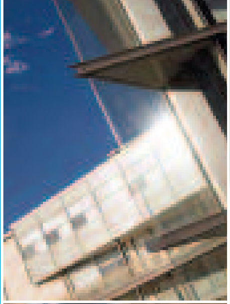


Building a brighter future

A guide to low carbon building design

CARBON TRUST

Making business sense of climate change

Understanding the need

Today, the built environment accounts for around half of all the UK's carbon emissions. Anything we can do to lessen that impact will help reduce climate change, meet our environmental goals, improve air quality and make this country a better place to live in.

Creating buildings that generate fewer carbon emissions is not only socially desirable but they can be cheaper to build and more pleasant to occupy. Because low-carbon buildings use less conventional energy sources for heating and cooling – and have less associated hardware – they cost less to run and are cheaper to maintain and refurbish. Thus, low carbon buildings make both economic and environmental sense.

This Guide has been designed to help you make informed choices about how to integrate energy efficiency into your building programme at all stages.

Getting the most out of the Building Design Advice Service

Regardless of whether or not you work with us directly, this Guide can be used throughout the construction process to assess the measures you need to incorporate low carbon design and monitor their implementation.

Although some of the recommended specifications and materials in this Guide may increase the build cost, it's important to remember that the long-term benefits they yield should more than compensate. Being able to achieve the necessary cooling and heating functions with far less plant will not only reduce fuel bills but lead to lower capital, maintenance and renovation costs.

At the same time, your building's occupants - whether office, industrial, student, medical or domestic – will benefit from an improved physical environment. Research has shown that people work better in buildings that use increased levels of natural lighting and ventilation.* Because they are more comfortable and feel more in control of their environment, they are more relaxed, more productive and less subject to minor illness and absenteeism.

Designing flexibility into the layout of the building can improve its ability to adapt to changing demands and uses in the future. For example, what was once student accommodation might later be used as open-plan office space. By designing your building in a way that allows services to be delivered when and where they are actually needed, you can save on both energy and building management costs.

To make it easy to find the information you're looking for, this Guide has been designed in clearly marked sections. In addition, a reference section has been included with contact details of all the main agencies involved in building design and regulation. If there's anything else you'd like explained or clarified, contact details for the Carbon Trust can be found at the top of the reference section.

* 'The Effect of Healthy Workplaces on the Well-being and Productivity of Office Workers', J Berg, 2002

Introduction

This building design advice guide provides information on how you can best obtain a productive, low carbon building, from the first design sketches through to occupation and operation. It will help you build a case for such a building, as well as providing pointers on how to go about producing a brief and choosing a procurement route. It also identifies different design strategies that can be used and when they're appropriate, and gives pointers on how to ensure low-carbon design features continue to provide savings once the building is occupied.

Using less energy reduces the related emissions of CO_2 and other combustion products that contribute to global climate change, acid rain and air pollution.

Buildings constructed in line with environmentally conscious principles are good long-term investments, with lower operating costs and a greater ability to meet changing environmental controls and legislation. These principles will help ensure that your building has a better chance of withstanding expected impacts of climate change.

Flexible design enables a building to be adapted for future changes in use, layout or occupant demand. This allows building services to be provided only when required and only to those parts of the building that need it.

Minimising mechanical systems reduces the potential sources of system failure or malfunction and the need for upgrades and maintenance. Effective use of the building fabric and form allows the building to cope better with our changing climate.

Summary

Designing a good, environmentally-sensitive building or improving the environmental performance of an existing building during refurbishment can significantly:

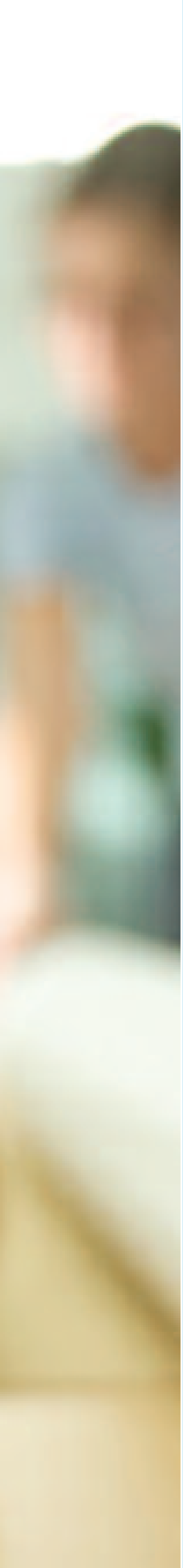
- Improve comfort which affects staff productivity and morale
- Reduce costs associated with energy use, maintenance and refurbishment
- Reduce environmental impacts associated with energy and resource use
- Improve a building's ability to cope with future changes in demand and climate

Providing better buildings makes good business sense and ensures a better future for our children.

Features	Benefits	Comments
The building itself moderates the effects of outside temperature and humidity swings	Simpler and more manageable environmental systems	Greater design effort is required to enable the building to give satisfactory operation Requires more thoughtful, less production-line design - need to anticipate all circumstances if mechanical plant is not to be retrofitted later
Reduced reliance on mechanical plant (e.g. air conditioning)	Lower capital, operating and maintenance costs	Greater care is needed to avoid any loss of flexibility in partitioning and layout
Greater personal control of the environment	Increased user satisfaction and productivity	Available only to occupants at the perimeter
Lower energy and water demands	Reduced operating costs and improved environmental performance	A greater range of internal temperatures, but more occupant control increases tolerance to temperature fluctuations

Figure 1: The benefits of an environmentally sensitive building

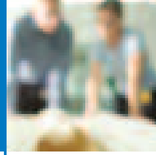
Phase 1



FIRST PRINCIPLES 1

- Starting out
- Impact of the built environment
- Principles of good design
- Producing the specification

Energy. Materials. Water
BREEAM
Commissioning
Users



Starting out

Better buildings begin at the concept and design stage so getting the brief right is a key factor in ensuring a building meets your requirements. The potential to make a difference is greatest at this stage. The role of the client in this first step is crucial. Demanding an environmentally benign building should be part of the brief.

Designing with energy management in mind will help ensure that the building energy performance is as close to the design standards as possible. Failure to appreciate this at the outset could result in the building failing to meet design expectations.

If new buildings are over specified and complex, they may put themselves beyond the competence of the building management team to achieve high standards of performance. Even if controls are set up and commissioned correctly, they may be over-ridden in a misguided attempt to improve occupant comfort. This often results in higher energy use, more uncomfortable conditions and less contented staff.

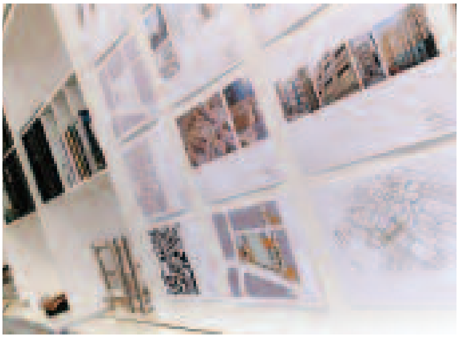
Aim to make your building as simple as possible by specifying easy-to-operate controls and ensuring clear operating instructions are available to users. During the development of the brief, keep the following questions in mind:

- **How are the occupants supposed to use the controls?**
- **If I were an occupant, how would I use the equipment?**

Pic: BT HQ, Edinburgh.
Careful treatment of a façade provides a stimulating internal environment for occupants.

The brief should state what level of control the occupants are expected to have and how the controls are expected to be used. This attention to detail could help you to spot potential problems early enough to correct them. Design and control options will be dictated by the site itself and whether the project is a refurbishment or a new build. Consider:

- **Can the building be orientated to face north/south?**
- **Can the building be 15m wide or less?**
- **If over 15m, could the building be ventilated using a mixture of natural and mechanical techniques?**
- **How is the building going to be used and controlled?**
- **Are there opportunities to allow the building to be upgraded easily?**
- **How long would you intend to occupy the building?**
- **For speculative builds, how much of the internal fit-out can be completed after an occupier has been found?**
- **For refurbishment, how much of the existing building structure can be reused?**



Choose a design team early, and include them in the development of the brief and the outline proposals. You may wish to seek independent advice at this stage to ensure the outline proposals will meet your requirements.

The design team should include an architect, a building services engineer, a quantity surveyor, a structural engineer and a client representative. A building manager should also be brought into discussions on the brief. This team's task is to assess the design decisions, the brief and the outline proposals. Make sure all members sign up to the need for a low carbon building alongside their other requirements.

Pic: Bennetts Associates, HQ.
Always consider the overall integration of a building into its surroundings.

Impact of the built environment

Energy used to heat, light and power our homes, workplaces, leisure facilities and shops accounts for around 45% of total UK energy use. Add manufacture and transportation of building materials to the equation and the built environment is responsible for over half of all energy use in the UK. This amounts to the release of over 250m tonnes of CO_2 into the atmosphere each year. In addition, most of our growing demand for transportation (33% of total UK energy use or a further 170m tonnes of CO_2) is driven by the need to travel between buildings.

The built environment has other environmental impacts, including the loss of and disruption to habitat, noise and air pollution and water related issues including use, ground water levels, surface permeability and run-off.

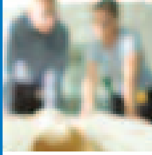
The greatest impact that buildings have on the environment is during their operation, but the upper limit of performance is set during the design phase of either a new build or extensive refurbishment project. It is therefore important to design buildings to the highest standards of energy (and carbon dioxide) performance.

Pic: Canon HQ, Reigate.
Lightwells on the roof provide daylight to the office space below.

Today's buildings are designed for an expected 20-50 year lifetime with the main services (e.g. heating and lighting systems) anticipated to last 10-20 years. In practice, however, many buildings can be expected to be in use for much longer. After all, the UK has thousands of buildings over 150 years old still in service today, in some cases with heating systems over 80 years old. So, building design has a significant long-term impact on the environment, both on a local and global scale.

The buildings of Britain's industrial past were designed mainly to protect people, equipment and goods from the weather. In contrast, today's buildings are expected to provide stimulating environments, increasing levels of occupant comfort and to accommodate greater densities of energy using equipment in a climate of tougher building regulations. Predicted rising summertime temperatures along with increased rainfall and damaging storms only add to the challenges facing the construction industry.

Pic: BT HQ, Edinburgh.
Consideration should always be given to the landscaping and layout of a site.



Principles of good design

Providing people with a functional, stimulating place in which to work and socialise will improve productivity, satisfaction and profitability. Comfort, quality, character, innovation, access, sense of place and impact on the community are all aspects of good design. Consider using Design Quality Indicators[1] to define and check the evolution of design quality at key stages in the development of a building.

Consider your building project in context:

- **What will it be used for?**
- **How many people will it serve?**
- **How will people get to the building?**
- **How else they might want to use it?**
- **Could the building's function be extended? Apart from the added income, this could raise the social and community presence of your business and your building.**

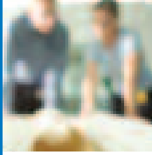
Pic: Sainsburys, Greenwich.
Building the store so that it is earth-sheltered helps to minimise running costs.

[1]The DQI (Design Quality Indicator) system is funded by CABE and DETR/DTI and widely endorsed.

While obviously important, individual elements cannot, on their own, guarantee a building's overall performance. Following a stepped process like the one below could reveal the bigger picture and improve your chances of getting it right:

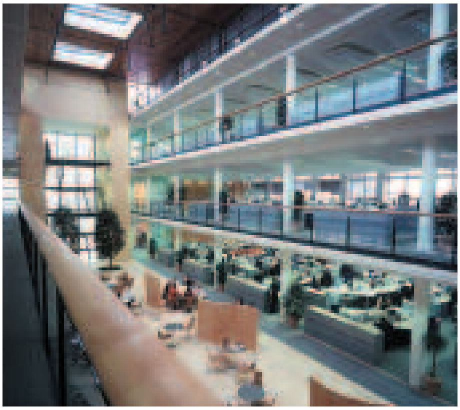
- **Consult internally to identify needs and expectations for the development**
- **Consult externally with people currently using the same area and facilities; ask about transport issues, current user perceptions, how they use and would like to use their break times – learn from their experiences and use them to identify potential opportunities**
- **Get a multi-disciplinary team together early to discuss needs and available options**
- **Brief the team on your main priorities, e.g. a well designed building capable of a high environmental performance including low-carbon impact and ask them to keep these in mind throughout the design and construction process**
- **Consider passive strategies for ventilation and day-lighting to improve occupant comfort and reduce operational costs**
- **Supplement these with high-efficiency services**
- **Predict heating, cooling and electrical loads and consider which cleaner technologies and renewable energy sources might be used to offset a proportion of them**
- **Get an independent opinion on the design from an expert outside the design team, perhaps from the Low Carbon Building Design Advice service, if the project is greater than 2500m^2**
- **Ensure time and resources are available within the project plan for commissioning of the building and services**
- **Ensure that a building log book is developed so as to provide operational information for facilities managers and occupants**
- **Review the design as it develops to ensure that a low carbon outcome is not compromised by other non-energy aspects of the design.**

Although new build presents most opportunities, significant savings can be made on refurbishments as well. These improvements can often come at little or no extra cost, so long as they are considered at the planning stage.



Producing the specification

A robust specification is the key to getting the building you want and should encompass design, commissioning, operation and maintenance.



Start by gathering detailed information about how the building will be used: how it will operate, the number of people it will accommodate, their work patterns and type of work. Overlooking key aspects, such as the extent of ICT equipment needed, could allow running costs to increase and may fail to produce the correct internal environment.

Using staff questionnaires and meetings will help in specifying how the building needs to function to suit the staff and hence enable higher productivity. Discuss and agree any issues this process throws up with your design team and make sure they are incorporated into the brief.

State required targets, outputs or outcomes within the specification. To be meaningful, these must be measurable or easily demonstrated. If they cannot, take time to reconsider what you are trying to achieve and revise targets accordingly. Failing to have measurable targets could result in them being ignored altogether.

Pic: Canon HQ, Reigate.
A well day lit atrium reduces the demand for electric lighting in a deep plan office space.

ENERGY

The 2006 Building Regulations require a percentage improvement of the energy or carbon performance over that which would have been required in the 2002 regulations. The 2002 performance is deemed to be that of a 'notional building'. This required improvement over the notional building varies, depending on whether a building is air conditioned[2].

It is recommended that specifiers go further than the building regulations by setting a design target as a percentage improvement which is greater than that required by the regulations, e.g. 70% or 60% of the CO_2 emissions of the notional building. Discuss the achievability of such targets with designers early in the process.

Where the Building Design Advice service provides for face-to-face consultancy, estimates will be made for the reduction of carbon emissions due to the recommended design enhancements. These improvements can be compared to the design target or Building Regulations target.

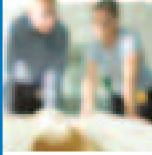
In the case of refurbishment it is recommended that specifiers call for improvements greater than the worst acceptable efficiencies listed in the building regulations. This means the best and most efficient boilers, air conditioning systems (if required), ventilation systems and lighting.

Targets should be challenging enough to prevent inefficient plant being provided and require designers/bidders to submit calculations and/or methodologies in their proposals.

The demonstration of specification compliance can be made a requirement, to show the building complies with the brief. This should take place at some point before handover. A list can be developed in consultation with the M&E consultant.

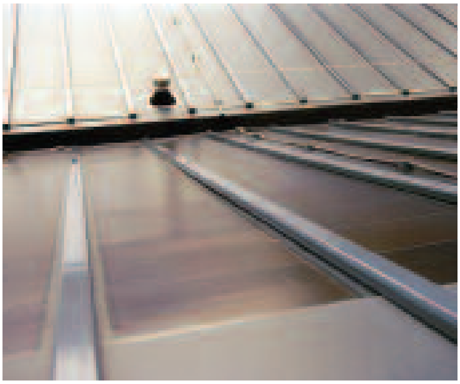
Pic: RNIB HQ, London.
Energy efficient refurbishment of buildings has huge potential to save carbon and running costs for occupiers.

[2]See Insert in this pack for latest information about the Building Regulations and how these may be used to specify carbon performance targets.



MATERIALS

The construction industry accounts for around 10% of the UK's GDP, or c.£60bn a year. The construction, refurbishment and demolition of buildings and related infrastructure has significant impacts on the environment. In 1999, the construction sector is estimated to have produced 72 million tonnes[3] of waste, 19% of the UK total. Up to 13 million tonnes (18%) of this is material delivered to site and thrown away unused[4].



By taking the opportunity to reduce this level of waste, you can reduce the environmental impact and waste disposal costs of your building. During the specification stage:

- **Identify product requirements and quantities - be aware of the tendency for adding contingency**
- **Identify materials currently on site that could be diverted to raise revenue, remain on site as they are, or form aggregate for the new construction**
- **Identify any waste on site that could be recycled, reducing landfill costs**
- **Specify materials with lower environmental impacts (the 'Green Guide to Specification', developed in consultation with the construction industry, can help with this)**
- **Specify a minimum recycled content of the building as a whole (WRAP - the Waste and Resources Action Programme website can help with this - www.wrap.co.uk)**
- **Specify reclaimed materials. A database of reclamation companies in your area can be accessed for free from www.smartwaste.co.uk**

When you eventually get on site, you can:

- **Ensure space is set aside to allow waste to be sorted and stored onsite prior to collection and disposal. This will reduce waste disposal costs**
- **Make everyone on site aware of the requirement to minimise waste. Monitor and segregate types and levels of waste and take action to rectify any problems identified**
- **Work with those on site to identify wasteful practices and develop alternative methods**
- **Involve site workers in the process and ask them for ideas: this can identify opportunities for reduction and improve morale too.**

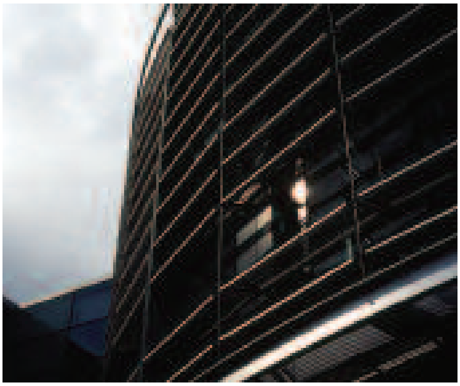
Pic: Canon HQ, Reigate.
Photovoltaics can help to reduce a building's electricity demand.

[3]Source: DEFRA
[4]Source: BRE Green Guide to Specification 2002

WATER

- **Specify low-water-using equipment and consider rain water collection for watering any grounds or for use in toilets**
- **Specify water-retaining materials for car parks and other hard landscaped areas. A high volume of surface water run off during heavy rains is a major cause of flooding. Such materials could reduce flooding onsite and nearby**

ENVIRONMENTAL ASSESSMENT



An environmental assessment can be used to score a building's likely environmental performance. The most common assessment method used in the UK is BREEAM, (BRE Environmental Assessment Method) which is supported by many independent consultancies. Using BREEAM can provide a holistic approach to designing non-domestic buildings; it covers management, health, energy, water, transport, materials, land use, ecology and pollution. Setting a minimum level of attainment for your project – for example, VERY GOOD – can provide an envelope within which the designer can exercise choice, while still providing a user-friendly, low impact building.

Alternatively, you could opt to include some requirements, like the energy and water consumption targets, in your specification. This could help in developing a set of mandatory requirements.

Pic: BT HQ, Edinburgh.
Shading systems are functional but also add visual interest to building architecture.

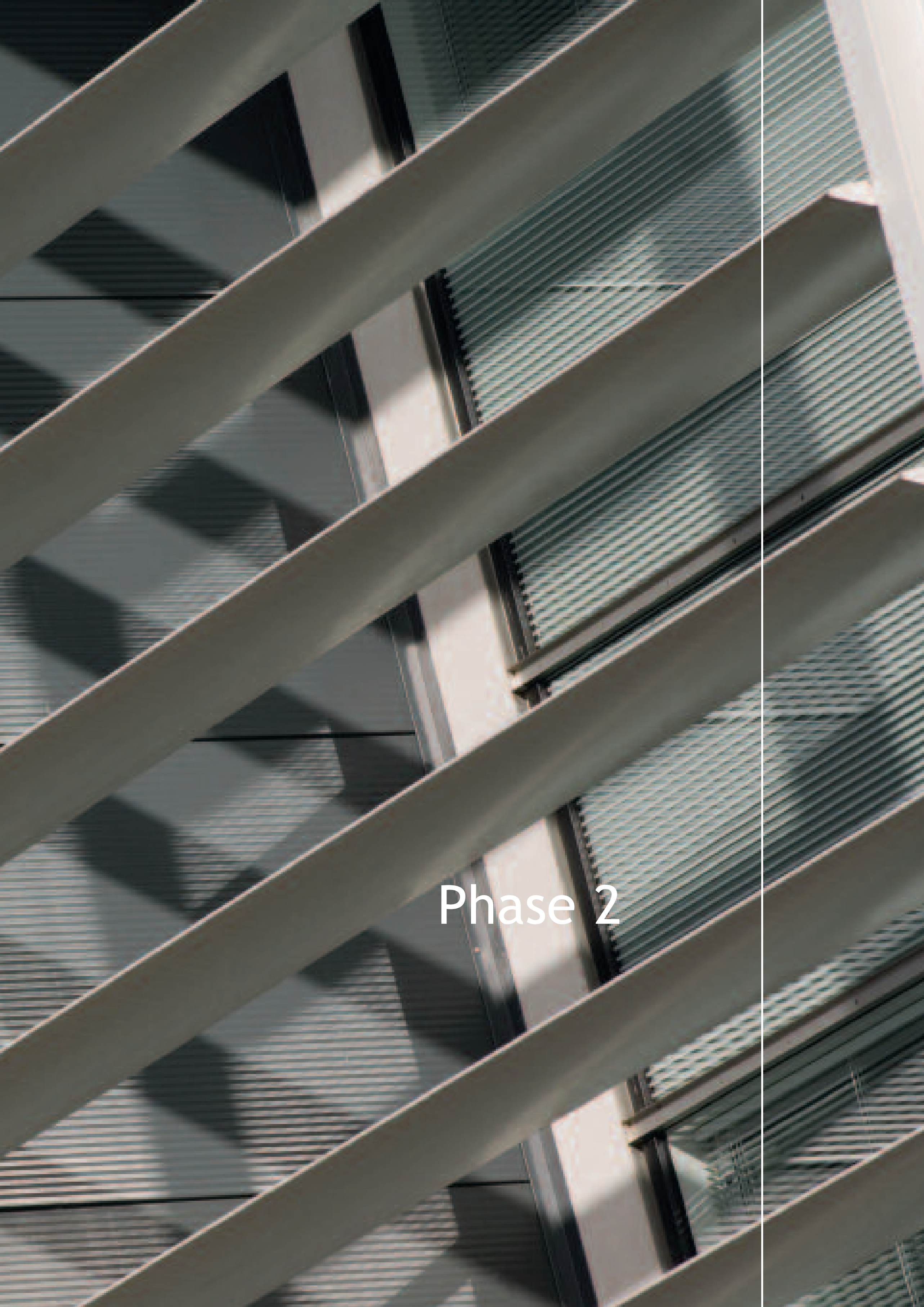
COMMISSIONING

To ensure your building continues to operate smoothly and remains easy to maintain, the specification needs to include a commitment to proper, documented and independently-verified commissioning and testing. The aim of this is to commission appropriate items of plant, assessing how they work together to affect the building's overall operation.

USERS

Include reference to the importance of users in your specification and make it a requirement for your developer to provide all users and facilities managers with information, training and guidance on building operation.

For Private Finance and Design, Build and Operation procurement, write incentives into the contract to ensure the contractor works in partnership with users. One way to do this is to



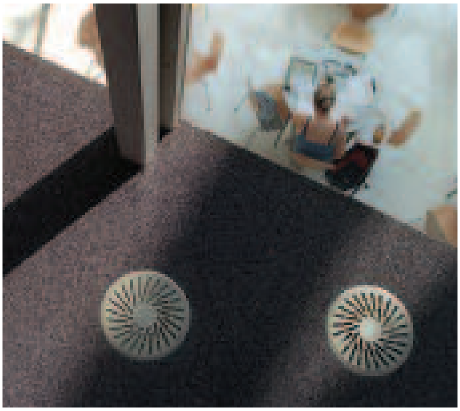
Phase 2

COST AND PROCUREMENT 2

- The cost of environmentally sensitive buildings
- Choosing the procurement route

The cost of environmentally sensitive buildings

'Green' buildings can achieve benefits for their owners and occupiers which include:



- **Net savings from lower running and maintenance costs**
- **Improved corporate image through a demonstrable commitment to the environment**
- **Lower carbon dioxide (CO_2) emissions thanks to efficient energy use and the use of renewable energy technologies where this makes design and business sense**
- **Better opportunities to let or sell in a competitive market**
- **Enhanced occupant comfort, improving productivity.**

Low energy or 'passive' buildings are often thought to cost more than traditional buildings. However, if energy-saving and carbon dioxide reduction concepts are considered and embraced early in the design stage, 'green' buildings can cost the same, although the cost breakdown may be different. Passively designed buildings generally cost less for mechanical plant but more for design and fabric.

Pic: Jubilee Campus, Nottingham.
Floor-mounted ventilation grilles can often be moved to suit desk layouts.

The De Montfort University Queen's Building in Leicester is an example. The client's spend profile shows lower building services costs but a higher spend on design and building fabric. Overall construction costs were about equivalent at £855/m^2, with lower running and maintenance spend providing savings every year. The energy costs are around half that of an equivalent academic building.

This spend profile is common in good, environmentally-sensitive buildings. Although the design process may involve more modelling to ensure the passive strategies will work as intended, the overall total cost will often be the same.

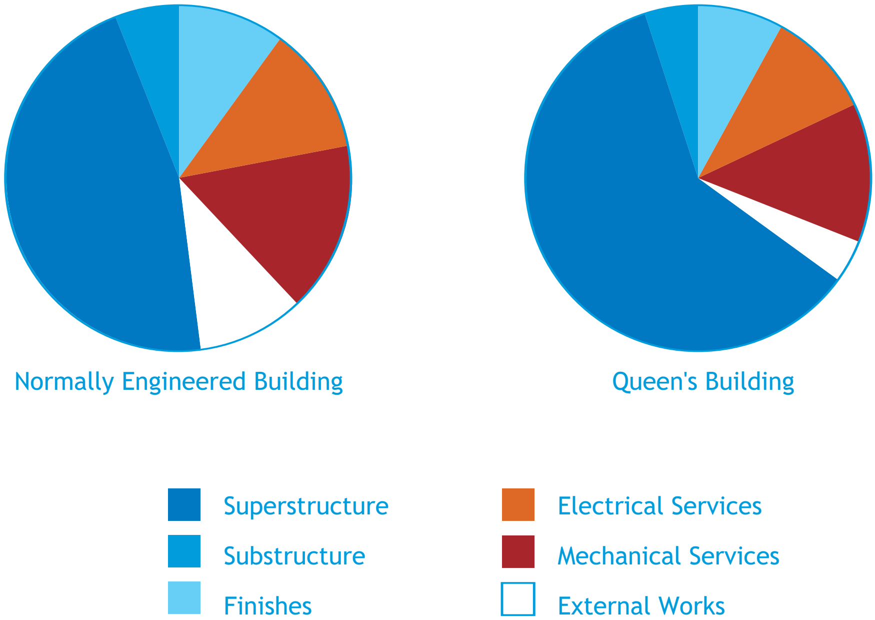


Figure 2: Comparative construction cost profile for the Queens Building

Choosing a procurement route

The process of getting a building built is invariably longwinded and the choice of procurement route can have a big impact on the outcome. Original design ideas may be compromised or jeopardised by demands of cost or the desire for ease of construction. As a result, a design that starts out with strong sustainability characteristics may result in a quite different building.

The choice of procurement route is influenced by priorities such as time, level of control, apportionment of risk, quality, project size and project complexity. The choice can in turn have a large influence on the extent to which sustainability is successfully integrated into the final building.

The main procurement routes detailed in this section have different benefits and risks. By understanding the risks associated with your chosen procurement route, you can ensure these are considered during the design and construction of your building.

TRADITIONAL PROCUREMENT

This separates the design and construction phases of the project with full design documentation being produced by the design team prior to the contractor(s) tendering for the work. The client commissions an architect or a project manager to co-ordinate production of this material, invite tenders, administer the project during construction and settle the final account. They would also advise the client on appointing other consultants for items such as quantities, costs, structural calculations and heating designs. The contractor has no design responsibility and will normally be selected by competitive tender.

Key benefits

- Specification is under full control of the client
- Greater control over detail; design delivers what is expected, including sustainability if it is adequately specified

Key Risks

- Lengthy and expensive: contractors price against extensive production information documents
- Risk of contractual conflict
- Split responsibility
- ‘Blame culture’ can develop
- Cost control

Sustainability is completely reliant on the effectiveness of the client and design teams, but may be jeopardised during construction if cost control becomes a significant factor.

DESIGN AND BUILD

The client obtains a fixed fee from the contractor, who then takes responsibility for design and construction of the project. The client's brief can range from a schedule of accommodation to a full design scheme. A Design and Build contractor can be appointed at the conception stage or further down the line, but would then take charge of the project until completion.

Key benefits

- Quicker and cheaper tendering period: less production information is required for tender
- Speed of delivery
- Low-cost process
- Early involvement of contractors allows a better appreciation of sustainability issues
- Single responsibility

Key Risks

- Specification is restricted by contract and is usually in the hands of the contractor
- Interpretation of specification
- Design quality can suffer as the role of the original design team is reduced
- Loss of sustainable vision through cost savings

Because the Design and Build contractor will aim to achieve stated requirements at minimum cost, sustainability needs to be adequately included in the specification.

Pic: Coventry University.
Stack-driven ventilation can help to minimise the use of fans for comfort cooling.

MANAGEMENT CONTRACTING AND CONSTRUCTION MANAGEMENT

Also known as 'fast track' procurement routes, these enable the first contractors to start on site while the rest of the scheme is still being designed.

In management contracting, a contractor is selected at an early stage. Construction work is then divided into packages and put out to competitive tender with all works contractors placed under contract to the management contractor. For construction management, trade contractors each have a contract with the client who also employs a construction manager to act as project manager.

Key benefits

- The client has greater flexibility and control over the specification
- Speed of delivery: 'fast track'
- Supply chain interaction
- Single responsibility

Key Risks

- Pressured timescale
- Co-ordination
- Critical interdependence of sub-contractor packages
- Cost uncertainty

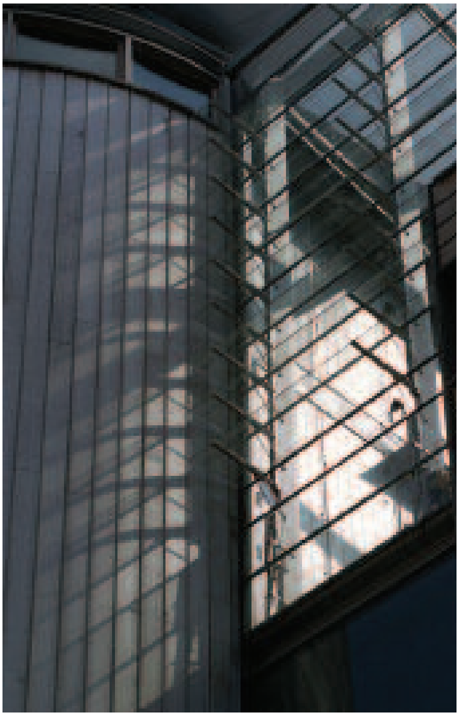
Speed of delivery is a primary concern and time to brief consultants or management contractors is often short. Sustainable features may not be incorporated during the design process, or may end up being left out during construction.

PFI/PPP

The Government's PFI (private Finance Initiative) is a Public Private Partnership (PPP). Like a mortgage it is a long term procurement route (typically 30 years) that allows a private sector consortia to design, build, finance and operate public sector facilities for a government client. The consortia will include a builder (designer), funder, and facilities management operator.

During the contract period, the client will pay the successful PFI bidder an agreed 'rent' to include running and maintenance costs. The balance of risk between the client and PFI bidder is critical to ensure optimum value for money of the service provision.

PFI can provide a sustainable building if the contractor has financial exposure to running costs over the contract term. Success is more likely if operational savings provide more profit for the contractor. However, without this, there is less incentive to specify and produce a sustainable building.



Pic: Jubilee Campus, Nottingham.
The use of different materials within a façade adds visual interest.

Key benefits

- The specification concentrates on outcomes/outputs or services
- Whole life cost becomes a fundamental consideration
- All parties involved in decisions
- Low-energy design encouraged

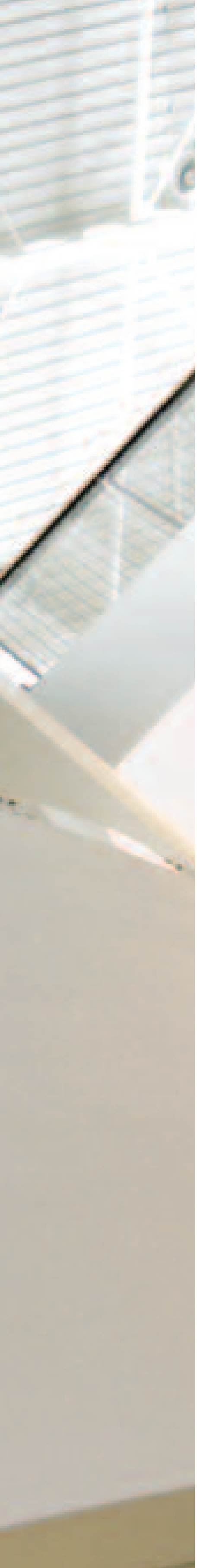
Key Risks

- Ownership at risk
- Design quality
- Contractor offloads energy consumption risk
- Team breakdown over long process
- Reduced incentive to invest in energy savings during the concession period
- Delivery does not match aspirations
- Operating arm of the consortia not bound by design targets

Summary

Success is more likely if a good relationship is encouraged between consultants, contractors and sub-contractors. Involving all participants at an early stage and keeping them fully briefed will improve their understanding of your aims as well as your chances of achieving them.

Phase 3



3 DESIGNERS’ OPTIONS

› **Producing comfortable buildings**

Passive opportunities

› **Producing comfortable buildings**

Active opportunities

› **Cleaner technology options**

Producing comfortable buildings – passive opportunities

To achieve a comfortable environment, it's important to ensure lighting, internal temperatures and fresh air are suitable for the occupants' activity. People prefer to work in natural light. On the other hand their sense of well being suffers from the noise, air flows and restricted sense of control associated with mechanical ventilation and cooling[5]. Creating a healthier working environment improves staff morale, productivity and profitability[6].

Your building's design is clearly going to influence future availability of natural light and the choice of ventilation system. It has always been important to optimise use of natural resources and today's additional incentive is the requirement to provide greater levels of safety, flexibility and comfort than ever before.

Many historic buildings follow some good design principles with high ceilings, exposed thermal mass, and stack driven ventilation. On the other hand, comfort, energy efficiency, and safety were secondary considerations and as a result, they are often draughty, hard to heat and difficult to adapt to today's requirements.

Almost all successful modern low-energy buildings have made use of these older design principles, combining them with a better understanding of heat loss and efficiency improvements in building service plant.

A low energy building exploits 'free' services like daylight and external temperature variations. A building's orientation, structure and shape all play a part in determining how much benefit can be gained from the environment. While new buildings offer greater potential savings, there are opportunities during refurbishment projects as well.

Specify high-efficiency supplementary services (heating plant and electric lighting) to back up these free services. Newer, high-efficiency electrical equipment emits less heat, reducing internal heat gains and further enabling passive design to provide internal comfort.

[5]'A survey for Richard Ellis on the British Office Market: Occupiers' preferences'. The Harris Research Centre, 1994 [6]'The Effect of Healthy Workplaces on the Well being and Productivity of Office Workers', J Berg, 2002.

DESIGNING FOR DAYLIGHT

Electric lighting can account for as much as a third of a business's energy costs. In addition, lighting can be a major source of internal heat gains, making the space hot and uncomfortable. Enhanced use of daylight is a partial solution but it's not just a matter of installing larger windows: this may bring additional heat gains or losses and glare problems. Lighting controls also have to be designed so as to turn down electric lighting when daylighting is available.

- **Maximise the use of available daylight by orientating a building within 30° of South**
- **Raise window heights to increase the depth to which daylight can penetrate. An unobstructed window will generally allow daylight to penetrate to a depth of approximately twice the height of the window head from the floor**
- **Reduce the size of windows on northerly aspects to reduce heat loss**
- **Install windows with the lowest thermal losses you can afford. New coatings for glazing can block the infra-red elements of sunlight responsible for heat gains while still allowing daylight into a space**
- **Fit external light shelves or stagger a building so that upper floors overhang lower ones to provide shade from direct summer sun. This also allows sunlight to enter the space in colder months when solar gains may be more welcome.**

Pic: Coventry University.
Ventilation stacks help the flow of outside air to cool

DESIGNING FOR NATURAL VENTILATION

Around a third of a business's heating costs are a result of having to heat fresh air that comes in to a building to replace that lost through ventilation and leaks. In addition, direct energy costs are incurred if fans are used to move the air around the space.

Ensure ventilation rates meet, but don't exceed, internal requirements. This is best done by improving an existing building's air-tightness during refurbishment or by specifying air-tightness requirements for new buildings. Air-tightness testing can be carried out on any building and can be especially useful during commissioning to ensure design specifications have been met.

There is a limit to the amount of heat a naturally-ventilated building can reject while maintaining internal temperature. During the design or refurbishment process, consider:

- **Maximising daylight to reduce the need for electric lighting**
- **Using blinds and coatings on glazing to reduce summer gains**
- **Specifying the most efficient lighting**
- **Specifying the most efficient small power equipment**
- **Placing high-heat-emitting equipment in dedicated areas with separate ventilation, or on the north side where heat gains are easier to overcome.**

As well as reducing heat gains, consider increasing and exposing the building's thermal mass. This allows the building to absorb heat during the day and release it again later when the building is empty. This effectively acts as a buffer for heat gains from both internal and external sources. Combining this strategy with night cooling, which involves opening windows or vents overnight to allow cooler air into the building, can allow a natural ventilation strategy to cope with greater heat gains than a conventional, naturally-ventilated building. Make sure vents are designed to avoid compromising security and that they are specified for differing heights and different walls to encourage cross ventilation.

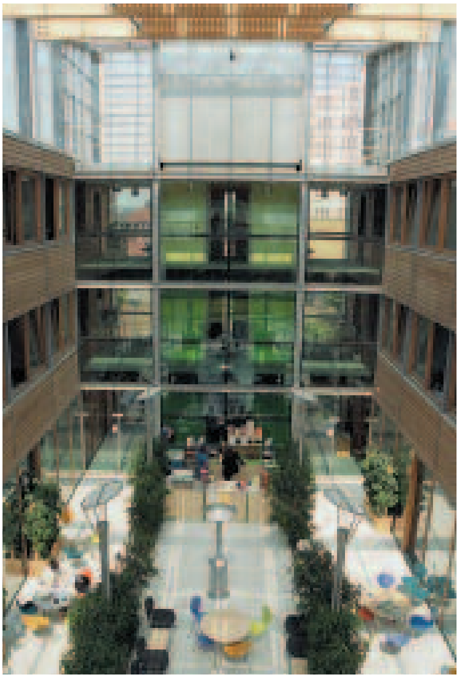
Natural ventilation works best in a narrow structure. Around 12m across the building, or from external façade to atrium, is ideal, although up to 15m can be accommodated with careful design (and probably specialist help).

Pic: Canon HQ, Reigate.
Shading systems can also act as lightshelves, increasing daylight in a space.

THE STACK EFFECT

Cool air rises in the building as it is heated by occupants, equipment and plant, drawing fresh air in at lower levels behind it. This effect can be put to good use. Specify ceilings of 3m in height, or more and controllable vents at ceiling height to allow warm air to collect and escape in the summer. This will create a negative pressure behind it, drawing fresh, cooler air in through vents at a lower level. As the building becomes hotter, the effect becomes stronger, increasing ventilation rates just when they're most needed.

Ceiling-mounted destratification fans can reverse this effect in the winter, so that heated air accumulating in taller spaces is redirected back into the occupied space. The natural ventilation strategy should be supported by calculation or building thermal simulation software.

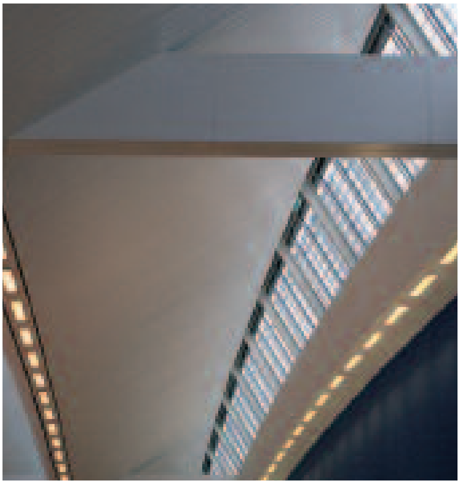


Pic: Jubilee Campus, Nottingham.
Atria provide great day lit circulation spaces and break-out areas.

Producing comfortable buildings – active opportunities

No matter how well a building is designed to benefit from passive opportunities, it will still need powered services for lighting, heating and ventilation. Specifying the most efficient options available and ensuring they have adequate controls, will reduce operating costs.

Knowing your heating and electrical loads also allows you to consider your renewable energy and 'clean' technology options. The lower the loads, the easier it will be to meet any renewable energy or CO_2 emission targets in the brief.



LIGHTING

Install the most efficient lighting system available to you and don't specify more illuminance than necessary: 350-400 lux is acceptable for most office work applications. Set a maximum energy density of, for example, 12.5W/m^2 in the brief, to ensure that efficient lights are chosen.

If fluorescent lights are to be installed, make sure the specification requires that they are tri-phosphor coated with high-frequency ballasts. Daylight-linked automatic controls should be used to control lights closest to the windows to allow them to be dimmed or switched off when adequate daylight is available. State the maximum number of lights to be controlled by each switch. In high-mounted locations, specify metal halides or newer, more efficient high-wattage compact fluorescent lighting.

Pic: Sainsburys, Greenwich.
Windows at the high-level can be used to cool a

HEATING, VENTILATION AND COOLING

There is likely to be a need to balance the heating, ventilation and cooling services with the building's mass and other passive systems. For example if, after the passive elements are accounted for, more cooling is necessary to meet the expected load, it may be possible to increase the mass to offset this. It will, however, affect the heating and cooling system requirements so it is important not to take decisions on plant sizing and operation in isolation.

HEATING

Reduce the need for heating before sizing the heating system. Use the best thermal insulation available and set a minimum air-tightness requirement. This will allow you to specify smaller plant to meet the remaining need for heat.

Consider the space you're heating: if it's a large open area like a store, workshop or sports hall with high ceilings and possibly large vehicle access doors, specify an efficient radiant heating system. In smaller spaces or areas where less cold air will enter, conventional heaters are more appropriate.

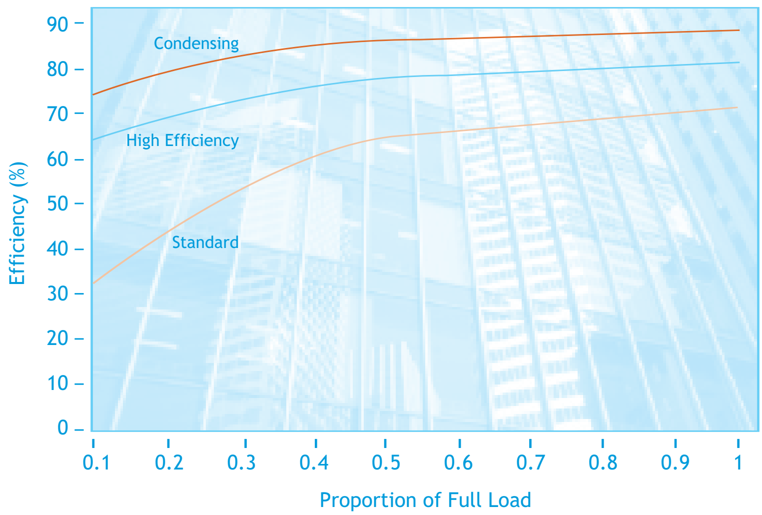


Figure 3: The efficiency of boilers is less when partially loaded

Specify condensing boilers. Relatively small efficiency gains on paper add up to significant savings in operation and efficient boilers are also more efficient at lower loads than conventional boilers.

Specify several smaller boilers to give you the flexibility to meet changing heating demands and allow boilers to be switched off-line for maintenance or repair. Control boilers using sequence controls to rotate the order they fire, on a weekly basis. This helps keep wear evenly distributed.

Consider the building's passive systems. In a well-sealed, heavyweight building with exposed mass, e.g. concrete and bricks and a slow heating response, oversized radiators or under-floor heating operating at lower temperature permit condensing boilers to operate more efficiently. A more lightweight building with plenty of windows will respond more rapidly to changing external and internal temperatures. For this reason, a higher-temperature, intermittently-operated system may be a better solution.

Buildings with different activities or occupancy times call for different heating provision. Specify heating circuits or zones to allow temperatures and times to be adjusted to match changing needs.

Specify high-efficiency motors and variable-speed pumps to allow the system to control flow rates according to demand.

Pic: Coventry University.
A well designed plant room provides plenty of access space for maintenance.

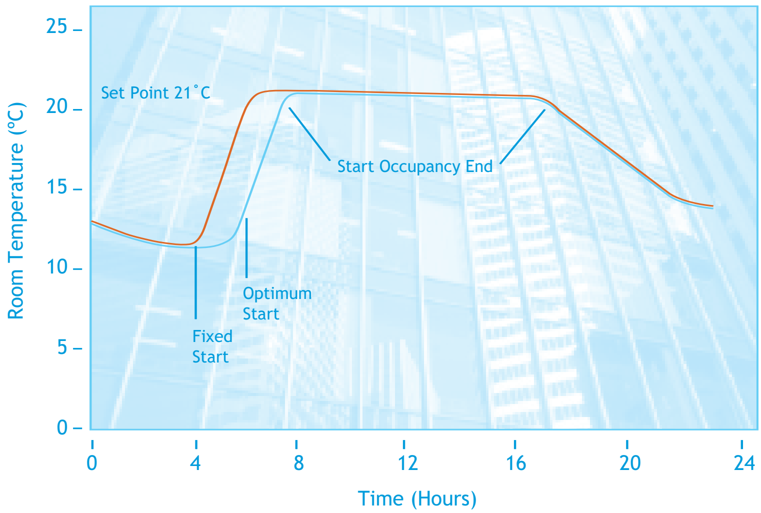


Figure 4: Optimised Start

Optimum start/stop and weather compensation controls are now mandatory so it is a good idea to ensure you and any occupants know how to use them. Optimum start controls 'learn' the heating performance of your building, switching on heating at the last moment and off as early as possible to maintain comfort temperatures during occupancy.

Weather compensation measures external temperatures and adjusts the flow temperatures accordingly. So on cold days, radiators will be hot, whilst on milder days they will be warm, thus saving money and improving occupant comfort. Other controls can detect longer-term changes in daily temperatures and switch the plant off for the summer.

VENTILATION

Where natural ventilation is not possible over the whole building, it may still be feasible to operate a mixed mode system where part of the building – or all of the building during a large proportion of the year – is naturally ventilated.

For buildings with a greater depth than 12-15m, a common approach is to have natural ventilation around the perimeter and mechanical ventilation near the building core. Seasonal control strategies may include using mechanical ventilation to provide minimum fresh air in winter to reduce heat losses, natural ventilation in spring and autumn and a mixed approach with cooling top-up in summer or overnight mechanical ventilation to make use of night cooling, or both.

Set energy consumption targets in the specification for individual components or the whole system and specify variable speed fans for control of air rates rather than dampers. Specify fans to use as little as 1 Watt per litre of fresh air per second by designing out pressure drops in the ductwork.

COOLING

There are a number of cooling options available at the design stage of a building. Consider the anticipated cooling load, running costs and the environmental impact of alternative solutions.

MINIMISE THE COOLING REQUIREMENT

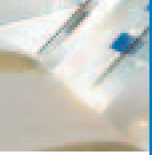
Specify high-efficiency lighting, fans and electrical equipment and focus on the building fabric, insulation levels and orientation so internal heat gains can be reduced and smaller plant can be specified.

For areas that would require large volumes of air movement to meet occupant comfort – for example, zones with very high heat gains – it may sometimes be more cost-effective to install air conditioning than just mechanical ventilation. This will enable lower air volumes to meet the same level of comfort.

EXPLOIT PASSIVE OPPORTUNITIES

There are efficient alternatives to conventional air-conditioning and your choice will depend on the amount of cooling needed. Free overnight cooling, using natural or mechanical ventilation to force cooler air through a heavyweight building structure, can deal with cooling loads of around $30W/m^2$. Higher heat gains will require some form of mechanical cooling.

Pic: Air Con Units.
Always specify intelligent controls for a/c systems with variable speed drives to reduce energy use.



SEEK NATURAL MEANS OF ACHIEVING ACTIVE COOLING

Because ground temperature below around 3m remains reasonably constant throughout the year, using the ground to cool your building can be a particularly effective all-year-round solution. The feasibility of this option depends on soil type and moisture content or availability of ground water. Extraction licences may be required from the local water authority. Any extracted water should be kept separate from the building's circulating systems and two boreholes will be required to ensure warmer extracted water is returned to a different location, usually through a shallower hole. Alternatively, a shallower ground loop may be employed.

The cooling effect of evaporation can take heat from the building's water or air based circulation system. Indirect evaporative cooling requires the evaporating water to be contained in a separate system linked to the ventilation via a heat exchanger. This is to prevent contamination and possible Legionnaire disease problems. Evaporative cooling is least efficient on hot, humid days but such conditions are relatively rare in the UK.

Chilled beams or ceilings have been around for over 40 years but have only recently become popular. Reduced duct work is required so less space is taken up compared to alternatives. They are water based systems, supplying water at temperatures of around 15-18°C, which cools the space in two ways: radiating coldness (or coolth) and cooling the air.

Colder air is more dense and sinks through the space. Using water requires less energy than equivalent air-based cooling systems and with few moving parts, they have significantly lower environmental impacts than typical air-conditioning systems. In addition to the environmental and economic benefits, they are also silent in operation and require relatively low air movement, providing better staff comfort.

ACTIVE MECHANICAL COOLING

Use active mechanical cooling as a last resort and make sure it will be controlled to ensure a match with actual demand to reduce its operating time.

Cleaner technology options

It may not be feasible to install zero or low carbon technologies to supply all the energy loads of your building, but 10-20% can often be achieved. Some local planning authorities have stipulated a minimum percentage of renewable energy supply for new buildings. Evaluate the building's expected loads, creating seasonal and daily profiles of demand for electricity and heat to identify which options would be the most appropriate. Some local authorities are making it a condition for planning permission to generate a portion of site electricity from renewables. It is important to evaluate in terms of whole life cost rather than simple payback.

The total energy requirement of a building should be reduced as much as possible through the use of low energy design, passive strategies and energy efficient equipment. Earlier Sections of this Guide deal with these issues. Reducing the energy requirement will reduce the size and cost of a low or zero carbon energy solution to meet a proportion of total demand. Furthermore, it does not make economic or environmental sense to add expensive renewable technologies to inefficient buildings.

'Clean' technologies are those using a renewable energy source, like sun and wind, or that provide heating, cooling or power more efficiently than conventional solutions. These might include heat pumps, combined heat and power (CHP) and 'free' cooling such as ground source or evaporative cooling. These more efficient technologies may not use renewable energy sources but they can achieve greater carbon savings for a given investment than renewables.

Building design affects the suitability of renewable energy technologies. For example, to maximise access to solar energy, buildings should be orientated within 30° of south and spaced at least twice their height apart to reduce shading. The choice of technology used is influenced by a number of factors, including:

- **Promotional value and links to corporate social responsibility**
- **Cost effectiveness which varies with building type, pattern of use and location**
- **The technology used, including its operational life, saleability of excess energy and available funding**
- **Carbon saving potential which may be relevant if local planning requirements state carbon targets or savings to be achieved**
- **Risks, or perceived risks, attributable to each technology.**

MEETING THERMAL LOADS

'Cleaner' options for meeting a building's heating and cooling demands include combined heat and power, solar thermal, biofuels and heat pumps.

SOLAR THERMAL - HEATING

Solar thermal technologies absorb some of the solar radiation in sunlight and daylight and convert it into useful heat. This is usually for the provision of domestic hot water or swimming pool water, although their use in providing warm air for space heating is on the increase in the UK.

Solar thermal technologies are established, easy to install and can offset the use of fossil fuels or electricity that would otherwise be used to provide the heating service.

Solar panels should be installed on southerly-facing roofs which are not overshadowed by other buildings or trees. Panels are usually installed in addition to a roof, so take care to ensure the roof structure can safely support the additional weight. Systems should generally have supplementary water heating capabilities to ensure adequate provision when the system is unable to provide the full hot water requirements.

Retro-fitting domestic sized collectors can cost up to £4,000 with payback periods of 10-40 years. However, prices can be reduced to half of this or less on major purchases for multiple or larger installations. Because they provide heat using a renewable source, solar systems can be used to offset renewable energy targets or to help a development meet a reduced carbon intensity target.

BIOFUEL - HEATING

Biofuels come in solid, liquid and gaseous forms including wood pellets, bio-diesel and methane. They're usually used to replace fossil fuels in providing heating and hot water in individual buildings. Because biofuels have a lower energy content than fossil fuels, more is needed to achieve the same heat.

Biofuels can now provide greater consistency of performance, improved outputs and reduced pollution as the technology becomes more refined. However, the pre-treatment involved can be energy intensive, affecting the fuel's overall carbon impact.

Biofuels are also not necessarily renewable, as wholesale fuel switching would deplete the resource over time, and their cultivation and transportation have significant energy, environmental and social impacts.

The source of the fuel should be as close as possible to the end user to minimise transport related impacts. Identify potential local fuel sources at the design stage and consider the impacts of transportation. Ensure there is adequate site infrastructure to deal with deliveries and set aside designated storage space as early as possible.

Biofuel boilers can be more expensive to buy but grant funding may be available to assist with the additional cost. Biofuels and solar thermal technologies can work very well together, with biofuelled boilers topping up hot water when there is less solar energy available.

Pic: BT HQ, Edinburgh.
Good labelling in a plant room will help the Facilities Management team in the future.

HEAT PUMPS – HEATING AND COOLING

Water and underground temperatures remain stable throughout the year at between 10-15°C. Heat pumps connected to buried or sunken 'collectors' containing circulating fluid can provide both heating and cooling. Heat pumps can produce flow temperatures sufficient for low temperature under floor or radiant panel heating.

The heat extracted has a negligible effect on the ground or water temperature but requires electrically powered pumps which if supplied from a renewable source, can provide heating and/or cooling with zero emissions.

Heat pumps should be in continual operation and are best suited to buildings or sites with continual heating or cooling demands. To ensure they're working at capacity, heat pumps should not be sized to meet full energy needs. Some conventional plant is therefore needed to meet peak demands but this will be smaller than if it were providing all the required load.

The technology is a 'fit and forget' option, with the collectors expected to have a 50 year life while the heat pumps themselves need minimal maintenance and can simply be replaced at the end of their anticipated 15 year lifecycle.

If water is extracted from the ground, rather than sealed in closed loops, extraction licences may be required and the Environment Agency should be contacted as early as possible to assess the options.

Heat pumps release fewer emissions than direct electric heating and can be an excellent option for inaccessible sites where gas or oil are not readily available.

Pic: Jubilee Campus, Nottingham.
Interesting architecture provides a stimulus for building occupiers.

MEETING POWER LOADS

Because much of the generation of mains electricity is dependent on fossil fuels like coal, gas and oil, it has a high carbon intensity. There are also many losses in the process including:

- **Heat (often lost to the atmosphere) as a consequence of the generation process**
- **Transmission losses caused by the distance from generation to supply and the need to change voltages during this process.**

Local generation can reduce losses associated with generation and transmission, especially if any waste heat can be recovered and put to use. Renewable sources of electricity, like wind turbines and photovoltaics, do not release carbon but in building integrated applications, generally produce only a proportion of the electricity required.

Pic: Canon HQ, Reigate.
Photovoltaics are best positioned on an inclined roof.

WIND TURBINES

Wind turbines can be building-mounted, integrated or stand alone. Current building-mounted varieties are smaller and have a power output of around 10-20kW. They may typically generate around a quarter of the total electrical requirement for a naturally-ventilated 4000m^2 good practice office building. Blade rotation on building-mounted turbines can cause vibration and drag, calling for careful consideration before installation.

Wind power can be considered for any site with average wind speeds of over 5m per second. Siting the plant is important to ensure wind turbulence is minimised before it reaches the turbine. Less turbulent air will produce more electricity and reduce wear and tear over the turbine's working life.

Power generated is related to wind speed and the area the rotors can sweep: the faster the wind speed and the bigger the 'swept area', the more electricity is generated. To reduce the impacts of turbulence and take advantage of faster wind speeds and larger blades, turbines are mounted on high towers.

Turbines have safety brakes that turn the turbine out of the wind if wind speed increases beyond maximum thresholds. These are well below the point at which structural damage to the turbine may occur, but extra consideration needs to be given where turbines are mounted on buildings.

Where there are good local wind speeds, turbines can repay investment in as little as 5 or 10 years, but this is dependent on site and turbine characteristics. A full feasibility study is recommended prior to any decision being made.

Wind turbines are highly visible and can produce some mechanical and aerodynamic noise. If you do choose to specify them, ensure local residents and businesses are consulted at the earliest possible opportunity and keep them informed throughout the design process. This will reduce the chances of local opposition preventing planning permission.

Pic: Sainsburys, Greenwich.
Wind turbines are becoming more and more popular with members of the public.

PHOTOVOLTAICS (PVs)

PVs convert a small amount of available light energy to electrical energy. They are highly visible and have been used to great effect for marketing purposes. Output is limited to daylight hours and increases with brightness so mount them on southerly-facing façades ideally sloped to face the sun.

They can be additional to the building fabric or an integral part of the façade, offsetting the cost of the fabric they replace. A south-facing array might provide around 100kWh/m^2/year.

PV arrays are made of many PV cells and can get very hot during operation. Ensure adequate ventilation and situate to reduce variable shade conditions across the cells. These actions will prevent hot spots building up which could lead to potential failure.

PV may add weight to the building which needs to be considered in the design to ensure the structure remains safe and stable.

The carbon reduction potential associated with PV is often lower than the other technologies discussed in this section and systems can be expensive to purchase, install and integrate into a building or connect to the grid. Because of this, the technology is best used for the onsite demands of small to medium scale installations.

PV is silent and has no moving parts or emissions. It may be attractively integrated into a building envelope to reduce carbon emissions.

Pic: Jubilee Campus, Nottingham.
Photovoltaics can help to reduce a building's electricity demand.

MEETING HEAT AND POWER LOADS SIMULTANEOUSLY - COMBINED HEAT AND POWER (CHP)

Traditional fossil fuel power stations produce large amounts of heat that is released as a waste product via large cooling towers. If this heat can be recovered to meet local thermal demands – cooling is possible using absorption chillers – then significant carbon savings are possible.

CHP is a smaller scale power station, offering savings by generating electricity locally and recovering heat from the generation process. If the CHP uses a locally available biofuel, it can even be carbon-neutral.

CHP is particularly suitable for sites occupied for 16 hours a day or more and with constant heat requirements; for example, swimming pools, hotels, hospitals or heat-dependent industrial processes. Such sites will have the shortest payback periods. However any heat demand can be satisfied by a CHP system. Although shorter operating hours will increase the payback period, CHP may still be competitive with other forms of low and zero carbon energy for reduction of carbon emissions.

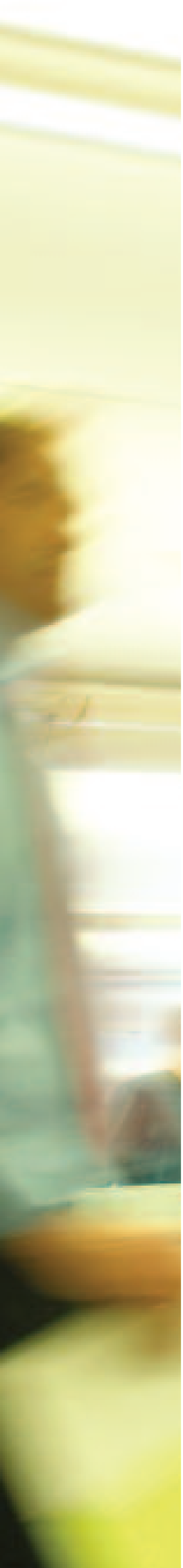
CHP may still be viable without these thermal demands if there is a nearby heat demand to sell the heat to. This is called district (or community) heating and could allow the site to install a larger CHP plant to supply a greater proportion of the electrical demand.

CHP commercial viability is susceptible to changes in fuel prices – usually gas or oil – and market electricity prices, which directly affect payback periods. However, if the CHP plant complies with the CHPQA good quality scheme, the fuel used and the electricity generated by CHP plant will be exempt from the Climate Change Levy. Enhanced Capital Allowances will also be available for investments in good quality CHP. The carbon savings associated with CHP may offer a way of meeting any carbon reduction targets.

For the best payback, CHP should be sized to meet base thermal loads which ensures minimal heat 'dumping' to the air, and should also be sized so that all the electricity produced is used on site. They are specified in terms of their electrical output (measured in kWe or MWe). A year round thermal load is best with supplementary services provided to meet additional demands above this level. The site will require grid electricity to overcome any mismatch in supply and demand and also to provide electricity during any maintenance down time.

Assessing CHP viability requires accurate demand profiles for both thermal and electrical loads. An independent feasibility study is recommended before making any decision and should incorporate potential maintenance costs. As a rule of thumb, these are currently less than a penny per kWh generated. Free CHP sizing software is available from the Carbon Trust who can also advise on Climate Change Levy and Enhanced Capital Allowance issues. The Carbon Trust also provides a free CHP Advice service.

Phase 4



TAKING OVER THE BUILDING 4

- Commissioning
- Producing a building log book

Commissioning

It is estimated that effective commissioning and re-commissioning of buildings during their operating life could save the UK over £500M a year. Studies[7] suggest energy savings of up to 40% can be achieved through the commissioning process, often paying back the cost of commissioning in under five years and in some cases, a matter of months.

Despite this saving potential, commissioning is often considered a one-off process at the end of construction and is often simply ignored. Commissioning tests that the building's services (heating, ventilation and air conditioning - HVAC) are operating as specified, prior to handover and occupation.

This has a double benefit in terms of extending the working life of the equipment and reducing overall energy costs. It is in everyone's interests to curtail commissioning time, as issues of responsibility and rectification of faults may arise. Even the client is motivated by eagerness to take up residence, however, this should be resisted. The period for commissioning is often squeezed, thus reducing its effectiveness.

For many heavily-serviced standard buildings, traditional commissioning has focussed on the HVAC systems, as these will be the most energy-intensive equipment on site.

However, modern environmentally-sensitive buildings frequently use integrated design features to minimise these services. These buildings often use the building fabric, orientation and form to manage internal temperatures and supplement these with efficient or novel HVAC solutions. Therefore, commissioning must address the way that building fabric and systems work together to provide comfort and carbon efficiency. Focusing mainly on HVAC systems may not be the best approach.

For such buildings, starting the commissioning process at the end of the construction phase is often counter productive. Any problems identified are unlikely to be rectified as they are already embedded within the building. For this reason, commissioning agents should be appointed earlier in the process. Components and equipment can then be checked and verified prior to and during their installation, ensuring that they meet the specification criteria.

[7] Commissioning Buildings for Energy Efficiency - BRECSU Scoping Report for the Energy Efficiency Best Practice Programme, 2001

Bringing in a commissioning agent earlier in the process will inevitably increase commissioning costs, but also improves the ability of the final building to meet the initial design criteria. Roles and responsibilities for dealing with issues raised during the commissioning process should be agreed from the outset to ensure problems are dealt with in a smooth and timely manner. In addition, the commissioning process assesses the behaviour of the building as a system. Failures to meet design standards are often as much to do with systems failure as with any particular individual component.

All elements of the building can undergo a commissioning process, from developing the design specification to purchasing and installing equipment and materials, to operational checks to ensure overall requirements are achieved. While parts of these procedures will involve commissioning individual items of plant, the main concern is how the installed plant and equipment affects the overall working environment and operation of the building.

The size and complexity of your project will dictate how thorough the commissioning process should be and when it should start. Whenever commissioning starts, the process should log any changes made. It should also record all tests conducted, their results and details of any actions required and show a clear audit trail of all activity. Adequate time should be allowed in the building programme and occupation schedule to incorporate appropriate commissioning.

Once construction has been completed, the entire building should be checked to ensure compliance with design specifications. A final report should be produced to include the entire commissioning process undertaken, all the findings of the testing and confirmation that the building can be handed over and prepared for occupation. In addition, a building operations and maintenance manual should be produced which, as a minimum, should provide details of the installed systems and their operation, including control settings.

It's a good idea to monitor the building performance for the first year of occupation and re-commission during a different season, as many buildings operate differently over the year. A full year of post-occupancy monitoring and commissioning allows control settings to be adjusted to meet changing requirements and these changes should be recorded within the building's operations manual and/or log book. It also allows any problems that were not initially picked up to be identified and rectified.

Remember to allow a 'settling in period' for the building and the commissioned controls before measuring operational performance of, for example, energy and water use. The specification needs to account for this and make provision for future testing, measurement and any possible rectification measures.

For PFI and Design, Build & Operation procurement, make sure full commissioning is included and that building availability and performance issues are linked to incentives reflected in the payment terms.

Producing a building log book

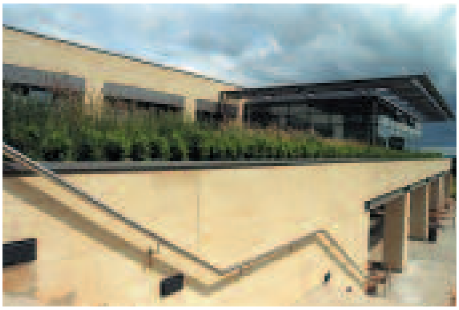
Low carbon buildings are not just about good design, as building use by the occupants and facilities management will have a huge effect on a building's overall carbon impact.

It is probable that operations or facilities managers will not be totally familiar with the control and operation of the buildings they inherit. This lack of knowledge could lead to increased running costs and unhappy occupants as controls are over-ridden to resolve short term problems rather than adjusted intelligently. The complete over-riding of controls will usually manifest itself in occupant discomfort in other parts of the building or times of the year, or in run-away energy consumption.

Example: a new building is designed to use 'night cooling' to lower internal air temperatures but is poorly commissioned and has no information to help operations or facilities managers. In the autumn, the building is cold in the mornings because controls require tuning, resulting in complaints from occupants. Facilities Management responds by over-riding the night cooling. This causes no immediate problems and resolves the staff complaints. However, the building then starts to overheat in late spring, half a year or more after the initial over-ride. The delay in noticing any effect could prevent the link being made between the cause (over-riding the night cooling) and the effect (the building overheating).

Such examples are not uncommon and are often the cause of dissatisfaction with new, innovative buildings. This not only increases occupant discomfort but also undermines the principles and strategies employed in such buildings. Whilst it's the operational decisions that have made the building fail, it's often the design that is blamed.

To tackle this problem, the 2002 version of Building Regulations (Part L2) requires the production of a Building Log Book. This is an operating manual intended for two groups of users: non-technical occupants and facilities or operations managers. Guidance on how to produce a log book is contained in CIBSE and Carbon Trust publications[8].



Pic: Wessex Water, Bath.
Planting on a 'green' roof provides a habitat for wildlife.

[8]Building Log Books – An authors guide and standard template for non domestic buildings – CIBSE Technical Memorandum TM31 (CIBSE 2003)
GPG348: Building Log Books – A user's guide (Carbon Trust 2004)

The log book should start with an introduction to the building as a whole, including the reasons behind design choices, what its expected energy and water use would be and how the building is expected to operate. Details of the heating and ventilation systems and how they should be managed should also be included, as well as the reasoning behind them and how they work. This will allow occupants and managers to compare actual performance with design expectations and provide the information required to manage the building in order to meet occupant expectations without vital systems being over-ridden.

More specific information covering all components of the building should also be provided. This includes details of the components installed, their expected lifetime and function, how they are controlled and how they operate. Information should also allow for preventative maintenance schedules to be developed and for failing or worn components to be replaced effectively. Building components to be covered include:

- **Building fabric**
- **Heating**
- **Lighting**
- **Air-conditioning**
- **Ventilation**
- **Specific energy-using equipment expected to be used within the building; e.g. office equipment**
- **Metering and monitoring**
- **Water distribution systems**
- **Water saving devices.**

The log book can help the building users and set up good management practice by the inclusion of:

- **A troubleshooting section that identifies the problems occupiers may encounter, based on previous knowledge or using case study material**
- **A schedule of zone operating hours and set-point temperatures and perhaps any seasonal variation that could help maintain comfort**
- **A checklist covering the most likely problems - for example, cold mornings in a building which night ventilates - and possible solutions, like changing the venting times.**

Leaving space for notes in the checklist section allows for the inclusion of new problems and solutions encountered during operation of the building that were not initially covered in the guide. This enables a process of learning from the past which would otherwise be lost, due to the relatively short-term nature of individual occupation against the long-term nature of buildings. The log book should also cover when to call on expert help.

To see how your company can benefit from working with the Carbon Trust

call 0800 085 2005

click www.thecarbontrust.co.uk/buildingdesign

The Carbon Trust works with business and the public sector to cut carbon emissions and capture the commercial potential of low carbon technologies. An independent company set up by the Government to help the UK meet its climate change obligations through business-focused solutions to carbon emission reduction, the Carbon Trust is grant funded by the Department for Environment, Food and Rural Affairs, the Scottish Executive, the Welsh Assembly Government and Invest Northern Ireland.

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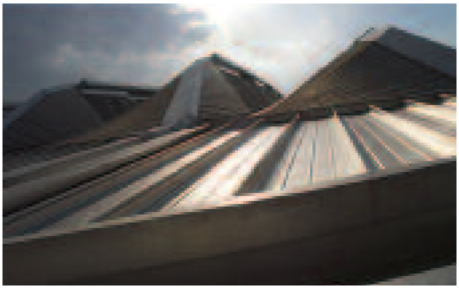
Making business sense of climate change

An increasing awareness of climate change, and a UK commitment to act after Kyoto, have led to the implementation of policy and legislation that seeks to lessen the impact of carbon emissions from buildings.

The tightening of Part L of the Building Regulations in England and Wales and Part J in Scotland, and the implementation of the new European Energy Performance of Buildings Directive (EPBD) in 2006 will have far-reaching implications for the owners, operators and developers of all buildings in the UK. The important requirements of each of these legislative drivers are as follows:

Pic: Boots HQ, Nottingham.
Buildings that are orientated East-West require a different type of shading system from those North-South.



1. BUILDING REGULATIONS – PART L

Part L of the Building Regulations for England and Wales addresses the energy efficiency of buildings. In September 2005, the Government published the final draft of the new Approved Document L in four parts:

- **L1A: Conservation of fuel and power in new dwellings and extensions**
- **L1B: Conservation of fuel and power in refurbished dwellings**
- **L2A: Conservation of fuel and power in new buildings other than dwellings.**
- **L2B: Conservation of fuel and power in refurbished buildings other than dwellings.**

Pic: Sainsbury's store, Greenwich.
The Sainsbury's store at Greenwich was designed to be as low energy as possible.

The amendments affect both the design and construction of buildings, and everyone working in them. Some provisions are intended to affect those managing the day-to-day running of buildings, especially the services. Part L also covers a wide range of refurbishment and improvement work. For example, fitting or replacing a window, roof-light or door with more than 50% glazing and space heating, water heating, boilers and lighting are all within the scope of the Regulations. The main changes for non-domestic buildings are:

- **Compliance to be based primarily on a calculated value of the carbon emissions potential of the building**
- **A significant extension of the definition of a 'controlled service'**
- **Minimum acceptable standards of insulation of the building fabric, windows, piping and ductwork systems**
- **Higher standards of detailed design and site workmanship to achieve better thermal performance**
- **New air-tightness standards, including provision for building control to require practical testing of buildings**
- **New requirements for commissioning and for information about operation and maintenance of installed services to be made available to users**

- **Performance standards for avoiding solar overheating, boiler efficiency, heating and hot water systems, pumps and fans, and lighting efficacy**
- **New performance requirements for air-conditioned or mechanically-ventilated buildings**
- **Requirements for installation of energy consumption meters and sub-metering**

Further information on the changes within Part L, which take effect from 6 April 2006, can be found at www.odpm.gov.uk or www.cibse.org.

To minimise the cost of compliance, the M&E design engineer should be involved early in the design process.

Pic: Coventry University Library.
Lightwells provide daylight to the occupied space below.

2. ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD)

Practical implementation of the Directive will be very demanding as the legislation is supposed to be in place by January 2006. Key provisions of the Directive are:

- **Minimum requirements for the energy performance of all new buildings**
- **Minimum requirements for the energy performance of large, existing buildings subject to major renovation**
- **Energy certification of all buildings, with frequently-visited buildings providing public services being required to prominently display the energy certificate**
- **Regular mandatory inspection of boilers and air conditioning systems in buildings.**

For new buildings with a useful floor area over $1000m^2$, governments must ensure that, before construction starts, formal consideration be given to the following alternative systems for heating:

- **CHP**
- **District (or block) heating or cooling**
- **Heat pumps**
- **Decentralised energy supply systems based on renewable energy**

Two key requirements – that all new buildings should meet minimum energy performance standards and that, whenever a building with a total useful floor area of over $1000m^2$ undergoes major renovation, its energy performance should be upgraded to incorporate all cost-effective energy efficiency measures – will be implemented when the new Part L requirements come into effect in April 2006. Further statements are awaited on how and when the remaining parts of the Directive will be implemented.

Further information on the EPBD can be found at the Directive Implementation Advisory Group (DIAG) website at www.diag.org.uk or at www.cibse.org.

3. THE EFFECT OF FUTURE ENERGY AND WATER PRICES

The price reductions seen for electricity and gas supplies as a result of privatisation have now come to an end. Future energy price predictions in the Government's energy white paper are for both electricity and gas prices to increase. Oil prices escalated by nearly 100% in 2004/2005 and it is expected that gas and electricity prices will also rise. At the time of printing, commentators disagree as to whether these rises are due to passing political problems or are more fundamental. Water price increases are governed by the regulator (OFWAT), and have already been set at 13% to 2010. Against this background, world oil prices have risen by nearly 300% since 2003, and this is known to have a knock-on effect on gas and electricity prices.

All utility prices are expected to rise in the medium term, further increasing building running costs. Price uncertainty beyond these periods means improving energy and water efficiency during any refurbishment or construction of a new building can reduce some of the long-term risks associated with running costs. Considering a whole life approach to costing your projects could ensure a better deal for your company over the whole period that the company uses the building, not just when it's built.

4. PLANNING REQUIREMENTS

In August 2004, the Government published its new Planning Policy Statement on renewable energy (PPS22). It sets out the Government's planning policies for renewable energy, which planning authorities should have regard to when preparing local development documents and when taking planning decisions. PPS22 reinforces the importance that the Government places on the development of renewables (together with improvements in energy efficiency and the development of CHP) in meeting its target to reduce CO_2 by 60% by 2050. It requires regional spatial strategies and local development documents to include policies designed to promote and encourage, rather than restrict, the development of renewable energy resources. This includes provision for policies that require a certain percentage of the energy to be used in new residential, commercial or industrial developments to come from on-site renewable energy technologies.

In London, the Mayor's Energy Strategy proposal 13 states, "To contribute to meeting London's targets for the generation of renewable energy, the Mayor will expect applications referable to him to generate at least ten per cent of the site's energy needs (power and heat) from renewable energy on the site where feasible. Boroughs should develop appropriate planning policies to reflect this strategic policy."

Various other planning authorities around the country are introducing similar requirements. As early as possible in the building procurement process, inform yourself of the local requirements.

5. FUTURE LEGISLATION

The UK will only be able to achieve the environmental targets set to 2050 through an increasing number of incentives and legislative instruments. Future revisions of the Building Regulations can only demand more and more resource efficiency within our built environment. Given how much the carbon dioxide emission contribution from the built environment represents, vigorous steps to reduce emissions will be needed in order for the UK to make the transition to a low carbon economy by 2050.

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