certificate	<b>NHS</b>	National Health Service
<b>DEER</b>	Design Energy Efficiency Rating	<b>NHSFT</b>	National Health Service Foundation Trust
<b>DEFRA</b>	Department for Environment Food and Rural Affairs	<b>NIHR</b>	National Institute for Health Research
<b>DH</b>	Department of Health	<b>OJEU</b>	Official Journal of the European Union
		<b>RHI</b>	Renewable Heat Incentive

<b>SIPs</b>	Structural Insulated Panel Systems
<b>SMEs</b>	Small and Medium-size Enterprises
<b>VO</b>	Voltage Optimisation
<b>VSD</b>	Variable Speed Drives

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